Amplifying In-Vehicle DTV Entertainment: ATSC 3.0 Broadcast Signal Relay via WiFi Gateway

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***Abstract*—This paper presents the relayed distribution of ATSC 3.0 broadcast signals to mobile users in moving vehicles. The gateway relay featured in this work seamlessly converts received ATSC 3.0 signals into a WiFi interface. This proposal exhibits the use of an ATSC 3.0-to-WiFi gateway to amplify broadcasting media in automotive, allowing personalized experience on individual seat positions.**

***Index Terms*—ATSC 3.0, in-vehicle entertainment, mobile broadcasting, ATSC 3.0-to-WiFi gateway.**

I. Introduction

In recent years, the demand for in-vehicle entertainment and connectivity has surged, fueled by the rising prevalence of self-driving technology and the ubiquitous consumption of digital media on mobile devices [1]. The community's approach, as a response, has first focused on developing technologies that facilitate direct-to-vehicle (D2V) content delivery [2], [3]. The major concern in this development has been building sufficient reliability to cope with dynamic channel situations. Notably, the use of multi-antenna diversity [4] and broadcast-broadband cooperation based on dual connectivity [5] have been proposed as solutions.

Within dynamic automotive environments, it is known as quite demanding to serve rich video content to every passenger [6]. Considering the cellular networks these days, various physical obstacles and traffic problems incur frequent streaming interruptions [7]. Moreover, from the user's view, it is also demanding to rely on paid data channels for streaming huge amounts of video data during a long journey on the road [8]. Advanced Television Systems Committee (ATSC) has long remarked on such issues and has made careful efforts to support vehicle broadcasting from the very first stage of developing a new standard, ATSC 3.0 [9], [1]. The broadcasting-based solutions such as [4] have hence been highlighted for this use case.

In fact, specific ideas to serve each individual passenger's device have been less identified so far. Such sort of detail has been recognized as the next step after building the D2V connectivity. Nonetheless, since the D2V supply is actually being embodied in the real world [4], it is no more a future work to hold off. This paper, in this context, introduces a feasible solution to build a bridge from air ATSC 3.0 signals to the end devices inside a vehicle.

Particularly, this is a showcasing of a WiFi gateway operating as an ATSC 3.0 relay with interface conversion ability. The presented gateway system seamlessly captures the received broadcast signals and converts them into a format compatible with WiFi-enabled devices, ensuring a smooth and uninterrupted streaming experience. Accordingly, the individual users at the seat are allowed to enjoy content on their own personalized displays in convenient positions. This paper presents the architecture design of the ATSC 3.0-to-WiFi gateway and its actual use in automotive systems. With the advent of this gateway system, the momentum of D2V broadcasting will be amplified, as it allows passengers to access a diverse array of ATSC 3.0 broadcast content on their personalized devices and displays while on the move.

II. Design and The Use for Mobile Broadcasting

Fig. 1 illustrates the concept of the ATSC 3.0-to-WiFi gateway. This system forwards the content in broadcasted airwaves to the local access users in a car interior. The physical layer conveyor is converted from ATSC 3.0 broadcasting to WiFi unicasting during then.

This solution tackles three relevant problems that arise when direct-to-mobile (D2M) serves the passengers: (*i*) Physical penetration loss, (*ii*) mobile environment distortion, and (*iii*) compatibility with ready-distributed legacy devices. The decode-and-forward procedure of this system allows the users to avoid penetration loss; multi-antenna diversity, enabled by spacious car top, alleviates the mobile distortions if deployed. Most notably, WiFi transmission at the end link will allow the legacy smartphones, yet not supporting ATSC 3.0 D2M, to access the ATSC 3.0-conveyed contents.

The implementation can follow a structure described in Fig. 2. Fig. 2 is a particular example that employs four receive antennas and provides opportunities to access four different broadcast channels, namely, a 4-by-4 configuration. Simply speaking, the presented system consists of ATSC 3.0 demodulators and a WiFi access point (AP), which includes a data scheduler and transceiver. The ATSC 3.0 airwaves in the target frequency are first captured by a dedicated tuner, and decoded by the ATSC 3.0 demodulator. The ATSC 3.0 demodulator module feeds ATSC link-layer protocol (ALP)

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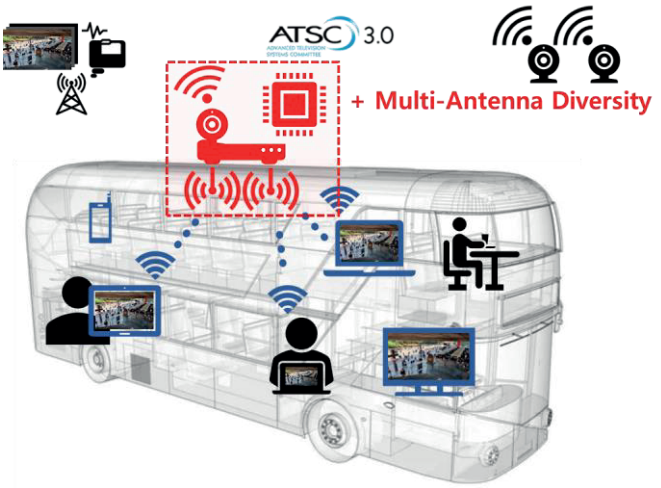

Fig. 1. Conceptual description of the ATSC 3.0-to-WiFi gateway mounted on vehicle: Mass transportation case.

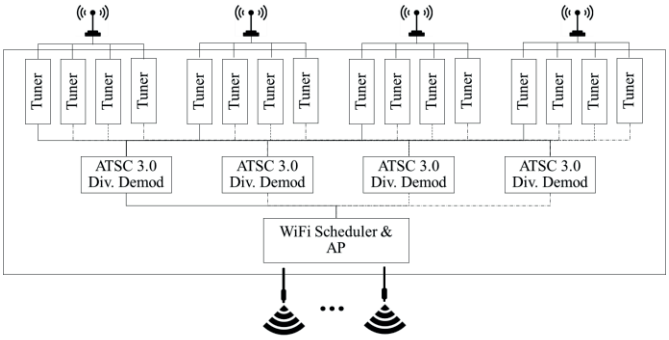

Fig. 2. System structure of the ATSC 3.0-to-WiFi gateway.

packets, which are Internet Protocol (IP)-based, to the WiFi AP. The WiFi AP at the end stage controls every access from each passenger device and forwards the received ALP packets respondingly to the requests. Delivered the content to the passenger device, the service content is then source-decoded by a dedicated app program, finally being presented on display.

The 4-by-4 or 4-by-2 cases would be reasonable examples if private cars are on the table. Many such personal motors have four seats where the display sets can be embedded. Therefore, accessibility to four different channels will give every user the authority to choose the channel to watch. 4-by-2, on the other hand, will give such an opportunity to the front and back seats. However, if a packed mass-transportation vehicle is considered, the mechanism for controlling the desired channel shall be differently made. For example, some *master users*, N users in an N_T-by-N case, can be selected, and the set of *watchable channels* is then determined by them, letting the other users consume one in this set.

Simultaneously, multi-antennas installed on the rooftop offer diversity gain to combat mobility-caused distortions. The diversity reception improves the effective signal power and also allows to cope with local shadowing issues dynamically. This advantage possibly propels the D2V broadcasting itself, boosting media entertainment in mobile environments.

The benefits extend beyond entertainment alone. The gateway system also opens up possibilities for educational content delivery, emergency broadcasts, and location-specific information dissemination to enhance the overall in-vehicle experience.

III. Conclusion

This paper addressed the challenge of delivering ATSC 3.0 broadcast signals to mobile users within a moving vehicle, leveraging the concept of a gateway system that converts these signals into a WiFi interface. The presented gateway system is a compact solution to provide terrestrial broadcast content to personal mobile devices, acting as a bridge between the ATSC 3.0 over the air and the WiFi network within the vehicle. Penetration loss, cabling burden, and position-dependent accessibility problems are hence resolved, thereby offering an enjoyable media experience condition. With the assistance of this vehicle gateway system, digital terrestrial broadcasting will be pleasantly embraced into infotainment systems in automotive, and would subsequently propel the expansion of D2V opportunities beyond media entertainment.

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