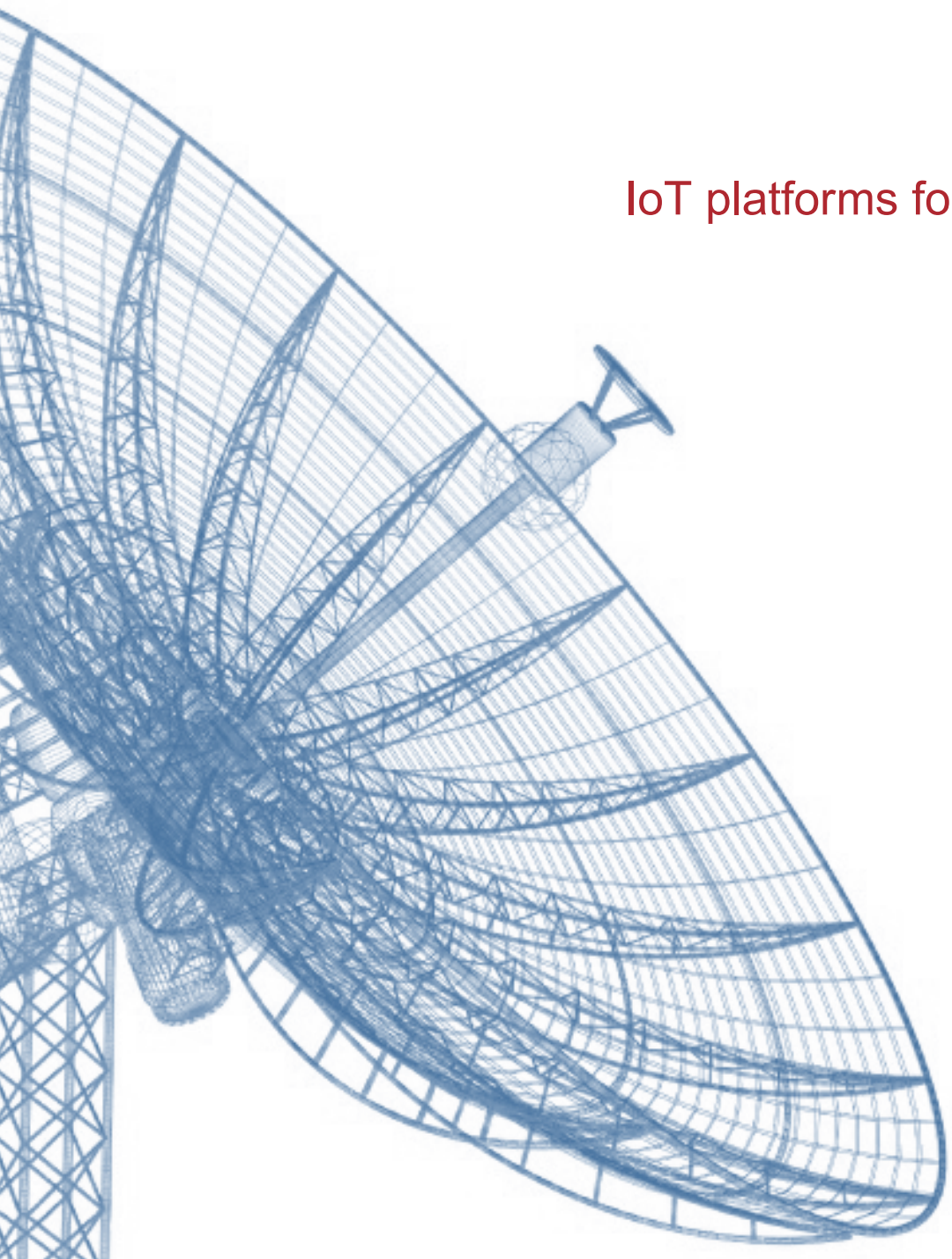
Digital CX & IoT I Europe I 2018

IoT platforms in Europe 2018

SITSI I Vendor Analysis I PAC INNOVATION RADAR

IoT platforms for smart cities



CXP Group

BARC · le CXP · PAC

RADAR

IT SUPPLIER ASSESSMENT FROM PAC

TABLE OF CONTENTS

TABLE OF FIGURES

DOCUMENT INFORMATION

Authors: Arnold Vogt (a.vogt@pac-online.com), Michael Sailer (m.sailer@pac-online.com), Katrin Schleife (k.schleife@pac-online.com)

Publication: September 2018
Last update: n/a

Scope ID: Digital CX & IoT I Europe I 2018
Portfolio ID: SITSI I Vendor Analysis I PAC INNOVATION RADAR
Related reports: IoT platforms in Europe 2018 – analytics applications
IoT platforms in Europe 2018 – device development
IoT platforms in Europe 2018 – device management
IoT platforms in Europe 2018 – rapid application deployment
IoT platforms in Europe 2018 – connected vehicles
IoT platforms in Europe 2018 – industrial devices

OBJECTIVE OF THIS REPORT

The purpose of the PAC RADAR from the market research and strategic consultancy Pierre Audoin Consultants (PAC) is to provide a holistic evaluation and visual positioning of leading IT providers within a defined service segment on a local market. Using predefined criteria, the providers' revenue volumes and development and market share are assessed and compared alongside their performance and specific competences in the relevant market segment.

REPORT LICENSE

PAC INNOVATION RADAR "IoT platforms in Europe 2018 – smart cities"

PAC RADAR Report License

As part of the report license, content from the PAC RADAR report may only be reproduced either in whole or in part (e.g. the PAC RADAR graph) for internal purposes (e.g. internal presentations). All content used – even in part – must clearly indicate "PAC" as the source. However, content must not be modified or used out of context of the overall document.

It is not permitted to use the content of the PAC RADAR report for external communication materials (including communication with clients, partners and the media).

Moreover, the copyright conditions for PAC RADAR apply (see "About the PAC RADAR" on the last page of this document).

INTRODUCTION

In the current market situation, it is fundamental to take the following two aspects into account to be able to provide a useful comparison of IoT platforms:

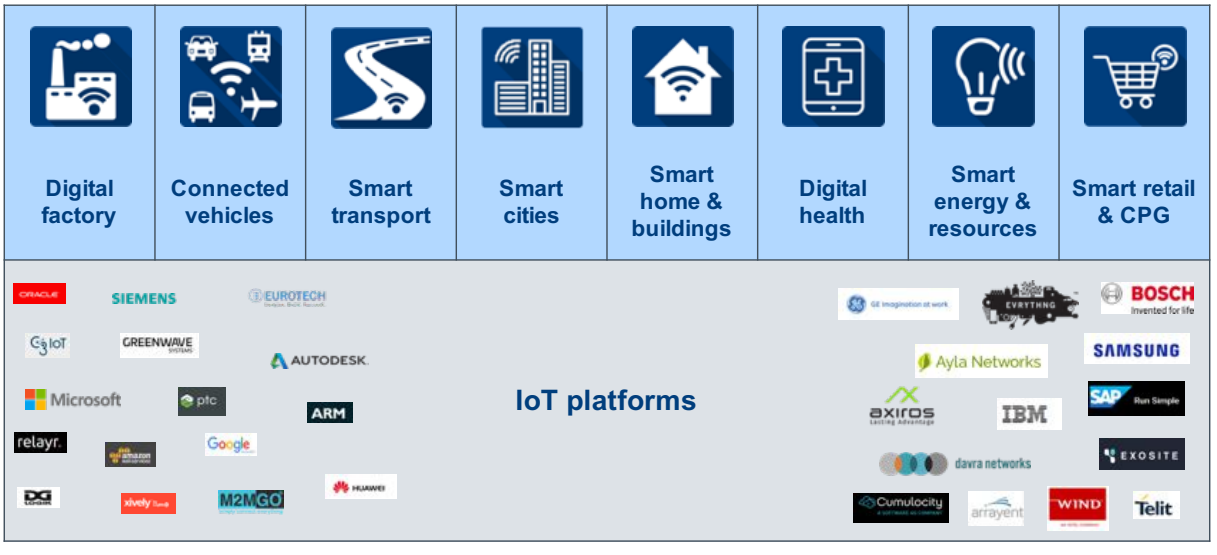
First, a clear definition of the term is required, given the many different functions an IoT platform should cover as well as the lack of a common understanding of what an IoT platform really is. Quite generally, an IoT platform is a collection of functions around IoT device and application management – often delivered through the cloud but also at the “edge”. Depending on one’s definition, there are thus either a handful or hundreds of IoT platforms in the market.

And second, being at an early market stage, we have to consider that existing IoT platforms are all different and serve different use cases. For this reason, PAC uses different RADAR segments, dedicated to specific uses cases, to evaluate the providers of IoT platforms in Europe. The PAC RADAR is in fact the first benchmark to apply such an approach.

THE WORLD OF IOT PLATFORMS IS CHANGING

Basic segmentation of IoT offerings

PAC divides the market for IoT solutions into two basic areas, horizontal IoT platforms and vertical IoT solutions. Horizontal IoT platforms provide the functional foundation on which individual IoT solutions for specific clients can be developed and deployed. We chose this structure because on top of these IoT platforms, different IoT solution providers act as total IoT solution providers; examples are big IT consulting and system integration providers such as Accenture, Capgemini, Atos or IBM, and also industry-specific players such as Siemens, ABB and Bosch, and management consulting companies such as Deloitte, EY or BearingPoint.



Basic segmentation of IoT offerings

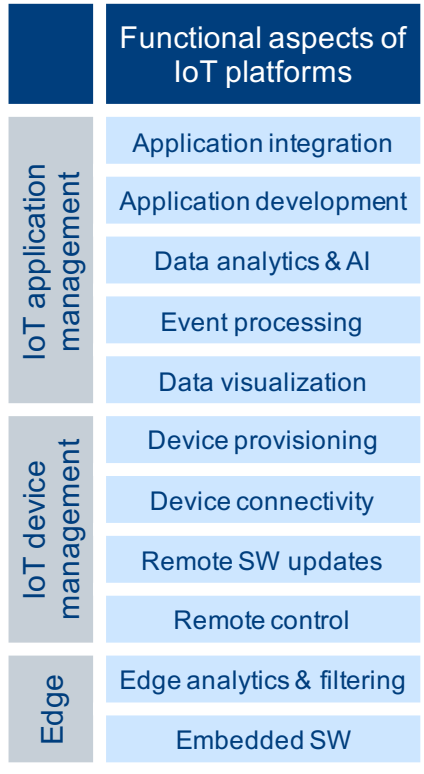
General definition of IoT platforms

According to PAC's definition, IoT platforms have to provide two basic types of functionality to clients: IoT device management AND IoT application management.

- **IoT device management** covers device provisioning, device connectivity, remote SW updates, and remote control.
- **IoT application management** includes application development & integration, data analytics & artificial intelligence (AI), data visualization, and event processing.

The following illustration shows all the relevant functional aspects of IoT platforms. The "edge" is included because IoT platforms interact with diverse edge devices such as IoT gateways or with software on embedded controllers. Important capabilities in this context are, for example, edge analytics and data filtering functions to limit the workload of communication networks. Moreover, embedded SW (incl. embedded IoT operating systems) gain in momentum when devices directly

communicate with IoT platforms. These functions may not necessarily be core capabilities of an IoT platform today, but they are highly relevant for many use cases in the IoT context.



Basic functional aspects of IoT platforms

Horizontal IoT platforms are well established

Existing IoT platforms actually do not support all client needs today. PAC has screened the market for IoT platforms, compared their capabilities and concluded that there is a category of IoT platforms available in the market that focus on specific horizontal use cases. These IoT platforms provide support for specific use cases across many industries and devices. We have identified four groups of these horizontal IoT platforms for specific use cases:

- **IoT platforms for rapid application deployment** allow simple and fast device connectivity, data visualization via drag & drop dashboards, and event processing. This use case often serves as an easy starting point for clients in their journey towards IoT and is therefore frequently applied in the context of rapid prototyping.
- **IoT platforms for device management** support the critical management of various device fleets on a large scale. From a functional perspective, besides device provisioning, these platforms mainly focus on centrally managed software updates at the device level (for security or functional reasons), but also remote configuration and control of devices.

- **IoT platforms for analytics applications** enable the development of more complex IoT applications such as predictive maintenance. For this purpose, an IoT platform has to provide dedicated capabilities around data analytics, artificial intelligence, application integration, and application development.
- **IoT platforms for device development** are a newly emerging topic; IoT platforms and IoT operating systems on embedded devices will increasingly communicate directly with each other. This market will particularly be driven by the advent of a new range of lightweight IoT devices (based on microcontrollers with embedded SW) that communicate directly with an IoT platform via LPWAN technology (LoRA, Sigfox, NB-IoT), enabling security updates over the air on a large scale for many small devices out in the field.

The functional focus areas of these four groups of IoT platforms are highlighted in orange in the illustration below:

	IoT platforms for device management	IoT platforms for rapid deployment	IoT platforms for analytics applications	IoT platforms for device development
IoT application management	Application integration	Application integration	Application integration	Application integration
	Application development	Application development	Application development	Application development
	Data analytics	Data analytics	Data analytics	Data analytics
	Event processing	Event processing	Event processing	Event processing
	Data visualization	Data visualization	Data visualization	Data visualization
IoT device management	Device provisioning	Device provisioning	Device provisioning	Device provisioning
	Device connectivity	Device connectivity	Device connectivity	Device connectivity
	Remote SW updates	Remote SW updates	Remote SW updates	Remote SW updates
	Remote control	Remote control	Remote control	Remote control
Edge	Edge analytics & filtering	Edge analytics & filtering	Edge analytics & filtering	Edge analytics & filtering
	Embedded SW	Embedded SW	Embedded SW	Embedded SW

Functional focus areas of horizontal IoT platforms (highlighted in orange)

Vertical IoT platforms are newly emerging

Besides the above-mentioned horizontal IoT platforms, PAC sees a new category of IoT platforms emerging in the market – vertical IoT platforms. Vertical IoT platforms cannot yet be found in all market segments, but they are starting to appear in some areas, for example in the contexts of digital factory, connected vehicles, smart cities, and smart homes. The differences between a vertical and a horizontal IoT platform are mainly related to the application side, and to some degree also to the aspect of connectable devices. Horizontal IoT platforms focus mainly on pure application enablement, while vertical IoT platforms go much deeper and also provide pre-developed vertical applications for use cases in specific contexts.

Digital factory	Connected vehicles	Smart transport	Smart cities	Smart home & buildings	Digital health	Smart energy & resources	Smart retail & CPG
Vertical IoT platforms	Vertical IoT platforms	---	Vertical IoT platforms	Vertical IoT platforms	---	---	---
IoT platforms for device management							
IoT platforms for rapid application deployment							
IoT platforms for analytics applications							
IoT platforms for device development							

Extended segmentation of IoT offerings including vertical IoT platforms

The purpose of an **industrial IoT platform** is to have full and deep transparency of shop-floor operations in real time, and to increase operational efficiency both on a micro level (individual assets and workers) and a macro level (processes). This includes the efficiency and availability of individual assets (e.g. machinery and equipment), worker efficiency and safety, and the overall process quality and efficiency of the entire manufacturing process. Examples of platforms available in this space are GE Predix and Siemens MindSphere.

According to PAC's definition, the capabilities of an industrial IoT platform have to focus on supporting the following dedicated IoT use cases in the context of a digital factory. The main use cases are:

Digital factory

A digital factory uses smart products and smart services to become a highly-efficient and integrated cyber-physical production system. This covers the improvement of internal production processes, intra-logistics and the supply chain. But also the delivery of smart products and services to help others in realizing a digital factory.

Includes, among other things, the following use cases:

Use case	Description
Connected worker (IoT)	A connected worker uses digital worker support systems (via augmented reality or other visualization technologies) to improve working decisions, quality and efficiency. In addition, they can collect data via sensors (e.g. via wearables or cameras).
Digital twin (IoT)	A digital twin allows the virtual development, testing, production and maintenance of a physical product, by using digital technologies like virtual reality. The digital product can be interacted with in the same way as would be possible with the physical product. A physical product can also gather sensor data that can be used to update a "digital twin" copy of the product's state in real time.
Traceability (IoT)	Use of digital technology within the whole production process and supply chain to verify the history or the location of raw materials, components, tools, end products, etc.

Use case	Description
Mass customization (IoT)	Intelligent production processes that allow the production of custom outputs/products on a (very) large scale, based on digital technologies.
Predictive maintenance (IoT)	Predictive maintenance allows upfront scheduling of maintenance services (based on analytics) to prevent unexpected equipment failures, thanks to automatic alerts gathering and triggering of incident tickets.
Digital quality control (IoT)	Automatic adjustment of the production process based on sample specifications and the analysis of data collected by sensors to lower the number of defective products.
Smart intra-logistics (IoT)	Sensor-controlled vehicles that act as autonomous delivery systems within a factory.
Products as a Service (IoT)	Usage-based pricing model for products, which guarantees a dedicated service level.

Digital factory use cases

From PAC's perspective, the main challenges for an industrial IoT platform supporting digital factory use cases (such as predictive maintenance or digital twins) are as follows:

- **Data volumes**: The amount of data that has to be processed is often huge.
- **Real time**: Processing data (analysis, visualization, event processing) in "real" real time is often a very critical requirement in the manufacturing space.
- **Analytics**: The analysis of data is often highly complex and domain-specific.
- **Communication protocols**: A huge variety of industrial devices with many different communication protocols have to be supported.

To support the use cases above and address the related challenges, industrial IoT platforms have to go beyond traditional MES solutions, especially in two functional areas – development of new applications based on data analytics and the variety of connected things (in addition to classic machinery and equipment, these include tools, wearables, or even environmental sensors). Moreover, unlike MES, the concept of an industrial IoT platform follows an "open system" approach. This means that an industrial IoT platform acts as an open, extendable platform of independent microservices, which enables more, and more varied, industrial use cases in an integrated way. The support of IoT gateways is relevant in this space to handle some of the above-mentioned challenges directly at the edge (edge/fog computing). IoT gateways act close to all kinds of connected devices, an advantage that makes true real-time processing of data possible. This is especially relevant for the analysis of large data volumes in real time. IoT gateways also help translate proprietary communication protocols and filter data, and reduce the amount of data that has to be transferred into the cloud for further processing.

IoT platforms for vehicles are designed to link vehicles to the external world for three main purposes, the first being to enable connected services for the driver, such as voice communication, contextual services, smart parking, or infotainment. The second purpose is to enable vehicle-related services such as fleet management or remote diagnostics. Finally, the platforms provide vehicle data to the back end for further processing in other services. This allows, for example, overall traffic management or the communication of free parking spaces or other relevant traffic information (e.g. accidents or traffic jams) directly to other cars. Examples are HARMAN Ignite Platform, Bosch Automotive Cloud Suite or Microsoft Connected Vehicle Platform.

According to PAC's definition, the capabilities of an IoT platform for vehicles have to support dedicated IoT use cases related to connected vehicles. The main use cases are:

Connected vehicles

Connected cars, trucks, buses, ships, trains and other vehicles can continuously and bi-directionally communicate with ecosystems (e.g. owners, drivers, OEMs, insurers, garages) and environments (traffic signals, other vehicles, smart home, etc.). IoT-related technologies enable smart services like traffic management, predictive maintenance, convenience services, after-sales solutions, etc.

Includes, among other things, the following use cases:

Use case	Description
Connected service chains (CX & IoT)	Digital technologies like mobility, sensor, artificial intelligence and innovative driver interfaces are paving the way for connectivity-related smart services like remote diagnostics and (predictive) maintenance, automated garage service, situation-based insurance, driver assistance or extended mobility services.
Contextual services (CX & IoT)	Services based on context-aware applications, providing personalized services to each individual user according to their particular needs and interests at any given point in time. A contextual service adapts to changing circumstances of users in real time (emergency, access, tracking).
Smart parking (CX & IoT)	Smart parking solutions support the reduction of (urban) traffic volumes by monitoring & managing available parking spaces on-street & off-street (e.g. car park facilities). Solutions include technologies (e.g. RFID/sensors), mobile apps for user (incl. space reservation, payment functionalities) & management platforms (incl. analytics capabilities). Also included are autonomous off-street parking concepts and infrastructure components (e.g. smart street lights) that monitor/scan street environments for available on-street parking spaces.

Use case	Description
Infotainment (CX & IoT)	Infotainment refers to a combination of information and entertainment. It includes services as well as hardware/software products and systems, "built in" or to be added to vehicles in order to enhance driver and/or passenger experience.
Driver assistance & autonomous vehicles (IoT)	Autonomous vehicles can detect surroundings using a variety of techniques (RADAR, LiDAR, GPS, odometry, computer vision) for the purpose of self-driving and navigation. Therefore, advanced control systems interpret sensory information to identify appropriate navigation paths as well as obstacles (other vehicles, pedestrians, road damages) and relevant signage. Autonomous vehicles are classified on six different levels, ranging from none to fully-automated systems.
Fleet management (IoT)	Fleet management includes commercial vehicles (cars, aircraft, ships, vans, trucks, rail cars) and integrates functions like vehicle financing, maintenance, telematics like tracking & tracing, fuel and consumption management as well as driver management for e.g. health and safety purposes.

Connected vehicles use cases

From PAC's perspective, the main challenges for an IoT platform for vehicles currently are:

- **Safety**: The safety of drivers, passengers and other people is vital – connected vehicles provide safety-related add-on services, but they also bring the fear of hacker attacks into the car.
- **Connectivity**: Transport routes are almost everywhere, but connectivity is not – we still have blank spots and areas with limited bandwidth.
- **Real time**: Data processing in real time will become increasingly safety-critical. The trend towards autonomous vehicles pushes demand for powerful onboard processing units.

To support the use cases above and meet the related challenges, IoT platforms for vehicles have to provide four main capabilities: IT security, dealing with changing connectivity conditions, complex

event processing and device management for large-scale software updates over the air (for security reasons and new functionalities). In addition, like industrial IoT platforms, IoT platforms for vehicles have to follow an "open system" approach, i.e. they have to be quickly extendable to accommodate more and more emerging use cases around connected vehicles.

IoT platforms for smart cities are designed to cover all kinds of use cases around the efficient use of existing city infrastructures and the delivery of the collected data to many different users across the city. This involves a large variety of different infrastructure elements such as parking spaces, streets, street lights, trash cans, traffic lights, and e-charging stations. Examples of IoT platforms for smart cities are Cisco Kinetic for Cities, Huawei Intelligent Operation Center, and Urban Pulse.

According to PAC's definition, the capabilities of an IoT platform for smart cities have to support the following city-related IoT use cases:

Smart cities

Ubiquitous and transparent integration of digital IT-based systems (mobile platforms, cloud computing and connectivity modules) to improve the operational efficiency of cities and enhance the citizen and visitor experience by means of data-based information and services. Based on IoT networks and platforms that can collect, secure and combine data from other ecosystems, remote equipment and mobile devices.

Includes, among other things, the following use cases:

Use case	Description
Smart administrative services (CX)	Use of digital technologies to enable online and mobile self-service for citizens and increase data availability for various administrative services (for example: tax, pensions, documents, etc.).
Digital law enforcement (CX & IoT)	Digital solutions designed for integrating multiple data streams and sources to enable streamlined operations of law enforcement services such as police, security services, etc.
Smart safety systems (CX & IoT)	IT solutions based on a diverse set of technologies and platforms including IoT, cloud, analytics, video surveillance, used for improving safety and security of indoor/outdoor public and private areas (parks, stations, shopping malls, etc.). Incl. also systems for police, fire fighters, homeland security, and military forces.
Smart parking infrastructure (IoT)	On- and off-street parking concepts and infrastructure components (e.g. parking sensors) that monitor/scan available parking spaces.
Smart urban infrastructure (CX & IoT)	Street lights, smart benches, smart info screens and displays equipped with connected sensors can enable both real-time data gathering and serve as a channel to provide urban data to citizens, such as weather data, local services data, transport data.
Digital campus services (CX)	Digital student services enabling quicker access to relevant data and campus-based services as well as digital cloud-based solutions for efficient student and asset management within the campus.
Smart environmental solution (IoT)	IoT-based solutions consist of various types of sensors and connectivity modules and serve to monitor environmental pollutants or phenomena such as noise, air pollution, radiation, waste management, etc.
E-charging infrastructure (CX & IoT)	An e-charging infrastructure enables digital payment and shows available charging spaces in cities.
Smart traffic management (IoT)	Connected traffic infrastructure that delivers actionable insights to optimize the flow of traffic.

Smart cities use cases

From PAC's perspective, the main challenges for an IoT platform for smart cities currently are:

- **Connectivity costs**: It is possible to upgrade city infrastructure with sensors, but the ongoing connectivity costs are a huge challenge.
- **Large number of connected things**: Many small connected sensors have to be added to build a city-wide connected infrastructure.
- **Large number of users**: Many different users, such as citizens, visitors, city administration officials and rescue workers, want to have access to this data and need reliable data visualization and event processing.

To support the use cases above and address the related challenges, scalability is the key capability IoT platforms for smart cities have to provide – scalability for connected devices and scalability for data visualization and event processing for users. Moreover, LPWAN support (Low Power Wide Area Networks such as LoRa, Sigfox, NB-IoT) is an essential connectivity option to reduce the overall cost of connectivity. In addition, like other vertical IoT platforms, IoT platforms for smart cities should follow an "open system" approach, i.e. they have to be quickly extendable to accommodate more and more emerging use cases around cities.

IoT platforms for smart homes & buildings are designed to integrate all kinds of smart devices within private homes and official buildings. This includes a large variety of different devices such as communication and entertainment devices, security systems (e.g. cameras), thermostats of heating/cooling systems, robots for vacuum cleaning, lighting control, and overall energy consumption management. In addition, we will increasingly see voice control systems such as Apple's Siri or Amazon Alexa integrated in these platforms, especially in the smart home space. For example, smart home platforms such as Qivicon or Innogy Smarthome already work with Amazon Alexa, while Apple's HomeKit platform is integrated with Apple's personal assistant, Siri.

According to PAC's definition, the capabilities of an IoT platform for smart homes & buildings have to support the following use cases:

Smart home & buildings

Usage of technical systems and technology in buildings (home & institutional) to increase e.g. the quality of living/working, safety, energy efficiency based on connected and tele-controlled devices and installations as well as automated processes (heating, surveillance, domestic appliances, entertainment, etc.)

Includes, among other things, the following use cases:

Use case	Description
Automation & predictive maintenance (IoT)	Predictive maintenance allows upfront scheduling of maintenance services (based on analytics) to prevent unexpected equipment failures, thanks to automatic alerts gathering and the triggering of incident tickets. This also includes the exchange of information between the various service providers of the building.
Entertainment, smart equipment & connectivity (CX & IoT)	All intelligent equipment that can be found in a building/home that will ease/improve the user experience (intelligent parking, elevators, touch-screens, live information on traffic, etc.)
Facility management (CX & IoT)	Augmented reality becomes an important technology in facility management, as even untrained workers, equipped with smart-phones, tablets or AR headsets, can zoom virtually into systems for maintenance and repair purposes.

Use case	Description
Security & control (CX & IoT)	Security cameras have been used for many years to monitor activity in buildings. With IoT technology such as pattern recognition software, an intelligent system can automatically detect anomalous patterns in the video data and immediately alert authorities of a possible intrusion. Advanced/intelligent access control systems with retina/fingerprint recognition, automatic fire detection (emergency management system).
Energy management (CX & IoT)	Thermostat and multiple sensors learn about user behavior and allow remote control to optimize energy consumption. Intelligent energy management systems can be used to automatically sense when a room is unoccupied or occupied and adjust heating/cooling and lighting as needed. There could also be a platform to manage bought and "built" energy (solar panels, garbage reprocessing, ...).
Connected appliances (lighting, cooking, cleaning) (CX & IoT)	Smart appliances utilize modern connectivity technology to make functions faster, cheaper and more energy-efficient. The appliances can take advantage of an energy "smart grid," implemented by utility companies nationwide.

Smart home & buildings use cases

From PAC's perspective, the main challenges for an IoT platform for smart homes & buildings currently are:

- **Interoperability**: Ensuring that smart devices from different vendors interact with each other.
- **Integrated control**: One single interface for users instead of several separate tools to manage the smart home – increasingly via voice control.
- **Simplicity**: Usage has to be as intuitive as possible.

To support the use cases above and address the related challenges, easy and rapid application deployment and the translation of different communication protocols are key capabilities IoT platforms for smart homes and buildings should provide. We see two different starting points for delivering these: Some IoT platforms start as a "closed system" which allows simple usage from the beginning but limits the interoperability with many different devices (the latter will be provided over time). Other IoT platforms do it the other way around, starting as an "open system" with a stronger focus on interoperability than on simplicity.

IMPACT ON THE EXISTING VENDOR LANDSCAPE

Surviving the shake-out in horizontal IoT platforms

Within the next two years, we will see the provider landscape in the area of horizontal IoT platforms change significantly. Existing horizontal IoT platforms, which today offer specific capabilities in functional areas such as analytics or device management, will evolve in three different directions – they will become providers of broad IoT developer platforms, niche players, or lose out on the market.

The big winners in this game will be existing horizontal IoT platforms that have the necessary capabilities to move quickly in the direction of open IoT developer platforms for the development, deployment and ongoing management of all kinds of IoT devices and applications. “Open” means two things in this context: On the one hand, these IoT developer platforms have to be publicly accessible via the web for all sorts of IoT developers – independent developers, developers at system integrators or internal developers on the client side. On the other hand, IoT developer platforms should support developers not only with own (self-developed) microservices, but also with well-integrated 3rd-party microservices (including all kinds of IoT platform capabilities such as data visualization, event processing, data management, analytics, device management, connectivity, etc.).

There is a group of existing horizontal IoT platforms that have strong potential to position themselves as IoT developer platforms. They include big players such as Microsoft, AWS, SAP and IBM; and there is also a new group of open-source platforms with more and more IoT capabilities, such as Eclipse IoT or FIWARE.

Apart from the providers of developer platforms, we will also see an emerging group of niche players. These niche players have a strong functional capability in one aspect of a horizontal IoT platform (e.g. device management, rapid application deployment or analytics) and they package this capability in a microservice (container). This gives them the opportunity to provide this microservice for the developer community to use under the umbrella of various developer platforms. This can be a successful approach for all kinds of horizontal IoT platform providers that do not have the capabilities needed to become a relevant developer platform. We already see a group of horizontal IoT platform providers that show a tendency to move into this role. For example, Bosch is currently integrating device management elements of the Bosch IoT Suite into IBM Watson IoT or AWS. PTC and Cumulocity are following the same path – strong niche players becoming part of bigger developer platforms. However, PAC believes that even niche players with unique microservices will come under pressure in the longer run, as we expect existing providers of developer platforms to sooner or later introduce similar functionalities to their developer communities, thus squeezing the niche players out of their platforms. To avoid this future scenario, we will see niche players such as PTC and Bosch follow a dual strategy. On the one hand, they will be integrating their microservices into the developer platforms of bigger providers (because they have no other choice if they want to reach the large group of developers), while on the other hand, they will also be looking to become vertical IoT platforms. This move makes perfect sense for players with a unique strength in a particular functional area that is highly relevant for a specific vertical context. For example, Bosch provides its strong capabilities in device management

not only as microservices to the market, but also leverages them as a core part of a vertical IoT platform around connected cars, the Bosch Automotive Cloud Platform.

The losers in this game will clearly be the remaining horizontal IoT platforms that neither have the capabilities required to become broad developer platforms nor do they have a unique (or at least very strong) functional capability to position themselves as relevant niche players for specific microservices across various 3rd-party developer platforms. These companies will simply disappear from the IoT platform market as there is no market potential for pure "me too" providers in the medium run. Only the best developer platforms and microservice providers will survive.

IoT developer platforms (integrated microservices for development, deployment and ongoing management of IoT devices and applications)			
IoT microservices (device management)	**IoT microservices** (rapid application deployment)	**IoT microservices** (analytics applications)	**IoT micro services** (device development)

Evolution from horizontal IoT platforms towards developer platforms

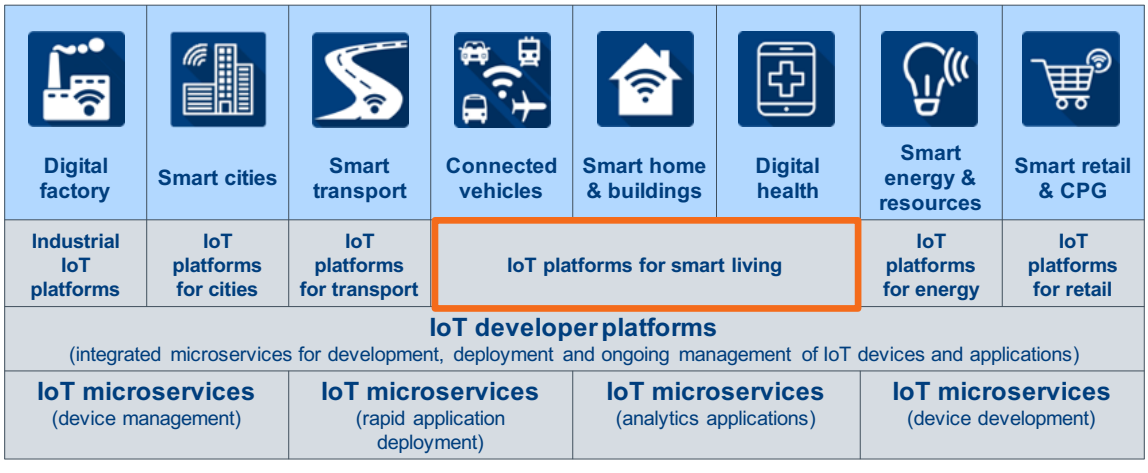
Explosion and consolidation of vertical IoT platforms

As the figure below illustrates, IoT developer platforms sometimes provide the foundation for the development of vertical IoT platforms. However, this is not always the case. We also see approaches where the above-mentioned niche players with their microservices bypass the IoT developer platforms and provide their own vertical IoT platforms, as the example of the Bosch Automotive Cloud Platform shows. Besides the already emerging vertical IoT platforms (in the fields of smart home, smart cities, connected vehicles and digital factory), we will see more and more vertical IoT platforms emerging in other vertical areas, too.

 **Digital factory**	 **Connected vehicles**	 **Smart transport**	 **Smart cities**	 **Smart home & buildings**	 **Digital health**	 **Smart energy & resources**	 **Smart retail & CPG**
Industrial IoT platforms	**IoT platforms for vehicles**	**IoT platforms for transport**	**IoT platforms for cities**	**IoT platforms for homes**	**IoT platforms for health**	**IoT platforms for energy**	**IoT platforms for retail**
IoT developer platforms (integrated microservices for development, deployment and ongoing management of IoT devices and applications)							
IoT microservices (device management)		**IoT microservices** (rapid application deployment)		**IoT microservices** (analytics applications)		**IoT microservices** (device development)	

Extended segmentation of IoT offerings (I)

Simultaneously with the explosion of new vertical IoT platforms, PAC expects these platforms to also start consolidating within the next 2-3 years. It will be interesting to see how this consolidation will proceed and how it will impact the provider landscape. We believe that consolidation in this vertical space will start in the consumer segment, because the complexity in all other segments will hamper quick consolidation. In addition, we think that the boundaries between some vertical platforms serving the consumer segment will increasingly blur and disappear. Consumers using smart home services, connected cars and digital health wearables will certainly be happy to integrate all these connected bits and pieces in order to reach the next level of integration and reduce complexity; let's call these platforms "smart living platforms". As a consequence, vertical IoT platforms will increasingly have to widen their scope. For example, a smart home platform will have to also integrate a customer's health-related wearables and connected car. The same applies to connected car platforms, which will have to be linked to smart homes and all other aspects of "smart living". This raises the level of complexity and will certainly lead to consolidation in the provider landscape. This trend to manage ever bigger and more complex systems and even systems of systems will also affect other vertical areas in the future and will lead to market consolidation.



Extended segmentation of IoT offerings (II)

PAC INNOVATION RADAR – EVALUATED MARKET SEGMENTS

How does PAC segment the provider landscape for IoT platforms?

PAC is going to evaluate the providers of IoT platforms in Europe in seven different PAC INNOVATION RADAR segments, which are dedicated to specific use cases:

Horizontal IoT platforms provide support for a specific use case across many verticals

- IoT platforms for device management enable SW updates for device fleets and/or remote control of devices,
- IoT platforms for rapid application deployment allow data visualization via drag & drop dashboards and event processing,
- IoT platforms for analytics application enable the development of more complex IoT applications such as predictive maintenance,
- IoT platforms for device development allow the communication of low-power devices with embedded SW via LPWAN.

Vertical IoT platforms provide support for a specific set of use cases, dedicated to the needs of one vertical context

- Industrial IoT platforms cover all kinds of use cases around the digital factory,
- IoT platforms for vehicles cover all kinds of use cases around SIM-connected vehicle fleets,
- IoT platforms for smart cities cover all kinds of use cases around the efficient use of city infrastructures.

PAC RADAR EVALUATION METHOD

The traditional RADAR evaluation method

The PAC RADAR is a tool for the holistic evaluation of IT providers. PAC publishes the PAC RADAR two to four times per year for different segments. Every PAC RADAR targets a specific IT services sector. In this PAC RADAR the leading providers in a local market are evaluated.

In the PAC RADAR, the performance, competence and market position of the key providers in a services segment are assessed and compared using approx. 50 pre-defined criteria.

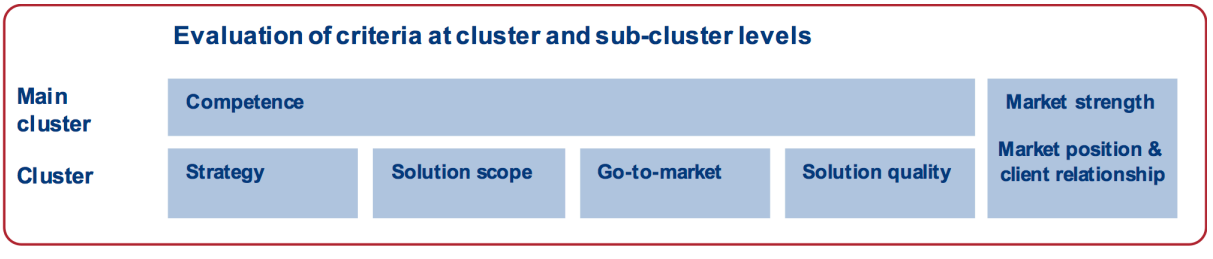
The criteria are classified by clusters (or categories) and can each be mapped to the “Competence” and “Relative Market Strength” main clusters as well as the underlying sub-clusters (see figure). There is an overall rating from the evaluation of the criteria as well as sub-ratings per cluster and sub-cluster.

From the weighted evaluation of all criteria and the resulting overall score, each provider receives their characteristic positioning in the PAC RADAR.

The PAC INNOVATION RADAR evaluation method

Concept and methodology of the PAC INNOVATION RADAR are similar to those of the traditional PAC RADAR. While the traditional PAC RADAR focuses on mature services segments, the PAC INNOVATION RADAR, however, positions providers in rather new and innovative service segments. Thus the focus of the evaluation is rather on the portfolio, vision, investment and capabilities than on existing references, projects and resources.

For the PAC INNOVATION RADAR the following applies: The closer a company is to the top right corner, the closer they are to meeting customers’ requirements!



Clusters and sub-clusters of the PAC INNOVATION RADAR by which providers are evaluated

Selection of providers

Providers are selected and invited according to the following criteria:

- **Size of revenues** in the segment to be analyzed in the specified region
- **"Relevance":** Even providers that do not belong to the top-selling providers in the segment to be analyzed are considered, if PAC classifies them as relevant for potential customers, for instance due to an innovative offering, strong growth, or a compelling vision.

There is no differentiation as to whether the providers are customers of PAC – neither in the selection of the providers to be positioned, nor in the actual evaluation.

The decision as to which providers are considered in the PAC INNOVATION RADAR analysis is entirely up to PAC. Providers do not have any direct influence on this decision.

The following providers have been positioned in the seven PAC INNOVATION RADAR analyses "IoT platforms in Europe 2018":

Providers positioned in the segment of IoT platforms for analytics applications:

- Amazon Web Services (AWS)
- C3 IoT
- GE Digital
- Google
- IBM
- Microsoft
- Oracle
- SAP
- Siemens
- Software AG

Providers positioned in the segment of IoT platforms for device development:

- Amazon Web Services (AWS)
- ARM
- Google
- Huawei
- Microsoft
- Samsung
- Siemens
- Wind River

Providers positioned in the segment of IoT platforms for device management:

- Amazon Web Services (AWS)
- Axiros
- Bosch Software Innovations
- Ericsson
- Eurotech
- Evrythng
- Exosite
- Google
- Greenwave Systems
- Microsoft
- Prodea
- relayr
- SAP
- Siemens
- Sierra Wireless
- Software AG
- Telit
- Wind River

Providers positioned in the segment of IoT platforms for rapid application deployment:

- Amazon Web Services (AWS)
- Autodesk
- Ayla Networks
- C3 IoT
- Davra
- DGLogik
- Google
- Microsoft
- PTC
- SAP
- Siemens
- Sierra Wireless
- Software AG
- Telit

Providers positioned in the segment of IoT platforms for connected vehicles:

- Airbiquity
- Bosch
- Bright Box
- Continental
- Ericsson
- Harman
- IBM
- Microsoft
- Nokia
- SAP

Providers positioned in the segment of IoT platforms for industrial devices:

- Altizon
- Axoom
- Bosch
- FORCAM
- GE Digital
- IBM
- Microsoft
- MPDV
- Oracle
- PTC
- SAP
- Siemens

Providers positioned in the segment of IoT platforms for smart cities:

- Ericsson
- FIWARE
- Huawei
- InterDigital
- Itron
- Sierra Wireless
- Urban Software Institute

Evaluation criteria (most relevant)

Main cluster "Competence"

Sub-cluster "Strategy"

- Strategic focus on IoT platforms
- Strategic activities over the last 12 months
- Thought leadership on IoT platforms
- Strategic cooperation with other top IoT providers

Sub-cluster "Portfolio"

- IoT device management capabilities
- User experience & rapid application deployment capabilities
- IoT analytics & complex application development capabilities
- Portfolio structure & user/developer support
- IoT applications to support vertical use cases*
- IoT platform capabilities (device management, analytics, application development)*

Sub-cluster "Go-to-market"

- IoT ecosystem of developers & systems integrators in Europe
- IoT labs in Europe
- Availability of IoT starter kits & free test access to IoT platform
- Go-to-market via third-party IoT platforms and developer communities

Sub-cluster "Portfolio quality"

- Unique selling proposition (USP)
- Client references in Europe
- Market perception in Europe
- Platform maturity

Main cluster "Market strength"

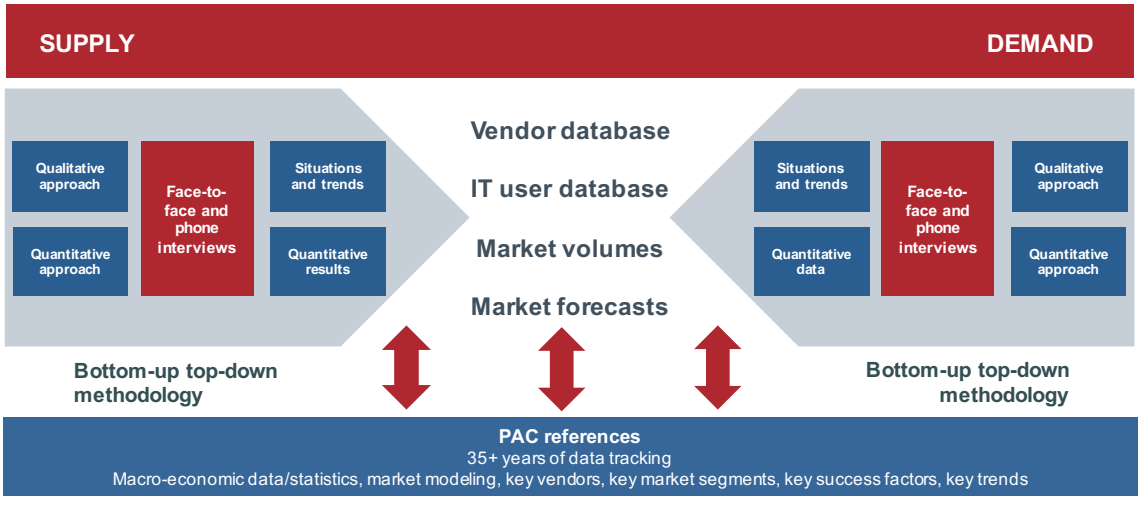
Sub-cluster "Market position & client relationship"

- Financial strength
- Market coverage in Europe
- Ecosystem of developers & systems integrators in Europe
- Client access and relationship in Europe
- IoT C&SI revenue in Europe in this IoT segment
- Market coverage across Europe (presence with local offices)
- Recognized as top provider in this IoT segment
- Financial strength

*vertical-specific criteria

General PAC research method

The following overview describes PAC's research method for market analysis and key differentiation features.



Description of the PAC methodology

Local research and face-to-face communication are two core elements of PAC's methodology. In our market studies, we can draw on more than 40 years of experience in Europe.

Positioning within the PAC RADAR

From the resulting overall score, each provider receives their characteristic positioning within a ring of the PAC RADAR. Here, the following applies: The closer the position is to the upper right corner, the closer the provider is to the customer requirements for that segment.

The "customer requirements" at the center represent a cross-section of the market; the position of the provider represents the completeness with which the provider's offerings and competence correspond with the requirements of all potential customers; i.e. purely local clients, international key accounts and SMEs alike.

The providers are positioned within ring 1 (innermost ring) to ring 4 (outermost ring), based on the total grade they achieved. The total grade is the average score of the two main clusters ("competence" & "market strength").

The rings of the PAC RADAR can be classified by the following attributes:

- Ring 1: "Best in Class" (total grade between 1 and 1.99)
- Ring 2: "Excellent" (total grade between 2 and 2.99)
- Ring 3: "Strong" (total grade between 3 and 3.99)
- Ring 4: "Solid" (total grade between 4 and 4.99)

MARKET SITUATION AROUND IOT PLATFORMS FOR SMART CITIES

Smart cities is one of the four main segments in which PAC has observed a rapid emergence of vertical IoT platforms (the other three being digital factory, connected vehicle, and smart home). However, while, for example, IoT platforms for industrial devices are already quite mature and characterized by a high diversity, smart city platforms in general have not yet reached such an advanced status.

In PAC's view, the potential of smart city platforms is huge. With the goal of enhancing public administration services and increasing the quality of life of inhabitants in cities and rural regions alike, smart city projects will have reached their highest value when able to smoothly integrate a broad range of cross-vertical data and services, such as those provided by energy companies, transport and logistics companies, car manufacturers, public administration, police and other safety organizations, environmental organizations, smart home providers, insurance companies, etc.

One of the most advanced areas of smart city solutions is "smart parking", a segment where a wide range of European cities and regions have started pilot projects with IoT platform providers to enhance traffic management. However, in most cases, these initiatives are not yet integrated with other mobility or environmental concepts of city administrations. Another segment that is quickly emerging is use cases around public safety, combining services like traffic lights management, motion sensor analytics, and police force management, for example, in order to rapidly detect or even predict security threats on the streets and take countermeasures. In addition, smart street lighting is already helping many public administrative bodies in reducing energy consumption and costs.

The smart city IoT segment will create a huge business opportunity, especially for those platform providers that rely on open and standardized data and architectures in order to enable the interoperability of decentralized IoT data and allow for the easy and agile development of new smart city solutions and business cases. However, in PAC's opinion, only very few platform providers already follow such a comprehensive approach.

For the PAC INNOVATION RADAR "IoT platforms for smart cities", we evaluated the approach of seven major players, placing particular emphasis on the maturity of dedicated use cases in Europe (besides our standard evaluation criteria). Two companies were found to be leading in the field of smart city platform providers, FIWARE and Itron, achieving a best-in-class ranking. Both have a very strong focus on interoperability and standardization; with their open frameworks and developer kits, they enable various market players to jointly develop smart city IoT solutions, thus creating a smart city ecosystem. Their platforms are already deployed in several European (and non-European) countries.

Smart city platforms currently often specialize in one or very few selected areas, but mostly do not have a comprehensive, integrated approach; or the platform providers have not yet been able to win a significant number of clients in countries across Europe. Both aspects have lowered the rankings of four of the players in this RADAR on IoT platforms for smart cities, even though "excellent" and "strong" are still very good ratings.

PAC RADAR "IOT PLATFORMS IN EUROPE 2018" – SMART CITIES

PAC RADAR IoT platforms in Europe 2018 – smart cities

REVIEW OF ALL SEEDED PROVIDERS

Overview of the providers[1]

Cluster	Ericsson	FIWARE	Huawei	InterDigital	Itron	Sierra Wireless
Competence	3.14	1.73	2.96	3.21	1.81	2.47
Market strength	2.38	2.13	1.88	3.75	2.00	2.88

Cluster	Urban Software Institute	Average
Competence	2.25	2.51
Market strength	3.63	2.66

Overview of the cluster evaluation on the providers positioned in the PAC RADAR

In the following, the criteria for each provider that resulted in a substantial up- or downgrading as compared to the participating providers are set out.

[1] *The cluster grades shown represent the respective weighted average of the evaluated sub-criteria.*

Itron

PAC RADAR IoT platforms in Europe 2018 – smart cities

Best in Class

Cluster	Itron	Average
Competence	1.81	2.51
Market strength	2.00	2.66

CRITERIA RATED AS SIGNIFICANTLY ABOVE AVERAGE (MORE THAN 0.5)

- Strategic cooperation with other top IoT providers
- IoT applications to support vertical use cases
- IoT ecosystem of developers & systems integrators in Europe
- IoT labs in Europe
- Go-to-market via third-party IoT platforms and developer communities
- Unique selling proposition (USP)
- Client references in Europe
- Ecosystem of developers & systems integrators in Europe
- Client access and relationship in Europe

CRITERIA RATED AS SIGNIFICANTLY UNDER AVERAGE (MORE THAN 0.5)

- None

FIWARE

PAC RADAR IoT platforms in Europe 2018 – smart cities

Best in Class

Cluster	FIWARE	Average
Competence	1.73	2.51
Market strength	2.13	2.66

CRITERIA RATED AS SIGNIFICANTLY ABOVE AVERAGE (MORE THAN 0.5)

- Strategic activities over the last 12 months
- Thought leadership on IoT platforms
- Strategic cooperation with other top IoT providers
- IoT applications to support vertical use cases
- Portfolio structure & user/developer support
- IoT ecosystem of developers & systems integrators in Europe
- Availability of IoT starter kits & free test access to IoT platform
- Go-to-market via third-party IoT platforms and developer communities
- Unique selling proposition (USP)
- Client references in Europe
- Ecosystem of developers & systems integrators in Europe
- Client access and relationship in Europe

CRITERIA RATED AS SIGNIFICANTLY UNDER AVERAGE (MORE THAN 0.5)

- None

Huawei

PAC RADAR IoT platforms in Europe 2018 – smart cities

Excellent

Cluster	Huawei	Average
Competence	2.96	2.51
Market strength	1.88	2.66

CRITERIA RATED AS SIGNIFICANTLY ABOVE AVERAGE (MORE THAN 0.5)

- Financial strength
- Market coverage in Europe
- Ecosystem of developers & systems integrators in Europe
- Client access and relationship in Europe

CRITERIA RATED AS SIGNIFICANTLY UNDER AVERAGE (MORE THAN 0.5)

- Strategic focus on IoT platforms
- Strategic activities over the last 12 months
- IoT applications to support vertical use cases
- IoT ecosystem of developers & systems integrators in Europe
- Unique selling proposition (USP)
- Client references in Europe

Sierra Wireless

PAC RADAR IoT platforms in Europe 2018 – smart cities

Excellent

Cluster	Sierra Wireless	Average
Competence	2.47	2.51
Market strength	2.88	2.66

CRITERIA RATED AS SIGNIFICANTLY ABOVE AVERAGE (MORE THAN 0.5)

- Availability of IoT starter kits & free test access to IoT platform
- Client references in Europe
- Platform maturity

CRITERIA RATED AS SIGNIFICANTLY UNDER AVERAGE (MORE THAN 0.5)

- Strategic activities over the last 12 months
- Thought leadership on IoT platforms
- IoT applications to support vertical use cases
- IoT labs in Europe

Ericsson

PAC RADAR IoT platforms in Europe 2018 – smart cities

Excellent

Cluster	Ericsson	Average
Competence	3.14	2.51
Market strength	2.38	2.66

CRITERIA RATED AS SIGNIFICANTLY ABOVE AVERAGE (MORE THAN 0.5)

- Financial strength
- Client access and relationship in Europe

CRITERIA RATED AS SIGNIFICANTLY UNDER AVERAGE (MORE THAN 0.5)

- Strategic focus on IoT platforms
- Thought leadership on IoT platforms
- Strategic cooperation with other top IoT providers
- IoT platform capabilities (device management, analytics, application development)
- Portfolio structure & user/developer support
- IoT ecosystem of developers & systems integrators in Europe
- IoT labs in Europe
- Go-to-market via third-party IoT platforms and developer communities
- Unique selling proposition (USP)
- Client references in Europe
- Platform maturity
- Ecosystem of developers & systems integrators in Europe

Urban Software Institute

PAC RADAR IoT platforms in Europe 2018 – smart cities

Excellent

Cluster	Urban Software Institute	Average
Competence	2.25	2.51
Market strength	3.63	2.66

CRITERIA RATED AS SIGNIFICANTLY ABOVE AVERAGE (MORE THAN 0.5)

- Strategic focus on IoT platforms
- Unique selling proposition (USP)
- Client references in Europe
- Market perception in Europe

CRITERIA RATED AS SIGNIFICANTLY UNDER AVERAGE (MORE THAN 0.5)

- Strategic cooperation with other top IoT providers
- Portfolio structure & user/developer support
- IoT ecosystem of developers & systems integrators in Europe
- Availability of IoT starter kits & free test access to IoT platform
- Go-to-market via third-party IoT platforms and developer communities
- Financial strength
- Market coverage in Europe
- Ecosystem of developers & systems integrators in Europe
- Client access and relationship in Europe

InterDigital

PAC RADAR IoT platforms in Europe 2018 – smart cities **Strong**

Cluster	InterDigital	Average
Competence	3.21	2.51
Market strength	3.75	2.66

CRITERIA RATED AS SIGNIFICANTLY ABOVE AVERAGE (MORE THAN 0.5)

- None

CRITERIA RATED AS SIGNIFICANTLY UNDER AVERAGE (MORE THAN 0.5)

- Strategic activities over the last 12 months
- Thought leadership on IoT platforms
- Strategic cooperation with other top IoT providers
- IoT applications to support vertical use cases
- Portfolio structure & user/developer support
- IoT ecosystem of developers & systems integrators in Europe
- IoT labs in Europe
- Availability of IoT starter kits & free test access to IoT platform
- Go-to-market via third-party IoT platforms and developer communities
- Client references in Europe
- Market perception in Europe
- Financial strength
- Market coverage in Europe
- Ecosystem of developers & systems integrators in Europe
- Client access and relationship in Europe

ABOUT PAC – A CXP GROUP COMPANY

Founded in 1976, Pierre Audoin Consultants (PAC) is part of CXP Group, the leading independent European research and consulting firm for the software, IT services and digital transformation industry.

CXP Group offers its customers comprehensive support services for the evaluation, selection and optimization of their software solutions and for the evaluation and selection of IT services providers, and accompanies them in optimizing their sourcing and investment strategies. As such, CXP Group supports ICT decision makers in their digital transformation journey.

Further, CXP Group assists software and IT services providers in optimizing their strategies and go-to-market approaches with quantitative and qualitative analyses as well as consulting services. Public organizations and institutions equally base the development of their IT policies on our reports.

Capitalizing on 40 years of experience, based in 8 countries (with 17 offices worldwide) and with 140 employees, CXP Group provides its expertise every year to more than 1,500 ICT decision makers and the operational divisions of large enterprises as well as mid-market companies and their providers. CXP Group consists of three branches: Le CXP, BARC (Business Application Research Center) and Pierre Audoin Consultants (PAC).

For more information, please visit www.pac-online.com.

PAC's latest news: www.pac-online.com/blog

Follow us on Twitter: @CXPgroup

ABOUT THE PAC RADAR

The PAC RADAR is protected by Pierre Audoin Consultants (PAC)'s copyright.

The PAC RADAR is a graphical representation and written analysis of the positioning of various IT providers within a defined market segment at a specific point in time. The positioning and characterization of selected companies within the PAC RADAR is conducted on the basis of an analytical assessment of criteria which PAC previously defined for this analysis.

The selection, positioning, and characterization of companies within the PAC RADAR is not subject to any vested interests whatsoever. PAC does not support any providers that are represented in the PAC RADAR, and does not give any recommendations to technology users. The PAC RADAR represents a result from market research only and must not be taken as a recommendation for action.

The contents of the PAC RADAR have been created with utmost diligence and care. However, PAC cannot be held responsible for any errors or omissions.

PAC excludes all express or implied claims, also if derived from warranties with respect to the PAC RADAR report, including any implied warranties of merchantability or fitness for a particular purpose.

The PAC RADAR may only be used for a license fee and with the consent of PAC. Moreover, the use and publication of the contents and the results of the PAC RADAR are subject to the "Terms & conditions for the usage of Pierre Audoin Consultants (PAC)'s SITSI® license".