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Survey on Approaches for Wireless Internet Connections on Trains

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ABSTRACT: This paper provides a study of solutions to provide wireless Internet connectivity to trains. Researcher investigate some of the obstacles that impede the usage of broadband Internet on trains and then address some of the potential for broadband implementation on trains. This study discusses some of the fundamental principles for delivering broadband Internet connectivity, and then explores the related network architectures. The analysis of network architectures reveals that researcher can subdivide networks to provide wireless Internet connectivity to trains on the train-based network, the connectivity network — to link the train to the service provider(s)—and the aggregation network — to collect user packets created in the access network. In addition, our analysis reveals that the latest practice is to provide Internet connectivity for passengers on trains using IEEE 802.11; however, a consistent mechanism for linking trains to the global Internet is yet to appear. A review of the deployment activities in Europe and North America helps to illustrate some of the systems that have so far been used to link trains to the Internet. They end by reviewing some of the models planned, from a technological point of view, to test the feasibility of delivering Internet connectivity to trains.

KEYWORDS*:*Architecture, Broadband Internet, Famous, Internet, Trains

I. INTRODUCTION

Since the acceleration in Internet expansion in the past 20 years, users are now more likely to be able to access the Internet regardless in their location. Before recently, trains and planes were two places where travellers were not usually able to access high-speed Internet links. In the special case of trains, the availability of Internet service for passengers on board trains makes good economic sense: Internet connectivity for passengers will provide a revenue source for the railway company thus drawing more passengers[1], [2]. For example, a survey in the United Kingdom showed that 72 per cent of business travellers were more likely to use trains than vehicles or aircraft if Wi-Fi connectivity was available on trains. The research also showed that 78% of these business travellers would use Wi-Fi service if it was made available on trains. In the case of freight trains, Internet connectivity may allow for real-time or near-real-time monitoring of freight-related incidents on board the train, possibly leading to a reduction in insurance costs for the freight carrier[3], [4]. In addition to the advantages, wireless Internet connectivity on trains will also improve train safety by allowing the operations centre to track train-related data in real time. Internet connectivity on board trains is also available in parts of Europe today[5], [6]. For example, a British train operator, GNER, started providing Internet access on some of its trains in July 2004. In 2005, another British firm, Nomad Digital, reported to have solved the problem of offering high-speed Internet connectivity for passengers on the London Southern Trains to Brighton via WiMax. In what follows, they give an analysis of communications on board trains, beginning with some of the early articles on wireless Internet connectivity for users on the move. The key purpose of this paper is to include a survey of work and execution aimed at making access to the Internet accessible on trains[7], [8]. The circumstances of the rail system that make it impossible for trains to communicate are illuminated. For purposes that will become evident later on, researcher make comparisons between research undertaken in Japan, Europe and North America on the grounds of the various characteristics of rail transport in those areas. The remainder of this paper is set out as follows: Section II describes the problems that impede high-speed rail communications. Section III provides a reference

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framework for connectivity to the Internet on trains and also lays out a context for handing over and addressing problems relevant to trains. Section IV addresses the basic principles that have driven the introduction of wireless Internet service to trains[9], [10]. In Section V, researcher include a taxonomy of technology used to connect trains to the Internet. Section VI examines the findings of the test beds that explored how to deliver wireless Internet to trains. In Section VII, researcher discuss the efforts made or ongoing for the introduction of high-speed train communications.

1. Difficulties and Opportunities

1.1. Difficulties

Communications on board trains are affected by a variety of factors. Researcher claims that Faraday railcars have cage-like properties that can lead to heavy penetration losses for signals. The researcher adds that other complicating factors include:

- A "high vibration environment" which may involve the mechanical isolation of communication equipment.
- A "thermally demanding" setting, as heat may be a big problem in some sections of the car.
- A harsh electrical condition due to: – the presence to elevated voltages, as with electric trains. – High magnetic currents, such as the Magnetic Levitation (Maglev) trains. – Trains are not equipped to provide computers with "clean" electrical supplies.
- The requirement for equipment with limited maintenance schedules — this may result in equipment with near-military requirements.
- Presence of trackside facilities, such as rail signalling equipment. Many reasons that impede interactions on trains include:
- Railway firms continuously add or delete rail cars from trains. As a consequence, it is important for the communication network to immediately discover these changes.
- Weak coupler connections on rail trains, which can lead to communications failures.
- Tunnels can restrict the visibility of the wireless communication infrastructure.
- Regular hand-offs in the wireless network. These handoffs can result in packet loss and packet reordering.
- Mobility of the train complicates the delivery of quality of service to various traffic flows. Despite these challenges, there are many ways to offer Wireless connectivity to trains using a range of systems, including Wi-Fi, WI-Max, cable and radio over-fibre. Any of these prospects are discussed in Section II-B.

1.2. Opportunities

The rise of wireless networking technology over the last two decades has opened up many ways to facilitate communications on board trains. For example, passengers on a stationary train may have access to the Internet via the current telecommunications network without much changes, except for an antenna on the outside of the train. Issues occur only when the train begins to run, especially at high speeds, which needs many hand-offs in a short period of time. Researcher believes that networking technologies on mobile devices are continuously growing, with some phones also providing multi-band and Wi-Fi capability. Currently, Wi-Fi is standard on notebooks, and soon WiMAX will also be widely available. These factors, in particular the latter, have the potential to increase Internet use, especially as accessibility becomes more widespread, use increases. Researcher further claims that there are major opportunities for Internet connectivity on trains where connections to the network can be made: easy, universal (as if no special software or terminal is required) and accessible (i.e., reasonable throughput and delay with little service interruptions). Under this context, fourth generation (4 G) networking systems, such as WiMAX, IEEE 802.16 m or LTE, may be effective options for delivering Internet connectivity on ships. It has been confirmed that WiMAX is being used in the United Kingdom to provide Southern Trains Internet connectivity. Researchers expect more increases in the provision of broadband Internet service on trains, as more rail operators are persuaded of the market potential of securing cellular connectivity along their tracks using WiMAX or some other 4 G technologies. Railway signalling is another method for wireless connectivity on ships. Researcher states that common networking networks such as IEEE 802 and IEEE 802.20 (Mobile Internet Wireless Access) should be used for rail signalling instead of cable systems currently in use.

2. Reference Architecture

In this segment, they present a reference architecture to lead our discussion of broadband Internet connectivity for trains. Researchers also have some information on hand-off and discuss problems that are specific to all Internet installations on trains. Fig. 1 demonstrates the conceptual architecture for computer networks on board trains used to provide passengers with connections to the Internet. This design, which integrates elements of the rail contact model,

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uses the gateways in each train car to create a track-level network. Broadband Internet service on the train is provided by the Train Service Terminal (TAT). This interface, which can accommodate one or more forms of equipment, attaches an antenna mounted on the exterior of a train car to the control network. The incoming signal from the train control terminal is then fed to the gateways and wireless access points of all rail cars in the line. IEEE 802.11 is widely suggested to provide access for passengers in each rail car; however, passengers may still link to a wired railcar network where one is available. The advantages of using such an architecture include the following:

- The wireless network infrastructure is not under pressure having to make handoffs for several fast-moving applications concurrently. In fact, new Internet Technology Task Force (IETF) standards for network mobility can be implemented to handle TAT hand-offs.
- The train control terminal will integrate different access technologies. TAT can also use certain "intelligence" to choose the appropriate means of contact between the train and the control network. Fig. 2 demonstrates the train connecting to the Internet using the reference architecture laid out in this paper.

The Internet connectivity infrastructure for trains is complex and consists of the communication network, the aggregation network and the network of content providers. The access network (shown here as a base station) is situated next to the train tracks and provides the last hop contact for the train control terminal. The aggregation network is situated between the access network and the network of service providers which forwards data from the access network to the global Internet. The access gateway in the system integrates the data from a group of users into a conduit and passes the data to the operation gateway. The service gateway acts as an interface between the distribution network and the network of service providers. Experts claim that aggregated tunnels per train are ideal for this system because they are more accessible and effective than per device link scheme. From the model architecture diagram, they can also see that there are various infrastructure choices for connectivity and convergence networks, including satellite technologies. This statement is in line with the writer, who states that there is generally general consensus about how to provide Internet connectivity for passengers on board trains. Disagreement occurs as to how best to link the running trains to the Internet infrastructure, i.e. how to link the antenna on the rail control terminal to the transmission network. The universal implementation of 4 G technology can, however, contribute to some consensus about the best way to do this.

3. Other Architectures

Experts suggest an Internet communication system based on common source network technology such as IEEE 802.11 and IEEE 802.16, Wireless IP, In-Rail Network Components, Rail to Backhaul Infrastructure Components, Trackside Communication System, Homeland Security Monitoring System, and Command and Control Centres. In fact, the planned design includes a subsystem that performs hand-offs as the train travels from the service area of one trackside unit to the next. The train to the backhaul part is similar to the access terminal of the train in Fig. 1. The trackside contact system is an authentication network, while the in-train network is the same as the one seen in Fig. 1. Researcher is developing an infrastructure that separates train communications into backhaul links, Ground-to-vehicle communications (GVC) and on-board vehicle communications (OVC). The GVC is similar to the control network of the reference architecture in Fig. 2 while the OVC network consists of customer equipment as well as other networking devices, such as a train server, located in the train. The OVC network is identical to the train dependent network seen in Fig. 1. On board each train, the OVC and the GVC are connected by a CM (connection manager) similar to the rail control terminal in Fig. 1.

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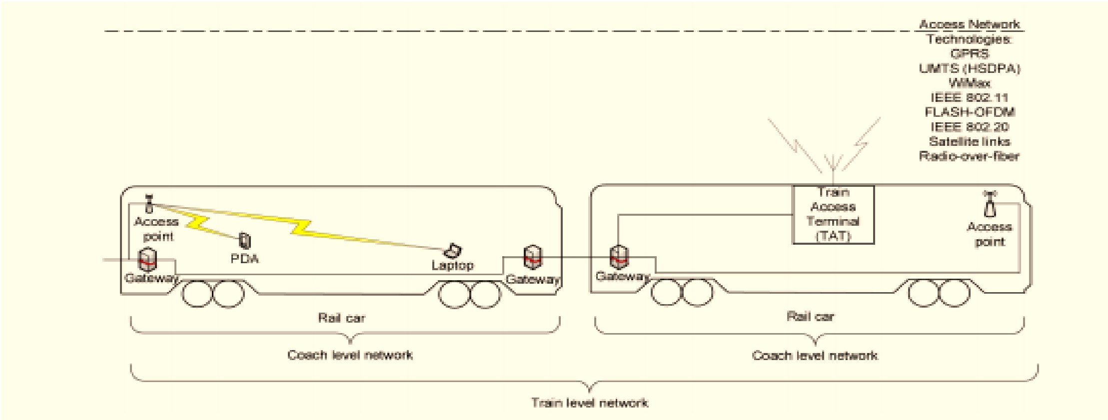

Fig.1: Architecture for Internet Connectivity between Rail Cars

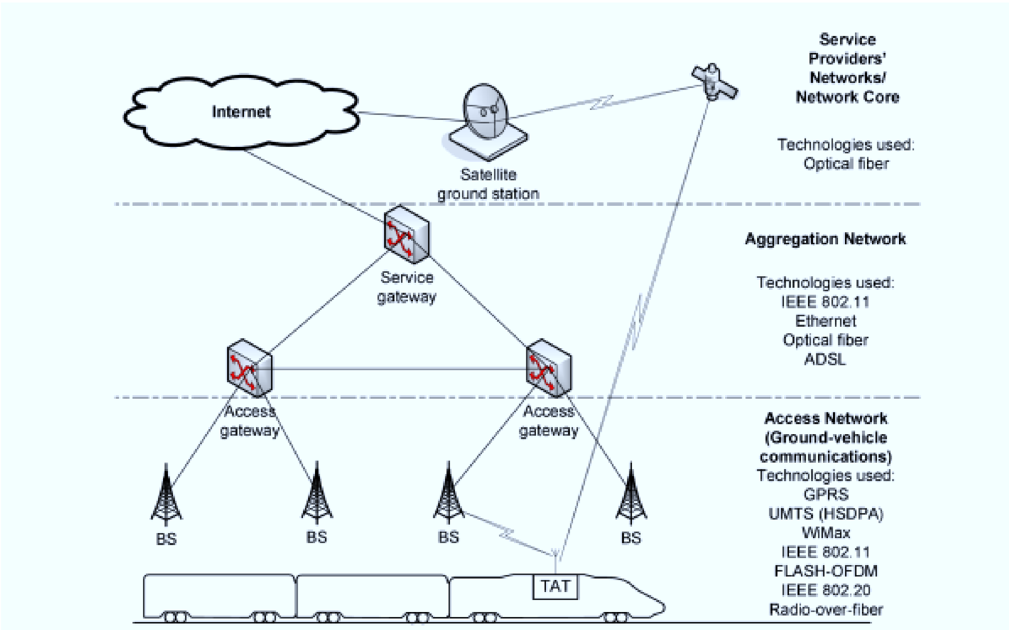

Fig.2: Reference Architecture for Internet Access on Trains

3.1. Handoff Issues

In 2003 it was reported that common Internet applications would not be available at high speeds due to lack of bandwidth, low quality of service and repeated hand-offs. These issues may be partly solved by: increasing network connectivity using smart antenna systems and MIMO technology, as well as better hand-off protocols that avoid lack of contact when switching from one base station to another. Scientists claim that the solutions described above are not adequate to enable high-speed broadband communications; modern modulation schemes and context-aware applications are still required to achieve high data rates in fast-moving vehicles.

- *Train Access Terminal Hand-offs*: Researcher claimed in 2005 that fast connectivity rates for end-users could only be reached in wireless networks by reducing the size of the cell to efficiently reuse the spectrum. Nevertheless, small cells do indicate more hand-offs between cells. In fact, Mobile IP is not a suitable protocol for providing high connection rates to fast-moving applications, because Mobile IP does not work well with repeated hand-offs

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due to latency hand-off, packet loss and message load power. As a result, it claimed that higher connection speeds could be provided to fast-moving train users by using small cells running in the millimetre waveband. In fact, these writers propose the use of radio-over-fibre with moving cells to minimize hand-off times, a concept that is an expansion of Gavrilovich's moving base station model.

- *Passenger Handoffs*: In 2005, a researcher researched smooth hand-off, roaming, quality of service (QoS) and links between heterogeneous wireless networks such as the on-board network and the trackside network. On through train, the Mobile Access Router (MAR) is similar to the Rail Access Terminal (TAT) in Fig. 1—will have one interface for each form of device, and will continuously select the best connection from the train to the outside world. Aboard the train, hand-offs can occur when a mobile computer is either unplugged from the train's wired network or when a smartphone user switches from one Wi-Fi hotspot to another on the train. In any case, the session of the user must be secured. Researcher tries to enforce this security by developing a compatibility layer that covers the Ethernet and WLAN interfaces and then provides a new computer network that has a new IP and MAC address allocated to it. The hand-off system implemented in has been successfully replicated and will allow passengers to be mobile when using a network on board trains.

3.2. Addressing Issues

So far, the researcher has provided a model framework for Internet connectivity on trains as well as a review of hand-off problems. However, they do need to take into account the network topology and the addresses on the train- network. Network topology on board trains is continually evolving, which is why it is important to build a reliable control system that can develop and sustain train connectivity while delivering logical and IP address services. Researchers suggest a connection management mechanism that uses the Train Communication Network Standard (TCN), the Dynamic Host Configuration Protocol (DHCP) and the Network Address Translation (NAT) to link devices on a coach-level network to a common network across the entire train. Addresses are automatically allocated to the coach level network and the Network Address Conversion is used to allow communication within the car.

3.3. Implementation Efforts

In the previous segment, the researcher checked the findings of the testbed implementation of the Internet connectivity to trains. In this section, they focus at how these concepts have been applied in Europe and North America. As stated in Section I, broadband Internet connectivity is becoming increasingly accessible on trains in Europe. In Europe, passenger demand for Internet service is strong, while in North America, rail traffic is dominated by freight. As a result, owing to business pressures, attempts to perform train interactions have developed in significantly different ways on these two continents. Researcher analyses the implementation efforts in Europe and North America separately, since lessons taken from one region that not automatically extend to the other. Moreover, deployment efforts in Europe are much more advanced than those in North America. In 2007, the researcher observed that railway¨ operators are switching away from proprietary connectivity systems technologies to generic off - the-shelf technologies to lower costs while increasing capacity and reliability. In this section, they can see applications based on open standards such as WiMAX and cellular technologies — a pattern that tends to confirm Horste's assertion.

II. CONCLUSION

The provision of wireless Internet service on trains will prove to be a source of income for operators. Previous UK tests have shown that rail operators will draw more customers if Wi-Fi connectivity is made available. In this paper, they discussed some of the original methods, emerging developments and possible concepts, such as IEEE 802.20 and Radio-Over-Fibre, related to Internet connectivity on trains. Researcher have received an overview of the attempts taken to guarantee universal Internet connectivity for trains in Europe and North America. These efforts, mainly from Europe, demonstrate that broadband Internet access on trains is feasible. Furthermore, business models built to test the feasibility of Internet service on trains demonstrate that wireless Internet connectivity on trains is better accomplished by a mix of communication technologies. However, successful operation requires the careful configuration of the device. North America does not have the same features of rail traffic as Europe, and so wireless Internet service on North American trains is not as readily accessible. In North America, wireless Internet connections on trains may be used to obtain operating data from trains as well as to track freight traffic. Future research may be to establish a business model for wireless Internet service on North American trains, taking into account the fact that North American

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rail traffic is dominated by freight. A successful business model could help to promote the rollout of broadband Internet service in North America.

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