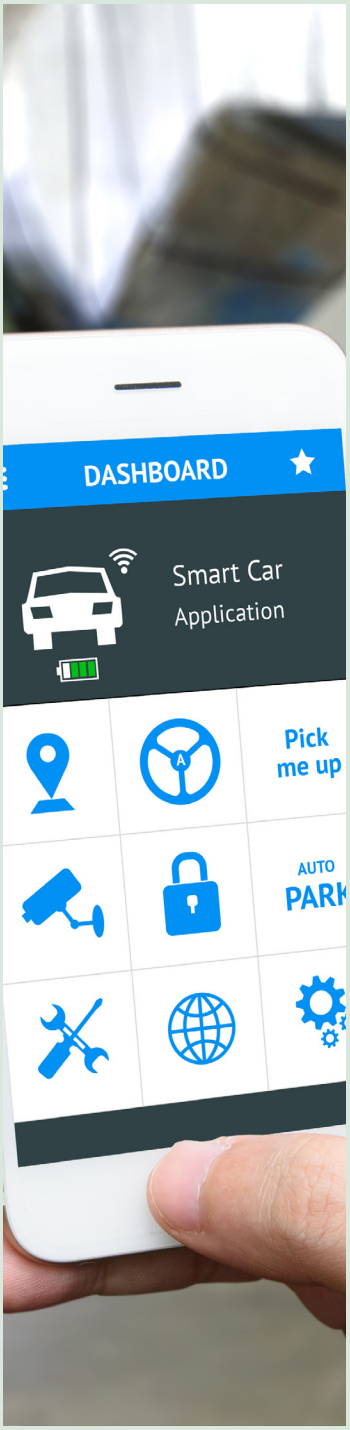
WHITE PAPER



DESPITE THE COVID-19 BUMP, OPPORTUNITIES APLENTY FOR COMMUNICATION SERVICE PROVIDERS IN INTERNET OF THINGS

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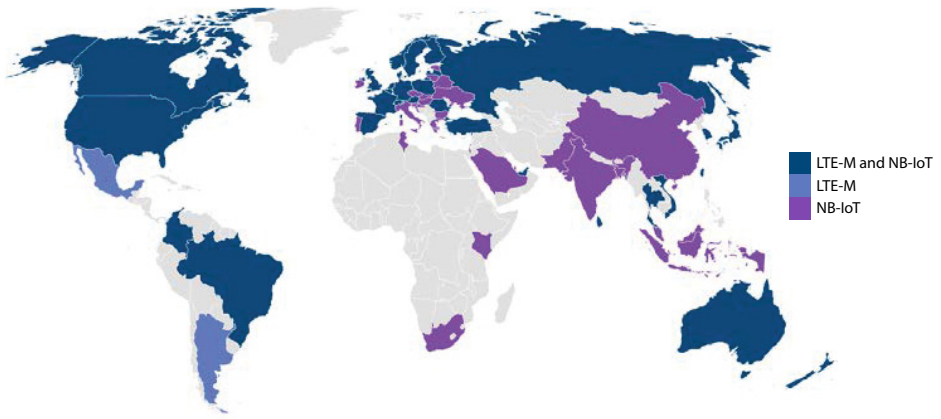
The concept of interconnectedness is not a recent one. The precursor to the Internet of Things (IoT), in its current avatar, were industrial control systems designed to automate and control the production lines on factory floors. Devices powered by 2G connectivity were the earliest and the most common use cases for IoT. The advent of high data rates, low latency & narrowband connectivity options coupled with advancement in hardware technology has thrown open a plethora of use cases and piqued the interest of consumers, communication service providers (CSPs), software vendors & the technology community. Devices powered by Bluetooth Low Energy (BLE) are cost-efficient with low power consumption and are opening newer areas such as contact tracing and improving the energy efficiency of buildings.

Covid-19 dampener but the market is still huge

By the end of 2020, it was expected that 31 billion IoT devices would be operational. However, recent reports suggest that a slowdown in IoT deployments is expected in the near term due to the Covid-19 pandemic. Notwithstanding, revenues are still expected to triple by 2025 and touch $900 billion albeit this projection has been lowered by $200 billion from initial estimates. The impact would be most felt in implementations in Smart City, Automobile, and Utility sectors [1]. This decline is a mere aberration, a speeding ticket, on an otherwise rapid growth trajectory. As the rollout of 5G networks picks up pace, acceleration in the adoption of IoT is expected. Though it is not the only network choice, 5G would be the cornerstone and a massive enabler for future IoT implementations. By the end of December'20, 3GPP compatible technologies like NB-IoT and LTE-M have been deployed by 128 operators across 62 countries with many more continuing to invest [2]. 5G, by its very characteristics, is tailor-made for IoT adoption with high data rates, low latency, and wider bandwidth, and the ability to empower edge devices. Time-sensitive services will receive a major boost with 5G deployments. The 5G IoT market, alone, is estimated to be worth $6.3 billion by 2025 [3].



Source: GSA, Dec 2020

Figure 1: NB-IoT and LTE-M Deployments

Role of CSPs beyond connectivity

To address this considerable market and monetize this IoT opportunity, CSPs must decide on the role they would like to play. The returns would be directly proportional to the scope of work undertaken and the investments they would like to make. They have few options. At the most fundamental level, it would be incumbent upon the CSPs to provide the connectivity. However, by GSMA estimates, this would only account for 5% of the revenue opportunity [4]. Also, connectivity alone is likely to be commoditized if CSPs don't innovate on the network and provide some value add. Emerging connectivity concepts such as Connectivity-as-a-Service (CaaS) [5] will provide the necessary value add to enterprises to meet specific needs and be an additional source of revenue for CSPs.

Secondly, to move up the value chain and corner more revenue, they are also making inroads in the IoT platforms market by providing customers with platforms that would help them manage their devices & data, provide built-in security and develop consumer applications with a quick turnaround thereby ensuring quicker time to market. Platforms along with applications and services would account for 67% of the revenue opportunity and should be of considerable interest to CSPs. This, in turn, would mean CSPs must build the platform which could then also be built into an end-to-end offering. We will look at IoT platforms in more detail in the next section and see how CSPs can leverage platforms to build a solution that would be mutually beneficial to them and their customers.

Lastly, as mentioned earlier, they have also ventured into building bespoke industry-specific end-to-end solutions and associated services [6][7][8][9][10]. This involves CSPs packaging the hardware, services, and operations, along with the connectivity,

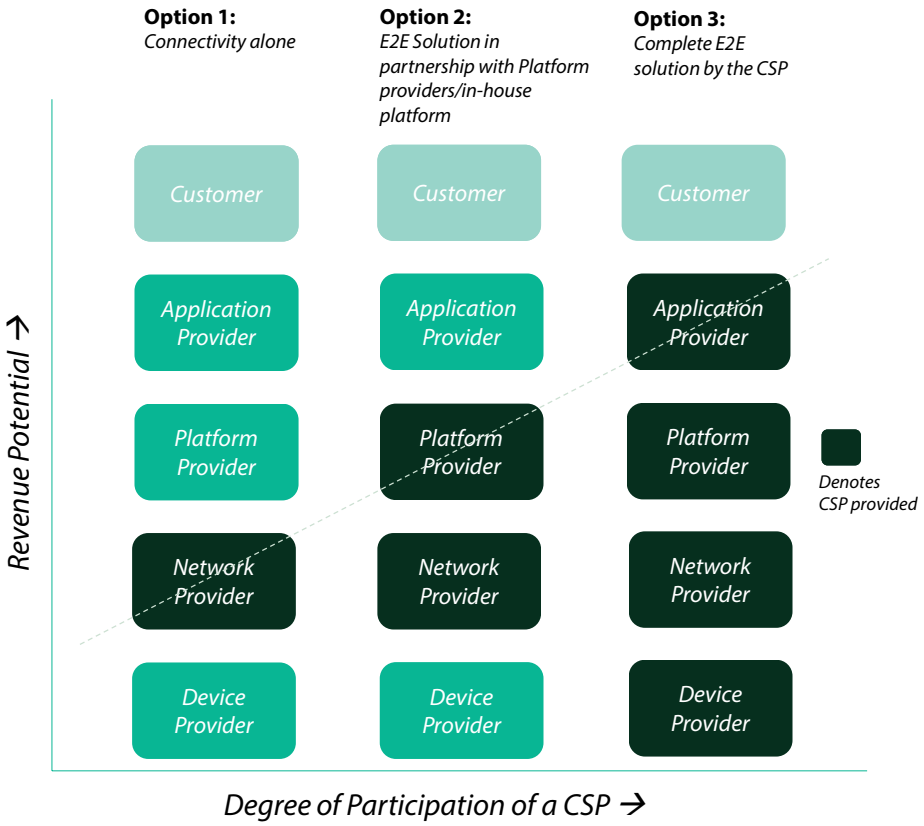


Figure 2: IoT Business Models

into an end-to-end service. It involves an element of risk as CSPs would have to build expertise within or augment their capabilities, by acquisitions or through agreements with vendors, to build an offering. They would then own this end-to-end offering and would have to bill for their services. Naturally, the uptake of these bespoke solutions should recoup the investments made towards developing them to justify this approach.

So, what would be the best course of action for a CSP to garner a larger share of the revenue pie beyond being the connectivity provider? We have briefly touched upon the pros and cons of each approach and CSPs must decide on the role they want to play in the larger IoT ecosystem. It is a pertinent argument made that CSPs should drive building an IoT ecosystem by partnering with platform providers or offering the platform capabilities rather than adopting a Do-it-yourself (DIY) approach, providing an end-to-end solution from devices to consumer applications [11].

Given how an IoT solution revolves heavily around a platform and the increasing revenue CSPs stand to make by providing the platform or by building an end-to-end solution, it is critical to understand the IoT platform better. To this end, let us look at IoT platforms, their capabilities, and the role they play in IoT solution development. We will also look at some of the offerings of leading vendors who are poised to make it big in this space (see Table1).

IoT Platforms: Spoilt for choice but the 'choice' is critical

An IoT platform is an amalgamation of features that enables the creation of an end-to-end IoT solution by connecting the devices, i.e. the things, collecting data, promoting information exchange, and deriving insights. To that end, IoT platforms perform a multitude of allied functions – managing the devices, providing application development capabilities, acting as a data store, ensuring security, to name a few. Platforms form the core of any IoT solution and as a result, there has been a proliferation of platforms in the market. As per IoT Analytics [12], there are more than 600+ platforms in the market today. It is estimated that the platform's market would be worth $6.1 billion by the end of 2026 [13]. Hyperscalers AWS, Microsoft Azure, and IBM are some of the key players in this fragmented market [14] and are continuing to augment their capabilities with massive investments and acquisitions.

IoT platforms offer a shorter application development lifecycle with a host of Out-of-the-box solutions. Security is built-in by design with encryption algorithms, certificates, and authentication & authorization protocols. They cater to a wide range of devices and communication protocols and are easily scalable making the solution future-proof. Therefore, they considerably reduce the pain points of building a custom solution.

Platform Capabilities

The following are key platform capabilities that should be under consideration while trying to zero in on a platform.

Device Management: Commissioning & de-commissioning of devices, Over-the-air (OTA) updates, Lifecycle management, device logging

Security: Authentication of devices, encryption of the data flow, single sign-on (SSO) feature for dashboards, network security

Connectivity: Support multiple connectivity protocols like MQTT, AMQP, HTTP, and multi-network connectivity like 5G, NB-IoT, LTE-M, C-V2X, Satellite, Broadband

Application enablement: Provide APIs and SDKs to enable plug-and-play, digital twin, drag-and-drop feature for customized dashboards, rule-based events and alerts, integration with open source solutions

Edge Deployment: Building intelligence on the edge for quick decisions or where humongous amounts of data are generated

Data Storage: Provide data connectors for storing historical data and data processing capabilities for transient data

Platform capabilities like Digital Twins and Device Shadow allow users to represent the physical world digitally. This opens myriad possibilities to run simulations, generate insights, and fine-tune the solution to a business problem even before the actual deployment of devices.

IoT Platform Vendor Offerings

With the plethora of IoT platforms available in the market, it is imperative to understand their built-in capabilities. The following table lists the services and features available of a few leading IoT platforms. All these platforms score high on user-centricity and technology implementation. AWS IoT was highly regarded for Analytics and Device Management as well as general usability. Microsoft Azure IoT scored well on security aspects. PTC ThingWorx supported manufacturing use cases particularly well [15].

Feature	AWS	Azure	IBM Watson	PTC ThingWorx
IoT Core/Hub	Connectivity, Business Rules/Alerts, Device Shadow	Connectivity, Device Twin, Data Connectors	Connectivity, Blockchain	Connectivity
Protocols	MQTT, HTTP, WebSockets	MQTT, HTTP, AMQP	MQTT, HTTP	ThingWorx Communication Protocol
Device Management	Bulk Registration, OTA Updates, Configuration & Control, Contextual Device Management powered by AWS *IoT Device Management*[1]	Bulk Registration, OTA Updates, Monitoring & Diagnostics, Configuration & Control	Bulk Registration, OTA Updates, Monitoring & Diagnostics	ThingWorx Utilities
Application Development	AWS IoT SDKs	Visual Studio	IBM Bluemix	ThingWorx Composer
Visualisation	Interactive dashboards using *QuickSight,* visualise logs using *Elasticsearch*	Azure App Service, Power BI, Azure Time Series Insights	Watson IoT Platform	ThingWorx Product Relationship Manager
AI/ML Capability	Build & Deploy ML models using *SageMaker*	*Azure Machine Learning*	Watson Analytics	ThingWorx Analytics Server
Security	Audit, Rules & Alerts using *Device Defender,* X.509, SigV4, Token based	X.509, SAS Token based	IAM OAuth	IAM through SSO, TLS encrypted communication
Data Storage	Amazon S3, DynamoDB	CosmosDB, SQL DB, Cassandra	IBM Cloudant NoSQL, DB2 Warehouse	Postgre SQL, Cassandra
Edge Intelligence	FreeRTOS, IoT GreenGrass	*Azure IoT Edge*	Edge Application Manager	ThingWorx Edge MicroServer
AR/VR		Hololens		Vuforia Studio Suite, Hololens Support

Table 1: Platform Features *Source: Company Websites.*

While each of these platforms provides generic capabilities, they have their strengths in specific features. Some are more geared towards specific industries than others. A case in point being PTC ThingWorx which has seen a lot of traction in the Industrial Automation space.

[1]*Italics* denote allied Service Offerings

Proposed IoT Platform Functional Model

Given the number of platforms available in the market, it is a cumbersome process to zero in on one that suits the needs of the enterprise. There is no one size fits all approach to this. Rather, it is driven by a combination of key factors keeping in mind the solution to be built.

Food for Thought

How many devices does the solution require?

Onboarding devices should be quick and simple if we require hundreds and are likely to grow rapidly.

What are the communication protocols supported?

Lightweight communication protocols like MQTT are preferred but devices could also require COAP or HTTP to be supported.

What are the network connectivity requirements?

There is a patchwork of network connectivity options available today. While 3GPP technologies are backward compatible, there are proprietary non-3GPP connectivity options available such as LoRa and Sigfox. The platform should be able to handle these connectivity options to be future-proof.

LPWAN (Low power wide area network) technologies like Sigfox & LoRa especially lend themselves well to M2M (Machine-to-Machine) applications. They considerably reduce network complexities associated with setting up a typical wireless network.

3GPP	Non 3GPP
• 5G • 4G/LTE • LTE-M • NB-IoT • C-V2X	• SigFox • LoRa • Weightless

Do we need Edge capabilities?

Value is moving from the cloud to the edge [16]. The platform should be able to support edge deployments for time-sensitive use cases such as robotic surgery.

What are the visualization capabilities required?

Dashboards should be intuitive, interactive, and easily accessible. Certain platforms allow mashups/drag and drop features to quickly build dashboards.

What are the data privacy requirements? Are there regulations around the localization of data?

With laws enacted to protect the use and transfer of data, it is of utmost importance to understand where the data resides and the ownership. Platform orchestrates the data collected from devices and they may be stored locally in a data center or may be transferred outside of the geographical boundary.

Does it support other platforms or platforms with niche capabilities?

The platform should make available APIs that would make it easier to integrate with other platforms providing niche capabilities. This would enable the enterprise to choose services that are fit for purpose as opposed to a walled garden ecosystem.

The above is not an exhaustive but a representative list of questions that businesses need to answer while selecting an IoT platform. Similar questions can be posited on pricing models, scalability, data storage requirements, and security. A functional view is presented based on these parameters to act as an enabler for businesses to make informed choices in selecting an IoT platform.

This can be used as a guideline to structure the thought process of making a platform selection around the capabilities offered by platform vendors. It is meant as a conversation starter for an enterprise to evaluate an IoT platform from different perspectives. Given the importance that an IoT platform plays in building an IoT end-to-end solution, businesses must make the platform selection purposefully and with thoughtful consideration. It should not only meet their current needs but should also be scalable to meet future demands. By design, platforms are optimized to work with a wide range of devices and technology with built-in security and flexible pricing models.

Security What is the level of security required by the enterprise? What are the data privacy requirements?	**Pricing Model** Does the platform support Pay-as-you-go/Subscription model/Outright purchase? What features are supported on the base tier and the price of an upgrade?
	Deployment Do we need to deploy on premise/cloud? Does it support the Edge?
	Data Visualisation What are the visualisation capabilities required?
	Data Storage What are the storage requirements? Are connectors available to Open Source data storage solutions?
	Connectivity What network connectivity does the platform need to support? What communication protocols are supported for device connectivity?
	Devices What is the ease of connecting devices? What are the device management capabilities required?

Figure 3: IoT Platform Functional View

Conclusion

Platforms are only one piece of the jigsaw puzzle that is an IoT end-to-end solution. An IoT solution comprises sensors, actuators, devices, applications on the cloud, and databases. There could be more. The platform, also sometimes called the Middleware, brings these disparate components together, by facilitating the data exchange, to create a holistic solution. With several actors required to realize the solution i.e. Original Equipment Manufacturer(s) (OEMs), Cloud platform providers, System integrators, Software Vendors, Connectivity partners to name a few, CSPs should endeavor to facilitate building these solutions with the partner network. Instead of doing the heavy lifting all by themselves, it would be more prudent to spread the risk. A more collaborative approach of working with customers and by bringing in the partner network would lead to the quicker rollout of solutions while also ironing out any difficulties by the experience the partner would bring to the table. This would allow CSPs to play to their strength and provide greater flexibility to consumers to pick and choose their services.

This would also free up CSPs to innovate on networks and make the necessary investments in 5G. Network slicing and Network-as-a-Service (NaaS) are inherent capabilities that CSPs would look to exploit shortly especially with commercial 5G deployments picking up pace. Connectivity-as-a-Service (CaaS) and private 5G networks are some of the new service lines that CSPs may want to innovate on that are more aligned with their core competency. These services would play a critical role in the true realization of an IoT solution given the advancement of these network connectivity options. High data rates, low latency, and wider coverage coupled with low-powered devices being integral to the solution.

However, it should be noted that Tier-1 operators will continue to make investments in turnkey vertical solutions to garner a larger chunk of the revenue pie. But not all operators will have the appetite or the deep pockets to make this choice. That doesn't mean that the rest must fall behind and not be able to dip into the revenue opportunity. IoT is a big opportunity for growth and operators should be smart to leverage their partner network and collaborate with customers to build IoT solutions.

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