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PROCEEDINGS

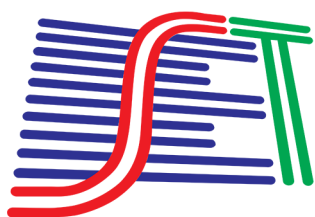
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Presentation

The **SET EXPO Technology Conference**, as well as the related concurrent events, seek to discuss the future of the Broadcast, Telecommunications, Audiovisual and New Media industry, as well as their inherent relationships with a range of issues: computing, infrastructure, communication, production and regulatory affairs. This magazine, called **SET EXPO PROCEEDINGS**, also known by its acronym SETEP, is a compilation of the entire conference agenda, that is, a description of the entire contents of all sessions at what is largest encounter of its kind in this region of the globe. Thus, as the entity staging this event, SET (the Brazilian Society of Television Engineering) believes that information sharing can but work to the benefit of rich and innovative discussions so that we can continue to build an active community and a strong sector, in addition to achieving the desire, with which we have always been imbued, to push the envelope. The board, president, members, associates, staff, directors, partners, organizations and supporters, whether from the public or private sector and/or government, Brazilian and/or international, wish to thank all those who have always been instrumental in helping us to fulfill our passion for the development of this area.

We would also like to reiterate the information that this publication has been properly registered with the ISSN in printed and electronic formats, and that each session was recorded and allocated a persistent link. It is worth pointing out that this magazine is available in three languages: Portuguese and English.

FUTURE OF CODING AND IMMERSIVE STANDARDS

In this session consisting of three lectures, we will cover coding applications in the near future. Speakers share their approaches and impressive results for coding using state-of-the-art standards and protocols.

Bitmovin presents a brief history and history of AV1 development and adoption, comparing the performance of AV1 vs VP9, HEVC/H.265 and AVC/H.264. It also brings AV1 implementation/support cases in the LATAM region and around the world.

The growing popularity of XR applications is leading the media industry to seek encoding and transmission technologies capable of supporting the immense volumes of data generated by immersive experiences. In this second lecture we will present the Visual Volumetric Video-based Coding (V3C) standard developed by the MPEG group for volumetric videos.

We will also provide an overview of the MPEG-H audio system and the TV 3.0 project requirements for the audio component. With broad industry support, the MPEG-H audio system brings immersive sound, advanced interactivity, and accessibility options, as well as advanced features such as hybrid delivery, consistent sound after user interaction, connectivity options for external sound devices, and changes settings transparently.

Chair: Hugo Nascimento - CTO of AD Digital | Coordinator of the Working Group “Industry 4.0 at SET”

• WHEN WILL AV1 BE READY FOR ADOPTION IN LATIN AMERICA? ALREADY?!

Speaker: Manfred Runkel - Senior Solutions Architect at Bitmovin

How efficient is AV1 compared to other codecs? Which browsers and devices support AV1 playback? Is AV1 ready for deployment in the LATAM region?

Join Manfred Runkel, Senior Solutions Architect at Bitmovin, as he answers these questions and more around encoding, testing and the potential ROI of adding AV1 to your multi-codec streaming strategy.

Brief history and background of AV1 development and adoption.

Benchmarking the performance of AV1 vs VP9, HEVC/H.265, and AVC/H.264.

AV1 deployment/support in the LATAM region & worldwide..

• OVERVIEW OF THE MPEG V3C STANDARD FOR IMMERSIVE VIDEO CODING

Speaker: Celine Guede - Architect in Research & Innovation – InterDigital

A volumetric video consists of a sequence of frames, where each frame is a static 3D representation of a real-world object or scene capture at a different point in time. However, such contents can consume significant bandwidth. Compression of volumetric video is required to obtain data rates and files sizes that are economically viable in the industry. Standardization is required to ensure interoperability.

The Visual Volumetric Video-based Coding (V3C) standard specified by the MPEG group defines a generic mechanism for coding volumetric video and can be used by applications targeting different types of volumetric content, such as point clouds, immersive video with depth or transparency of visual volumetric frames.

• MPEG-H AUDIO SELECTED FOR THE NEXT GENERATION TV 3.0 BROADCAST SYSTEM IN BRAZIL

Speaker: Adrian Murtaza - Senior Manager, Technology and Standards - Fraunhofer IIS

Under the name “TV 3.0 Project”, the Brazilian Terrestrial Television System Forum (SBTVD) has issued the Call for Proposals (CfP) for a next generation Brazilian digital TV system, in July 2020.

After a very strict testing and evaluation phase conducted by independent laboratories, and considering market and intellectual property aspects of all the candidate technologies, the SBTVD Forum. has selected the VVC video codec and the MPEG-H Audio system, for the next generation TV 3.0 broadcast system in Brazil.

This lecture provides an overview of the MPEG-H Audio system and the TV 3.0 Project requirements for the audio component.

• VERSATILE VIDEO CODING (VVC) – THE NEXT GENERATION VIDEO CODEC

Speaker: Ralf Schaefer - Vice President Standards – InterDigital Research & Innovation – InterDigital

The video coding standard named Versatile Video Codec (VVC), jointly developed by MPEG (ISO/IEC) and VCEG (ITU-T) in the JVET (Joint Video Expert Team) has been published respectively by ISO and ITU-T and end of 2021 VVC has been adopted by SBTVD as the main video codec for TV3.0.

VVC can be considered as the state-of-the-art next generation video codec, succeeding HEVC (High Efficiency Video Coding), with an estimated bitrate gain of 40% versus HEVC for HD and 4K formats. VVC can be seen as an incremental design on top of HEVC, with enhancements of existing coding tools, along with introducing multiple new coding tools in all components of the codec architecture.

This presentation aims at providing an overview of the VVC development phases, VVC use cases & requirements and of major new coding tools.



Chair: Hugo Nascimento - CTO of AD Digital | Coordinator of the Working Group “Industry 4.0 at SET”

Graduated in engineering, he has more than 15 years working in Broadcast and PayTV projects in various fields such as IPTV, DTH and production and post-production environments. In his career, he has worked in companies and clients that are reference in the market, such as Cisco, Google, Telefonica, etc, as well as in projects involving multidisciplinary teams in different countries for Telefônica, Megacable, Claro, NET and his experience includes projects in pre and after-sales service with deep technical knowledge in this market. He has worked in the most demanding markets such as Germany, the United States, Mexico, Colombia, Argentina, Spain, among others.



Manfred Runkel - Senior Solutions Architect at Bitmovin

Senior Solutions Architect at Bitmovin, enabling Customers/Developers to achieve great results on the OTT Streaming Platforms. Postgraduate Software Architect/Data Science & Microsoft Azure Solutions Architect Expert with 15 years of tech experience acting as a Developer, Cloud Architect and Software Manager.



Celine Guede - Architect in Research & Innovation – InterDigital

Celine Guede graduated in engineering in 1998 from Polytech Orleans School, France. The following year, she joined Technicolor as an R&D engineer, where she first specialized in real-time software development, and in 2013 she joined the Advanced Television Systems activities, where she dedicated her expertise to contributions to the ATSC 3.0 television transmission standards.

In late 2016, Celine joined the Point Cloud Compression project and made contributions to the emerging MPEG Point Cloud Compression standard called V-PCC (Video-Based Point Cloud Compression).

In 2019, she moved to InterDigital as an architect, where she contributed to finalizing the MPEG V-PCC standard. Since 2022, her work is dedicated to volumetric video transmission, and she is heavily involved in the dissemination of V-PCC and MIV (MPEG Immersive Video) developing a real-time codec for these technologies and preparing standard contributions.



Adrian Murtaza - Senior Manager, Technology and Standards - Fraunhofer IIS

Adrian Murtaza received his M.Sc. degree in Communication Systems from the École Polytechnique Fédérale de Lausanne, Switzerland in 2012 with a thesis on “Backward Compatible Smart and Interactive Audio Transmission”. Upon graduation he joined Fraunhofer IIS, where he works as a Senior Research Engineer.

Adrian Murtaza joined MPEG in 2013 and since then contributed to development of various audio technical standards in MPEG-D and MPEG-H. He serves as Fraunhofer’s Senior Standards Manager in a number of industry standards bodies, including DVB, ATSC, SBTVD, CTA and SCTE, and is the co-author of multiple specifications in those groups.

More recently he focused on specification of Next Generation Audio delivery and transport in ATSC 3.0 systems and MPEG-2 Transport Stream based DVB systems, as well as on enabling of MPEG-H Audio services in different broadcast and streaming ecosystems.



Ralf Schaefer - Vice President Standards – InterDigital Research & Innovation – InterDigital

Ralf received his engineering degree (Dipl.–Ing.) from the Technical University Kaiserslautern/Germany and joined InterDigital in June 2019. As full time standard professional, Ralf chairs the MPEG WG7 AhG on Video-based Graphics Coding, is vice-chair of the DVB Commercial Module and is elected member of the DVB Steering Board.

Furthermore, Ralf is an active contributor to standards working groups in DVB, ETSI, SBTVD Brazil, NorDiG and FAVN France. Previously he chaired the MPEG 3DG AhG on Point Cloud Compression, which advanced the work on Video-based Point Cloud Compression (V-PCC) between MPEG meetings and led to the publication of ISO/IEC 23090-5:2021.

Before moving to Interdigital, Ralf occupied a similar position in Technicolor, where he contributed to ATSC3.0 and NGBF South Korea. Earlier he held R&D positions at various levels in Thomson and chaired working groups in DVB related to IPTV, Home Networking and Companion Screens.

IP INFRASTRUCTURE – WILL MY NEW ARRAY BE 2110 OR WILL IT BE IN THE CLOUD?

How should I face the video transport infrastructure at my station? Is SDI history and should I only look at the IP? The worst is over and it is already the best choice? And cloud, did it really come to dominate or will it be another variable in this equation? In this panel we will discuss the evolution of the infrastructure and try to answer, with renowned experts, some of these questions.

Moderator: Roberto Hoffmann Netto, Technology and regulatory project manager at RBS TV Porto Alegre

Speakers:

- **Boris Kauffmann - Senior Specialist Solutions Architect - AWS**
- **Felipe Domingues - Pre-Sales Manager - CIS Group**
- **Eduardo Lopes - Technology Director of Rede Amazônica**
- **Marcelo Minami - Solutions Architect | AD-Digital**



Roberto Hoffmann Netto, Technology and regulatory project manager at RBS TV Porto Alegre

Electrical engineer, with an emphasis on automation, graduated from Unisinos. He has been working for over 15 years in broadcast and telecommunications companies, with extensive experience in management systems projects, multiservice networks and in IT and Broadcast platforms. He has worked on deployments in Brazil and Latin America, having worked at Claro, Deutsche Telekom and Smartcom PCS. He is currently manager of technology projects and regulatory at RBS TV Porto Alegre.



Boris Kauffmann - Senior Specialist Solutions Architect – AWS

Graduated in Electrical and Electronic Engineering with emphasis in Telecommunications from Universidade Presbiteriana Mackenzie, he is currently a Solution Architect Specialist in Broadcast at Amazon Web Services (AWS). He has over 15 years of experience in the audiovisual industry providing solutions for broadcast and post-production companies using cutting-edge technologies for the transport and processing of sound and image. He has developed several on-premises video over IP infrastructure projects based on the SMPTE 2110 and SMPTE 2022-6 standards, and is currently responsible for designing cloud architectures for AWS's media and entertainment customers in Latin America.



Felipe Domingues - Pre-Sales Manager - CIS Group

Electrical engineer with over 18 years of experience in the Broadcast market, always working in technical areas. During this period, he worked at companies such as Snell Advanced Media (SAM), Imagine Communications and Grass Valley. For 4 years he has been working as Pre-Sales Manager for CIS Group helping clients to find the best solution for their needs.



Eduardo Lopes - Technology Director of Rede Amazônica

Eduardo Lopes holds a degree in Electrical and Telecommunications Engineering from Inatel. He has specializations in Systems (Center for Higher Education in Management, Technology and Education – FAI), Project Management (Fundação Getúlio Vargas – FGV), Digital TV and IPTV (Inatel), Business Administration (Postgraduate and Graduation Institute – IPOG) and Digital Strategies for Media Companies (ISE Business School). Currently, he is the Director of Technology at Rede Amazônica, an affiliate of TV Globo in the North Region.



Marcelo Minami - Solutions Architect | AD-Digital

Graduated in Systems Analysis, he has over 28 years of experience in the Broadcast market.

In his professional journey he has led technical projects, project management, support and deployments. He has worked intensively on relevant digitization projects with major manufacturers and integrators in Brazil and Latin America.

OPPORTUNITIES AND CHALLENGES OF FAST CHANNELS

Moderator: Marcelo Souza - Technology Director for Digital Products at Globo | SET advisor

- **MONETIZATION OF FAST CHANNELS AND THE RISE OF CONNECTED TV**

Paul Finster - VP, Global Business Development – Amagi

Leveraging Cloud technologies, Amagi has built the next-gen Broadcast infrastructure including scalable DAI for the future.

Learn why Amagi believes that all Broadcast is set to migrate to the Cloud and why Amagi believes that FAST channels will dominate the broadcast industry over the next 20 years..

- **Rita Mesquita - Director - Xandr, a Microsoft Company**

- **REVOLUTIONIZING THE TV ADVERTISING LANDSCAPE AND CONNECTING CONTENT, BRANDS AND CONSUMERS**

Essio Floridi - Sales and Operations Director Latin America – Samsung Ads

Unveiling Samsung's new TV advertising platform ecosystem – Samsung Ads – and all the possible connecting opportunities supported by our holistic knowledge on content consumption habits powered by proprietary data and insights. Know more about our key role in revolutionizing the Latin American advertising landscape with our Smart TV Advertising model and impactful formats.



Marcelo Souza - Technology Director for Digital Products at Globo | SET advisor

Technology leader for Globo's digital products including Globoplay, Globosat Play, Premiere Play, Combate Play, Sites Globo.com, G1, Globoesporte, GShow, Cartola. Graduated in electronic engineering and computing at UFRJ, master's degree in image processing at COPPE/UFRJ, MBA in business management at IBMEC-RJ and specialization course in Leading Product Innovation at Harvard Business School. For 21 years in the media industry, he has worked on digital video transmission projects, implementation of Digital TV in Brazil, TV channel distribution operations and Content Post Production, Strategic Planning, Advertising Technology (ADTECH) and Technology Strategy in Digital Media



Paul Finster - VP, Global Business Development - Amagi

Paul Finster is an accomplished technology executive with expertise and history in Solution Selling, Service Delivery and Operations, Product Development and Software Engineering across diverse business sectors, working now with a focus on the Media and Entertainment market. At Amagi, he's responsible for Streaming Innovation & Business Development.



Rita Mesquita - Director - Xandr, a Microsoft Company

Rita Mesquita is director of Xandr in Brazil. With over 10 years of experience in the digital marketing industry, Rita is responsible for the commercial and client services areas, with in-depth knowledge of digital media and technology platforms, having worked with different clients throughout Latin America, both in buy-side, with agencies and trading desks, as well as on the sell-side, with vehicles and publishers from all over the region.



Essio Floridi - Sales and Operations Director Latin America – Samsung Ads

Essio Floridi is an executive with over 20 years of experience in the advertising industry. He holds a degree in economics from USP, an MBA in Services Marketing from ESPM and Strategic and Economic Business Management from FGV.

He started his career in Milan (Italy) in 1998 and, back in Brazil in 2000, he worked as Digital Media Director for 2 years both at JWT and at AgênciaClick.

As a vehicle professional he was Sales Manager at Yahoo! Brazil from 2004 to 2009 and Director of Digital Media Advertising at Globosat for 6 years.

In 2016, he assumed the position of Country Manager at Tradelab (French programmatic media startup) where he stayed until 2020, when he assumed – within Samsung Electronics – the position of Sales and Operations Director Latin America, of the new Samsung Ads business unit. (Samsung's omnichannel advertising solution) implemented with its arrival.

ASSET MANAGEMENT – THE FUTURE OF MAM AND PAM PLATFORMS

Moderator: Marcelo Souza - General Director of Technology - CNN Brasil

In this panel, we will show how companies are dealing with the topic of asset management, from the point of view of those who produce content. We will have a vision of how to control and share, in view of the need for process optimization, reformatting and monetization. We will also see the testimony of a company that uses these services, pointing out their challenges in using and integrating the various formats. Participate with us!

- **ASSET MANAGEMENT IN THE CLOUD CREATING NEW INCOME**

Ronaldo Dias - Director of Sales Americas - Amagi

The cloud technology is revolutionizing the speed and process of content creation, management, distribution and monetization allowing high scale in a short time to make the content available to the market through different segments such as Broadcast, Cable and Streaming.

- **THE ROLE OF MAM AND PAM PLATFORMS IN A “CLOUD-IFIED” WORLD**

Matt Silva - CEO of CIS Group Corp

This presentation will address how the evolution and adoption of modern technologies in the media and entertainment industry, along with the convergence of the broadcast and IT worlds, has been influencing and shaping the role of MAM and PAM platforms in the content creation chain over the last few years..

- **Rafael M. Duzzi Oliveira - Director of Engineering and Technology - CNN Brasil**

- **Carol Alberto Correia Garcia - Engineering Manager - Bandeirantes Radio and Television**


Adilson Dolci - General Director of Technology - CNN Brasil

Adilson Dolci is currently CTO at CNN Brasil. Graduated in Systems Analysis, he is also a Master in Information Technology, specialist in Financial Management and Entrepreneurial Business Management.

He was a university professor and worked for more than 20 years at the affiliate Globo TV TEM, where he was responsible for the strategic management of the Technology and Broadcast areas.


Ronaldo Dias - Director of Sales Americas - Amagi

Ronaldo Dias is Director of Sales at Amagi, where he is responsible for Hispanic and Faith & Family segments across the Americas. With over 15 years of experience in the media & entertainment market, Ronaldo is involved in all business stages supporting the broadcast journey to the cloud and, on FAST opportunities from content creation, distribution and monetization. Prior to this role, Ronaldo held the positions of Director of Sales and Business Development at Ericsson/MediaKind, and Director of Strategy & Business Development at SondaIT, and Director of Broadcast and Cable Solutions at Harmonic. Ronaldo has a degree in Electrical Engineering from the Faculdade de Engenharia Industrial (FEI), Brazil, and a postgraduate degree in finance and marketing (MBA/CEAG) from Fundação Getúlio Vargas (FGV), Brazil.


Matt Silva - CEO of CIS Group Corp

Matt Silva earned a B.S. Business, Finance and Economics from the Stern School of Business – New York University. He has worked as an investment analyst at financial institutions such as Citl and Credit Suisse in N.Y. At CIS Group he served as Director of Corporate Development, COO and currently CEO.


Rafael M. Duzzi Oliveira - Director of Engineering and Technology - CNN Brasil

Graduated in Telecommunications Engineering with a postgraduate degree in project management from SENAC, Rafael Duzzi has been working in the M&E and Technology market for over 20 years.

With stints at NET, RedeTV, AD-Digital, LM Telecomunicações and Adstream, he managed and executed Technology and Broadcast projects in several TV stations.

At the moment, he works as director of engineering and technology at CNN Brasil and his daily challenge is to manage the areas of Engineering, IT, IS and technology projects in general.


Carol Alberto Correia Garcia - Engineering Manager - Bandeirantes Radio and Television

Electrical Engineer and Production Engineer from FEI, he has been working for 18 years in the television and content production market, managing and conducting implementation, integration and operation processes of integrated systems such as MAM, automation, video servers, graphics, among others.

He participated in events such as the World Cup and the Olympics with the usability and applicability of these solutions.

He works as engineering manager at RTV Bandeirantes, leading the technical areas of systems, implementation, media center and exhibition center, operating and guiding the broadcaster's workflow, between the areas of journalism, sports and entertainment for a better flow of production and delivery of content.

SET EXPRESS | PRODUCTION

Chair: Raimundo Lima - Executive Director of PRODUPIX / Member of the Board of SET

“Cloud-Based Workflow: A new modern way to create, edit, share, and stream

“Who Killed Sara?” – a successful case using remote editing

Unreal: revolutionizing the way of producing and telling stories

• CLOUD PRODUCTION – REVOLUTIONIZING CONTENT CREATION FOR LIVE NEWS AND SPORTS

Speaker: Jose Luis Reyes - Vice President for Latin America - Live U

Outside Broadcaster Truck or VANs (DSNG) were synonymous of good services and quality. However, year by year, with advanced of technology and cost pressure, it is pushing for more innovative solutions, cutting expensive hardware and replacing with state of art technology for remote production. The presentation explores new modern way to create, edit, share and transmit, by using the Live U new concept called Cloud Based Workflow, building a flexible, scalable and cost efficiency production for Live News and Sports Broadcasts.

• VIRTUAL PRODUCTION IN UNREAL

Speaker: André Dias Arnaut - Virtual Production Manager – RecordTV

We are experiencing a revolution in media production in the world, and this movement is being led by the Epic game engine called Unreal. The beginning of this movement begins mainly with Disney productions in Hollywood, among them Mandalorian, which made everything we had learned in virtual production to be rethought.

The projection that in the next 6 years until 2028 virtual production will grow 15% per year and this tends to continue with a demand that was repressed due to not having access to this technology.

We will show case studies, research and how to prepare for this process that puts virtual production at the center of content production discussions and changes how we tell our stories.

• NETFLIX CASE “WHO KILLED SARA” – COLLABORATIVE REMOTE EDITING

Speaker: : Luis Bechtold - Strategic Manager at Adobe

The Spanish language series “Who Killed Sara?” became one of the surprises Netflix hits of 2021, earning a spot as the streaming service’s most popular non-English language title a month after its launch.

The Post-production team achieve a smooth remote editing workflow and set up an efficient, collaborative, and reliable workflow using Productions in Adobe Premiere Pro and LucidLink.

Simultaneous editing using Productions in Premiere Pro meant that multiple editors could attack the same episode. It made the edit more collaborative because everyone was working together. If someone was getting stuck on a scene, I could have another editor take a look at it with fresh eyes.

**Raimundo Lima - Executive Director of PRODUPIX / Member of the Board of SET**

With stints on the main Brazilian television networks, he collaborated in the Production, Engineering, Broadcasting, Operations and Technology sectors, working in the areas of Entertainment, Journalism, Dramaturgy and Sports. He is an active member of the main associations in the sector and an active participant in fairs and conferences in the media market.

**Jose Luis Reyes - Vice President for Latin America - Live U**

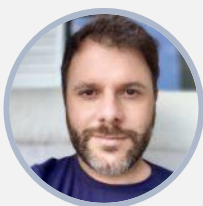
Broadcast industry since 1985. Sales Manager for Cine Materiales – 2003. Broadcast Project Manager and then sales manager at Inviso in Miami (Miranda – ADC-Belden – 2005 to 2007), Vice president Sales & Operations at Inviso (Miranda – ADC-Belden – 2007 to 2013), Regional Sales Manager LaTam South (Grass Valley – 2013 to 2016). VP Latin America at LiveU since 2016 to the present. In charge of direction of business operation in the Latin American region for Mexico, Central America, South America (Including Brazil) and the Caribbean.

**André Dias Arnaut - Virtual Production Manager - RecordTV**

Specialist in virtual production and leading a team of 42 people at Recordtv.

With 19 years of experience in various platforms and participating in the main deployments of graphic platforms and virtual productions in broadcasters and content producers participating in more than 40 projects of virtual studios.

With works and passage through SBT, Rede Bandeirantes, Tv Cultura, Espn, Fox, Globo São Paulo, Rede Tv, Rede Vida, Rede Amazonia, Maze, TsMusic, Ministry of Health Tv Sus, Pixit among others.

**Luis Bechtold - Strategic Manager at Adobe**

I am currently driving Strategic Business Development across Adobe's Creative Cloud Enterprise SaaS business with Adobe's Latin America Enterprise Customers & Industry Partners to accelerate Business growth & Product Innovation.

Customer focus leader with 20+ years of experience in the Digital Media and Entertainment Industry.

SET EXPRESS | CONNECTIVITY

Chair: Valderez de Almeida Donzelli - Technical Director of ADTHEC | SET Counselor

This panel will address the technical aspects of connectivity in support of TV production, reach and audience expansion, hybrid and multi-orbit network communications.

• INTELSAT: PAST, PRESENT AND FUTURE – INNOVATION AND INVESTMENT IN GLOBAL CONNECTIVITY

Speaker: Marcelo Amoedo - Senior Sales Director - Intelsat Broadcast Services, Brazil

A discussion of Intelsat's history as the foundational architects of satellite technology; a look at a recent investment in Latin America, and around the globe, that empowers our media customers to expand their reach and viewership; and a preview of our plans to build the future of global communications with world's first hybrid, multi-orbit, software-defined 5G network.

• VIDEO TRANSPORT OVER 5G: THE POTENTIAL OF TECHNOLOGY IN SUPPORT OF TV PRODUCTION

Speaker: Glaucia Mattioli - Executive Sales Manager – Embratel

Graduated in Telecommunications Engineering from UFF, with an MBA in business management from IBMEC-RJ.

She works at Embratel as a sales manager for the Media segment.

She has more than 20 years of experience in the Telecommunications market, having worked in the pre-sales, post-sales and sales areas.

She participated in tests with 5G technology to serve media customers.

• THE IMPORTANCE OF MONITORING IN AN OTT WORKFLOW

Speaker: Guilherme Castelo Branco - Director - Phase Engenharia

OTT platforms continue to multiply and offer diverse content and experiences to the growing subscriber base. Providing a quality of service of excellence is crucial for the success of the streaming service, in addition to being an immense challenge due to the ecosystem being extremely complex, especially when compared to traditional linear services. In this presentation we will address the importance of monitoring in an OTT platform and ways to implement it.



Chair: Valderez de Almeida Donzelli - Technical Director of ADTHEC | SET Counselor

Graduated from FEI in electronic, electrotechnical and production engineering. Master in electrical engineering. Postgraduate in Neuroscience from Instituto Israelita Abert Einstein. Specialization in IT by FESP, ICT management and Project Management by FGV, Data Science by Awari, Advanced Digital TV System by INATEL and DMC – Decoding Mente Corpo with Dr Carlos Alberto Ribeiro. She develops research projects in connectivity, digital media and application of neuroscience concepts in engineering and human development.

Director of Engineering, Technology and Regulatory at the engineering company ADTHEC (www.adthec.com.br), working in the areas of consultancy, advisory, planning, projects, training, research and solution analysis for radio, television and telecommunications stations from the public and private sectors, with an emphasis on the design and implementation of transmission systems. She participates in several work groups coordinated by Anatel, Ministry of Communications, Universities, Associations and Research Centers. The company is a member of the SBTVD Forum.

Member of the deliberative council of SET (Sociedade de Engenharia de Televisão), of the technical committee of AESP (Association of Radio and Television Broadcasters of the State of São Paulo)



Marcelo Amoedo - Senior Sales Director - Intelsat Broadcast Services, Brazil

Professional in the business area with more than 20 years of experience in the Broadcast market and with knowledge in video transmission and compression systems, digital television and satellite communication services. At intelsat, is responsible for the commercialization of space segment for permanent and occasional use broadcast services, as well as managed media services. Technologist in Computer Networks, Bachelor's in business administration and Post-Graduating in the MBA of Digital TV, Broadcasting and New Media.



Glaucia Mattioli - Executive Sales Manager - Embratel

Graduated in Telecommunications Engineering from UFF, with an MBA in business management from IBMEC-RJ.

She works at Embratel as a sales manager for the Media segment.

She has more than 20 years of experience in the Telecommunications market, having worked in the pre-sales, post-sales and sales areas.

She participated in tests with 5G technology to serve media customers.



Guilherme Castelo Branco - Director - Phase Engenharia

Graduated in Electronic Engineering at UFRJ, with MBA at FGV-SP, has been working with broadcast solutions since 2004. He is currently a partner at Phase Engenharia and based in São Paulo.

A TRANSFORMATION OF ADVERTISING – INNOVATIVE BUSINESS FORMATS WITH ADVERTISING INTEGRATED INTO THE BUSINESS

Moderator: Marcos Cabrera - Director of New Advertising Formats and Future – Globo

The Advertising Market is much more competitive than it was ten years ago. Consumer habits are changing, driven by new technologies.

Many advertisers are adopting the D2C (Direct to Consumer) strategy so that they can have more and more knowledge about their consumers in order to add value to them.

Media companies will evolve in partnership with advertisers, participating in the journey of building their brands, supporting them in achieving their KPIs, seeking to connect with their target audience, forming new business models through innovative advertising products through creativity and technology and that generate effective value for these advertisers.

Speaker:

- **Leonardo Pontes - Digital Product Manager - Globo**
- **Gabriela Amarante - Media Manager - L'oreal**



Marcos Cabrera - Director of New Advertising Formats and Future – Globo

With a degree in engineering from USP and an MBA in Economic and Strategic Business Management from FGV, Marcos Cabrera is director of New Formats and Future at Globo. He started at the company in 2013, as Director of Market Intelligence in the Digital Media Marketing area, working in several areas within Globo such as Commercial Operations, Digital Products and Projects, Merchandising and Content Project Planning. Previously, he worked in the advertising market at agencies such as Havas (MediaContacts), Ogilvy, AgenciaClick and X%



Leonardo Pontes - Digital Product Manager - Globo

Digital Product Manager at Globo, where he started his journey in 2014 as a trainee and went through areas such as Business Research & Development, Digital Creation, Account Manager, Commercial Development. HE has experience in topics such as innovation, agile methodology, product management, commercial strategies focused on advertising and marketing, business development, management of multidisciplinary teams. Leonardo has worked in companies such as Itaú, Colgate, Walt Disney Company and Mercedes-Benz.



Gabriela Amarante - Media Manager - L'oreal

I am a multi-platform media professional with solid experience in large advertising agencies and in the industry. I currently work at L'Oréal. Digital enthusiast, data driven and always focused on business results, I believe in good ideas and execution excellence.

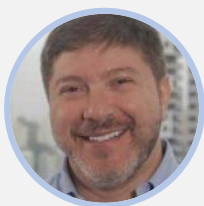
5G – BEYOND INFRASTRUCTURE – HOW 5G APPLICATIONS WILL EXPAND MEDIA POSSIBILITIES

Moderator: Fernando Gomes de Oliveira - Director - Future Maker

The 5G connectivity infrastructure is under construction, this year all capitals plus the Federal District will have access to 5G SA networks and new possibilities and opportunities will be created, but applications for the full use of this new technology are essential. Brazil, known for its creativity, will be able to play a leading role in the development of 5G software and applications in the media and entertainment market. For that, a lot of collaboration and cooperation between all the actors involved in the communication ecosystem is necessary.

Speaker:

- **Hermano Pinto - Director - Informa Markets**
- **Alexandre Britto - President of Abott's – Brazilian OTT Association**
- **Guilherme Saraiva - Sales Director – Embratel**
- **Uirá Moreno Rosário e Barros - Telecom Analyst – Strategy and Technology | Globo**



Fernando Gomes de Oliveira - Director - Future Maker -

Fernando Gomes de Oliveira studied Computer Engineering at POLI-USP, Governance/Compliance analyst, specialist in broadcast, mobile services (4G/LTE, 5G and WiFi 6), optical fiber, angel investor at Poli Angels, mentor in startups, co-founder of Roboyell, an AI startup focused on computer vision, and KYtron, a Deep Tech focused on robotics.

Member of the Innovation, Machine Learning and ESG committees at I2AI – International Association for Artificial Intelligence, innovation committee at ABOTTs – Brazilian Association of OTTs, columnist at SET Magazine, OLA-CCI Advisor and coordinator of the 5G Working Group at ACATE – Santa Catarina Technology Association.

He talks about the digital world, innovation, disruptive technologies, futurism, startups, people, diversity, education, environment, 5G, IoT, smart cities and society.



Hermano Pinto - Director - Informa Markets

Hermano Pinto is an electrical engineer, graduated from Escola Politécnica da USP (EPUSP) and a BA in Economics from FEA-USP, with a professional master's degree in business management from Duke University, North Carolina (USA).

He worked for 30 years in companies of the Siemens Group, in the areas of telecommunications and technology, where he held several positions in Brazil, Latin

America and Europe. He was Worldwide President of the Wireless Access Business Unit at Siemens AG in Munich.

Advisor to several trade associations, in addition to holding the position of Director of the Telecommunications Division of the Department of Infrastructure (DEINFRA) at FIESP. He is currently General Director of the Infra & Tech Nucleus (Infrastructure & Technology) for Brazil at the British group Informa.



Alexandre Britto - President of Abott's – Brazilian OTT Association

Graduated from the Federal University of Rio de Janeiro in Engineering, he has over 20 years in the technology, telecommunications, TV, streaming, digital content and media industry. Specialized in Business Development, Planning and Implementation, Marketing and Commercial Strategy Formulation, and Go-to-Market Strategy and Execution.



Guilherme Saraiva - Sales Director - Embratel

Guilherme Saraiva is the commercial director for the Media and Satellite segments at EMBRATEL, where he supports clients in the development of their business in the physical and digital worlds. In Grupo Globo he acted as CTO of Telecine, where he launched the streaming platform Telecine Play. He was technology planning manager at Globosat during the migration of channels to HD and the launch of OTT digital products. He led NET's marketing and corporate products area, participating in the launch of broadband internet services. He coordinated British Telecom's expansion plan in Latin America, collaborating on digital inclusion projects in several countries.

Telecommunications engineer from IME, with an MBA in marketing from FGV, Master in Finance from FGV and an MBA in Data Science from PUC-RJ.



Uirá Moreno Rosário e Barros - Telecom Analyst – Strategy and Technology | Globo

Graduated in Electrical Engineering and also in Radio and TV, with a Masters in Electrical Engineering from Universidade Mackenzie, he works as Senior Telecom Analyst in Strategy and Technology at Globo.

In the Telecom area, it focuses on the study and implementation of new technologies at the station. He was responsible for the First Live Stream in Dolby Atmos on ISDB-T, in 2020, and currently implements immersive audio on Digital TV in São Paulo. In the last year, he has as one of his fronts the study of applications of innovation with 5G in Globo products, having already carried out the São Paulo Carnival 2022 with the technology. In addition to Globo, he is also a university professor at Faculdade Cásper Líbero, teaching in the Radio, TV and Internet Course, leading the subjects of "Technology" and "Audio Capture and Editing".

FAR BEYOND THE LINEAR GRID: DIGITAL STRATEGIES THAT BOOST BUSINESS FOR RADIO AND TV

Moderator: Carlos Aros - Content Director | Rede Jovem Pan News

Audiovisual productions are increasingly going beyond the limits of radio and TV. Social networks and digital platforms have become high-engagement environments and compete for the attention of the viewer and the listener. What are the success cases? How can digital leverage the offline business? What are the trends and challenges for the industry? How to develop a truly multiplatform business environment?

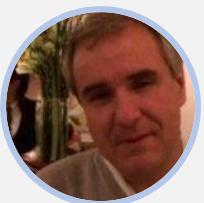
Speakers:

- **Roberto Araújo - CEO - Grupo Jovem Pan**
- **Felipe Aranha (Jimmy) - Planning and Performance Coordinator at Viu Hub – Globo**
- **Izabela Ianelli - Digital Director na Endemol Shine Brasil**
- **Antonio Abibe - Head of Content Growth- Kwai Brasil**



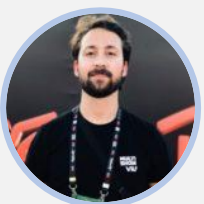
Carlos Aros - Content Director | Rede Jovem Pan News

Content Director of Rede Jovem Pan News, journalist specialized in Technology and Innovation, executive editor of MIT Technology Review Brazil.



Roberto Araújo - CEO - Grupo Jovem Pan

CEO of Jovem Pan Group with MBA in FIA with specialization in Cambridge, Lion and Beijing. His career is based on the structuring of companies in multiple segments. He is an enthusiast about the future and how technology will transform human relationships.



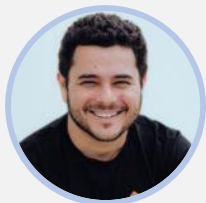
Felipe Aranha (Jimmy) - Planning and Performance Coordinator at Viu Hub - Globo

He has been working on the development of branded content projects for 11 years and currently coordinates the planning at the VIU Hub business unit, where multiplatform commercial models are implemented that unite Globo channels with social networks and influencers in integrated strategies.



Izabela Ianelli - Digital Director na Endemol Shine Brasil

Izabela Ianelli leads the digital department at Endemol Shine Brasil, which creates, produces and distributes cross-platform content and strategies and won the Rising Star of Development award. The executive has a degree in Radio and TV at Universidade Metodista and has worked at UOL and Record.



Antonio Abibe - Head of Content Growth- Kwai Brasil

DEEPFAKE

Chair: Diego Piffaretti - Red Team Lead | CyberSecurity – Globo

In this panel, we will show how deepfake has developed, the security implications and threat scenarios it can bring to our media context. We will also demonstrate the potential use of this type of technology. Additionally, we will talk about the elections and how these themes are related.

Speakers:

- **Fernando Ribeiro - Technology and Innovation Specialist - Globo**
- **Bruno Sartori - Journalist and Deepfaker | CEO - FaceFactory.AI**



Chair: Diego Piffaretti - Red Team Lead | CyberSecurity - Globo

Piffaretti has a degree in Computing and is currently studying for a master's degree in computing at the Instituto Militar de Engenharia (IME). He has 17 years of experience in IT, with 10 years of experience in information security, with an emphasis on offensive security, acting as an ethical hacker in several clients and segments, experience with intrusion tests in ATM (ATM), networks, infrastructure and applications.

He has been developing personal deepfake research since 2019, when he used a Chinese app ZAO for his first experiments.

At Globo, he acts as the technical leader of the offensive security team, a team formed by "hackers for good", working with penetration tests and supporting other areas as a technical reference in the cybersecurity theme.

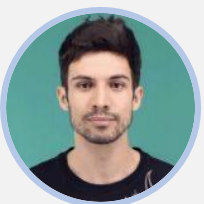


Fernando Ribeiro - Technology and Innovation Specialist - Globo

Fernando has 11 years of experience working in game development, education and as a generalist in national and international companies. His professional experience includes mobile and VR game development, 3d modeling, animation, motion capture, photogrammetry techniques, composition and motion graphics for companies and educational institutes.

With extensive experience in creating VR experiences in his work for OculusVR/Facebook and previously as a consultant for Unity Technologies developing UMA – Unity Multipurpose Avatar, Fernando also runs the Goblin Workshop, where he is involved in the research, creation and customization of avatars, consulting for UMA users and high quality content for Unity AssetStore.

Currently Fernando works at Globo as a specialist at the MediaTech Lab focusing on synthetic humans and virtual scenarios, leading research lines using DeepLearning, developing new methodologies for generating virtual characters and creating dynamic virtual scenarios.



Bruno Sartori - Journalist and Deepfaker | CEO - FaceFactory.AI

Bruno Sartori, also known by the name of Bruxo dos Vídeos (Video Wizard), is a Brazilian journalist, comedian and digital influencer considered one of the pioneers in creating satire through the deepfake technique in Brazil. Sartori gained notoriety with videos that satirize public entities such as Jair Bolsonaro, Sérgio Moro and Lula.

Some of his most famous works using the technique of synthesizing human images or sounds with artificial intelligence involve rendering videos from famous series such as Chaves and Chapolin Colorado; classic scenes from telenovelas such as Tietê and Avenida Brasil; and of music clips contained in the works of Whitney Houston and those of Mariah Carey in the making of satire.

OPENING

GUESTS:



Carlos Fini, President of SET



Madeleine Noland, President of ATSC



Masayuki Takada, Executive Director of DiBEG



Luiz Claudio Costa, Presidente do Fórum SBTVD



Hiroshi Yoshida, Vice-Minister of the MIC of Japan



Keynote: Eco Moliterno



Fabio Faria, Minister of Communications

STREAMING: THE TECTONIC PLATES CONTINUE TO MOVE

In the world of advertising and D2C, a model that has been gaining ground is FAST (Free ad – supported streaming TV). Several of the new formats were designed for the consumption of these platforms on Connected TV sets in conjunction with activations on the cell phone, as a second screen. FAST companies indicate that they will strengthen their offerings and ways to improve their monetization, with better integration of TV streaming in marketing mix models and digital advertising solutions in linear distribution (DAI), in addition to meeting the needs of consumers who are fatigued with the number of current subscriptions. We also have the need for many content producers and/or distributors to create new business opportunities in new windows. Is this the new future for TV? What is TV? In this panel, we will approach the topic with the discussion between professionals who represent the entire value chain, from the content owner, platforms, metrics and consumer behavior.

Moderator: Daniela Souza - Advisor at SET and SVP AD Digital

SPEAKERS:

- **Melissa Vogel – CEO, Kantar IBOPE Media - Brazil**
- **Roberto Araújo - CEO - Grupo Jovem Pan**
- **Aline Jabbour - Director | Business Development and Content Acquisition Latin America - Samsung**
- **Luis Camargo - Media & Entertainment Business Developer Lead – Google Brasil**



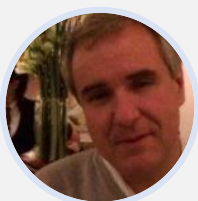
Daniela Souza - Advisor at SET and SVP AD Digital

Daniela Souza is the founder of AD Digital, where she currently works as SVP, SET Advisor and Co-curator of SET Experience. She entered the Media and Entertainment business in 1994. She is a guest speaker at major events related to content creation, management and distribution, where she shares her vision on market and future trends for the industry. He has been participating in major projects at Grupo Globo, YoutubeSpace, Grupo Jovem Pan, CNNBrasil, Afya, Google, among many other communication groups, both national and regional.

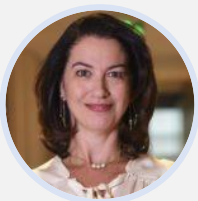
She also participates in WIN (WIN is a women's space for everyone, where experiences and challenges are exchanged on topics related to innovation.)


Melissa Vogel - CEO, Kantar IBOPE Media - Brazil

She has more than 26 years' experience in the media research and intelligence market, having held positions at Kantar IBOPE Media in Brazil and Panama, as well as global experience at Kantar Media. Melissa has held leadership positions in different areas of the company, such as Sales, Customer Service, Development of New Business, Operations, Marketing and Products. Within the scope of the remit in Brazil and LatAm, she has an in-depth understanding of clients' needs, collaborating with the industry in developing metrics, products business encompassing the company's complete portfolio and range of services. Before heading up Kantar IBOPE Media in Brazil, she was Global Director for agencies at Kantar Media, as well Executive Director, Multimedia for two years, for the Target Group Index Radio measuring business. Melissa has a degree in Radio & TV from the University of São Paulo – USP, and has a graduate degree in Communication with the Market from the ESPM and in Administration from Fundação Getúlio Vargas. She was professor on the ESPM Market Intelligence graduate course.


Roberto Araújo - CEO - Grupo Jovem Pan

CEO of Jovem Pan Group with MBA in FIA with specialization in Cambridge, Lion and Beijing. His career is based on the structuring of companies in multiple segments. He is an enthusiast about the future and how technology will transform human relationships.


Aline Jabbour - Director | Business Development and Content Acquisition Latin America - Samsung

Aline heads LATAM content acquisition strategy for Samsung TV Plus, Samsung's owned and operated streaming service available in 23 countries and over 100 million devices across TV globally. She brings more than 20 years' experience in product, marketing and content acquisition for multinational and national companies such as SKY and Claro.


Luis Camargo - Media & Entertainment Business Developer Lead – Google Brasil

Seasoned professional with +13 years of experience in the technology and digital marketing industry, working in major tech and media companies such as Predicta, Globo Group and Google. Talks about Google TV, Media & Entertainment, Video, Cloud for Media, Media Supply Chain, MarTech and AdTech fluently.

Nowadays I'm supporting Media, Entertainment & Telecom companies to better understand their digital transformation strategies and how technology can work on their behalf, reducing costs, improving performance and generating insights to high-level decision making.

I'm leading Google TV conversation in Brazil, bringing local content and new direct to consumer apps into Google's m&e ecosystem.

NEW PARABOLIC: THE MIGRATION TO THE KU BAND

The migration of domestic satellite receptions from C Band to Ku Band will be partly funded with funds raised by the 5G Auction. About 18 million Brazilian families have free open satellite TV as their main source of information and entertainment. Of this total, about 10 million families that are part of the federal government's social programs (CadÚnico) will be able to receive the kit with the new equipment free of charge. We will understand all the details of this process with representatives of ANATEL, MCOM and the entity created to manage this process and promote a debate with the participation of broadcasting associations.

Moderator: Ana Eliza Faria e Silva, Senior Manager of Technology Regulatory, Globo
SPEAKERS:

- **Maximiliano Salvadori Martinhão - Secretário de Radiodifusão - MCom**
- **Moisés Queiroz Moreira - Conselheiro da Anatel - Anatel - Agência Nacional de Telecomunicações**
- **Leandro Guerra - CEO - Entidade Administradora da Faixa**
- **Luiz Carlos Abrahão - Diretor de Tecnologia da ABERT**
- **Samir Nobre - Diretor-geral da Abratel**



Ana Eliza Faria e Silva, Senior Manager of Technology Regulatory, Globo

Ana Eliza is a senior regulatory manager for Globo's strategy and technology area. In nearly 25 years of her career, she has already led numerous innovative projects for digital content distribution and played a prominent role in the various stages of the analogue-digital transition for Globo and the sector. She works in several technical media organizations, such as the Brazilian Society of Television Engineering, the Brazilian Digital TV System Forum and the International Telecommunications Union. Graduated in Electrical Engineering from UNICAMP, she has a Masters in Telecommunications and an MBA in Management.



Speaker: Maximiliano Salvadori Martinhão - Secretary of Broadcasting at the Ministry of Communications – MCom

Telecommunications Engineer graduated from the National Institute of Telecommunications – INATEL, in Santa Rita do Sapucaí – MG, Master in Telecommunications Management from the University of Strathclyde in the United Kingdom, Lawyer graduated from the Higher Education Institute of Brasília – IESB. From 1993 to 1998 he was Planning Engineer for the Telebrás System. From 1998 to 2005 he was a Systems Engineer at Telebrás, assigned to Anatel. Since 2005 he has been a Specialist in Regulation of Public Telecommunications Services at ANATEL.

From 2003 to 2007 he was the Spectrum Engineering Manager at Anatel. From 2007 to 2010 he was General Manager of Certification and Spectrum Engineering at Anatel. From 2011 to 2016 he was National Secretary of Telecommunications at the Ministry of Communications – MC.

From 2016 to 2017 he was the National Secretary for Information Technology Policies at the Ministry of Science, Technology, Innovation and Communications – MCTIC. From 2017 to 2018 he was President of Telecomunicações Brasileiras S.A – Telebrás.

From 2018 to 2019 he was National Secretary for Technological Development and Innovation at the Ministry of Science, Technology, Innovations and Communications – MCTIC.

From 2019 to 2020 he was Special Advisor to the Minister for Science, Technology, Innovations and Communications. He is currently Secretary of Broadcasting at the Ministry of Communications – MC.



Moisés Queiroz Moreira - Anatel's Board Member - Anatel - National Telecommunications Agency

Public administrator. Over the last 15 years I have held public office in the federal government, as well as at state and local level in the State of São Paulo. I coordinated the technical advisory activities at the Consumer Protection Agency – PROCON SP and was special advisor to the Metropolitan Housing Company of São Paulo – COHAB and the São Paulo State Legislature between 2003 and 2006. In 2006, I became chief of staff at the Municipal Health Department of São Paulo. Member of the Board of Directors of SPTURIS – São Paulo Turismo S.A. from April /2008 to March /2009. Since 2015, I have worked for the Brazilian government as special advisor to the Minister for Cities, Head of Parliamentary Advisory and Special Advisor to the Minister at the Ministry of Science, Technology, Innovations and Communications. Currently as Secretary for Broadcasting at the Ministry of Science, Technology, Innovations and Communications, I currently hold the presidency of GIRED – Implementation Group for the Redistribution and Digitization Process of TV and RTV Channels and member of ANATEL's Board of Directors.



Leandro Guerra - CEO - Entidade Administradora da Faixa

Leandro Enrique Lobo Guerra has a degree in Electrical Engineering from the Federal University of Paraná (UFPR) and in Law from the Tuiuti University of Paraná (UTP). He has a postgraduate degree in Executive MBA from the COPPEAD Institute of Administration at the Federal University of Rio de Janeiro (UFRJ).

He has been working in telecommunications for over 35 years in the areas of Engineering, Regulatory Affairs and Institutional Relations as an executive of the TIM Groups, BCI / TIW (currently Claro), Global Telecom (merged by Vivo), Telepar and Telepar Celular.



Luiz Carlos Abrahão - Director of Technology at ABERT

He is a Telecommunications engineer with specialization in the areas of TV Engineering and Business Management.

He worked for more than 42 years at Rede Globo de Televisão, where he held several positions. He worked on projects such as, for example, the implementation of Estúdios Globo in Rio de Janeiro, coverage of major national and international events (Olympics, World Cup, Formula 1) and the implementation of the digital TV Tower in DF. He joined ABERT in 2018, where he holds the position of Director of Technology.



Samir Nobre - General Director of Abratel

Lawyer, with a specialization in Public Law from the Fundação Escola Superior do Ministério Público do Distrito Federal. He began his career in the broadcasting sector in 2008 and spent more than ten years in the public sector, holding some of the top positions in the Ministry of Communications. He currently holds the position of General Director of Abratel.

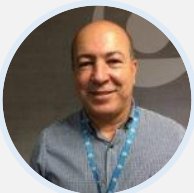
FROM PRODUCTION TO CLOUD DISPLAY AND DISTRIBUTION

More than a technological change, an opportunity for business.

Moderator: Carlos Cesar Abrahão – Director of the Content Production Platform – Globo

SPEAKERS:

- **INTRODUCTION AND CONCEPTUALIZATION**
Paulo Rabello – Executive Director of the Operations and Content Distribution Hub – Globo
- **CLOUD LIVE PRODUCTION**
Dr James Westland Cain - Chief Software Architect at Grass Valley
- **CLOUD PLAYOUT & DISTRIBUTION**
Diego Scillamá - Vice President, Video Sales and Services, Latin America at Harmonic
- **MORE THAN AN ABSTRACTED INFRASTRUCTURE, THE ROLE OF CLOUD PROVIDERS IN THE MEDIA SUPPLY CHAIN JOURNEY TO THE CLOUD – GCP (GOOGLE)**
Anshul Kapoor - Head of Media Broadcast Solutions - Google Cloud



Carlos Cesar Abrahão – Director of the Content Production Platform – Globo

Graduated in electronic engineering from Universidade Gama Filho and MBA in project management from IBMEC, he has worked at Globo since he started his professional activities. He participated in the largest projects covering national and international events such as World Cups, Olympics, Rock in Rio, among others, in addition to being part of the company's large media solutions technology projects.

For several years, he led the Media Solutions Support area and is currently the Director of the Capture and Production Platform where he is responsible for defining technologies and capture and production processes, in addition to the entire operation for all different genres (Entertainment, Sports and Journalism).



Paulo Rabello – Executive Director of the Operations and Content Distribution Hub – Globo

Paulo Rabello holds a degree in electronic and telecommunications engineering from the Federal University of Rio de Janeiro, with a postgraduate degree and an MBA in project management from Fundação Getúlio Vargas, a certified member by the PMI (Project Management Institute) since January 2003. He works at Globo since 1994 and has led the Projects and Support areas, being responsible for the implementation of several important projects, such as the new studios for soap operas, shows and the post production center at Estúdios Globo.

He currently holds the position of Technology Director at the Content Distribution and Operations Hub, whose responsibility is in the definition of technologies, technological processes, operations for the production of Entertainment, Sports and Journalism content and their respective distributions.



Dr James Westland Cain - Chief Software Architect at Grass Valley

Dr James Westland Cain is Chief Software Architect at Grass Valley, where he develops innovative software to support collaborative workflows in News and Sports Television Production. Responsible for software architecture across the whole of Grass Valley, James is leading the transition to developing microservice based applications. His work research interests include file systems innovation and browser based video production. He was granted a PhD in Advanced Software Engineering by Reading University and is a Visiting Research Fellow at Brunel University. He has over twenty international patents granted, has published dozens of refereed academic papers and regularly speaks at conferences.



Diego Scillamá - Vice President, Video Sales and Services, Latin America at Harmonic

Diego Scillamá lives in Buenos Aires and has been working in the field of telecommunications and video for more than 25 years. He is currently the Vice President of Harmonic for the video business in Latin America, where he works on video solutions both on prem and in the public cloud for streaming, distribution, dynamic ad insertion, broadcast or personalized playout, among others.



Anshul Kapoor - Head of Media Broadcast Solutions - Google Cloud

Anshul is a media and entertainment executive who helps media companies launch differentiated video services in the market. Anshul heads Broadcast solutions for Google Cloud globally and additionally heads Media Business Development in EMEA.

Our mission at Google Cloud is to empower media organizations to transform audience experiences through innovation in content production and distribution.

Previously, Anshul had various leadership roles in Ericsson, including Head of product for Online Video and Media Management.

SET EXPRESS | INFRASTRUCTURE

In this panel, the technical aspects of the infrastructure of a broadcasting station will be discussed: Project digitizes Brasil -PDB from the project to the situations under implementation and already installed; a methodology to predict lightning strikes and thus protect stations and equipment and the importance of maintenance of stations by city halls in the PDB.

Chair: Valderéz de Almeida Donzelli - Technical Director of ADTHEC | SET Counselor

SHARED INFRASTRUCTURE CONCEPT USED IN THE DIGITALIZA BRASIL PROGRAM

Francisco Peres - Coordinator of the Infrastructure Sharing WG at SET

The biggest program to build stations in the history of Brazilian Broadcasting got off the ground with a project that houses up to 8 stations in a single tower and in a simple and versatile structure.

LIGHTNING ALERTS

Dr. Moacir Lacerda - CEO of EPL Informática

We will talk about atmospheric electrical discharges in general and present a summary of the damage caused by lightning strikes in broadcast transmission facilities.

We will present the YANSA computational platform that detects lightning strikes, in real time, 10 to 20 minutes in advance.

In conclusion, we will present the possibilities of using the YANSA platform to increase the security and uninterrupted of broadcast transmission systems as well as the elaboration of a product in the meteorological area for journalistic dissemination.

HOW THE MAINTENANCE OF THE DIGITALIZA BRASIL PROJECT STATIONS WILL BE CARRIED OUT: AN ANALYSIS OF THE SCENARIO AND POSSIBILITIES FOR OPTIMIZING COSTS AND RESULTS.

Sérgio Martines - Executive Director - SM Facilities

32 years of professional experience in television, especially in the area of maintenance and implementation of transmission systems.

Executive Director of SM Facilities, a television engineering services company.

Professional in Project Management, PMP®, with experience as a consultant in several areas, such as IT, finance, legal, industry and third sector.

Degree in Civil Engineering – UFPR and Electronic Technician – Cefet-PR (currently UTFPR).

MBA in Project Management – FGV, and Post-Graduation in Construction Management – Cefet-PR.

Vice-president of the Project Management Institute – Chapter Paraná (PMI-PR).
MBA professor in project management at several institutions.



Chair: Valdez de Almeida Donzelli - Technical Director of ADTHEC | SET Counselor

Graduated from FEI in electronic, electrotechnical and production engineering. Master in electrical engineering. Postgraduate in Neuroscience from Instituto Israelita Abert Einstein. Specialization in IT by FESP, ICT management and Project Management by FGV, Data Science by Awari, Advanced Digital TV System by INATEL and DMC – Decoding Mente Corpo with Dr Carlos Alberto Ribeiro. She develops research projects in connectivity, digital media and application of neuroscience concepts in engineering and human development.

Director of Engineering, Technology and Regulatory at the engineering company ADTHEC (www.adthec.com.br), working in the areas of consultancy, advisory, planning, projects, training, research and solution analysis for radio, television and telecommunications stations from the public and private sectors, with an emphasis on the design and implementation of transmission systems. She participates in several work groups coordinated by Anatel, Ministry of Communications, Universities, Associations and Research Centers. The company is a member of the SBTVD Forum.

Member of the deliberative council of SET (Sociedade de Engenharia de Televisão), of the technical committee of AESP (Association of Radio and Television Broadcasters of the State of São Paulo)



Francisco Peres - Coordinator of the Infrastructure Sharing WG at SET

Graduated in Telecommunications Engineering from Universidade Federal Fluminense, Master's Degree in Electromagnetism from PUC-Rio and MBA from FGV. He is currently Manager of the Projects and Licensing area of Globo's Telecommunications Systems.



Dr Moacir Lacerda - CEO of EPL Informática

Graduated in Physics from the Federal University of Pernambuco (1988). Master in Physics from the Physics Institute of the University of São Paulo (1993). PhD at the National Institute for Space Research (INPE) (1998), Post-Doctorate in Meteorology at the Institute of Astronomy and Geophysics of the University of São Paulo (2012-2014). Over the last 30 years he has been dedicated to the study of atmospheric electricity and its implications for the application of existing technologies and the development of new technologies. I am currently CEO of EPL Informática developing and implementing impactful technological innovations that generate information for decision making in real time.



Sérgio Martines - Executive Director - SM Facilities

32 years of professional experience in television, especially in the area of maintenance and implementation of transmission systems. Executive Director of SM Facilities, a television engineering services company.

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Vice-president of the Project Management Institute – Chapter Paraná (PMI-PR).

MBA professor in project management at several institutions.

SET EXPRESS | IP

In this panel, the technical aspects of the infrastructure of a broadcasting station will be discussed: Project digitizes Brasil -PDB from the project to the situations under implementation and already installed; a methodology to predict lightning strikes and thus protect stations and equipment and the importance of maintenance of stations by city halls in the PDB.

Chair: Caio Klein - General Director of TVE-RS

STATE-OF-THE-ART AI-POWERED IP BROADCAST ECOSYSTEM INFUSING MACHINE AND DEEP LEARNING APPROACHES INTO AV OVER IP

John Lau - Director, Solution & Service Architecture, Caton Technology

With the rapid development of the Internet, network-based real-time video transmission systems have been widely used in various fields such as live streaming of sporting events, mission-critical applications like telemedicine, and video communication tools. The convergence of Information Technology (IT) and Audio/Video (AV) has allowed the industry to move towards a faster, more cost-effective and advanced content delivery method. Compared to traditional methods, AV over IP is not only cheaper, but also offers better signal quality and functionality.

While convergence has introduced many benefits, IP transmission is known to have packet loss, delay, and other limitations that affect transmission performance.

In this session, the audience will learn about traditional IP transport protocols and how their limitations have brought about a range of transmission protocols and next-generation distribution platforms. With high-quality (4K) content and real-time low-latency delivery slowly becoming the standard, these next-gen ecosystems are slowly falling behind, resulting in a pressing need for more advanced technologies. Audiences will learn about how data science can be applied to next-generation broadcast ecosystems to meet tomorrow's demand.

LEVERAGING INTEROPERABILITY IN AN IP WORLD

Vinicius Val de Casas - Solution Architect / Project Manager at Pebble

Vinicius will provide an overview of what it means to connect devices within an IP workflow and the importance of leveraging interoperability especially as interoperable workflows allow broadcasters to take advantage of the best features of each manufacturer's technologies. He'll explain how it's possible in an ideal world to combine different technologies from different vendors into one seamless, highly customisable and adaptable workflow and why interoperability provides the highest levels of flexibility and scalability that organisations require to accommodate future growth.

IP CONTRIBUTION WHEN 3G/4G/5G FAILS (OR IS NOT AVAILABLE)

Bart Van Utterbeeck -VP Business Development - ST Engineering

We cannot always rely on terrestrial (cellular) network availability for IP journalism. Congestion, shady areas or even areas without permanent – (remote places) or temporary (after storm) coverage mean that alternatives may be necessary.

During the lecture, some cases will be discussed where of satellite IP contribution will complement to cellular connectivity:

- Solar Power Punch desert race
- Cellular + satellite combination for Royal Wedding in England
- Contribution of traveling sporting events (Tour de France)

**Caio Klein - General Director of TVE-RS**

Electrical Engineer graduated from UFRGS, with a postgraduate degree in Strategic Leadership in Business and People from ESPM-RS. He started his career at RBS, passing through various roles within the group. Then, for 10 years, he was the Technical Director of TVE-RS. He returned to RBS to be the Technical Manager of the Group's Radios and then the Executive Manager of TV Operations, where he participated in the coverage of the 2006, 2010, 2014 and 2018 World Cups, 2008 and 2012 Olympics and Interclub World Cup in 2006. , 2010 and 2017, coordinating the logistics of Grupo RBS in these events. Currently he is the General Director of TVE / RS

**John Lau - Director, Solution & Service Architecture, Caton Technology**

Heading the Global Caton Solution & Services Architecture Team, John leverage innovative & new cutting-edge technologies & product to offer future proof solution and services for different business. With over two decades of leadership experience in the technology, network, Telco & broadcasts industries, John has successfully directed teams to develop some of the most revolutionary innovations, propelling organizations to greater heights. Prior to joining Caton, John led teams at Vodafone, BT & former Alcatel Lucent and become a bridge amongst the network, telco and broadcast industries providing architectural framework for the industries.

**Vinicius Val de Casas - Solution Architect / Project Manager at Pebble.**

Vinicius Val de Casas has been working in the broadcast industry for over 20 years with extensive experience in supporting solutions for integrated networks, video and data systems.

He held a variety of senior roles for renowned and highly respected organisations such as TV RECORD, BAND, SBT and ESPN Brasil, as well as major systems integrators. His experience spans across business development and sales functions, as well as in technical and operation roles. Over the last 5 years he focused his career in the fields of playout automation delivering leading broadcast solutions across Brazilian and global markets.

**Bart Van Utterbeeck -VP Business Development - ST Engineering**

Acting for 15 years in the Latin American satellite market, Bart started the regional office for Newtec in Brazil in 2006. Under his leadership as GM/VP Sales Latam he grew the business in the region, transitioning Newtec from being a broadcast oriented player towards a key player in the telco, offshore and enterprise markets. After the acquisition of Newtec by ST Engineering in 2019 he continued his role as General Manager of the regional office where he now focusses on Business Development in Latin America for ST Engineering iDirect.

Prior to moving to Brazil he worked as Project Manager for commercial and R&D projects at Newtec in Belgium.

Bart Van Utterbeeck holds a degree of Electromechanical Engineering from KIH De Nayer/Thomas More and a Master of Biomedical Engineering from the Catholic University Leuven.

BUSINESS MANAGEMENT

It is imperative that media companies have internal business governance.

The structuring and cleaning of databases, determination of business KPIs, construction of dashboards for internal stakeholders, among others, will support the projection and monitoring of revenues and indicators, as well as decision-making and the strategic and operational planning of Business.

In addition, the existence of a CRM is essential. This system must contain features that facilitate the monitoring and supervision of the different stages of sales, from prospecting to conversion, in order to obtain a view of the sales pipeline that can leverage the generation of commercial opportunities.

Chair: Patrícia Rego - Planning and Contracts Director - Globo

SPEAKERS:

- **Cadu Ventura - Business Management Director for Advertising – Globo**
- **Tais Costa - Communications Solution Management & Strategy Director, LATAM – Salesforce**
- **Anna Vidal - Head of expansion and growth - iFood**



Patrícia Rego - Planning and Contracts Director – Globo

Graduated in Engineering at PUC Rio, with Executive MBAs at the IAG Master at PUC RJ, IBMEC RJ and FDC Minas, in addition to a POST MBA at Kellogg Executive Education, she is currently director of Planning and Contracts in the Affiliates area at Globo, responsible for negotiations between Globo and its Affiliates, for the formation and monitoring of business models and the implementation of multidisciplinary projects, collaborating with inputs for the management and distribution strategy of the Network. She worked in different areas of Globo, including Globo of NY, benchmarking American business models and was responsible for the implementation of an indoor theme park. She is trained as a board member by IBGC and GONew.



Cadu Ventura - Business Management Director for Advertising - Globo



Tais Costa - Communications Solution Management & Strategy Director, LATAM - Salesforce

Tais has been with Salesforce for 4 years and 1 year ago took over as director of Salesforce's Communications, Media and Technology industries for Latin America. In this position, Tais is responsible for leveraging the successful transformation of

companies through his knowledge of businesses and industries, Salesforce solutions, and client projects around the world.



Anna Vidal - Head of expansion and growth - iFood

Graduated in Marketing from USP and Postgraduate in Financial Engineering from Fia, in the last 13 years she worked for renowned multinationals, such as Ambev and Whirlpool, the technology Startup. She currently holds the position of Head of expansion and growth with the challenge of leading the Customer Success, Expansion and commercial digitization and automation projects.”

REGULATORY UPDATE: MCOM AND ANATEL / DIGITIZE BRAZIL PROGRAM

Brazilian Broadcasting has never had so many stations installed and licensed in such a short time. The Digitaliza Brasil Program made the sector take a huge leap in the digitalization of terrestrial TV in deep Brazil. Along with it, we clearly see evolutions in the regulatory environment and in the digital transformation process of the Ministry of Communications and Anatel.

Let's discuss what happened in the last year and find out what's to come in the broadcasting regulatory environment.

Moderator: Francisco Peres - Coordinator of the Infrastructure Sharing WG at SET

SPEAKERS:

- ***Geraldo Cardoso de Melo - Representative of the SET Southeast Regional and member of the SET Spectrum Working Group***
- ***Vinícius Caram - Superintendent of Granting and Resources for Provision – Anatel***
- ***Otavio Caixeta - Director of Innovation, Regulation and Inspection - Ministry of Communications***



Francisco Peres - Coordinator of the Infrastructure Sharing WG at SET

Graduated in Telecommunications Engineering from Universidade Federal Fluminense, Master's Degree in Electromagnetism from PUC-Rio and MBA from FGV. He is currently Manager of the Projects and Licensing area of Globo's Telecommunications Systems.



Geraldo Cardoso de Melo - Representative of the SET Southeast Regional and member of the SET Spectrum Working Group

Geraldo Cardoso de Melo is a Telecommunications engineer with a degree and specialization from the Pontifical Catholic University of Minas Gerais (PUC-Minas). Consultant engineer in broadcasting services, Professor at PUC-Minas, member of the SET Spectrum Working Group and coordinator of SET Sudeste.



Vinícius Caram - Superintendent of Granting and Resources for Provision - Anatel
Superintendent of Granting and Resources for the Provision of Anatel. Master in Telecommunications Engineering and postgraduate in Telecommunications Management from the University of Brasília (UnB). Specialist in Governance and Control of Regulation by the National School of Public Administration (ENAP). Telecommunications Network Consultant between 1998 and 2011. Professor in Electrical Engineering courses at private universities in Brasília. Agency employee since 2011, having worked in the regulatory area, in the area of Critical Infrastructure Management and manager of Quality Obligations Control.



Otavio Caixeta - Director of Innovation, Regulation and Inspection - Ministry of Communications

Otávio Viegas Caixeta is an Electrical Engineer graduated from UnB and is currently studying for a Masters in Public Administration at FGV. Public servant of the infrastructure career, he has been at the Ministry of Communications since 2009. He has worked on policy for telecommunications and innovation, with a focus on startups. He currently holds the position of Director of Innovation, Regulation and Inspection at the Broadcasting Secretariat.

HOW THE TV 3.0 WILL IMPACT THE USER EXPERIENCE AND THE MEDIA SUPPLY CHAIN?

The next generation of Digital Terrestrial TV in Brazil (under development through the TV 3.0 Project of the SBTVD Forum) will bring a series of new technological features. We will discuss how these features will impact the user experience and the broadcasters' audiovisual production and distribution chains.

Moderator: Luiz Fausto de Souza Brito , Chair – Technical Module, SBTVD Forum

SPEAKERS:

- **TV 3.0 APPLICATION CODING: NEW USER EXPERIENCES AND BUSINESS OPPORTUNITIES**

Débora Christina Muchaluat-Saade - Full Professor - Universidade Federal Fluminense (UFF); Member of the TV 3.0 Application Coding Technical Group – SBTVD Forum

This talk presents the application coding layer proposal for the TV 3.0 Project. We discuss new facilities for application development, including application-oriented TV, advanced user interfaces, immersive TV with sensory effects and VR/AR/XR content. New use cases and business opportunities are also highlighted.

- **TV 3.0: CAPTIONS AND AUDIO AND VIDEO CODING**

Carlos Cosme - MediaTech Lab – Globo

An overview of the captions layer and audio and video coding layer of the future TV 3.0 in Brazil.

- **TV 3.0 PHYSICAL AND TRANSPORT LAYER: NEW FEATURES AND APPLICATIONS**

Cristiano Akamine - Researcher at the Digital TV Laboratory at Universidade Presbiteriana Mackenzie

Frequency Reuse-1, MIMO 2x2, Channel Bonding, Reception with negative C/N in Rayleigh channel, Targeted Advertising, and Internet/CB Enhancement Layer are some new features present in the TV 3.0 Physical and Transport Layer. This presentation aims to explain and exemplify these concepts that will be present in TV 3.0.


Luiz Fausto de Souza Brito, Chair – Technical Module, SBTVD Forum

Professional Master's Degree in Applied Computing (UECE – 2015), Executive MBA on IT (UFRJ – 2011), extension course in Networks and Video over IP (UFRJ – 2009), Bachelor's Degree in Electrical Engineering with emphasis in Electronics (UFRJ/USU – 2005). Currently working as Technology & Regulatory Specialist for Globo, SBTVD Forum Technical Module Coordinator, chairman of SWG 6B-2 (Multimedia) of ITU-R WP 6B (Broadcast service assembly and access), member of the Delegation of Brazil in ITU-R (SG 6 – Broadcasting Service) and CITEL (PCC.II – Radiocommunications).


Débora Christina Muchaluat-Saade - Full Professor - Universidade Federal Fluminense (UFF); Member of the TV 3.0 Application Coding Technical Group – SBTVD Forum)

Débora Christina Muchaluat-Saade holds a degree in Computer Engineering (1992), a Master's in Informatics (1996) and a PhD in Informatics from the Pontifical Catholic University of Rio de Janeiro (2003). She is a full professor at the Institute of Computing of the Fluminense Federal University (UFF). She has a DT level 1D productivity scholarship from CNPq and Scientist of Our State (CNE) from FAPERJ. She was Young Scientist of Our State (JCNE) from 2009-2011 by FAPERJ. She was vice-coordinator of the Graduate Program in Computing at UFF, evaluated with grade 6 by CAPES, from 2017 to 2021, and was also coordinator of the Technology in Computer Systems Undergraduate Course at UFF from 2014 to 2019. She founded the MídiaCom Lab at UFF in 2003 focusing on research in computer networks and multimedia (www.midiacom.uff.br) and since then she has been one of the lab deans. She is a member of the Technical Module of the SBTVD Forum. Her areas of interest are multimedia, mulsemmedia, computer networks, wireless networks, smart grids, Internet of Things, interactive digital TV and digital health. She has participated in the development of the NCL – Nested Context Language – adopted as the ABNT NBR 15606-2 standard in the GINGA middleware of the Brazilian Digital TV System and as an international recommendation by ITU-T H.761 for IPTV services.


Carlos Cosme - MediaTech Lab - Globo

Carlos Cosme holds a degree in Electrical Engineering from Universidade Estácio de Sá (2007), a postgraduate degree in Control and Automation Engineering from Universidade Gama Filho (2011) and a specialization in Computer Networks from PUC Rio (2013). He has been with Globo since 1998, where he worked in the areas of operation, support and currently works at the MediaTech Lab – Globo's research and innovation area. He is a member of the Technical Module of the Brazilian Terrestrial Digital TV System Forum (SBTVD), where he coordinates the Audio, Captions and Video for TV 3.0 working groups.


Cristiano Akamine - Researcher at the Digital TV Laboratory at Universidade Presbiteriana Mackenzie

Received the B.Sc. degree from Mackenzie Presbyterian University, Sao Paulo, Brazil, in 1999, and the M.Sc. and Ph.D. degrees from the State University of Campinas, Sao Paulo, in 2004 and 2011, respectively, all in electrical engineering. He is a Professor of Embedded Systems, Software Defined Radio, and Advanced Communication Systems, Mackenzie Presbyterian University. Since 1998, he has been a Researcher with the Digital TV Research Laboratory, Mackenzie Presbyterian University, where he had the opportunity to work with several digital TV systems. His research interests are in SoC for broadcast TV and software defined radio.

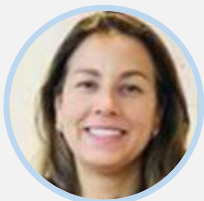
BUSINESSES IN ADVERTISING: NEW OPPORTUNITIES, DATA AND PERFORMANCE

Success in this new world of advertising will depend on data and proof of performance for customers. Crossing audience and consumer engagement data with content and advertising campaigns, where, how and when engagement takes place, insights, recommendations and optimization will be generated that will equip advertisers so that they can obtain better performance in campaigns and, consequently, greater return about your media investment. Performance table is an example of how this can occur.

Introduction and Moderation: Clarissa Gaiatto – Director of AI & Data | Digital Transformation | Media & Payments - Deloitte

PALESTRANTES:

- **Arthur Rebeque - Data Intelligence Manager - Globo**
- **Bruno Moreli - Performance Manager - Globo**



Clarissa Gaiatto – Director of AI & Data | Digital Transformation | Media & Payments - Deloitte

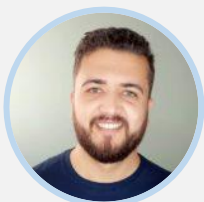
Clarissa Gaiatto, has been in the market for 25 years, has been in the roles of executive, entrepreneur, and is currently a consultant at Deloitte in AI&Data.

She has worked in media and payments companies such as Visa, Terra, Turner, América Online and Grupo WPP, passing through agencies, vehicles and advertisers.

She currently leads digital transformation projects connecting and developing solutions with cutting-edge data and technologies.

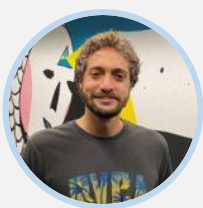
She believes in the power of the Cloud and collaboration to innovate and generate more value for organizations.

She holds a degree in Advertising, a degree in Business from FGV and extensions from ESPM and Stanford University.



Arthur Rebeque - Data Intelligence Manager - Globo

More than 12 years of experience in technology. He leads the Data Intelligence team at Globo and is passionate about solving problems using technological solutions. Specialist in behavioral studies for large brands and portals, with experience in data intelligence companies such as Predicta and Tail.



Bruno Moreli - Performance Manager - Globo

Graduated in Advertising from Cásper Libero, he has more than 10 years of experience in the advertising market, working for large agencies in São Paulo. 4 years ago he joined Globo, with the challenge of supporting the construction of the Performance team. Today he is one of the Area Managers, leading his team's performance in the management of digital and linear TV campaigns.

THE USE OF AI / ML AS A SOLUTION FOR ENRICHMENT AND OPTIMIZATION OF THE CONTENT PRODUCTION CHAIN

Moderador: Fábio Ferraz - Director of Media Solutions – Globo

- **WHERE ARE IDEAS BORN?**

Paulo Henrique Castro – Director of Mediatech Lab - Globo

Where are Ideas born? From ideation to applied development of solutions based on audio and video standards (AI & ML), generating value for Content and User Experience.

- **COMPONENTIZATION**

Gabriel Carvalho - Key Account Executive - Google Cloud

Componentization – it is not just infrastructure that is sought in the Cloud Provider: Set of Google engines and APIs to support companies and developers in the ideation and construction of artifacts.

- **REAL APPLICATIONS BASED ON AI & ML FOR MEDIA SUPPLY CHAIN**

Fernando Alonso - Director of the Post Production Platform - Globo

Real applications based on AI & ML for Media Supply Chain – Automation and Process optimization, possibility of monetization and helping content to tell new stories.

- **MESSAGES FROM SILICON VALLEY**

Luiz Gabriel Vasconcelos, Specialist of Ecosystem & Partnerships - Globo

Messages from Silicon Valley: What the Innovation Ecosystem Brings of Future Trends and Opportunities with AI & ML for Media Supply Chain.

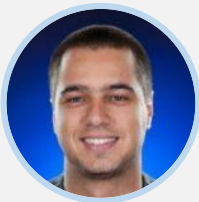


Fábio Ferraz - Director of Media Solutions – Globo

Specialist in Project Management, Business and IT at FGV-RJ (Post-MBA and MBA) and in Software Project Management at PUC-RJ, Fabio Viviani Ferraz completed 22 years working as a Technology Business Executive in the Media Industry (Television and Radio), being in recent years in charge of the management of Globo's Media Solutions Technology Projects portfolio, aimed at the Content Value Chain (Capture, Production, Post-Production, Media Preparation, Exhibition and Distribution).



Paulo Henrique Castro – Director of Mediatech Lab - Globo



Fernando Alonso - Key Account Executive - Google Cloud



Luiz Gabriel Vasconcelos, Specialist of Ecosystem & Partnerships - Globo

Graduated in Electronic and Computer Engineering from UFRJ, with a Masters in AI/ML and Signal Processing from COPPE, he has more than 15 years of experience in innovation, technology and product development. Today he is based in Globo's Silicon Valley, California office, from where he connects with the international innovation ecosystem to establish partnerships that accelerate the company's growth. He is a Stanford alum and won a Silver Lion at Cannes in the Technological Innovation category.

HOW TV 3.0 WILL IMPACT THE TV MARKET?

Moderator: Sergio Eduardo Di Santoro Bruzetti - Engineering Planning Advisor - RecordTV

SPEAKERS:

- ***Carlos Fini - President of SET***

- **STATUS OF ATSC 3.0 DEPLOYMENT IN THE U.S.**

Madeleine Noland - President of the Advanced Television Systems Committee Inc

A television technology transition is sometimes characterized as a “chicken & egg” challenge, i.e., considering only station launches and consumer receivers. While these two elements are important, there are other key pieces that also need to fall into place for a successful transition, be it mandatory or voluntary. This presentation will explore the ATSC 3.0 transition underway in the U.S. considering station launches, available services and content, consumer devices, looking beyond television services, business drivers, consumer messaging and more.

- **5G BROADCAST – UNLEASHING NEW BUSINESS ATMOSPHERE**

Fiore Mangone - Sales & Business Development - Qualcomm Latin America

As part of 5G ecosystem, 5G Broadcast offers broadcasters and network operators opportunities to create exciting consumer experiences across a range of new and existing business areas – all while enabling high spectral efficiency and reduced costs. Broadcast over 5G is not restricted to linear and live content distribution. For media content providers and network operators it offers a completely new range of business models for delivering content or data to unlimited numbers of consumers and without affecting the regular cellular 5G mobile network. Venue and automotive sectors are particularly suitable for new consumer applications while the high power, high tower free-to-air/no-SIM offers emergency services and national authorities more secure ways to deliver public messages during natural disasters or emergencies.

**Sergio Eduardo Di Santoro Bruzetti - Engineering Planning Advisor - RecordTV**

Graduated in Electrical Engineering and Post-Graduate in Accounting and Financial Administration, and in Software Engineering, he has been working in the broadcasting market since 1977, had occupied several positions in the engineering areas of TV Gazeta de SP, SBT and CNT. Currently on Record TV Network, he coordinated the implementation of the terrestrial digital broadcasting systems of its main broadcasting stations and currently coordinates the broadcasting of international sporting events such as the London Olympics 2012, the Sochi Winter Games 2014, the Toronto Pan American Games in 2015, Rio Olympics 2016 and Lima Pan American Games 2019. Now a days, works as an Engineering Planning Advisor.

Acts as a coordinator of the Market Module of the Brazilian Terrestrial Digital TV Forum – SBTVD and advisor to the Television Engineering Society – SET.

**Carlos Fini - President of SET**

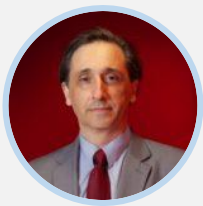
Consultant and advisor for technological renewal, innovation and adaptation, with a career in the media and communication segment and experience in the main technological innovations and business transformations of the last decades. He worked at TV Globo and affiliates, participated in the implementation of Digital TV in Brazil and served as Technology Director of Grupo RBS.

He currently has an active participation in the sector as a member of the Board of Directors of SET (President of the CD), Board of the FSBTVD (Brazilian Digital TV Forum), Member of the IBC Council and owner of CF Tecnologia e Assessoria LTDA (www.cftecnologia.com), and great know-how about organizational and corporate demands, being able to create and implement the technological direction in line with the business premises.

**Madeleine Noland - President of the Advanced Television Systems Committee Inc**

Widely respected for her consensus-building leadership style, she chaired the ATSC technology group that oversees the ATSC 3.0 next-generation broadcast standard before being named ATSC President in May 2019. Previously, she chaired various ATSC 3.0-related specialist groups, ad hoc groups and implementation teams since 2012.

A 15-year industry veteran, Noland held key technology management and standards roles at Backchannelmedia Inc., Telvue Corp. and LG Electronics. She received TV NewsCheck's "2019 Futurist" Women in Technology Award and was named one of 2018's "Powerful Women in Consumer Technology" by Dealerscope magazine. In 2016, she received the ATSC's highest technical honor, the Bernard J. Lechner Outstanding Contributor Award. She graduated cum laude from the University of Massachusetts.

**Fiore Mangone - Sales & Business Development - Qualcomm Latin America**

Fiore Mangone works at Qualcomm Latin America as Senior Director – Sales & Business Development Director. With +30 years' experience on Telecom / IT areas, he has worked at Product Marketing, Business Development and Sales at multinational companies such as Microsoft, Apple, Nokia, Nortel Networks and NEC. Fiore is graduated in Electronic Engineering at FEI –Faculdade de Engenharia Industrial, with MBA at FGV – Fundação Getúlio Vargas.

VIRTUAL PRODUCTION/IMMERSIVE TECHNOLOGIES

Companies with great expertise in using and providing solutions for these demands will show their vision and ability to deliver the flexibility and scalability so needed today. The panel will bring examples of productions already carried out, showing the enormous gain when using these resources. Come participate and be inspired by the exhibitions of our panelists.

Moderator: Carlos Cauvilla - Operations Technology Director - SBT

SPEAKERS:

• VIRTUAL AND IMMERSIVE TECHNOLOGIES APPLIED IN BROADCAST PRODUCTIONS

Paula Brecci - Latam Director of Sales Operation - Vizrt

Presenting our technology for live production to provide visual producers with unlimited possibilities to easily tell stories that engage audiences in any size studio using advanced, interactive, 3D virtual sets, augmented reality graphics, and mixed reality presentations for any production. AI (Artificial Intelligence) technology for Object Tracker application, that tracks multiple objects in a video in real-time to add graphics and enhance the viewer's experience.

• VIRTUAL PRODUCTION USING CLOUD COMPUTING

Marlon Campos - Specialist SA M&E – Content Production - Amazon Web Services

Understand through a reference architecture, where and how to use the cloud to increase collaboration, reduce complexity and cost of your project.

• GRAPHICS IN STORYTELLING

Alexandre Arrabal - Director Globo Design

Virtual reality, augmented reality.

Rendering in real time as a tool for creating language integrated into the content to help tell stories on TV.

That's our topic at SET Expo 2022.

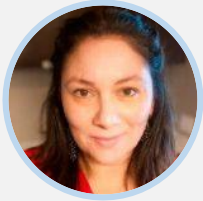
Cases will be presented where these technologies were tools to generate audience engagement.

Work carried out to cover the 2018 World Cup, the Olympics and Globo variety shows, among others, will be shown and explained..



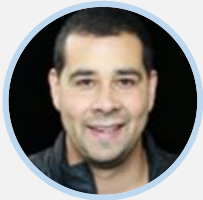
Carlos Cauvilla - Operations Technology Director - SBT

Director of Technology and Operations at SBT, Engineer with an MBA in Business and Information Technology. Cycling close to the mountains is my way of freeing up space to absorb new



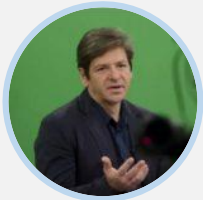
Paula Brecci - Latam Director of Sales Operation - Vizrt

Paula Brecci works in Vizrt as Latam Director of Sales Operation based in Santiago de Chile. Has more than 10 years of experience working closely with broadcasters in the region expanding Vizrt usage on live productions.



Marlon Campos - Specialist SA M&E – Content Production - Amazon Web Services

Marlon Campos has a degree in Telecommunications Networks from the Federal University of Minas Gerais, and currently works as a Specialist Architect in Content Production at AWS in London, UK. With over 8 years of experience in the industry, Marlon is passionate about production and post-production. In his current role, he has guided global customers to innovate through cloud computing adoption. In his spare time, he enjoys playing FIFA 2022 against his wife, as well as traveling the world to experience new cultures.



Alexandre Arrabal - Director Globo Design

For several years at Globo, he had a remarkable participation in several innovations in Brazilian television.

The first virtual scenario (with tracking and cropping of cameras) to air, in 1996, the presentation of local television news from panoramic studios, showing the city (the subject of the program) were some of these. Then came the transfer of Jornal Nacional to the newsroom in 2000 and all the evolution in its graphic/scenographic experience until reaching the current model, where the real and the virtual merge.

At the Rio Olympics, leading a group of designers, he defended the implementation of a building in the Olympic Park to house the Globo group. The studio and the building were integrated with virtual complements, related to the events of the event in a design in favor of the storytelling of the transmission. The studio became a postcard, in harmony with the beautiful arenas.

In the coverage of the Russian Cup in 2018, he led the creation of the “magic box”, a design project that “transformed” the 20 square meter studio into a spacious area with 180 degrees of vision. . The project was developed, in fact, like all the others, with intense integration between all areas of technology and content.

More recently, along the same lines of collaborative action, came the “magic box 2.0”, an evolution of the Russian version, which transported Tokyo to Globo studios.

With the creation of the Globo Design Center, which brought together almost all of Globo’s graphic production areas, it started to lead around 300 designers, who seek, every day, to surprise and delight our audience. From then on, he also began to participate in contributions to entertainment, with emphasis on Big Brother, rich in design, virtual insertion and engaging situations such as the dispute “Tadeu X RoBBB mau” and Metaverso BBB. During this period, several awards were won, also in the area of visual

effects, highlighting Passaporte para Liberdade and Falas da terra, which joined the various international acknowledgments given to the group at the Design Center.

ARE WE ALREADY A CONNECTED COUNTRY?

In this panel, a partnership between SET and Futurecom, we will explore and debate:

- Overview of infrastructure and capillarity in Brazil
- End consumer situation
- Capacity and robustness in large centers to support cloud migrations
- Ratio of small operators x large operators
- Expected investments

Moderator: General Director of the Infra&Tech Nucleus (Infrastructure & Technology) for Brazil - Informa (UK)

SPEAKERS:

- **Eduardo Tude** – *President, Teleco Consultoria*
- **Vitor Menezes** - *Director of Institutional Relations - Ligga Telecom*
- **Diogo Della Torres** - *Infrastructure Coordinator at Conexis Brasil.Digital*
- **Mauricio Almeida** - *CEO of Watch Brasil*
- **André Bedin Alves** - *Network Evolution, AI & 5G Executive for Latin America at IBM Consulting*



Hermano Pinto - General Director of the Infra&Tech Nucleus (Infrastructure & Technology) for Brazil - Informa (UK)

Hermano Pinto is an electrical engineer, graduated from Escola Politécnica da USP (EPUSP) and a BA in Economics from FEA-USP, with a professional master's degree in business management from Duke University, North Carolina (USA).

He worked for 30 years in companies of the Siemens Group, in the areas of telecommunications and technology, where he held several positions in Brazil, Latin America and Europe. He was Worldwide President of the Wireless Access Business Unit at Siemens AG in Munich.

Advisor to several trade associations, in addition to holding the position of Director of the Telecommunications Division of the Department of Infrastructure (DEINFRA) at FIESP. He is currently General Director of the Infra & Tech Nucleus (Infrastructure & Technology) for Brazil at the British group Informa.



Eduardo Tude - President | Teleco Consultoria

President and partner of the consulting firm Teleco, he has been working since 2002 as an analyst in the Telecom market, coordinating consulting projects, publishing weekly articles, preparing sector reports and presenting workshops.

Telecom Engineer (IME 78) and Master in Telecom (INPE 81) is a member of the Judging Committee of the Global Mobile Awards of the Mobile World Congress in Barcelona and served as a visiting specialist professor at Unicamp (2013).

He has held several management positions in Telecom companies in areas such as Cellular Systems (Ericsson), Optical Networks (Pegasus Telecom) and Satellites (INPE).



Vitor Menezes - Director of Institutional Relations - Ligga Telecom

Lawyer, with a postgraduate degree in Administrative Law, Public Management and Advanced Regulation of Public Telecommunications Services, he was Superintendent of Grants and Resources for Provision of Anatel, as well as Secretary of Telecommunications both at the Ministry of Science, Technology, Innovations and Communications and at the Ministry of Communications. He was also Executive Secretary of the Ministry of Communications, Chairman of the Board of Directors of Telebras and member of the Board of Directors of Correios. He is currently Director of Institutional Relations at the Copel Telecom Group.



Diogo Della Torres - Infrastructure Coordinator at Conexis Brasil.Digital

Telecommunications Engineer graduated from the University of Brasília (UnB), with extensive experience in the telecommunications sector in manufacturers and operators in the area of mobile network operation: voice core, data core and 2G/3G/4G/5G access. Currently, he works as Infrastructure Coordinator at Conexis Brasil.Digital (entity that represents the operators) dealing with regulatory issues and institutional relationship following topics of interest in the sector.



Mauricio Almeida - CEO of Watch Brasil

Maurício Almeida holds a degree in Electrical Engineering from Mackenzie and studied Marketing at São Paulo Business School. He has over 25 years of experience in IT projects, infrastructure and hardware and software development support. He led the development of one of the first e-commerce sites in Brazil in the 2000s and spent the last 10 years in the technology convergence industry, where he developed new solutions for TVIP and Digital TV, ISDBT. He was co-founder of ISP Nova Telecom, co-founder and current CEO of Watch Brasil, a streaming content hub.



André Bedin Alves - Network Evolution, AI & 5G Executive for Latin America at IBM Consulting

André Bedin Alves started at IBM in early 2021, with the responsibility of developing the Telecommunications industry in the Latin America region by promoting open network solutions, Artificial Intelligence and Telco Cloud. Previously, he was responsible for Huawei's Marketing and Sales area for the same region, working directly with several operators in several countries in the preparation of their networks for 5G. He also worked at Vivo in several areas related to Network Planning. He is a telecommunications engineer, graduated from the National Institute of Telecommunications (INATEL), with an MBA in Business Management from Fundação Getúlio Vargas (FGV-SP).

TRENDS: THE FUTURE OF MEDIA

The transformation of consumption habits and, consequently, of business is a latent agenda nowadays, although it has been a tracking of the SET congress for about 20 years. In this panel, we will understand from the point of view of experts what the current scenario is, what to expect from the future and especially what is necessary to succeed in this transformation that is being designed.

Moderator: Roberto Dias Lima Franco, SET Advisor and Director of Institutional and Regulatory Affairs at SBT

SPEAKERS:

- **Melissa Vogel - CEO - Kantar IBOPE Media – Brazil**
- **Luis Mauricio Chopard Bonilauri- Managing Director – Media & Entertainment Industry Lead for Latam – ACCENTURE**
- **Jefferson Lopes Denti - Deloitte Partner in Artificial Intelligence & Data**



Roberto Dias Lima Franco, SET Advisor and Director of Institutional and Regulatory Affairs at SBT

Graduated in electrical engineering with focus in electronics and telecommunications by the Federal University of Bahia and Post in Marketing and Business Management by FGV and ESPM. During the course of his career, he was responsible for the design and implementation of several radio and television companies in Brazil. He was President of SET – Brazilian Society of Television Engineering – from 2002 to 2008 and President of the Brazilian Digital TV System Forum from 2005 to 2008 and from 2015 to 2017. After this period he joined the Council of both Entities. In 2009 He was a member of ANATEL's Advisory Board. In August 2012 took office in the Social Communication Council until 2017 and is currently Head of Institutional and Regulatory Affairs of SBT.



Melissa Vogel - CEO - Kantar IBOPE Media - Brazil

She has more than 26 years' experience in the media research and intelligence market, having held positions at Kantar IBOPE Media in Brazil and Panama, as well as global experience at Kantar Media. Melissa has held leadership positions in different areas of the company, such as Sales, Customer Service, Development of New Business, Operations, Marketing and Products. Within the scope of the remit in Brazil and LatAm, she has an in-depth understanding of clients' needs, collaborating with the industry in developing metrics, products business encompassing the company's complete portfolio and range of services. Before heading up Kantar IBOPE Media in Brazil, she was Global Director for agencies at Kantar Media, as well Executive Director, Multimedia for two years, for the Target Group Index Radio measuring business. Melissa has a degree in Radio & TV from the University of São Paulo – USP, and has a graduate degree in Communication with the Market from the ESPM and in Administration from Fundação Getúlio Vargas. She was professor on the ESPM Market Intelligence graduate course.



Luis Mauricio Chopard Bonilauri- Managing Director – Media & Entertainment Industry Lead for Latam - ACCENTURE

Experienced consultant with a demonstrated history of working in the professional services industry, leading the media and entertainment industry practice in Latin America for Accenture.

Specialist in Digital Transformation, Corporate Turnaround, Mergers and Acquisitions, he had the opportunity to lead several transformations of companies in the sector in recent years. Graduated in Electronic Engineering from UFRJ, he has a postgraduate degree in Systems Analysis from PUC and an MBA from Coppead/Ufrj

Married with 3 children, his hobbies are music and sports, and he has participated in several blues and jazz festivals as a musician in Brazil. He is currently dedicated to sports, where he plans to complete his 3rd marathon in Chicago this October.



Jefferson Lopes Denti - Deloitte Partner in Artificial Intelligence & Data

Jefferson is the leader of Deloitte's Artificial Intelligence & Data practice in Brazil. His mission is to help companies become Insight Driven Organizations. Graduated in Business Administration (UAM) and MBAs in Finance (FGV), Marketing & Data Mining (ESPN) and Strategy (FAAP). He has more than 25 years of professional experience, serving clients from different sectors, with initiatives in information management, digital transformation, IoT, Analytics, Big Data and artificial intelligence, including the implementation of intelligence centers and training programs.

He believes in the combination of emerging technologies, customer experience and data monetization. It fosters the connection and development of media ecosystems, betting on digital transformation with the collaboration of traditional companies, startups, bigtechs, regulators and associations.

Jefferson participated in several forums as a speaker and teaches support classes at the main universities in Brazil, in addition to developing programs for young talent and diversity in data and technology skills.

HOW TO SUPPORT AN AUDIENCE OF MILLIONS ON THE INTERNET

The transmission of major events over the internet is a reality, and how is it possible to guarantee an audience of millions of viewers that was previously only possible through open TV? In this panel we will discuss the various aspects that guide this discussion and what are the challenges to meet this demand that only grows!

Moderator: Carolina Duca, Sr. Technology Manager, TV Globo

PALESTRANTES:

- **Erike Souza - Gerente de Tecnologia, Google Cloud**
- **Elisangela Bottino - Product Owner da Infra CDN, Globo**
- **Rogério Mariano - Global Head, Network Edge Strategy da Azion**
- **Antonio M. Moreiras – Gerente, NIC.br**



Carolina Duca, Sr. Technology Manager, TV Globo

Engineer and Master in Digital Transmission Systems, has been working for over 10 years in the area of content production and distribution. She is currently responsible for Globo's telecommunications area.



Erike Souza - CE Manager Telco & Media Brazil

Engineering Manager at Google Cloud for Telecom and Media Industry. He has participated in different projects focusing on connectivity, resilience and scalability in cloud and on-premise environments.



Elisangela Bottino - Product Owner da Infra CDN - Globo

Graduated in Telecommunications Engineering from CEFET-RJ and MBA in Business Management from IBMEC.

Certified in CSPO, LSS Black Belt, CBPP and ITIL. More than 15 years of experience in end-to-end technology projects and processes for production, post-production, quality control and broadcasting and digital distribution. It works in the strategy for expanding the points of presence of CDN of Globo.



Rogerio Mariano - Global Head, Network Edge Strategy at Azion

Rogerio Mariano is Global Head, Network Edge Strategy at Azion. Graduated from the UGF and founder of the Brasil Peering Forum – BPF, he was president of LACNOG (Latin America and the Caribbean Network Operators Group) between 2014-2018, at ICANN (Internet Corporation for Assigned Names and Numbers), was a fellow of the ICANN 54 program in Ireland. He was a student at the Brazilian School of Internet Governance (EGI.br) and at the South School on Internet Governance (SSIG) at the OAS in Washington, DC, a graduate and alumni of the OSA Submarine Cable School (Polvijärvi, Finland) and a member of the Subsea OFC. He is currently also a member of the Global Peering Forum-GPF program committee and a student at the London School of Economics and Political Science. He has 20 years of experience in Network-Scale, Submarine Cables, Interconnection and Edge Networks.”



Antonio M. Moreiras - Manager - NIC.br

Antonio M. Moreiras is an engineer and works as a manager at NIC.br, working on several initiatives to improve the technical quality of the Internet and promote its use, such as the Internet Exchanges at IX.br and the shared infrastructure project called OpenCDN.

Previously, he worked at Agência Estado, in various technical roles, and was a professor at faculties such as Unicid, Radial and Tancredo Neves, as well as in technical courses and free courses. By training, Moreiras is an electrical engineer, with an emphasis on computing, from Escola Politécnica da USP, and a master's degree in engineering from the same institution. With an MBA from UFRJ and specializations in Internet Governance from SSIG and Diplo Foundation.

FULL CONNECT

Moderator: SET Advisor and SET eXPerience Full Connect Curator

- **WEB3 THE ONGOING REVOLUTION THAT YOU ARE NOT SEEING**

Speaker: Robson Harada - MB Guild CMO

EXPLOITING RETAIL MEDIA OPPORTUNITIES ON CONNECTED TV

Palestrante: Marcelo Mattar - Manager Director- LiveRamp

What are your company's strategies and priorities for developing a retail media business?

The best first step is to consider building your media services, products, and go-to-market strategy around what matters most to your business.

But how can the new reality of TV and its networks help to generate assertive and accurate results?

Is it true that today we can have more results from such an explored and known medium?

What are the strategies that advertisers can use to take advantage of the more traditional medium with layers of intelligence to carry out their actions.

PAST, PRESENT AND FUTURE OF OOH

Speaker: Aga Porada and Fábio Palma - Co - presidents of Rua.Africa

Before the pandemic, the OOH (Out-of-Home) advertising sector was the fastest growing medium in relation to the others. With the restriction on circulation, the sector had a sudden drop in performance. Today, when people return to the streets, is there a revival? On what level?

With the evolution of digital display technologies and the possibilities of production and remote control of content, OOH evolves into DOOH (Digital Out-of-Home). Real-time displays, geo-located ads, consumer-display interaction, open new avenues for advertisers.

Fábio Palma and Aga Porada, two renowned publicists, will take us to the future of OOH.



Wagner Kojo, Wagner Kojo, SET Advisor and SET eXPerience Full Connect Curator

With consistent experience in business, marketing, innovation and technology over the last 10 years, he has assumed leadership positions in reference companies in the Technology and Communication sectors. Advisor, Consultant, Angel Investor, Curator and Speaker, Kojo, also has great proximity to the startup and digital business ecosystem and collaborates with strategic initiatives involving business, management and leadership schools, such as, Inova Business School, FDC, HSM, MIT and INSEAD.

Graduated in Marketing and Communication from Universidade Paulista, MBA from Business School São Paulo, specialization in International Business at UPC Barcelona Tech, post-MBA in TrendsInnovation and Advisor TrendsInnovation from Inova Business School and Member of ACTIB – Association of TrendsInnovation Advisors in Brazil



Speaker: Robson Harada - MB Guild CMO

Specialist in innovation and digital transformation in complex organizations and digital native companies. Currently as CMO of MB Guild – the largest crypto exchange in Latin America, responsible for branding, content, experience and growth. Ambassador and Web 3.0 enthusiast, on a mission to accelerate adoption and provide access to the benefits of blockchain technology. Active marketing professional and investor in the e-sports games segment. Catalyst member of Alma DAO and member of the boards of the Mobile Marketing Association, Grupo de Mídia de São Paulo and Dux Cripto. He has worked in technology companies and large corporations such as Facebook, Uber, Google and Itaú Unibanco, developing businesses and methodologies to integrate marketing, growth and technology. Bachelor in Marketing and Information Systems.



Marcelo Mattar - Manager Director- LiveRamp

Marcelo has over 18 years of experience in data-driven ad sales, business development and digital marketing in leading national and global companies. Its role is to help increase demand among brands and agencies for data-driven solutions provided by LiveRamp's partner Carrefour Links, which enable the analysis of customer data and activation of high-value audiences within the Carrefour retail platform.

In his role, he also drives the adoption of Retail Media Networks in Brazil, which allow advertisers to buy advertising space in the retailer's stores. He specializes in leveraging consumer data on digital platforms such as Microsoft AD Expert, Terra/Telefônica, Samsung TV Plus, Samsung Pay and Mastercard Database for Latin America. Prior to LiveRamp, he was Regional Director of Client Partnerships in the Brazilian office of Teads, the world's leading video advertising marketplace. He also worked at Mastercard Advisors, Samsung, Microsoft, Globo, Terra Networks and Jovem Pan.



Aga Porada is a professional with over 15 years of experience and a solid international career in the media market. Polish based in Brazil for almost 9 years, the Africa executive has been vice president and leader of the entire media, data and performance area for over a year, and is co-president of Rua. Africa, division specializing in OOH.

In his career, Aga has worked at agencies such as Zenith Optimedia, i-Level and Isobar Global, all in London, and AKQA and RGA, DPZ&T and Wieden+Kennedy in São Paulo, serving renowned clients such as Itaú, Vivo, Natura, Coca-Cola, Uber, Facebook, Nike, Reckitt Benckiser, JP Morgan, Google, Toyota, Netflix, TIM, Samsung, Mastercard and Red Bull.



Fabio Palma is CTO for Africa and Co-President of Rua.Africa. It has more than 50 Lions in Cannes, being a Grand Prix, of these awards, 18 are in OOH. Graduated in Electronic Engineering, he has been working in the advertising market for over 15 years. A reference in innovation and special interactive OOH projects, he has worked with companies such as Eletromídia, JCDecaux, Ótima, Clear Channel, among others, on projects for numerous clients in OOH. In addition to the advertising market, he is a serial investor and co-founder of Distrito, the largest open innovation hub in Latin America.

SET EXPRESS | CLOUD

Moderator: Luiz Vinicius Febrônio - Technology Project Coordinator - SBT

OPTIMIZING USE OF NEW TECHNOLOGIES IN HYBRID ARCHITECTURES

Speaker: Marcelo Blum - Architecture and Technology Manager – Videodata

- Collaborative video workflow in the cloud
- Cloud Playout and hybrid architecture alternatives
- Video and Television App Ecosystems
- Centralization of TV Infrastructures with Interoperability in the IP & Cloud Transition
- Implementation of DAI (Dynamic Ad Insertion) systems with successful CASES.

SIGNAL DISTRIBUTION SYSTEMS IN THE CLOUD

Speaker: Danilo Ono - Technical Support Manager - Phase Engenharia

With the use of new technologies such as SRT and Zixi, the signal distribution without using dedicated links (e.g. using a regular public internet) has become a reality in the broadcast market as an alternative to traditional signal distribution forms such as satellite and IP links.

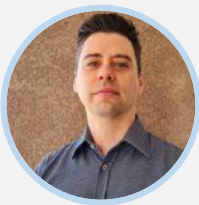
In this context, the cloud has proved to be a very efficient means for different kind of media processing, including the distribution part. From the “simple” SRT routing to the ease and agility of generating different formats and/or the possibility of generating variant channels with regionalized commercialization have attracted the market in the search for this type of solution. The presentation will cover the advantages and important aspects to consider in the process of distributing signals in the cloud.

THE MOVE OF A/V MEDIA APPLICATIONS WITHIN MULTI-LAYER HYBRID CLOUD DEPLOYMENTS

Speaker: Manuel Martinez Serruys - Head of sales engineering LATAM

As the media migration to cloud-native functions accelerates, the challenge for engineering and operations teams is twofold. They must first consider software/application vendor functional differences and how they integrate and interoperate. Second, they must review the differences related to how each is deployed into a multi-layer cloud-fog-edge architecture.

Through this lecture, we have considered some of the current cloud deployment models, how the multi-layer cloud concept applies, and explored the advantages and challenges surrounding them.


Luiz Vinicius Febronio - Technology Project Coordinator – SBT

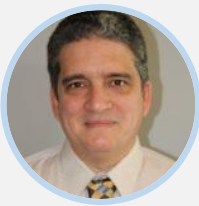
With an MBA in Project Management from the University of São Paulo and Business Management from Rio Branco, graduated in Telecommunications Technology from Faculdades Oswaldo Cruz and Law from Rio Branco, he has been working in the broadcast segment for 22 years. He currently coordinates the Technology Projects department at SBT, working with research and study of technologies, management and implementation of important projects of different natures and areas such as production, post-production, infrastructure, connectivity, delivery, archive, among others. In addition, he worked at ESPN Brasil in the area of reception and transmission of signals, participating in important events such as the World Cup and the Olympics.


Marcelo Blum - Architecture and Technology Manager - Videodata

Electronic Engineering by UFRJ, with 30 years of experience in the Television Engineering market, Architecture and Technology Manager of Videodata, specialized in Business Development and partnerships, Project Management and Video Technologies with emphasis on mission-critical systems including playout, media asset management, cloud, streaming and OTT. Partner of Set for more than 26 years, has contributed by presenting numerous lectures at its events.


Danillo Ono - Technical Support Manager - Phase Engenharia

Bachelor degree in Electrical Engineering and Master Degree in Digital Communications Systems from Mackenzie University. Worked at Mackenzie's Digital TV laboratory, performing comparative tests between the three Digital TV standards and as a consultant in the development of SBTVD. For 6 years worked as a R&D engineer and RF supervisor at Globo SP. Currently is a partner at Phase Engenharia based in São Paulo, where since 2014 has been working in the design of solutions for television systems.


Manuel Martinez Serruys - Head of sales engineering LATAM

Principal Solution Architect with 20 years experience in the media and entertainment industry leading design, integration activities of end to end streaming/broadcast solution in MVPD / broadcasters / D2C

Leading the sales engineering group in LATAM for MediaKind to help customers on their media path evolution as per their technology, operational business and consumer base needs.

Customer oriented mindset with architecting, implementing and integrating E2E media flows (A/V pipe) following a cloud distributed architecture between on premise and public cloud with aaS solutions.

Working with customers on the overarching E2E with bringing backend and client together with streaming media flows

Pushing for integration solutions/product gaps and evolution with product management, R&D organizations.

SET EXPRESS | MCOM

DIGITAL TRANSFORMATION OF THE MINISTRY OF COMMUNICATIONS

Presenter: Thiago Aguiar Soares - *Head of Innovation & Regulation of Broadcasting Services - Ministry of Communications (MCom)*

In this session, the Ministry of Communications will present the evolution of its computerized systems, which are being developed within the scope of the Digital Transformation Program, established in 2021. In particular, the new systems for requesting grants for Digital RTV and the Digital Protocol will be presented, GOV.BR platform system that will replace the petitions currently made via CADSEI.



Thiago Aguiar Soares - Head of Innovation & Regulation of Broadcasting Services - Ministry of Communications (MCom)

Thiago Aguiar Soares is graduated in electrical engineering from the University of Brasília (UnB), Brazil, post-graduated in telecommunications regulation from the National Institute of Telecommunications (INATEL), and currently pursuing a master's degree in electrical engineering at UnB. He worked for 12 years with the National Agency of Telecommunications (Anatel), coordinating projects on digital television, digital radio, broadcasting technical regulation, IT systems implementation, among others. Since 2020, he is Head of Innovation & Regulation of Broadcasting Services in the Brazilian Ministry of Communications. He is Vice-Chairman of the Study Group 6 (Broadcasting) of the Radiocommunication Sector of the International Telecommunications Union (ITU-R).

HOW THE TRANSFORMATION OF MEDIA CONSUMPTION HAS IMPACTED BUSINESS: IS IT NECESSARY TO INSIST OR REINVENT?

Continuing with tracking, where the point of discussion, for more than 20 years at SET, is the transformation of media consumption and, consequently, the transformation of the market. We invited leading executives from the main media markets to a debate in which the central point is to map out what is happening and where the market should go.

Moderator: Marcelo Torres - Journalist, presenter of SBT Brasil

Speakers:

- **Roberto Dias Lima Franco, SET Advisor and Director of Institutional and Regulatory Affairs at SBT**
- **Raymundo Barros - SET Advisor and CTO, Globo**
- **José Marcelo Amaral - Director of Engineering and Operations – RecordTV**
- **André Luiz Costa - CEO of Vibra Digital**



Marcelo Torres - Journalist, presenter of SBT Brasil

Graduated in journalism from Unesp, with a master's degree in International Journalism from the University of Westminster (London). He worked at Globo, the BBC World Service and has been with SBT for 17 years, starting as a correspondent in London. He has been the main presenter of SBT Brasil for two years. As a reporter he covered the wars in Iraq, Afghanistan and the Arab Spring, as well as two World Cups and two Olympics. He has also participated in the coverage of every election in the country since 1998.



Roberto Dias Lima Franco, SET Advisor and Director of Institutional and Regulatory Affairs at SBT

Graduated in electrical engineering with focus in electronics and telecommunications by the Federal University of Bahia and Post in Marketing and Business Management by FGV and ESPM. During the course of his career, he was responsible for the design and implementation of several radio and television companies in Brazil. He was President of SET – Brazilian Society of Television Engineering – from 2002 to 2008 and President of

the Brazilian Digital TV System Forum from 2005 to 2008 and from 2015 to 2017. After this period he joined the Council of both Entities . In 2009 He was a member of ANATEL's Advisory Board. In August 2012 took office in the Social Communication Council until 2017 and is currently Head of Institutional and Regulatory Affairs of SBT.



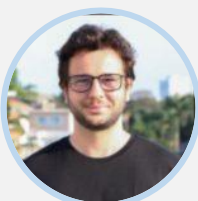
Raymundo Barros - SET Advisor and CTO, Globo

As Executive Director of Technology Strategy at Globo, Raymundo Barros is at the forefront of the areas of corporate strategy, partnerships and ecosystems in addition to technology. At the company, the executive led initiatives of great relevance to the media industry, such as the Project to expand the digitalization of the analogue signal in Brazil, the implementation of IP infrastructure, 4K in the production and distribution of content, Globoplay and the integration of technology areas of Grupo Globo companies. He is currently responsible for the implementation of Globo's D2C, Adtech and Data Monetization strategy. Raymundo has been at Globo for 39 years. Before taking over as CTO / CSO of the company, Raymundo served as a technician, engineer, operations manager and, subsequently, director of Engineering in SP. He also held the position of Director of Entertainment Technology, where he led projects for soap operas, series and variety shows. Raymundo is also an active director in entities such as SET.



José Marcelo Amaral - Director of Engineering and Operations - RecordTV

With a degree in Mathematics from FAHUPE-RJ, a graduate degree in Information System from PUC-RJ and FGV-SP and an MBA in Information Technology from USP-SP, José Marcelo do Amaral has made an extensive contribution to the broadcasting sector. He joined Record TV in 1991 and is today the director for Engineering and Operations. At the television station he has developed systems for the radio and TV commercial operations area; implemented a system for producing news; managed the integrated management system (ERP) project and created a system for monitoring audiences from mobile devices, among other tasks. As technology director he has participated in initiatives for implementing non-linear editing, digital archiving and tapeless work flow systems. During this period, he has also become involved with issues referring to digital video and video transmission using internet protocols (IP). He was Director of the Free-To-Air TV Segment at SET (the Brazilian Society for Television Engineering), his principal challenge being to develop digital television technology for Brazil, and he is responsible for its implementation and expansion throughout the entire Record group. Amaral's work also extends to the Forum of the Brazilian Digital TV System, where he served as President of the institution for several terms. One of his most challenging projects was the launch of the R7 portal, which is now the second-largest internet portal in Brazil. During his career he has also had the opportunity to head up the technical and operational planning and coordination of major sporting events broadcast by Record TV.



André Luiz Costa - CEO of Vibra Digital

André Luiz Costa is CEO of Vibra Digital, an innovation and technology company of Grupo Bandeirantes de Comunicação. Journalist graduated from ECA / USP, he worked 25 years in Journalism, as a reporter, editor and newsroom director. He led the creation and implementation of the BandNews FM Network, of which he was director for 9 years until he moved to TV, where in 2013 he took over the executive direction of Journalism at Band. In 2020, he stepped down to deploy and lead startup Vibra

REMOTE PRODUCTION: HOW TO CONNECT BOTH SIDES

Remote content production is already a reality. Different approaches have been adopted, from the most traditional model to Cloud production. It is known that these models enable greater capillarity and cost reduction, but how is it possible to guarantee a quality of connection between the structure of capture and that of production? In this panel, our participants will share and discuss about their experiences in using these technologies and about the connection between these two universes.

Moderator: Cauê Franzon, Executive Manager of TV and Radio Technology, RBSTV

SPEAKERS:

- **HOME-EDITING: REMOTE EDITING – APPROACHES, PROS AND CONS.**

João Paulo Quérette - Founder and CEO | ALFRED

Never has so much video been produced as in this age of more cameras and screens than people. The pandemic stopped the world, but made the wheel of digital history spin faster. What was already a trend became a necessity and work became remote for most of us. It's been no different with video editing.

Learn about the different ways to edit video remotely, their techniques, equipment, software and workflows, and understand the advantages and disadvantages of each approach.

- **CONNECTIVITY FOR EVENT PRODUCTION IN THE CLOUD**

Fernando Wiktor - Telecom Solutions Manager in the Infrastructure and Security area at Globo

In this presentation, connectivity possibilities for the production of events in the cloud will be discussed. Aspects that should be taken into consideration when deciding between occasional or permanent hiring and when to employ wired or wireless technologies will be discussed.

- **CONNECTIVITY CHALLENGES FOR REMOTE PRODUCTION**

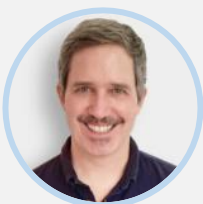
Mauricio Belonio - Director - Alliance

Practical and updated approach about connectivity for remote production. Classification and qualification of needs and integrated management of the operation. Practical examples of IP and proprietary technologies.



Cauê Franzon, Executive Manager of TV and Radio Technology, RBSTV

Graduated in Engineering, Master in Production Engineering, Federal University of Rio Grande do Sul, with an MBA in Project Management, FGV. He started his career in TV in 1996. He worked for over 10 years as a technician and support engineer for audio and video systems, coordinated a research group for television products and solutions for 3 years, served as infrastructure and project manager for TV and Radios and currently manages the technology area of RBSTV. He was the leader of several projects such as the remodeling of Rádio Gaúcha, implementation of virtual scenography, modernization and restructuring of productions and exhibitions of the group's stations in the interior of the state, implementation of IP infrastructure (2110) in the station in Porto Alegre, among others.



João Paulo Quérette - Founder and CEO | ALFRED

João Paulo Quérette is the founder and CEO of ALFRED, a developer of digital media management software. With a background in physics and computing, and a history of more than 25 years dedicated to digital video, he led the implementation of dozens of projects in companies and institutions across the country, in addition to being at the forefront of research and development projects. João Paulo has already presented at events such as SET, NAB, IBC, IFTA and TNW.



Fernando Wiktor - Telecom Solutions Manager in the Infrastructure and Security area at Globo

In his 26-year career, he has worked in the areas of projects, operations and support, carrying out highly relevant deliveries, such as connectivity solutions for 4 World Cups and 2 Olympics. He is currently responsible for the teams that develop and implement projects in the areas of local networks, WAN and in the cloud, security and telecom solutions for broadcast.



Mauricio Belonio - Director - Alliance

Graduated in Electronic Engineering and Post-Graduation in Telecommunications from University São Judas Tadeu. He has worked for 26 years in the broadcast and content production markets as a Project Engineer, Engineering Manager and Technical Director. He is a Founding Partner of Alliance Technologies, Riedel and Coralbay, Reseller for Ross Video, EVS, Aviwest e Quantum for the Brazilian market.

DIGITAL PRODUCTS: EXPERIENCES THAT GENERATE DIRECT BUSINESS WITH THE CONSUMER

Digital products have provided a way for companies to be able to speak directly to their consumers and thereby boost and expand their business. In this panel, we will address the strategies, techniques and processes used in product development, with an innovative look at user-centric experiences and the intensive use of data in the construction and optimization of the user journeys.

Moderator: Daniel Monteiro - Head of Product Development and Technology – Globoplay

SPEAKERS:

STRATEGIC PRODUCT MANAGEMENT AS A LEVER FOR INNOVATION

Roberta Luzio, *Product Manager – Globoplay*

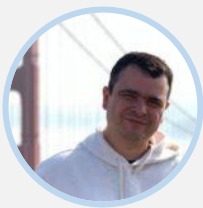
Innovation can be defined as the process by which new ideas are developed, tested and brought to market. However, the cost of failure has always been high, so avoiding it was and still is key. It is in this context that we will address the importance of Product Management in a strategic way, going through the skills, knowledge and processes adopted by Product Managers that are at the heart of creating successful innovative products.

GROWTH: THE TESTING METHODOLOGY TO GIVE TRACTION TO THE BUSINESS

Efrain Corleto, *Chief Growth Officer (CGO) & Partner- Vidia*

TECHNOLOGY CHALLENGES IN NEW PRODUCT LAUNCHES

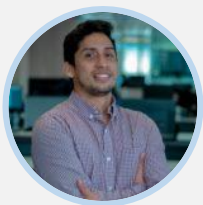
Bruno Bulso - *Director of Operations and Co-Founder of Kobe – Creative Software House*

**Daniel Monteiro - Head of Product Development and Technology - Globoplay**

Graduated in Electronic Engineering from UFRJ and passionate about new technologies, he joined Globo as an intern in 1998, working for 20 years in R&D and innovation areas. Since the beginning of 2021, he has been at the forefront of Globoplay's product and technology development, leading the teams that create and develop Globoplay's applications for all platforms.

**Roberta Luzio - Product Manager – Globoplay**

With an MBA in Business Management from FGV and CSPO and Product Management Leadership certificates, he currently holds the position of Product Manager at Globoplay, working in the construction and communication of the product strategy, leading the evolution through the union between business and technology and the orchestration of multidisciplinary teams. Passionate about people, strategy and digital products, she also has specializations in Social Media, Reputation and Branding and a postgraduate degree in People Management, career, leadership and coaching.

**Efrain Corleto - Chief Growth Officer (CGO) & Partner- Vidia****Bruno Bulso - Director of Operations and Co-Founder of Kobe – Creative Software House**

Graduated in Information Systems, with an MBA in Digital Project Management, Marketing and Management, he leads teams in the creation of a SaaS mobile application to enhance sales and user experience, applying techniques used by the most successful companies and startups in the market.

As director of operations at Kobe, a reference startup in mobile commerce technology in Brazil with more than 40 million people impacted around the world, he participated in the construction of high performance products and reference in the market, for brands such as Tok&Stok, Decathlon, Mobly, Grendene and Multilaser.

FUTURE OF GAMING: THE ENTRY OF THE GAMING ECOSYSTEM INTO THE METAVERSE AND WEB 3.0

With the construction and constant evolution of Web 3.0, games and users are already preparing for new possibilities and game formats. What are the biggest difficulties faced in adapting to web3? How does the metaverse work? In this panel, market experts discuss these and other issues related to the future of gaming.

Moderator: Gui Barbosa - General Director – BAYZ

Speakers:

- **Ronaldo da Silva Marques - TikTok Brazil Entertainment Partnership Leader**

- **THE POWER OF COMMUNITIES IN WEB 3.0 PROJECTS**

Heloisa Passos de Sousa - CEO Sp4ce Games and Creator of Boom Boogers

How strong are communities within blockchain projects? Why are the dynamics of communication and engagement so important within Web 3.0? In this new decentralized environment, co-creation and construction with users is what makes all the difference, and it is within this theme that we will be doing the discussions in this panel.



Gui Barbosa - General Director - BAYZ

Gui Barbosa recently led gaming partnerships on TikTok and ByteDance for Latin America. Previously, he was responsible for regional business development at Krafton (PUBG Corp), also holding executive positions at nØline, BBL and ESL Brasil. Prior to working in the games industry, Gui spent over a decade in finance at companies including Cerner, Universal Music Publishing Group and Deloitte.



Ronaldo da Silva Marques - TikTok Brazil Entertainment Partnership Leader

Leader of the TikTok Brasil content partnerships team, Ronaldo Marques is 33 years old, holds a degree in journalism from the Universidade Metodista de São Paulo and brings the experience of ten years of content production and audience in newsrooms and digital sectors of traditional communication vehicles – such as Band, UOL and SBT – to the short video application.



Heloisa Passos de Sousa - CEO Sp4ce Games and Creator of Boom Boogers

Heloísa Passos is CEO of SP4CE Games, one of the main companies in the blockchain games sector in Brazil, creator of the game Boom Boogers and founder of one of the largest Instagram communities in Latin America of NFT Games. Graduated in Animation Design and Postgraduate in Management in Creative Economy, she worked on the development of creative projects for startups and companies such as Stone, Magalu, ABIPAG, Disney, Honda, Rabobank, among others.

TECHNICAL FEASIBILITY ANALYSIS – BASIC BROADCASTING PLANS / MOSAICO – ANATEL

Moderator: Geraldo Cardoso de Melo - Representative of the SET Southeast Regional and member of the SET Spectrum Working Group

Speakers:

Paulo Eduardo dos Reis Cardoso - CCoordinator of Systems and Models of Broadcasting Management - Anatel



Geraldo Cardoso de Melo - Representative of the SET Southeast Regional and member of the SET Spectrum Working Group

Geraldo Cardoso de Melo is a Telecommunications engineer with a degree and specialization from the Pontifical Catholic University of Minas Gerais (PUC-Minas). Consultant engineer in broadcasting services, Professor at PUC-Minas, member of the SET Spectrum Working Group and coordinator of SET Sudeste.



Paulo Eduardo dos Reis Cardoso - Coordinator of Systems and Models of Broadcasting Management -Anatel

Holds a PhD from DECOM-FEEC-Unicamp (2018) in Digital TV Regulation; Master's degree in Electrical Engineering (Electronics) from DEMIC-FEEC-Unicamp (2005); and degree in Electrical Engineering from FEEC-Unicamp (2002). He is currently Regulation Expert of the National Telecommunications Agency – Anatel, where he works as Coordinator of Systems and Models of Broadcasting Management, in the Spectrum, Orbit and Broadcasting Management, being responsible for studying, improving and elaborating the Technical Regulation of Broadcasting. , including its technical and operational requirements acts; for accompanying the development of new broadcasting technologies and prospecting the future of broadcasting, including the definitions of its needs; in addition to accompanying the development of the broadcasting modules of the Mosaic System. He is the leader of the Reporting Group of GRR6: Broadcasting, of the Brazilian Communication Commission – CBC2: Radiocommunications, coordinating the group's international activities, including the coordination of broadcasting service stations in border areas; working mainly in Study Group 6 – SG6 of the International Telecommunication Union – ITU.

OPEN INNOVATION: FOSTERING GROWTH THROUGH THE ECOSYSTEM

In a scenario of increasing global competitiveness and accelerated growth, it is paramount that companies whether entrants or incumbents recognize that the time of building the future alone is behind us. McKinsey found that 51% of Brazilian corporations already have the Corporate Venture Capital topic in their agendas, which underlines the belief that collaboration is key to drive change. In this panel, we will discuss the benefits of being an active player in the Innovation Ecosystem from the perspectives of startups, corporations, accelerators, and investors.

CORPORATIONS AS PLAYERS OF THE INNOVATION ECOSYSTEM

Corporations have realized that being part of the Innovation Ecosystem not only speeds up the pace of innovation in the company, but also acts as launchpads to fuel new technologies, products, and ventures across the industry. In this talk, we will discuss how collaboration models can be used as a lever for corporations that wish to achieve their goals even faster.

Moderation and Introduction: Luiz Gabriel Vasconcelos - Specialist of Ecosystem & Partnerships – Globo

Speakers:

WHAT ISRAEL CAN TEACH US ABOUT FOSTERING INNOVATION ECOSYSTEMS?

Daniel Ibri, *Managing Partner | Mindset Ventures*

Israel has been long known as the Startup Nation, given its incredible track-record producing innovation and successful entrepreneurs. But what makes Israel such a successful ecosystem? What are the main characteristics that allow for this ecosystem to thrive and produce so many great companies? The lecture will explore some elements and lessons learned from the Israeli ecosystem and how this can be applied as best practices in other developing ecosystems around the world.

HOW TO BUILD AN ECOSYSTEM TO FUEL OPEN INNOVATION?

Mehrad Moeini - Head de Business Development | Plug and Play Tech Center

In this session, we will discuss an open innovation model and share how Plug and Play has successfully built an ecosystem across 37 locations in 17 different countries. Through this session, the audience will have the opportunity to learn how Plug and Play has achieved this global model through collaboration with the following change-

makers: Universities, Service providers, Venture capitalists, Advisers, and Angel Investors, Corporations, Government organizations, Accelerators + Incubators.

COLLABORATION IN THE ECOSYSTEM FROM A STARTUP PERSPECTIVE

Robby Arguelles, Sales Executive | Headspin

With the speed of digitalization we're witnessing today, collaboration in the ecosystem is no longer an option but an imperative in accelerating innovation. Startups can provide a fresh, agile, and digital-first perspective on people, process, and technology, while benefiting from resources and access from other players in the ecosystem. Through real customer stories and partnerships Robby will demonstrate the mutual benefits synergy in the ecosystem can bring.



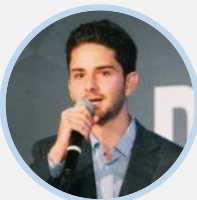
Luiz Gabriel Vasconcelos - Specialist of Ecosystem & Partnerships - Globo

Graduated in Electronic and Computer Engineering from UFRJ, with a Masters in AI/ML and Signal Processing from COPPE, he has more than 15 years of experience in innovation, technology and product development. Today he is based in Globo's Silicon Valley, California office, from where he connects with the international innovation ecosystem to establish partnerships that accelerate the company's growth. He is a Stanford alum and won a Silver Lion at Cannes in the Technological Innovation category.



Daniel Ibri - Managing Partner | Mindset Ventures

Daniel is Managing Partner and Co-Founder of Mindset Ventures and was listed as one of the most influential investors by Venture360. Besides that, Daniel is also a board member in several startups in Brazil and abroad, a mentor at Endeavor, Artemisia, Quintessa, ACE and Lisbon-Challenge, member of the Entrepreneurship and Innovation Committee of ABVCAP and professor of entrepreneurship and finance at INSPER, in Sao Paulo. Daniel is also a co-author of the book Private Equity and Venture Capital in Brazil.



Mehrad Moeini - Head de Business Development | Plug and Play Tech Center

Mehrad has over 8 years of experience in business development, strategy, and consulting working for technology companies including Oracle [NYSE: ORCL] and Paycom [NYSE: PAYC]. He started his career at Plug and Play in 2019 to spearhead efforts to launch the Media & Advertising innovation ecosystem. Plug and Play is an early-stage VC firm known for exit like PayPal, Dropbox, and Honey and innovation platform to Fortune 500 corporations. Lastly, Mehrad is an investor and adviser to early-stage startups.



Robby Arguelles - Sales Executive | Headspin

Robby studied at the University of São Paulo and also lived in Mexico City and San Francisco, making him trilingual. His experience with startups in San Francisco has given him an understanding of how emerging technologies and engineering solve business problems. He's passionate about working with technical teams and introducing new technologies to key stakeholders. Robby's professional goal is to empower Latin American businesses by introducing high tech solutions so they can compete in the global market through digital transformation.

IS THE FUTURE OF RADIO IN THE NETWORKS?

The increase in the number of affiliates to Radio networks has been a phenomenon in high expansion in recent years.

The migration from AM Radio to FM and the Radio Networks of the Amazon region, with the preservation of local content, opened up possibilities for the networks' brands.

Quality, national and local journalistic content, in addition to advertising optimization, favor its growth.

Come and get to know the subject more closely with the network executives in the panel moderated by Daniel Starck.

Moderator: Eduardo Cappia, SET Board Member and EMC Director

Co-moderator: Daniel Starck - Director at tudoradio.com

Skeapers:

- **Carlos Aros - Content Director | Rede Jovem Pan News**
- **Luiz Benite - General Director at Massa FM Network**
- **Jean Pierre Zanetti Vandresen - Technical Manager at Grupo Bandeirantes de Comunicação**



Eduardo Cappia, SET Board Member and EMC Director

JOSE EDUARDO MARTI CAPPIA – Graduation 1979 from the University of Mogi das Cruzes. Electrical Engineer with qualification in: Electronics and Electrotechnics. Specialist in FM radiant systems, measurement and coverage.

Director of the Company EMC – TELECOMMUNICATIONS SOLUTION since 1991
EMC – distinguished company for the implementation of Digital Radio tests at UFMG – Belo Horizonte, in partnership with the Ministry of Communications. Technical Responsible for HD Radio tests in Cordeirópolis – SP and DRM in Belo Horizonte, focusing on low power stations. Evaluation and defense of a thesis with IBiquity in the USA, on the coexistence of digital broadcasters in the first adjacent FM channels.

Implementation in 2014 of a scientific and experimental test station in eFM – 84.7 MHz – Jovem Pan – São Paulo with the support of AESP- ASSOCIAÇÃO DAS RADIO AND TELEVISION IN THE STATE OF SAO PAULO, where it acts as leader of the Technical Committee since 2011 having been renewed in its performance until 2023.

Board of Directors / Council SET – TELEVISION ENGINEERING SOCIETY – since 2011.

Author of articles in columns and websites for the dissemination of the sector and thematic works on spectral efficiency, with support for measuring diagrams of radiating antennas and their effective gains.

Active participation in Regulatory Groups and Discussion of Standardization of the Sector, acting in the Migration process from Radio AM to FM since 2009, (MCTIC and Anatel (Mosaico)).



Daniel Starck - Director at tudoradio.com

Daniel Starck is a journalist, entrepreneur and owner of tudoradio.com. With 20 years on the air, it is the largest Brazilian portal dedicated to broadcasting. He has a degree in Social Communication from PUC-PR. He had stints on radio stations such as CBN, Rádio Clube and Rádio Paraná. He works as a consultant and speaker in the artistic and digital areas of radio, having participated in events promoted by leading associations for the sector, such as AESP, ACAERT, AERP and AMIRT. He also has knowledge in the technology area, with an emphasis on applications, programmatic media, new devices, websites and streaming.



Carlos Aros - Content Director | Rede Jovem Pan News

Content Director of Rede Jovem Pan News, journalist specialized in Technology and Innovation, executive editor of MIT Technology Review Brazil.



Luiz Benite - General Director at Massa FM Network

Advertiser with a postgraduate degree in Marketing. Created the expansion model for Rede Massa FM, the second largest radio network in Brazil and leader in several markets.

He created and expanded Radio Network formats such as Rede Transamérica Hits. He was Director of Rede Band FM Santa Catarina and Top FM São Paulo



Jean Pierre Zanetti Vandresen - Technical Manager at Grupo Bandeirantes de Comunicação

With a systemic, dynamic vision, project management, processes and execution, in the search for the best solutions with quality and results for the company. Development of OPEX and CAPEX of operations. Training in technical, engineering and certifications in networks (IT), focusing on audio and IP systems in radio and television stations. In the last 21 years, leading two large radio networks, such as Grupo RBS and Grupo Bandeirantes, leading teams in the engineering and internal and external operations, developing projects and solutions with manufacturers and suppliers, especially studios and central of Rádio Gaúcha and AoIP in Grupo Bandeirantes, in addition to planning and executing national events of all sizes and international events (4 World Cups, 3 Olympics, 3 Copa America, Champions League, Club World Cup, Panamericano, F1) between other sporting, entertainment or news events.

CHALLENGES OF DEPLOYING TVRO IN KU BAND

To mitigate the potential interference of the 5G cellular technology signal in the Band C range, a program was created to migrate domestic satellite dish receptions from Band C to Ku Band, part of this migration being supported with resources from the 5G auction. Mainly considering the deadlines defined in the 5G entry schedule, this program has a major technical and operational challenge in the uplink of the TVRO signal in a new MCPC (Multiple Channels per Carrier) transmission system in Ku Band, the challenge of specification, purchase, manufacture, supply and installation of a kit of receivers for families that are part of the social programs of the federal government (CadÚnico), and also the challenge of adapting the software of the legacy domestic receivers base but with the ability to migrate band along with the new models.

With a technological focus, we will understand the details of this program with representatives of EMBRATEL/CLARO, EAF – Entity Administering the 3.5GHz Band created to manage this process and which operates under the brand Siga Antenado – and the participation of a manufacturer of Home Receivers.

Moderator: Claudio Borgo – Video Engineering Director - Claro

Speakers:

- **Guilherme Saraiva - Sales Director - Embratel**
- **Antonio Parrini – Director of Operations - EAF**
- **Marcio Cauduro – Business and TV Products Manager - Elsys**



Claudio Borgo – Diretor Engenharia de Vídeo - Claro



Guilherme Saraiva - Sales Director - Embratel

Guilherme Saraiva is the commercial director for the Media and Satellite segments at EMBRATEL, where he supports clients in the development of their business in the physical and digital worlds. In Grupo Globo he acted as CTO of Telecine, where he

launched the streaming platform Telecine Play. He was technology planning manager at Globosat during the migration of channels to HD and the launch of OTT digital products. He led NET's marketing and corporate products area, participating in the launch of broadband internet services. He coordinated British Telecom's expansion plan in Latin America, collaborating on digital inclusion projects in several countries.

Telecommunications engineer from IME, with an MBA in marketing from FGV, Master in Finance from FGV and an MBA in Data Science from PUC-RJ.



Antonio Parrini – Director of Operations - EAF

Antônio Parrini has almost 30 years of professional experience, all of them in Telecom. The last 8 years were as C-level Executive in tower companies such as BR Towers (COO), Centennial (CEO) and Phoenix Tower (VP). Before that, he worked for telecom operators such as ATL (before being acquired by Claro), Oi and GVT (before being acquired by Vivo).

At Oi, he was Director of Networks and Operations, in the Fixed and Wireless divisions, for almost 10 years. He participated in several startups, such as Oi Mobile (employee #3) and BR Towers (employee #2). He is a telecommunications engineer with a degree from Universidade Federal Fluminense and an MBA from COPPEAD UFRJ business school.



Marcio Cauduro – Business and TV Products Manager - Elsys

Executive with more than 20 years of experience in strategy, management, development and launch of Products and Services working in Telecom Operators, Startups, Electronics Industry and Service Providers. Acting in different Technology markets such as TV, Internet, Mobile Applications and database search engines. Building technological and commercial partnerships with local and international partners to offer customized products.

Computer Engineer from UNICAMP with a postgraduate degree in Business Administration from FGV/SP and an MBA from IE Business School – Spain.

SET EXPRESS | RADIO

Moderator: Ronald Almeida - Technical Manager – Engineering | O Povo – Communication Group / Representative SET Nordeste

Speakers:

RADIO YEAR 101 – RELEVANCE FOR GENERATING NEW BUSINESS

Juliana Paiva, *Partner-director Radiodata*

130 million people consume some type of audio in Brazil.

Consumption is broad and ranges from the housewife's radio to the mobile application of a multinational executive

There is nothing to question about the strength of radio communication in the country. The growth in the consumption of podcasts further reinforces the relevance of the radio medium with the possibility of on-demand distribution.

Investment in the sector increases with programmatic digital media and the migration from AM.

Why then does a small group of broadcasters take most of the advertising budget?

The 10 broadcasters that earn the most in the Brazilian market are those that customize their programming and focus on specific audiences.

All of them have a niche programming and audience profile, which gives them a repertoire to compete in the market with other media.

In these stations, the sponsor is a partner within a business project. The relationship with sponsors must always be long-term.

The audience is increasingly personalized. It's not a matter of the number of listeners, but the type of listener the market wants to talk to.

The difficulty in the medium is precisely in seeking this customization since 3 out of 5 radio stations in the country broadcast exactly the same type of content. The discussion is no longer on which device we are going to deliver the content, but what we are going to deliver to our listener.

THE AUDIENCE RELATIONSHIP MANAGEMENT AS KEY TO MODERN RADIO SUCCESS

Carolina Sasse, *Partner and Director of Marketing and Sales - Cadena*

Since its origins, radio has sought to deliver relevant content to its audience. In most of its centenary in Brazil, interaction with listeners was essentially one-way. As it is a mass medium, programming sought to reach the maximum number of listeners and feedback from surveys gained strength from the 1940s onwards. In the advertising context, radio shared the audience and the total media budget with only a few players.

In the last 15 years, significant changes in technology have transformed people's behavior and expectations, increasing their power of choice and the way they consume, interact and engage with content and advertising. Some of the factors that contributed the most: the arrival of smartphones; the expansion of internet access; the rise of streaming services and the boom of social networks.

The wide range of options and the ease of access on demand require radio stations to think of new formats to connect listeners to programming and brands.

At the same time, the evolution of technology and marketing brought new metrics for ROI analysis, which made negotiating contracts and presenting results/campaign check more complex.

Giants like Netflix, Amazon, Meta and Google have invested in getting to know their customers in depth to deliver more results. Radio broadcasters need to follow along. Actions, tools and options to qualify the audience and turn other media into allies are the focus of this lecture.

HOW PROGRAMMATIC MEDIA PUTS RADIO IN TUNE WITH THE ADVERTISING MARKET

Thiago Fernandes, *founder of Nextdial*



Ronald Almeida - Technical Manager – Engineering | O Povo – Communication Group / Representative SET Nordeste

Engineer with more than 17 years of experience in Broadcasting, working for TV, radio and web portal stations. Developing activities related to Telecommunications, Engineering and IT. Acting mainly in management, planning, maintenance, implementation of new projects, among others.

Director of External Relations of ACERT – Ceará Association of Radio and Television Broadcasters (2nd Biennium)

Worked in the operation and technical implementation of affiliated stations of TV Cultura, Canal Futura, SBT and Band, radios CBN, Nova Brasil and Globo, in the city of Fortaleza/CE.



Juliana Paiva - Partner-director Radiodata

Experience in production audio and video content. Management of integrated projects for media companies with an emphasis on expansion and consumption for companies such as Rádios CBN and Globo, CNN Rádio/Rede Transamerica, UOL, Nova Brasil and Antagonista.

I have more than 20 years of experience in audio, with stints on Jovem Pan, CBN and Rádio Globo radio stations.



Carolina Sasse - Partner and Director of Marketing and Sales - Cadena

Carolina Sasse has a degree in Business Administration and is currently Marketing & Sales Director at Cadena, a company for over 20 years providing software solutions for management, automation and audience intelligence for radio stations.

Since 2007, she has been in contact with thousands of radio professionals throughout Brazil to learn more about their routines, daily challenges and how to help them simplify

processes, increase listeners' engagement and sales of radio and its advertisers, with tools and content. She believes in the power of radio to connect people and brands. She worked for 10 years in Quality and Customer Success in Brazil & Latin America leading teams and projects.

She has already spoken at the main events in the field, such as SET EXPO 2018, ACAERT Congresses 2018/2022, Regional Seminars and Meetings SERT/SC 2016-2022, AESP Talks, Regional Meetings and Lives from AMIRT and AESP, Fala Norte and Nordeste.

In addition to being a guest columnist for TudoRadio.com, she periodically provides content and lives with radio experts at Cadena's blog and YouTube channel.

She regularly participates in Radio and Marketing events like NAB Show, RD Summit and other.



Thiago Fernandes - founder of Nextdial

Thiago Fernandes, founder of Nextdial (@nextdialbr), a technology startup that is making life easier for radio professionals, agencies and advertisers. He was a Microsoft Evangelist and holds a degree in Computer Science, an MBA in Software Engineering from ITA and a specialization in Marketing from ESPM.

RADIO 100+ THE MEDIA, THE LISTENER AND THE BUSINESS

Completing 100+ years in Brazil, radio is undergoing continuous transformation. Its adaptability and agility make it always contemporary, incorporating new technologies and new properties. Today's radio is a digital and amplified mix of audio content. Reinventing itself every day, the radio of the future will be an even better version than the current one.

In this panel, we will discuss the current landscape of cross-platform audio content represented by radio, podcasts and streaming. We will also discuss the process of digital transformation that is imposed as a change strategy and that has an impact on the business model, customer relationships and user engagement (the listener inserted in a broader context).

Moderator: Eduardo Cappia, *SET Board Member and EMC Director*

Co-Moderator: Marco Moretto - *Director at Rádio HOT107 FM and Member of the Board of Directors of AESP*

Speakers:

- **LISTENERS' MEDIA CONSUMPTION HABITS IN THE DIGITAL UNIVERSE**
Giovana Alcantara - *Director of Regional Business Development at Kantar IBOPE Media*
- **RADIO'S DIGITAL TRANSFORMATION – NEW PARADIGMS, BUSINESS MODELS, CUSTOMER RELATIONSHIPS AND AUDIENCE ENGAGEMENT**
Allen Chahad, *Head of Strategic Partnerships -Vibra Digital (Bandeirantes Group)*
Habits change more and more quickly. A radio station's competitor is no longer just another radio station. The digital world and the growing diversity of media make the challenge of gaining and, above all, keeping attention, increasingly complex. At the same time, producing and distributing on multiple platforms brings new opportunities for monetization of content and relationship with the public. There is no right model, but not testing new models is a mistake.
- **PODCASTS IN BRAZIL AND THE WORLD**
Rodrigo Tigre, *Country Manager - Entravision Cisneros Interactive*


Eduardo Cappia, SET Board Member and EMC Director

JOSE EDUARDO MARTI CAPPIA – Graduation 1979 from the University of Mogi das Cruzes. Electrical Engineer with qualification in: Electronics and Electrotechnics. Specialist in FM radiant systems, measurement and coverage.

Director of the Company EMC – TELECOMMUNICATIONS SOLUTION since 1991

EMC – distinguished company for the implementation of Digital Radio tests at UFMG – Belo Horizonte, in partnership with the Ministry of Communications. Technical Responsible for HD Radio tests in Cordeirópolis – SP and DRM in Belo Horizonte, focusing on low power stations. Evaluation and defense of a thesis with IBiquity in the USA, on the coexistence of digital broadcasters in the first adjacent FM channels.

Implementation in 2014 of a scientific and experimental test station in eFM – 84.7 MHz – Jovem Pan – São Paulo with the support of AESP- ASSOCIAÇÃO DAS RADIO AND TELEVISION IN THE STATE OF SAO PAULO, where it acts as leader of the Technical Committee since 2011 having been renewed in its performance until 2023.

Board of Directors / Council SET – TELEVISION ENGINEERING SOCIETY – since 2011.

Author of articles in columns and websites for the dissemination of the sector and thematic works on spectral efficiency, with support for measuring diagrams of radiating antennas and their effective gains.

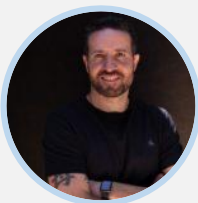
Active participation in Regulatory Groups and Discussion of Standardization of the Sector, acting in the Migration process from Radio AM to FM since 2009, (MCTIC and Anatel (Mosaico)).


Marco Moretto - Director at Rádio HOT107 FM and Member of the Board of Directors of AESP

Marco Moretto started his radio activities in 2006, still as a child, at the age of 12. Integrated into the medium, he became professionalized and specialized in administration focused on communication vehicles. He is one of the youngest administrators of Brazilian radio. He graduated from Centro Universitário de Bauru (Toledo Teaching Institution) and specialized at FGV EAESP (School of Business Administration of Fundação Getúlio Vargas). He frequently participates in national and international congresses and exhibitions. He is Director of Rádio HOT107 FM and Member of the Board of Directors of AESP (Association of Radio and Television Broadcasters of the State of São Paulo).


Giovana Alcantara - Director of Regional Business Development at Kantar IBOPE Media

Giovana Alcantara is Director of Regional Business Development at Kantar IBOPE Media and leads the service teams at the company's branches across the country. The executive has a degree in Social Communication and a postgraduate degree in Marketing. Giovana Alcantara has been working in the Brazilian advertising market for more than two decades, having held strategic positions in agencies and vehicles, in the areas of planning and research.


Allen Chahad - Head of Strategic Partnerships -Vibra Digital (Bandeirantes Group)

Allen Chahad is Head of Strategic Partnerships at Vibra, a spin-off company and digital strategist of Bandeirantes Group. Journalist with more than 20 years of experience in the market, always connected to the mission of promoting digital transformation. He was a Reporter, Editor, Coordinator and Content Manager for Terra Networks. At Jovem Pan Radio he was content director for digital platforms. And at Bandeirantes Group he worked as Integration Coordinator and Newsroom Manager of Journalism TV before

participating the set-up of Vibra. In 2022, coordinated the Collaboration Project of ABERT with Meta and ICFJ in the “Digital Transformation Accelerator” program for radio and TV stations throughout Brazil.

**Rodrigo Tigre - Country Manager - Entravision Cisneros Interactive**

Rodrigo Tigre has been developing projects on the Internet since 1997. He has also participated in the creation and development of several start-ups. Rodrigo is a partner at RedMas / Audio.ad, the first digital audio advertising solutions company in Latin America. Headquartered in Argentina and established in São Paulo in 2016, it has more than thirty customers locally, including Nissan, Outback and Losango. In addition to Brazil, RedMas / Audio.ad has offices in more than 15 countries in Latin America and the USA and has more than 200 employees. Since 2011, it has been part of Grupo Cisneros, one of the largest private media, entertainment, telecommunications and mass communications products groups in the world.

PIRACY – ACHIEVEMENTS AND NEW CHALLENGES

In a context of accelerated digitalization, economic crisis and post-pandemic, we will take stock of the fight against piracy in recent years and discuss the guidelines for acting from now on, approaching the subject from the angle of technology, industry, public and legal authorities.

Moderator: André Felipe Teixeira, Content Security Manager - Globo

Speakers:

AUDIOVISUAL PIRACY: HOW TO RESTRICT ILLEGAL INTERNET STREAMING?

Jonas Antunes - Director - ABTA - Brazilian Pay TV Association

Audiovisual piracy has evolved. New techniques and modern operations spread over the internet have challenged the legal industry and national public authorities. Thousands of pirated offers are available on the internet and are preferred by millions of Brazilians, who are unaware of the cyber risks they are taking. The problem is serious and needs to be addressed. How, then, to restrict pirated transmissions over the internet in Brazil? Coordinated actions, public and private, use of technology and blockages in the telecommunications infrastructure. Those are some of the ingredients.

Eduardo Luiz Perfeito Carneiro - Piracy Combat Coordinator – Ancine

VIDEO: TECHNOLOGY EVOLUTION AND PIRACY

Danilo de Almeida, *Director Solutions Engineering* - Synamedia

ACCOUNT SHARING AND SUBSCRIPTION PIRACY

Felipe Senna, *Director of Ltahub, Partner of CQS | FV Advogados*



André Felipe Teixeira, Content Security Manager - Globo



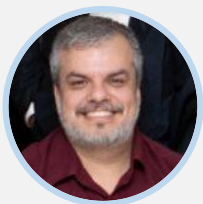
Jonas Antunes - Director - ABTA - Brazilian Pay TV Association

Jonas Antunes Couto is an economist and lawyer, with a PhD in Economic Law from USP. Director of ABTA (Brazilian Association of Pay TV), today he is a member of the National Council to Combat Piracy of the Ministry of Justice and coordinates the industry's efforts to prevent and combat audiovisual piracy.



Eduardo Luiz Perfeito Carneiro - Piracy Combat Coordinator - Ancine

Bachelor in Law. Specialist in Intellectual Property at PUC-Rio. Coordinator for Combating Piracy at ANCINE. Member of the National Council to Combat Piracy of the Ministry of Justice. Member of the State Council to Combat Piracy of Santa Catarina. Consultant to the OAB/SP Intellectual Property Commission. Member of the Council for Combating the Illegal Market of Fecomércio/RJ.



Danilo de Almeida - Director Solutions Engineering - Synamedia

Technical director of solutions engineering at Synamedia, graduated in Information Systems by FIAP, having specialization in Operations Management by POLI-USP and Innovation/Digital Transformation by FIAP. He has worked for more than 20 years in the technology business and 11 years in the digital TV business. Industry speaker about technology, ad-tech, broadcast & streaming and combat the piracy in audiovisual business. Guitar play and barbecue maker on occasion.



Felipe Senna - Director of Ltahub, Partner of CQS | FV Advogados

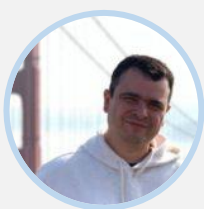
Felipe Senna is a lawyer, LL.M in United States Law from Temple University Japan Campus and a Postgraduate Degree in Business Law from FGV. He is a Partner at CQS FV Advogados and Director of Public Policy and Industry Relations at LTAHub. Specialist in Intellectual Property, Cyber Crimes, Anti-Piracy and Content Protection, having worked as Associate at Azevedo Sette Advogados, Head Anti-Piracy at SKY Brasil and Director of Anti-Piracy at FOX Networks Group Latin America. He is on the board of private associations and public initiatives to combat piracy and protect content.

LEADERSHIP & INNOVATION

Moderator: Daniel Monteiro - Head of Product Development and Technology – Globoplay

Speakers:

- **Pablo Canano, COCEO founder of Driven.cx**
- **Fernando Bittencourt, Former president of SET**
- **Carlos Henrique Moreira, Sr. Director of International Ecosystem & Partnerships at Grupo Globo / Silicon Valley.**
- **Thiago Taranto, CEO and founding partner of Mobi2buy**



Daniel Monteiro - Head of Product Development and Technology - Globoplay

Graduated in Electronic Engineering from UFRJ and passionate about new technologies, he joined Globo as an intern in 1998, working for 20 years in R&D and innovation areas. Since the beginning of 2021, he has been at the forefront of Globoplay's product and technology development, leading the teams that create and develop Globoplay's applications for all platforms.



Pablo Canano - COCEO founder of Driven.cx

COCEO founder of Driven.cx, a company specialized in consumer experience and the purchase journey.

Master's Degree in Digital Marketing – ESPM

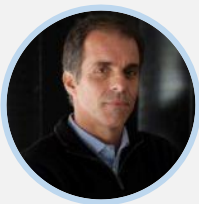
Pablo has a Post in User experience – Centered Design.

He was the founder of the first agency specialized in UX for e-commerce, Profite. Selecionado por e-commerce Brasil among the best professionals in Brazil in UX. Professor by Estácio de Sá, Instituto Infnet and Impacta. It has 10 national and international awards in shopping experience.



Fernando Bittencourt - Former president of SET

An electronic engineer, he is the founder of FB Consultoria and former general director of Engineering at Rede Globo. He is part of the Deliberative Council of the SBTVD Forum and is a member of the international entities: IEEE, IBC and SMPTE. In 1994, he became the coordinator of the group created by SET and ABERT that studied and implemented digital TV in Brazil. He was a member of the Council of Social Communication of the Federal Senate. He is recognized worldwide as an engineer of notorious knowledge in the field of communications.

**Carlos Henrique Moreira - Sr. Director of International Ecosystem&Partnerships at Grupo Globo / Silicon Valley.**

Co-founded and developed Esporte Interativo, Brazil's first national television network and multi-media platform fully dedicated to live sports with an unprecedented engaging format, acquired by WarnerMedia. Leadership roles at Nike and Twitter. Now leading innovation and CorpDev as Sr. Director of International Ecosystem&Partnerships at Grupo Globo based in Silicon Valley.

Investor at JWS, Galy, Strofe, Jiffy.ai, FeverUp, Republic (via Tribe Capital), Conta Simples, Hamama, IDWall, GamersClub (exit to Immortals Team), Peer5 (exit to Microsoft) and EasyCarros. Operating LP at Canary, Venture Partner and Advisor at Mindset Ventures, Founder and BoD at Reaction Global, and investor at Tau Ventures. Mentor at Endeavor and Supernode, consultant at Stanford Seed Program and member of Stanford Angels and Entrepreneurs. Father of 3. Sportsman and ocean lover.

**Thiago Taranto - CEO and founding partner of Mobi2buy**

Entrepreneur since he was 17 years old when he launched the security portal hacker.com.br, passionate about technology and how it can provide business innovation. Today in his fourth startup, he serves as CEO and founding partner of Mobi2buy, a technology company with more than 8 years of experience in the market serving clients such as Oi, Claro, TIM, Havaianas, Estácio, among others.

SET EXPRESS | DIGITAL TV

Moderator: Alberto Botelho - Broadcasting Project Engineer - LM Telecom

Speakers:

REDE AMAZÔNICA: EXPERIENCE WITH IMPLEMENTING MPEG-H AUDIO ON THE AMAZON SAT CHANNEL

Gabriel Thomazini - *Audio Consultant - Fraunhofer IIS*

Grupo Rede Amazônica is the first broadcaster in Latin America to provide a 24/7 MPEG-H Audio service on the Amazon Sat channel using ISDB-Tb.

MPEG-H Audio has been included in the TV 2.5 standard, particularly due to its capabilities to deliver immersive sound and, even more important, its advanced personalization and accessibility options, which no other audio system can currently deliver.

Since the MPEG-H Audio system is designed to work over unmodified HD-SDI embedded audio channels, or IP, stations can begin implementing MPEG-H Audio features as they choose, without changing their internal plant or operating procedures. You will be presented to a working example of how MPEG-H is integrated into professional production and distribution facilities today..

HDR TV TRANSMISSIONS WITH DYNAMIC METADATA

José Filipe Ferraz Valente - *Video Standardization Engineer - Philips*

SBTVD includes HDR solutions with dynamic metadata in their TV2.5 and TV3.0 specifications. In this presentation we will elaborate on HDR using dynamic metadata. We start by briefly discussing what HDR is and its advantages for television transmissions compared to standard SDR transmissions in this presentation. Subsequently, we will explain the benefits of using dynamic metadata for HDR transmissions and how it can be used to get perfectly adapted pictures for a TV display by so-called display adaptation.

We furthermore explain that a dynamic metadata HDR system can operate with different base layers, such as SDR, HDR10 and HLG, and as such fulfill different type of technical and commercial requirements. This will be followed by showing how to use these different systems in a production chain and by an example of the Rock in Rio 2019 trial where SL-HDR1 and MPEG-H Audio were deployed. SL-HDR1 is the SDR base layer variant of the Advanced HDR by Technicolor dynamic metadata HDR system.

We continue by elaborating on the technical characteristics and performance parameters of an HDR system. We will use the SL-HDR1 and 2 parts of Advanced

HDR by Technicolor, which are publicly specified by ETSI, to discuss technical characteristics. The typical performance parameters checked during tests of HDR systems will also be taken along. We conclude with some typical high-level results.

THE MPEG V3C STANDARD (V-PPC, MIV) FOR IMMERSIVE VIDEO

Celine Guede - *Architect in Research & Innovation - InterDigital*

The Visual Volumetric Video-based Coding (V3C) standard defines a generic mechanism for coding volumetric video used in XR immersive videos.

The Moving Picture Experts Group (MPEG) has specified two applications that utilize V3C: Video-based Point Cloud Compression (V-PCC) – ISO/IEC 23090-5, and MPEG Immersive Video (MIV) – ISO/IEC 23090-12. V-PCC and MIV have been adopted at the end of 2021 for TV3.0 for fulfilling XR requirements by the SBTVD Forum.

This presentation provides an overview of the generic concepts of V-PCC and MIV technologies.

The presentation is related to demonstrations that we are presenting at our joint booth with Philips and Fraunhofer at the SET2022 show floor.



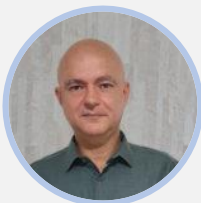
Alberto Botelho - Broadcasting Project Engineer - LM Telecom

Is a PhD student in electrical engineering (Mackenzie). Has degree in Electrical Engineering (UNIP), specialized in Engineering of Digital Television Systems (Inatel) and Engineering of Telecommunications Networks (Inatel), MBA in Project Management (FGV) and Master of Science in electrical engineering (Mackenzie). Worked on Rede TV! and currently works at LM Telecom as a broadcast project engineer, since 2002.



Gabriel Thomazini - Audio Consultant - Fraunhofer IIS

Gabriel Thomazini started his career as a recording engineer and went to different studios, working with artists from different genres. In the early 2000s he began designing audio systems and creating immersive content for planetariums. At the same time, he worked as an audio engineer in TV stations and since then he became increasingly involved in AV applications. He carried out projects in IP-based OB vans, studios, and control rooms, as well as the development of remote workflows and mixing for 3D audio formats. He has collaborated on extended reality initiatives, developing audio solutions for VR and AR applications. After more than 20 years in the broadcast area he joined the Fraunhofer IIS Institute in 2021, where he acts as an audio consultant for the development of the MPEG-H audio ecosystem in Brazil.



José Filipe Ferraz Valente - Video Standardization Engineer - Philips

Jose Filipe Ferraz Valente is Bachelor in Electronic Engineering. He already works in the Broadcast area for more than thirty years in different roles. Currently he is working as video standardization engineer for Philips and as such involved in the new TV2.5 and TV3.0 standards in Brazil by the SBTVD forum. Previously, at Globo | Globosat he was active in the implementation and projects of TV systems and participated in the elaboration and execution of major events such as the Olympics, World Cups and musical shows, such as Rock in Rio. During this period, Filipe also acted as coordinator in the area of live events production. Furthermore, he worked at Seal B&C-Convergint, a broadcast systems integrator company, as a Systems Engineer and at Oi, a Telecom company, as a Consultant Specialist.

**Celine Guede - Architect in Research & Innovation - InterDigital**

Celine Guede graduated in engineering in 1998 from Polytech Orleans School, France. The following year, she joined Technicolor as an R&D engineer, where she first specialized in real-time software development, and in 2013 she joined the Advanced Television Systems activities, where she dedicated her expertise to contributions to the ATSC 3.0 television transmission standards.

In late 2016, Celine joined the Point Cloud Compression project and made contributions to the emerging MPEG Point Cloud Compression standard called V-PCC (Video-Based Point Cloud Compression).

In 2019, she moved to InterDigital as an architect, where she contributed to finalizing the MPEG V-PCC standard. Since 2022, her work is dedicated to volumetric video transmission, and she is heavily involved in the dissemination of V-PCC and MIV (MPEG Immersive Video) developing a real-time codec for these technologies and preparing standard

2:00pm | Room 1 | Thursday – August 25

RADIO

THE MOST FRUSTRATING TALK AT SET EXPO 2022

“Better to enjoy the contents of rooms 2 and 3, which will also take place at the same time, so as not to waste your precious time. There’s nothing interesting about technology here.” Robson Ferri, Creativity with RF, promises to have nothing compelling in his talk. In an hour and a half of the time allotted to the presentation, right after lunch, he was unable to sensitize guests... so he will do a “stand up alone”. Good luck to those who venture to enter room 1 at 2 pm.

Presenter: Robson Ferri - Director | RF Conteúdo Play



Robson Ferri - Director | RF Conteúdo Play

24 years of experience in the communication field.

Passage through the radio stations Metropolitana FM 98.5 São Paulo, Rede Transamerica, Rádio Mix FM 106.3 São Paulo.

Standard voice of more than 25 radio stations in Brazil, plus 2 abroad.

He is currently one of the voices responsible for creating institutional and promotional pieces for TV Globo Rio de Janeiro and for the Globo de Rádio system.

Founder and executive director of RF, a digital content agency serving several segments that seek strategic content to strengthen their brand in communication on digital platforms.

Heading a team of more than 40 employees, with a dedicated structure located in São Paulo – SP, offers a wide range of solutions in content creation, production and distribution.

ACADÊMICO CALL FOR PAPERS – SESSION 1

This panel will present a set of scientific works that were submitted to the Call for Papers promoted annually by SET.

The selected works will be published in the SET International Journal of Broadcast Engineering (SET IJBE) an international scientific journal whose objective is the dissemination of knowledge about communications engineering, especially in the areas of broadcast and new media.

Moderator: Rangel Arthur - Professor at School of Technology in University of Campinas, Brazil

RADIO ADVERTISING AND AUDIENCE METRICS

Ticiane Pfeiffer Bronze - Superintendent - AERP - Paraná Radio and Television Association

Brazilian radio stations are highly regulated, and due to specific rules and processes, bureaucracy has become a barrier to participation in national or state advertising campaigns, especially for stations outside large cities. Added to this is the competition with major internet players, with little or no regulation, in search of the same resources available for advertising campaigns. In this ecosystem, the requirement of audience metrics and reports of proof of placements is a reality that needs to be treated with precision and seriousness, in order to guarantee the good use of public funds and the good performance of the campaigns. The way that radio needs to go is to speed up the generation of such reports, matching large technology companies, which will place it in a prominent position, considering its capillarity and close proximity to the public. That said, this article intends to demonstrate, through a temporal report, how through the identification of an opportunity in the broadcasting sector, it was possible, through the use of streaming combined with a programmatic media solution, to develop a system that gives autonomy to the advertiser to place a request for direct commercial insertion into the broadcaster's commercial operations system. The placement takes place automatically, and then integrates audience research data, performs the accounting and automatic delivery of proof and performance report. A solution that makes the medium more efficient and makes it possible to broadcast national and state campaigns on all broadcasters in the state or country. With this unprecedented model, Nextdial and AERP, the Association of Radio and Television Broadcasters of the State of Paraná, foster business and drive the economy, reinforcing the broadcasters main attributes: creativity and credibility. Finally, after validating the model and presenting it to the Federal Government's Secom Media Center, the result was the creation of a new category

in MidiaCad, a system that integrates all media providers for the Federal Government, a category that was called the AERP Nextdial Radio Network.

COMPARISON OF THE PHYSICAL-LAYER PERFORMANCE BETWEEN ATSC 3.0 AND 5G BROADCAST

Sung-Ik Park - Principal Researcher & Project Leader - ETRI (Electronics and Telecommunications Research Institute)

This paper compares the physical-layer performances of ATSC 3.0 and 5G-Broadcast in providing mobile broadcasting services. The differences of physical-layer between ATSC 3.0 and 5G-Broadcast are discussed in terms of transmission efficiency, overheads, and BICM performance over mobile environments. The computer simulations show that ATSC 3.0 can provide more robust and enhanced physical-layer performance than 5G broadcast over mobile environments.

ADVANCES IN VIDEO COMPRESSION: A GLIMPSE OF THE LONG-AWAITED DISRUPTION?

Dr. Mickaël Raulet - CTO na ATEME

The consumption of video content on the internet is increasing at a constant pace, along with an increase of video quality. As an answer to the ever-growing demand for high quality video, compression technology improves steadily. About every decade, a new major video compression standard is issued, providing a decrease of bitrate by a factor two. Interestingly, the technology does not change radically between codec generations. Instead, the same block-based hybrid video coding scheme principles and ideas are re-used and pushed further. All along the video compression history, there were several attempts to depart from this model, but none achieved to be competitive. Following the latest codec generation, VVC, the research community has started focusing on deep learning-based strategies. Could it be the new contender to the classical hybrid approach? This presentation analyzes the benefits and limitations of deep learning-based video compression methods, and investigates practical aspects such as rate control, delay, memory consumption and power consumption. Overlapping patch-based end-to-end video compression strategy is proposed to overcome memory consumption limitations.

CONTRIBUTIONS TO TV 3.0 USING 5G-MAG REFERENCE TOOLS

Wesley Henrique Silva de Souza - Master's student and electrical engineer - Mackenzie Presbyterian University

The evolution of the evolved Multimedia Broadcast Multicast Service (eMBMS) to the Further evolved Multimedia Broadcast Multicast Service (FeMBMS) in Release 14 of 3GPP enabled broadcast transmission in a format 100% dedicated to user devices. As a result, the 5G standard for cellular networks expanded and began to be quoted in the broadcasting sector as 5G Broadcast. This standard is one of the quoted ones to integrate the TV 3.0 architecture in Brazil, being responsible for the physical layer. To be possible, this technology must meet some requirements, such as negative noise carrier ratio, MIMO antennas and channel bonding. In order to complement the tests carried out by the SBTVD Forum, this paper aims to evaluate and discuss the SNR and minimum signal level tests using an Open-Source

receiver called 5G-MAG that is managed by the group of the same name. The tests were performed using a Universal Software Peripheral Radio (USRP) Software Defined Radio (SDR) playing an I/Q file with 5G Transmission data with bandwidths of 3, 5, 6, 7 and 8MHz to transmit the signal via GNU Radio software and another USRP SDR as a receiver, interfaced with 5G-MAG.

SPECTRUM AVAILABILITY FOR THE DEPLOYMENT OF TV 3.0

Thiago Aguiar Soares - Head of Innovation & Regulation of Broadcasting Services - Ministry of Communications (MCom)

In this paper, we study the current and future spectrum availability of the VHF and UHF bands in Brazil for the deployment Next-Generation Digital Terrestrial Television Systems, which are being studied under the “TV 3.0 Project” initiative, coordinated by The Brazilian Digital Terrestrial Television System Forum (SBTVD Forum). Coverage simulations of all expected operating stations in Brazil were computed in different scenarios to estimate the spectrum availability over the Brazilian territory. Results indicate that hybrid approaches should be implemented to smoothly introduce new digital television systems.

CONVOLUTIONAL NEURAL NETWORK IMPLEMENTATION IN FPGA FOR IMAGE RECOGNITION

Fadi Jerji - Ph.D. Candidate and postgraduate Researcher - Mackenzie Presbyterian University, São Paulo, Brazil

Neural networks (NN) are being researched and improved to a degree that machines are able to closely resemble the capacity to execute complex tasks that only an intelligent animal is capable of, vision used in the interpretation and recognition of the environment is one of such tasks that is being researched so future technologies can simulate vision in autonomous vehicles to further improve self-driving capabilities, increasing driver convenience, help avoid accidents and even autonomous delivery, convolutional neural networks, inspired by the mechanics of animal vision, are utilized for the complex task of image recognition. Field Programmable Gate-Arrays (FPGA) recent developments have given it more parallel processing and processing speed making it a prime candidate for the implementation of NNs efficiently, with more processing capabilities and low response times compared with the alternatives. The objective of this work is to evaluate the performance viability of FPGA implementation of an image classification NN with acceptable accuracy and low response time.



Rangel Arthur - Professor at School of Technology in University of Campinas, Brazil

Rangel Arthur is a Professor at School of Technology in University of Campinas, Brazil. He received the Electrical Engineering degree from the State University of São Paulo, Brazil in 1999, MSc and PhD degrees in Electrical Engineering in 2002 and 2007, respectively, from University of Campinas, Brazil. His current research interest includes telecommunication systems, image processing and artificial intelligence. From 2011 to 2014, he was Coordinator and Associate Coordinator of the Technology Courses in Telecommunications Systems and Telecommunications Engineering at FT, which was created during his management. From 2015 to 2016 he was Associate Director of the Faculty of Technology (FT) at Unicamp. Since 2016 he has been an Advisor to the Innovation Agency (Inova) at Unicamp. He is a member of the Association of Innovation Environments of Limeira-SP, of the Business Incubator of Unicamp and of the Municipal Council of Science, Technology and Innovation of the Municipal Government of Campinas-SP.



Ticiane Pfeiffer Bronze - Superintendent - AERP - Paraná Radio and Television Association

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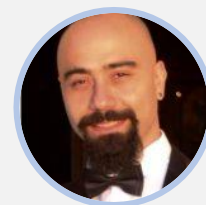
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PUBLICIDADE DO MEIO RÁDIO E MÉTRICAS DE AUDIÊNCIA

BRONZE, Ticiane Pfeiffer, AERP
FERNANDES, Thiago, AERP

Abstract: As emissoras de rádio brasileiras são altamente regulamentadas, e por conta de regras e processos específicos, a burocracia se tornou uma barreira para que, em especial para as emissoras de fora das grandes cidades, participassem de campanhas publicitárias nacionais ou estaduais. Soma-se a isso a competição com grandes players da internet, com pouca ou nenhuma regulação, em busca dos mesmos recursos disponíveis para as campanhas publicitárias. Nesse ecossistema, a exigência de métricas de audiência e relatórios de comprovação de veiculações é uma realidade que precisa ser tratada com precisão e seriedade, de forma a garantir o bom uso das verbas públicas e o bom desempenho das campanhas. O caminho que o rádio necessita percorrer é o da celeridade na geração de tais relatórios, se equiparando às grandes empresas de tecnologia, o que o colocará em posição de destaque, considerando sua capilaridade e grande proximidade com o público. Isto posto, este artigo pretende demonstrar através de um relato temporal, como através da identificação de uma oportunidade no setor de radiodifusão, foi possível através da utilização do streaming unido a uma solução de mídia programática, desenvolver um sistema que dá autonomia para o anunciante colocar um pedido de inserção comercial direto no sistema de operações comerciais da emissora. A veiculação ocorre de forma automática, e em seguida integra os dados de pesquisa de audiência, faz a contabilização e a entrega automática da comprovação e do relatório de performance. Uma solução que torna o meio mais eficiente e viabiliza a veiculação de campanhas nacionais e estaduais em todas as emissoras do estado ou do país. Com esse modelo inédito, Nextdial e AERP, a Associação das Emissoras de Rádio e Televisão do Estado do Paraná, fomentam negócios e movimentam a economia, reforçando os principais atributos das emissoras: criatividade e credibilidade. Finalmente, após validação do modelo e apresentação do mesmo ao Núcleo de Mídia da Secom, do governo federal, alcançamos como resultado a criação de uma nova categoria no MidiaCad, sistema que integra todos os fornecedores de mídia para o Governo Federal, categoria esta que foi nominada de Rede de rádios Aerp Nextdial.

Palavras-Chave: Rádio, métricas, audiência, streaming

Introdução

No Brasil, segundo dados da ABERT, Associação Brasileira das Emissoras de Rádio e Televisão (<https://www.abert.org.br/web/>), há cerca de 5.000 emissoras de rádio comerciais com outorga do Ministério das Comunicações. Destas, 375 estão no estado do Paraná, que juntas, levam diariamente informação, entretenimento e prestação de serviços gratuitos para os mais de 11 milhões de habitantes do estado (<https://cidades.ibge.gov.br/brasil/pr/panorama>).

Com a evolução da Internet e o avanço tecnológico dos Smartphones a transmissão via Streaming do conteúdo das rádios vem atingindo um público cada vez maior. Durante a pandemia, de acordo com dados analisados de mais de 100 emissoras de diversos portes e cidades do território nacional, a audiência aumentou expressivamente (<https://www.nextdial.com.br/solicitacao-pt-br-nextondial-20-q1/>). Por outro lado, muitos investimentos publicitários foram cancelados. Especialmente os de comércios e serviços locais. Muitos anunciantes com campanhas que abrangiam todo território nacional redirecionaram suas ações para mídias digitais. Uma realidade que se apresentou ao setor, contrastando menores verbas direcionadas para o rádio, e cada vez maiores e mais detalhadas exigências por parte dos anunciantes e agências, apontando para uma urgência por soluções rápidas, efetivas e de baixo custo.

Com a audiência da transmissão via Streaming crescendo e campanhas governamentais precisando alcançar toda população, a solução que se apresentou para os anunciantes governamentais federais, foi o investimento nas mídias online, nos já mencionados grandes players de tecnologia, o que resultou em dificuldades em garantir a idoneidade dos locais onde as campanhas eram veiculadas, portanto, colocando em risco a credibilidade de cada campanha.

Por conta de ser um setor altamente regulamentado desde sua criação, a radiodifusão, é sabido, atua com base em altos custos de operação, para atender a todos os processos que garantem a manutenção dos seus serviços de comunicação, como por exemplo, a obrigatoriedade da gravação e guarda por 5 anos do que é transmitido na programação. Opera com utilização de sistemas distintos, com destaque para os sistemas de Operação Comercial, Exibição e Censura. De maneira distinta desta, acontece a programação da emissora via streaming, onde identifica-se uma oportunidade. A utilização do streaming das emissoras de rádio, para veiculação de mídias de forma automática, utilizando um espaço que não interfere na grade que segue no dial, gerando uma novo espaço de monetização para as emissoras. Esse novo formato, além de garantir celeridade, acompanhamento das métricas de performance dos anúncios, e apresentar a devida geração dos relatórios das veiculações, vai além, e oferece a credibilidade e a criatividade do veículo rádio aos anunciantes que buscam por maior segurança em suas campanhas.

Metodologia

Com esse objetivo Nextdial e AERP, a Associação das Emissoras de Rádio e Televisão do Estado do Paraná, celebraram um acordo para desenvolver um modelo de trabalho para habilitar todas emissoras do estado do Paraná a, também, veicularem campanhas publicitárias governamentais destinadas a sites e aplicativos em formato de áudio.

O modelo desenvolvido segue as diretrizes do DIGITAL AUDIO BUYER'S GUIDE v2.0² (<https://www.iab.com/news/digitalaudiobuyersguide/>) e é fundamentado em dados de audiência, baixa burocracia na distribuição de pedidos de inserção comercial e fiscalização automatizada da veiculação.

A esse modelo foi dado o nome de Rede de Rádios AERP Nextdial.

O formato se apresenta como áudio, com até 30 segundos de duração, executado logo após o ouvinte iniciar a escuta e antes do conteúdo ao vivo da rádio (pre-roll³), em sites, aplicativos, TVs ou caixas de som inteligentes.

Todas as emissoras do estado são apresentadas juntas, num só lugar, onde o anunciante obtém um único pedido de inserção comercial seguindo um padrão de mercado, o formato Digital Video Ad Serving Template (<https://iabbrasil.com.br/publicacoes/ebook-portfolio-atualizado-de-formatos-padrao-iab/>), com o acompanhamento da performance das campanha pelo serviço de rastreamento de anúncios favorito do anunciante. Tudo via software e sem ação humana. Ou seja, negociação, veiculação e fiscalização acontecendo de forma automatizada via software, em tempo real.

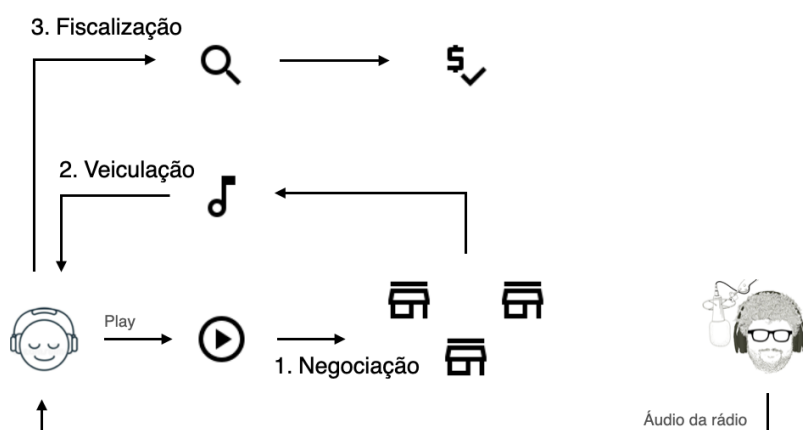


Figura 1. Modelo desenvolvimento

Os benefícios do modelo são claros. Para as emissoras, tanto da capital, quanto do interior, de grande ou pequeno porte, todas têm acesso a campanhas publicitárias nacionais e estaduais. Um diferencial deste modelo: possibilitar às emissoras competirem em pé de igualdade com grandes players de Internet. Para os anunciantes, acesso a toda rede com um único pedido de inserção comercial, com proteção de marca (https://www.iab.com/wp-content/uploads/2020/12/IAB_Brand_Safety_and_Suitability_Guide_2020-12.pdf), já que as campanhas são veiculadas nos sites e aplicativos das emissoras de rádio e agregadores com cada veiculação sendo verificada e contabilizada por serviços de rastreamento de anúncios de terceiros.

Conclusão

O último passo era homologar o modelo. Então, foi apresentado ao Núcleo de Mídia da Secom, responsável pela comunicação do Governo Federal, coordenando um sistema que interliga as assessorias dos ministérios, das empresas públicas e das demais entidades do Poder Executivo Federal. O modelo foi avaliado com rigor por um comitê especializado do Núcleo de Mídia da Secom que, ao final, concordou que o mesmo atende aos requisitos de a) controle de veiculação b) controle de exclusão de um ou mais site e ou aplicativo e c) contabilização por serviços de rastreamento de anúncios de terceiros.

Com isso, criou-se uma categoria inédita e específica para a Rede de Rádios AERP Nextdial no Midiacad, que é o sistema de cadastro de veículos de mídia e inovadores digitais da Secom que visa fornecer ao SICOM informações formais de dados cadastrais, comerciais e negociais dos veículos dos diversos meios de comunicação para utilização dos planos de mídia pelas agências contratadas pelos órgãos e entidades do SICOM.

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Comparison of the Physical-layer Performance between ATSC 3.0 and 5G Broadcast

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Abstract—This paper compares the physical-layer performances of ATSC 3.0 and 5G broadcast in the scenario to provide mobile broadcasting services. The differences of physical-layer between ATSC 3.0 and 5G broadcast are discussed in terms of transmission efficiency, overheads, and BICM performance over mobile environments. Through the computer simulations, it is shown that ATSC 3.0 can provide more robust and enhanced physical-layer performance than 5G broadcast over mobile environments.

Index Terms—ATSC 3.0, 5G broadcast, mobile broadcasting, physical-layer.

I. INTRODUCTION

In 2016, the Advanced Television Systems Committee (ATSC) approved the physical layer standard of ATSC 3.0 systems, which support efficient and flexible delivery of broadcast services for both fixed and mobile receivers [1]. As a result, high quality broadcasting services such as three-dimensional and ultra-high definition (UHD) contents are possible over ATSC 3.0 thanks to its superior spectral efficiency, channel robustness, and flexible transmission. Since ATSC 1.0 was first standardized, many innovative physical-layer technologies have been evolved and applied to ATSC systems. For example, low-density parity-check (LDPC) codes and non-uniform constellation (NUC) are regarded as two representatives of the superiority of ATSC 3.0 physical layer.

On the other hand, in the 3rd generation partnership project (3GPP), a work item for LTE-based 5G terrestrial broadcast (referred to as 5G broadcast in this paper) is carried out during 3GPP release (Rel-) 16 and finished with some enhancements in 2019 [2], [3]. The major improvements of the 5G broadcast over the underlying technology further evolved multimedia broadcast multicast service (FeMBMS) is to support a large geographical area up to 100km inter-site distance (ISD) and high mobility up to 250km/h. Due to the above enhancements, 5G broadcast not only can meet the 5G terrestrial broadcast requirements but also becomes a competitive technology comparable to ATSC 3.0.

As the proportion of mobile terminals is increasing in terms of the receiving terminal for broadcasting services, the capability to provide services for mobile user equipment (UE) is becoming more and more important. For this reason, 5G broadcast has been drawing attention as a future terrestrial broadcasting solution. Recently, a Mark One smartphone has

TABLE I
PHYSICAL LAYER OVERHEAD OF ATSC 3.0 AND 5G BROADCAST

	ATSC 3.0	5G broadcast
Guard band overhead (%)	2.8	10.0
Cyclic prefix overhead (%)	20.0	20.0
Pilot pattern overhead (%)	16.7	16.7
Total overhead (%)	35.2	40.0

been released that enables ATSC 3.0 service in mobile terminals to facilitate the reception of ATSC 3.0 in a mobile environment. According to the trend of mobile broadcasting services, this paper comprehensively compares the capability of both technologies in terms of providing mobile broadcasting services.

II. PHYSICAL LAYER OVERVIEW

To provide stable terrestrial broadcasting services over mobile environments, superior and robust physical-layer performance is essential, which can be expressed as transmission efficiency as the following formula:

Efficiency = $SE(SNR) \times (1 - OH_{SP}) \times (1 - OH_{GB}) \times (1 - OH_{CP})$ (1)
where OH_{SP} is the scattered pilot overhead of channel estimation, OH_{GB} is the overhead of guard band, and OH_{CP} is the overhead of the CP of an orthogonal frequency-division multiplexing (OFDM) symbol. In addition, $SE(SNR)$ represents bit-interleaved coded modulation (BICM) spectral efficiency, which means the number of data bits per channel use that can be received successfully, depending on the received signal-to-noise power ratio (SNR). The main overheads in the physical layer of both systems are compared in Table I. For fair comparison, CP length and pilot pattern of ATSC 3.0 are chosen as closely as possible to those of 5G broadcast, although other parameters are permitted in ATSC

TABLE II
BICM COMPONENTS OF ATSC 3.0 AND 5G BROADCAST

	Channel codes	Constellation	T/F interleaver
ATSC 3.0	LDPC codes	NUC/QAM	Used
5G Broadcast	Turbo codes/ Convolutional codes	QAM	Not

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TABLE III
EVALUATION ASSUMPTIONS

	ATSC 3.0	5G broadcast
FFT size	8192	12288
Guard interval	222.22us	200us
OFDM duration	888.83us	800us
Subcarrier spacing	1.125kHz	1.25kHz
Center frequency	500Hz	
Bandwidth	8MHz	
Channel Model	India-Urban [5]	
UE Mobility	60km/h	
Channel estimation	LS estimation + Linear interpolation	

3.0 standard. As shown in Table I, the total overhead of 5G broadcast is slightly larger than that of ATSC 3.0.

The BICM spectral efficiency and robustness is mainly determined by the component technologies such as channel codes, signal constellation, and time/frequency (T/F) interleavers [4]. Since 5G broadcast is based on the LTE physical layer, which is first standardized in 3GPP Rel-8, there are limitations in the viewpoint of physical-layer performance. Table II summarizes them between ATSC 3.0 and 5G broadcast.

III. PERFORMANCE RESULTS

In this section, physical-layer performances of ATSC 3.0 and 5G broadcast are evaluated by computer simulations in terms of block error rate (BLER). Note that the Log-MAP algorithm with 8 iterations is used for turbo codes and sum-product algorithm with 50 iterations is used for LDPC codes. The BLER performances of the data channel of two systems are evaluated over additive white Gaussian noise (AWGN) channel and India-Urban channel [5] in Fig. 1 and Fig. 2, respectively, whose evaluation assumptions are given in Table III.

For ease of comparison, data rate of 5Mbps, 10Mbps, and 15Mbps are chosen for performance comparison. Thanks to the superiority of the LDPC codes in ATSC 3.0 compared to the turbo codes in 5G broadcast, the decoding performance of ATSC 3.0 is better than that of 5G broadcast over AWGN channel. In addition, in the case of 15Mbps, ATSC 3.0 provides strictly better performance than 5G broadcast due to the shaping gain of NUC under high-order modulations (HOMs).

The performance gain of ATSC 3.0 under mobile environment is evaluated over India-Urban channel in Fig. 2. As shown in Fig. 2, the performance gain is larger than that over AWGN channel due to the time interleaver. For this reason, the performance gain increase as the target BLER decreases because the BLER curves of ATSC 3.0 is steeper than that of 5G broadcast. As a result, SNR gain for achieving $\text{BLER} = 10^{-4}$ reaches up to about 8.5dB, 9.0dB, and 12.5dB for 5Mbps, 10Mbps, and 15Mbps, respectively.

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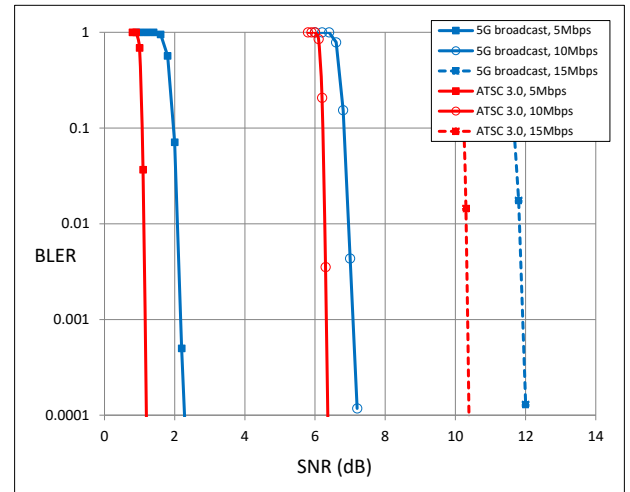


Fig. 1. BLER performance over AWGN channel

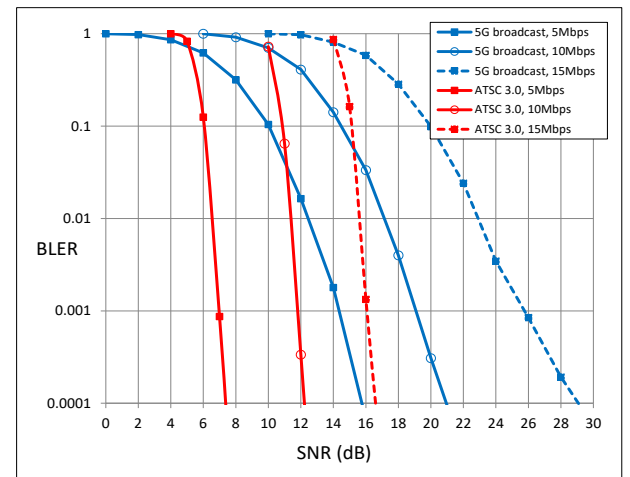


Fig. 2. BLER performance over India-Urban channel

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Advances in video compression: a glimpse of the long-awaited disruption

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Abstract— The consumption of video content on the internet is increasing at a constant pace, along with an increase of video quality. As an answer to the ever-growing demand for high quality video, compression technology improves steadily. About every decade, a new major video compression standard is issued, providing a decrease of bitrate by a factor two. Interestingly, the technology does not change radically between codecs generations. Instead, the same block-based hybrid video coding scheme principles and ideas are re-used and pushed further. All along the video compression history, there were several attempts to depart from this model, but none achieved to be competitive. Following the latest codec generation, VVC, the research community has started focusing on deep learning-based strategies. Could it be the new contender to the classical hybrid approach? This paper analyzes the benefits and limitations of deep learning-based video compression methods, and investigates practical aspects such as rate control, delay, memory consumption and power consumption. Overlapping patch-based end-to-end video compression strategy is proposed to overcome memory consumption limitations.

Index Terms—Video Compression, Video codec, MPEG-2, H.264, AVC, HEVC, VVC, artificial intelligence, machine learning, deep learning, end-to-end video encoding.

I. INTRODUCTION

THE consumption of video content on the internet is increasing at a constant pace, along with an increase of video quality. Cisco [1] estimates that by 2023, two-thirds of the installed flat-panel TV sets will be UHD, up from 33 percent in 2018. The bitrate for 4K video is more than double the HD video bitrate, and about nine times more than SD bitrate. As an answer to the ever-growing demand for high quality video, compression technology improves steadily. Video compression is a highly competitive and successful field of research and industrial applications. Billions of people are impacted, from TV viewers and streaming addicts to professionals, from gamers to families. Video compression is used for contribution, broadcasting, streaming, cinema, gaming, video-surveillance, social networks, videoconferencing, military, you name it.

The video compression field stems from the early 80's. Since then, it has grown continuous improvements, and strong attention from the business side - the video encoder market size is planned to exceed USD 2.2 Billion by 2025 [2]. About every decade, a new major video compression standard allows halving the required bitrate to achieve a given quality. The latest milestone is the Versatile Video Coding (VVC)

standard, issued in 2020. From generation to generation, until VVC, coding efficiency has been improved by relying on the same principle, that is, the block-based hybrid video coding scheme [4]. For more than 30 years, the video compression field has known no revolution or disruption. Instead, the same principles and ideas have been re-used and pushed further. At each generation, existing tools are enhanced, new local coding tools are added, but the overall structure remains the same. In other words, each generation is a complexified version of the previous one. The algorithmic complexity increase is directly reflected by the implementation complexity. For instance, the VVC verification software model (VTM) is about 10 times slower than its predecessor, the High Efficiency Video Coding (HEVC) verification model (HM). Many attempts have been made to depart from the block-based hybrid scheme, none of them have been successful so far.

As of today, the tremendous progression of video compression technology is not compensating for the increase in the demand for always more and higher quality video services. Therefore, the research effort is still ongoing, seeking improvements over VVC, as it was over each previous codec generation. Indeed, The Joint Video Expert Team (JVET), a working group managed by both ISO/IEC MPEG and ITU-T VCEG international standardization bodies, responsible for the development and support of VVC, is currently conducting explorations beyond VVC. There is a new situation arising though: this exploration is following two distinct tracks. One is “classical”, consisting in adding or enhancing coding tools to VVC, while the other is dedicated to the exploration of the usage of machine learning (ML). The field of ML, and more particularly deep learning (DL), has made dramatic advances during the last decade, especially in the computer vision domain. There are several ways of applying ML to video compression. One can consider creating elementary coding tools, replacing, or complementing the existing tools in the hybrid block-based scheme. At the other extremity of the spectrum, one can completely replace the hybrid block-based scheme by a deep learning model. The latter solution is highly disruptive with respect to the current video compression history. Hence the question: to what extent is ML becoming essential to video compression?

The goal of this paper is to analyze the benefits and limitations of deep learning-based video compression methods, and to investigate practical aspects such as rate control, delay, memory consumption and power

consumption. In a first part, the evolution of video compression is recounted, with a few words on previous attempts to depart from the hybrid block-based model. In a second part, the deep-learning strategies are described, with a focus on tool-based, end-to-end, and super-resolution-based strategies. In a third part, the practical limitations for industrial applications are analyzed. Finally, a technology is proposed, namely overlapping patch-based end-to-end video compression, to overcome memory consumption limitations. Experimental results are provided and discussed.

II. A SHORT HISTORY OF VIDEO COMPRESSION

A. CODECS and applications

The idea of temporal prediction for video compression can be tracked back to 1929, with a patent advocating the coding of successive image differences [3], but the modern history of video compression really starts in the 80's. Two organizations are essentially responsible for video coder/decoder (codec) standardization [5][6]: the International Telecommunications Union – Telecommunication Standardization Sector (ITU-T) Video Coding Expert Group (VCEG), a United Nations Organization (formerly CCITT) [7], and the International Organization for Standardization and International Electrotechnical Commission (ISO/IEC) Moving Picture Expert Group (MPEG). ISO is an independent, non-governmental international organization with a membership of 167 national standards bodies [8]. Aside from standardization, many proprietary or independent codecs exists. Nonetheless, the most successful and well-known line of codecs stems from standardization and constitutes the focus of this paper.

The first standardized video codec, ITU-T H.120 [63], has been issued in 1984, then updated in 1988. It already includes a form of intra prediction (Digital Pulse Coded Modulation, DPCM), scalar quantization, entropy coding in the form of variable length coding (VLC) and motion compensation.

ITU-T H.261 [64] was first issued in 1988. It is dedicated to video telephony and introduces the most important block-based motion compensation and Discrete Cosine Transform (DCT). It is the first practically successful video codec. It was later replaced by the dramatically improved ITU-T H.263 [65] in 1995.

Meanwhile ISO/IEC developed MPEG-1 [66], issued in 1993. It was designed to compress VHS-quality raw video, thus enabling first digital TV applications (videos CD, Cable, satellite). One may note that the best-known part of MPEG-1 is the MP3 audio format it introduced. MPEG-1 has been followed by the non-obviously numbered MPEG-4 part 2 [67], in 1998, also called MPEG-4 visual because of its object-oriented approach.

Interestingly, in the 90's, two lines of standards were coexisting. The ITU-T H.26X line was designed for video telephony, while the ISO/IEC MPEG was meant for digital TV broadcasting. However, both were sharing many technological aspects. There is even a certain degree of compatibility between MPEG-4 visual and H.263. Quite logically, ISO/IEC MPEG and ITU-T VCEG have been joining their effort in the development and publication of

common video compression standard, thus starting a particularly successful line of video codecs.

MPEG-2/H.262 [68] has been a tremendous success in the 90's, and the enabler of widespread digital TV. MPEG-2 has been present on cable TV, satellite TV, DVD, and is still running nowadays. In the early 2000's, AVC/H.264 [69] has been a key component of the HD TV development, on traditional networks as well as on internet and mobile networks. AVC/H.264 is also used in HD Blu-Ray discs. Ten years later, in the 2010's, HEVC (H.265) [70] has been the enabler of 4k/UHD, HDR and WCG. Finally, VVC (H.266) [71] has been issued in 2020. Although it is a young codec, not yet widely deployed, it is perceived as an enabler for 8k [9] and as a strong support for the ever-growing demand for high quality video over the internet.

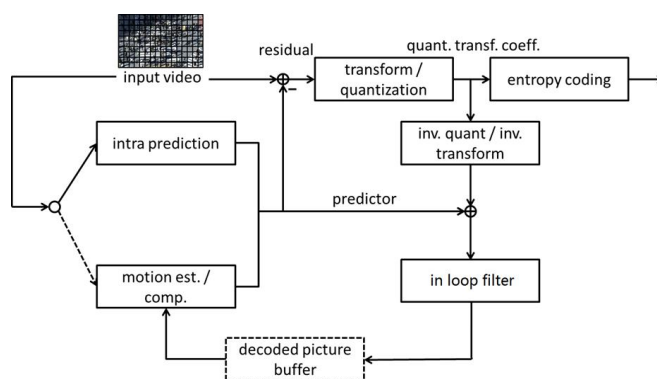


Fig. 1. The block-based hybrid video coding scheme.

B. The block-based hybrid video coding scheme

The block-based hybrid video coding model is depicted on Fig. 1. It constitutes the basis of all current video compression standards. The main elements are

- Intra prediction, for coding intra frames, i.e., frames without temporal dependency, or intra blocks inside inter frames, for managing local areas that cannot be temporally predicted, such as uncovering areas.
- Inter prediction combines the capabilities of keeping a buffer of previously encoded frames and addressing these previous frames with motion compensation for efficient prediction.
- Transform and quantization are applied on residual blocks of pixels output by the prediction step. The transform tends to compact the information on a few coefficients, while the quantization adjusts the trade-off between quality and bitrate. Quantization is a lossy process.
- Entropy coding is a fundamental information theory concept. Its goal is to determine the statistically shortest representation of the data. It is a lossless process.
- In-loop filtering is applied on the frames which are stored for future temporal prediction, to improve their quality, hence the quality of the upcoming predictions. The most advanced codec, VVC, implements four successive loop filters (LF), luma mapping with chroma scaling

(LMCS), deblocking filter, sample adaptive offset (SAO), and adaptive loop filter (ALF).

Interestingly, the technology does not change radically between codec generations. Instead, the same principles and ideas are re-used and pushed further. Of course, there are new coding tools, but the overall structure remains the same.

Compared to MPEG-2, AVC/H.264 brought notably reduced complexity integer discrete cosine transform, multiple reference inter-frame prediction, in-loop deblocking filter, variable block sizes and flexible handling of interlaced video, all contributing to its excellent coding efficiency. The profiles definition allows adapting to multiple use-cases, making it suitable for any application. At the same period, the video compression research community has also been focusing on the concept of 3D wavelet filtering [10]. The wavelet transform has been used successfully in the JPEG2000 image compression standard [11]. The wavelet transform is a signal decomposition and analysis tool. Applied on an image, it replaces usual transforms such as DCT for energy compaction and provides a resolution scalable representation. That is, a wavelet compressed image can be reconstructed progressively, from lowest to highest frequencies, without coding efficiency loss. When applied to video, the same principle is extended on a 3D pixel volume [12]. The MC-EZBC codec is a good example of state-of-the-art 3D wavelet-based video coding [13]. This kind of technology was promising, but never reached the AVC/H.264 performance [14].

Jumping to the next generation, HEVC brought many improvements over AVC/H.264, including a much more flexible partitioning scheme, with up to 64x64 pixels partition sizes instead of 16x16, multiple transforms, improved motion compensation filtering and a new loop filtering restoration tool called Sample Adaptive Offset (SAO).

In parallel, a strong research focus was set on sparse modeling for image and video representation and analysis. As explained in [15], sparse coding consists in representing data with linear combinations of a few dictionary elements. Generally, the dictionary must be learned to be best adapted to the data. Considering images, the underlying idea is that only a tiny subset of the huge set of all possible pixel values combinations actually represents viewable images. Therefore, images can be represented by a smaller set of variables, as few as possible if compact representation is desired. Although the idea seems quite simple, building a dictionary is a non-trivial task. In [16], a method is proposed to learn basic texture elements representations and is used for intra coding. Video compression is tackled in [17], where dictionary learning is performed in the DCT domain of a block motion compensated structure. These methods can outperform the state-of-the-art codecs, well, if one considers AVC/H.264 as such. None of these methods reached the general performance and flexibility of HEVC. One may note though that sparse coding shines in specialized applications, such as very low bit rate human face coding [15]. Also the dictionary learning strategy anticipates the upcoming machine learning.

Finally, VVC outperforms HEVC thanks to further enhanced coding tools, such as an even more flexible partitioning scheme or a new in-loop restoration filter.

Moreover, VVC includes from start several features that makes it “versatile”, including 360° video coding, screen content coding, gradual decoder refresh for low delay applications, and scalability, based on reference picture resampling (RPR) the ability to perform temporal prediction on reference images of different resolutions.

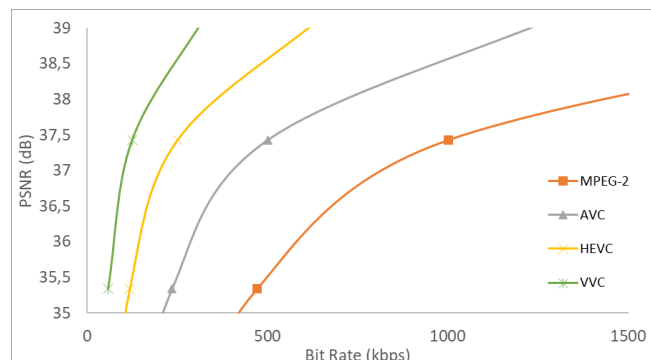


Fig. 2. Video codecs rate distortion performance progression example.

C. Video CODECs performance, limits, and discussion

Each codec generation allows decreasing the bitrate approximately by a factor two (Fig. 2). This comes however at the cost of increased complexity. For instance, the reference VVC encoder is about 10 times more complex than the reference HEVC encoder. Let us illustrate this process with a simple example: Intra prediction mode, illustrated on Fig. 3, which consists in encoding a block of a frame independently from previous frames. In MPEG-2, intra block coding is performed without prediction from neighboring blocks. In AVC/H.264, intra blocks are predicted from neighboring blocks, with 9 possible modes. In HEVC, the prediction principle is reconducted, with 35 possible modes, while VVC is pushing further to 67 possible prediction modes. Having more prediction modes allows better predictions, hence better compression (even though mode signaling cost increases), at the cost of more complexity.

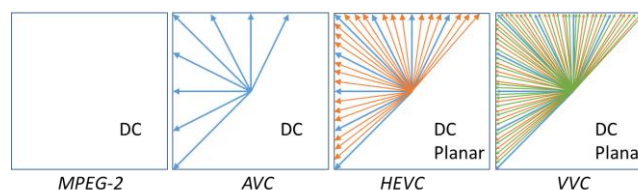


Fig. 3. Evolution of intra prediction in video codecs from MPEG-2 to VVC.

One natural question which arises is how far we can push this model. In other words, can we improve steadily the compression performance of this model decades after decades, by pushing the parameters and adding more local coding tools, or are we converging to a limit? At each codec generation, the question has been raised, and answered by the next generation. None of the proposed competing models have ever succeeded in outperforming the hybrid block-based model.

Nowadays, the recognized industry benchmark in terms of video compression performance is VVC. Can we go beyond the VVC performance? Well, the answer is already known,

and it is yes. Indeed, the JVET standardization group is currently conducting explorations. The Ad-Hoc Group 12 (AHG12) is dedicated to the enhancement of VVC. Around 15% coding efficiency gains are already achieved, only two years after VVC finalization [18]. So, we may continue the process for at least another decade.

However, there is a new contender arising: artificial intelligence; or more precisely, machine learning, or deep learning. In another Ad-Hoc Group, AHG11, JVET is exploring how machine learning can be the basis of new coding tools. This also brings coding efficiency gains of about 12% [19]. Hence the question: will the future of video compression include machine learning? At this stage, we would like to point-out two new facts.

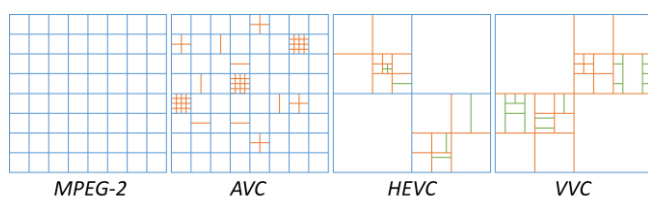


Fig. 4. Evolution of frame partitioning in video codecs from MPEG-2 to VVC.

First, considering the “traditional” methods explored by AHG12, there is a coding tool which seems to stop bringing gains: frame partitioning. The partitioning is a fundamental tool for video compression. It defines how precise can be the adaptation of the encoder to local content characteristics. The more flexible it is, the better the coding efficiency. All the subsequent coding tools depend on the ability to partition the frame efficiently. As illustrated on Fig. 4, AVC/H.264 has 16x16 pixels blocks, with some limited sub-partitioning. HEVC implements a much more flexible quadtree based partitioning from 64x64 pixels blocks. VVC combines quadtree partitioning with binary and ternary tree partitioning, from 128x128 pixels blocks for even more flexibility. During the exploration following HEVC standardization, the single fact of enhancing the partitioning brought up to 15% coding efficiency gains. Similarly, in the AHG12 context, people came with new extended partitioning strategies. However, only marginal gains were reported [20]. Does that mean we are finally approaching a limit?

The second fact is the development of end-to-end deep learning video compression. This strategy is highly disruptive. In short, the whole block-based hybrid coding scheme is replaced by a set of deep learning networks, such as auto-encoders. These types of schemes are competing with state-of-the-art fixed image coders [21]. For video applications, they are matching HEVC performance [22][23]. This level of performance has been reached in only five years. That’s an unprecedentedly fast progression. One may easily extrapolate, even if the progression slows down, that the state-of-the-art video compression performance will soon be the end-to-end strategy prerogative. Therefore, we may very well be at a turning point of the video codecs history.

III. THE ADVENT OF ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) refers to technologies that allow

computers to perform tasks that have so far required human intelligence. The AI term is born in the 1950s with among others the work of Alan Turing and its famous Turing test [34]. Already at this time, researchers tried to create artificial neurons to mimic the human brain. The first neural machine, the Stochastic Neural Analog Reinforcement Calculator (SNARC) has been built in 1951 by Marvin Minsky and has been the beginning of larger research in this field. This leads to the creation of the well-known Perceptron in 1957 which is the basis of modern deep learning. But researchers were too optimistic creating an intelligent machine. After several failures, funding and interest in the field dropped off, leading to the first AI winter. Researchers were mainly constrained by the limited computing power. Some of them persisted in the idea of creating a machine capable of carrying out complex human tasks, and in 1997, IBM’s Deep Blue became the first computer to beat a chess champion. A lot of modern deep learning architectures such as Convolutional Neural Networks (CNN) or Recurrent Neural Networks (RNN) were designed during the 1980s et 1990s, but they required too many data and power to train, and they were forgot during several years. Researchers then focused on more practical and more humble problems. This was the emergence of machine learning (ML).

ML is a technology that allows algorithms to realize tasks without having been explicitly programmed to do them. It is a subfield of artificial intelligence that let the algorithms discover patterns in data to improve their performances on a specific task. A dataset needs to be prepared in order to train the model for a given task. This is the training step. After several iterations, the algorithm, or model, learns to extract more useful features from the dataset which makes him do better predictions. The model is then evaluated on a validation set to check that it generalizes well, i.e., that it performs as well on data that it has never seen before. ML have been used in different fields such as speech or character recognition for example, and many of the ML algorithms widely used today were invented before the 2000s (nearest neighbor, boosting, multilayer perceptron, ...)

In the 2000s, computing power had improved, and the era of big data started to make a lot of, well, data available. AI started to succeed in many industrial use cases such as robotic. In the 2010s, computing power had improved further, specifically with the progress of Graphical Processing Units (GPUs). Moreover, public datasets were built with annotated samples, such as ImageNet [35], created for image classification task. Few years after the dataset creation, ImageNet launched the ImageNet Large Scale Visual Recognition Challenge (ILSVRC), an annual AI object recognition challenge. This led to the first deep learning-based solution in 2012 [36], outperforming all other solutions based on traditional machine learning.

This work triggered an explosion of applications using deep learning technologies, allowing to achieved performances never reached before on various tasks related to natural language processing and computer vision. Deep learning allows to automatically create a hierarchical representation of data, highlighting features and their relations that are hard, if possible, to describe manually. Today, DL allows cars to drive themselves, robots to

communicate with humans, but it can also generate data, with automatic picture colorization or realistic/artistic creations such as the recent Meta's make-a-scene tool [32]. This field is growing very quickly since a decade, and models improve every year.

IV. MACHINE LEARNING BASED VIDEO COMPRESSION

A. Tool based ML-based video compression

As AI and ML is gaining attention in all possible fields of research, video compression is no exception. The JVET standardization group has started an exploration activity dedicated to the introduction of ML in the VVC framework [38]. The idea here is to keep the hybrid block-based model and to replace or complement elementary coding tools by ML-based tools.

Intra prediction is addressed in [39] and [40]. Both approaches consider the prediction of a block of pixels from a causal pixel neighborhood. The prediction is performed by a neural network (NN) replacing the traditional directional or planar intra prediction (Fig. 3). The NN is expected to be able to predict complex shapes and textures. 2 to 3% coding efficiency gains are reported.

Inter prediction is considered using several strategies. In [41], an enhanced bi-prediction mode is proposed. Instead of predicting a block with an average of two motion compensated reference blocks, the two predictors are fed to a NN which outputs the final prediction. Up to 1% coding efficiency gains are reported. A similar approach is considered in [42], but with a single predictor. In [43], a whole reference frame is generated by a NN. This new frame is added to the reference list for temporal prediction. Therefore, each image block can be predicted either from a past encoded frame or from a NN generated frame without changing fundamentally the encoding/decoding process. Up to 2% coding efficiency gains are reported.

A strong focus has also been set on loop filtering [38]. The general idea of loop filtering is to restore already encoded frames. It serves both as a post processing, improving the visual quality of the compressed video, and as a coding efficiency improvement, as it allows better temporal predictions. As ML has been explored for many image processing tasks, it is a natural candidate for loop filtering. First attempts considered replacing all the loop filters by a ML process. The idea has then been refined with adaptive methods trying to take advantage of the best of two worlds, signal processing and ML. The CNNLF [44] is proposed as an alternative to the deblocking and SAO filters of VVC. It is up to the encoder to decide locally to activate CNNLF or not. The filter inputs many data, including quantization parameter (QP), a prediction image and a partition image. The filter also includes a scaling as a post processing after the NN step. Up to 12% coding efficiency gains are reported, illustrating the huge impact of the single loop filter coding tool. The filter proposed in [45], replaces all VVC LF, though it can be turned off at block level. It similarly relies on rich input and post-scaling, while making use of attention models. Similar performance is reported.

Overall, the coding efficiency gains obtained with these approaches are largely significant. However, they come at an

unprecedented cost in complexity, with figures going up to 400 times slow-down of the decoder.

B. Super-resolution-based video compression

The idea of using super-resolution stems from the well-known over the top (OTT) streaming concept. Depending on available bitrate there exists an optimal combination of resolution and compression tuning. In other words, when the bitrate decreases, it becomes more efficient to decrease the video resolution rather than getting more compression artifacts. By factoring in the fact that ML has been studied as a mean of recovering fine details when increasing image resolution, one arrives naturally to the idea that encoding videos at a lower resolution may lead to better trade-off than the current approaches, thanks to the capability of NN to up-sample content without generating the traditional blurring and aliasing phenomenon.

In [46], the video sequence is first decomposed before being compressed using a traditional codec. It is then synthesized to retrieve the original resolution. The decomposition consists in down-sampling only the inter coded frames. Thus, the intra frames are carrying texture information, while inter frames are carrying the temporal information. Synthesis, or up-sampling, is assisted by a motion compensated NN. Up to 9% coding efficiency gains are reported.

In [47], the whole video is encoded at a lower resolution. NN-based super-resolution is applied as a post-processing to recover the original resolution. However, in order to better adapt to frame characteristics, the last layer of the NN is specialized for each sequence. The corresponding parameters are transmitted along with the video stream. About 6.5% coding gains are reported.

Depending on the complexity of the chosen NN approach, complexity gains can be observed. Indeed, thanks to the lower video resolution, the coding/decoding step is much less complex, potentially compensating for the NN complexity [48].

Finally, [49] proposes a different approach. No NN based super-resolution is involved. Rather, linear down/up-sampling is performed using the VVC RPR feature. The point is that resolution is chosen on encoder side by classical rate-distortion optimization. Therefore, depending on the sequence, one obtains either identical or better results than VVC. It shows that ML is not necessary to obtain gains by playing with resolution.

C. End-to-end learned video compression

Nowadays, learned image and video compression has been the target theme for both the Machine Learning and image/video compression communities. In this context, the Challenge on Learned Image Compression (CLIC) [37] aims to encourage both communities to advance the field of image and video compression using machine learning algorithms by either designing new codec architectures or by introducing new perceptual metrics. Therefore, each year, publications are gathered, evaluated, and compared against the traditional codecs. Then, the winners are presented in the CVPR workshop.

Recently, learned image compression has achieved

significant progress in coding performance. The state-of-the-art of such methods are currently competitive with the latest traditional coding system VVC in intra mode. Inspired by this success, deep learning methods were extended to learned video coding.

Learned video compression approaches can be divided into two main categories. The first one keeps the traditional coding pipeline, that deals with the inter frame redundancies, unchanged (motion estimation, motion compensation, residual coding). Then, for each step, deep learning architectures such as auto-encoders and optical flow architectures are used. For instance, [51] introduce the first low latency compression framework called DVC using auto-encoders to code motion vectors and residuals, a pretrained optical flow model for motion estimation and a bilinear warping for motion compensation. [53] improves the DVC performance by using multiples frames as references. This new coding system is called MLVC, it added four neural modules to the DVC framework. The first explored a buffer of multiple previous motion vectors to achieve motion estimation of the current frame. The second does the same for motion compensation. The two remaining modules aim to refine the motion vectors and the residuals, respectively. In the same context of low latency coding, [55] introduces a recurrent learned video codec (RLVC) using a recurrent autoencoder and a recurrent probability model to compress the motion and the residual features. The goal is to thoroughly explore the temporal correlation between frames and latent representations. In fact, this work enables using all the previous decoded frames as reference for compressing the current frame. In addition, the recurrent probability model tends to achieve lower bitrate since the latent representation of the current frame is conditioned with the previous ones. While DVC manages to outperform the low-delay P frames (LDP) configuration of x264 and compete with the same configuration of x265, MLVC and RLVC outperform DVC and x265 in terms of coding efficiency.

[52] presents a framework to code a GOP structure, which includes P and B frames, with different level of quality (HLVC). P and B frames are coded using two architectures of networks which achieve motion estimation, motion compensation and residual coding with hierarchical quality levels. Then, a Recurrent Neural Network (RNN) module is used to enhance quality of the decoded frames. This work's proposed framework depends on GOP structure, which is set manually before proceeding to the training stage. Although this method codes a GOP structure with B and P frames, it was evaluated against the LDP mode of x265 and the low latency model DVC. Compared with x265, it manages to obtain gains in BDBR: -6% for PSNR models and -35.94% for MS-SSIM models. [54] presents a method to achieve perceptual learned video compression (PLVC) using a recurrent conditional GAN. This framework consists of a compression network based on RLVC [55], that serves as generator, in addition to a recurrent discriminator that take as input spatial and temporal conditions as well as the current and previous reconstructed frames. The training process minimize a combination of an adversarial loss function with the rate distortion one. This work manages to get the best results in terms perceptual metrics such as LPIPS [60] and

FID [61] compared to the leaned codecs: RLVC, HLVC, MLVC and the traditional codec HEVC (HM16.20). However, in terms of objective metrics like PSNR and MS-SSIM, it is on-par with DVC, and it performs worse than the previously mentioned learned video codecs as well as HEVC (HM 16.20).

While in the previous works, I frames are compressed using either the BPG codec for [51][53][55][52] or a learned image codec for [54], [56] proposes a neural coding framework for I and P frames, and [22] introduced a neural architecture, consistent with all type of frame I, P and B frames. The system contains two networks: MOFNET deals with motion estimation and compensation and CodecNet achieves conditional coding which replace residual coding. This approach achieves performance competitive with the state-of-the-art video codec HEVC (HM 16.20).

The second category of end-to-end learned video compression focuses on reducing temporal redundancy using algorithms that are different from the traditional pipeline. For example, [57] proposes a video compression framework based on an 3D auto-encoder combined with temporally conditioned entropy model. The performance of this method is competitive with x265 in terms of MS-SSIM. Other works used frame interpolation for video coding. [58] explores Generative Adversarial Networks (GAN) as a decoder to reconstruct separate frames, then used linear interpolation to reconstruct the missing frames. This work is evaluated on low resolution gray sequences in low bitrate. Unfortunately, the results of this approach are only comparable with MPEG4. [59] uses a learned image codec to compress key frames and then uses an interpolation model to predict the missing frames. This approach is compared with handcrafted codecs such as HEVC, AVC and MPEG on the VTL dataset [62]. It outperforms MPEG4 and is matching H264.

All in all, although learned video coding in intra mode (learned image coding) performance is on-par with the latest handcrafted codec VVC, extracting spatiotemporal features is more challenging which makes learned inter coding more difficult. Therefore, the state-of-the-art of learned video compression currently matches the coding efficiency of HEVC. However, one can predict that the progress in this field will be significant in a short period of time.

V. PRACTICAL APPLICATION OF MACHINE LEARNING BASED VIDEO COMPRESSION

A. Delay, rate-control and content adaptation

There is a huge difference between a codec, as defined by standards, and a ready to production live video encoder. The codec is only a part of a video encoder. A video encoder must manage various inputs or capture, decoding, encoding, muxing and output, all along with system functions and user interface. Even when focusing on the encoding part, there is more than the codec. Live encoding requires optimization of the complexity/quality trade-off, which generally translates into added delay. This delay must of course stay under control. Delay is caused among other things by Pre-processing and analysis in a look-ahead buffer, frame reordering for efficient group of pictures (GOP) structure coding, pipelining, and rate-control.

Content adaptation is desirable for optimal quality. GOP structure is generally adapted to the nature of the content. Scene-cuts are detected, and temporal prediction is avoided across them. Considering end-to-end video coding, the same ideas may apply. However, depending on the end-to-end implementation, it may be simpler. The idea of GOP structure may be managed in a transparent manner by the ML model. The notion of successive GOP may be easily conserved, allowing easy chunking for OTT and short zapping time.

In short, content adaptation does not seem to be an obstacle to the end-to-end video encoders development. Rate-control, on the other hand, may be more difficult. Indeed, in traditional video coding, there is an understandable, though non-trivial, relationship between the QP and the bitrate. In an end-to-end video encoder, there exist a parameter tuning the bitrate. However, the effect of this parameter is generally not easy to model. Some encoders are actually trained for a single value of this parameter. It implies that if one needs 64 rate levels, like the 64 QP values of VVC, 64 models must be trained and stored. In an attempt to answer to this issue, [50] proposes a new loss function, where the λ parameter, responsible for rate tuning, is non constant. It allows to design a training procedure where several values of λ are fed randomly to the system, thus making a model that can react appropriately to any value of λ at inference time. Literature on this topic is limited as of today, and there is no doubt that further research is needed, but this example is encouraging.

Finally, the main difficulty to handle may very much be the huge operational complexity of NN.

B. Computing resources

During several years after the deep learning emergence, researchers did not really care about models' complexity. The solutions proposed for various public challenges were more complex every year, while their performances continued to grow exponentially. In their analysis, [24] have shown that the largest model training runs have doubled the computational power used every 3.4 months since 2012. As an example, Danish researchers used the "Carbontracker" tool [25] to show that the energy required to train a GPT-3 model (one of state-of-the-art model for natural language tasks) could have the carbon footprint of driving 700,000km. The training step of machine learning models is highly resource-intensive, but the inference one consumes far more power. Indeed, while the model is trained once, it can be used for billions of inferences. It is estimated that inference accounts for up to 90% of the computing cost [26].

The increase in the model's complexity has been made possible thank to the hardware evolution. For deep learning technologies, Graphical Processing Units (GPUs) are often the default choice, because of their ability to perform a lot of low-level mathematical operations in parallel. Initially designed for games and graphically intensive applications, researchers thought their capabilities were suited to run deep learning models. This market is dominated by Nvidia, and since the deep learning development, they have built new GPU architectures that make their hardware more effective for models training and inference. But this kind of hardware still is a general-purpose solution. Some manufacturers decided to build specific chips designed to run deep learning

models even more effectively. One can think about Google Tensor Processing Units (TPUs), or Microsoft Catapult project. They are based respectively on Application-Specific Integrated Circuits (ASIC) and Field Programmable Gate Array (FPGA) and allow power consumption reduction related to GPUs. These solutions are available in cloud infrastructures, so they can be used for models training and online inference. These use cases are rarely constrained by consumption resources. If more power is needed to speed up training or inference, it is simple to scale by adding GPUs for example. But what about edge devices?

Edge devices are appliances on which data collection takes place. It can be desktop computers, smartphones, or connected devices. While GPUs or TPUs are still the default solutions for training models, a lot of works has been done for performing inference on edge devices. In contrary to cloud platforms, scaling is very hard due to limits in space, power, and connectivity. But this is a very important use case as it allows processing data locally, mitigating networks limitations, increasing security, and improving data privacy. Researchers and manufacturers have then put a lot of effort improving edge computing hardware for processing deep learning models. Hence new types of AI-optimized accelerators have been designed during the past few years, that can be regrouped under the name Neural Processing Units (NPU). Main mobile manufacturers have designed their own solution. This includes chips such as the Apple Neural Engine, the Kirin 980 from Huawei, or the Exynos 9820 from Samsung. There also exists development boards such as the Nvidia Jetson Nano or the Google Coral Edge TPU. NPUs are based on specific architectures that make deep learning model execution faster while having limited consumption. A lot of accelerators exist today [27], and this is a very active research field. Few years ago, MLPerf benchmarks [28] have been released in order to make AI platforms performances comparison simpler. It allows to get training time, inference time, and more recently power consumption of a specific hardware configuration for different AI models. Despite these initiatives, AI accelerators comparison remains very hard as performances are related to too many factors, not only the accelerator itself. Performances are also impacted by the CPU, and the software library used to deploy the model.

In addition to work on specialized hardware, a lot of work has been done on the software part. Some of them are designed for CPUs (OpenBLAS, Intel MKL, ...), and others for GPUs (cuBLAS, cuDNN, ...). All of them optimize matrix operations in order to make AI model execution faster using only algorithmic optimizations. These are libraries allowing low-level mathematic operations, but they are mainly used through higher-level frameworks and tools. For example, Openvino [29] and TensorRT [30], respectively developed by Intel and Nvidia, are platforms offering runtimes with optimized operations implementation, but also some model optimization strategies. This includes weights quantification, network pruning, or operations fusion.

The combination of hardware and software evolution allows the execution of powerful AI models on edge devices in real time. But the AI field is evolving really fast. Even with this progress, models' complexity keeps growing every year,

and hardware and software providers must continue to improve their solutions to make model execution faster or less energy consuming. Recent trends such as neuromorphic computing [31] show there is room for improvement with completely different designs. Also, new hardware is challenging dominant existing solutions. For example, the Hailo 8 chip [33] presents performances up to 13x those of Google TPUs. All of this shows that the Moore's law continues and makes possible further improvements in AI.

VI. A CASE-STUDY: END-TO-END MEMORY CONSUMPTION

A. Problem statement

As models' sizes are growing continuously, memory consumption is also becoming an issue, along with computing power. The case of end-to-end learned encoding is considered here. The auto-encoder architecture, built with convolutional layers, enables processing different video resolutions, no matter the resolution used during the training step. However, with growing models' sizes and video resolutions (4K, 8K), these solutions are facing hardware memory saturation. One way to solve this issue is to use a patch-based coding approach. The video frames are divided into patches smaller than the frame size, that can be encoded independently. Then, the decoded patches are gathered to reconstruct the decoded frames.

This solution addresses the hardware limitation issues, but the reconstructed frames can have block artifacts at the patch boundaries, widely deteriorating the video quality.

B. Patch-based end-to-end video encoding

A solution to the memory saturation is proposed to perform patch encoding while removing block artifacts. The idea is to encode overlapping patches and then use a linear function to combine the reconstructed overlapped pixels. If b_m and b_{m+1} are two consecutive reconstructed patches overlapping horizontally on N pixels, the value of the i^{th} overlapped pixel $p_{rec}(i)$ for a given line in the reconstructed frame is determined by the following equation:

$$p_{rec}(i) = \left(1 - \frac{i}{N-1}\right)p_{b_m}(P + i) + \left(\frac{i}{N-1}\right)p_{b_{m+1}}(i), \quad (1)$$

where $i \in \{0, \dots, N-1\}$ is the index of the overlapped pixels, P is the size of the patch without overlapping, p_{b_m} and $p_{b_{m+1}}$ are pixels values, for a specific line, of two consecutive decoded patches b_m and b_{m+1} respectively. The same equation applies for vertically overlapping patches.

The proposed approach has been applied to encode I frames, using an end-to-end learned image codec which is an implementation of the model architecture introduced in [21]. This model was trained on CLIC 2020 dataset [37]. For training, 256×256 sized patches were randomly cropped from each image of the training set. The loss function to be minimized is:

$$J = D + \lambda R \quad (2)$$

where D refers to the distortion measured by the Mean Square Error (MSE) or the Multi-Scale Structural Similarity Index (MS-SSIM) metrics, and R refers to the rate used to

transmit the bitstream, estimated using the Shannon entropy. λ is the Lagrangian multiplier, allowing to adapt the bit rate targeted by the learned image coding model.

The method is then evaluated on Class B, C, D, E and F of the JVET Common Test Conditions (CTC) sequences (8-bit sequences) [72]. For each sequence, one frame is extracted and compressed both entirely (referred to as the full image approach) and by the proposed patch-based approach, with and without overlapping, where $N \in \{0, 2, 4, 8, 16, 32\}$ overlapped pixels and $P = 256$, as the training resolution.

BD-rate gains of the patch-based learned image coding with and without overlapping were computed comparing to full image learned image coding, using an end-to-end model trained to minimize MSE as distortion metric.

For MSE models, patch-based image coding without overlapping presents a slight loss in BD-rate (Average BD-rate +0.013), comparing to full image coding, which mostly corresponds to the block artifacts issue caused by patch-based approaches.

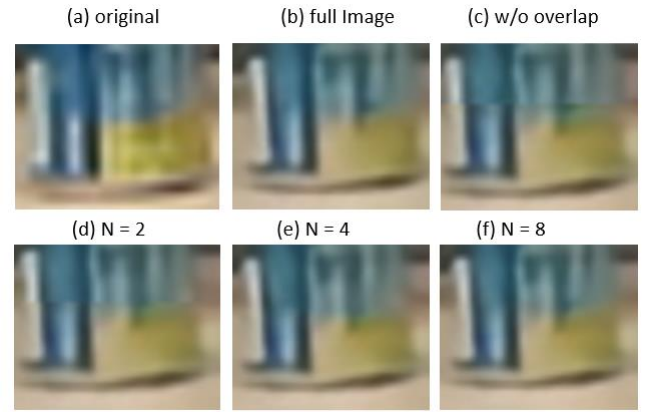


Fig. 5. Visual results of comparison for FourPeople. The model used optimizes the MSE metric with $\lambda = 4096$.

On the other hand, the proposed method achieves a gain in BD-rate, which increases as the number of overlapped pixels is increased. For $N = 2$, the average BD-rate gain among CTC sequences is: -0.025, which shows that two overlapped pixels seems to be sufficient to eliminate the borders artifacts. With $N = 8$ and $N = 16$, small gains are observed comparing to full image coding: -0.034 and -0.041 respectively. For $N > 16$, BD-rate gains saturation is observed. An example of decoded images is presented in Fig. 5. Overlapping with $N = 2$ and $N = 4$ reduce the block artifacts while overlapping with 8 pixels eliminates them entirely.

The experimental complexity and memory consumption are reported in Table I. Frames of different resolutions were extracted from the JVET CTC and were coded using two machines with powerful GPUs: GeForce RTX 2080ti and GeForce RTX 3090 with memory capacity of 11Go and 24Go respectively. Full resolution coding of an HD image is not possible on both GPUs due to "Out Of Memory" (OOM) error, while full coding an 1280x720 image, can only be run on the machine with the GPU RTX 3090. It is important to note that these resolutions are standard resolutions in practical applications of image compression. 4k is not even considered. Therefore, the fact that they cannot be run on one of the latest GPUs is inconvenient. In this case, the proposed

method provides a solution that enables coding high resolution images without deteriorating quality. While the method is necessary for resolution 720p and above, it is adding some complexity to the system for smaller resolutions. For instance, when running the resolution 832x480 on 2080ti GPU, patch-based coding increases the coding time by 3.63% compared with full resolution coding. This is expected since our method requires coding more pixels to overlap patches.

To conclude this section, the proposed approach addresses the hardware memory limitation problem since it allows coding resolutions such as HD and 720p, while maintaining same or better quality as the full resolution learned coding.

TABLE I: PERFORMANCE OF PATCH BASED END-TO-END ENCODING.

Resolution	Method	Coding Time GPU 2080 11Go	Coding Time GPU 3090 24Go
1920x1080	Full Resolution Coding	OOM	OOM
	Patch coding in parallel with overlapping	3.82s	2.05s
1280x720	Full Resolution Coding	OOM	0.93s
	Patch coding in parallel with overlapping	1.91s	1.012s
832x480	Full Resolution Coding	1.06s	0.52s
	Patch coding in parallel with overlapping	1.10s	0.55s

VII. WRAP-UP

From MPEG-2 in the 90's to VVC nowadays, four successive major generations of codecs have made video ubiquitous, from TV screen to smartphones, from over-the-air to internet. All these codecs are based on the same general structure, the hybrid block-based model. Previous attempts to overcome this model have all failed, despite of their numerous technical qualities and features. But how long will this model continue to dominate?

Today, one observes a small hint of a decline of the hybrid block-based model, along with the rise of machine learning. Machine learning is the state-of-the-art technology in many image and video processing fields, but still not in video compression. ML may not be ready yet for video compression, but it is progressing fast. We argue in this paper that current limitations can be addressed, either through plain technological progress, or through dedicated algorithmic progress.

As an example, a new method of memory management for machine learning based end-to-end image and video compression is described in this paper, namely patch encoding with overlapping.

All in all, for the upcoming video codec generation, two approaches are competing. Time will tell, but our guess is that there will be another generation of hybrid block-based model before the advent of machine learning based video compression. Researchers are just needing a few years to refine and make the technology practical. Model sizes and hardware capabilities will eventually converge.

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Contributions to TV 3.0 using 5G-MAG Reference Tools

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Abstract— The evolution of the evolved Multimedia Broadcast Multicast Service (eMBMS) to the Further evolved Multimedia Broadcast Multicast Service (FeMBMS) in Release 14 of 3GPP enabled broadcast transmission in a format 100% dedicated to user devices. As a result, the 5G standard for cellular networks expanded and began to be quoted in the broadcasting sector as 5G Broadcast. This standard is one of the quoted ones to integrate the TV 3.0 architecture in Brazil, being responsible for the physical layer. To be possible, this technology must meet some requirements, such as negative noise carrier ratio, MIMO antennas and channel bonding. To complement the tests conducted by the SBTVD Forum, this paper aims to evaluate and discuss the SNR and minimum signal level tests using an Open-Source receiver called 5G-MAG that is managed by the group of the same name. The tests were carried out using a Universal Software Radio Peripheral (USRP) Software Defined Radio (SDR) reproducing I/Q file with 5G Broadcast data with a bandwidth of 6MHz, the width of interest of the Forum, to transmit the signal via GNU Radio software and another USRP SDR as a receiver, having as interface the 5G-MAG.

Index Terms—5G-Broadcast, TV 3.0

I. INTRODUCTION

Linear TV has a prominent role in Brazilian society. According to a study called “Inside Video 2022” conducted by Kantar IBOPE Media, a global leader in media intelligence, the reach of linear TV arrived 93% of the Brazilian population in 2021, with a dedication of 79% of the time in open TV stations. and 21% on video platforms [1]. These data are important, as they encourage interest in modern technologies around broadcasting in the country. Digital TV in Brazil is undergoing a process of evolution, which has been called TV 3.0. A disruptive evolution with improvements in image definition and processing, in addition to audio. 5G Broadcast was one of the standards evaluated at the physical layer and will be analyzed in this article. As the name suggests, the standard uses the fifth evolution of the mobile network for linear TV broadcasting. This feat is possible using a feature called Further evolved Multimedia Broadcast Multicast Service (FeMBMS) released in Release 14 of LTE and which allows up to 100% dedication to

broadcast and multicast services. The proponents responsible for presenting this standard to the SBTVD Forum's Call for Proposals were Qualcomm, Rohde & Schwarz, and Katherin [2]. An open-source solution is managed by the 5G Media Action Group (5G-MAG) [3]. This group is an independent, non-profit association whose objective is to be a bridge between the media sectors and the ICT (information and communication technology) industries. They manage a range of tools called 5G-MAG Reference Tools that aim to receive 5G broadcast transmission in dedicated mode, as specified in Release 14 and 16 of 3GPP; combine transmission with mobile broadband, with the possibility of switching modes and developing interactive applications. The receiving system has three interfaces, the MBMS modem, middleware, and a web interface. The last two are optional unless the media content to be received is in HLS format. The system can be configured using two SDRs, one to transmit the content played by GNU Radio and the other to receive the content (see Fig. 1).



Fig. 1. Representation of the test setup used in the laboratory.

This paper aims to discuss the results of SNR and minimum signal level tests and to evaluate the performance of the open-source receiver.

Based on the above, this paper will be organized as follows: Section II will present the theoretical framework that provides the basis for the investigation; Section III will describe the materials and methods involved in the tests; Section IV will present the performance evaluation and comparison with the SBTVD Forum test results for TV 3.0 and conclusions are drawn in Section V.

II. TECHNOLOGY OVERVIEW

A. TV 3.0

TV 3.0 is the name given to the new open TV project, already in its final testing phase, which aims to replace the current model, SBTVD, which is currently in transition to TV 2.5. Its development is being led by the SBTVD Forum together with the Brazilian Ministry of Communications. TV 3.0 will bring new high-tech experiences to Brazilian homes. The SET's TV 3.0 Working Group [4] cites interactive services such as multi-angle camera service, which allows the viewer to watch a certain scene with a specific camera view; TV social service, which provides interactivity between people in a chat room; Emergency Warning Broadcast System (EWBS), as the name suggests, is an emergency information service that consists in making the viewer aware of the importance of the message and how to proceed; multi-language hidden language service, this service offers the possibility of inserting subtitles in another language via the internet; and sign language animation service that enables the insertion of other services for hearing and visually impaired people. The TV 3.0 architecture proposed by the SBTVD Forum is seen in Fig. 1Fig. 2.

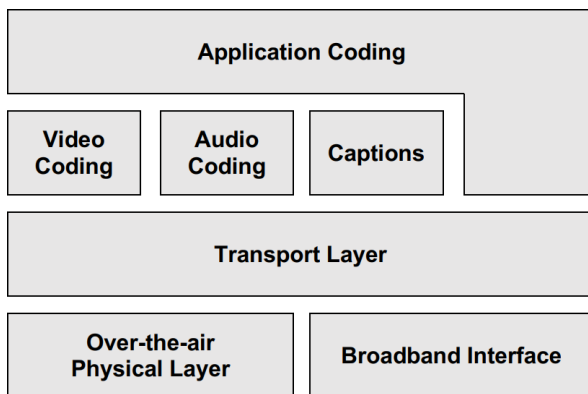


Fig. 2. TV 3.0 Architecture [2].

The system considers two complementary delivery methods: over-the-air and Internet. The physical Internet access interface (broadband interface) is outside the scope of the TV 3.0 system definitions and is considered any IP-based, bidirectional broadband access interface. From the architecture shown in Fig. 2, one can say:

The over-the-air physical layer comprises the unidirectional transmission modulation/ demodulation scheme and error correction. The transport layer comprises the multiplexing and transport of video, audio, subtitles, and applications, as well as all necessary metadata. The application coding in TV 3.0 includes, in addition to the interactivity and broadcast-band integration functions, handles the presentation of all audiovisual content. The audio, video, and subtitle encoding are self-evident and are responsible for the treatment of video, audio, and subtitles in transmission and reception. The intention of the third generation of Brazilian terrestrial television is to bring together the best of the current broadcasting technologies. Each block shown in the architecture of Fig. 2 was subject to proposals for evaluation by the SBTVD Forum. The over-the-air physical layer is the flagship of this work. For TV 3.0 this layer should, in principle, be deployed in the bands currently allocated to digital terrestrial TV in Brazil (VHF and UHF), using the 6 MHz channel bandwidth and should coexist with adjacent

ISDB-T channels for a long time without mutual interference. Another specification is frequency-1 reuse, i.e., the use of the same RF channel by independent stations covering adjacent service areas. Such a feat would provide great flexibility for the transmission network, which could be freely expanded and subdivided using the same channel. It would also increase the resilience and robustness of the network. Transmission of the reuse frequency requires $C/N \leq 0$ dB. Taking advantage of this robustness, the new physical layer is also intended to target external mobile and fixed internal mobile reception with the same signal with a single modulation, coding and quality while maintaining the current network topology so as not to increase the cost of signal distribution. Another specification is the use of MIMO antennas, such antennas and Channel Bounding increase the channel capacity to compensate for $C/N \leq 0$ dB in a Rayleigh channel which implies a very limited channel capacity. Another feature needed for the TV 3.0 physical layer is to carry a "wake-up" signal (to turn receivers on stand-by) in case of an emergency warning. Finally, it should be noted that the physical layer must allow for future extensions.

B. 5G Broadcast

5G Broadcast is a candidate technology for the TV 3.0 physical layer. It enables broadcast, i.e., point-to-multipoint transmission, and can operate in receive-only mode without the need for SIM cards and network subscriptions. This system can operate in the same band used for terrestrial broadcasting services, it is important to note that 5G broadcast is different from 5G mobile, 5G defines two modes of broadcast communication, standalone and multicast in mixed mode. 5G broadcast is in standalone mode, while the other mode contemplates 5G New Radio (NR). The transmission of 5G Broadcast is conducted by broadcasters, the advantage is that cell phones with 5G can receive the 5G broadcast signal. With the 5G spectrum auction taking place in Brazil in 2021, 5G Broadcast would add value to traditional TV broadcasting, offering additional functionalities and applications and contributing to an efficient distribution of the TV signal to mobile users in the country.

5G Broadcast has been incorporated into Release-14 of 3GPP. The study of EnTV (Enhanced TV) has opened up the opportunity for broadcasters to offer all their services - linear and non-linear to 3GPP devices, enabling broadcast capabilities within the 3GPP system itself.

According to Barquero [5] the European Broadcasting Union (EBU) has coordinated all activities regarding broadcasters' involvement in 3GPP. In Release-15 [6] the emphasis was on the possibility to dynamically switch between unicast, multicast and broadcast modes in order to respond to varying demands, for example as a consequence of varying user distributions and simultaneous service requests. Transmitter site-to-site distances, even beyond, must be considered to cater for very large coverage areas, as well as dedicated modes to support mobile MBMS services up to 250 km/h.

For [7] and [8] the main improvements to the eMBMS system architecture introduced in EnTV are:

- A receive-only device mode to allow the transmission of free-to-air content that can be received by all devices, including devices without uplink capabilities, SIM cards or 3GPP network subscriptions. A specific application of this mode is to allow the transmission of free-to-air content on eMBMS.

- A transparent (transport/pass-only) delivery mode for using the eMBMS network as a content delivery platform that allows reuse of broadcast services without decoding, ensuring backward compatibility and minimal effort to migrate from legacy systems. It allows, for example, the use of MPEG-2 Transport Stream (TS) over IP. This mode has been added so as not to limit the supported TV formats to the standardized 3GPP media layer services.

The main enhancements to the eMBMS Radio Access Network introduced in EnTV are:

- Dedicated carriers with up to 100% allocation of broadcast content without any resources allocated for unicast and autonomous system information and synchronization signals.
- New subframe type without unicast control region to reduce signaling overhead in downlink-only eMBMS transmissions.
- Shared broadcast networks where different operators can aggregate their radio access networks and MBMS to create a common distribution platform, avoiding the transmission of the same broadcast content on multiple networks; and
- - Support for longer inter-site distances in SFN with a new OFDM numerology.

[5] discusses this topic in depth.

[9] presents two cases of open source 5G receivers using SDRs.

III. MATERIALS AND METHODS

A basic telecommunications system consists of something that transmits the message and something that receives it, and the medium that is the communication channel. The equipment used is shown in TABLE 1

Table 1. List of the equipment used.

1	PC Core i7, ninth generation, 16GB RAM (RX)
1	PC Core i7, 12th generation and 16GB RAM (TX)
1	USRP UHD Ettus B200 (TX)
1	USRP UHD Ettus B210 (RX)
1	Variable Attenuator Model 50DR-001
1	NOD 5200 Noise Generator - Micronetics
1	Anritsu MS8901A Spectrum Analyzer

The I/Q files for transmission are available on the 5G-MAG Github [10]. All files share the same characteristics of cyclic prefix (1.25 kHz), MCS16 (16QAM) and differ in bandwidth, with 3, 5, 6 MHz. From the tests performed by the SBTVD Forum [11] these configurations did not obtain negative C/N, which is one of the requirements for the new TV system in Brazil. This requirement was partially achieved with MCS3 and MCS2 values. Although TV 3.0 requires MIMO, 5G-MAG supports only SISO.

To transmit the RF signal on the SDR the open-source software GNU Radio that provides signal processing blocks for implementing radio and digital processing systems was used. Channel 37 which occupies the UHF band from 608 MHz to 614 MHz was used to transmit the data to the receiver. The 5G-MAG receiver consists of up to three

interfaces depending on the payload to be received. If the payload contains DASH (Dynamic Adaptive Streaming over HTTP) or HLS (HTTP Live Streaming) content, then there is a need for MBMS Middleware, otherwise there is no need and the content can be viewed by another application, such as FFMPEG or VLC. The MBMS Modem is the head and can operate either automatically or manually via commands. The Webinterface is optional, but it shows the constellations and other data, such as the type of bandwidth used and the gain of the receiver. The transmit and receive setup has been validated and no errors have occurred. Fig. 6 shows the receiver interface, it displays the current SDR, synchronization and constellations settings of PDSCH, PMCH and services.

1) *SDR*: This field provides information about the interface device settings.

- Frequency*: is the system's operating frequency.
- Gain*: indicates the receiver gain.
- Antenna*: indicates which input of the SDR is being used.
- Sample rate*: indicates the sample rate.
- Filter BW*: indicates the size of the bandpass filter; and
- Buffer Level*: indicates the System buffer level.

2) *SYNC*: Displays data regarding system synchronization. The features are:

- Status*: indicates the synchronization status.
- CFO (Carrier Frequency Offset)*: indicates the size of the frequency offset to achieve synchronism.
- Cell ID*: Cell ID.
- PRB (Physical Resource Block)*: is the smallest provisioning unit in an LTE frame and differs with bandwidths.
- Width*: indicates the bandwidth used.
- Subcarrier Spacing*: indicates the spacing between the carriers; and
- CINR (Carrier to Interference Noise Ratio)*: is a measure of signal effectiveness, the higher the level, the better.

3) *PDSCH (Physical Downlink Shared Channel)*: This is the downlink data channel for the users. The more concentrated the points are, the better the reception of the

4) *PMCH (Physical Multicast Channel) (MCCH, Multicast Control Channel)*: Control channel, does not need high rates, so MCS2.

5) *PMCH (MCH 0)*: Transport channel, MSC16, constellation 16QAM.

6) *Services*: shows the information regarding the transmitted services.

All constellations show bit error rates and block errors.

B. Least Signal Level test versus Gain of the 5G-MAG Receiver

The minimum signal level test is intended to evaluate the reception sensitivity of the 5G-MAG. The transmitter signal level was set at -30 dBm, and the receiver gain varied from 10 to 50 dB, with a 5 dB interval. The I/Q files used were 3, 5, 6 MHz. The TOV (Threshold of Visibility) was taken as the 1 dB level above the point where artifacts occur in the image, observed on the TV. The setup used is shown in Fig. 3. For the transmission setup a GNU Radio flow Graph was used, to which the channel, TX gain and I/Q file was set. The attenuator 50DR-001 has an accuracy of 1dB, the spectrum analyzer was used to check the signal level when the video

started to show artifacts on the screen. The video time to validate the configuration was 1 minute. The receiver was configured in manual mode, i.e., controlled via commands in the Ubuntu terminal.

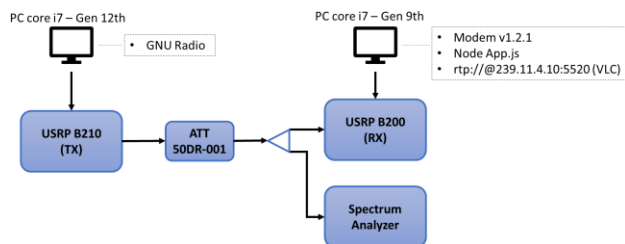


Fig. 3. Setup of the minimum signal level test.

C. C/N test

In addition to the minimum signal level test, the C/N test is important, because digital TV depends on other factors to work without interruptions, the signal level alone is not enough. The current SBTVD system uses a carrier/noise threshold of 19dB [12]. The purpose of this test is to find out this threshold for TV 3.0.

The transmitter signal level was set to -30 dBm, and the receiver gain to 20 dB. The I/Q files used were 3, 5, 6 MHz. The TOV was considered to be the level 0.1 dB above the point where artifacts occur in the image, observed on the TV. The setup used is shown in Fig. 4. In the transmission setup a GNU Radio flow Graph was used, to which the channel, TX gain and I/Q file was set. The NOD 5200 noise generator has an accuracy of 0.1dB, and has three levels of accuracy, tens, units, and hundredths. The control was made to change the values in the higher levels and taper off as the transmission image presented artifacts. The spectrum analyzer was used to fix the signal level. The video time to validate the configuration was 1 minute. The receiver was configured in manual mode, i.e., controlled via commands in the Ubuntu terminal.

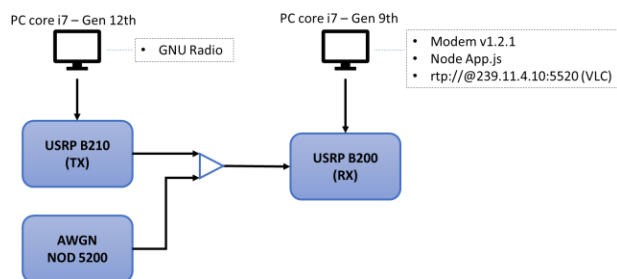


Fig. 4. Setup for the C/N test.

D. C/N test versus Gain of the 5G-MAG Receiver

The test setup is like the C/N test (see Fig. 4), the band chosen was 3MHz, as it was the configuration that was currently running. The transmitter signal level was set at -30 dBm, and the receiver gain varied from 10 to 50 dB, with a 5 dB interval. The TOV was considered to be the level 0.1 dB above the point where artifacts occur in the image, observed on the TV. The video time to validate the configuration was 1 minute. The receiver was configured in manual mode, that is, it was controlled via commands in the Ubuntu terminal.

IV. RESULTS AND COMMENTS

The C/N versus receiver gain test was performed first to have a basis for the other tests. Although Fig. 5 shows an increasing trend, there was inconsistency of values.

The best receiver setting was $G = 20$ dB. In this setting the signal synchronized quickly. The gain set at 50 dB did not get a good response, with the image freezing even without noise.

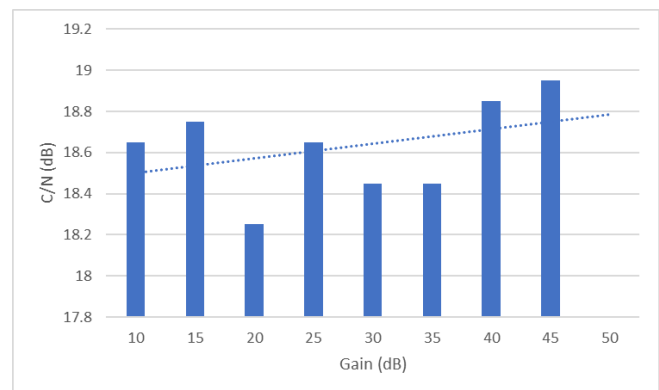


Fig. 5. C/N with different gain values in the 3MHz band receiver.

For the minimum signal level test (see Table 2) the average system margin was -80.5 dBm for the 3MHz band, -75.7 for the 5MHz band, and -65.8 for the 6MHz band. The best sensitivity occurred with the 45 dB gain.

Table 2. Result of the minimum signal level test.

Gain (dB)	BW (MHz)		
	3	5	6
10	-59,87 dBm	-61,9 dBm	-63,0 dBm
15	-67,17 dBm	-64,08 dBm	-63,2 dBm
20	-67,32 dBm	-64,40 dBm	-63,71 dBm
25	-67,25 dBm	-65,96 dBm	-65,81 dBm
30	-68,79 dBm	-67,06 dBm	-68,62 dBm
35	-77,58 dBm	-73,18 dBm	-72,19 dBm
40	-79,63 dBm	-76,50 dBm	-73,08 dBm
45	-80,5 dBm	-78,38 dBm	-78,08 dBm
50	-	-75,66 dBm	-75,70 dBm

The C/N test showed that the carrier-to-noise ratio was very close to the threshold in effect in the current transmission system which is 19dB. Figures Fig. 6 and Fig. 7 show the receiver interface without and with AWGN noise, respectively. The CINR value depicts what is seen in the constellations. Fig. 7 shows no BLER and BER errors in any of the constellations. However, it is important to note that the $C/N \leq 0$ condition was not observed in any of the tests, indicating that the system does not match the SBTVD Forum requirements for TV 3.0.

Table 3. Results of the C/N test.

BW (MHz)	C/N (dB)
3	18,25
5	19,24
6	18,60

Table 4 and Table 5 present the results obtained by the SBTVD Forum during the second phase of tests using the 5MHz band. Table 4 brings the results of the C/N test for VHF channels 7 and 10 and UHF channels 14, 33 and 51 with signal level of -28dBm. Analyzing the data in Table 4 with the tests performed in this paper, it is evident that the bit rate of the MCSs has an impacting factor on the C/N, the higher the modulation order, the more susceptible to errors the

system becomes, this demonstrates that 5G Broadcast is not a robust system. Table 5 presents the minimum signal level values for the 5MHz band. The tests done by the SBTVD Forum for the 5MHz band resulted in -83.9 dB for the field tests [13] and -98.5 dB [11] for the laboratory tests. Compared to the test in this paper the receiver used by the Forum had a sensitivity of more than superior to the 5G-MAG used in this paper, this indicates that both receivers are sensitive to signal variations, with the receiver used by the Forum being more sensitive than the 5G-MAG. The sensitivity of the receiver is important, since the medium used by radio transmitters is air, and air is susceptible to various sources of noise, which degrade the signal.

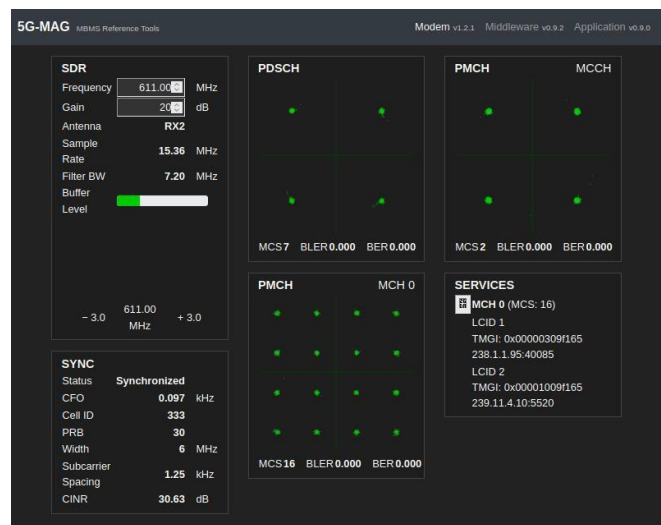


Fig. 6. Signal reception in the absence of noise for BW = 6MHz.

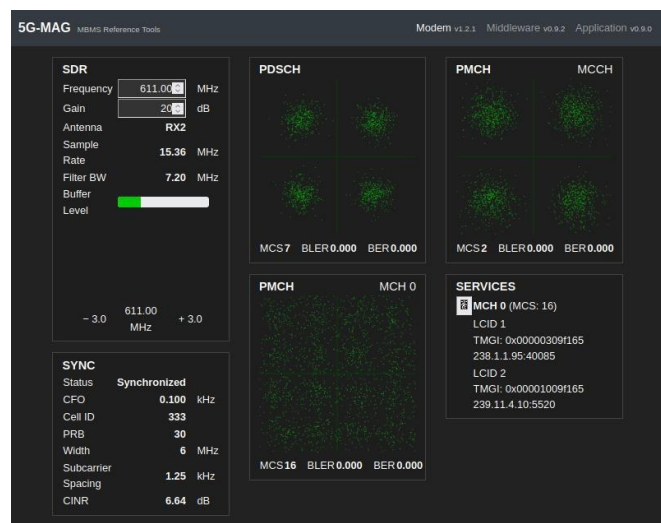


Fig. 7. C/N test at the reception threshold for BW = 6MHz.

Table 4. C/N test done by the SBTVD Forum using BW = 5MHz.

CH	C/N			
	MCS2	MCS3	MCS4	MCS9
7	0,1	0,00	0,10	4,50
10	0,2	-0,10	0,10	4,60
14	-0,1	0,00	0,00	4,70
33	0,2	-0,20	0,10	4,80
51	0,1	-0,10	0,30	4,60

Table 5. Receiver Minimum Level for SISO Configuration done by SBTVD Forum using BW = 5MHz.

CH	Min. Level Signal (dBm)
7	-98,7
13	-99,0
14	-98,2
33	-98,3
51	-98,6

V. CONCLUSIONS

The receiver does not have an automatic gain control, and although the webinterface presents a method for varying this characteristic, it does not work, because when changed the modem abruptly stops. This could be a point of improvement to the system. Another feature to be improved is the synchronization, sometimes the receiver cannot synchronize and locate the channel, being necessary to run the application several times for this to happen. Considering that TV 3.0 is a disruptive system, the fact that the 5G-MAG receiver is open-source contributes to the easy adhesion by the industry, which will have to change devices when this new system starts to be implemented in 2024. In 2023 phase 3 of the TV 3.0 trials will begin, and if 5G Broadcast can meet the requirements of TV 3.0 it is expected that this system will enter commercial operation in 2025. The fact that this receiver can operate in other bands is a positive point, and this feature is provided for in the Forum requirements, however, more importantly, the negative C/N and operability using MIMO have not been met, even for low MCS numbers. The use of MIMO is not contemplated by 5G-MAG/ 5G Broadcast. Further testing can be done, provided there is a configuration that meets the negative C/N.

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Spectrum Availability for the Deployment of TV 3.0

Thiago Aguiar Soares, Paulo E. R Cardoso, Ugo Silva Dias

Abstract—In this paper, we study the current and future spectrum availability of the VHF and UHF bands in Brazil for the deployment Next-Generation Digital Terrestrial Television Systems, which are being studied under the “TV 3.0 Project” initiative, coordinated by The Brazilian Digital Terrestrial Television System Forum (SBTVD Forum). Coverage simulations of all expected operating stations in Brazil were computed in different scenarios to estimate the spectrum availability over the Brazilian territory. Results indicate that hybrid approaches should be implemented to smoothly introduce new digital television systems.

Index Terms—Digital Terrestrial Television (DTT), Next-Generation Digital Terrestrial Television Systems, Regulation, Spectrum Policies, TV 3.0.

I. INTRODUCTION

Digital Terrestrial Television (DTT) Systems continue their technological evolution. The second generation of digital terrestrial television broadcasting transmission systems is meant as systems offering higher bit rate capacity per Hz and better power efficiency and there is no general requirement for backward compatibility with first-generation systems. So, transitioning from first to second-generation DTT systems will require spectrum availability.

In Brazil, studies for Next-Generation Digital TV Systems have already been initiated. In July 2020, The Brazilian Digital Terrestrial Television System Forum (SBTVD Forum) released a Call for Proposals (CfP) seeking input from interested organizations for Brazil’s next-generation Digital Television system components and sub-components. The initiative is called the “TV 3.0 Project”.

Nonetheless, the availability of spectrum resources for DTT Services is declining worldwide, especially in the UHF Band. This paper analyzes the current and future spectrum usage of television services in Brazil to develop realistic transition approaches for the deployment of TV 3.0.

II. METHODOLOGY

To evaluate spectrum usage of TV Services in Brazil, simulations were made to estimate the coverage of all operating channels. Firstly, a database analysis was conducted to estimate the number of operating TV stations in Brazil. Figure 1 shows the distribution of the estimated operative DTT Channels in Brazil.

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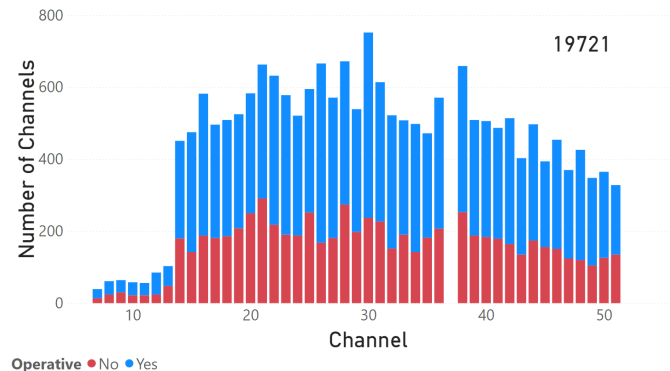


Fig. 1: Distribution of Operative Digital TV Channels in Brazil.

As few of the total DTT stations are currently licensed, the availability of technical data is scarce. So, some approximations were implemented to estimate the antenna patterns and the effective radiated power of all operational stations. Figure 2 illustrates the predicted coverage of DTT channel 20 as an example.

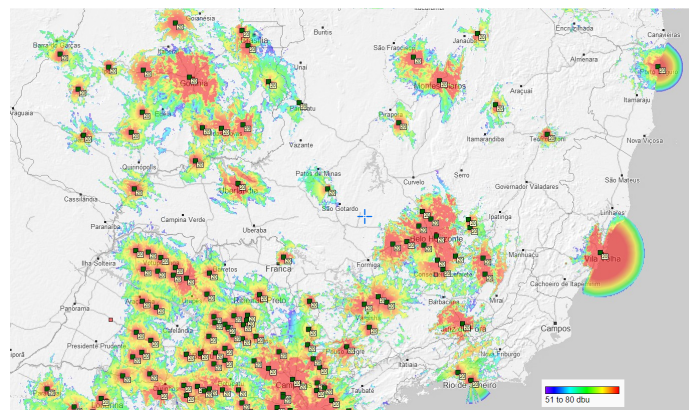


Fig. 2: Example of predicted coverage for DTT Channel 20.

III. ANALYSIS AND RESULTS

The numerical results of the simulations are summarized in Table I, which contains the number of municipalities covered by at least one TV channel (digital, analog, or any of them):

A straightforward finding that can be extracted from data analysis is that digital television has huge penetration in Brazil. As shown in Table I nearly 96% of the Brazilian municipalities can receive at least one DTT channel. On the other hand, analog TV is still covering about 75% of

TABLE I: Number of municipalities covered per frequency band.

Frequency Band	Municipalities with at least one digital channel	Municipalities with at least one analog channel	Municipalities with at least one channel
All Bands	5312 (96.27%)	4210 (75.57%)	5418 (97.32%)
Channels 2 - 6	0 (0.00%)	2691 (48.31%)	2691 (48.31%)
Channels 7 - 13	946 (20.36%)	3800 (67.99%)	4042 (72.73%)
Channels 14 - 36	5179 (94.47%)	2510 (44.45%)	5232 (95.01%)
Channels 38 - 51	4417 (81.69%)	1508 (26.61%)	4565 (83.70%)

the municipalities, which shows the importance of well-defined policies for switching-off television.

Geographically, the Brazilian States from the North, Midwest, and Northwest regions are the ones with a fewer average of received DTT channels. Figure 3 shows the average of received DTT channels per Brazilian State.



Fig. 3: Map view - Categorized average of received DTT channels per Brazilian State: red (less than 5), orange (from 5 to 10), yellow (from 10 to 15), blue (from 15 to 20), and green (more than 20 channels).

Television analog switch-off is expected to be completed in Brazil by the end of 2023. However, there is a huge amount of planned DTT channels that are currently not operative. After developing a database analysis, it was concluded that besides 9,230 analog channels will soon cease operations with the analog switch-off in Brazil, about 4 thousand new DTT channels are expected to start transmission in the short-term. Hence, DTT channel distribution in Brazil after the analog switch-off is expected

to contain about 16,492 operative channels as illustrated in Figure 4.

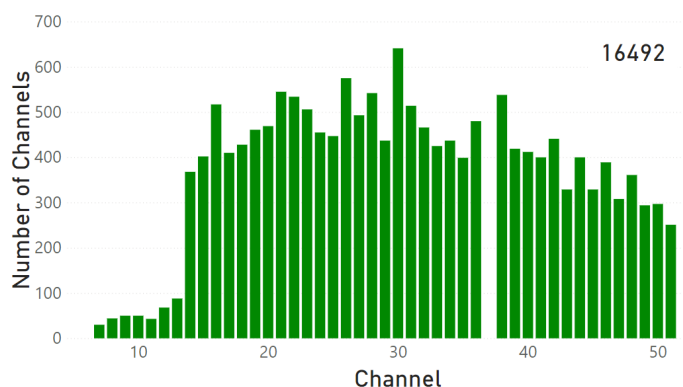


Fig. 4: Expected distribution of Digital TV Channels in Brazil after the analog switch-off.

As could be found in the coverage analysis, spectrum occupancy of DTT services is not uniformly distributed. So, hybrid approaches should be implemented to introduce new digital television systems. Based in the obtained results, some proposals are listed below:

- **Reserve High-VHF Band (Channels 7 to 13) for the transition to TV 3.0.** The CfP for TV 3.0 in Brazil includes the requirement that the over-the-air Physical Layer should consider the deployment in the High-VHF band. Hence, updating the regulation to reserve the band would bring the benefit of having a specific spectrum portion to deploy next-generation DTT networks.
- **Re-plan current DTT channels in some areas to free continuous spectrum portions.** Current DTT channels were planned in a simulcast scenario where analog TV channels had to be protected to guarantee a smooth transition. So, the planning process was not optimized. Channeling optimization would promote spectrum efficiency and release parts of the UHF spectrum for the deployment of next-generation DTT networks.
- **Update regulation to allow multi-programming.** The current Brazilian regulation just allows public broadcasters to transmit more than one program in a single 6 MHz channel. However, it will not be possible to allocate a second 6 MHz channel for all broadcasters for the transition to next-generation DTT Systems, mainly in Brazilian state capitals regions and high dense metropolitan areas. So, multi-programming will be necessary to allow optimize spectrum usage and facilitate the transition
- **Promote installation of shared infrastructure.** Broadcasters have taken advantage of their current analog TV infrastructure to install DTT transmission sites on their own, doing the transition channel by channel. Recent public policies have been established to install complete shared DTT transmission sites in small municipalities to facilitate the transition

from analog to digital television, but more incisive policies are required for the deployment of shared next-generation DTT transmission sites.

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IMPLEMENTATION OF CONVOLUTIONAL NEURAL NETWORK IN FPGA FOR IMAGE RECOGNITION

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Abstract—Neural Networks (NN) are being researched and improved to a degree that machines can closely resemble the capacity to execute complex tasks that only an intelligent animal is capable of. Vision used in the interpretation and recognition of the environment is one of such tasks that is being researched so future technologies can simulate vision in autonomous vehicles to further improve self-driving capabilities, increase driver convenience, help avoid accidents, and even autonomous delivery. Convolutional neural networks, inspired by the mechanics of animal vision, are utilized for the complex task of image recognition. Field Programmable Gate-Arrays (FPGA) recent developments have given it more parallel processing and processing speed making it a prime candidate for the implementation of NNs efficiently, with more processing capabilities and low response times compared with the alternatives. The objective of this work is to evaluate the performance viability of FPGA implementation of an image classification NN with acceptable accuracy and low response time.

Index Terms—FPGA; CNN; autonomous vehicles; MNIST.

I. INTRODUCTION

Artificial intelligence has attracted attention from the most varied types of industries, with several studies being carried out on the subject and with recent advances in hardware, increasingly complex algorithms are being developed with adequate processing time, making it possible to derive useful and fast information from large amounts of information, but the question of efficient hardware implementation remains to execute these algorithms quickly and efficiently.

Along with the development of techniques and studies, the applications of convolutional neural networks (CNNs) have grown considerably, mainly in activities that require understanding at a level comparable to that of a human being, such as natural language processing and computer vision and it is possible to incorporate CNNs to assist in processing audio, image classification, scenario labeling, and facial recognition [1], [2]. Some networks achieve better results than human performance as evidenced in the work of [3]. The impressive performance of these networks comes at the cost of large memory bandwidth and intensive use of computational logical resources [4].

CNNs have excellent performance when it comes to image classification, but such networks require millions or even

billions of operations per second to classify an image, which makes network implementation a challenge in terms of computational power and memory storage capacity. For example, in 2012 Alexnet [5], with a network architecture that required the storage of 60 million parameters to process an image, won the Imagenet contest [6]. In 2014 the VGGNET network [7] wins the same contest, but its design required loading about seven times more parameters, because of this, the network required dedicated hardware to run.

CNNs have enabled the increasing automation of tasks and machines such as autonomous cars, the idea of product delivery via drone is already being discussed [8], but in the same way, as autonomous cars require a large amount of information and an equally large processing power together with a robust algorithm to detect and recognize obstacles [9], drones or autonomous aircraft require an even faster processing and image recognition capacity. To be able to follow the movements and maneuvers performed by these vehicles. The choice of hardware for implementing CNNs is important because it will influence the needs and results of the network, for training the choice mostly adopted is a graphics processing unit (GPU), due to its great capacity for parallelism of calculations, reaching 11 trillion floating point operations per second (TFLOP/s) and due to the need to train the neural network only once, the GPU's energy consumption does not significantly impact the process, as for the implementation of the network in themselves, they can be implemented either on GPU, Field Programmable Gate-Arrays (FPGA) or Central Processing Unit (CPU), being more flexible FPGAs when compared to ASICs, counting on easy and fast implementation in the market and upgradeability even after implementation compared to CPU and it is also worth mentioning its potential for improving the architecture, energy savings compared to GPU and the possibility of using different formats and numerical representations. Microsoft has recently explored the possibility of CNNs on FPGAs as cost-effective network accelerators in a data center [10], [11]. Many studies are being carried out on accelerators for CNNs implemented in FPGAs [12], [13], as well as tools to generate such accelerators automatically [14], [15]. Studies have also been carried out on

CNNs networks with low accuracy, networks using weights and activation function with numbers in binary format [6], [16] and in some cases, the network has an accuracy comparable to networks using 32-bit floating point, these types of implementation are attractive in FPGAs because they take advantage of the efficiency of operations performed on Look Up Tables (LUTs). The implementation in FPGAs has seen more and more attention due to the constant development of tools that help and automate the development of implementations on the board, the Xilinx Vivado tool for high-level synthesis (HLS) allows the user to write code with a reasonable level of abstraction and the tool's algorithm compiles the code for register transfer level (RTL) between registers [17].

For complex tasks that require a large number of calculations, but which, at the same time, demand efficiency and low response time, CNN in FPGA focused on image recognition would be a tool that would drive the development and implementation of such technologies to advance sectors that would benefit from autonomous aerial vehicles and make the autonomous car industry even more robust.

II. NEURAL NETWORKS

A fundamental component of neural networks, in general, are artificial neurons, inspired by biological neurons, which are responsible for most of the processing that occurs in artificial neural networks (ANNs) and can be arranged within a network in various ways.

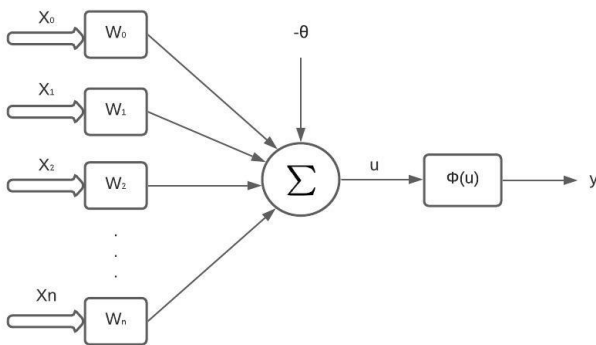


Fig. 1: Perceptron.

It's possible to observe the general structure of a neuron or perceptron in Fig. 1 where from X_0 to X_n representing input data or signals from neurons from another layer, the synaptic weights W_0 to W_n that determine how excitatory or inhibitory the signal is for the neuron. The adder block is responsible for summing the modified input signals with a predetermined value θ called bias, its function is to increase or decrease the net input, in order to translate the activation function on the axis, it can also be used so that, in the network training process, changes in synaptic weights result in less drastic changes in the network as a whole since the bias is independent of the input value in the system, which helps the network to converge on an ideal solution and can also

be used to make the value needed to activate the activation function larger or smaller. NNs generally have a forward propagation architecture where signals entering the system propagate towards the output in a single direction. The model represents artificial neurons and can be represented by the following equations 1 and 2

$$u = \left(\sum_{i=1}^n X_n \times W_n \right) - \theta \quad (1)$$

$$y = \Phi(u) \quad (2)$$

The weight parameters W_n and bias θ are adjusted in the training of neurons in the network according to the final application.

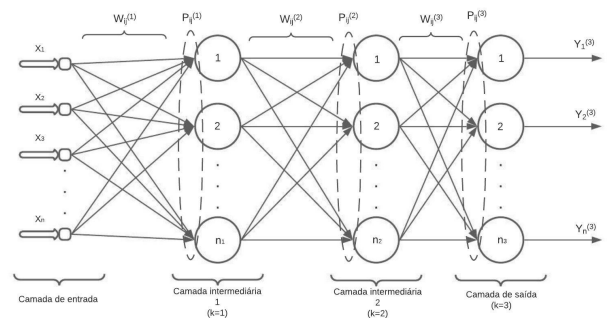


Fig. 2: MLP network.

An ANN can have a different number of layers which can be classified into three categories:

- Input layer: responsible for receiving data, signals, or characteristics from the external environment that are usually normalized in relation to the ranges of dynamic variations produced by the activation functions, which improves the accuracy of the network as a whole.
- Hidden layers: composed of neurons with the function of extracting characteristics associated with the system to be inferred.
- Output layer: a layer of neurons responsible for presenting the final results of the network, from the signals received by the layers that precede it.

The Multiple Layer Perceptron (MLP) network contains at least one intermediate layer, in contrast to the single-layer perceptron network, the MLP has one or more hidden or hidden layers between the input and output layers. MLP networks are more complex in their structure, which allows them to perform more complex work compared to the networks mentioned above and can solve problems that would go beyond binary classification. MLP networks have feed-forward regardless of the number of layers, the first layer captures the signals to be processed, then the intermediate layers extract information about the signals, process and encode through their respective synaptic weights, bias, and activation function and the output layer receives the resulting stimuli from the intermediate layers and produces the network response. Note

that in an MLP network it is possible to have multiple neurons in the output layer, resulting in the network having multiple output possibilities.

The adjustment of synaptic weights of the MLP network takes place through the backpropagation process, which consists of an algorithm that calculates the gradient of the error function, starting at the output layer and propagating towards the input layer, partially reusing the calculations of the gradient of the previous layer to carry out the weight adjustments of the next layer [18]. The specific configuration of an MLP network must be determined from a series of factors such as the class of problem to be treated by the network, arrangement of training samples, initial values, and attributes so that the network can be implemented efficiently.

A. Convolutional Neural Networks

CNNs commonly used for pattern recognition in images have an MLP network architecture, but they stand out for the presence of convolutional layers and often, pooling layers observed in Fig. 3 in addition to the concepts already present in MLP networks.

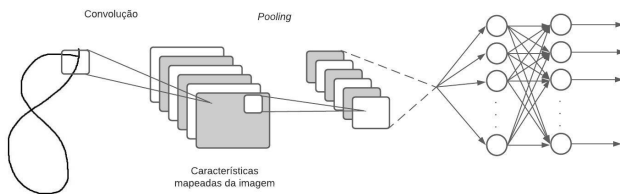


Fig. 3: Convolutional network representation.

Convolutional layers have the function of convolving a weight matrix sectioned across an image to extract relevant information so that subsequent layers can make use of the extracted information to recognize patterns in specific parts of the image. Thus, a convolutional layer can identify intrinsic characteristics of different parts of the image such as horizontal and vertical lines, and specific angles, among other patterns to be processed by the next layers [19], [20]. Pooling layers accompany the convolution layers and their function is to reduce the dimensions of the data provided by the convolution layer, connecting the output of a group of neurons from the previous layer into a single neuron from the pooling layer. The pooling layer can have different aspects, neurons can extract the maximum value or they can average the values received from the group of the previous layer [19], [20].

III. FPGA

The FPGA has a structure with three main components, LUT is responsible for implementing the logic functions, the input and output blocks allow communication with peripherals and the interconnectors that carry out the communication between the blocks and some other components with more specific functions such as the blocks random access memory (BRAM) and digital signal processing blocks (DSP). All the

blocks are configurable so that the user when programming the desired logic into the FPGA, the circuit forms the design structure using the blocks which are essentially a vector or array of combinational logic. Along with LUTs, other resources such as D-flipflops, multiplexers, and transport logic, carry, among others, to implement more complex functions such as boolean functions and multipliers, then LUTs are now called configurable logic blocks (CLB) illustrated in Fig. 4.

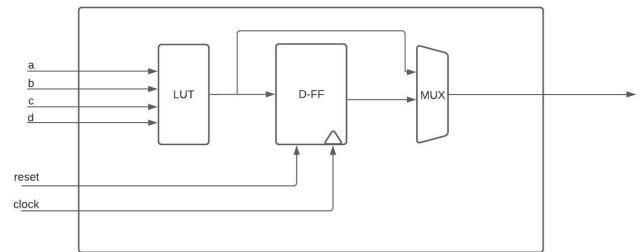


Fig. 4: CLB representation.

Fig. 5 represents a LUT with three inputs (A, B, and C), the possible values of the LUT are stored in a register, because of this, the LUT can be implemented as any function that has the same number of inputs. Once configured the output values are selected according to the inputs. Modern FPGAs have 6-input LUTs and 64-bit registers.

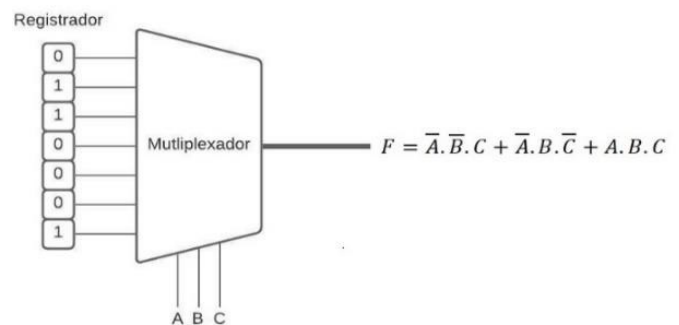


Fig. 5: 3 input LUT representation.

By itself, a single LUT or CLB is very simple and incapable of performing complex logic functions but connected in large amounts are capable of performing complex functions even if the individual power of each block is limited, there are also FPGAs that have a carry chain which connects the LUTs of CLBs with the LUTs of neighboring CLBs allowing the creation of arithmetic functions as adders, with low-level logic efficiently and quickly.

As the priority of FPGA circuits is efficiency in the use of resources present on the board, the interconnection of the most recent FPGAs has logic circuits to assist in the interconnection and routing of the other blocks as seen in Fig. 6, such as connection blocks (CB) that are responsible for connecting the logic blocks with the interconnection rails with the possibility of using any of the rails to assist in routing, and also the switching blocks, which are configurable blocks that connect

the rails themselves to provide more routing possibilities at the time of implementation [21].

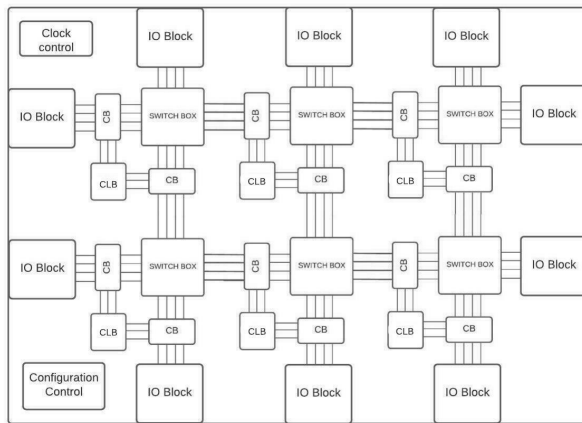


Fig. 6: FPGA structure representation.

BRAMs are memories that allow fast access to data and have the ability to read and write data and are much more efficient for data storage than LUT memory implementations, it is also possible to access two memories in the same block simultaneously, which allows the data preloading or data writing and reading at the same instant. BRAMs can be inferred by the synthesis tool or can be instantiated by the user during design elaboration.

DSP blocks are blocks that allow multiplication operations followed by result accumulation without the use of LUTs, DSPs have a series of configurable functional blocks, the DSP48E1 block present in FPGA Xilinx Series 7 features a 25-by-18-bit two's complement multiplier, a 48-bit accumulator, a pre-adder, a block that can perform the addition, subtraction or accumulating result of multiple data simultaneously, a unit of logical operation with bits like AND, OR, NOT, NAND, NOR, XOR, XNOR, overflow and underflow detectors and configurable pipeline [17].

IV. METODOLOGY

For the implementation of a neural network in an FPGA, it was necessary to generate and train the network externally, for this, R and Python programming languages and the Keras package were used for the elaboration of the neural network and the export of the weights and bias of the trained network with MNIST dataset [22], tests were performed with different network configurations, such as number of layers, number of neurons and activation function to test the implementation in FPGA.

A. Network Weights Preparation

Once the network was trained, the values of the weights and bias of each neuron were exported and manipulated using Excel, with the use of formulas elaborated in the spreadsheets,

it was possible to easily process the data for later implementation in the FPGA. For an integer implementation, the weight and bias values were multiplied by a multiple of 10, depending on how accurate the decimal places would be, for example, for three decimal places the values were multiplied by 1000, then rounded using the formula “=round(‘N’, ‘N° of decimal places’)”. The result was a number with no decimal places, for example, for a weight value of 0.6457, the value implemented in FPGA would be 646.

For training and testing the elaborate network, the MNIST dataset was used, which consists of handmade images of numbers from 0 to 9, widely used for training and testing image processing systems, containing 60,000 images for training and 10,000 for testing, all images are in grayscale with dimensions of 28x28 pixels, so the network input will be 784, a value for each pixel [22].

B. FPGA Implementation

Tests were carried out with different types of networks in the implementation, varying the number of layers, the number of neurons in each layer, except for the output layer, the type of activation function, the precision of decimal places, and the differences between implementation with number integer and with the library for numerical representation with fixed point. For the evaluation of the implementation results, the following parameters were observed: the response time, the network accuracy, the use of board resources, and the energy used for its operation.

1) *Block structure:* For the implementation in FPGA, using VHDL programming language, different blocks were elaborated that together compose the neural network elaborated previously.

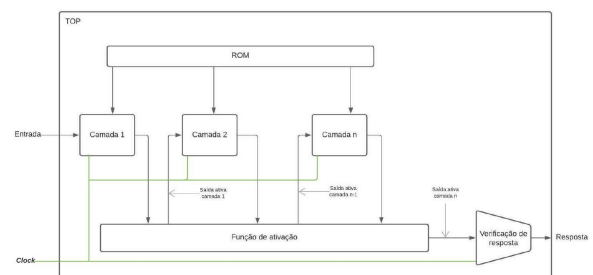


Fig. 7: Representation of the network structure implemented with data storage in LUT.

As illustrated in Fig. 7, the network has six basic blocks in its structure, the TOP block that receives the external data, in the case of this work, receives the values of the pixels of the image to be identified and provides the final response of the network according to the active output of the last layer, the neuron block, illustrated in Fig. 8, is responsible for weighting the inputs by synaptic weights and finally adding the bias, the neurons layer block is responsible for receiving the external input or data from the active output of the previous

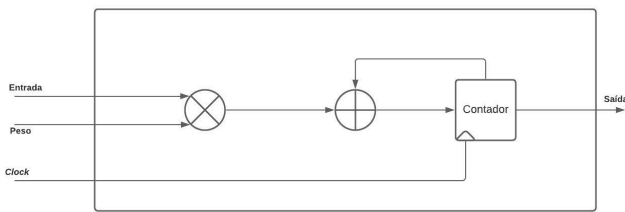


Fig. 8: Single neuron representation.

layer and distribute it to all neurons contained in it, after the completion of the calculations performed by the neurons, the layer sends the accumulated output to the block containing the activation function stored in LUTs or in BRAM, after activating the outputs of the last layer, the data is sent to the block responsible for comparing the activated outputs of the last one and verifying the value most likely to be the correct answer.

The VHDL code was designed in such a way that it is possible to modify the number of neurons and layers with minimal configuration of the code itself, which facilitates testing and adapting the code to different needs such as greater accuracy, fewer used resources, faster response time, etc. after any necessary modifications to the code, the Xilinx Vivado HLS tool is used to synthesize the code for RTL and implement it on the FPGA board.

2) *Numerical Representation:* As it is not possible to synthesize real numbers in VHDL, tests were carried out with two types of numerical representation. The first form of representation used as integers, with the arithmetic operations already implemented in VHDL through the `numeric_std` library, to represent decimal places the input and weight values were multiplied by multiples of ten, depending on the determined precision. For example, for the representation of two decimal places the values were multiplied by one hundred, and the remainder was rounded, the values were then transferred to the FPGA.

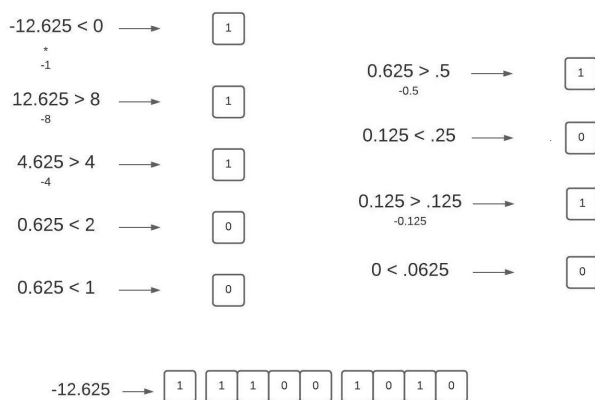


Fig. 9: Fixed point conversion.

The other form of numerical representation used for tests was binary with fixed point, for that, a package was elaborated

and implemented that includes conversion from real number to binary with fixed point, addition and multiplication so that it was possible to implement the network using such numerical representation. with ten bits for the decimal part, 14 bits for the integer part, and one bit for the sign. The conversion was done by an algorithm elaborated in Octave and is done in software before the implementation, it consists of comparisons, between the number you want to convert and each of the numbers that are represented by the bits at a fixed point, as illustrated in Fig. 9.

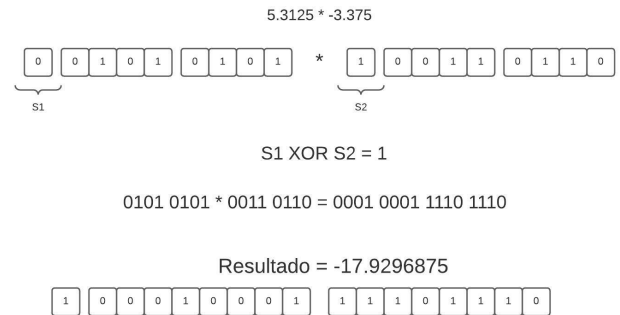


Fig. 10: Fixed point multiplication.

The implemented fixed-point number multiplication is represented in Fig. 10, the operation is relatively simple, performing a standard binary number multiplication and then dividing between the vector that represents the integer number and the vector that represents the decimal. In the example, it can be seen that for multiplication between two numbers with four bits in the decimal part, the result will have the eight least significant bits as the decimal part.

3) *Activation Functions:* Tests were performed with different activation functions to evaluate results, mainly observing the accuracy and resource requirements of the FPGA used to implement the activation function.

For better response times and simplicity of implementation, the activation functions were calculated in software with a programming language with a high level of Octave abstraction, used primarily for mathematical computation, the values were tabulated and stored in BRAM on the board.

Due to optimizations made by the Xilinx Vivado HLS tool during synthesis and implementation, the algorithm can conclude that the activation function can be implemented in a combination of LUTs, multiplexers, and registers for better use of the final design area.

The tests highlighted that implementing the activation function more efficiently is through LUTs elaborated outside the FPGA and stored in RAM for quick access, saving DSP blocks and processing time due to calculations of the implemented model. The test implementation of the activation function determined that the calculations necessary for the sigmoid activation function would be performed in at least four clock cycles for each value, however with the values in LUTs or RAM only one cycle is needed for each value, decreasing

response time without sacrificing accuracy, it is also possible to utilize more resources on the board to calculate the response of the activation function of all output values of a layer at the same time.

4) *Weight Storage*: Two network models were developed in terms of the way of storing the weights of the network, one of the ways was implementation directly in LUTs of the FPGA, once implemented the weights were stored as functions in LUTs, registers, and multiplexers while the other way is initial storage external value of the weights that are then stored in the FPGA's BRAM and during the calculations, the BRAM supplies the weights to the neurons.

The process of storing the values in RAM requires instantiating the blocks according to the number of neurons so that there is one block per neuron, so there will be no difference in the network response time, the process requires an initialization period for the data to be provided by an external source to RAM, however, it is only necessary to perform the process once.

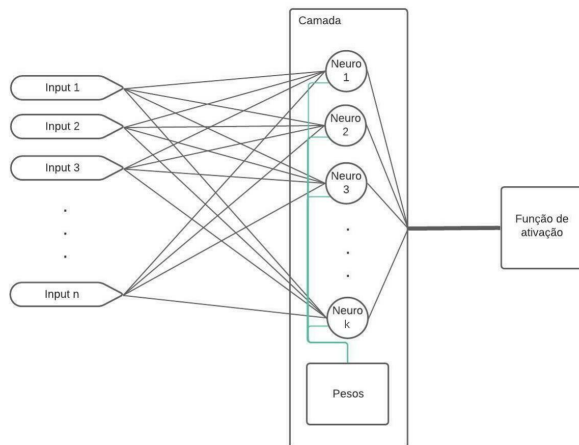


Fig. 11: Representation of a layer with data storage in BRAM.

Fig. 11 illustrates a layer when the method of implementing weights in BRAM is used, the layer block distributes the weights stored in RAM to the respective neurons according to the input, so the layer block has a vector of BRAMs, and each BRAM stores the weight value of each neuron in vector form, so that during the weighting calculation the neuron receives the weight corresponding to the input for each clock period.

5) *FPGA Board Used in Tests*: To perform the tests, the FPGA Basys 3 Artix-7 board was used, which has 33,280 logic cells in 5200 slices, each containing four LUTs of six inputs and eight flip-flops, 50 RAM blocks of 1,800 Kbits each, 90 DSP48E1 slices. For the implementation, 100MHz was used as clock time [17].

V. RESULTS

A. Parallelism

The initial implementation had total parallelism, with a completely asynchronous network it was possible to perform all the necessary calculations in parallel and obtain the result in the picoseconds scale, however for a small network of ten neurons in the hidden layer and ten in the layer of output were used around 103800 LUTs and more than 10000 DSP slices making the implementation unfeasible for the board available for testing.

Based on this experience, it was decided to perform the calculations synchronously, but many of the calculations are still performed in parallel. The network was then modified to perform the multiplication and accumulation calculations for each neuron synchronously, so that each multiplication and addition calculation for a neuron takes three clock cycles at 100MHz to perform, conserving board resources in exchange for a longer response time, but this allows all neurons to perform calculations in parallel so that the number of neurons in the hidden layer minimally changes the total response time of the layer, but increases the number of input values of the next layer which increases the response time on the order of approximately 20ns per neuron. With the reduction of parallelism, it was possible to reduce the resources used by the implemented network considerably.

B. Decimal Place Precision and Numeric Representation

The variation of the precision of decimal places allows both savings in the use of resources on the board with the use of less precision, while greater precision guarantees greater accuracy of the network in exchange for a greater number of resources used, both in the implementation with integers and in the implementation with fixed point. tests were carried out with a different number of decimal places to verify the use of resources. Table I and II demonstrates the test results for the implementation with two and three decimal points, respectively, while Table III test results for the fixed point implementation.

Varying decimal places and comparing with the final accuracy of the network, it was determined that even using more resources, the implementation with greater precision of decimal places, both in the case of the use of integers, as in the use of 25 bits at a fixed point, offered better results, since better network accuracy is expected due to higher numerical precision.

C. Network Design

The VHDL code was designed in such a way that it allows flexibility both in the number of neurons and in the number of intermediate layers and also in the number of input values in the network, to be able to adapt the implementation according to the need, without being limited for the MNIST dataset [22], to only one model or the board used for the tests performed in this work.

Tests were carried out with different numbers of layers and neurons, which varies the number of resources used, the

TABLE I: Integer implementation results with two decimal places of precision.

Integer – 2 decimal places	784x10x10	784x15x10	784x30x10	784x45x10	784x100x10	784x10x10x10
LUTs	6273	7704	11979	13960	33117	7811
DSP	10	25	40	55	100	30
BRAM(18KBits)	10	15	30	45	50	30
Registers	2023	2320	3240	4372	8377	2483
F7 MUX	323	546	973	2330	3229	682
F8 MUX	50	101	150	846	648	168
Original accuracy	92,75%	94,92%	96,70%	97,55%	97,88%	92,42%
Energy consumption	0,133W	0,184W	0,190W	0,197W	*	0,211W
Response time	23.77µs	23.97µs	24.57 µs	25.17µs	27.37µs	47.85µs

TABLE II: Integer implementation results with three decimal places of precision.

Integer - 3 decimal places	784x10x10	784x15x10	784x30x10	784x45x10	784x100x10	784x10x10x10
LUTs	9655	11300	13518	17559	27854	14132
DSP	20	25	40	55	110	30
BRAM(18KBits)	0	15	30	45	50	20
Registers	2955	3026	3423	4460	9652	3358
F7 MUX	1357	1187	1333	1689	3152	1493
F8 MUX	220	228	249	263	740	304
Original accuracy	92,75%	94,92%	96,70%	97,55%	97,88%	92,42%
Energy consumption	0,259W	0,274W	0,307W	0,312W	*	0,288W
Response time	23.77µs	23.97µs	24.57 µs	25.17µs	27.37µs	47.85µs

TABLE III: Implementation results with fixed-point binary.

Fixed point – 25 bits	784x10x10	784x15x10	784x30x10	784x45x10	784x100x10	784x10x10x10
LUTs	7863	8344	10573	12792	22570	9532
DSP	20	25	40	55	110	30
BRAM(18KBits)	10	15	40	45	50	20
Registers	2506	2729	3693	4888	8762	3058
F7 MUX	1146	917	1242	1799	3420	1493
F8 MUX	323	128	157	217	613	304
Original accuracy	0,9275	0,9492	0,967	0,9755	0,9788	0,9242
Energy consumption	.179W	.186W	.26W	.198W	*	.192W
Response time	23.77µs	23.97µs	24.57µs	25.17µs	27.37µs	47.85µs

accuracy of the model, and the response time of the network, after different tests it was concluded that networks with more than one layer did not only consumed more resources and more time, as they did not guarantee better results in the accuracy of the network in general, the network response time being independent of the number of neurons, since all neurons in a layer perform calculations in parallel, the network is more effective, both in response time and accuracy, by increasing the number of neurons in the hidden layer.

D. Activation Function

Tests were performed with different activation functions, taking into account the accuracy of the elaborated network and the consumption of resources on the board, as the output layer needs the Sigmoid or SoftMax activation function, tests

were carried out with the two functions that presented the best accuracy during training was Sigmoid and as the number of resources consumed when implementing any of the functions is similar, around 2000 LUTs or five BRAMs for implementation with integers with three places of precision and binary with fixed point and around 1000 LUTs for precision with two decimal places the most used features in the implementations, the tests were carried out with Sigmoid, while the activation function of the middle layer were carried out tests with different activation functions as mentioned above and hyperbolic tangent and RELU, the tests carried out demonstrated that the hyperbolic tangent activation function has lower accuracy and would consume more board resources than the function RELU which also had better accuracy compared to Sigmoid.

Observing the results of test implementations, it can be concluded that the number of neurons directly affects the resources used by the network and the expected accuracy, while the number of layers also affects the accuracy, consumes more energy and more resources, and increases the response time without a significant increase in.

Comparing the results of integers with representation using binary with a fixed point we can see that there is significant conservation of resources and less consumption of energy, the only obstacle is the conversion of the input data to binary with a fixed point since the algorithm runs externally, the data needs treatment before processing, which would make the network response time larger.

E. Comparison with CPU and GPU Acceleration

The response time in the different tests performed with the hardware implementation was measured and compared with the results of the software implementation using different tools. For testing with CPU, a test was carried out with Intel i7-6700K 4.00 GHz and 16 GB of RAM, it was also carried out in a Kaggle virtual environment, and the results showed an average response time of 20ms for each image, compared with the response time of one-layer network with 45 neurons implemented in 25.17 μ s FPGA, it is possible to notice that the response time is considerably lower. It was also compared to GPU acceleration on both an Nvidia GTX 980TI GPU with 6Gb of dedicated video RAM and a virtual environment so the time reduction was not very significant, reducing the average response time for individual images to 18ms.

VI. DISSCUSSION

Regarding the network accuracy, it is possible to notice that the consumption of resources is directly related to the precision of decimal places of the network, which affects the final accuracy of the implementation, with the calculated error we can estimate the accuracy of the network according to the expected results.

Taking the results of tests carried out with the network implemented with a response time of 25.17 μ s and considering the average speed of a commercial aircraft as 300 km/h, we can estimate that, with the network response time, the plane would travel 0.0020975 meters or 2.0975 millimeters approximately, between the input of the image and the decision making, considering that the response time depends directly on the number of inputs in the network, even if the number of inputs was ten times greater, the plane would still travel less than one meter between image input and decision making.

There is the possibility of using boards with a greater number of resources to implement networks with a greater number of inputs, neurons, and layers.

The greatest demand of convolutional networks is the memory to store parameters and processing power to perform arithmetic and logic operations the main components of FPGA for neural networks are LUTs, BRAM, and DSPs.

VII. FINAL CONSIDERATIONS

Considering the results acquired through the tests of the research carried out, it can be concluded that the implementation of neural networks for image recognition in FPGA has enormous potential for reducing response time, in addition to being economical in terms of energy consumed.

Initial comparisons with CPUs and GPUs show a significant reduction in response time with the potential for optimizations in the implementation to obtain even better results, in addition, the FPGA implementation allows flexibility in updating the network if necessary, complemented by the fact that the code is itself flexible.

A. OPTIMIZATION PROPOSALS

As previously mentioned, there are several ways to implement neural networks for image recognition in FPGAs, being important factors: the number of input values (pixels), the number of dense layers, the number of neurons in each layer, the representation number and its precision. All these factors influence the complexity of the calculations performed, the consumption of logical resources, memory and power on the board, and the total time required for image processing.

There are a series of optimizations that are possible to perform in the model elaborated, in future works, which could further reduce the response time and improve the consumption of resources by the model, some of these improvements are:

- Develop a controller unit for the arithmetic operations performed by the network, thus improving the use of DSPs, using fewer LUTs, and enabling greater parallelism of the calculations performed, limited only by the amount of DSPs on the FPGA board.
- Greater parallelization of the calculations performed, since the calculations consume more time in image processing, using techniques such as parallel reduction could considerably reduce the response time in exchange for greater consumption of resources and energy per image.

B. FUTURE WORKS

The focus of this work was to evaluate the response time for calculations performed by a neural network developed for image recognition, also considering the use of resources and the energy consumed during tests performed with different parameters, but due to the time required, in addition to limitations of resources on the board used for tests for studies carried out on neural networks, FPGA, VHDL, and implementation techniques. It was not possible to implement different types of layers such as the convolution layer and the max pooling layer to test convolutional neural networks completely implemented in FPGAs, considering that the code elaborated is flexible in terms of the number of input values, number of layers and amount of neurons per layer, it is possible to continue the work in the future with the development of convolution and max pooling layers and integrate them into the work already done. Due to the difficulties of testing large amounts of images to verify the accuracy of the network, it would be necessary

to devise a way to send images quickly to the board to verify the accuracy of the implementation.

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TECHNOLOGIES APPLIED TO CONTENT. HOW TO PREPARE FOR THE CONTENT OF THE FUTURE

In a period of so much technological evolution, what can we expect from the future of entertainment and content, how to consume, how to interact, how to create?

At the panel, Experts will discuss the future of audio, video and even content consumption with an approach to emerging technologies and real-world use cases already applied, such as image and audio synthesis, the integration of new computing processes to generate content, and how we should prepare ourselves for this moment.

Moderator: Pablo Bioni - Researcher, VFX Supervisor, and Head of Innovation - Future of Content - Globo

Speakers:

Luiz Kruszielski, Audio Producer - Globo

Sandro Di Segni, Animation and VFX Supervisor

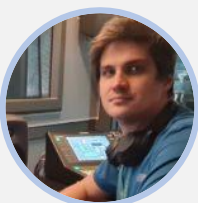
Flavio Mayerhofer, Head of Metaverso Meta4Chain, Director and founder Studio XR



Pablo Bioni - Researcher, VFX Supervisor, and Head of Innovation - Future of Content - Globo

With more than 18 years of experience in VFX, Pablo is a former computer engineer with a master's degree in image processing at PUC-RJ. His main focus is on innovation and technology roadmap forecasts. Pablo has lead R&D academic laboratories and worked in Europe with famous VFX teams and had active participation as a member of ACM, SMPTE, and VES.

Pablo joined Globo's R&D in 2011 as Technical Director, worked on more than 30 products, and is currently head of Innovation and New Technologies applied on content.



Luiz Kruszielski - Audio Producer - Globo

Luiz Kruszielski is an audio producer at Rede Globo, being responsible for the audio of several series and soap operas. He holds a Master's and a Doctor's degree from Tokyo University of the Arts, Japan, where he specialized in psychoacoustics applied to audio-visual. He has also dedicated himself to research on spatial audio and artificial intelligence applied to voice synthesis.

**Sandro Di Segni - Animation and VFX Supervisor**

Working in the animation and VFX market for over 20 years Sandro has participated in big names in the world of Animation such as Star Wars: Clone Wars and Cinema in Harry Potter, Man of Steel, Jurassic Park and more recently in the Miss Marvel series and in Shazam 2 movie yet to be released.

In addition to being an effects specialist, he also created his own startup and ran for a while and acted as an effects supervisor in several national films such as the recently released Pluft, the Fantasminha.

**Flavio Mayerhofer - Head of Metaverso Meta4Chain, Director and founder Studio XR**

Graduated in technology, cinema and marketing, he is a pioneer in immersive technologies in Brazil. Flavio is co-founder of the XRBR Brazilian association of extended reality companies and professionals. He is also the founder of Studio XR, a company specializing in extended reality with several projects using 5G in Brazil, having directed the first holography and VR streaming using 5G in Latin America. He is co-founder of 3DParade, a platform for building metaverses in WEBXR, where he held the first metaverse fair in Latin America, with around 2000,000 simultaneous access. He also created the Futurecom 2021 Metaverse which took place on the 3DParade platform. In its portfolio of projects carried out are the following companies: Globo, Netflix, Samsung, HBO, TV Escola, Petrobras, Shell, Ericsson, Motorola, LG, Casa Bahia, McLaren, Claro, Serasa, Stone, XP Investimentos, L'Oréal, Accor Hotels, among others.

OPEN TV, OTT PLATFORMS AND CONSUMPTION HABITS IN THE POST-PANDEMIC

With the changes in television consumption habits, the need for content producers and broadcasters to understand the real adjustments necessary for audiovisual products made available on online platforms to be delivered to users with high retention/engagement rates has become increasingly evident. The maturing of multiplatform services has shown that the simple transposition of television content to online platforms does not generate satisfactory numbers or effective communication. The panel aims to draw the attention of participants to this problem and how broadcasters can tackle it without drastic changes in their work routines.

Moderator: Fernando Moura - *Editor of the SET Magazine*

Speakers:

Prof. Dr. Francisco Machado Filho - *Assistant Professor at the State University of São Paulo Júlio de Mesquita Filho*

Professor Ph.D. Deisy Feitosa - *Coordinator and professor of the Journalism course at FAPCOM*

THE IMPORTANCE OF LINEAR TV PROGRAMMING IN THE AGE OF STREAMING SERVICES: STRATEGIES AND TACTICS IN THE GRID AND IN THE PROGRAMS GIVEN THE WIDE POSSIBILITIES OF VIDEO CONSUMPTION.

Prof. Dr. Renato Tavares Junior - *Broadcaster, journalist and university professor*



Fernando Moura - Editor of the SET Magazine

Fernando Carlos Moura is a Doctor of Language and Communication Sciences with a specialty in Communication and Culture from the Nova University of Lisbon, Portugal. Editor-Chef of the SET Magazine since 2013 and professor of the Audiovisual Production Degree at the National University of Três de Febrero (UNTREF), Buenos Aires, Argentina. Researcher associated with the Brazilian Observatory of Digital Television (Obted).



Prof. Dr. Francisco Machado Filho - Assistant Professor at the State University of São Paulo Júlio de Mesquita Filho

Graduated in Social Communication, Radio and TV Qualification – Faculdades Espírito Santense (1999), Master's in Communication from the University of Marília (2006) and PhD in Social Communication from the Methodist University of São Paulo (2011). He is currently an assistant professor at the Universidade Estadual Paulista Júlio de Mesquita Filho. He has experience in the field of Communication, with an emphasis on Radio and Television, working mainly on the following topics: communication and technology, convergence, internet, digital TV and business model. He is Vice Coordinator of Intercom's Television and Televisualities Research Group and Director of TV UNESP



Professor Ph.D. Deisy Feitosa - Coordinator and professor of the Journalism course at FAPCOM

Journalist, broadcaster, master in Digital Television, PhD in Communication Sciences, post-doctorate in Humanities, Rights and Other Legitimacies and post-doctorate in Audiovisual Media and Processes. Coordinator and professor of the Journalism course at FAPCOM (Paulus College of Technology and Communication) and collaborating professor at the Department of Cinema, Radio and Television at the School of Communications and Arts at the University of São Paulo (CTR-ECA/USP). Researcher at LabArteMídia and co-founder/co-coordinator of the Brazilian Observatory of Digital Television and Technological Convergence (Obted). Partner of the Television Engineering Society (SET) and contributor to the SET Magazine.



Prof. Dr. Renato Tavares Junior - Broadcaster, journalist and university professor

Author of the book "TV programming: concepts, strategies, tactics and formats". PhD in Audiovisual Communication, Master in Social Communication Interfaces. Bachelor in Radio and TV. Coordinator and professor of the Radio and TV course at the Centro Universitário Belas Artes de São Paulo. Supervisor of the Audiovisual Producer and Rádio Gazeta Online at Faculdade Cásper Líbero, where he teaches courses in Journalism, Radio, TV, Internet and Advertising. Director of the program "Edições Extra" aired on TV Gazeta.

ACADEMIC CALL FOR PAPERS – SESSION 2

This panel will present a set of scientific works that were submitted to the Call for Papers promoted annually by SET.

The selected works will be published in the SET International Journal of Broadcast Engineering (SET IJBE) an international scientific journal whose objective is the dissemination of knowledge about communications engineering, especially in the areas of broadcast and new media.

Moderator: Cristiano Akamine, Professor - Universidade Presbiteriana Mackenzie

ATSC 3.0 DIVERSITY RECEIVER TRIALS

Sungjun Ahn, Senior Researcher - ETRI (Electronics and Telecommunications Research Institute)

This paper identifies the practical gain of diversity receivers by introducing the broadcast field trials conducted in South Korea. The presented results are primarily on the on-vehicle reception of ATSC 3.0 services and were obtained in an operating commercial network. Through the technical review in the first part, it is emphasized that multi-antenna diversity brings a significant reliability gain to mobile broadcasting delivering HD content. This paper also presents original field results that verify the diversity gain in distributing ultra-HD services.

AN IOT BASED PROPOSAL FOR TELEMETRY AND TELECOMMAND SYSTEMS FOR TV 3.0

Alberto Botelho, PhD student in electrical engineering (Mackenzie) | LM Telecom

With the forthcoming evolution of television broadcast systems from TV 2.0 to TV 3.0, the equipment used for remote monitoring and maintaining the quality of services will have to go through a technological update in order to add greater efficiency and interaction between computer networks and the physical world. Telemetry and remote control are widely used in TV 2.0 by means of using GPRS technology. TV 3.0 will need an increased level of interactivity to meet the expected requirements for performance and features. In this context, the joint use of Internet of Things and TV 3.0 in an intelligent and collaborative way is a natural evolution of current Telemetry and Telecommand systems.

AUDIENCE AND COMPLEXITY AWARE ORCHESTRATION

Dr. Mickaël Raulet, CTO at ATEME

Video encoding services are known to be computationally intensive. In a software environment, it is desirable to be able to adapt to the available computing resources. Therefore, modern live video encoders have the “elasticity” feature. That is, their algorithmic complexity adapts automatically to the number and capabilities of available CPU cores. In other words, the more CPU are allocated to a live video encoder, the higher the encoding performance. Until recently, the elasticity feature was used as an ad-hoc adaptation to uncontrollably varying conditions. In this paper, mechanisms allowing to take control of the computing resource are presented. Two real-time resource optimizations strategies are then proposed. The first one is based on video content complexity and manages the video head-end costs, while the second relates to audience measurements and targets network bandwidth usage optimization.

CHANNEL BONDING AND MIMO OF ATSC 3.0 BROADCASTING SYSTEM

Bo-mi Lim - Senior Researcher - ETRI (Electronics and Telecommunications Research Institute) Korea

This paper introduces channel bonding and multiple-input multiple-output (MIMO) technologies adopted in Advanced Television Systems Committee (ATSC) 3.0, a recently developed digital terrestrial television standard. Channel bonding and MIMO are aimed at enhancing the channel capacity, so they enable to deliver rich media services such as 8K ultra-high definition (UHD) video. Several researches to evaluate the two technologies through intensive computer simulation, laboratory tests, and field experiments are also introduced briefly, in addition to a newly conducted laboratory test of channel bonding.

IMPLEMENTATION OF RECONFIGURABLE COMMUNICATION SYSTEMS FOR LOW EARTH ORBIT SATELLITES BASED ON SIMULINK

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he initiatives to create constellations of low-orbiting satellites have paved the way for the development of communication systems for them. Given that these systems have to be robust, in order to provide unlimited connectivity across the planet, helping to connect the unconnected.

Thus, the article describes an implementation of a reconfigurable system for low-orbit satellites based on Simulink. Reconfigurability is possible through Software Defined Radio technology, which allows some or all of the physical layer functions to be implemented via software. This is a great advantage for satellites, since in space it is not feasible to change the hardware. Thus, it is possible to modify the communication parameters through a radio base station, that is, remotely.

Therefore, through the simulation in the Simulink software, reconfigurability becomes capable insofar as it makes it possible to change the parameters of the blocks and the blocks themselves. In it, the system presents the receiving chair that receives information from the subsystem called Command, that is, command data from the ERB related to the proper functioning of the satellite systems. These data, modulated in BFSK (Binary Frequency-shift Keying) and in FM (Frequency Modulation), are demodulated. Then, in the transmitting chair, called Telemetry, it is modulated in BPSK (Binary Phase-shift

Keying) to be sent back to the ERB with information related to the health and status of the satellite.

MOBILE RECEPTION ON TV 3.0: A CASE STUDY WITH ADVANCED ISDB-T TECHNOLOGY

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This article presents the results of mobile reception tests in the field of Advanced ISDB-T in Rio de Janeiro, taking as parameters the requirements defined in the call for proposals for TV 3.0. This scenario is particularly challenging due to the rugged topography and the presence of large bodies of water. It is noteworthy that, unlike the tests in Japan, which sought a high transmission rate, the tests carried out in the city of Rio de Janeiro aim to evaluate the robustness and performance of the system under various reception conditions, thus validating pre-established criteria.



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ATSC 3.0 Diversity Receiver Trials

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Abstract—This paper identifies the practical gain of diversity receivers by introducing the broadcast field trials conducted in South Korea. The presented results are primarily on the on-vehicle reception of ATSC 3.0 services and were obtained in an operating commercial network. Through the technical review in the first part, it is emphasized that multi-antenna diversity brings a significant reliability gain to mobile broadcasting delivering HD content. This paper also presents original field results that verify the diversity gain in distributing ultra-HD services.

Index Terms—Multi-antenna diversity, mobile broadcasting, field trial, receiver-on-vehicle.

I. INTRODUCTION

ONE featured use case of ATSC 3.0, the 2nd generation terrestrial broadcasting standard, is mobile broadcasting. The physical layer of ATSC 3.0 has accordingly adopted ultra-robust transmission modes that can cope with severe signal conditions. As infotainment has recently arisen as essential in the automotive industry, television-in-vehicle has become a great interest of media broadcasters, so that it lets ATSC 3.0 become more attractive. However, still, a featured knowledge in this field is that the users moving at very high speed are prone to lose the service signal due to the mobility-caused effects, such as Doppler spread [1].

A diversity receiver exploiting multiple receive antennas is a promising solution to this mobile-vulnerability issue [1], [2]. This solution is seen as impactful because it readily allows expanding the broadcasters' market toward the automotive industry. From this motivation, several studies have reported the feasibility of diversity receivers on broadcasting-over-vehicles, particularly on top of the ATSC 3.0 systems [3]–[6]. This paper comprehensively identifies the mobile coverage gain of diversity receivers in the real world. Focused on the field trials in South Korea, the results in [4] are first summarized, and the sequel test results are subsequently introduced as an original work.

II. DIVERSITY RECEIVER MOUNTED ON VEHICLE

It is a feasible idea to implant multi-antenna diversity into the vehicle-type broadcasting receivers. Terrestrial broadcasting typically exploits UHF or VHF bands, whose wavelengths are longer than that of cellular carriers. For instance, the 700 MHz UHF signal has 42.9 cm wavelength. For this reason, in contrast to the cellular handheld terminals, the broadcasting sector has suffered from a problem with

employing multiple co-located receive antennas in the mobile terminal. However, in case of vehicle-mounted receivers, it is possible to acquire sufficient inter-antenna distance to avoid undesired coupling.

A. Receiver Structure: Signal Combining

This physical capability allows the diversity receiver being a solution for the high-speed reception issue in mobile-oriented broadcast media. To this end, a prototype product of ATSC 3.0 diversity receiver has been developed to perform MRC over the input branches [3]–[6]. The diversity receiver performs a weighted summation across the signals received at each antenna branch to feed it into the demodulator. For this procedure, down-converted, post-ADC signals were used. According to the presented implementation, up to four-antenna combining is supported. If a branch signal is lost, the corresponding branch was dropped from signal combining.

III. FIELD TRIALS AND RESULTS

A. Test Environment

The diversity receiver trials took place in Seoul and the surrounding metropolitan area within the Gyeonggi Province. In the service area of interest, more than ten coordinated towers operate to form an SFN [7]. To be emphasized, every trial was conducted in the commercial broadcaster's ATSC 3.0 network currently operating for service. The experiments used 768 MHz UHF channel for transmission.

The measurements were performed in a customized test vehicle equipped with an ATSC 3.0-specific measurement platform. For the diversity reception, 0 dBi isotropic antennas were installed on the rooftop of the vehicle, where sufficient isolation was secured by guaranteeing the distance of more than a half of signal wavelength between every pair of antennas.

B. Previous Results: Mobile HD

We first discuss the results reported in [4], which the HD video services were of interest. The experiment evaluated the reduction of required field strength subject to the ESR5 criterion of ITU-R. The service signal was modulated under 8k-FFT and held 1.6 Mbps capacity. Within the expected service area, driving through a predetermined urban route, the test vehicle recorded the physical layer error rate and field strength simultaneously with the GPS location data.

From the resultant data presented in Fig. 1, it was demonstrated that 4-antenna diversity can advantage the on-vehicle reception by reducing the field strength requirement by 13 dB compared to the single-antenna reception.

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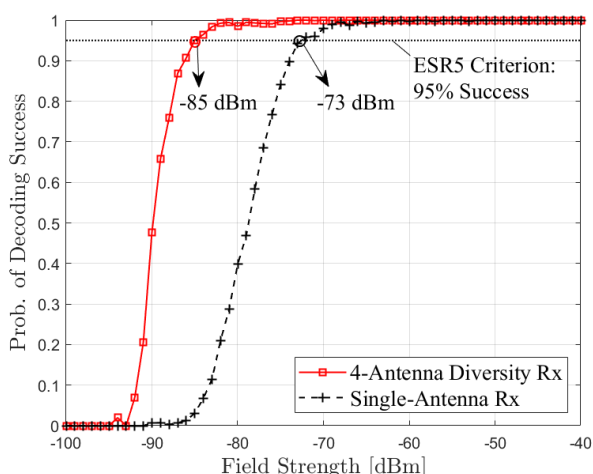


Fig. 1. Field experiment results for mobile HD scenario (reported in [4]): Decoding success probability vs. field strength.

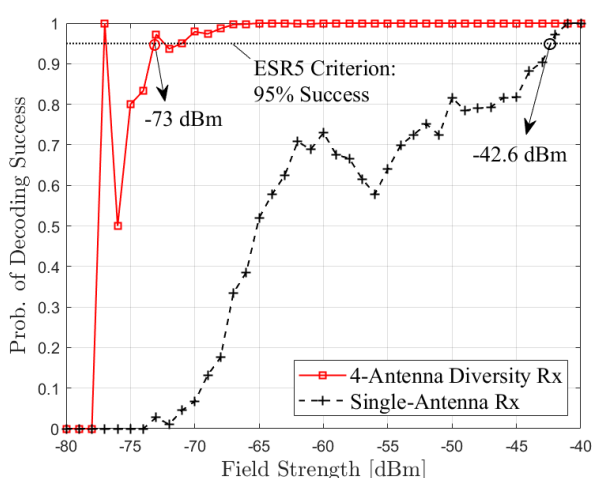


Fig. 2. Field experiment results for UHD reception in vehicle: Decoding success probability vs. field strength.

C. New Results: UHD Reception on Vehicle

In addition, the possibility of terrestrial UHD TV in vehicle was newly testified in this work. Particularly, a 16.4 Mbps video content was transmitted for the experiment. To make the system suitable for a mobile scenario, 16k-FFT was applied to reduce inter-carrier interference, different from the previous experiments [3] conducted in 2020.

Fig. 2 shows the ESR5 curve of this UHD trial. The 4-antenna diversity receiver required -73 dBm for ESR5 while the single-antenna receiver was seen to require 20 dB more. In addition, it was also verified that using 4 antennas can allow the receiver to keep under service while driving at 100 km/h.

IV. CONCLUSION

This paper investigated the practical gain of diversity receivers, specially by introducing the field trials conducted in South Korea. Based on the results obtained in operating networks, the feasibility of multi-antenna diversity was verified for *ATSC 3.0-on-vehicle*. Particularly, significant reliability gains on HD and ultra-HD services were observed, where vehicle-mounted four-antenna reception was compared with the conventional single-antenna reception.

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An IoT Based Proposal for Telemetry and Remote Control Systems for TV 3.0

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Summary— With the forthcoming evolution of television broadcast systems from TV 2.0 to TV 3.0, the equipment used for remote monitoring and maintaining the quality of services will have to go through a technological update in order to add greater efficiency and interaction between computer networks and the physical world. Telemetry and remote control are widely used in TV 2.0 by means of using GPRS technology. TV 3.0 will need an increased level of interactivity to meet the expected requirements for performance and features. In this context, the joint use of Internet of Things and TV 3.0 in an intelligent and collaborative way is a natural evolution of current Telemetry and Remote Control systems.

Index Terms— IoT, TV 3.0, NB-IoT, Telemetry, Remote Control.

I. INTRODUCTION

In Brazil, terrestrial broadcast TV services still have great penetration among the population and the market. The behavior of broadcast TV consumers is different from the behavior of stream video consumers internet, which have specific requirements, characteristics, and particularities. Nonetheless, as the next generation of TV, TV 3.0, is introduced, new services are expected to be offered to the general population, providing a more realistic and interactive user experience to users. In this context, broadcast TV systems need to adapt to the new behavior and expectations of video consumers [1].

Normally, terrestrial TV relays are installed in remote locations, difficult to access and to monitor. To overcome the difficulties and costs of technical visits to stations that are difficult to access, broadcasters choose to install telemetry and remote control interfaces to the transmission equipment. GPRS (General Packet Radio Service) is the telecommunications network widely used in telemetry and remote control of relay stations because it is not very complex, has low instability and is present throughout the Brazilian territory, unlike the third, fourth or fifth generation of wireless mobile networks.

With the evolution from TV 2.0 to TV 3.0, concepts to identify the quality of TV service will need greater efficiency and interaction between computer networks and the physical world. Therefore, broadcast TV needs to

consider migrating from GPRS to a technology that maintains its advantages but also adds the flexibility of providing a range of new services.

Internet of Things (IoT) technology allows things or devices to act intelligently and collaboratively, in an architecture that encompass sensing, communication, storage, decision, reporting and knowledge extraction. The use of IoT enables a plethora of possibilities to remote control of remote TV stations, by means of an IP protocol wireless communication link such as EC-GSM-IoT (Extended Coverage GSM Internet of Things), LTE-M (Long Term Evolution for Machines), NB-IoT (Narrowband Internet of Things), LoRa (Long Range) and SigFox technologies.

This article presents a proposal for the telemetry and remote control of TV 3.0 stations based on IoT systems. The some basic features of GPRS, currently in use, and IoT proponent technologies such as EC-GSM-IoT, LTE-M, NB-IoT, LoRa and, SigFox, NB-IoT is designed to meet IoT requirements and needs and with the potential to be the evolution of current telemetry and remote control systems on TV 3.0, with the main advantage of being widely broadcast in Brazilian territory.

II. TELEMETRY AND REMOTE CONTROL IN TV BROADCAST 2.0

Brazilian legislation regulates the transmission of terrestrial TV, in compliance with the Brazilian Telecommunications Code. Generator stations carry out audio and video broadcasts of programs originating from their own studios and relay stations capture the generator's signals for retransmission in full without interruption [2]. Each generator has, on average, approximately 12 relay stations, but some larger networks may have more than a hundred relay stations. Usually, the relay stations are installed in remote locations, difficult to access and difficult to communicate [3]. Figure 1 shows a typical example of a relay station in a hard-to-reach location.

To overcome the difficulties and costs of technical visits to remote stations, broadcasters choose to install telemetry and remote control by telecommunications network. Telemetry includes sensors in the transmission system whose data will be forwarded to a monitoring and control center to process and display the collected information. The

remote control allows one to send commands to the transmitter, such as changing settings and turning equipment on or off.



Figure 1- Relay station in a hard-to-reach location.

In telemetry, sensors are designed to identify the quality of TV service. The mains voltage sensor monitors single-phase or three-phase mains and converts it to the digital standard 0 to 5 VDC. The temperature sensor monitors the temperature of the indoor environment, where it is converted into voltage levels. An RF detector provides a voltage level correlated with the output power that allows accurate tracking of information from the transmitter circuitry. The battery bank sensor provides a reading of the capacity of the batteries that supply the relay station in the event of a power failure. The door sensor is installed in the equipment's internal environment for property security. Telemetry components are displayed in table format for easy viewing [4].

In remote control, the interfaces are designed to change settings or turn equipment on and off. The remote-control access page has been designed to facilitate the configuration of the equipment. The system is configured to generate alarms when reaching pre-assigned critical levels. These alarms can be audible or sent by electronic messages such as email and messaging app [4].

The communication of telemetry and remote control with the user is done by means of an existing telecommunication infrastructure. Usually, communication is implemented by GPRS (General Packet Radio Service), a second-generation mobile telephony service that reuses the GSM infrastructure [5].

GPRS has a very low data rate for most applications, but sufficient for telemetry and remote control. It is not very complex, has a very stable profile and is present throughout the Brazilian territory. Installation is simple, as the equipment only needs a chip to connect to the internet, without the need to adapt equipment and with good cost-benefit due to data plans paid monthly to operators. The

station is “Always-on” which facilitates instant connection and ensures connection most of the time [5].

GPRS uses an architecture with 2 network nodes, the SGSN (Serving GPRS Support Node), which delivers the packets to the mobile station and the GGSN (Gateway GPRS Support Node), which interfaces between the backbone and the external network. It supports QoS and allows you to configure service, reliability, delay, and throughput parameters. The GPRS location management is based on the definition of a mobile station model, being able to perform some or many location updates. Allows efficient use of radio resources, as it allocates one to eight time slots per TDMA frame, only when data packets are sent or received, being released after the packets are transmitted [6].

In addition to physical channels, a series of logical channels are defined in the GPRS system to perform a multitude of functions, such as signaling, transmission of general system information, synchronization, channel assignment, paging, or payload transport [6]. Figure 2 shows the essential components of the GPRS architecture. Mobile stations establish connection and communicates with BTS (Base Transceiver Station). BTS establishes communication with BSC (Base Station Controller). BSC establishes communication with MSC (Mobile Switch Center), registers (home locations, visited locations, identity and registration) and GMSC (Gateway MSC).

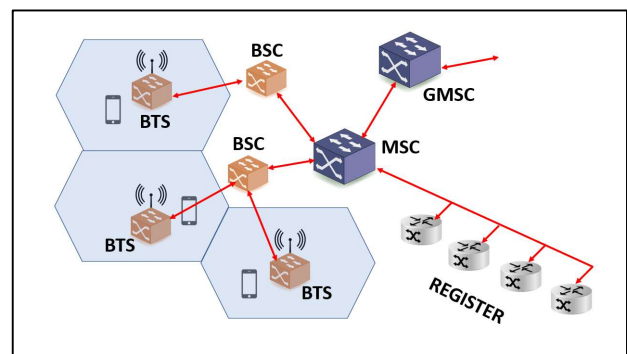


Figure 2- Essential components of the GPRS architecture.

Figure 3 shows block diagram of current telemetry and remote control system [7] [8].

III. TV 3.0

The next generation of TV, TV 3.0, needs to adapt to the new behavior of video consumers, with new concepts of physical layer, transport layer and application layer.

The physical layer must support traditional over-the-air transmission and a broadband internet interface and will be based on frequency-1 reuse, which allows the use of the

same RF channel by independent stations [9].

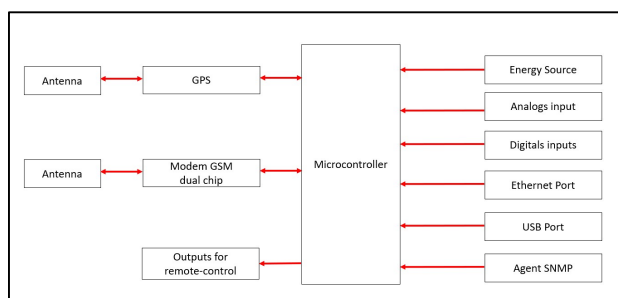


Figure 3 - Block diagram of TV 2.0 telemetry and remote control.

The transport layer must allow synchronization of audio, video, and data frames across different dynamic content delivery platforms or in enhancement layers. It should be IP-based, real-time, low-latency, low-overhead error detection, and deliver encrypted Internet content. Taking advantage of the physical layer's frequency-1 reuse, each broadcast station must be uniquely identified. Emergency notices must be supported, over the air and over the Internet [10].

The transport layer must be enhanced with video on demand, synchronized supplemental content, audio-visual enhancement over the Internet, and targeted content. In addition to the interactivity and integration functions between over-the-air and over the internet broadcasting, the TV user experience will now be application-oriented [10].

The complexity of TV 3.0 will require a more intelligent monitoring network capable of managing its own activities. The infrastructure will need greater integration between the data available in the objects, thus, the communication between the relay stations and the user must happen more efficiently, and more resources can be exploited.

TV 3.0 will need to adapt to new applications, but it must also maintain the same efficiency in current telemetry and remote control applications, not very complex, with low instability, easy connection, presence throughout the Brazilian territory, simple installation and at a good cost-benefit from data plans paid monthly to operators. The data rate is not critical and can be kept low as long as it is sufficient for telemetry and remote control [5].

IoT applications enable smarter monitoring and are the natural evolution of telemetry and remote control.

IV. IOT IN TV 3.0

IoT is a concept by which objects, equipment, systems, people, and services share data, information, services, and actions in large volume through computer network connections. IoT applications are becoming a major force in the economy and a challenge due to their

multidisciplinary nature in a wide variety of areas. IoT technologies allow things or devices to act intelligently and collaboratively, which along with cybernetic systems, cloud computing and machine learning, form the basis for the so-called "Industry 4.0". The biggest challenges are the lack of IoT application standards, multitude of technologies and products from various manufacturers [11].

As IoT devices are expected to grow, long range wireless internet technologies have been standardized on EC-GSM-IoT, LTE-M, NB-IoT, LoRa and SigFox. Therefore, broadcast TV needs to consider migrating from GPRS technology to one of those just listed in order to profit from migrating to IoT applications.

SigFox and LoRa are unlicensed carrier technologies. SigFox uses ultra-narrow band, with a rate of 100 bps, coverage of 50 km, asynchronous transmission, random frequency, transmits 3 replicas in 3 frequencies, module always listening, with high energy efficiency and a downlink window of 20 to 25 seconds. LoRa is a noise-robust spread spectrum technology with a rate of 0.3 to 27 kbps, 15 km coverage, 20 dB of indoor penetration and 3 module classes always listening, listening only after transmission from the end device and listening on a regularly adjustable frequency [12]. Both technologies depend upon the existence of a dedicated infrastructure that may or not be available at the TV station location.

EC-GSM-IoT, NB-IoT and LTE-M are carrier licensed technologies. EC-GSM-IoT reuses 2nd generation GSM infrastructure with original GSMK modulation that can be switched to 8PSK, downlink rate up to 240 kbps for 8PSK, high latency of 700 ms to 2 seconds and bandwidth of 200 KHz per channel [13]. NB-IoT uses ultra-narrow band, with rate up to 144 kbps, coverage of 11 km, bandwidth of 200 kHz and 3 operating modes, in-band, guard-band and autonomous. LTE-M uses narrowband, with a rate of up to 1 Mbps, coverage of 11 km, bandwidth of 1.08 MHz and in-band operation [12].

SigFox and LoRa were developed for specific applications, depend on a dedicated infrastructure and are not widespread throughout the Brazilian territory. This is an important disadvantage for TV, as the stations can be located anywhere in the country, usually in remote areas. EC-GSM-IoT, NB-IoT and LTE-M are easy to implement with software updates of the existing cellular network, widespread throughout the Brazilian territory [12].

NB-IoT is the most popular technology in Brazil, with 4,091 municipalities served and 93.7% of the population covered as of March 2022 [14]. Because TV relay stations are usually installed in areas that are difficult to access, the covered area is as important an indicator as the covered population.

NB-IoT connects devices that require small amounts of

data, over long periods, in hard-to-reach areas. It is designed to deliver 20dB coverage, 15+ years of operation on a single battery charge, and compatibility with existing cellular network infrastructure, with the same level of security as LTE, in a variety of frequency bands using a wide bandwidth of just 200 kHz. It offers eDRX (Extended Discontinuous Reception) and PSM (Power Saving Mode) capabilities, allowing devices to switch to a deep sleep state for up to 310 hours. It supports maximum coupling loss of 164 dB, which is a 20 dB better link budget compared to GPRS, which facilitates its penetration capability in hard-to-reach places [15]. Penetration capability is important for television relay station applications.

In standalone operation mode, NB-IoT uses dedicated carrier to take advantage of GSM exclusive channel. In in-band mode, NB-IoT operates within the bandwidth of an LTE broadband carrier. In guard band mode, NB-IoT operates LTE guard band [15].

The NB-IoT architecture can be visualized in Figure 4. NB-IoT UE establishes connection and communicates with eNodeB (Evolved Node B). eNodeB performs air interface access processing and manages the cell. EPC (Envolved Packet Core) forwards IoT data to the IoT platform. IoT Platform accumulates the IoT data from various access networks and forwards it to the respective application server. Application Server is the data aggregation endpoint and processes the data as per the customer's specifications and requirements.

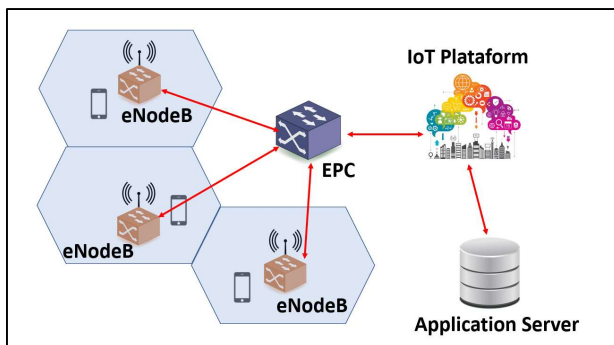


Figure 4 - NB-IoT architecture.

NB-IoT is becoming widespread around the world, however, migration from the current system, from telemetry and remote control in GPRS technology, to telemetry, remote control and IoT applications in NB-IoT technology needs specific application development in the new technologies of TV and adaptation of existing equipment.

New applications are challenging and will require development of an IoT application methodology. To solve real-world TV 3.0 projects, it will be necessary to define the

problem, brainstorm, summarize, formulate objectives, search for data, discussions, and solutions [11].

To adapt existing equipment, the critical point is the GSM modem that needs to be replaced by an NB-IoT modem. The user configures the modem with the IP address and port for accessing the remote application and with the cellular network identification parameters, which can be configured for Ethernet, TCP/IP or serial interfaces [16]. IoT system block diagram for TV 3.0 can be similar to TV 2.0 telemetry and remote control with modem upgrade as Figure 5.

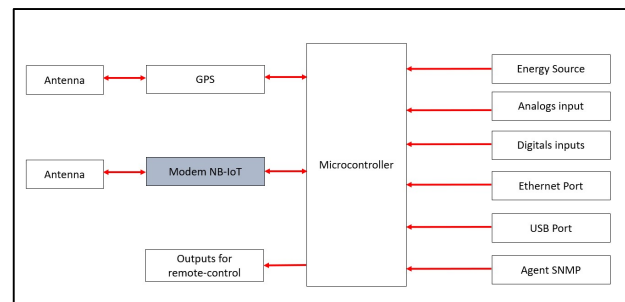


Figure 5 - IoT block diagram for TV 3.0.

The adoption of an IoT solution enables the use of a light protocol to transfer information. Among the protocol candidates, MQTT (Messaging Queuing Telemetry Transport) is a serious candidate for TV3.0 telemetry and remote control due to its characteristic of being a lightweight very effective protocol. It works on a publish-subscribe basis, as illustrated by Figure 6 [17].

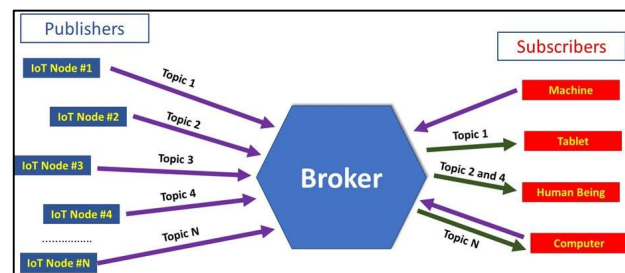


Figure 6 - MQTT system

The central role of MQTT protocol is a centralized server to which sensors will publish and clients will be subscribed. Whenever a remote node has a new information to be posted, it publishes it to this server. The server, then, sends this information to the clients that have subscribed previously to receive that specific topic. This way data sources, and information recipients are decoupled in both time and space, avoiding deadlocks in the network.

MQTT provides 3 levels of Quality of Service (QoS) to

allow flexibility in the data traffic requirements for the IoT system. This protocol also assures scalability to support a wide range of numbers of relay station locations and control points as a TV network. For all its inherent features, MQTT may be the protocol of choice for TV 3.0 supervisory system.

V. CONCLUSION

GPRS is the telecommunication network widely used in telemetry and remote control of TV relay stations in a unstructured system. However, the next generation of TV, TV 3.0, will need a more effective and flexible approach for its supervision. IoT applications allow things or devices to act intelligently and collaboratively and will surely be able to accommodate the new requirements in TV 3.0.

The basic technical characteristics of the most important IoT technologies such as EC-GSM-IoT, LTE-M, NB-IoT, SigFox and LoRa technologies were reviewed in this article.

SigFox and LoRa are technologies from unlicensed operators, they were developed for specific applications, require dedicated structure and are not widespread and spread throughout the Brazilian territory. EC-GSM-IoT, NB-IoT and LTE-M are carrier-licensed technologies, easy to implement with software upgrade from existing network. NB-IoT is the most widespread throughout the Brazilian territory, developed for penetration in areas of difficult access, the main characteristic of TV relays.

New data transport protocols are necessary to be used to enable the flexibility and scalability of supervisory system of a TV 3.0 network. Out of them, MQTT is a serious candidate to fulfill these requirements and provide the possibility of implement new services.

The migration of the current system, from telemetry and remote control in GPRS technology, to telemetry, remote control and IoT applications in NB-IoT technology, is possible with the development of an IoT application methodology and adaptation of existing equipment, being that the critical point is the switch from GSM modem to NB-IoT modem.

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Audience and complexity aware live video encoders orchestration

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Abstract—Video encoding services are known to be computationally intensive. In a software environment, it is desirable to be able to adapt to the available computing resources. Therefore, modern live video encoders have the “elasticity” feature. That is, their algorithmic complexity adapts automatically to the number and capabilities of available CPU cores. In other words, the more CPU are allocated to a live video encoder, the higher the encoding performance. Until recently, the elasticity feature was used as an ad-hoc adaptation to uncontrollably varying conditions. In this paper, mechanisms allowing to take control of the computing resource are presented. Two real-time resource optimizations strategies are then proposed. The first one is based on video content complexity and manages the video head-end costs, while the second relates to audience measurements and targets network bandwidth usage optimization.

Index Terms—Video compression, live encoding, Kubernetes, orchestration

I. INTRODUCTION

In the field of video encoding, microservices architecture is becoming more and more beneficial over monolithic applications. The concept of microservices [1][2] allows a dramatic reduction of the design and implementation cycles durations and simplifies support and update of the applications. The virtualization concept on the other hand, allows being highly flexible and independent of the hardware. In the case of video compression, where performance is critical, the optimal granularity of the microservices must be optimized under constraints of real-time, low-latency, efficient data flow and availability. Practically, microservices must be stored in containers. The high number of containers requires orchestration. Among many available solutions [4][5][6], the work presented in this paper relies on Docker [7] for containerization and Kubernetes [5] for orchestration.

The video encoding solution considered in this paper is composed of several independent services which are thus managed by Kubernetes. However, the performance of a practical implementation of a video encoder is a trade-off between bitrate, perceived video quality, computing resource and architecture design. Kubernetes allows controlling the number of resources dedicated to each microservice. Thus, in the video compression context, one may consider allocating the resource non uniformly to different video services, depending on the desired trade-off for each video service. This must be carried out explicitly by the user though, since

Kubernetes, as an orchestrator, is blind to the specifics of each application.

The proposed allocation solution will leverage previously introduced method [8] to seamlessly update the CPU for a service running on Kubernetes without service interruption. A full experimental system is demonstrated, applying the proposed dynamic resource allocation to a set of live encoders deployed in a Kubernetes environment. The rest of this paper is organized as follows: first, some elements of context and preliminary results are provided. Then two versions of the custom-orchestrator are detailed, complexity-based and audience-based. Finally experimental results are provided for each mode before conclusion.

II. CONTEXT, ELASTICITY AND CPU ALLOCATION

A given video encoder implementation can provide several trade-offs between resource consumption and video quality. This is the case, for example, with the High Efficiency Video Coding (HEVC) implementation x265 [9]. The tuning parameter (`-preset`) allows choosing a speed/coding performance trade-off in a range of predetermined settings. In this paper, the considered encoder adapts automatically to the available computing resources. That is, given the real-time constraint, the encoder chooses its parameters automatically depending on the platform capacity and current load. This tuning is updated dynamically. If the overall load of the platform changes, the tuning changes accordingly. The more computing resources available, the better the delivered coding efficiency. This concept is called video encoder elasticity [14].

As an illustration of the elasticity concept, example experiments have been conducted using the HEVC codec in its default configuration. All the considered video sequences have a 1080p (high definition, HD) resolution. Fig. 1 presents rate-distortion curves [12] for several encodings of the same 12 minutes movie extract. Each encoding is performed in real-time, with a fixed number of central processing unit (CPU) cores allocated to the corresponding microservice. In the video compression context, a rate-distortion curve illustrates the trade-off between bitrate and distortion (or quality) achieved by an encoder implementation or configuration. A configuration is found to be better than a reference configuration if its rate-distortion curve is above the reference rate-distortion curve. That is, for a given distortion, the bitrate is found to be lower, or conversely, for a given bitrate, the quality is found to be higher. The experimental observations confirm that the encoder adapts to the available

computing resource. Indeed, all the curves of Fig. 1 have been generated with strictly the same configuration, except for the number of CPU allocated. Thus, the rate-distortion performance improves as the CPU number increases.

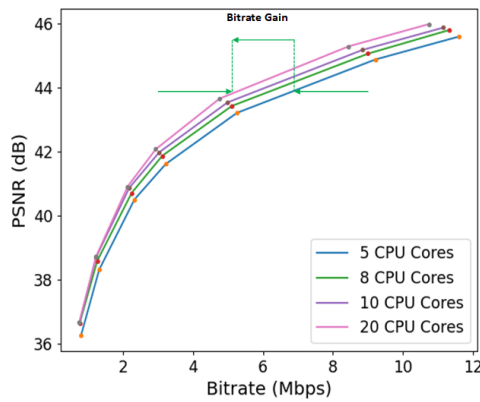


Fig. 1: Rate-Distortion curves for different CPU core allocations.

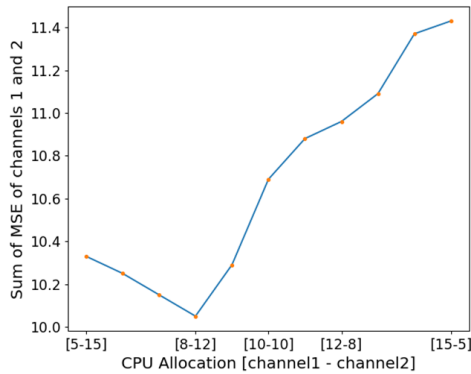


Fig. 2: Sum of Mean Squared Errors (MSE) for different CPU allocations among two video channels.

In a second experiment, the encodings of two different 12 minutes movie extracts are considered. The two contents have the same resolution and are both encoded using HEVC. An arbitrary fixed budget of 20 CPU cores is allocated to be shared between the two encoders. One must note that this fixed CPU budget is shared in a controlled manner between the two channels. A first part is allocated exclusively to the first channel, and the remaining part is allocated exclusively to the second channel. One may split it even and allocate 10 CPU cores to each channel or decide to allocate more CPU cores to one of the channels. The goal of this experiment was to find the optimal repartition of these 20 CPU cores between the two encoders, which minimizes the distortion for a given bitrate. The experiment showed that the allocation that maximizes the overall quality is not uniform, as illustrated on Fig. 2.

Both encoders have the same configuration, the difference is the encoded content itself. The channel 2 contains more complex content compared to channel 1. A video sequence is said to be more complex if it contains more information, like more motion or image texture, than the other sequence. The encoder must make more effort on a complex sequence to achieve the same coding efficiency as on a simple sequence.

III. COMPLEXITY BASED ORCHESTRATION

A. Dynamic CPU allocation

The second experiment (Fig. 2) showed that for two channels with the same configuration, the allocation that minimized the distortion – thus maximizes the video quality – is not a uniform allocation, but rather a CPU cores distribution where the channel with high content complexity needs to be allocated more than the lower content complexity channel. Additionally, it is well known that the characteristics of contents are not constant in time. This is especially true for a 24/7 live channel. With a limited number of computational resources, dynamic resource allocation can improve the overall compression efficiency of a set of live channels.

The encoders run as part of a micro-services application in a Kubernetes cluster. All encoding services are running in Pods, the smallest Kubernetes manageable unit. A Pod contains one or several containers, and the hardware resources (CPU, memory, ...) are managed at the container level. The native and supported way for Kubernetes to update the resources allocated to a container in a given Pod is to stop and restart the Pod with the desired resources allocation.

For a live video encoder, the reboot of the Pod even for milliseconds will lead to the loss of multiple video frames. However, service interruption of a live service is not acceptable. In a previous work [8] authors proposed a method for dynamic resource allocation for Kubernetes Pods with zero downtime.

The allocation system relies on an interaction between operating system features and Kubernetes device plugin feature [11]. It consists in updating the number of resources advertised to the Kubernetes scheduler and changing the current allocation using the Linux system tools in a way that is transparent to Kubernetes.

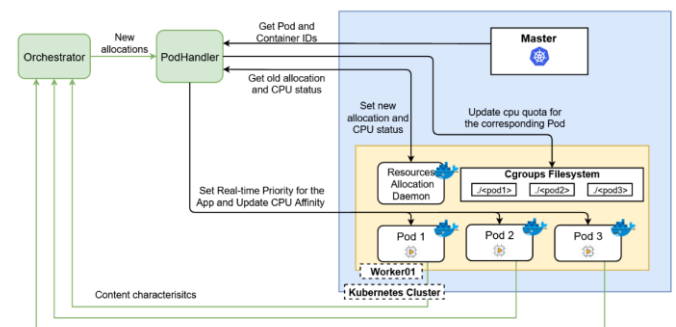


Fig. 3: Resources updating and orchestration process.

Fig. 3 present the interaction between Kubernetes cluster and the dynamic allocation service (PodHandler). The PodHandler gets the new allocation computed by the orchestrator, then interacts with the device plugin to update the number of custom resources advertised to Kubernetes Scheduler, the next step is to update the Pod's Cgroups [10] Completely Fair Scheduler Quota (CFS Quota) that controls the Pod's CPU usage limit. Linux tool taskset is used to change CPU affinity to meet the new allocation. Finally, the resource state is updated for every server in a database managed by the Resource Allocation Daemon service.

B. Complexity based orchestration

The orchestrator computes optimal CPU resource allocation and relies on the PodHandler to apply this allocation. The orchestration algorithm is organized in two steps:

- Predicting the bitrate gain with the help of a machine learning algorithm
- Computing the optimal allocation that minimizes the function (1), based on the bitrate gain predictions:

$$J = \sum_{i=1}^N b_i + \lambda * d_i, \quad (1)$$

where, N is the number of channels b_i is the bitrate of the channel i , d_i is its video distortion and λ is the Lagrange multiplier.

For the first step, the orchestrator uses a trained machine learning model that predicts for every channel the possible gain of a given CPU allocation with respect to a reference allocation, the model takes as input several parameters:

- Video Codec (HEVC, AVC, AV1...)
- Channel configuration (Frame rate, resolution, bit depth...)
- Video quality (PSNR)
- Number of CPU cores
- Channel's complexity estimation

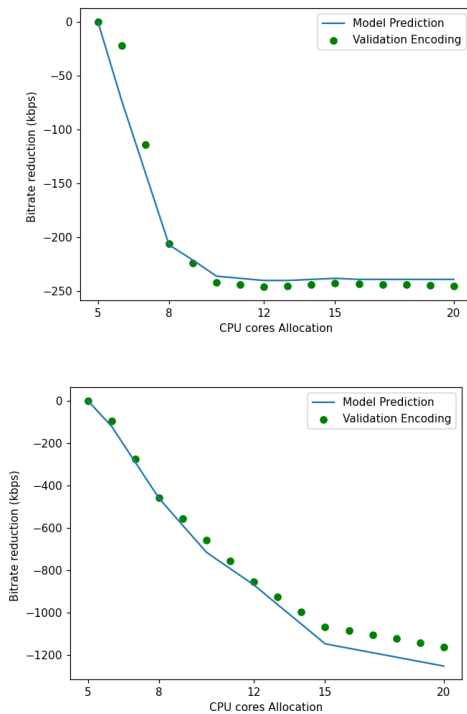


Fig. 4: Bitrate gain predicted by KNR model for, (a) low complexity channel, (b) high complexity channel.

A K-Neighbors Regressor (KNR) [18] algorithm is used for this task. The dataset is composed of various encodings with different configuration and content complexity. Fig. 4 illustrates the predictions made by the model for two different video sequences. The first sequence exhibits low complexity content and the second one high complexity. Both contents are encoded by an HEVC encoder and have the same configuration (25 fps, 1080p resolution, 8-bit depth...). The graphs in Fig. 4 show the KNR model estimation of the

bitrate gain for a given CPU allocation with respect to the minimum allocation (5 CPU cores here), the video quality remaining constant. The complex channel takes better advantage of any additional CPU core. Additionally, from a CPU cores number threshold, additional CPU core will no longer provide bitrates reduction. This threshold is much higher for the high complexity channel than for the low complexity channel. Finally, the reliability of the prediction is assessed by comparing it to the actual encoder behavior.

In a second step, the result of gain estimation is used to compute the optimal allocation that will minimize the cost function. The algorithm proposed is a greedy algorithm, and since all curves predicted by the KNR model are strictly decreasing, it is guaranteed that it will return the optimal solution.

Let N be the number of channels in a given server, $minAllocation$ returns the minimum allocation possible for a video channel to operate normally and M is the disputed CPU cores given in function (2):

$$M = totalCPUs - \sum_{i=1}^N minAllocation_i \quad (2)$$

Allocation Algorithm

Initialize with the minimum allocation

Output: allocation

For channel = 1 to N **do**:

 allocation[channel] $\leftarrow$ minAllocation[config]

End

For cpu $\leftarrow$ 1 to M **do**:

For channel = 1 to N **do**:

 CurrentAlloc $\leftarrow$ allocation[channel]

 gain[channel] $\leftarrow$ $KNR(currentAlloc, complexity, quality, config) + \lambda * d_i$

End

 ChosenChannel $\leftarrow$ argmax(gain)

 allocation[ChosenChannel] = allocation[ChosenChannel] + 1

End

Fig. 5: Allocation algorithm for complexity-based orchestration.

Since the model returns the bitrate gain for a constant PSNR, the distortion term in the algorithm is also constant, thus, the Lagrange multiplier can be put to 0.

The algorithm provided on Fig. 5 will return the allocation that minimizes the total bitrate of all channels while keeping the same video quality. Note that the number of allocated CPU cores to the channels is an integer number, in order to ensure optimal usage of threading and CPU cache memory. After receiving the number of cores, the PodHandler will take care of finding the best CPU affinity considering the NUMA architecture [13] of the physical processor.

C. Complexity-based orchestration experimental results

1) Bitrate minimization

Many tests have been conducted with various configurations and repeated to validate the stability of the

system running live. From a large set of varied sequences, several subsets have been selected to perform our experiments. Little variation in the results has been observed, as long as the subsets are heterogeneous. In a sense, the behavior of the system is comparable to a statistical multiplexer (statmux), as an allocation for a set of sequences having all the same characteristics brings little to no gain. The following example has been kept as a meaningful representative of these experiments.

Four 1080p channels of 5 minutes duration, encoded using an HEVC encoder, configured in constant quality mode and targeting the same video quality. This mode delivers variable bitrate (VBR) streams. Therefore, the performance at a given quality is measured by the bitrate. The better the allocation, the lower the bitrate. An arbitrary number of 28 CPU cores is available to be shared between the 4 channels. These channels have all different content complexity levels.

Two allocation scenarios are run and compared. The first is a uniform allocation, where every channel gets a fixed 7 CPU cores no matter its content. The second is dynamic allocation; in this mode, the orchestrator will compute the optimal allocation periodically based on the content complexity.

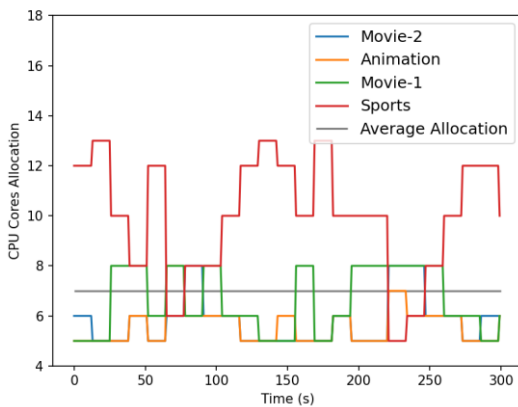


Fig. 6: Dynamic allocation of 28 CPU cores among 4 channels encodings.

Fig. 6 illustrates the changes of the allocation over time for the four channels depending on their respective complexities. As one may expect, the sports content is more complex than the others, hence a larger allocation has been granted to it almost all the time.

TABLE I: BDRATE GAINS COMPARED TO UNIFORM ALLOCATION.

	Movie-1	Movie-2	Sports	Animation	Mean
BDRate	2.93%	2.63%	-8.85%	1.23%	-0.51%

For the proposed combination of sequence and settings, rate distortion curves are derived from which Bjøntegaard Delta Rates (BDRates) [3] can be computed. Table I presents the BDRate gains relative to the uniform allocation. Negatives values indicate a gain (bitrate reduction), and positives values a loss. The first observation is that resource augmentation for one channel implies resource reduction for at least one other channel, leading to BDRate losses. Still, with the proposed dynamic allocation, an overall BDRate gain is achievable.

However, the BDRate is a relative performance metric

especially when comparing sequences with different content types. The actual bitrates are provided in Table . The overall performance is measured by the sum of the bitrates for the 4 channels, with a lower total bitrate indicating better performance.

TABLE II: BITRATES IN MBPS FOR ALL RUNS AT THE SAME QUALITY.

	Uniform	Dynamic	Gain
Movie-1	0.686	0.709	3.35%
Movie-2	0.245	0.250	2.04%
Sports	4.015	3.469	- 13.6%
Animation	0.195	0.198	1.54%
Total	5.141	4.626	- 10%

Compared to uniform allocation, dynamic allocation reduces the bitrate by 10%. For the highest bitrate sequence, Sports, the required bitrate is reduced by 13.6% thanks to dynamic allocation, which represents more than 0.5 Mbps on a very demanding content. The absolute bitrate increase on the other channels is comparatively negligible. Gaining more than 0.5 Mbps on a channel is an opportunity to reach more users with the full resolution quality. For the content provider, it also translates into cost control. With uniform allocation, more CPU cores would be necessary to reach the same bitrate as the proposed solution, hence a higher cost. In a summary, this experiment showed 10% overall bitrate gain in dynamic allocation mode while using the same CPU budget and achieving the same video quality.

2) CPU Usage Optimization

In the previous experiment the goal was to allocate the available CPU cores in order to reduce the required bitrate at a given video quality. In a case where the aim is to minimize the encoding cost, i.e., to use less CPU cores (e.g., when using public cloud) or increase the channels density (have more channels in the same server), dynamic allocation allows reducing the total CPU cores required for a set of channels compared to the uniform allocation mode while achieving the same bitrate for the same video quality.

TABLE III: BITRATES (MBPS) FOR UNIFORM AND DYNAMIC ALLOCATION WITH DIFFERENT CPU BUDGET.

	Uniform 44 CPU Cores	Dynamic 28 CPU Cores	Gain
Movie-1	0.679	0.709	4.42%
Movie-2	0.246	0.250	1.63%
Sports	3.546	3.469	-2.17%
Animation	0.2	0.198	-1%
Total	4.671	4.626	-0.96%

The experiment setup is the same as the previous one, four live HD channels are encoded with an HEVC encoder in constant quality mode. For the uniform allocation, 44 CPU cores are allocated to the channels (11 cores for each). The Table III shows the bitrates achieved for a given video quality in the uniform and dynamic CPU allocation modes. For the dynamic allocation, a total budget of 28 CPU cores is allocated which is 36% less than the 40 CPU cores of the uniform allocation. Yet, a gain of 0,96% of required bitrate is achieved compared to the uniform allocation mode. In

summary, this experiment shows that one can save up to 36% of CPU cores when applying a content complexity aware dynamic allocation on a set of live channels in a public or private cloud.

IV. AUDIENCE AND COMPLEXITY BASED ORCHESTRATION

The complexity-based allocation method optimizes the video encoding performance in the video head-end. The result was a lower overall bitrate compared to a uniform allocation. However, some channels have seen their required bitrates increased because they are less complex. In a real use-case, some channels may be more popular than the others, so the bitrate gain, or loss, of a channel affects the video traffic on the network and is eventually multiplied by the number of viewers that are watching the channel.

In this chapter, a new method is introduced to take the channel audience into account in addition to the content complexity when computing the allocation. Just like complexity, the number of viewers of a live channel can change over time, therefore dynamic allocation is the more suitable allocation mode.

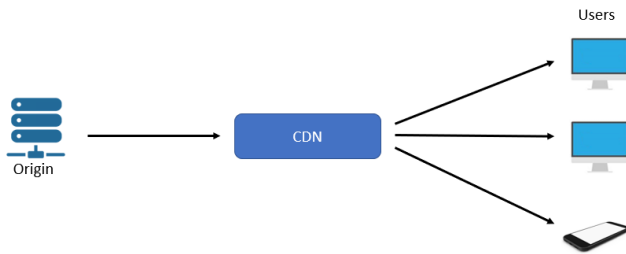


Fig. 7: Video streaming over CDN.

A. Video distribution network

Live Video streaming can be performed through different set-ups, either a digital video broadcast or an OTT (Over the Top) media streaming. A typical example is OTT streaming over a content delivery network (CDN) as presented in Fig. 7, which is one of the most used set-ups for live and VOD streaming (Video on Demand).

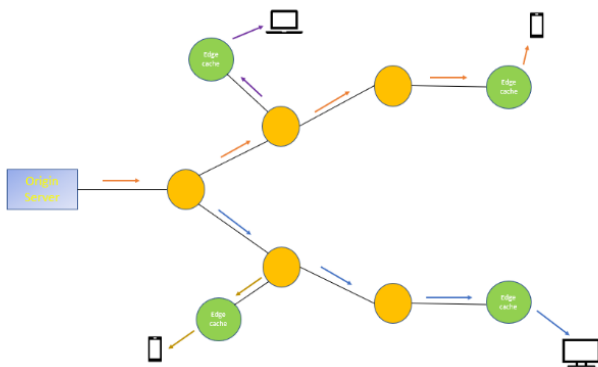


Fig. 8: Example of CDN architecture, with Origin server in blue, nodes in yellow and edge caches in green.

A CDN is a group of geographically distributed and interconnected servers, it provides cached content to the end users. In the field of video streaming, CDN is an essential component in the distribution scheme. Video channels

require a high bandwidth to be transmitted, some channels can have thousands or possibly millions of viewers watching at the same time. The origin server usually has limited capabilities, thus cannot serve all the viewers, even if it can, the viewers could be distributed all over the world, the stream then should travel a long distance for every single viewer. Using a CDN, the stream is provided once by the origin and delivered to the edge cache servers in the viewers' regions, so all the viewers in the same geographic area can fetch the content from the nearest CDN edge cache (Fig. 8).

There are various solutions to get the audience measurements, from the CDN itself like Wowza Media System, which provides a near real-time API [16] to query the number of viewers for a given channel, or, directly from the players, as for example, Smart Sight API [17] by Media Melon, which gives real-time analytics collected from the players.

Allocation Algorithm

Initialize with the minimum allocation

Output: allocation

For channel = 1 to N **do**:

allocation[channel] <-- minAllocation[config]

End

For cpu <-- 1 to M **do**:

For channel = 1 to N **do**:

CurrentAlloc <-- allocation[channel]

$gain[channel] <-- (1 + v_i) * KNR(currentAlloc, complexity, quality, config) + \lambda * v_i * d_i$

End

ChosenChannel <-- argmax(gain)

allocation[ChosenChannel] = allocation[ChosenChannel] + 1

End

Fig. 9: Allocation algorithm for audience and complexity-based orchestration.

B. Cost function optimization

The goal is to minimize the overall distributed data over the network by the streaming, going from the origin server where the channels are encoded, to the end users passing through the CDN edge cache servers, under the constraint of the video head end limited CPU resource. The cost function to minimize is given as (3):

$$J = \sum_{i=1}^N b_i (1 + v_i) + \lambda * v_i * d_i \quad (3)$$

Where, N is the number of channels, b_i is the bitrate of the channel i , d_i is its video distortion, v_i the number of viewers and λ is the Lagrange multiplier. The 1 in the term $(1 + v_i)$ corresponds to the stream distributed from the origin server to the CDN.

To optimize the function, the previously trained KNR model is still applicable. The greedy algorithm however

needs to consider the number of viewers of the channels. The updated algorithm is presented in Fig. 9.

TABLE IV: OVERALL BITRATES GENERATED BY TWO CHANNELS, FOR DIFFERENT VIEWERS DISTRIBUTIONS.

Sports-1 Viewers	Movie-3 viewers	Uniform (Gbps)	Dynamic (Gbps)	Gain (%)
0%	100%	602.51	577.02	-4.23
5%	95%	617.41	596.0	-3.47
25%	75%	676.99	651.5	-3.77
50%	50%	752.09	751.46	-0.08
75%	25%	825.94	790.15	-4.33
95%	5%	885.52	820.1	-7.39
100%	0%	900.41	829.24	-7.9

C. Primary experiments

Several experiments have been conducted to emphasize the importance of including the audience measurements along with the complexity to maximize the encoding performance in a cost-effective manner. In the first experiment, two HD channels that have a nearly equivalent complexity levels are encoded with an HEVC encoder in various scenarios. The first channel Sports-1 is a 5-minutes rugby match sequence, and Movie-3 is an action movie with the same duration. An arbitrary total number of viewers is taken as 100000 viewers for both channels. The considered scenario is that X% (percent) of the viewers are watching Sports-1 and (100 - X) % are watching Movie-3.

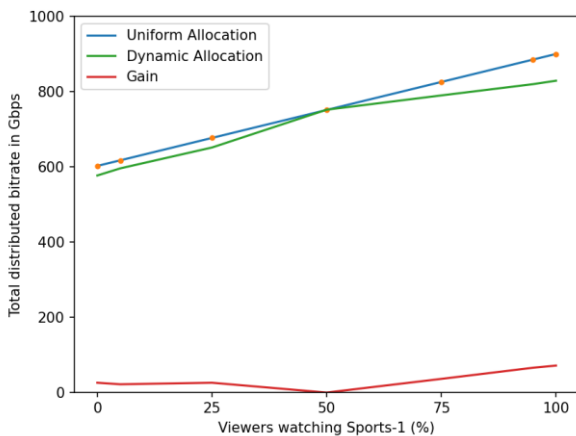


Fig. 10: Bitrate over the distribution network of two similar complexity channels with uniform and dynamic CPU allocation.

In all the different scenario presented in Table IV and Fig. 10, the proposed dynamic orchestrator managed to perform better than the uniform allocation, with a gain varying as a function of the viewers distribution. In the case where the two channels are equally popular, the number of viewers is the same and the complexity is equivalent, so the dynamic orchestrator will allocate approximately a uniform allocation and that explain why the gain is low. Also, the sequence Sports-1 is slightly more complex than Movie-3, that why the

total bitrate and the gain are larger when the Sports-1 is the most viewed.

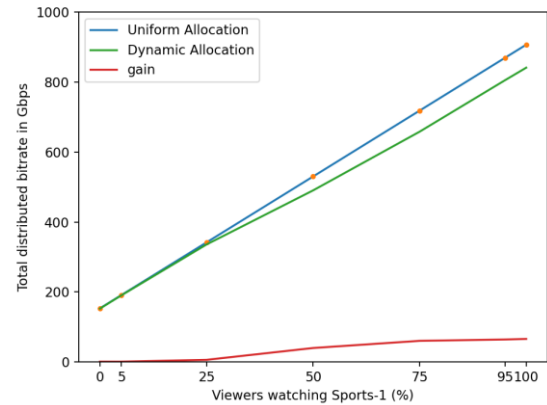


Fig. 11: Bitrate over the distribution network of two different complexity levels channels with uniform and dynamic CPU allocation.

The second experiment is conducted in the same configuration, two HD channels encoded with an HEVC encoder. However, the sequences in this experiment have different complexity levels. The first sequence is Sports-1, and the second is Movie-1, a historical movie. The results are shown in Fig. 11. In the case of equal popularity, the orchestrator still reduces the overall bitrate, because of the complexity difference. Moreover, when the less complex channel is the most viewed, there is always a gain with respect to uniform allocation even if it's smaller.

D. Full-scale experimental results

Here, a real use-case is simulated, where a content or service provider has a set of live channels distributed to its subscribers, each channel may be watched more or less than the others. In this experiment four HD channels are encoded with an HEVC encoder with the same configuration. The video sequences used have different intrinsic content complexity levels. The goal is to reduce the overall bitrate generated by the channels over the distribution network (CDN) when applying audience and complexity based dynamic allocation compared to a uniform static allocation.

Several scenarios are considered where the distribution of viewers is different. The total number of viewers is 100000, the different distributions of the viewers over the 4 channels are provided in Table V.

TABLE V: VIEWERS DISTRIBUTIONS SCENARIO DESCRIPTION.

	Sports	Movie-1	Movie-2	Animation
Scenario-1	70000	10000	10000	10000
Scenario-2	10000	70000	10000	10000
Scenario-3	10000	10000	70000	10000
Scenario-4	10000	10000	10000	70000

In the first scenario, the channel **Sports** is considered the most watched, with 70% of total number of viewers, while the other channels get each 10% of the total viewers. The results are presented in Table VI, corresponding to the total data generated by the four channels. The dynamic allocation mode reduced this number by 13.33%, it is 45.95 Gbps

(Gigabit per second), and more than 14% of the most popular channel spared just by changing the way that the available CPU cores are allocated to the channel.

TABLE VI: TOTAL DATA GENERATED BY THE CHANNELS IN (MBPS).

	Uniform	Dynamic	Gain
Movie-1	7812	8386	7.35
Movie-2	2920	2998	2.66
Sports	331813	285137	- 14.07
Animation	2163	2237	3.42
Total	344708	298758	- 13.33

The other scenarios have been tested as well; the results are summarized in Table VII. In all the presented use cases, the orchestrator succeeds in finding the optimal allocation that reduces the total bitrate. The most popular channel will have a larger weight (3), and consequently may be allocated more CPU cores. The gain is maximal when the complex channel is the most viewed, this is the expected behavior as illustrated in Fig. 2, where the potential bitrate gain increases with the content complexity.

TABLE VII: PERCENTAGE OF TOTAL BITRATE REDUCTION MADE IN DYNAMIC CPU ALLOCATION COMPARED TO UNIFORM CPU ALLOCATION.

	Scenario-1	Scenario-2	Scenario-3	Scenario-4
Movie-1	7.35	-8.12	0.06	0.63
Movie-2	2.66	12.37	-8.84	7.19
Sports	- 14.07	-6.73	-6.46	-6.56
Animation	3.42	1.84	-0.34	-1.06
Total	- 13.33	-5.42	-7.41	-2.01

V. CONCLUSION

In this paper, a new method is introduced for computing the CPU allocation for live video encoders. It is demonstrated that dynamic allocation is more suitable and give a significant bitrate reduction compared to a uniform static allocation. In a first mode, complexity aware dynamic orchestration showed a gain up to 13.6% on a very demanding content, and an average of 10% reduction of the overall bitrate required by four channels. The second proposed mode considers the number of viewers for each channel in an OTT streaming environment. This method offers further gains, with more than 14% reduction of the overall bitrate distributed over the network by a complex channel, and an average of 13.33% compared to a uniform allocation.

Finally, the proposed method needs 36% less CPU cores compared to a uniform allocation to achieve the same video quality at the same bitrate, which could reduce the operational costs significantly.

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Overview of Channel Bonding and MIMO of ATSC 3.0 Broadcasting System

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Abstract—This paper introduces channel bonding and multiple-input multiple-output (MIMO) technologies adopted in Advanced Television Systems Committee (ATSC) 3.0, a recently developed digital terrestrial television standard. Channel bonding and MIMO are aimed at enhancing the channel capacity, so they enable to deliver rich media services such as 8K ultra-high definition (UHD) video. Several researches to evaluate the two technologies through intensive computer simulation, laboratory tests, and field experiments are also introduced briefly, in addition to a newly conducted laboratory test of channel bonding.

Index Terms—terrestrial broadcasting, channel bonding, multiple-input multiple-output, MIMO

I. INTRODUCTION

ADVANCED television systems committee (ATSC) recently developed a new digital terrestrial television standard, ATSC 3.0, to increase the channel capacity and flexibility of spectral usages. It adopted thoroughly new technologies from video encoding to physical transmission resulting in non-backward compatibility with the previous ATSC 1.0 standard [1]-[3]. South Korea and USA successfully launched the ATSC 3.0 broadcast service, whose adoption is actively discussed in several nations. Recently, thanks to the spread of 8K display panels, the demand for rich media services beyond 4K ultra-high definition (UHD) such as 8K UHD, virtual reality (VR), and augmented reality (AR) is increased. To achieve the enhanced data rate, ATSC 3.0 adopted channel bonding and multiple-input multiple-output (MIMO) techniques.

Channel bonding combines multiple radio frequency (RF) channels as a single wide band so that the channel capacity linearly increases as the number of available RF channels increases [4]. MIMO utilizes multiple transmit and receive antennas to enhance the system capacity without additional RF channels [5]. Several studies have been published to verify and evaluate two techniques through intensive experiments [6]-[10]. This paper briefly introduces the channel bonding and MIMO techniques in ATSC 3.0 broadcast systems and considers their feasibility by reviewing the previous research and an additional laboratory performance test.

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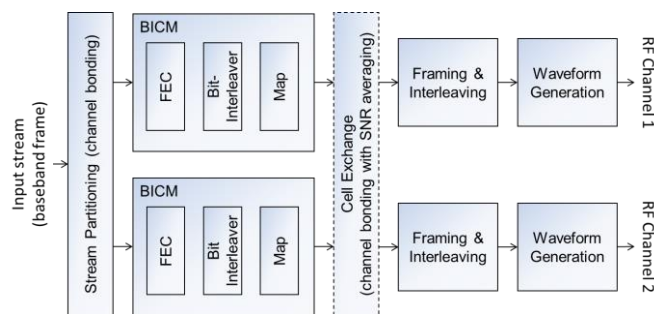


Fig. 1. Block diagram of ATSC 3.0 transmitter employing channel bonding.

II. CHANNEL BONDING

A. Overview of ATSC 3.0 Channel Bonding

ATSC 3.0 physical layer standard includes the channel bonding techniques to combine two RF channels, which can be located contiguously or non-contiguously, achieving twice the system capacity as a single RF channel [1],[4]. Therefore, the broadcaster enables services to be allocated within two RF channels as if they are configured within a single RF channel. Fig. 1 shows the block diagram of the ATSC 3.0 transmitter employing channel bonding. The transmitter, applying channel bonding, partitions the input service streams in a baseband frame unit, which are processed in the two independent bit-interleaved coded modulation (BICM) blocks to deliver the service on two RF channels. Two different channel bonding modes can be supported: plain channel bonding and channel bonding with signal-to-noise ratio (SNR) averaging [1],[4],[6]. In plain channel bonding, the split streams can be configured with thoroughly different physical layer parameters such as modulation, code rate, time interleaving, and waveform, resulting in different data rate and robustness for each RF channel. On the other hand, in channel bonding with SNR averaging, two output streams of BICM blocks in a cell unit are exchanged in the cell exchange block. Therefore, two consecutive cells of each BICM block are transmitted using different RF channels. If two RF channels are non-contiguous, the two cells experience different propagation channels so that frequency diversity gain may be achieved, improving the reception performance. Unlike plain channel bonding, the physical layer configuration should be identical between two RF channels

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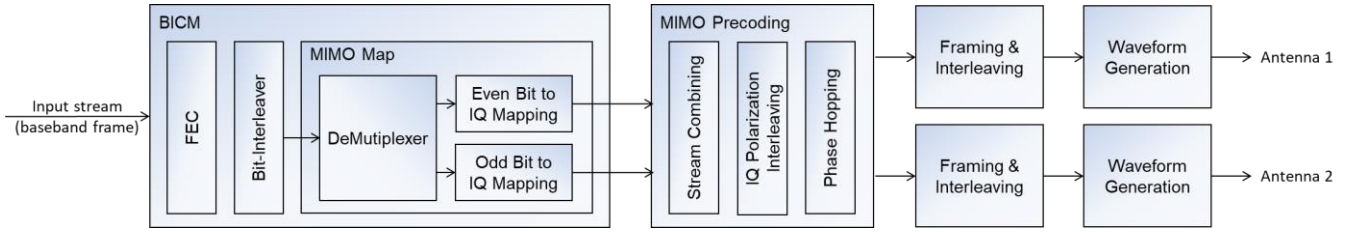


Fig. 2. Block diagram of ATSC 3.0 transmitter employing MIMO.

TABLE I
CHANNEL BONDING PERFORMANCE BASED ON THE MINIMUM RECEIVED
SIGNAL STRENGTH CONSIDERING TYPES

Minimum Received Signal Strength [dBm]		Power Imbalance [dB]
RF Channel 1	RF Channel 2	
-66	-66	0 (plain channel bonding)
-67	-65	2
-67	-64	3
-68	-63	5
-68	-62	6
-68	-61	7
-68	-60	8
-68	-59	9
-68	-58	10
-68	-57	11
-69	-56	13

in the current version of the ATSC 3.0 standard to reduce the complexity of implementation.

B. Performance of Channel Bonding

The reception performance of channel bonding has been studied in [6]–[8]. In [6] and [7], the performance of two types of channel bonding was compared through the computer simulation with respect to the different channel conditions. In [8], the ATSC 3.0 transmitter and receiver including channel bonding were developed as hardware, and a laboratory test was conducted to verify the performance and feasibility of the 8K UHD service. If two RF channels have different channel conditions, the test results show that channel bonding with SNR averaging has better reception performance than plain channel bonding as the distance between two RF channels increases, especially in mobile receiving environments.

Additional reception performance test of the channel bonding based on the hardware was newly conducted in this paper to examine the two types of channel bonding. The physical layer parameters used in this test were the same as in [8]. TABLE I shows the measured minimum received signal strengths of two RF channels combined with channel bonding. The test result under 0 dB power imbalance was the minimum received signal strength of the plain channel bonding case. When the channel bonding with SNR averaging was applied, the two RF channels compensated each other. Therefore, if one of two RF channels acquired at least -56 dBm, 3-dB less power was allowable to decode the received signal successfully.

III. MIMO

A. Overview of ATSC 3.0 MIMO

MIMO increases the spectral efficiency within a single RF channel by using spatial multiplexing [5]. ATSC 3.0 allows

two transmit and two receive antennas having different polarization. In general, the terrestrial broadcast system utilizes cross-polarized antennas such as horizontal and vertical polarization to guarantee spatially separated propagation paths with high cross-polarization discrimination (XPD). Therefore, the ATSC 3.0 MIMO broadcast can achieve a nearly double data rate compared to SISO broadcast systems depending on the physical layer configurations [5]. Fig. 2 shows the block diagram of the ATSC 3.0 transmitter that involves MIMO processing. The transmitter divides the bit-interleaved bit streams, generates two separated cells in the MIMO mapper, and independently processes to radiate through antenna 1 and 2. The MIMO precoding block comprises three inner blocks: stream combining, IQ polarization interleaving, and phase hopping. Since each block is individually applied to BICM output cells, any on-off combinations of three blocks are possible, including all offs. Since two polarized antennas between transmitter and receiver may interfere with each other, different pilot encoding or allocation are required to estimate the MIMO channel. Therefore, ATSC 3.0 adopts two orthogonal pilot encodings: Walsh-Hadamard and null pilot [1],[5].

B. Performance of MIMO

The reception performance of MIMO is provided in [9], [10]. Based on the computer simulation, laboratory test, and field test, the reception performance of the ATSC 3.0 MIMO system was evaluated concerning channel characteristics such as XPD. Also, 8K UHD service requiring 100 Mbps data rate through the MIMO broadcasting was verified in the real field environment using the Korean commercial broadcast site. As the XPD decreases or the interference between two antennas was increased, the reception performance was degraded so that tuning the direction of cross-polarized antennas should be significantly considered for extremely high data rate services.

IV. CONCLUSION

This paper considered the channel bonding and MIMO technologies in the ATSC 3.0 physical layer standard to achieve a high data rate. Their functional feasibility and reception performance were intensively verified by the developed hardware equipment in addition to the theoretical point of view. ATSC 3.0 channel bonding and MIMO are practical solutions for 8K UHD terrestrial broadcast services requiring at least 50 Mbps data rates.

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Implementação de um sistema de comunicação reconfigurável para Satélites de baixa órbita baseado no Simulink

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1. INTRODUÇÃO

O desenvolvimento de satélites de baixa órbita (LEOs, do inglês *Low Earth Orbit*) têm crescido diante de novas perspectivas, tais como: a redução do custo de lançamento e de produção e iniciativas de utilizá-los em constelações, isto é, múltiplos satélites juntos que fornecem internet, de tal maneira a prover conectividade ilimitada por todo o planeta, auxiliando a conectar os não conectados [1].

Assim, torna-se necessário sistemas de comunicação que sejam capazes de fornecer uma comunicação flexível entre esses satélites e a estação radio base (ERB), alterando as características do enlace como frequência da portadora, largura de banda, taxa de dados e esquema de modulação [1]. Essa flexibilidade pode ser atingida por meio de sistemas dinâmicos, isto é, aqueles que permitem reconfigurar os parâmetros de comunicação em tempo real. Sendo que, isso pode ser realizado (a) de acordo com a interação entre a relação sinal-ruído (SNR, do inglês *Signal-to-noise Ratio*) e a taxa de erro de bit (BER, do inglês *Bit Error Rate*) da transmissão; ou (b) segundo as necessidades do enlace, por exemplo, o valor necessário de taxa de dados (ou *bit rate*, do inglês) para enviar a informação desejada.

Uma alternativa para habilitar essa reconfigurabilidade é o Rádio Definido por Software (SDR, do inglês *Software Defined Radio*), o qual torna possível que algumas ou todas as funções da camada física do *hardware* sejam modificadas de maneira remota [2]. Isso é uma grande vantagem, visto que no espaço é inviável alterar as partes físicas do *hardware*.

Diante disso, este trabalho visa simular o desempenho de um sistema de comunicação reconfigurável para os LEOs, através do *MATLAB/Simulink*, a fim de futuramente implementar esse sistema em um *hardware*.

2. METODOLOGIA

O sistema é dividido em 2 subsistemas: *telemetry* (TM) e *tele command* (TC). O primeiro se destina a monitorar a saúde e o status do LEO enviando informações de tensão, corrente elétrica, temperatura, entre outras, para a ERB, caminho denominado de *downlink*. Enquanto o segundo se dá no caminho inverso, chamado de *uplink*, referindo-se ao controle adequado do satélite que recebe os comandos da ERB.

Assim, levando em consideração o *link budget* de [3], o objetivo é simular o recebimento de uma informação pelo LEO, vinda da ERB, e depois reenviar a ela. Para isso é utilizado um sinal modulado em FM (*Frequency Modulation*) e em BFSK (*Binary Frequency-shift Keying*)

para o TC, de tal modo que ele seja demodulado após ser propagado por um canal AWGN (*Additive White Gaussian Noise*), o qual simula os processos aleatórios que poderiam inserir ruído no sinal transmitido. Em seguida, o sinal demodulado é modulado em BPSK (*Binary Phase-shift Keying*) para simular o envio pelo TM.

O *software MATLAB/Simulink* possibilita a criação do sistema de comunicação através da biblioteca *Communications System Toolbox* que fornece diferentes blocos que auxiliam na criação de novas técnicas de modulação e demodulação, além das que já são disponibilizadas prontas.

3. RESULTADOS

Os resultados para a demodulação foram avaliados a partir dos valores obtidos para o BER para diferentes valores de SNR, obtendo para um SNR de 30dB, BER da ordem de 10^{-4} , menor valor encontrado na simulação. Bem como, as formas de onda recebidas foram avaliadas comparando com as enviadas, demonstrando que a informação não foi perdida. Por outro lado, para a modulação BPSK, a análise do resultado foi realizada em torno da densidade espectral de potência do sinal, na qual foi obtido uma potência de transmissão de aproximadamente 0 dBm em torno do pico, o que é satisfatório, tendo em vista que o sinal passará ainda por um amplificador de potência para atingir o nível mínimo requerido de potência de transmissão, o qual é +23dBm, de acordo com [3].

4. CONSIDERAÇÕES FINAIS

O objetivo proposto de simular uma comunicação entre um satélite de baixa órbita com a estação rádio base, em que o LEO recebe a informação, processa e realiza o tratamento para o reenvio, foi promissor tendo em vista os resultados obtidos. Em [3] foram apresentadas as formas de onda obtidas por meio da simulação, entretanto, os valores de taxa de erro de bit para a comunicação não foram mostrados, o que o presente trabalho faz.

Além disso, a reconfigurabilidade é possível na medida em que o *software* possibilita a alteração dos blocos. Por exemplo, para o *downlink*, quando é necessário um aumento na taxa de dados é possível alterar a modulação de BPSK para QPSK (*Quadrature Phase-shift Keying*), haja vista, ela dobra esse fator na medida em que é uma modulação de quarta ordem.

5. PALAVRAS-CHAVE

Satélite de baixa órbita; Sistema de comunicação reconfigurável.

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Recepção Móvel na TV 3.0: um caso de estudo com a tecnologia *Advanced* ISDB-T

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I. INTRODUÇÃO

A tecnologia de mídias digitais evoluiu muito nos últimos anos, levantando a necessidade de definição de um novo padrão de recepção para o Sistema Brasileiro de TV Digital (SBTVD). Com isso, o Fórum SBTVD especificou uma série de requisitos para a nova versão da transmissão da televisão no Brasil. Tal definição impacta a recepção fixa e a móvel, trazendo diversos desafios em termos de robustez de recepção e taxa de dados. Entre os requisitos para a TV 3.0 [1], tem-se o euso-1, que dá maior flexibilidade para as transmissoras, permitindo a superposição de transmissores em um mesmo canal em uma mesma área com conteúdos diferentes. Para tanto, um pré-requisito é de que deve existir demodulação do sinal para condições recepção de $C/N < 0$. Um segundo requisito é uma melhor qualidade para o vídeo recebido em carros. Objetiva-se ter uma única transmissão para televisores e carros, diferentemente do modelo atual do ISDB-T.

Entre as propostas para a TV 3.0, tem-se o *Advanced* ISDB-T [2], proposto pelo DIBEG, que evolui o padrão ISDB-T para prover *ultra-high definition TV* (UHDTV). Para avaliar esse novo padrão, Shirai et al desenvolvem um modulador e um demodulador experimentais para realização de testes em laboratório e em campo [3]. Miyasaka et al analisam como a transmissão hierárquica do *Advanced* ISDB-T pode ser utilizada para transmissão fixa e móvel simultaneamente em um único canal, por meio de simulações [4]. Miyasaka et al [5] também analisam a recepção móvel no Japão por meio de simulações e testes de campo, discutindo como o uso de pilotos dispersos pode melhorar a recepção.

Este artigo apresenta os resultados de testes de recepção móvel em campo do *Advanced* ISDB-T no Rio de Janeiro, tomando como parâmetros os requisitos definidos na chamada de propostas para a TV 3.0. Esse cenário é particularmente desafiador, devido à topografia acidentada e à presença de grandes corpos d'água. Destaca-se que diferentemente dos testes no Japão, que buscavam uma alta taxa de transmissão, os testes realizados na cidade do Rio de Janeiro visam avaliar a robustez e o desempenho do sistema em diversas condições de recepção, validando assim critérios pré-estabelecidos.

II. METODOLOGIA DE TESTES

O teste de recepção móvel é realizado com um veículo de teste equipado com antena MIMO em polarização inclinada. A antena de recepção e a antena de GPS são fixadas na parte superior do veículo. A transmissão é realizada a partir da estação da Rede Globo, no Sumaré, no canal 30 (566-572 MHz) a 200 W em cada polarização. A configuração dos parâmetros de transmissão é mostrada na Tabela 1. O transmissor gera um sinal PRBS a uma taxa de bits constante de 3,6 Mb/s.

Tabela 1 - Parâmetros de transmissão do *Advanced* ISDB-T.

Modulação	QPSK
Constelação	Constelação uniforme
Correção de erro	LDPC (3/16) + BCH
FFT	16k
Razão do GI	800/16384
Piloto	$D_x=6, D_y=2$
Intercalação de tempo	$I=3$
Camada	Camada-A, 35 segmentos
Largura de banda	6MHz
Programa	2K (1080p), 3,4 Mbps

O percurso de teste é mostrado na Figura 1, abrangendo uma área que engloba Barra da Tijuca, Jacarepaguá e Recreio dos Bandeirantes. Os testes foram realizados em outubro de 2021, dentro do contexto dos testes de campo do Projeto TV 3.0 [1].

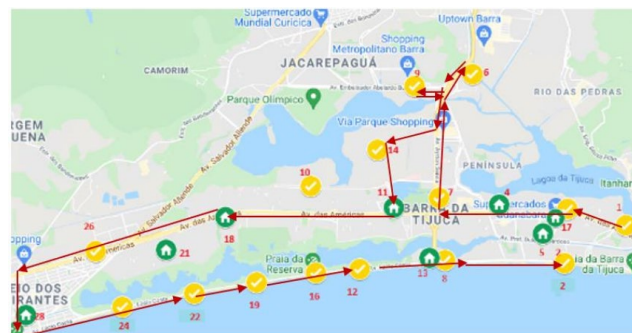


Figura 1- Percurso do teste móvel.

1 – Dep. de Eng. de Telecomunicações – Universidade Federal Fluminense.

2 – Pontifícia Universidade Católica do Rio de Janeiro

3 – Universidade Estadual do Maranhão

Os autores gostariam de agradecer ao Fórum SBTVD, à Rede Globo e à DIBEG pelo suporte com os testes. Também agradecem ao CNPq pelo financiamento da pesquisa.

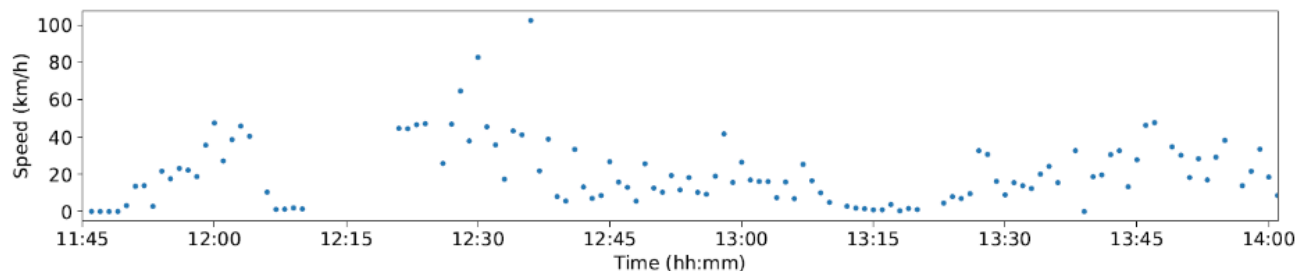


Figura 4 - Variação da velocidade em função do tempo.

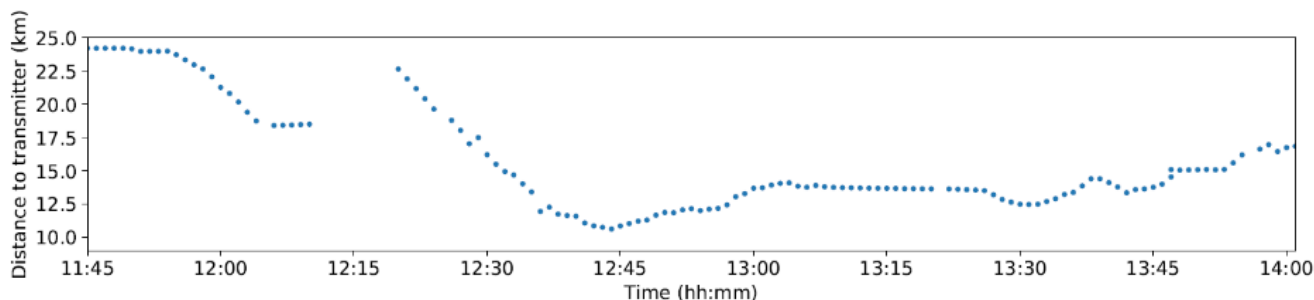


Figura 3 - Variação da distância para o transmissor em função do tempo.

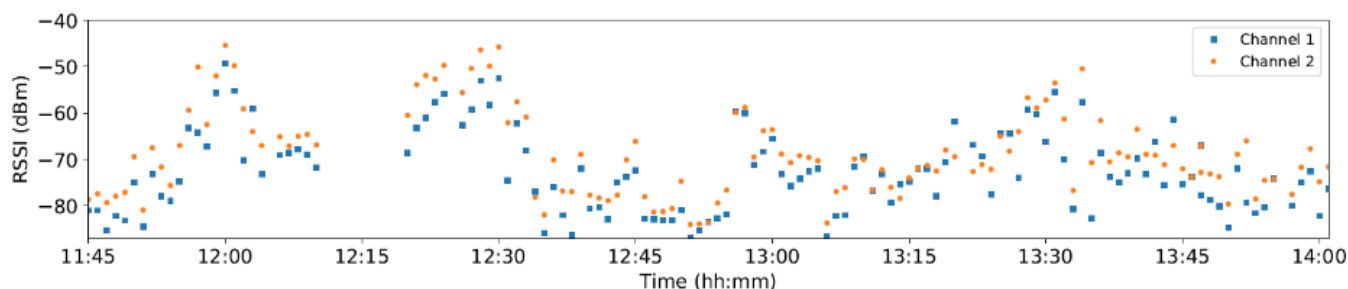


Figura 2 - Variação do RSSI em função do tempo.

A medição conta com o receptor Socionext - SC1502A-B03, o gravador Eiden RF Capture & player - 4422A e o analisador Eiden BER Tester- 7709C. O Eiden BER Tester disponibiliza a taxa de erro de pacote (*Packet Error Rate* - PER), contagem de pacotes perdidos, taxa de recepção, entre outros. Os dados desse equipamento permitem avaliar a taxa de erros da sequência PRBS transmitida. Uma taxa $PER > 10^{-4}$ representa erro de recepção perceptível pelo telespectador.

III. RESULTADOS

O perfil de velocidade do teste é mostrado na Figura 2. A velocidade alcançada é de até 100 km/h e as variações são causadas por semáforos ou congestionamentos. A distância entre o veículo e o transmissor é mostrada na Figura 3, enquanto a evolução do RSSI ao longo do tempo é mostrada na Figura 4. Observa-se que não há correlação direta entre o valor da potência recebida e a distância, o que se explica pela topografia da área que insere interferências no sinal transmitido por meio de mecanismos de propagação complexos.

Observou-se a taxa de erro de pacotes (PER), mostrada na Figura 5 e na Figura 6. A PER é menor para valores RSSI mais altos, mas até aproximadamente -75 dBm há um número significativo de medições que mostram PER muito baixa.

IV. CONCLUSÕES

O teste de recepção móvel permitiu avaliar que mesmo com uma potência de transmissão baixa, em uma área com topografia desfavorável, a tecnologia *Advanced ISDB-T* conseguiu atingir uma recepção com poucos momentos de falhas, assumindo uma configuração que permite o reuso-1 na recepção fixa. Espera-se, como trabalhos futuros, repetir o teste com outras configurações no receptor e, também, realizando o reuso-1.

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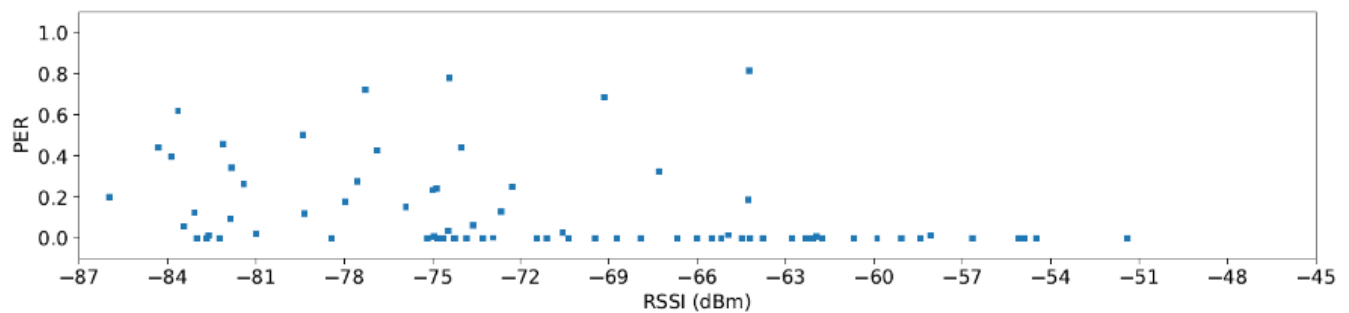


Figura 6 - Variação do PER no canal em polarização +45°.

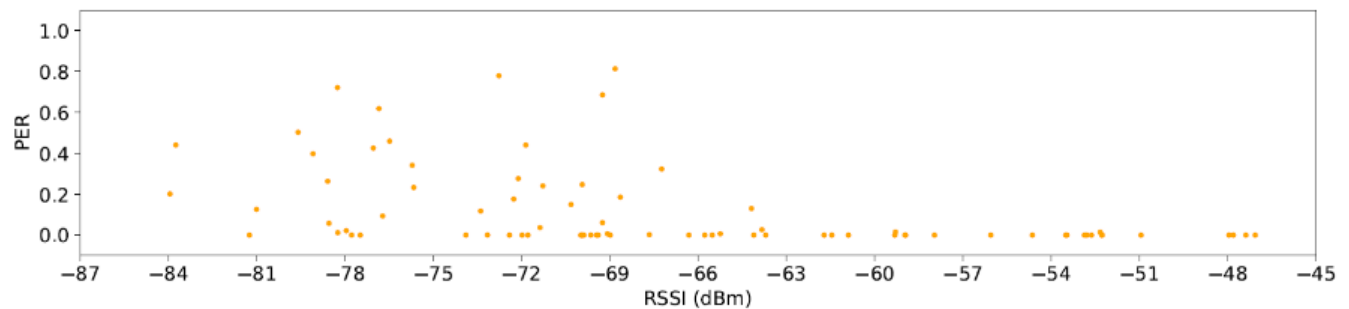


Figura 5 - Variação do PER no canal em polarização -45°.

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CLOUD TECHNOLOGIES

Moderator: Eduardo Lopes, *Technology Director of Rede Amazônica*

CAMERA TO CLOUD: THE FASTEST AND MOST SECURE WAY TO GET FOOTAGE FROM CAMERAS TO COLLABORATORS, ANYWHERE IN THE WORLD

Luis Bechtold, Strategic Manager - Adobe Systems

First there was film, which had to be developed. Then came tape, which had to be digitized. Then there were files on hard drives. Not to mention shipping. Now it's in the cloud. This changes everything.

Frame.io is all about getting your teams closer to the assets as quickly as possible. We recently launched C2C Camera to Cloud technology to reduce the time it takes to get audio and video files from production sets directly to post teams so all stakeholders can start the collaborative.

BROADCAST MIGRATION TO THE CLOUD & WHY FAST WILL DOMINATE THE NEXT 20 YEARS OF TV

Paul Finster, VP, Global Business Development - Amagi

Learn why Amagi believes that all Broadcast is set to migrate to the Cloud and why Amagi believes that FAST channels will dominate the broadcast industry over the next 20 years.

- Why Cloud? How next-gen cloud-native solutions can augment and ultimately replace traditional on-premise uplinks and data centers. How cloud enables flexible workloads, built-in redundancy, new revenue streams, and business agility.
- Why FAST? A brief history and evolution of Free Ad Supported Streaming TV. Why have connected TV devices taken over 70% of the free and paid TV market?

PLANNING YOUR HYBRID CLOUD PLAYOUT JOURNEY

Vinicius Val de Casas, Solution Architect / Project Manager - Pebble

Vinicius will discuss the importance of creating a solid strategy when it comes to planning your journey into the cloud and in what circumstances it would be feasible to operate wholly in the cloud or when it's not!

That said, it is understood that broadcasters may not want their playout in the cloud yet, so in this short presentation Vinicius will discuss why this is the case. He will also talk about the benefits of hybrid cloud playout, what broadcasters need to consider when planning their strategies of implementing these workflows and the variety of playout deployment models that have emerged as the industry diversifies further into different broadcast offerings such as dynamic FAST channels (free ad-supporting streaming TV services).

THE IMPACT OF CLOUD AND STREAMING INNOVATIONS ON LATAM BROADCASTERS

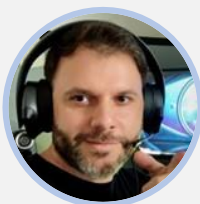
Eliério Silva Júnior, *Sales Director Brazil - Video Solutions Harmonic*

Major transformations are happening across the LATAM video industry, most notably a rise in video streaming consumption and acceleration in cloud adoption. During this presentation, attendees will gain insights into the future of linear TV as well as the growth opportunities related to OTT delivery. This session will talk about the technology trends impacting the LATAM broadcasters and video service providers including how SaaS has emerged as a popular business model. The session will also detail recent case studies highlighting new developments in playout; statmux; distribution; live sports streaming, including ultra-low-latency and dynamic ad insertion; quality of video, and other innovations to enable outstanding viewer experiences for enhanced monetization.



Eduardo Lopes - Technology Director of Rede Amazônica

Eduardo Lopes holds a degree in Electrical and Telecommunications Engineering from Inatel. He has specializations in Systems (Center for Higher Education in Management, Technology and Education – FAI), Project Management (Fundação Getúlio Vargas – FGV), Digital TV and IPTV (Inatel), Business Administration (Postgraduate and Graduation Institute – IPOG) and Digital Strategies for Media Companies (ISE Business School). Currently, he is the Director of Technology at Rede Amazônica, an affiliate of TV Globo in the North Region.



Luis Bechtold - Strategic Manager - Adobe Systems

I am currently driving Strategic Business Development across Adobe's Creative Cloud Enterprise SaaS business with Adobe's Latin America Enterprise Customers & Industry Partners to accelerate Business growth & Product Innovation. Customer focus leader with 20+ years of experience in the Digital Media and Entertainment Industry.



Paul Finster - VP, Global Business Development - Amagi

Paul Finster is an accomplished technology executive with expertise and history in Solution Selling, Service Delivery and Operations, Product Development and Software Engineering across diverse business sectors, working now with a focus on the Media and Entertainment market. At Amagi, he's responsible for Streaming Innovation & Business Development.



Vinicius Val de Casas - Solution Architect / Project Manager at Pebble

Vinicius Val de Casas has been working in the broadcast industry for over 20 years with extensive experience in supporting solutions for integrated networks, video and data systems.

He held a variety of senior roles for renowned and highly respected organisations such as TV RECORD, BAND, SBT and ESPN Brasil, as well as major systems integrators. His experience spans across business development and sales functions, as well as in technical and operation roles. Over the last 5 years he focused his career in the fields of playout automation delivering leading broadcast solutions across Brazilian and global markets. Vinicius Val de Casas – Marketing & Communications Manager – Pebble

**Speaker: Eliésio Silva Júnior - Sales Director Brazil - Video Solutions Harmonic**

Eliésio Silva Júnior is Harmonic's sales director in Brazil for the company's video solutions. He manages direct sales to key accounts, while also planning and executing the company's growth strategy in Brazil. Eliésio has more than 27 years of professional experience in television engineering and manufacturing for large multinational and national companies, including Globosat and TV Globo. Prior to that, Eliésio was the LATAM manager and regional video sales leader at Tektronix. Eliésio has a teaching degree in electronics from FABES, an MBA in business management from Veiga de Almeida University and an MBA in digital TV and new media from the Federal University of Niteroi. In addition, Eliésio has technical degrees in electronics and telecommunications.

