Outcomes, Insights and Best Practices from IIC Testbeds: LTE for Metro Testbed

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To extend the usefulness of the published testbeds in the Testbed Program of the Industrial Internet Consortium (IIC), the Testbed Working Group has developed an initiative to interview the contributors of selected testbeds to showcase more insights about the testbed, including the lessons learned through the testbed development process. This initiative enables the IIC to share more insights and inspire more members to engage in the Testbed Program.

This article highlights the LTE for Metro Testbed. The information and insights described in the following article were captured through an interview conducted by Mr. Howard Kradjel, Vice President of Industry Programs at IIC, with Mr. Yaling Zhou, Industrial IoT Industry Development Director at Huawei Technologies. Yaling is an active member in the IIC where he serves as a co-lead of the LTE for Metro Testbed, co-chair of the Chinese Regional Team and co-chair of the Standards Task Group.

LTE for Metro Testbed – From Concept to Reality

Within a metro system, a wireless communication sub-system carries multiple types of services for train control and management between devices on moving trains and ground facilities. Many wireless technologies are used to support different services. To guarantee service, two separate Wi-Fi networks are set up to carry critical and non-critical services. A typical critical service is Communication Based Train Control (CBTC) while a non-critical service may include video surveillance and Passenger Information Systems (PIS). Implementing two separate wireless networks introduces vendor-specific extensions that lack standardization and interoperability. The metro rail industry is in need of a next-generation solution for wireless communication in metro systems.

The Long-Term Evolution (LTE) for Metro Testbed establishes and validates a profile for the use of LTE technology in metro environments for the purposes of wireless communication and quality of service (critical and non-critical) for metro control and operation. The results of this testbed are applicable to discussions around future international standardization in the metro rail industry and promote the collaboration between Standards Developing Organizations (SDOs) and various parties in the metro field.

The testbed's areas of experimentation include services needing support (CBTC, trunking, PIS), the performance and reliability of critical services (CBTC delay, jitter, packet loss) and the performance of non-critical services. The output of the testbed will address system specification for various key challenges and best practices for system architecture and key technology selection. Furthermore, the testbed will provide insight on the necessary architecture, features, configurations and profiles to meet service requirements under various conditions.

The LTE for Metro Testbed addresses two key use cases. The testbed first focuses on validating the network capability in critical services to support CBTC, adjusting the profile as necessary (architecture, configuration, installation) to ensure service is not degraded under various conditions and find a working profile. The second use case addresses multi-service support, CBTC testing, trunking communication and network function in various scenarios such as emergency calls, priority calls, area broadcasts, call transfers and system recordings. The testbed also tests PIS and video surveillance uses under the new network.

In phase one of the testbed, connectivity issues were fixed by using one network to support multiple services, including critical services. In phase two, the testbed team will continue working for a scenario of moving the large amount of data collected from all metro service systems to a cloud platform. Looking ahead, the team hopes to implement more possible technologies such as big data analysis, artificial intelligence (AI) and knowledge maps in the metro rail industry.

There are four key technology areas found in the rail industry that apply to the LTE for Metro Testbed. The first is Quality of Service (QoS) enhancement, aiming to guarantee the reliable transmission of CBTC signals. CBTC is the highest priority because it prevents preempting resources needed for other services.

The second key technology is wide coverage. One remote radio unit (RRU) can cover 1.2 kilometers, a greater range than that of most network coverage methods—such as Wi-Fi. An RRU can therefore reduce the number of signal handovers.

Next, a fast handover algorithm can support high train speeds—more than 400 kilometers per hour. Finally, metro systems use anti-interference technology to avoid interference with Wi-Fi and Bluetooth via licensed, dedicated spectrums.

The testbed is deployed in Huawei's OpenLab in Suzhou, Jiangsu province in eastern China. This lab was established by Huawei in 2017 to promote the development of the industrial internet ecosystem through in-depth cooperation. The testbed's field test is performed on Ningbo Rail Transit's metro line in the city of Ningbo in eastern China. An LTE network is deployed along the test rail track of about one kilometer, covering 500 meters above ground and 500 meters underground—accounting for two typical scenarios in a metro environment.

The testbed team plans to produce four deliverables, starting with a technical report. The technical report is a summary of the lab test and field test results. The lab test report is finished, and the field test report will be produced upon the completion of the test in the near future.

The second deliverable is an experience report comprising the challenges and lessons learned in the field test. This report will also provide feedback to the IIC Networking Task Group on network architecture, challenges in mission critical systems and other considerations in a metro environment.

The next deliverable will be a consolidated profile providing best practices for train-track control and management in the metro rail industry, as well as an input for discussions around possible future standardization in the rail industry.

The final deliverable will be a white paper presenting the testbed's solution and technical recommendation for the rail industry—including the profile and lessons learned.

TESTBED PLANNING

The IIC is a world-leading industry organization that has accumulated a plethora of experience in the industrial internet field. Huawei's industrial internet goals and concerns led to the development of the Huawei OpenLab ecosystem lab where testbeds based on smart city and metro ecosystems exist in the smart city and transportation fields and extend to energy, manufacturing and other industries. The IIC ecosystem has helped Huawei establish alliances with other IIC members, such as China Academy of Information and Communications Technology (CAICT), and the testbed team works together to conduct technology tests efficiently—using the IIC's guidance for operating a testbed and addressing an existing problem in the field.

Huawei and its testbed partners have derived significant value from the IIC ecosystem. The IIC provides a common framework, interoperability guidance and open standards to connect and integrate devices with people, processes and data while accelerating the development of the industrial internet through innovative business achievements. The consortium gathers organizations in related industries to jointly identify, integrate and promote the best technologies and solutions for the development of the industrial internet and digital transformation. As an active contributing member of the IIC, Huawei collaborates with the IIC to promote the application of innovative Information and Communication Technologies (ICT) and conversations with relevant international SDOs.

In addition to metro testbed cases, the IIC has launched a series of innovative activities in the smart city field including smart water, smart building energy saving, traffic optimization, ambulance and firefighting. These areas implement technologies in IoT, networking, big data and cloud computing to help realize smart transportation, energy conservation, environmental protection, clean water supply and efficient and safe operations. Huawei anticipates collaborating with other IIC member companies in smart city-related testbed projects to promote the research and development of new technologies and applications in the smart city field.

Huawei chose partners for the LTE for Metro Testbed using an end user perspective, aiming to create and fulfill the role missing in the end-to-end solution. The testbed team expects to select more end users and system integrators in the future to participate in subsequent testbed projects in an effort to enhance the maturity of the use cases in commercial scenarios, as well as to build an evolving ecosystem under the new network deployment pattern.

Because the lab test environment for the LTE for Metro Testbed is quite complex, multiple stakeholders in the industry chain needed to work together to deploy the testbed. The project requires an actual test environment provided by the metro company, as well as dedicated test time. To account for the day-to-day operations of the metro company, tests were performed very early in the morning.

IIC Interactions

The principles found in the IIC's Industrial Internet Reference Architecture (IIRA) and Industrial Internet Security Framework (IISF) play a significant role in the testbed. There are aspects of the testbed design which may have been missing a vital function or service to fulfill the sought-after solution. The IIC's frameworks help to fill gaps in information or knowledge, providing guidance in identifying the problem.

Phase one of the testbed will contribute to the IIC's work around networks and connectivity, especially how to use connectivity and networking in mission critical environments. The testbed's second and later phases will demonstrate the implementation of cloud platforms and industrial AI applications that can be used in the metro rail industry.

Standards

The LTE for Metro Testbed incorporates the B-Trunking standards of the International Telecommunication Union (ITU), as well as the Urban Rail Train-Ground Integrated Communication System specifications of the China Association of Metros (CAMET). CAMET has more than 500 members including more than 50 metro owners/operators, so it will be vital to promote the adoption of LTE-for-metro-related technical specifications to a wider industry community based on real industrial needs.

Currently, no technical standards based on LTE for the urban rail industry have been released by international standards organizations. The testbed team hopes that the IIC LTE for Metro Testbed will introduce the benefits achieved by the application of LTE technology in urban rail wireless communication for rail operators worldwide. Before LTE for metro, metro operators commonly used Wi-Fi as the major ground-to-train communication standards and technology. LTE for metro intends to enable operators to evolve Wi-Fi network standards to the next generation on an international scale.

Testbed Results

The LTE for Metro Testbed lab test and corresponding technical and experience reports have been completed, and the field test will be completed in the next several months. The testbed has successfully verified that urban rail operators can use LTE wireless communication technology to carry multiple services rather than having to use different communication network technologies to separately address critical and non-critical services. One network is capable of carrying all critical and non-critical services.

From the business perspective, the LTE network technology greatly simplifies the architecture of urban rail wireless networks, helping end users reduce network maintenance costs and improve operational efficiency and reliability. The testbed team has found that with the high-speed mobile handover algorithm, a PIS system is able to run video streams at 160km/hour without frame freezing. In addition, the high-bandwidth, open spectrum allows a single cell to support uploads of six high-definition video streams.

Traditionally, operators use proprietary technology that is very difficult to operate. The testbed confirms that operators can use LTE technology and still comply with the global 3GPP standards. End users are therefore able to avoid potential vendor lock-in issues.

At 2019's Global Public Transport Summit in Stockholm, the testbed demonstrated the feasibility of adapting LTE to the urban rail industry, exemplifying how LTE provides operators a benchmark and technical choice for future urban rail construction. An international LTE for metro ecosystem would provide an effective reference for urban rail owners throughout the world to evolve to the next-generation train-to-ground wireless communications technology.

The LTE for Metro Testbed team has encountered some challenges in their testbed journey, however. The first challenge came from gathering a team comprised of different backgrounds; the testbed needs ICT engineers, OT engineers and also field experts. The main challenge is managing the contributors under one team, understanding the many different perspectives and developing a common understanding of the issues at stake. While horizontal technology and OT engineers discuss the technology, the end user participants may be focusing on services; and bridging these two areas is no easy task. The Huawei OpenLab has played a pivotal role in integrating these aspects by providing simulations of actual services.

In terms of logistics, it is difficult to negotiate with an end user metro system to find a time slot for the field test. A metro system does not typically leave much time for a test given its ongoing operations day-to-day.

Another challenge arises due to the large number of service systems in the metro field. Interconnecting these systems within a traditional metro environment is a tremendous work load and demands the necessary technology and expertise.

Looking to promising prospects for the testbed, many metro operators in China are starting to adopt LTE related technologies defined by CAMET. The testbed team also hopes to engage with global customers by sharing the testbed platform through the IIC.

Through their activities, the testbed team has learned that if there is no standard between different systems, a large interoperability workload is required. The team hopes the testbed will be used to build and influence globally unified standards and reduce the cost of using and promoting new technologies.

Experience

Participating in the IIC Testbed Program enabled the LTE for Metro Testbed team to set up benchmark projects throughout the testbed. The testbed is able to help metro customers implement digital transformation through a path of communication network evolvement, bringing service systems to the cloud and making the best use of data on the cloud. This transformation will improve metro owners' operational efficiency and expand the market space of the metro rail industry. By driving the establishment of industry standards, the testbed will reduce the cost of adopting new technologies across the industry and reduce market fragmentation. Without the support and guidance of the IIC Testbed Program, these accomplishments would not be possible.

The coordination between multiple vendors in the testbed lab and the preparation of the field test environment were slower tasks than previously expected. The collaboration between multiple industry alliances and various other organizations also hinders the testbed's overall progress.

The testbed team would advise other testbeds and companies considering an IIoT implementation to attract end user engagement at the beginning of their journey. If end users are engaging in a testbed early in the process, the whole testbed's progress is expedited. It is also important to build industry standards and prevent industry fragmentation to reduce the cost of using new IIoT technologies for end users.

CLOSING

The next step for the LTE for Metro Testbed team is to fix the issues found in testing and finish other remaining tasks, afterward moving on to make use of the collected data. Determining how to efficiently use the collected data is a difficult task the testbed team had not considered early on. A comprehensive cloud platform must be established to support data usage (including big data and metadata) to move toward cloud-oriented digital transformation.

Having already completed its lab test, the testbed will complete its field experiment in the near future and collect and analyze results to offer best implementation practices and benefits for LTE for metro. The testbed will continue to use the vital resources provided by the IIC on its journey toward end-to-end solutions.

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