Taking communication out of silos

As metro networks become busier, more capacity is required — not only for passengers, but also for data. A research project is examining the possibility of consolidating communication networks using 4G LTE.

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Metro networks are facing enormous pressures from increasing ridership and growing expectations from passengers — not just for reliability and security, but also for value-added services such as wireless broadband connectivity. To address these challenges, the French government has set up the ‘Investments for the Future — National Fund for the Digital Society’ initiative, which aims to modernise municipal infrastructure through the introduction of new digital technology. The part of this programme concerning metros and trams is known as Système télécoms pour le Transport Urbain du Futur, or SyStuf.

The primary aim of SyStuf is to demonstrate the feasibility of using a single radio communication technology to deliver both safety-critical and non-safety-critical services on a metro network simultaneously. The project’s initial phase ran from July 2012 to July 2015, during which time the technology was tested in Alcatel-Lucent’s Transportation Solution Labs. The testing covered elements including network design, radio planning simulation and performance in terms of throughput and response time at various simulated train speeds. The work is now moving into the next stage, with live testing to begin on the driverless Line 14 of the Paris metro from October until April or May 2016.

### Consolidating networks

The specific technology being tested in SyStuf is 4G LTE mobile broadband. This is being developed as the foundation for a dedicated mobile network that is envisaged as the basis of the next generation of a ground-to-train radio network.

The scope includes the definition and characterisation of both traditional and new applications, and an LTE-based end-to-end communication architecture. One facet of the project is the development of a reference architecture and its business model, and the creation of an ‘ecosystem’ allowing wider deployment of the technology. In this way SyStuf acts as a spur for further innovation in the transport industry.

SyStuf is managed by Alcatel-Lucent, which is supplying the 4G LTE technology. The company is also responsible for testing at its Transportation Solution Labs. Its R&D subsidiary Bell Labs is assisting with advanced development of LTE small cells onboard and relay.

Alcatel-Lucent is working with seven partners:

- Paris metro operator RATP has defined the applications that the network will support, and is providing the live environment for testing.
- Alstom is supplying communications-
based train control, which includes a new LTE onboard mobile router.

- Eurecom is responsible for the tools and methodology to evaluate the performance of the subsystems, including the LTE network.
- The Ifsttar consortium of research laboratories is in charge of simulating performance measurement and tests.
- Mitsubishi Electric R&D Centre Europe is developing LTE relay technologies for future networking architectures.
- Telecom Bretagne is defining future radio infrastructure architectures.
- Simpulse is defining new signal processing algorithms and developing prototypes.

In addition to these project partners, Railenium, SystemX and B-COM are technological research institutes associated with the project. The total cost of Systuf is €4·56m, which is partly funded by a €1·64m grant from Banque Publique d’Investissement; the remainder is coming from government funds.

An LTE-based network was chosen to address the problems with existing railway communications technology. Traditionally, each service such as signalling or voice communication uses a separate network. This ‘silo’ approach presents enormous management and maintenance challenges. Moreover, as the various technologies become obsolete, an opportunity has arisen to consolidate them onto a single wireless network.

CBTC and onboard CCTV use separate radio networks, generally proprietary or based on wi-fi, whereas voice communications between the driver and control centre or passengers are delivered over a Tetra or other private mobile radio network. To add complexity, platform CCTV uses a third network, either based on wi-fi or digital video broadcast technology. This situation is almost certain to worsen as more applications are added. Building out new networks for each application is therefore becoming increasingly untenable.

The separate infrastructures have a cumulative effect on maintenance and cost over time as the number of services and their associated networks multiplies. Furthermore, these infrastructures are not necessarily designed to support IP-based services, which are likely to be the foundation for communications networks in the future. As a result, it will be increasingly costly, if not impossible, to integrate newer services with these older, dedicated networks.

Beyond wi-fi

As metro ridership grows, the need for greater capacity becomes more pressing. Plans for new lines often run into cost or physical constraints, forcing transport authorities to squeeze additional capacity out of existing infrastructure. Automation is an attractive option, as it is one of the most cost-effective ways to increase capacity, which is achieved through shorter headways. However, automated metros place large burdens on communications. Additional CCTV cameras for obstacle detection need to be installed and managed onboard, with a huge amount of images sent to the control centre. CCTV cameras are also needed inside the train for passenger security.

To support the enormous amount of data generated by these cameras, an ultra-broadband radio network is required. However, existing wi-fi connections that are currently used to support CBTC are not a good fit for this. Most wi-fi networks in place on metros are incapable of carrying both safety-critical and non-safety-critical traffic, owing to limitations such as a lack of sophisticated quality of service support and the use of unlicensed spectrum, which can result in interference.

Wi-fi has other limitations that are difficult to overcome. Standard wi-fi is not optimised for transport, and cannot support ‘always on’ connections between the trains and the control centre, which is mandatory with train control technologies such as CBTC. CBTC currently uses proprietary wi-fi technology with features developed to compensate for the weaknesses of standard wi-fi. As a result, the expensive proprietary wi-fi can only be used for CBTC. Standard wi-fi networks also do not support real-time monitoring of the air interface to guarantee the performance of the modem or other terminal.

Perhaps the most important concern, however, is cyber security. Because wi-fi uses unlicensed spectrum, there is always a risk that some hostile party could seek to jam the network, undermining safety.

A new generation of radio technology is therefore required, capable of improving performance, supporting the deployment of new services, reducing operational costs and guaranteeing the security of the network against cyber attacks. A technology that answers all of the above challenges and allows the consolidation of multiple radio systems is 4G LTE, a commercial off-the-shelf technology.

The primary characteristics of LTE are high speed, high security and high capacity. It can carry voice and data for train control, onboard video surveillance and passenger information simultaneously on a single IP network. LTE has low latency — the time for a packet of data to get from one point to another is as low as 10 milliseconds — so it can support highly time-sensitive applications and provide high levels of quality-of-service management. It can be deployed in many different frequency bands and has multiple features related to encryption and authentication. Moreover, LTE technology guarantees the segregation of the various data flows, which is crucial for CBTC applications.

The following applications will be tested on Line 14:
- operational voice communications with push-to-talk and group calls;
- CBTC;
- onboard emergency passenger communications;
- onboard CCTV;
- platform CCTV;
- the passenger information system;
- onboard sensors that monitor performance to make maintenance recommendations.

The performance of the radio network will be tested in terms of latency, error bit rate and bandwidth for each of the applications that the network supports. The tests will be performed while the network is fully loaded with data and while two trains are passing one another at full speed, which is the worst-case scenario for a radio network, as it can introduce radio interference and lead to a rapid increase in data traffic in the radio cell.

The network includes innovative functions such as onboard femtocells and small cells (cellular base stations) to provide in-compartment 4G LTE coverage, as well as mobile relay functions that are currently part of the specification process with the 3G Partnership Project, which oversees the development of the 4G LTE standard.

The need for greater capacity is the driver behind developments in communications technology.