Connected Factory as a Service helps better control of OPEX

In this whitepaper, we discuss the concept of how wireless sensors/IT/OT/mobility convergence is addressing some of the challenges in digital domain while reducing the OPEX and circumventing major technology turnover. In first section, all the four essential components with their ensuing benefits are introduced. In subsequent sections, their role is discussed in detail along with the emerging trends. In conclusion, a synergistic collaboration of components is drawn along-with a suggested business model to showcase a better control on the OPEX.

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1. Introduction

There are four essential components to a solution in IIoT paradigm. Any asset in question needs

- Connectivity (wired or wireless)
- a bunch of sensors, gateways, devices (along with OT components like SCADA, Control systems and HMIs). Let's call this gamut of sensors, gateways and devices as SGD and refer to OT components as OT.
- IT Infrastructure (to run different apps and platforms)
- Dashboards and Mobile Apps

Together, these 4 components can be referred to as Connected Asset as a service. In Phygital (a combination of Physical + Digital) world, these four components form the basis of decision enablement with the stakeholders.

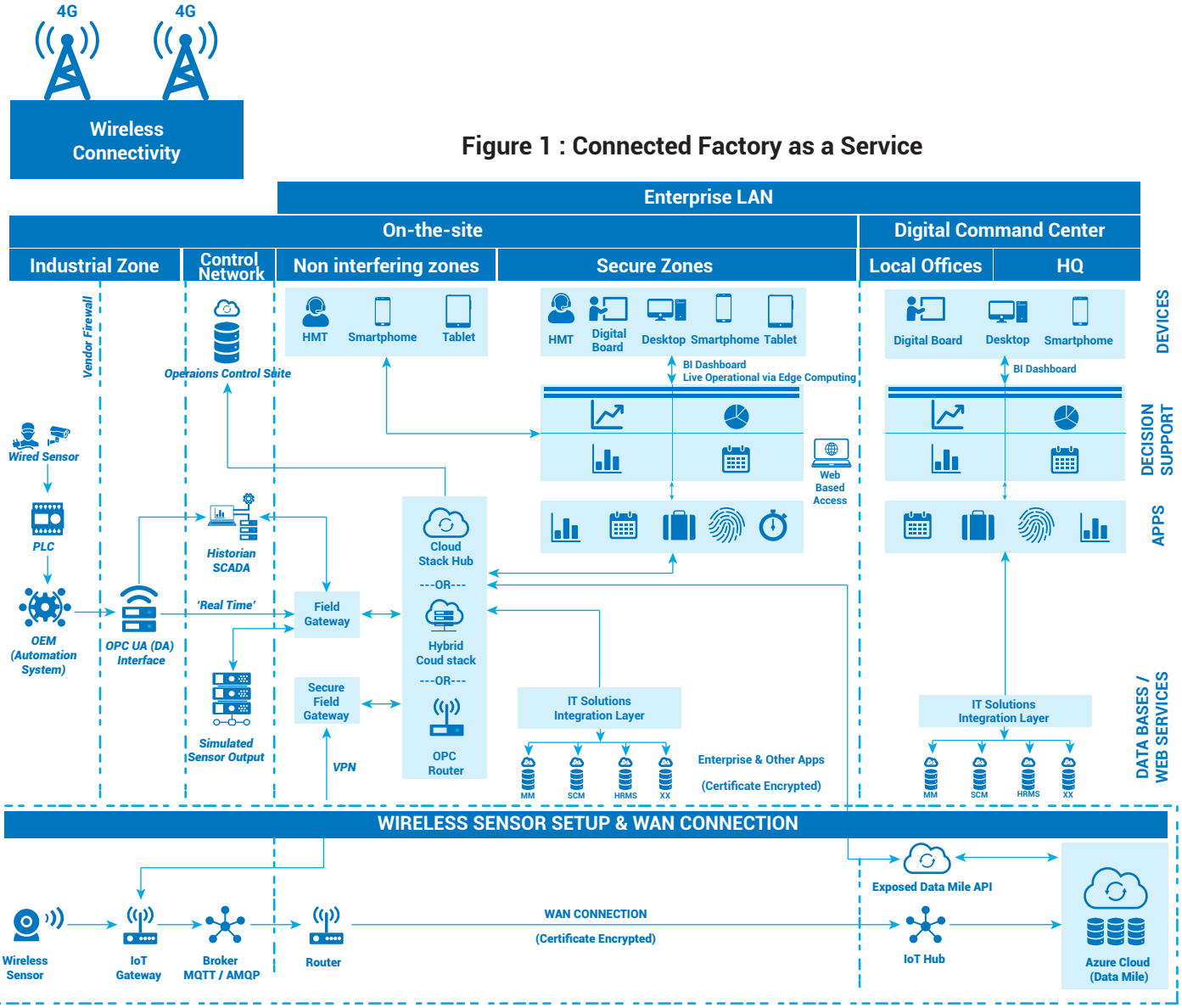
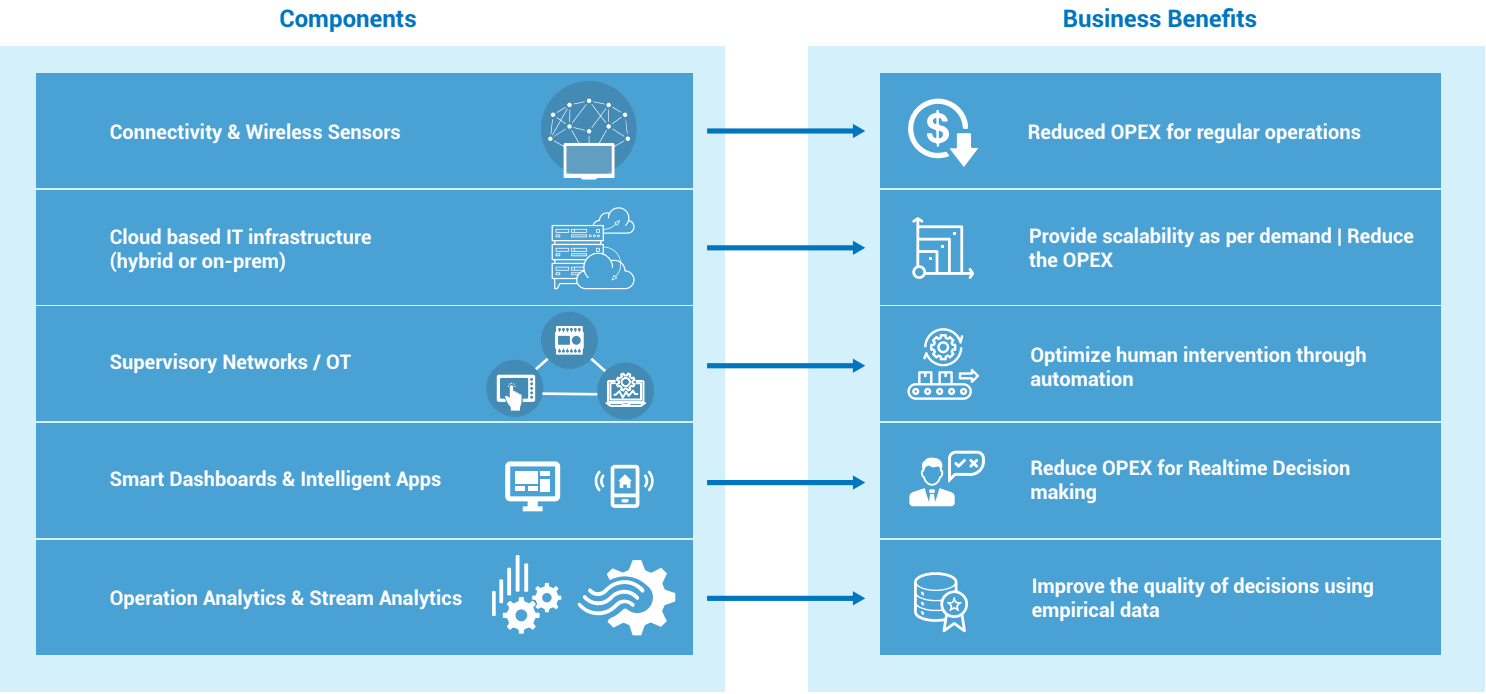


Figure 1 : Connected Factory as a Service

While the data-based decision-making is on the rise, it is imperative to note that accuracy of decision making is one of the most significant factors in this play. Analytics and AI / ML are therefore embedded into decision enablement through smart dashboards and intelligent apps. In this paper, we will discuss only the decision enablement through these components and how the entire solution can be offered as a service so that the IIoT project becomes RoI positive within the first year itself.

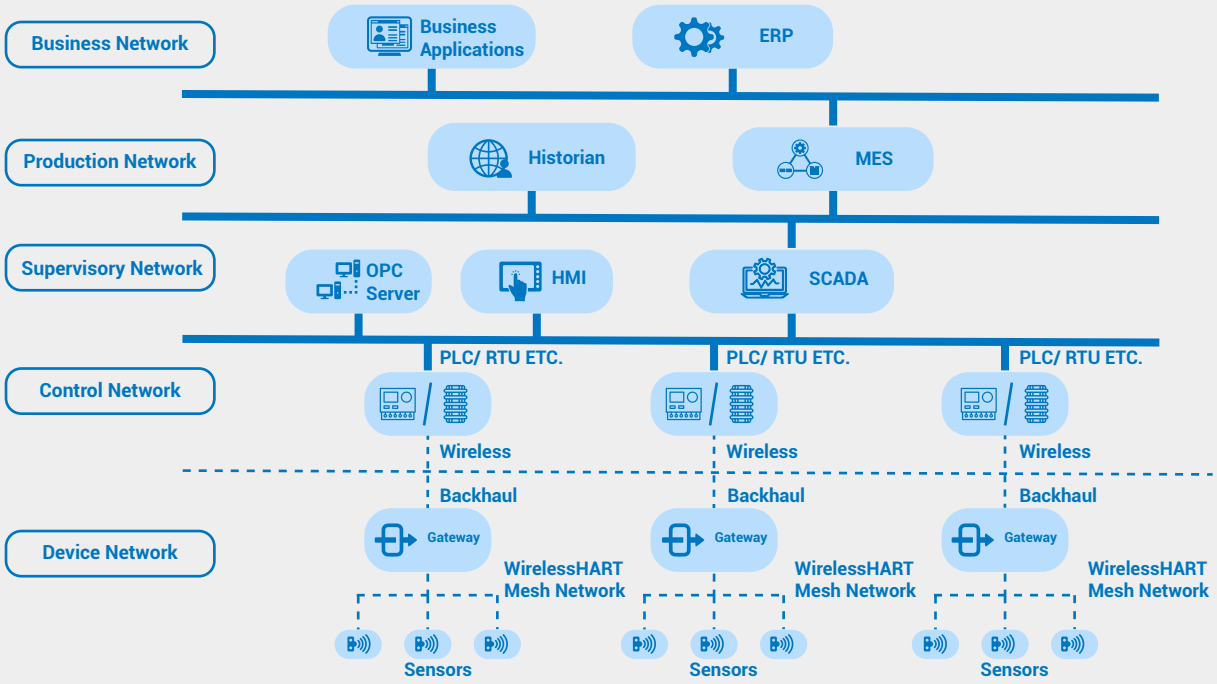
2. What is the value proposition / driver for such a concept?

The primary driver of a connected factory is to stimulate accrual of efficiencies throughout the plant that will help cut down the OPEX and deliver tangible benefits to the bottom line of the plant. Here's a brief summary of the benefits of all the components including analytics.



As you will notice, the common theme across the components is OPEX. Individually, all components will function into delivering a better OPEX. Eventually, it depends on how the business model ties all the components towards delivering the overall benefit.

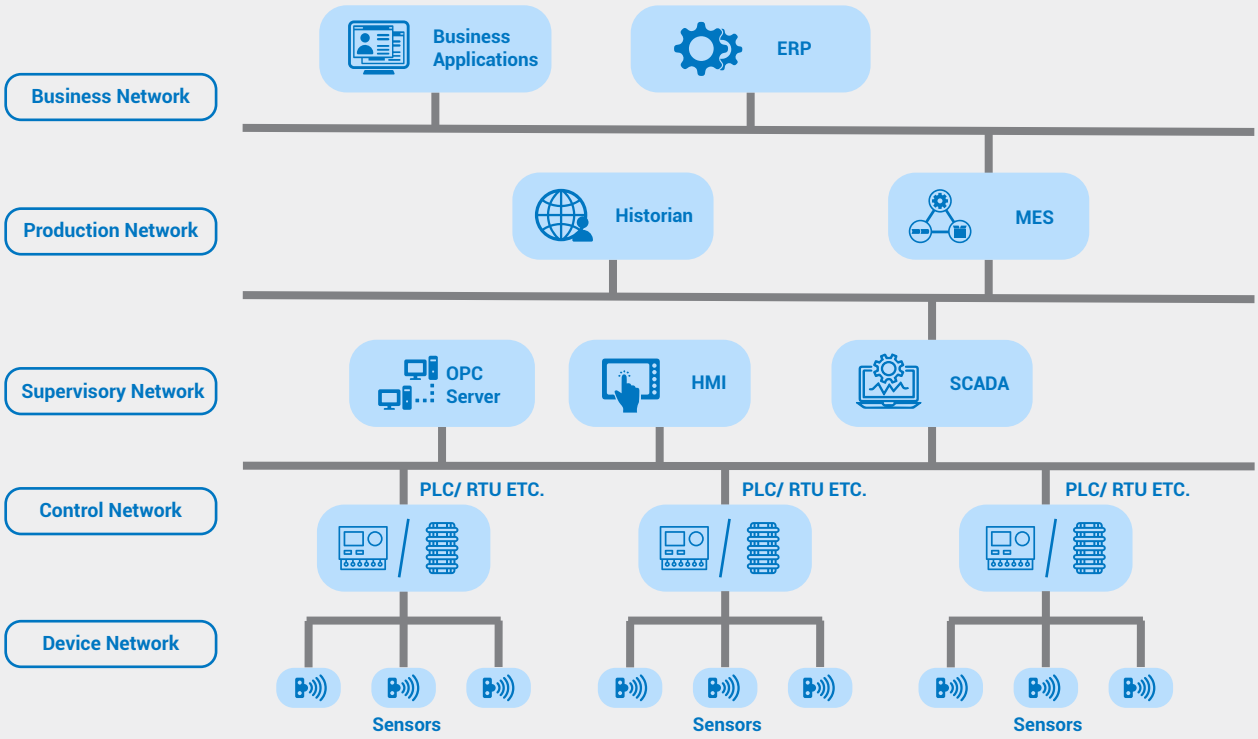
Figure 2: A standard implementation of a connected asset / equipment would typically be like graphic below:



2.1 What is the need of such a concept to emerge? Was the benefit not delivered with manual processes and existing OT?

Emergence of Cloud has been a kick-starter to the concept of having a better control on OPEX. If a manufacturer needed a better output, the major constraint to automation would be the IT layer. One would have to answer questions like: How much storage do I need? Is there a business case for such an investment into more servers, network storages, switches and architecture? With multitude of apps, do I need to also invest in integration layers or a need-based investment towards point to point data integration will suffice? What will I do with such IT/OT infrastructure if the demand of the product scales up or down? Cloud-based architectures have addressed these requirements very well. Most of these requirements (e.g. IaaS, PaaS, iPaaS) can be delivered through an optimal combination of cloud and EDGE.

Figure 3: Wired SGD systems and Wireless SGD systems



Wireless SGD systems (with their ever-improving reliability in industry) have posed a serious threat to the expensive wired sensors industry. OT players do not share their IP and thrive with premium pricing on basis of proprietary protocols for communications with OT systems. Cloud based decision enablement systems bypass the proprietary standards and deliver same value with wireless SGD with the objective still being to deliver the data onto the cloud running on 4G / LTE type of connectivity. Wired sensor systems connect to the wireless networks through digital gateways and last mile connectivity is usually ethernet. LoRa / SigFox / Zigbee / Wireless-HART and proprietary protocols using radio waves spectrum for local connectivity to sensors is also gaining popularity within the industry.

3. Components of IIoT Paradigm

Let us now look at how each of the components combine in detail and what are the latest trends in each segment that can help improve the bottom line of the plant.

3.1 Connectivity:

Comparison of WiFi to 4G / LTE

For large scale plants, WiFi based connectivity may not be enough, particularly for hazardous environments where WiFi APs have to be covered in ATEX casings. In such cases, 4G / LTE based inward facing antennas (ATEX certified) are recommended for complete coverage.

Pragmatically, 4G/LTE internal coverage of an asset / factory does not compare to the likes of Mesh Wi-Fi APs. A single 4G antenna can provide close to 80% of coverage easily in uninhibited line of sight. With 2 antennas, even the remotest of locations within a factory can be covered (up to 99% coverage). Mesh-WiFi may provide sufficient coverage but the bandwidth will break down so as to not support use cases.

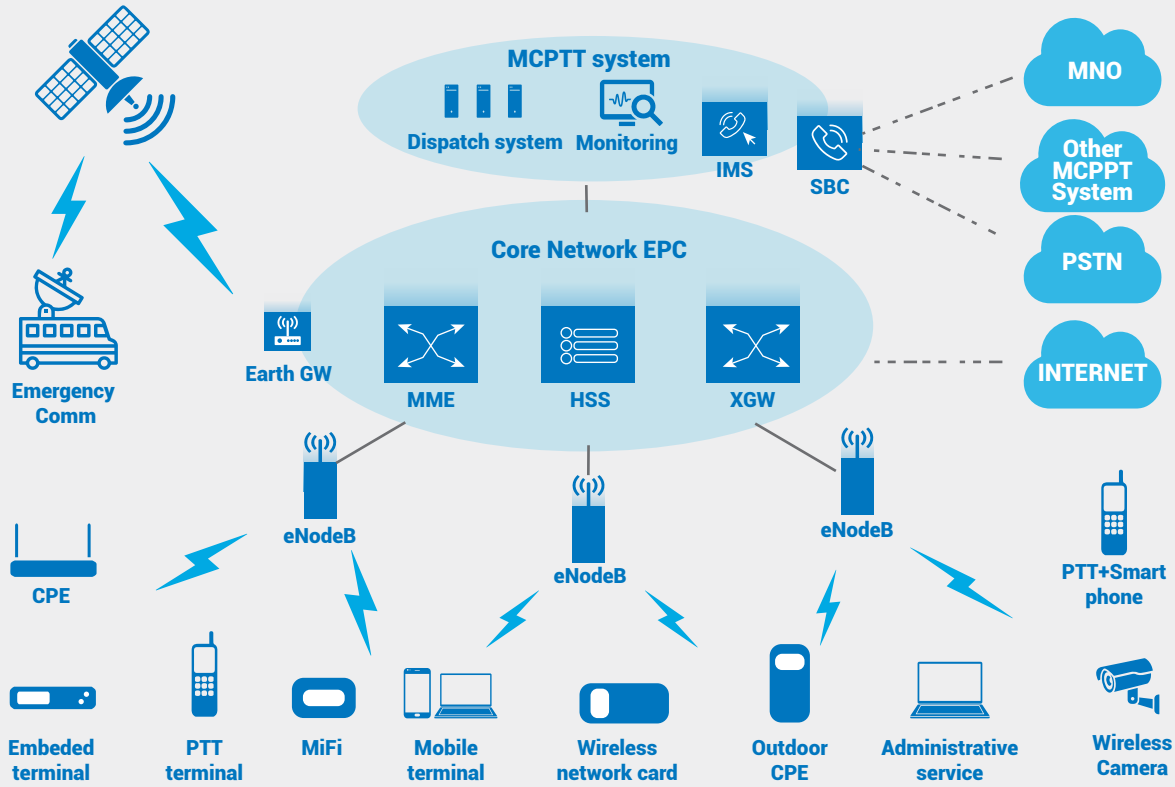
Some of the most common Use Cases for connectivity comparison can be:

a. Calling on Teams / VoIP
b. Push to Talk (radio as backhaul)
c. Connecting all wireless sensors, gateways and devices
d. All apps on devices are performing as per expectations

Independent Mobile infrastructure

A Wi-Fi like solution that can provide an independent 4G / LTE network to the plant is called a breakout solution using 4G spectrum. This solution is useful when the plant must work in island mode disconnected from the world. vEPC solutions have become popular because of their capability to virtualize the mobile infrastructure hardware requirements on IT infrastructure (x86 or Cloud). Cloud providers looking to benefit from IT / OT convergence are investing to build this capability as well.

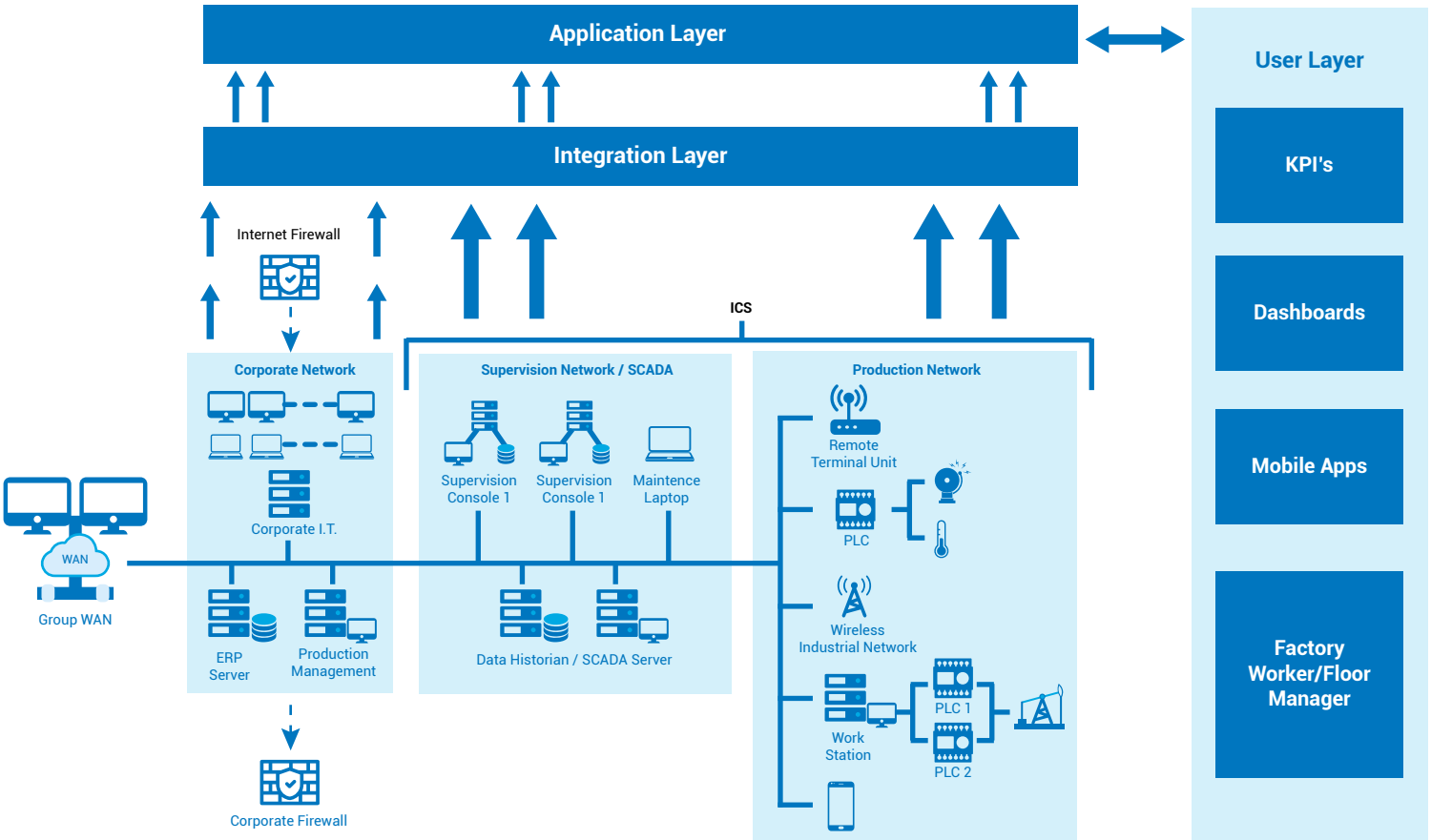
Figure 4: v-EPC and EPC and connectivity Infrastructure with WiFi



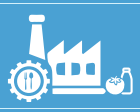
3.2 Sensors / OT / Gateways / Devices / Protocols

Following diagram is a logical representation of how data moves from the source to the User layer. However, the user layer is expected to be as close as possible to business, hence the emergence of EDGE devices. Figure 7 elaborates on how EDGE devices placed close to business can expedite decision making and data need not go to the cloud for processing. With the improving speed of microprocessors, the devices with as low as 4GB RAM have been found to be useful in industrial environments.

Figure 5: Following is an indicative diagram of how Wireless and backhaul connections work together to deliver the data on the cloud.



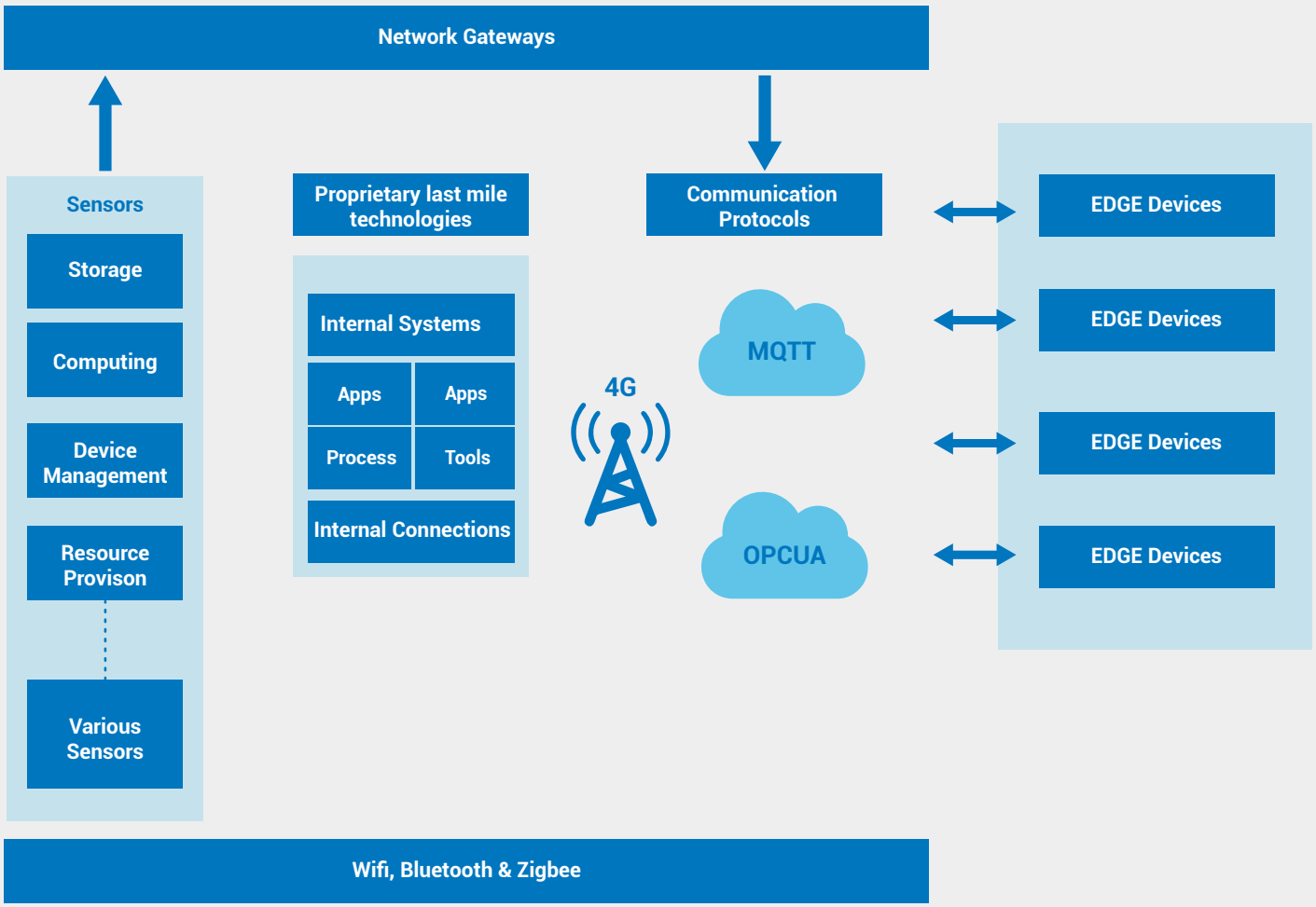
Some of the most common applications of converging sensors + OT exist in

Manufacturing	
Power Plants	
Pharma	
Food and Beverages industry	
Oil and Gas industry	

It is also understood that factories of today have MES and other ERP system software that help to ensure decision making is expedited with minimal human intervention. Examples galore, all of these systems could be based on different technologies that don't talk to each other (they were made by different people). Last mile proprietary technologies or communication protocols complicate the data transfer and usage. Hence, a simple protocol converter that translates all the data into a comprehensible format is necessary for any modern solution architecture. Sensors, Network Gateways prefer OPC-UA or MQTT protocols for transfer of data.

In order to automate a simple orchestrated workflow, the data has to be exposed through APIs to an integration layer that helps move the structured and unstructured data as per the automation workflow. Structured data could be something like (Employee id, Name, time of Entry etc.) ie. anything that can be put into tables as rows and columns and unstructured data could be something like pictures or sound files used for condition monitoring of the equipment. EDGE devices could talk to sensors (or sources of data via an e-sim like a network gateway) via an interface that takes a URL or an IP address to search for the device. The mishmash of all applications needs to necessarily have a device management layer for all sensors and mobile devices. Typically, device management layer is expected to have functionalities to include sensors and gateways. Mobile Device management platforms are different from sensor device management layer given the fact that data frequency and protocols are different for them. Device management layers sit within the cloud or the on-prem infrastructure. Following figure showcases a logical representation of how EDGE devices can connect to network gateways or sensors alike for the decisions to be made close to business. MQTT typically travels on TCP/IP protocol and helps queuing of the data received from multiple sensors. The application on the network gateway will typically be a broker collecting messages and queuing them before they are transmitted to the data store / cloud.

Figure 6: EDGE devices with communication protocols in detail and data integration view



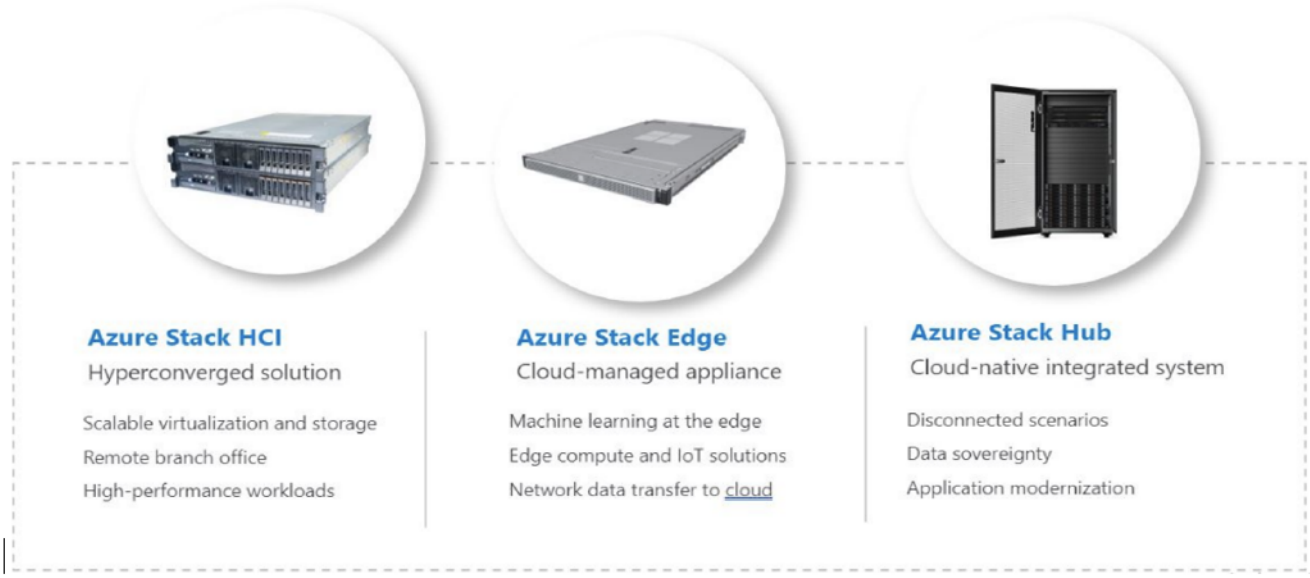
3.3 Infrastructure

Cloud has been a significant component affecting the control of OPEX. However, the manufacturers (or operators) are still reluctant to share their data outside their boundaries. Most of the cloud vendors have started providing IoT services and event management service on cloud that help communicate with sensors and gateways on standardized protocols (like OPC-UA or MQTT) or through brokers (e.g. MQTT brokers). The on-prem versions of cloud infra provide same experience and benefits to users as those provided by enterprise cloud. IoT services and event detection services are some of the key components required on cloud (on-prem or hybrid) so as to make IIoT solutions successful.

Some of the questions with respect to IT infrastructure must include the following considerations.

a. Do the devices have a high-end capability to ensure AI models can be run at EDGE for hyper local results?
b. Do you need to run AI models / analytics in the cloud or will they run at level of EDGE?
c. How many VMs and Servers are required on-Prem for work to be done efficiently?
d. Is the network architecture clear enough to decide which apps / devices will sit in different industrial / production / OT layers?

Based on the answers to questions above, one can choose an appropriate version of the on-prem / hybrid cloud solution. E.g. if the plant is going to be disconnected from outer world for a month (many times a year), then a Stack Hub with IIoT services of Azure would be the best solution. If synchronization with enterprise cloud is important and EDGE computing is required, then a careful selection of services and alternate solutions to run on EDGE devices need to be readied. This choice of solution can be constrained through a tight budget and hence allows the operator to control the OPEX as per demand.



Source : Microsoft

Some of the common use cases of EDGE computing include:

- Running AI models on the EDGE devices to deliver the best possible image quality
- Running analytics engine on the device for an optimal output

3.4 Intelligent Apps and Smart Dashboards

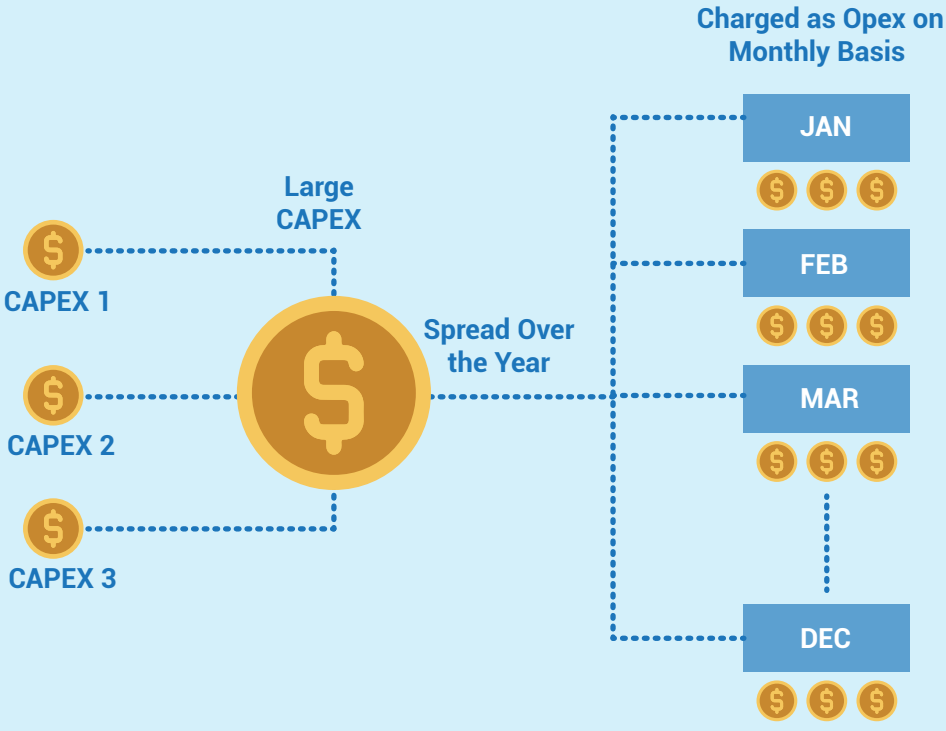
As you have seen in earlier sections that the main objective of IIoT is to ensure data reaches the cloud and devices. This data can now easily be pulled into the devices (through cellular connectivity) or Digital Command Center Dashboards (offsite decision making) or dashboards at the plant level. It is imperative that automation of the work-flows amongst the apps is the key driver of quick and reliable decision making.

Another significant challenge is improving the reliability and trust of the KPIs. There are enough alarms beeping at the plants because some business rule has been violated. Analytics should be able to remove false positives and assist human decision making meaningfully.

In context of decision enablement and automation of workflows, some of the critical questions to discuss here would be:

- Are there too many apps with enough APIs exposed so that data integration is one of the problems to be solved within the cloud? This could mean that you must create an integration layer for the apps in the cloud so that wasteful point to point interaction / integration of apps can be avoided. iPaaS achieved through established solutions like LogicApps, WSO2, BizTalk, Dell Boomi etc. is yet to achieve maturity on cloud systems.
- Have you optimized the number of KPIs on the smart dashboards?

Figure 7: CAPEX to OPEX (EMI concept)



4. What is As-a-service concept?

The idea here is to recreate a business model that avoids heavy upfront investments or technology turn-overs and utilization of technology is completely based on demand.

e.g. if there are wired sensors existing and functional, then can the partner identify why is the data stranded and not reaching the cloud? It could be a problem of "stranded" data wherein only a digital gateway solution is required for decision enablement that can be ***charged as a monthly support service*** as against a technology turnover solution like replacing all the wired sensors to wireless sensors working on cellular connectivity technology like CAT-M1.

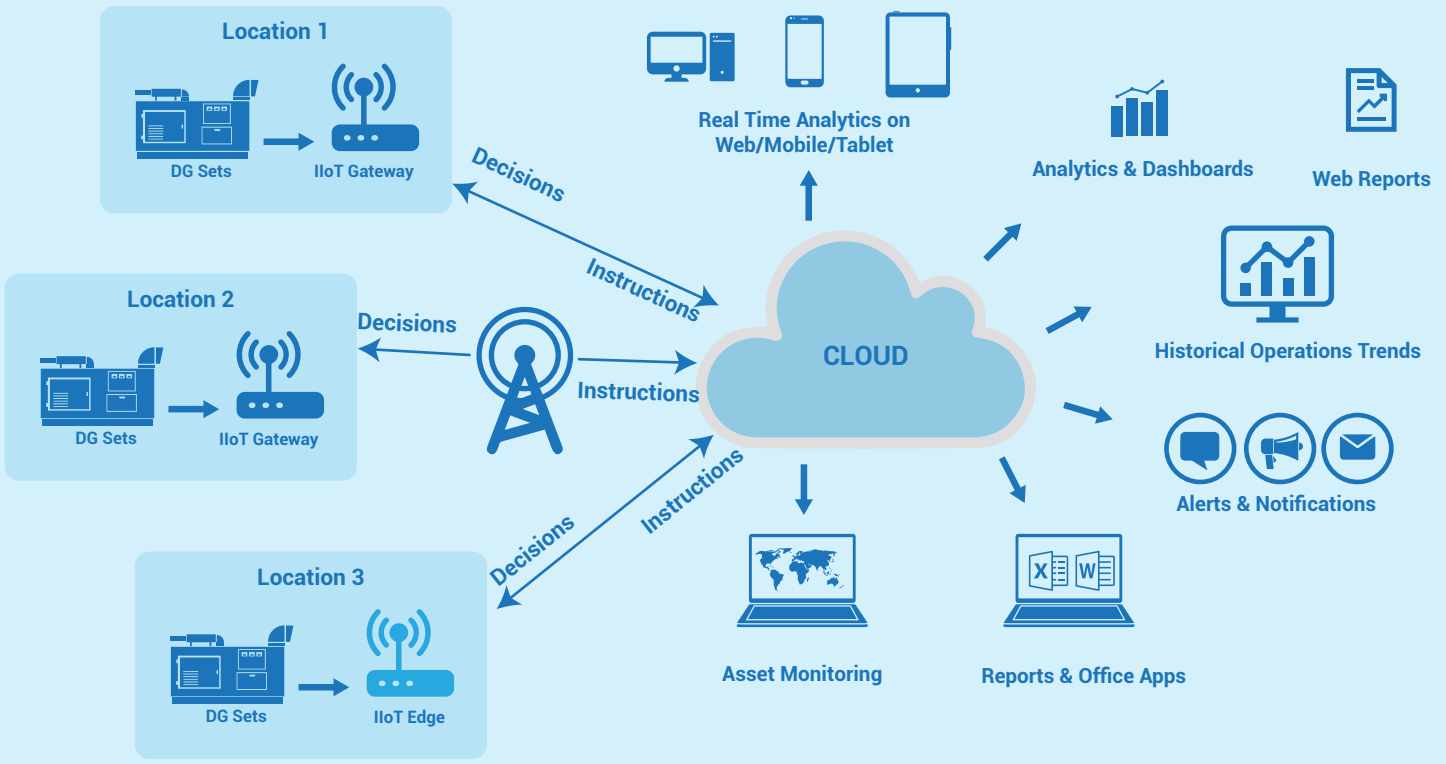
4.1 How can we create a business model around service concept for the connected Factory?

The idea here is to share the pain with the customer (a typical Build, Own, Operate and Transfer model). Couple of ideas that can help are:

- Charge any CAPEX converted into OPEX over a minimum guaranteed time.
- Any IoT project should deliver a positive ROI within 12 months – i.e. any benefits quantified due to IIoT project are recognized as notional revenue.
- Bake all support, deployment and COGS into a monthly service fees for a minimum guaranteed period. This will also help customer plan their OPEX better without having to pay any upfront monies. A monthly fees concept makes a partner more accountable and responsible for support services. Although this concept front-loads the accounting books for the partner, but it helps realize the benefits like improved margins (recognizing depreciation as an expense on equipment sold) and top line (e.g. charging for procurement services)

A simple explanation could be showcased through accruing FTE benefits due to automation. In Oil and Gas industry, these FTE benefits are huge owing to POB costs running to an average of 350K USD per annum. An IIOT project that helps save 3 FTEs should be completed within a year and not cost more than 1M$ per annum.

Figure 8: Connected Factory as a Service concept



The connected factory solution provided by AWS elaborates on some high-level use cases.

- Modernize the operations to achieve specific business outcomes rapidly – e.g. Predictive maintenance, predictive quality and remote asset management. The theme here is always going to be faster, better and cheaper
- Visualize and gain a better control of plant through visualization of all operational metrics from all sources of data
- Accelerate deployment through deployment frameworks provided by AWS across all the production lines and plants

In essence, all the use cases center around how digital transformation can assist manufacturers in these uncertain times. The central idea is to provide a holistic solution through amalgamation of concepts and components above.

Some of the most common use cases are mentioned below. These use cases can also be used for creating digital twins and Azure trying to integrate IIoT within the world of Digital Twins as a service is context for another white-paper.

	Type	Use Case	Details
	Monitor	Emissions Management	Use sensor, Operations & third-party data to visualize and analyze the relationships and working of emission management systems.
	Operate & Maintain	Optimize Operational performance	Improve operational performance of the equipment or process. (e.g., compressor, valve control)
	Operate & Maintain	Predictive Maintenance of equipment	Predict equipment failure using AI models leveraging historical maintenance data
	Simulate/Monitor	Safety Management	Use sensor, Operations & personnel data(IT HR) to track and monitor employee's location and proximity to hazardous environment

5. Conclusion: Synergising the benefit from all the components towards a better control on OPEX

As you may have noticed by now, that not all the components will deliver a major significant benefit due to practical issues related to deployment, operations, human judgement and operational inefficiencies. The benefits are accrued over time incrementally as all the components become increasingly efficient. In most use cases there are some known levers associated with the IIoT project components that can help control OPEX.

Following list may be helpful for an understanding of levers that can have a positive impact on OpEx.

#	Components of IIoT project	Lever	Impact
1	Sensors, Gateways and Devices	Technical Support & Commercials (As a service)	Capex to Opex
2		Wireless sensors (NB-IoT, CATM1)	Reduced Opex for Massive IoT use cases only (Wireless sensors are cheaper)
3		Open Gateways	Easily configurable, Lesser Support requirements (reduced Opex)
4		Devices form factor, type	Android devices help drive OPEX down
5	Connectivity / mobile network	4G / LTE	Direct coverage to backhaul. Can be used for WAN
6		5G	Unlicensed spectrum. Security considerations will drive OPEX up
7		Last mile connectivity on LoRa, Zigbee, SigFox etc.	Security investments will drive OPEX up
8		4G/LTE based breakout / vEPC	Expensive replacements for WiFi type intranet requirements. Good for harmonization of networks
9		MEC by Azure Stack Edge	Will help drive down connectivity backup requirements
10	IT Infrastructure	Enterprise cloud	Flexibility to OPEX based on demand
11		On-prem cloud	Enterprise level features delivered on EDGE devices or as a backup cloud. Fit for purpose usage can help drive OPEX down
12	Dashboards / Mobile Apps	Smart dashboards	Spend on optimization for best KPIs and dashboards can help drive down OPEX through optimized governance
13		Mobile Apps	Will help in automation of workflows and hence drive down OPEX

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