PAC RADAR

Digital Innovation & IoT I Europe I 2020

Open Digital Platforms for the Industrial World in Europe 2020

SITSI I Vendor Analysis I PAC RADAR

Platforms for the industrial edge cloud

– Positioning of Canonical –

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OBJECTIVE OF THIS REPORT

The PAC RADAR by teknowlogy | PAC is an effective tool for the holistic evaluation and visual positioning of software and ICT service providers on local markets. Numerous ICT and business decision-makers in user companies of all industries and company sizes rely on the PAC RADAR when selecting their partners and developing their sourcing strategies.

With the help of predefined criteria, teknowlogy | PAC evaluates and compares providers' strategies, development, and market position in addition to performance and competencies within specific market segments.

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INTRODUCTION

Lessons learned from the first wave of digital factory projects

Before looking into the current market dynamics, it is, as always, very helpful to take a step back and analyze past developments. In the past 24 months, many digitalization projects were initiated and driven forward to take the level of digitization in many factories across the world to the next stage. In this report, we categorize these projects as the "first wave of digital factory projects". This first wave of projects was especially driven by the following four factors:

- Many new technologies emerged, such as Internet of Things (IoT), artificial intelligence (AI), augmented reality (AR), 3D printing, 5G, cobots, cloud, and edge computing. Each individual technology, but also the potential value derived from combining these new technologies, attracted a lot of awareness in the market.
- Based on the technologies mentioned above, many new use cases (e.g. remote machine monitoring, fleet management, predictive maintenance, connected workers, and digital quality control) became a subject of public discussion, promising significant value creation potential through efficiency gains in the production environment and around industrial field services.
- Enthusiasm among innovators and industrial pioneers, who predicted that even more use cases would be possible based on these new technologies and, in addition, these new use cases could potentially create even more value. This led to huge expectations across the industrial world, especially on all management levels. There was a common perception that digitization projects in the factory would lead to efficiency gains in the double-digit range.
- The above-mentioned enthusiasm among digital leaders put a lot of pressure on all other players in the market to follow suit. These followers felt a significant competitive risk of falling behind by doing nothing, or just by moving too slowly.

Ultimately, new technologies, new use cases, enthusiasm, and competitive threat led to a "high sense of urgency" for digital factory projects. Driven by these factors, common patterns emerged across companies in the manufacturing industry in their approach to initiating and driving these digital factory projects as fast as possible. Basically, companies followed this five-step approach:

1. Start bottom-up in the organization and identify many different potential use cases.
2. Prioritize these use cases based on attractiveness (value and time to market).
3. Initiate proofs of concept (PoCs) to check the technical feasibility of the most highly prioritized use cases.
4. Broader deployment of successful PoCs across the company.
5. Measure the outcome and draw lessons for the next cycle in the process.

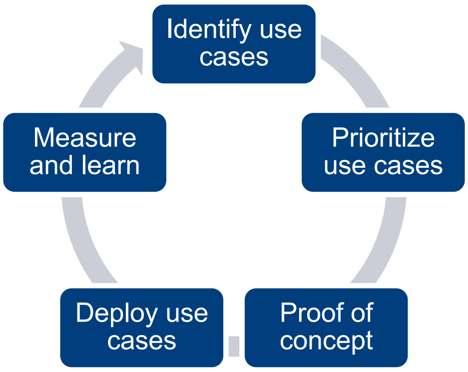

Fig. 1: Initial approach of many digital transformation projects in manufacturing

Some companies step by step went through the list of initially identified and prioritized use cases and tried to push them through the process. Other companies again and again started from the beginning, aiming to continually identify new use cases. They were constantly looking for new, high-value use cases – a real "killer app", if possible, which introduces dramatic improvements.

When going through this process, many companies learned quite similar lessons. First of all, many potential use cases are thinkable. (If you need food for thought, teknowlogy evaluated an extensive list of digital factory use cases in our SITSI® InSight Analysis report "Digital Factory: Use Cases and Maturity"). Second, technology is typically not the main problem. Many use cases are technically feasible. While this finding may not have come as a big surprise, the third lesson learned was definitely more interesting, but in a negative way. They often realized that individual use cases generated a more limited return on investment (RoI) than expected. Digitalization projects often do create value, which, however, not necessarily lives up to the high expectations. This created some level of disappointment and disillusion on the user side of the market.

Excessive expectations in terms of fast market growth based on new technologies were of course also a challenge on the provider side of the market. For example, GE Digital, which made huge investments in Predix, and German machine tool and laser manufacturer Trumpf, with its digital start-up Axoom, emerged as real digital pioneers in the European market for industrial IoT platforms. They have silently left the market through the back door since. They do deserve great respect. There was a real chance that these early movers would become successful digital leaders in the industrial world. In reality, however, their ambitions and investments turned out to be based on excessive expectations as to how fast the market would accelerate.

In summary, we are in a good position today to learn some valuable lessons from the first phase of digital factory projects in the market:

- There is no "killer app" on the horizon that enables significant efficiency enhancements (double-digit). Instead, many different use cases allow step-by-step improvements for industrial companies. We expect further use cases to emerge in the future, but we do not expect to see a killer app.
- To overcome the bottleneck described above, manufacturing companies need an efficient approach (e.g. low code) in order to develop simple new applications for new use cases at a fast pace.
- The digital factory needs efficient scalability (simple and fast) to transfer successful PoCs of newly developed applications to many different machines, production lines, and factories.
- Agile application development and agile scalability have to be combined with agile application management to handle updates (new functions, security) as efficiently as possible.

In short, there is a need for an agile DevOps approach to manage the digital factory as efficiently as possible.

Fig. 2: More efficient approach to managing digital projects in manufacturing

Open digital platforms for the industrial world

As described above, there is the clear need to make the development, scaling, and management of new applications for the digital factory more efficient, simple, and agile. Platforms can help to provide all these capabilities in an efficient, i.e. integrated, way. Let's take a quick look at the evolution of industrial IoT platforms first. IoT platforms started with the ambition to help clients mainly with two aspects, application development and application management around their devices connected to the IoT. Some platform vendors initially focused more on agile application development, centered around low-code and/or analytics-related application development capabilities. This was often supported by co-innovation approaches (design-thinking workshops, together with their clients, held in innovation centers) and a big ecosystem of application development partners. Other platform vendors started more from an application management background and first of all helped clients to manage their applications on IoT devices (including device management, as this basically represents just another application). Application scaling across IoT devices is another capability offered by IoT platforms, albeit often more restricted so far. IoT platforms with good application management capabilities may provide good support of software updates for homogeneous IoT device fleets, but not necessarily for more heterogeneous device fleets (such as connected cars or machines with a long useful life) that run on different underlying hardware and software (firmware, operating system). Container technology can help overcome these limitations today. Their big advantage is that containers allow to manage applications independently from the underlying technology. This independence is a key requirement for efficient application scaling and management across highly heterogeneous, "brownfield" environments like a factory. On top of this, a microservices-based application architecture can make application scaling and management even more efficient. It allows to run applications on distributed infrastructure (at the edge, in the cloud, or in hybrid scenarios). This is why we already observe initiatives underway to re-architect industrial applications such as MES with the aim to split monolithic applications into smaller, containerized microservices (around specific functions and capabilities).

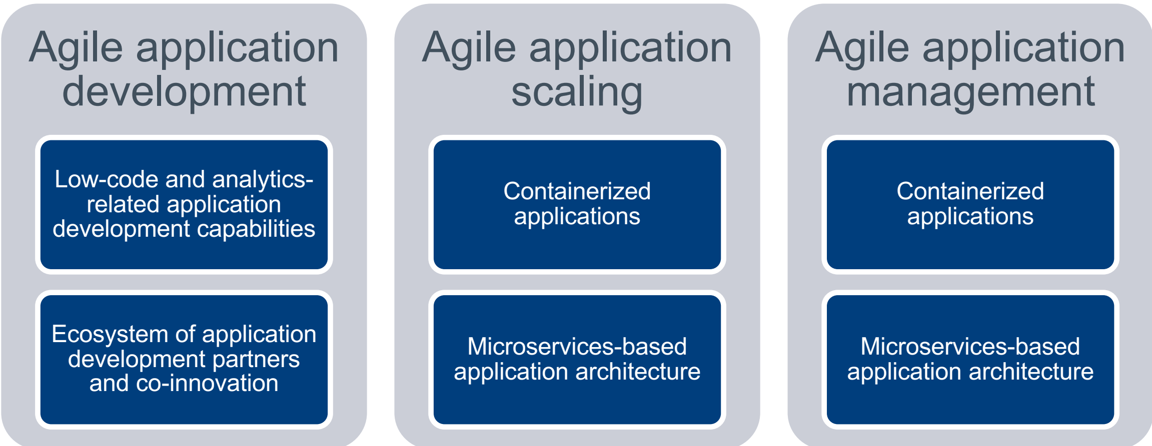

Fig. 3: Required capabilities to enable agile DevOps for the digital factory

Digital platforms for industrial purposes can take digital factory initiatives to the next level by providing agile DevOps capabilities across all industrial applications in the factory. These platforms go beyond industrial IoT (not limited to device and sensor data), orchestrating applications and data in a holistic way across connected devices (embedded systems, programmable logic controllers), industrial edge computing (e.g. industrial PCs, gateways, servers), and the cloud. To underline the described evolutionary shift, we move away from the terminology of industrial IoT platforms towards “digital platforms for the industrial world”. These platforms have the ambition to manage the factory with all its applications as an increasingly integrated and agile digital system.

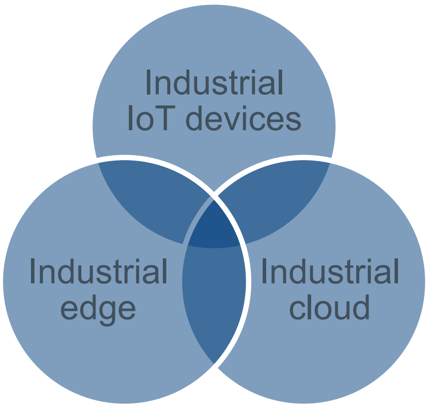

Fig. 4: Digital platforms for the industrial world orchestrate applications across IoT devices, edge, and cloud

The final aspect we have to consider in this context of emerging digital platforms for the industrial world is “openness”. As already mentioned, the shop floor is a highly heterogeneous place, and it will remain so in many respects. It remains a heterogeneous environment across applications, IoT devices, edge and cloud infrastructures. While digital platforms can help to handle the infrastructure-related heterogeneity through an efficient abstraction layer (containerized applications that provide infrastructure flexibility), and integrated IoT capabilities help to connect all kinds of IoT devices, there is still the need to make newly emerging applications (potentially for innovative use cases) quickly and efficiently available to users of the digital platform. To facilitate this, an open app store model integrated with the digital platform would be appropriate. This would give users not only access to new, internally developed applications, but also to external applications from the platform provider or other 3rd-party developers. Only a big ecosystem and openness to all 3rd-party application developers can provide the maximum agility required in the market today. In a high-speed world, no individual application creates a lasting competitive advantage – it is the ability to move faster on a large scale that makes the difference. Today, open digital platforms are the best approach to achieving this for the digital factory in an efficient way.

Open app store		
Agile application development	**Agile application scaling**	**Agile application management**
Industrial cloud computing		
Industrial edge computing		
Industrial IoT devices		

Fig. 5: Stack of open digital platforms for the industrial world

TRENDS: DIFFERENT CONCEPTS OF OPEN DIGITAL PLATFORMS ARE STARTING TO COMPETE IN THE INDUSTRIAL WORLD

The emergence of edge computing is currently making companies reconsider the best basic architecture for their digital factory and other operational environments. Edge computing can be helpful in this respect. It is not really a new technology in itself, but it opens up new perspectives in terms of different architectural concepts. Edge computing can be seen as a competing concept to the cloud world. However, in reality, both elements are often closely connected. teknowlogy strongly believes in two things: First, the future of the digital factory is hybrid (edge and cloud together), not pure cloud or edge. Second, even in a hybrid future, we will see different, competing concepts in the market. A basic differentiation of these different hybrid architecture models is edge-centric vs. cloud-centric. However, teknowlogy distinguishes three different concepts in the market today that are increasingly competing with each other. And vendors are starting to position themselves around these different concepts. The following sections provide an introduction to the different concepts and highlight their general strengths and weaknesses:

- Industrial cloud
- Industrial edge
- Industrial edge cloud

Industrial cloud concept

The “industrial cloud” concept is not a “cloud-only”, but rather a “cloud-centric” concept. The idea is to bring data from industrial devices at the edge to the applications in the cloud for central data processing. This means that the cloud acts as the central hub for all data (including data management, access, and storage). In addition, the cloud acts as the central hub for all applications (including the app store). However, this does not mean that all applications are only running in the cloud. We also observe the extension of the cloud-centric concept to enable some data processing at the edge, albeit tightly integrated and controlled by the cloud. AWS Outposts is a good example of this. AWS Outposts enables edge data processing but is not designed to act independently from the cloud (Outposts needs connectivity to the cloud at least all 6 hours). The vendor landscape for this concept comes mainly from two corners of the market. The first group are hyperscalers such as Microsoft and AWS, which are increasingly moving their cloud platforms into the industrial space. The second group are providers of industrial IoT platforms (e.g. PTC ThingWorx) and industrial software (e.g. the MES solution FORCAM FORCE), which are increasingly offering their application portfolio via the cloud.

Industrial cloud	• Applications and app store are running in the cloud. • Data storage and management mainly take place in the cloud.
Industrial edge	• Only limited data processing takes place at the edge, such as data filtering before transmission to the cloud.
Industrial IoT devices	• Data flow can go directly to the cloud (unfiltered) or can be transmitted to the cloud via edge gateways (filtered).

Fig. 6: Basic aspects of the industrial cloud concept

Obviously, each concept has specific strengths and weaknesses. The big advantage of the industrial cloud concept is certainly the speed of innovation in the cloud. Today, the cloud world is certainly the pacemaker for the entire IT industry. The “cloud first” slogan stands for this paradigm. “Cloud first” illustrates well that IT vendors are increasingly introducing innovations first for the cloud space. This is true for various aspects of digital platforms. One aspect is application development – in the cloud, new features and functions (including security updates) can immediately be deployed to all users of the application. In addition, as mentioned in the previous chapter, container technology and microservices-based application architectures are two “cloud innovations” which improve the scalability and management of applications. Another interesting innovation for the cloud in this context is Kubernetes. Kubernetes is a highly automated approach to managing and scaling a large amount of containerized applications across clusters of distributed infrastructures (called nodes/pods). In summary, the cloud brings real strengths to the table in application innovations (application development), application scalability, and application management. In addition, the fully managed approach of software as a service makes cloud applications especially attractive for many user companies with rather limited internal IT resources and capabilities. This reduces the burden for them of managing applications by themselves.

The main weaknesses of the cloud concept are not unique to the manufacturing industry, but they are of particular significance as regards the requirements of the digital factory. As has often been discussed, the key disadvantages of the cloud are latency, data sovereignty (not necessarily security), and vendor lock-in. The latency issue is already being addressed by many vendors; they are trying to overcome low latency by integrating more edge capabilities into the overall concept. AWS Outposts and Microsoft Azure Stack are two typical add-ons to the overall cloud-centric concept here. To alleviate concerns about data sovereignty, vendors are doing their best to build a high level of trust. However, trust is a very volatile element, especially in uncertain times like these. As protectionism is spreading in more and more areas across the world, we expect to see a growing tendency among European user companies to prefer highly trusted and/or local vendors as their strategic suppliers. Another aspect is dependence on a provider in general. This not only refers to the dependence on large cloud platform providers from the US or China; it is a broader issue. Manufacturing companies have the clear intention to limit their dependence on individual suppliers within their supply chains – flexibility is key. Supply chains in the automotive industry are a good example in this context. We observe the same attitude towards IT-related suppliers. Some companies in the manufacturing industry are unlikely to be willing to place all their applications and data in the hands of one critical provider. The hyperscalers are trying to alleviate these concerns through a large ecosystem of local partners. This gives user companies a little more flexibility to work with different partners, even though the “cloud core” is potentially the same.

General strengths of the concept	General weaknesses of the concept	Providers' approach to overcoming the weaknesses of the concept
• Speed of innovation in application development, scalability, and management • Fully managed SaaS approach	• Latency challenges around cloud applications • Data sovereignty • Strong dependence on one provider	• Provide more edge capabilities to solve latency issues • Build trust in data sovereignty • Open partner ecosystem

Fig. 7: Strengths, weaknesses, and providers’ approach to overcoming the weaknesses of the industrial cloud concept

Industrial edge concept

Similar to the industrial cloud concept, the industrial edge concept is not an "edge-only", but rather an "edge-centric" concept. The idea is to bring applications to the data at the edge for local data processing. This means that the edge acts as the central hub for all data (including data management, access, and storage). It does not mean that data storage only takes place at the edge. The cloud may also act as an extended data storage, but in an edge-controlled setup. While applications run at the edge in this concept, the related app store can operate in a private back end (edge, data center, private cloud) or in the public cloud. These central app stores enable users to download relevant applications to the edge (just like the cloud app stores from Google or Apple enable the download of apps to smartphones). In this setup, IoT devices do not directly communicate with the cloud, only via the edge. This enables an edge-controlled system with local data management and data processing plus extended data storage in the cloud. The Siemens edge management system is a good example in this context. It allows to run app stores for edge applications in different back-end systems (at the edge or in the cloud). The currently emerging vendor landscape in this field has a strong background in industrial automation (e.g. Siemens, Bosch Rexroth, Phoenix Contact).

Industrial cloud	• Cloud app store provides application download to the edge. • Only extended and edge-controlled data storage in the cloud.
Industrial edge	• Applications run at the edge (edge app store is an option). • Data management and storage mainly takes place at the edge.
Industrial IoT devices	• Data flow is edge-controlled (edge gatekeeper) and not directly linked to the cloud.

Fig. 8: Basic aspects of the industrial edge concept

The key strengths and weaknesses of the industrial edge concept are the reverse of the above-mentioned strengths and weaknesses of the industrial cloud concept. When data management and processing take place at the edge, low latency, data sovereignty, trust, and vendor independence are certainly the advantages of this concept. These advantages are especially interesting for companies and industries that process real-time and/or sensitive data. Speed of innovation in developing, scaling, and managing applications is one of the disadvantages. Providers of industrial edge solutions are trying to overcome this disadvantage by transferring cloud innovations to the edge as fast as possible. "Cloud-native" basically refers to the adaption of cloud-centric innovations to areas outside the cloud (edge, data center). Two of these innovations are the above-mentioned cloud-driven innovations in container technology and microservices-based application architectures. Both are core elements of the industrial edge concept. To further increase the speed of innovation in industrial automation and the digital factory, we also observe the increasing adoption of Linux and more modern programming languages such as Python (especially relevant for analytics-related applications) within this concept. In addition, a strong ecosystem of application development partners is also important to maximize the speed of application innovation for the edge. Another disadvantage of the concept is the fact that application management is the user company's responsibility, which, besides independence, also brings with it the need for internal IT resources and capabilities. Providers of industrial edge management solutions are trying to address this by building very easy-to-use solutions that do not require deep IT skills to manage applications. The ambition is for non-IT staff (factory workers) to be able to use the systems largely on their own. Another weakness as compared to the cloud certainly is scalability at the edge. We will address this topic in more depth in the next section (industrial edge cloud concept).

General strengths of the concept	General weaknesses of the concept	Providers' approach to overcoming the weaknesses of the concept
• Minimized latency through edge applications • Data sovereignty • Limited dependence on one provider	• Speed of innovation in application development, scalability, and management • Internal IT skills required for application management • Limited scalability at the edge	• Cloud-native approach • Open partner ecosystem • Easy-to-use solutions for non-IT staff

Fig. 9: Strengths, weaknesses, and providers' approach to overcoming the weaknesses of the industrial edge concept

Industrial edge cloud

The two concepts described above – industrial cloud and industrial edge – have a clear focus on today's requirements of the digital factory. However, when companies consider choosing a concept today, it is highly recommendable to do so also with the future in mind. This means considering further requirements that are expected to arise soon. It is pretty obvious, in our high-speed world, that tomorrow comes ever faster. So what should companies take into consideration? Predicting the next cloud innovations is not that simple, but predicting the next innovations that will impact the edge is possible. Thanks to the latest innovations in the cloud world, we can predict quite easily what the next wave of "cloud-native" innovations will bring to the industrial edge (and the data center). Kubernetes will be the next big thing at the edge, as it already is in the cloud. As mentioned above, Kubernetes is a highly automated approach to managing and scaling a large amount of containerized applications across clusters of distributed infrastructures (called nodes/pods). The basic aspects of the industrial edge cloud concept are therefore quite similar to the industrial edge concept, with one addition – Kubernetes manages the edge applications.

Industrial cloud	• Cloud app store provides application download to the edge. • Only extended and edge-controlled data storage in the cloud.
Industrial edge	• Kubernetes-managed applications run at the edge. • Data management and storage mainly take place at the edge.
Industrial IoT devices	• Data flow is edge-controlled (edge gatekeeper) and not directly linked to the cloud.

Fig. 10: Basic aspects of the industrial edge cloud concept

Kubernetes takes scalability at the edge to a new level and helps to overcome the above-mentioned challenge of edge scalability (see section on industrial edge). Another big advantage of Kubernetes is multi-cloud. This means that Kubernetes can go beyond the efficient management of edge infrastructures and also integrate cloud infrastructures from different providers. Kubernetes-based multi-cloud is therefore an efficient way to manage cloud vendor dependence and edge scalability. Two challenges are currently linked to the adoption of Kubernetes at the edge – complexity and "expected need". Kubernetes brings clear advantages in application management and scalability at the edge, but it is currently still more complex to handle. Complexity is a very typical issue during the introductory phase of a new technology. Providers of Kubernetes-based solutions for the edge (e.g. IBM or Red Hat) will of course further reduce this complexity over time, but right now, user companies have to take into account that they need a certain level of internal IT skills to cope with the current level of complexity. The second aspect, “expected need”, is linked to the expectation that we will see a growing number of use cases for the digital factory. This would lead to a growing number of applications, plus increasing complexity in managing these applications efficiently. The big question is how fast this will happen in the digital factory and how significant the “need” will be in the future. Does it make sense to invest in this concept now, or maybe at a later stage? We expect to see different answers to this question, mainly for two reasons. First, it depends on each company’s specific stage of digitalization. Second, it depends on the specific sub-vertical in which a manufacturing company is active. Large companies with an high level of factory automation and the clear need to further optimize their operations certainly have a stronger need to evaluate this concept today than other companies.

General strengths of the concept	General weaknesses of the concept	Providers' approach to overcoming the weaknesses of the concept
• Minimized latency through edge applications • Data sovereignity • Limited dependency on one provider • Improved scalability through Kubernetes at the edge	• Speed of innovation around application development, scalability and management • Internal IT skills for application management required	• Cloud-native approach • Multi-cloud to further improve scalability beyond the edge • Open partner ecosystem • Easy-to-use Kubernetes • Underpin demand for edge cloud concept

Fig. 11: Strengths, weaknesses, and providers’ approach to overcoming the weaknesses of the industrial edge cloud concept

Other forms of open digital platforms

Besides the above-mentioned core concepts of open digital platforms for the industrial world, we see other forms of platforms emerging in the market. All of them address very interesting and highly attractive niche markets. They help to reduce the complexity of specific processes and workflows (as illustrated below). This allows users to become much more agile and efficient.

Open digital platforms for 3D printing services: Digital marketplaces for 3D printing services orchestrate not just the open interaction of different service providers and clients, but increasingly also provide additional digital services to both sides of the market (instant quoting and design optimization services to users and MES capabilities to providers).

Marketplace for 3D printing service		
Agile design validation and optimization	**Agile marketplace with instant quoting**	**Agile production of parts**
Industrial cloud computing		
Industrial edge computing		
Industrial IoT devices		

Fig. 12: Stack of open digital platforms for 3D printing services

Open digital platforms for connected workers (AR): These platforms are open to many different HW devices (smart glasses) and provide two core functions to clients, low-code AR application development and AR data visualization.

App store for different AR services		
Agile application development for AR	Agile visualization of AR applications at scale	Agile AR application management
Industrial cloud computing		
Industrial edge computing		
Industrial IoT devices		

Fig. 13: Stack of open digital platforms for connected workers (AR)

Open digital platforms for IoT data exchange & monetization: These platforms provide an app store for IoT data (often including open source data), additional digital add-on services such as data analytics, and/or a governance framework for the open sharing of this data between 3rd parties.

App store for data (incl. IoT) and add-on services (e.g. analytics)		
Agile data onboarding	Agile application development	Agile data and app management
Industrial cloud computing		
Industrial edge computing		
Industrial IoT devices		

Fig. 14: Stack of open digital platforms for IoT data exchange and monetization

Open digital platforms for enterprise IoT: These platforms enable large-scale IoT deployments across different industries. For this purpose, they provide highly scalable digital services to manage IoT devices, data, and applications. These platforms are based on open source and interact openly with all kinds of IoT devices and applications.

App store for IoT services		
Agile device onboarding	Agile application development	Agile device management
Industrial cloud computing		
Industrial edge computing		
Industrial IoT devices		

Fig. 15: Stack of open digital platforms for enterprise IoT

MARKET SITUATION – OPEN DIGITAL PLATFORMS FOR THE INDUSTRIAL EDGE CLOUD

Open digital platforms for the industrial edge cloud have the clear aim to leverage Kubernetes for enhanced scalability of the industrial edge and enable vendor-independent, multi-cloud scenarios. Existing vendors of container-based platforms that are already using Kubernetes in other enterprise environments (e.g. private clouds in data centers) are certainly well-positioned to also adapt their platforms to the needs of the industrial edge. Therefore, it is no surprise that vendors such as Red Hat, SUSE, IBM, and Rancher Labs make up the vendor landscape in this evaluation. However, we did not include vendors of container-based platforms such as Docker that have shown no ambitions at all to position their platform in the context of the industrial edge. While the market is still at a very early stage, the RADAR graph provides a first picture of the current market situation. It will be interesting to observe two aspects in the coming months – first, which vendors are the most keen to increasingly position themselves in the industrial space and extend their platform accordingly? Second, will we see an increasing overlap of capabilities between industrial edge platforms and industrial edge cloud platforms? This might lead to an integration of these market segments, which have been separate so far, into one market with one vendor landscape. For the time being, the overlap is limited. Today, industrial edge cloud platforms are certainly more complex to use because of their Kubernetes-based capabilities to support scalability and multi-cloud. Industrial edge platforms, on the other hand, focus more on very easy-to-use container management and simplified application development.

What makes an open digital platform for the industrial edge cloud attractive to users?

From teknowlogy's perspective, three aspects are very important at the initial stage of this market – an open source approach in order to avoid vendor lock-in, a strong developer ecosystem to ensure openness and innovation speed, and the clear ambition to move into the industrial edge world. Some comments on the first aspect, an open source approach in order to avoid vendor lock-in: Kubernetes was first developed by Google and made open source in 2014. Today it is maintained by the Cloud Native Computing Foundation (CNCF). The strengths of the cluster-based concept led to the establishment of an active Kubernetes community and a strong developer ecosystem to further enhance Kubernetes. This is why we believe that more proprietary approaches around Kubernetes will have no chance in the market. Regarding the second aspect, a developer ecosystem to ensure openness and innovation speed, we believe that only those platform vendors who are able to progress in cooperation with a strong and supportive developer community will be successful. It will of course be critical to find a fair and well-balanced business model to foster and monetize this approach. The third requirement is for vendors to have the clear ambition to move into the industrial edge world, aiming to integrate industrial IoT devices in this highly scalable edge management system and make the solution more easy to use.

Who are the leading vendors in this field today?

Red Hat is one of the driving forces behind many open source initiatives in the context of Kubernetes (Platinum member of CNCF, which maintains Kubernetes), IoT, and edge computing (group leader of the IoT Edge Working Group at CNCF, with a focus on leveraging Kubernetes for developing and deploying IoT and edge-specific applications). In addition, Red Hat is also a strategic member of the Eclipse Foundation, where, together with other members, it drives the IoT Working Group and the Edge Native Working Group (whose target is to enable cloud-native architectures to run at the edge). In this context, it is worth noting that the IoT Edge Working Group at CNCF and the Eclipse Edge Native Working Group started to collaborate in 2019 to jointly drive Kubernetes for the IoT edge. Red Hat's OpenShift Container Platform (OCP) is built on top of the open source Kubernetes orchestration technology. OpenShift 4 is designed to deliver a cloud-like experience from hybrid clouds to the edge, by driving automated updates across Kubernetes deployments. Moreover, the newly launched (April 2020) Red Hat Advanced Cluster Management for Kubernetes enables organizations to manage their Kubernetes clusters with consistency across different footprints – from Red Hat OpenShift deployed on-premises, in the cloud, or at the edge. In April 2020, Red Hat also announced an open cloud marketplace (operated by IBM) as a simple way to buy and manage enterprise software (OpenShift-certified applications), with automated deployment in different container-based environments (cloud, on-premises). Industrial edge/industrial IoT solutions are increasingly adopting open source technologies to accelerate the development and would benefit from using this marketplace.

IBM's solutions are based on the strong foundation from Red Hat, as described above. In August 2019, right after acquiring Red Hat, IBM announced that its entire software portfolio would run on Red Hat's OpenShift container platform. This will be enabled by preintegrated solutions called Cloud Paks. We expect that more and more containerized applications and services from IBM (e.g. Cloud Paks and other industrial applications such as IBM Visual Insights, IBM Production Optimization, IBM Connected Manufacturing, IBM Asset Optimization, IBM Maximo Worker Insights, and IBM Visual Inspector) will soon be available via the Red Hat marketplace (operated by IBM). Moreover, since the beginning of 2020, the IBM Edge Application Manager has also been running on Red Hat OpenShift – an autonomous management solution that allows a single administrator to manage and deploy applications (around AI, analytics, and large-scale IoT) simultaneously across 10,000 edge nodes. In May 2020, the core technology of the IBM Edge Application Manager was open-sourced by IBM as the Open Horizon software project under LF Edge (a new Linux Foundation working group). IBM believes that an open architecture is critical to a successful edge strategy – teknowlogy fully agrees. IBM, like Red Hat, is strongly committed to open source. Like Red Hat, IBM is also a Platinum member of CNCF and a strategic member of the Eclipse Foundation. Both companies have the joint ambition to drive Kubernetes, industrial IoT, and edge computing forward through the open source community.

Rancher Labs, with "Rancher", delivers an open source platform that enables organizations to deploy and manage Kubernetes at scale, on any infrastructure across the data center, the cloud, and the edge. Rancher is 100% open source, has more than 14,000 stars on GitHub, and uses its own operating system called RancherOS to run all services inside containers. In February 2019, Rancher launched a lightweight Kubernetes solution for edge and IoT scenarios called "K3s". K3s allows to run Kubernetes on x86 and ARM computers with 1GB or less of RAM; it has already gained more than 12,000 GitHub stars. In March 2020, Rancher Labs received additional funding of $40 million (Series D funding, total of $95 million) to further enhance Kubernetes for the edge, improve its go-to-market model, and build out vertical solutions. The industrial edge certainly is a top priority on its agenda for vertical solutions.

A lot is currently happening at VMware in this space. After the acquisition of Heptio, a specialist in on-premises Kubernetes, at the end of 2018, and Bitnami, an application packaging solutions provider with a large catalog of click-to-deploy applications, in May 2019, VMware also integrated Pivotal Kubernetes Service back into VMware at the end of 2019. Based on this, in early 2020, VMware launched Tanzu, its new container orchestration platform based on Kubernetes (proprietary software). One interesting element of Tanzu is the Tanzu Application Catalog (based on the Bitnami acquisition). This catalog currently does not include any industrial IoT applications, but there clearly is an option to add some in the near future – everything is in flow these days.

Canonical, the publisher of Ubuntu, provides several solutions around the industrial edge cloud, and also drives interesting initiatives around multi-cloud solutions. First, Canonical offers Charmed Kubernetes, an elastic Kubernetes distribution that can run anywhere – on bare metal, VMware infrastructure, and all major public clouds from AWS, Azure, and Google. One of the core strengths of Charmed Kubernetes is the widely respected, well-understood, and commonly deployed Ubuntu Linux distribution underneath. Charmed Kubernetes gets its name from charms, software components that drive software application lifecycle operations. Second, Canonical provides MicroK8s, a lightweight, fast, secure Kubernetes environment that runs on Linux, Windows, and MacOS. MicroK8s is CNCF-certified, and it cannot only be used for prototyping, testing, and development of microservices, but also allows to leverage Kubernetes in edge and IoT production environments. MicroK8s has already reached more than 3,750 stars on GitHub, a strong proof point for its relevance to the developer community. Third, Charmed Kubernetes and MicroK8s are fully open source-based, and Canonical can provide Enterprise support in an integrated way, for both solutions together. Fourth, Canonical already has established a footprint in industrial IoT through Ubuntu Core (embedded Linux) and major industrial partnerships with the likes of KUKA and ABB. At the beginning of 2020, Bosch Rexroth also selected Ubuntu Core for its app-based platform ctrlX AUTOMATION (teknowlogy evaluated this solution under the RADAR topic of industrial edge and rated Bosch Rexroth as “Best in Class”). ctrlX AUTOMATION leverages Ubuntu Core, designed for embedded devices, and snaps (Linux-based application containers) to deliver an open source platform for the industrial edge. This cooperation basically has the ambition to build an app store (like Canonical’s Snap Store) dedicated to industrial automation and centered around Bosch Rexroth. Partnerships like this have the clear potential to be extended to Kubernetes (MicroK8s) in the future.

SCOPE & DEFINITION

Definitions

What is the basic PAC definition of an open digital platform?

- A **digital platform** provides many digital services based on a joint technical integration layer. The digital platform provides a governance framework which ensures technical interoperability of all independent digital services. This simplifies the use of the different digital services for all users and allows them to add more and more digital services.
- An **open digital platform** extends the above concept by various different aspects:
    - Openness to add **digital services** (applications) from 3rd-party vendors – this creates an open ecosystem.
    - Openness of the **technical integration** layer to integrate different types of hardware and/or software – this is key for IoT.
    - Openness regarding the underlying source code – these platforms are based on **open source**.
    - Openness to **sharing data** with independent parties – but within a controlled environment.
    - Openness of the OT world to leverage **new concepts from the IT world** (such as containers and app stores).

What is the specific PAC definition of the different types of open digital platforms evaluated in this RADAR?

- **Open digital platforms for industrial cloud applications**: On these platforms, users can choose from a large range of different IoT applications (ultimately cloud-based and delivered in SaaS mode) provided by an open ecosystem of partners, often via an app store model.
- **Open digital platforms for the industrial edge**: These platforms introduce several modern IT concepts to the so far closed world of industrial automation. This includes Linux, the open source-based operating system, as the new basis for industrial PCs and PLCs; modern programming languages like Python, especially for analytics-related applications; container technology, to enable the simplified management of container-based applications and app stores to efficiently share code internally or even externally.
- **Open digital platforms for the industrial edge cloud**: Manufacturing companies are often looking for platform vendors that simplify the scalability of their digital transformation projects and avoid vendor lock-in. Kubernetes at the edge is a newly emerging solution for this. Kubernetes substantially simplifies the deployment and management of microservices and even allows to operate them in multi-cloud scenarios.
- **Open digital platforms for enterprise IoT**: These platforms enable large-scale IoT deployments across different industries. For this purpose, they provide highly scalable digital services to manage IoT devices, data,

and applications. These platforms are based on open source and interact openly with all kinds of IoT devices and applications.

- **Open digital platforms for IoT data exchange & monetization**: These platforms provide an app store for IoT data (often including open source data), additional digital add-on services such as data analytics, and/or a governance framework for the open sharing of this data between 3rd parties.
- **Open digital platforms for connected workers (AR)**: These platforms are open to many different HW devices (smart glasses) and provide two basic functions to clients, low-code AR application development and AR data visualization.
- **Open digital platforms for 3D printing services**: Digital marketplaces for 3D printing services orchestrate not just the open interaction of different service providers and clients, but increasingly also provide additional digital services to both sides of the market (instant quoting and design optimization services to users and MES capabilities to providers).

Segmentation of open digital platforms

How does PAC segment the provider landscape for open digital platforms?

PAC has evaluated the providers of **open digital platforms in Europe** in seven PAC INNOVATION RADAR segments dedicated to specific use cases:

How will the providers be matched to the different types of open digital platform?

Depending on their specific focus area, the providers will be positioned in one or more of seven PAC INNOVATION RADAR analyses.

Why is PAC introducing and evaluating new types of platforms?

First, from a provider perspective, PAC observes a constant stream of new types of digital platforms emerging in the market. The concept has been quickly spreading into many different areas. This is due to the fact that the underlying business model of digital platforms is highly attractive for many IT providers. Building a digital platform and establishing an ecosystem of clients and partners is a promising foundation for future growth.

Second, as the established market segments of IoT platforms grow more mature, we asked the users for their opinion. The IoT Survey 2019 is the world's first annual survey of IoT platform users, based on a sample of over 2,000 survey responses. For details on the survey, please visit https://www.iot-survey.com.

Third, the feedback from user companies is that they are increasingly looking for digital platforms which are "open" and provide additional capabilities for very specific use cases. Therefore we will frequently enhance the perspective of the PAC INNOVATION RADAR with insights from newly emerging areas in the industrial IoT context to address fast-evolving user needs. This year, we focus on edge computing, new concepts for industrial automation, 3D printing services, augmented reality (AR), open source, IoT application marketplaces, and IoT data exchange and monetization.

PAC RADAR EVALUATION METHOD

Provider selection & participation

Which providers are positioned in the PAC INNOVATION RADAR?

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.

What do providers have to do in order to be considered in a PAC INNOVATION RADAR analysis?

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.

However, in the run-up to a PAC INNOVATION RADAR analysis, providers can make sure in an indirect way that PAC can adequately evaluate their offerings and positioning – and thus their relevance – e.g. by means of regular analyst briefings, etc.

Why should providers accept the invitation to participate actively?

Whether or not a provider participates in the RADAR process does not actually affect their inclusion and positioning in the PAC INNOVATION RADAR, nor their assessment. However, there are a whole host of benefits associated with active participation:

- Participation ensures that PAC has access to the largest possible range of specific and up-to-date data as a basis for the assessment;
- Participating providers can set out their specific competencies, strengths, and weaknesses as well as their strategies and visions;
- The review process guarantees the accuracy of the assessed factors;
- The provider gets a neutral, comprehensive, and detailed view of their strengths and weaknesses as compared to the direct competition – related to a specific service in a local market;
- A positioning in the PAC INNOVATION RADAR gives the provider prominence amongst a broad readership as one of the leading players in the segment under consideration.

Considered providers by segment

Open digital platforms for industrial cloud applications	Open digital platforms for the industrial edge	Open digital platforms for the industrial edge cloud	Open digital platforms for enterprise IoT
• ADAMOS • Advantech • Amazon Web Services (AWS) • FORCAM • Microsoft • MPDV • OSIsoft • PTC • SAP • Siemens	• Beckhoff Automation • Bosch Rexroth • Controllino • KUNBUS • Mitsubishi Electric • Phoenix Contact • Siemens • WAGO	• Canonical • Edgeworx • IBM • IOTech • IoTium • Litmus Automation • Rancher Labs • Red Hat • SUSE • VMware • Wind River	• Bosch.IO • DeviceHive • DGLogik • EMQ • Eurotech • Kaa • Mainflux • MathWorks • SiteWhere • Thinger.io • ThingsBoard

Open digital platforms for IoT data exchange & monetization	Open digital platforms for connected workers (AR)	Open digital platforms for 3D printing services
• Amazon Web Services (AWS) • Caruso • Databroker • Deutsche Telekom/ T-Systems • MathWorks • Otonomo • Streamr • Terbine	• Amazon Web Services (AWS) • Atheer • DIOTA • EON Reality • Microsoft • oculavis • PTC • RE'FLEKT • Scope AR • Ubimax • Upskill	• 3D Hubs • Dassault Systèmes • Fictiv • GE Additive • Jellypipe • makexyz • PROTIQ • Siemens • Xometry

The concept

Evaluation of criteria at cluster and sub-cluster levels

Main cluster	**Competence**			**Market strength**	
Cluster	**Strategy**	**Portfolio**	**Go-to-market**	**Market position**	**Market growth**

Evaluation method

PAC uses predefined criteria to assess and compare the providers within given service segments.

The assessment is based on the report-card score within the peer group of the positioned providers.

This is based on:

- The provider's detailed self-disclosure about resources, distribution, delivery, portfolio, contract drafting, pricing, customer structure, customer references, investments, partnerships, certifications, etc.;
- If applicable, a poll among customers by PAC;
- The analysis of existing PAC databases;
- Secondary research;
- Dedicated face-to-face interviews as relevant.

The provider data is verified by PAC and any omissions are rectified based on estimates.

If the provider does not participate, the assessment is performed using the proven PAC methodology, in particular based on

- Information obtained from face-to-face interviews with the provider's representatives, analyst briefings, etc.;
- An assessment of company presentations, company reports, etc.;
- An assessment of PAC databases;
- An assessment of earlier PAC (INNOVATION) RADARs in which the provider participated;
- A poll among the provider's customers (as required) on their experiences and satisfaction.

Reissue of published RADARs

The assessments in the PAC INNOVATION RADAR represent an assessment of the providers within the given peer group in the year in which the respective PAC INNOVATION RADAR was published.

The evaluations may not be directly comparable with those of any previous version due to subsequent content modifications. In particular, they do not depict a development of individual providers over time.

Methodological and/or organizational modifications may be made due to changing market conditions and trends and may include:

- Different peer group in the focus of the analysis;
- Modification of individual criteria within clusters and sub-clusters;
- Increased or altered expectations by user companies;
- Adjustment of the weighting of individual criteria.

Evaluation criteria

Main cluster "Competence"

Sub-cluster "Strategy"

- Strategic focus on the topic
- Strategic activities over the last 12 months
- Unique selling proposition (USP)

Sub-cluster "Portfolio"

- Specific criteria for open digital platforms for industrial cloud applications:
    - Open application marketplace
    - IoT device and data management
    - Complementary service capabilities
    - Portfolio quality based on client references
- Specific criteria for open digital platforms for the industrial edge:
    - Application development and marketplace
    - Edge platform and device management
    - Complementary service capabilities
    - Portfolio quality based on client references
- Specific criteria for open digital platforms for the industrial edge cloud:
    - Edge cloud platform
    - Industrial IoT capabilities
    - Complementary service capabilities
    - Portfolio quality based on client references
- Specific criteria for open digital platforms for enterprise IoT:
    - Open source-based capabilities of the IoT platform
    - Open source-based capabilities at the edge
    - Complementary service capabilities
    - Portfolio quality based on client references
- Specific criteria for open digital platforms for IoT data exchange & monetization:
    - Total number of data sources
    - Value of data sources
    - Addressed use cases
    - Complementary service capabilities
- Specific criteria for open digital platforms for connected workers (AR):
    - Addressed industrial use cases
    - Device flexibility and HW-related interoperability
    - Application and data integration (PLM, IoT, ERP)
    - Portfolio quality based on client references

- Specific criteria for open digital platforms for 3D printing services:
  - Addressed use cases
  - Marketplace attractiveness for suppliers and buyers
  - Complementary service capabilities
  - Portfolio quality based on client references

Sub-cluster "Go-to-market"

- Business model and pricing
- Sales approach and capabilities
- Partner strategy and marketing

Main cluster "Market strength"

Sub-cluster "Market growth"

- Market perception in Europe
  - Awareness
  - Image
- Ability to grow
  - Agility
  - Momentum

Sub-cluster "Market position"

- Ecosystem leadership
  - Number and quality of partner ecosystem
  - Activities in relevant communities
- Client base and relationship in Europe
  - Client base in Europe
  - Client relationship in Europe

General PAC research method

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

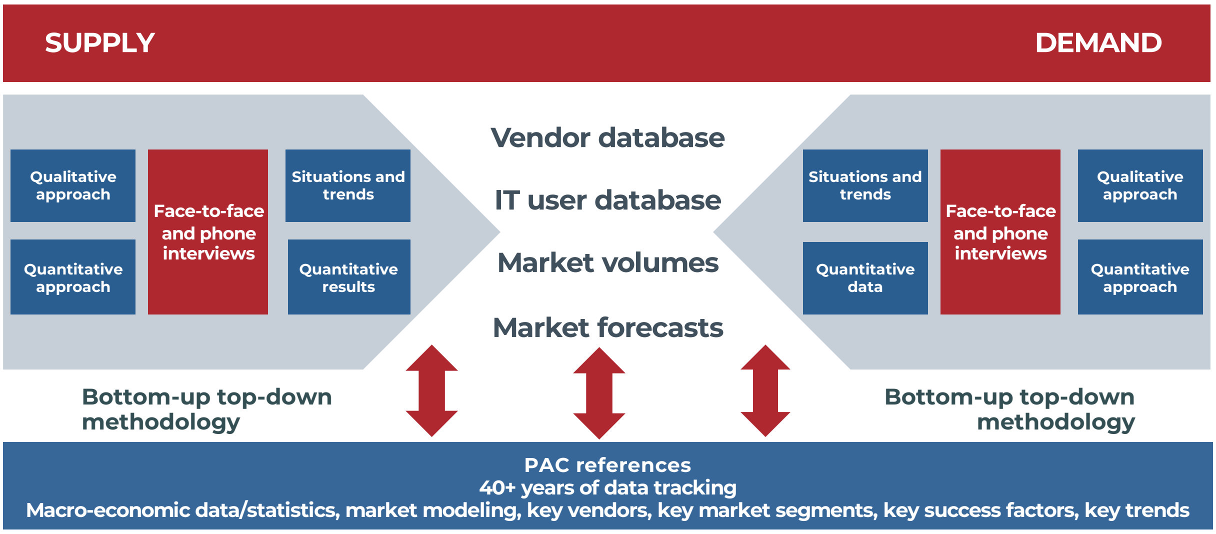

Fig. 16: Description of the PAC methodology

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 INNOVATION RADAR

Based on the scores in competence and market strength, the overall score is calculated (calculation: competence score plus market strength score, divided by two). From the resulting overall score, each provider receives their characteristic positioning within the PAC INNOVATION RADAR. Here, the following applies: The closer a provider is to the upper right corner, the closer they are to meeting customers' requirements for that segment.

The classification of providers is based on the overall score:

"Best in Class" – grade between 1 and 1.99

"Excellent" – grade between 2 and 2.99

"Strong" – grade between 3 and 3.99

"Solid" – grade between 4 and 4.99

PAC RADAR "OPEN DIGITAL PLATFORMS FOR THE INDUSTRIAL WORLD IN EUROPE 2020 – PLATFORMS FOR THE INDUSTRIAL EDGE CLOUD"

Fig. 17: PAC RADAR open digital platforms for the industrial edge cloud in Europe 2020

REVIEW OF TOP-SEEDED PROVIDER CANONICAL

Canonical

PAC RADAR Open Digital Platforms for the Industrial Edge Cloud in Europe 2020 **Excellent**

Cluster	Average	Canonical
Competence	2.29	**2.34**
Market strength	2.71	**2.43**
Total score	2.50	**2.39**

Criteria rated as significantly ABOVE AVERAGE (more than 0.5)

- Client base and relationship in Europe

Criteria rated as significantly UNDER AVERAGE (more than 0.5)

- Strategic activities in the last 12 months
- Portfolio quality based on client references

ABOUT TEKNOWLOGY GROUP

teknowlogy Group is the leading independent European research and consulting firm in the fields of digital transformation, software, and IT services. It brings together the expertise of two research and advisory firms, each with a strong history and local presence in the fragmented markets of Europe: CXP and PAC (Pierre Audoin Consultants).

We are a content-based company with strong consulting DNA. We are the preferred partner for European user companies to define IT strategy, govern teams and projects, and de-risk technology choices that drive successful business transformation.

We have a second-to-none understanding of market trends and IT users' expectations. We help software vendors and IT services companies better shape, execute and promote their own strategy in coherence with market needs and in anticipation of tomorrow's expectations.

Capitalizing on more than 40 years of experience, we are active worldwide with a network of 150 experts.

For more information, please visit www.teknowlogy.com and follow us on Twitter or LinkedIn.

ABOUT THE PAC RADAR

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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.

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