CYIENT

IMPROVING RAIL SAFETY AND RELIABILITY THROUGH IoT

How the Internet of Things can take new and legacy railway systems to the next level

CONTENTS

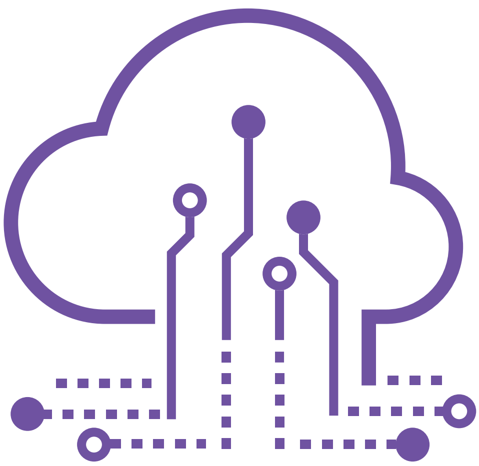
Abstract

The increasing use of the Internet of Things (IoT) has profound implications across industries including the railways. Sensors, devices, systems, and applications are integrated on smart networks and work in a collaborative and cohesive railway ecosystem to enhance passenger safety, improve asset reliability and efficiency, and lower capital and operating expenses. The shift from legacy infrastructure to building a holistic, cloud-based train management systems is the way forward for railway companies if they are to use assets—tracks, equipment, and stations—resourcefully and significantly bring down safety threats.

The Internet of Things (IoT) is a term widely used in today's discussion about emerging technological trends.

Definitions vary, but common characteristics include:

- Intelligent devices with unique identification codes...
- ...communicating with multipe devices
- Devices include electronics, software, sensors, and potentially actuators
- Operation within the (Internet-) network infrastructure
- Real-time analytics



For the railway industry, this is not a new concept; elements of IoT are integrated into every modern train with multiple control units managing technical systems while communicating with each other. Examples include the mechanical and electrodynamic brake system, and the train control unit as a 'master' of the information infrastructure in a train. This is true for both train-based and wayside systems. However, in the past, the focus has been predominantly on the function of the individual sub-systems. Rarely have the information processing systems on the train been leveraged as a source of valuable information and insights.

This had significant consequences:

- Sensors were deployed sparingly, only as far as necessary for the individual system function
- Data collection acted only as a support for maintenance crews for fault-finding purposes
- Only recently have trains begun collecting and communicating information to the wayside for further use to a larger extend
- Flexibility and the possibility for upgrades have been neglected. This makes addition of an intelligent system on a train—or even a few additional sensors—an effort-intensive exercise for integration and (re-)certification

IoT IN RAILWAY IS ESPECIALLY CHALLENGING, SINCE THE EXPOSURE TO THE INTERNET MAY LEAVE THE NETWORK VULNERABLE TO ATTACK. INTERNET ACCESS IN RAIL SYSTEMS MUST BE ALLOWED ONLY UNDER A WELL-DEFINED AND CONTROLLED FRAMEWORK TO ENSURE SAFETY AND SECURITY.

What makes the concept of IoT in railway systems even more challenging is the access/exposure to the Internet, which may leave rail systems vulnerable. Internet access in rail systems must be allowed only under well-defined and controlled frameworks to ensure seamless safety and security. While cyber-security has not been addressed in this paper, the implications of a robust cyber-security policy are obvious and far from being resolved satisfactorily yet.

Figure 1 is a generic representation of an IoT system. A set of devices is communicating via a gateway with cloud-based applications, which take care of asset management, data management, analytics, and dashboards. Mobile devices can be connected as well. Simpler instances of an IoT application might include a single device that is directly connected to the cloud.

This paper will address the implications of IoT for newly built railway systems and also discuss specifics of how to use IoT functionalities in the legacy systems—be it trains or wayside systems. We will also throw light on the impacts that can be expected from IoT, especially in the areas of reliability and safety. Finally, we present some thoughts on how to approach IoT in a practical manner for the new, as well as, for legacy systems.

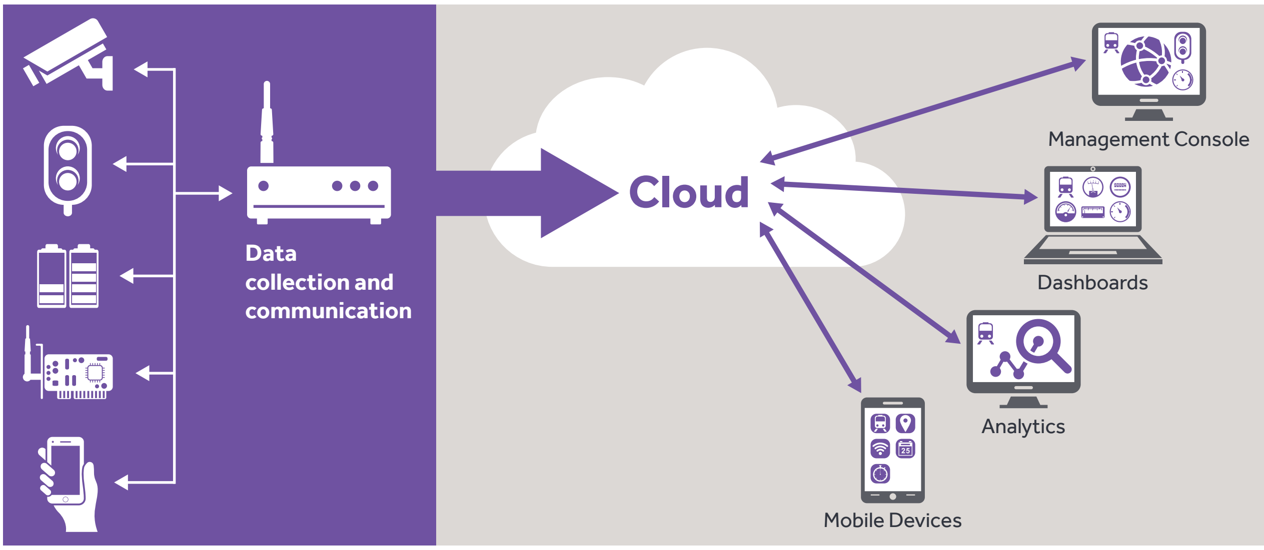


Fig. 1 | Generic framework of an IoT system

Application for New Railways Systems

The application of IoT-type technologies for the new trains have a major advantage—the end-to-end system (along with integrated subsystems) can be designed with an architecture that supports flexible generation and easy collection of data. At the same time, passengers have high expectations from the new trains. While older train technology may not support onboard Internet, it will be perceived as a deficit in new generation trains.

Architecture-wise, some key decisions will have to be brought into consideration when designing new trains that incorporate IoT aspects:

- Separate bus systems for safety-critical applications and 'comfort' functions, without impact on safety or core functionality
- Redundancy of control functions via bus and 'hardwired' functionality
- Data collection and reporting should be configurable. Door controllers, for example, might measure the current of door motors to detect obstacles or deteriorating mechanical properties. In some cases, just the maximal value might be sufficient; in others, the curve measured with a 1,000 Hz frequency might be required, for example, to detect a worn out door mechanism
- Reserves in bandwidth and processing power for future upgrades
- Flexibility in attaching additional sensors or subsystems with minimal impact on the architecture
- A train to wayside connection, which is a critical element not only for the IoT-type applications, but also for CCTV and passenger Internet access
- Train to wayside connections, often via public wireless telecom networks, or via WLAN in stations or depots. In any case, with high bandwidth (real-time monitoring of train conditions or CCTV or Internet access by passengers can each, on its own, fully absorb the available bandwidth today)

Without getting into a discussion on different approaches to Train Control and Management Systems, it is critical to recognize that current and future developments must be considered in the architecture, especially considering the long lifetime of railways. However, in any new train procurement, this should be one of the focus areas, especially since it will determine the reliability and correlate strongly with operational costs. It will also be visible to passengers and influence their perception and selection of transportation modes.

Application for Legacy Trains

Applications of IoT for legacy railway systems are expected to be an even bigger market, given the huge installed base and the long lifetime of railway assets.

To deploy IoT in this context, it is possible to start small and grow from there. For example, in a train fleet or a signaling installation, there might be two or three recurring technical issues that affect its reliability and/or safety. Whereas, for new trains, the whole system architecture would need to be considered. Here, one simple IoT device with the capability to collect data from a handful of sensors and send it via mobile telecom networks or WLAN to the wayside might offer a good business case. As experience grows, the approach can be extended to cover more and more trains or wayside systems. Consequently, the initial cost for entering the field of IoT is manageable, as is the effort in management, engineering, and operations.

One aspect that should be considered is the level of integration of IoT into the existing trains or infrastructure. It is recommended to initially implement any IoT technology in a way that does not impact the functionality of the railway system, as this would often lead to high efforts in authorization/certification. Even if such an IoT system is improving the safety of the railway system, careful thought must be given on classifying it as safety relevant, with the resulting requirements such as SIL levels.

How IoT technologies can be used in railway systems

Use Case 1: **Switch Monitoring**

Switches are one of the most stressed systems in a railway network. Safety-relevant issues can arise from:

- Mechanical elements wear out
- Mechanical failures like cracks
- Blocking objects that obstruct operations
- Impact of temperature variations

Regular inspections often do not reveal issues in the dynamic behavior of the switch, and root-causes often go unnoticed.

With a comparatively simple IoT device, data like the timing of switch operations, motor currents, and vibrations can be collected. Vibrations can be measured when the train passes, and with big data analytics, trends can be analyzed. Evaluation of this data will show deterioration of the switch mechanisms as well as the dynamic behavior of the switch under different weather conditions. Real-time warnings can be issued to the operation center when measurements indicate imminent failure. This can be done for switches operated manually or by point machines.

Use Case 2: **Elevators at Railway Stations**

Deutsche Bahn in Germany started the application of IoT technologies for monitoring elevators with the intent to ensure that the disabled or elderly customers, as well as those with child carriages, have easy access to public transportation. This objective led to the installation of elevators in almost all stations. In total around 2,100 elevators were equipped with monitoring systems to report failures and trigger repairs. As a result, Deutsche Bahn was able to raise the availability of elevators from 89% to 95% in urban areas. This improved accessibility and safety for commuters. Additional benefits included:

- Integration of elevators from multiple manufacturers into one monitoring system
- Visibility into the real-time status data of elevators on the web and in special apps for passengers
- Systematic improvement of elevator reliability and safety based on failure data

Additionally, Deutsche Bahn has made elevator data available via their open data portal to encourage external partners to come up with innovative solutions.

Potential Impact of IoT on Reliability and Safety

Achieving an increase in reliability and safety parameters by even a few percentage points is a rare statistical event, given that both these factors are already performing at very high levels.

Despite this high-performance rate, incidents where a train must be taken out of service or is delayed, may create problems. Passengers may not be able to reach their connections in time or may be delayed in reaching their destinations. Given the domino effect of a single delayed train, extensive rescheduling may have to be undertaken across the whole network. To some extent, the current schedules maintain reserves to accommodate such delays, which means that the infrastructure is not used as efficiently as it could have been and the service to passengers is not as good as it should be.

On the safety side, while trains generally offer one of the safest modes of transportation, there is a consensus that every person harmed is one too many, and that safety must improve continuously. Hence, IoT should not be used to collect data on accidents, but to collect data based on which the probability of accidents can be reduced.

Some areas where a further investigation for IoT-based solutions might be fruitful to improve reliability and safety include:

- Monitoring of failure-prone systems on locomotives, such as the engine or electrical systems can increase the reliability significantly
- Supervision of mechanical systems such as running gear and track. The failure of mechanical systems causes several hundred deaths per year, which could be significantly reduced. Collecting acceleration data from bogies will, in many cases, make the identification of potential track failures possible
- Train doors could be monitored to see if they are properly closed. However, this would require operational changes as well, since passengers often leave doors open or even cling to the outside of the train in case of overloaded trains
- Warning systems (light/acoustic) in case a train nears areas, which are prone to accidents with people crossing the tracks
- Monitoring of bridges regarding material stress or dynamic behavior to detect changes indicating future failure
- Monitoring the speed of trains by GPS-driven speed measurements. Evaluating the speed profiles to validate the adherence of drivers to speed limits, but also to have real time train location to optimize traffic

More examples can be found, especially when looking at data of safety incidents along with reliability data. A simple ABC analysis leads to the identification of priority areas, which can then be tackled first.

THE CYIENT THOUGHT BOARD

Improving Rail Safety and Reliability through IoT

What are the challenges in enhancing the efficiency and competitiveness of railways?

- Deploying consistent safety standards
- Ensuring streamlined asset availability
- Reducing greenhouse gas emissions
- Mitigating operation and maintenance costs
- Augmenting capacity of rail network

Which segments of rail operations can be improved by IoT technologies?

- Machine-to-machine communication
- Signaling systems
- Wayside communication
- Level crossings
- Station information
- End point security

What can rail companies expect by successfully implementing IoT?

- Improved operational efficiency
- Enhanced automation
- Higher safety levels
- Better passenger experiences
- Reduced risk of downtime

What are the best practices for deploying IoT in the railways?

- Integrate IoT to make it future-proof
- Identify areas for IoT implementation
- Demarcate what aspects can be outsourced
- Partner with an experienced service provider

Best Practices in how to deploy IoT

There is no question on whether railway operators need to deploy IoT applications. The focus now is on how to approach this technology. While this has to be decided for every operator individually, there are some principles that should be considered:

- For new procurements of trains or railway systems, IoT needs to be integrated in a future-proof way, right from the beginning. All manufacturers have something to offer in this space, and their solutions should be compared carefully
- For legacy railway systems, it is necessary to identify areas for potential application of IoT technologies and prepare a business case
- The ability to understand and manage IoT technologies is/will be one of the core competences of operators. This does not mean that they should execute all projects in-house, but the capacity to identify opportunities and manage external partners is a must
- A good solution to get a jump start is to partner with a service provider who has the domain experience and knowledge to combine IoT and railway functions

Cyient offers a generic and modular IoT solution that can be applied for legacy rolling stock and railway infrastructure. This solution consists of a set of intelligent devices with multiple sensor inputs and communication units that transmit collected data into the cloud. This data is then used for dashboards presenting the real-time status of assets and also for big data analytics.

ABOUT THE AUTHORS

Dr. Jan Radtke

Dr. Radtke had a distinguished career with 10 years of military service, followed by a doctoral thesis at the University of the German Federal Armed Forces. He has, since then, had a 20-year career in the railway business with Bombardier Transportation. During this period, he worked as project manager for major railway projects, like the Munich Metro and the FLEXITY 2 Street Tram platform project. In addition, he led various special projects like developing research programs.

In his last position with Bombardier Transportation, he was the Vice President of the Engineering Management Office at the company headquarters in Berlin, Germany. In that role he was leading a team of 40 specialists, with global responsibility across diverse functions like people development, engineering processes and tools, change initiatives, engineering offshoring, bid approval, and various special projects. In July 2017 Dr. Radtke joined Cyient as the Vice President and Head – New Business Accelerator and is focused on developing solutions that will help the company bring in non-linear growth. He works very closely with all Cyient BUs to identify and execute new technology solutions.

Murali Ayyagari

Murali Ayyagari is a delivery manager with Cyient. He has over 20 years of experience in managing global teams across diversified domains/ industries/technologies delivering software services to fortune 500 companies.

Murali has strong experience in managing projects/ programs in the railway domain, especially in the areas of the integrated train to wayside solutions, signaling software development and safety and reliability.

One of the key projects Murali has been attached with for nearly a decade has significantly contributed towards improving the safety and reliability of the onboard and wayside railway subsystems.

About Cyient

Cyient (Estd: 1991, NSE: CYIENT) provides engineering, manufacturing, geospatial, networks, and operations management services to global industry leaders. We leverage the power of digital technology and advanced analytics capabilities, along with domain knowledge and technical expertise, to solve complex business problems. As a Design, Build, and Maintain partner, we take solution ownership across the value chain to help our clients focus on their core, innovate, and stay ahead of the curve.

Relationships lie at the heart of how we work. With more than 15,000 employees in 22 countries, we partner with clients to operate as part of their extended team, in ways that best suit their organization's culture and requirements. Our industry focus spans aerospace and defense, medical, telecommunications, rail transportation, semiconductor, utilities, industrial, energy and natural resources.

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