KNOWLEDGE BRIEF

THE INTERNET OF THINGS IN PUBLIC TRANSPORT

NOVEMBER | 2020

INTRODUCTION

With our changing habits, people are moving faster because of busy schedules and an increasingly fast-paced lifestyle. As a consequence, this requires smarter ways of managing our lives and maximising our time. By 2025, forecasts suggest that there will be more than 75 billiion devices connected to the internet. The notion of connecting with one another and the necessity for quick information is not a trend that is going to slow down.

How will this impact the transportation world? Public transport is expected to follow this trend with the aim of improving the quality of service and reducing delays for passengers.

'Internet of Things' (IoT) is dramatically accelerating the pace of innovation in the local transportation industry and providing real solutions. This Knowledge Brief will explain the concept, offer some interesting case studies and provide an outlook for the future.

INTERNET OF THINGS ECOSYSTEM

In 1999, Kevin Ashton, an innovator and consumer sensor expert, coined the phrase "Internet of Things" to describe the network connecting objects in the physical world to the internet. Since then, smart connected objects have become a part of everyday life. The widespread use of smartphones is a prime example. Each phone is equipped with a suite of sensors including accelerometer and GPS, a feature that transforms people into smart objects and can communicate locations and habits through the internet.

Another relevant aspect is the edge computing capability that allows data processing at the edge of the network near to the data source. Connected cars can avoid obstacles by processing real-time data produced by on-board sensors which are taking actions independently.

Once produced, data is conveyed to a platform through the network. These platforms allow the interaction between people, devices, processes and data in order to achieve the maximum value from all the potentials of the IoT.

PLATFORM EVOLUTION

Nowadays, the way to collect and combine data is undergoing a transformation. From a multitude of unrelated vertical services, we have begun to move towards the Platform as a Service (Paas) model. This is a horizontal cloud-based solution with the ability to correlate large streams of data to produce and aggregate information accessible to different types of users.

Furthermore, PaaS is a business and mission critical platform. This means that it is essential to the immediate operation and a priority for the long-term survival of an organisation. According to market requirements, PaaS should be device-agnostic in order to guarantee connection with future devices and able to scale with the connection of new devices and applications with no down-time.

What does a modern IoT PaaS need in order to interact with a multitude of ecosystems? The target is to have most of the following components:

- A system of **identity & access management** for the authentication and profiling of users and devices, so to guarantee high levels of security.
- A **communication channel** for managing integrations with devices and accessing services to applications.
- A **real-time processing engine** that guarantee automation for machine to machine (M2M) communications and the analysis of data coming from and directed to devices and applications, even outside the platform.
- A **device management tool** for the creation of device lists and for their management and direct configuration through the platform, even remotely.
- **Big data tools** to handle and store the large amounts of IoT data.
- A **market place for the API Economy**, which can expose APIs as business building blocks for proprietary and third-party applications.

During the IoT revolution, transport vehicles have been transformed into veritable computers on wheels, now filled with thousands of sensors. These sensors make it possible to record information on movements, vehicle status, fuel consumption, anomalies and number of passengers. When these new intelligent vehicles drive on smart-cities' roads, which have their own sensors built into the infrastructure, it is possible to monitor the passage of vehicles and the status of traffic. Through data ingestion processes, all of this information can be processed by the IoT platform.

Transport vehicles have been turned into veritable computers on wheels.

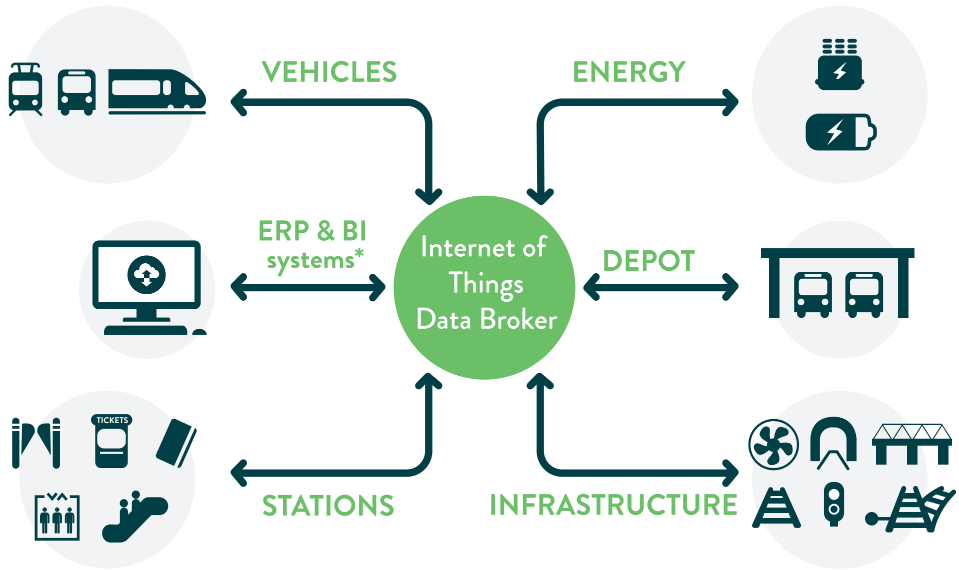
A PaaS for local public transport offers:

- **Fleet management** in order to be aware of the geographical position of vehicles, ensuring compliance with established routes and schedules, reduce fuel costs by controlling routes and work processes, and reduce CO^2 emissions by managing employee driving style.
- **Ticketing management** which tracks the number of passengers on vehicles and monitors revenue.
- **Advanced business intelligence** to produce a dashboard, interactive reporting and alerts in highly visual forms. These are useful to improve business performances on third-party logistics (TPL) Management.

EACH COMPONENT OF THE ECOSYSTEM

A fleet management system for public transport is a distributed IT system.

The core system for operations management consists of the vehicles, the control centre, depot management and road/track infrastructure elements like traffic lights, switches etc. On a broader sense, fleet management also includes system components for passenger guidance,



*Enterprise resource planning & business intelligence systems

information and communications: information displays, public announcement speakers, passenger counting devices, gates, turnstiles etc.

Every existing fleet management installation has an underlying internal communications infrastructure, and technology integrates the distributed system elements. Traditionally, the communication was based on analogue or digital radio systems, and a message-oriented application protocol layer was either vendor-specific or defined by public transport-specific open standards. Even with the introduction of IP-based radio communication (e.g. with public mobile radio) the approach on the application protocol level was not changed.

In this context, the availability of concepts and products from the IoT is a game changer: protocols like MQTT or AMQP support communication patterns like "request/response" or "publish/subscribe". Middleware products, i.e. "message brokers" are available from the commercial sector as well as from the Open Source (e.g. HiveMQ, RabbitMQ, Mosquitto).

By using these technologies, a large part of the former public transport domain-specific specifications becomes obsolete: Message transmission, transaction concepts, buffering, timeouts, IP address translation, resilience, and connection loss handling are all covered by the underlying IoT technology. To obtain interoperability between system components from different vendors, it is only necessary to define the really public transport domain-specific aspects of the payload. For example, how a vehicle codes its actual position in a message to the control centre.

This new approach has numerous advantages:

- Loose coupling of the components allows for open, flexible and expandable system architecture.
- Use of technologies and implementations from the large IoT sector ensures continuous support and future development, which is key to investment protection.
- Communication client applications are available on practically every system platform, ranging from small embedded systems to server and cloud-based solutions. This ensures that future new infrastructure elements can be easily integrated into the fleet management system.

WHAT IS THE VALUE FOR PUBLIC TRANSPORT?

Is IoT the next big thing for public transport?

SIGNIFICANT IOT GROWTH

IoT forecasts and market estimates have aroused great interest and have become extremely popular across sectors for some years now. Number of connected devices, IoT spending and market growth forecasts are the top three indicators on which the industry focuses its attention.

These recent years have defined IoT trends, outperforming growth expectations and enriching the sector' insights. Still, as with many emerging technologies and future trends, now is also the opportunity for broad considerations and comparisons between expectations and facts.

Overall, we are seeing strong IoT potential. This technology matches business needs while clearly indicating that traditional markets are reconfiguring their shape through the propulsion of digitalisation/Industry 4.0. The early explosion of insights regarding the future of IoT adoption and spending reflect firms' high expectations for scale and Return on Investment (ROI) from their IoT-oriented programmes. The underlying key benefit to IoT introduction is expanding the business opportunities and scope, and this is what drives organisations to experiment with IoT and invest in Proof of Concepts (PoCs) as well as in large-scale initiatives. IoT expectation is pushing a new research agenda across many firms, which is why are hearing about the 'IoT ecosystem" more and more. It is a vast and complex scenario of actors, an orchestrated combination of both mature products and emerging technologies, as well as new ways of cooperations and partnerships, driven by a remarkable innovative paradigm. IoT ecosystem enables consumers, businesses and governments to connect to, and control, their IoT devices in different application fields, including agriculture, manufacturing, the home, and transportation.

On the other hand, across many sectors, IoT is commonly adopted to retrieve metrics and Key Performance Indicators (KPIs) that cover:

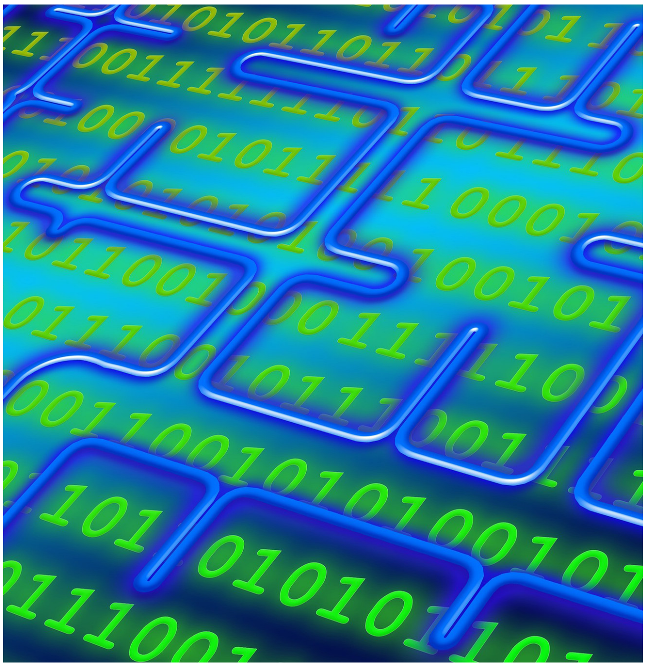
- Operational improvements
- Intelligent maintenance
- Customer experience
- Logistics and supply chain

Moreover, connected devices and sensors are becoming crucial for businesses thanks to real-time data, helping to accelerate decision making, perform automated tasks, and create value by enabling organisations to become data-driven.

In fact, firms are getting value from their IoT data in three significant areas:

- Monitoring/tracking
- Analytics
- Action/control

The majority of sectors are immersed in this 'digital revolution' as part of a more comprehensive industry transformation. This is why, as in other areas as well as in public transport, the standard imperative for the following years is 'leading this transition'. Analysts and experts have labelled IoT as 'the next industrial revolution' because of the way it will shape the next generation's lives, work, entertainment, and travel.



WHERE IS THE IOT GROWTH IN THE PUBLIC TRANSPORT SECTOR?

Forecasts and insights show that the significant investments are mainly reflected within smart cities and communities, transportation systems technologies and energy efficiency/power consumptions. Concerning investments' prioritisation, generally many public transport suppliers are digitising essential functions within their internal vertical value chain and also with their horizontal partners. Besides, transportation companies are enhancing their product portfolio with digital functionalities and introducing innovative data-based services.

CASE STUDIES

DIMO-FUH

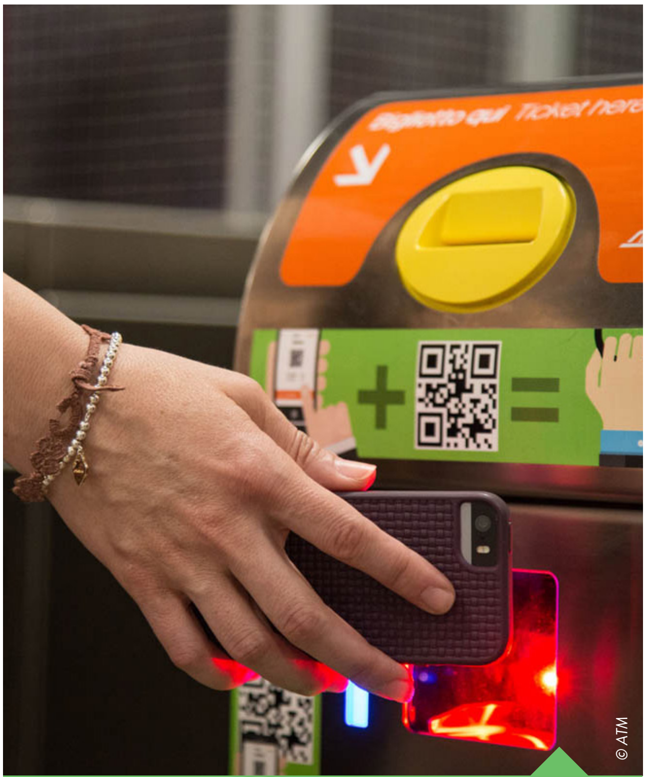
A new and open protocol standard for communication between central and field systems in public transport, based on the IoT protocol MQTT, was defined in the research project DiMo-FuH. In pilot tests between buses and control centres, the communications was demonstrated and tested on ticket machines, informations systems and audio installations with the aim to improve the passenger experience. The project consortium consisted of industry (INIT, Trapeze, IVU), public transport operators (MVG Munich, KVB Cologne), universities (RWTH Aachen, TU Ilmenau) and the Association of German Transport Companies (VDV) and was partially funded by the German Federal Ministry of Transport and Digital infrastructure.

MOVIA

In Copenhagen, Denmark, Covid-19 regulations have limited the number of passengers allowed on buses. As of 29 June 2020, every seat can be used but only half of the standing places are allowed. This means that a normal city bus can have 50-60 passengers, whereas beforehand the number was 70-80. Movia, the public transport authority of East Denmark, wants to test if detected smartphones can be used to figure out whether buses are busy or empty. As part of a pilot project, IoT sensors in the buses will count the amount of cell phones with internet signal. This number will be used to determine whether the bus is full or not, and this information will be pushed out to the passengers waiting at the bus stops. If a bus is full, the driver must not pick up new passengers.

MITT & TRENTINO TRASPORTI

Mobilità Integrata dei Trasporti (MITT) implemented IoT for real-time monitoring of local public transport vehicles and travel time management for Trentino Trasporti, an operator in Trento, Italy. IoT technologies are used to detect the position of buses in real time and transmit information on journey times to passengers. The technology, Almaviva Giotto, is based on OpenSource components and available on an on-premise model or PaaS, which enables the implementation of IoT applications, by exploiting an already available Back-end system with fully integrated components.



ATM

ATM, the public transport authority of Milan, Italy, and the city municipality are committed to improving the quality of life of citizens. A significant number of IoT systems are available in the area, such as Automatic Vehicle Monitoring (AVM) systems and sensors for parking areas. PoCs have been launched to provide detailed information about crowded metro stations, and the beacon Bluetooth Low Energy (BLE) technology is used for counting people. New applications will be introduced to allow users to receive punctual information and preferred routes. Moreover, CCTV is used to detect congested areas or people counting, using images and video analysis in metro stations, trains, buses, trams and trolleybuses. ATM has also adopted GPS-based systems for Mobility as a Service (MaaS) applications. The MaaS system facilitates the exchange of data for travel information and data for integrated ticketing fare collection between stakeholders and public transport companies in the region, moving from MaaS to TaaS (Ticketing as a Service).

NOMAGO

After acquisition, Nomago faced the challenge of consolidating, modernising and streamlining 12 different bus operations across Central and Eastern Europe. With the help of LIT Transit, Nomago now runs its fleet operations with one transit management platform.

A set of IoT devices were installed on city and regional buses, including on board units with GNSS, IMU and connectivity to CAN BUS, announcement systems and passenger counters. The data from these devices feeds into the same open platform and is comprehensively visualised in order to improve operations performance and raise customer satisfaction. The vehicle location data is also used to calculate accurate journey time prediction using machine learning that are displayed in real-time on connected displays.

IKAAS

The EU-funded project iKaaS (intelligent Knowledge as a Service) had a specific objective to promote Japanese-European cooperation. The project involved 15 partners including European and Japanese hi-tech companies, universities and public entities. The aim was to develop innovative Cloud technologies to tackle the large amount of data coming from the IoT required for businesses, industrial and social applications. In this sense, iKaaS aimed to integrate these three technological fields to develop a new platform to leverage the advantages of IoT such as object virtualisation, real-time processing, and big data analysis. Platform features were demonstrated through smart city applications to promote the self-management of health and security of citizens and improving information systems and data analysis to achieve a more intelligent city, focused in areas like epidemiological surveillance.

FATIGUE MANAGEMENT

One of London's latest road safety projects has commenced with Abellio adding fitdrive to the driver cabs of their buses, a solution based on Streamax technology. The project aims to reduce the risk of accidents, and to change current disciplinary culture to a more open and transparent one, through a combination of risk prediction, fatigue monitoring and behavioral change. The IoT-based solution brings together embedded telematics, real-time video analytics, artificial intelligence (AI) and driver psychology to present a holistic approach to driver management, specifically aimed at reducing the risk of fatigue related accidents. The predictive algorithm enables informing drivers about their risk level in real time, helping them understand their own alertness levels and therefore becoming more risk aware and safety conscious while driving. The project is expected to go live later in 2020.

DOJOT

Following the directions of the Brazilian National IoT Police, who defined investments and regulations on IoT at nationbal level, the Brazilian Innovation Funding Agency and the Ministry of Science, Technology & Innovation supported the development of an Open Source Platform (DOJOT) for IoT. The IoT platform has a focus on healthcare, public security and urban mobility. Based on innovations such as Open APIS, managing device lifecycle, data flow, object visualisation, data persistence and real-time data interfaces, DOJOT has enabled various projects. For example, the municipality of Campinas implemented a series of pilots on public transport management and monitoring.

AUTOPILOT

The EU-funded Autopilot project has assessed the feasibility and the added value of the IoT for a number of automated driving services in different locations across Europe, including parking, platooning and urban driving. The pilot tests have highlighted some technical improvements which are expected to have a positive impact on urban mobility in the future, mainly by enhancing travel efficiency, safety and comfort, and therefore improving the urban environment and quality of life.

These technical improvements have been also considered by the project consortium as favourable from a business perspective, by accelerating the development and time to market of new mobility services, as well as their integration into MaaS-type services. Cooperation and interoperability between IoT platforms from different suppliers is a key factor to accelerate the deployment of such services, as it reduces costs while solving the vendor locking issue.

Andrea Masini for AUTOPILOT

CONCLUSION

Internet of Things technologies enable new advanced services thought a flexible usage of existing data, IoT services improve the quality and efficiency of transport services. Passengers know when and where the transport will arrive, and operators can alert the public to any schedule delays. Definitely, both passengers and operators benefit from the IoT services.

Case studies collected in this paper clearly evidence that the transport sector has started to implement IoT technologies in a variety of contexts, from passenger information to data management applications and new services.

Whereas the ICT industry today is massively investing in IoT technologies and services, in the future there will be even more components and 'glue-technologies' available on the market, which will enable a smoother IoT deployment on a large scale.

Ultimately, system integration capabilities and 'ready-to-go' solutions will also be necessary to enable all the possible benefits of IoT in public transport.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This Knowledge Brief was prepared by the Information and Telecommunications Technology Committee (ITT) Committee. For more information, you can contact Jaspal Singh (jaspal.singh@uitp.org).

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