An IoT Based Proposal for Telemetry and Remote Control Systems for TV 3.0

Alberto Leonardo Penteado Botelho, Paulo Batista Lopes

***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 needsand 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

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remote control allows one to send commands to the transmitter, such as changing settings and turning equipment on or off.

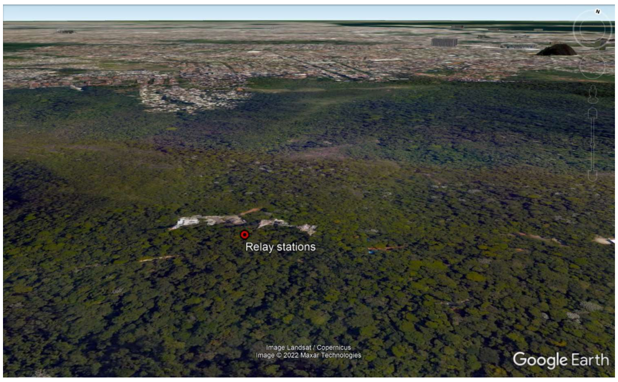

Figure 1- Relay station in a hard-to-reach location.

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).

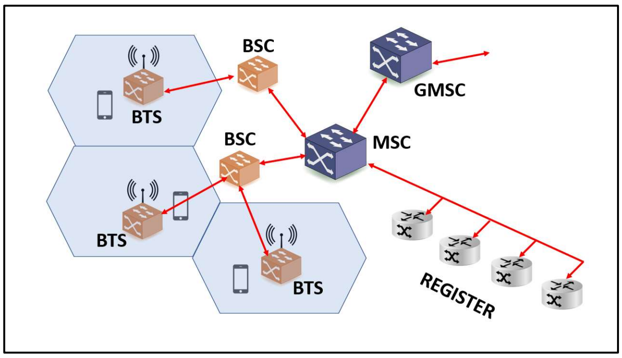

Figure 2- Essential components of the GPRS architecture.

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

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same RF channel by independent stations [9].

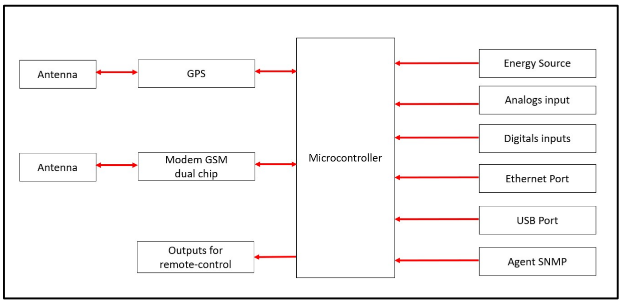

Figure 3 - Block diagram of TV 2.0 telemetry and remote control.

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

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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.

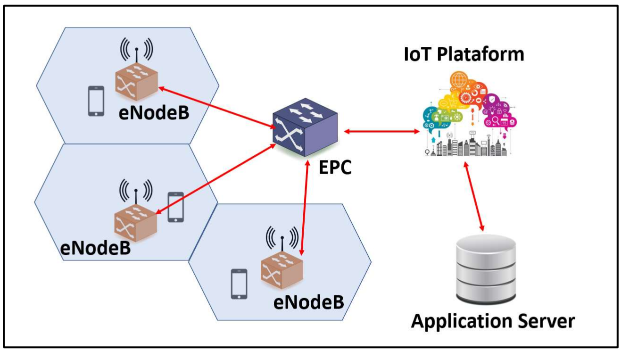

Figure 4 - NB-IoT architecture.

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.

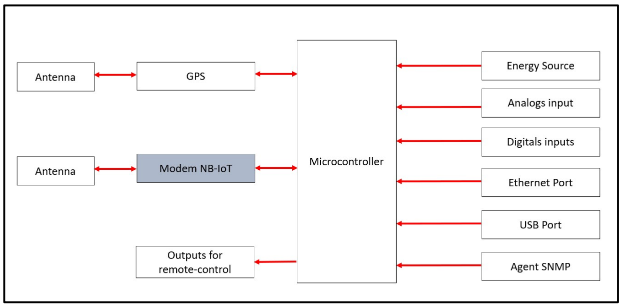

Figure 5 - IoT block diagram for TV 3.0.

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].

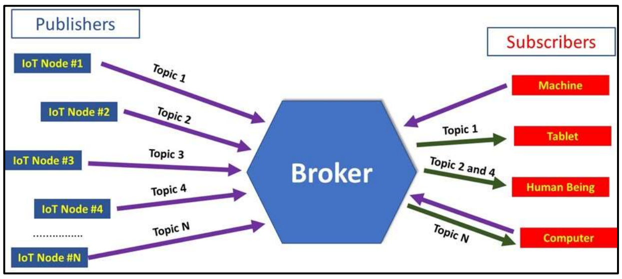

Figure 6 - MQTT system

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

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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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Alberto Leonardo Penteado Botelho is a PhD student in electrical engineering at the Universidade Presbiteriana Mackenzie. Has degree in Electrical Engineering from the Universidade Paulista (UNIP), specialized in Engineering of Digital Television Systems by the Instituto Nacional de Telecomunicações (Inatel), Engineering of Telecommunications Networks by the Instituto Nacional de Telecomunicações (Inatel), MBA in Project Management by Fundação Getúlio Vargas (FGV) and Master of Science in electrical engineering from Universidade Presbiteriana Mackenzie. Worked on Rede TV! and currently works at LM Telecom as a project engineer, where he has had the opportunity to work with Broadcast network projects since 2002.

Paulo Batista Lopes has received the B.Sc. and M.Sc. in EE from Federal University of Rio de Janeiro, Brazil, in 1978 and 1981, respectively, and the Ph.D. in EE from Concordia University, Montreal, Canada, in 1985. From 1985 to 1988, he was with Elebra and CMA, two Brazilian companies, working on the design of several communication equipments. From 1988 to 1999, he was with Texas Instruments as a DSP specialist. In 1999, he moved to Motorola-SPS (later to become Freescale Semiconductor) as a Sales and Application Manager. Since 2009, he has been with Mackenzie Presbyterian University as a professor in the School of Engineering. His research interests are Circuit Theory, Digital Signal Processing, Analog Circuit Design and Communication Theory and Internet of Things.

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