Where is the Edge of the Edge of Industrial IoT?

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Ariel curiously asks "Where is the Edge of the Edge of the sea" in Disney's Little Mermaid as she explores her underwater world in a quest to learn about the unknown. [1] Just as she swims in a sea of adventure, we will soon swim in a sea of information from data, sensors, analytics and Industrial IoT if analyst predictions of 25-50bn devices by 2020 are true. [2] Sadly, we process less than 0.5% [3]of the data we currently have and this sea of new information will continue to be underutilized if we don't leverage more extensive analytics to make sense of it.

IoT and more specifically, Industrial IoT (IIoT), promises to enable us to respond faster with better business outcomes provided we can effectively process the information. Being effective means "adequate to accomplish a purpose, producing the intended or expected result". [4] Effectively processing IIoT data to achieve a specific business outcome requires the processing to happen at the point in the system architecture where it will deliver the expected result with a high level of certainty.

As devices, sensors, gateways and other IIoT hardware components increase computing power, the point of processing moves along a continuum that is most often referred to as the Edge.

The Industrial Internet Consortium (IIC) Edge Computing Task Group is currently formulating a formal definition for Edge and Edge Computing as there are many (and often conflicting) views of what the Edge is. The current working definitions from this Task Group are:

> ***Edge****: a logical layer consisting of the IoT devices, sensors, actuators, nodes, gateways and components of the functional domains deployed therein.*
>
> ***Edge Computing****: All computation, storage, communications, and processing associated with collecting, transforming and acting upon information captured from the Edge, or transmitted to the Edge.*

As the Edge is defined as a logical layer rather than a specific physical divide, it is often open to individual opinion and interpretation on "where" it is. "Does it include the cloud or is limited to local deployment" is an example of the types of questions organizations such as the IIC and standards bodies such as OMG seek to resolve.

The IIC's Industrial Internet Reference Architecture (IIRA) outlines four different viewpoints that provide excellent guidance for determining where the Edge is. These viewpoints are:

- Business viewpoint
- Usage viewpoint

[1] http://disney.wikia.com/wiki/The_Edge_of_the_Edge_of_the_Sea

[2] http://www.gartner.com/newsroom/id/2905717

[3] https://www.forbes.com/sites/bernardmarr/2015/09/30/big-data-20-mind-boggling-facts-everyone-must-read/#380c419717b1

[4] http://www.dictionary.com/browse/effective

- Functional viewpoint
- Implementation viewpoint

The functional and implementation viewpoints mostly deal with the technical aspects of the Edge, but the business and usage viewpoints provide strong clues on "where" the Edge is.

There may be a continuum of fundamental capabilities for an IoT solution and the Edge can move along this continuum based on the key objectives. Where the Edge is will be influenced by the key business drivers that can be classified at a high level around three, to include privacy, latency and connectivity.[6]

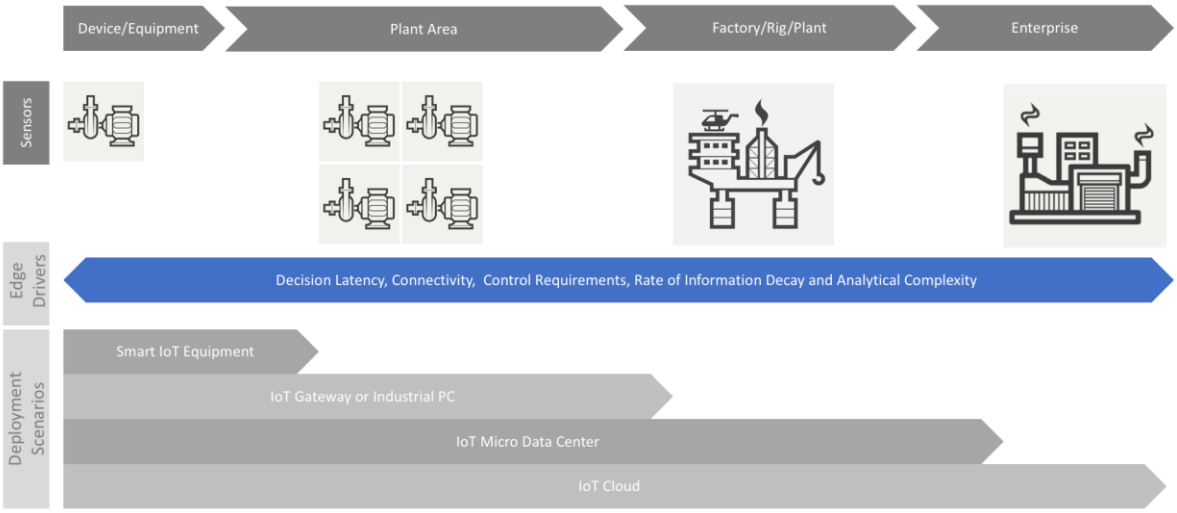

Figure 1: Edge continuum for typical industrial deployment scenarios

In terms of the Business Viewpoint of the IIRA this means that exceeding the boundary of the Edge is where an Industrial IoT solution cannot achieve its *Key Objectives* through *Fundamental Capabilities*. The IIRA defines key objectives as "quantifiable high-level technical and ultimately business outcomes expected of the resultant system ..." and fundamental capabilities refer to "high-level specifications of the essential ability of the system to complete specific major business tasks." [5]

All three of these drivers are equally important to consider, but latency is often the least understood as a driver for key objectives. Rate of information decay, analytical complexity and decision latency all contribute to overall latency requirements.

This is best described in an example found in typical industrial operations, as shown in Figure 1. This is not a complete set of deployment scenarios and is not intended as an architecture diagram but it serves as an illustration of how the Edge can move on a continuum based on the business problem that is addressed with IIoT.

[5] Section 4.4 and 4.5 http://www.iiconsortium.org/IIC_PUB_G1_V1.80_2017-01-31.pdf

[6] https://www.ibm.com/blogs/internet-of-things/edge-iot-analytics/

Key Objective 1: Protect equipment from damage by overheating

In this scenario, a "dumb" thermocouple can measure temperature on a pump. A pump with edge computing capability can perform basic analytics to determine if a defined threshold is exceeded. From a control perspective, it may have the ability – in millisecond response time – to immediately shut the pump down. There is no decision latency and no need for connectivity to perform this fundamental capability. It does not mean that it can't be connected for notification purposes, it is just not necessary for this capability. The time value of the temperature information will decay rapidly as delayed response will result in equipment damage. In this case the Edge will be at the device level as it will still be able to achieve the key objective, even if connectivity to higher level systems and networks are interrupted.

Key Objective 2: Proactively monitor the performance of critical plant areas or production lines

The performance of critical equipment and production lines are often expressed through performance indicators like OEE (Overall Equipment Effectiveness). Near real-time analytics on multiple data points from sensors on the plant area can be processed on a local gateway at the plant area level and provide alerts to operational systems or personnel on areas with specific OEE trends, for example. In this instance, the fundamental capability requires information from multiple equipment sources to perform simple analytics. The time value of information is high, as response delays (decision latency) of minutes and hours can amount to significant losses. This business problem dictates that the Edge is at the plant area level.

Key Objective 3: Optimize supply chain for a location or factory on a twice daily basis

Optimizing supply chain processes for a local facility, factory or an oil field requires data from multiple sources at short intervals (typically hours) to apply optimization algorithms and analytics that will adapt supply chain plans in business systems such as SCM or ERP solutions. The fundamental capability requires at least local or factory level connectivity with decisions made in hours. Additional information outside the perimeter of the factory may be useful, but not mandatory for effective optimization. In this instance, the Edge is at the perimeter of the factory, plant or local facility.

Key Objective 4: Predict equipment failure and schedule proactive response

Building machine learning models to predict ESP (Electric Submersible Pump) failures requires data from multiple offshore platforms. The analytics models are complex and a large amount of data is needed to train and re-train the models. It also requires regular data feeds from operating ESPs to determine each unit's RUL (Remaining Useful Life). The data from individual ESPs need to be analyzed on a regular interval but information decay is much slower than in the other scenarios and decisions can be taken on a daily or weekly basis. In this scenario, the fundamental capability is typically performed at the enterprise or even cloud

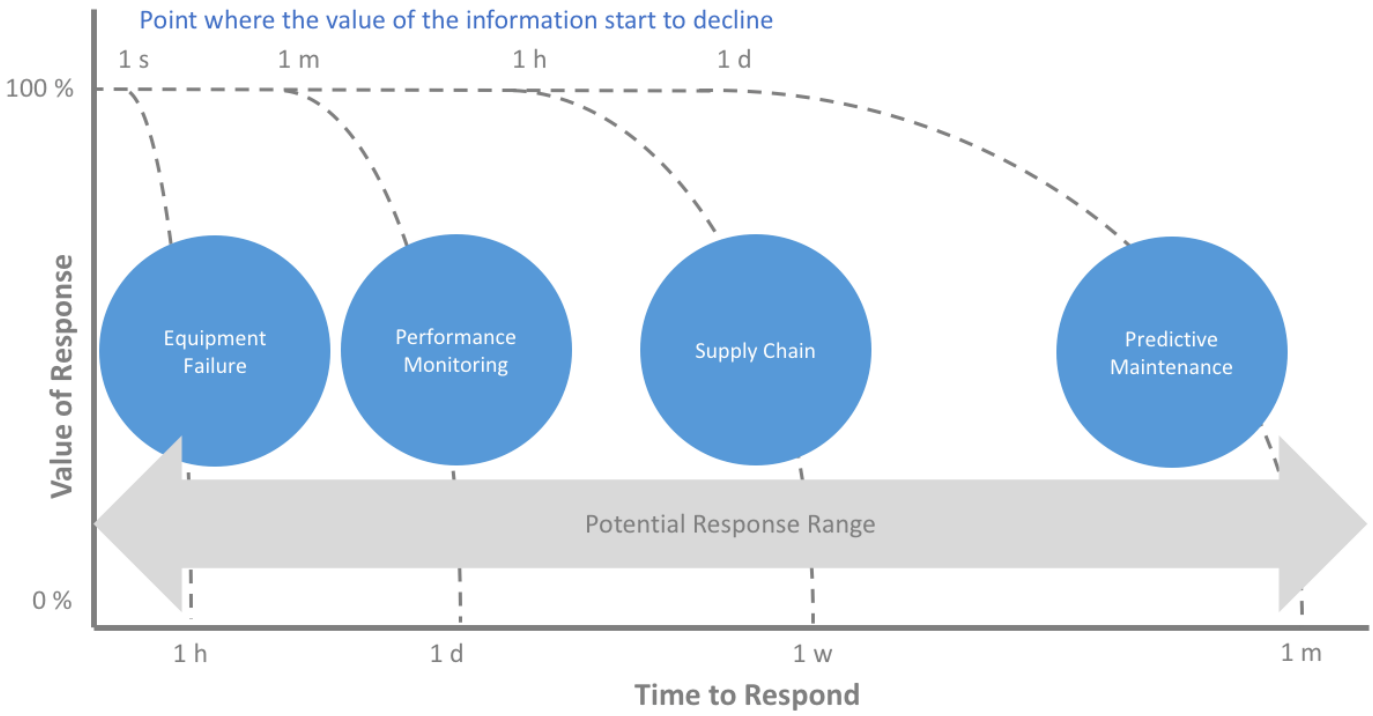

Figure 2: Rate of Information Decay

level and is at the top end of the Edge continuum.

These four objectives demonstrate how the Edge can move along a continuum to meet the unique requirements of individual IIoT Systems. In addition to security and connectivity, the rate of information decay is often the most important latency driver that dictates where the Edge of the Edge should be along the time-value graph [See Figure 2[7]].

Just as Ariel says "Let's go" as she explores the Edge of the Edge of the Sea, Edge Computing opens new frontiers for those who want to find the business value and competitive advantage of IIoT. Edge Computing is quickly evolving with many organization focusing on improving the smarter use of the deluge of data nearer the IoT devices that generate it. It is expected to greatly impact the business value of IoT as we know it.

[7] http://xmpro.com/what-is-a-business-moment-in-your-business/ and https://www.linkedin.com/pulse/what-business-moment-your-pieter-van-schalkwyk/?trk=object-photo

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