IoTSP – FORUM SPRINT 3 2017-06-15

IIoTSP – Industrial Internet of Things Services and People

Funded by Vinnova, Process Industrial IT and Automation (PiiA), and ABB

Outline

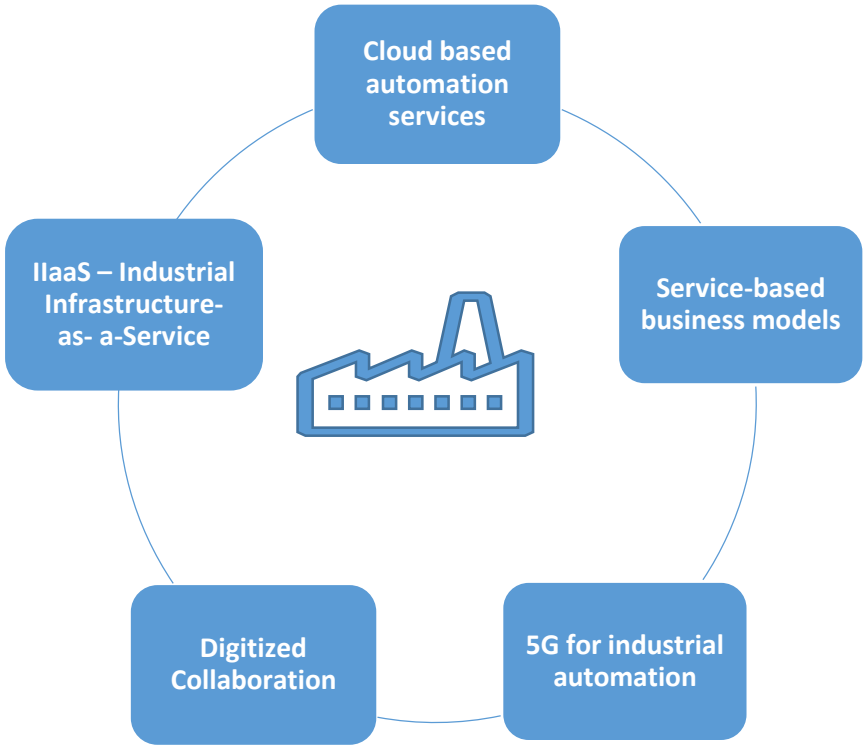
- Introduction
  - Goal/Scope/Recap
- Sprint 3
  - Cloud I/0
  - Industrial Cloud QoS
  - Business Models for the Internet-of-things
  - Concept demonstrators
    - Mine ventilation as a cloud service
    - IoT Hub connect

Introduction

Goal

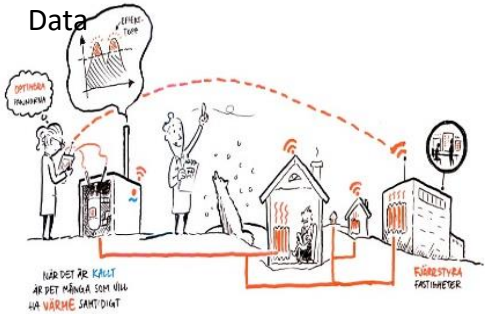
”Visa på möjligheterna med digitaliseringen genom konkreta och imponerande piloter tillsammans med svensk processindustri”

Scope – Future process industry solutions



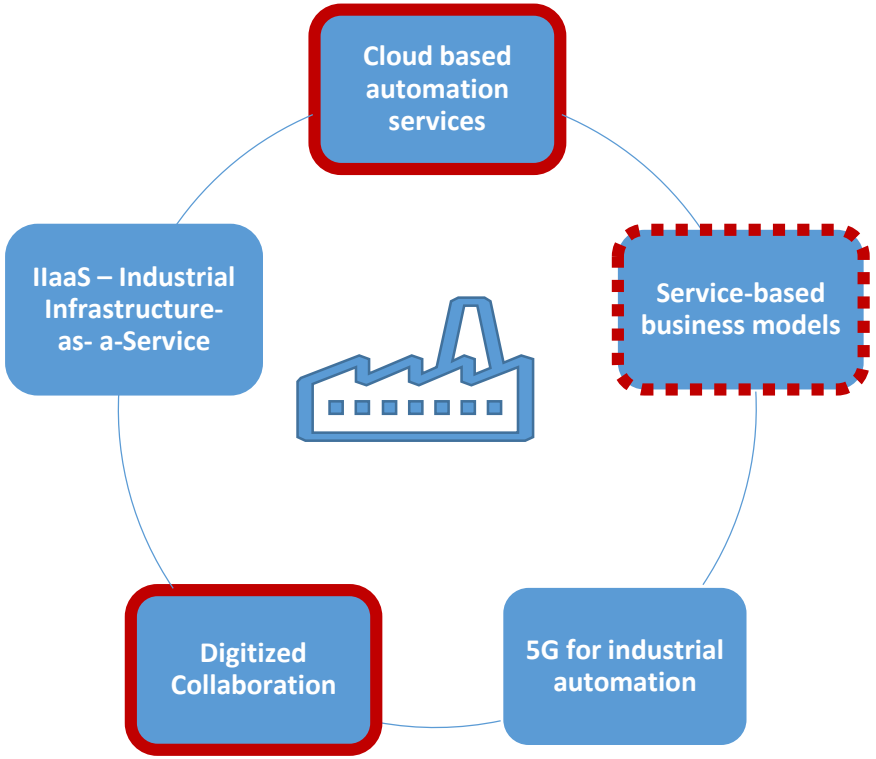
Scope - Sprint 1&2

Field Metering Data

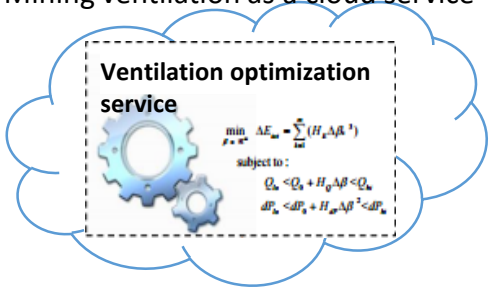


GDPR

Design of new digital services



Mining ventilation as a cloud service



Dissemination of results

MARCH 13-16, 2017 | HOUSTON, TEXAS
ABB Customer World
Connect. Collaborate. Outperform.

PAPER PROVINCE

BIG

NyTeknik
*Här utvecklas industrins smarta maskiner (*C.A.G Mälardalen*)*

ABB Mining User Conference 2017 i Stockholm, 2-6 maj

RI. SE
Press release January 2017

Dataskyddsförordningen
Axel Tandberg
Tandberg & Partners
26 april 2017

storaenso

LINKÖPINGS UNIVERSITET

KTH VETENSKAP OCH KONST

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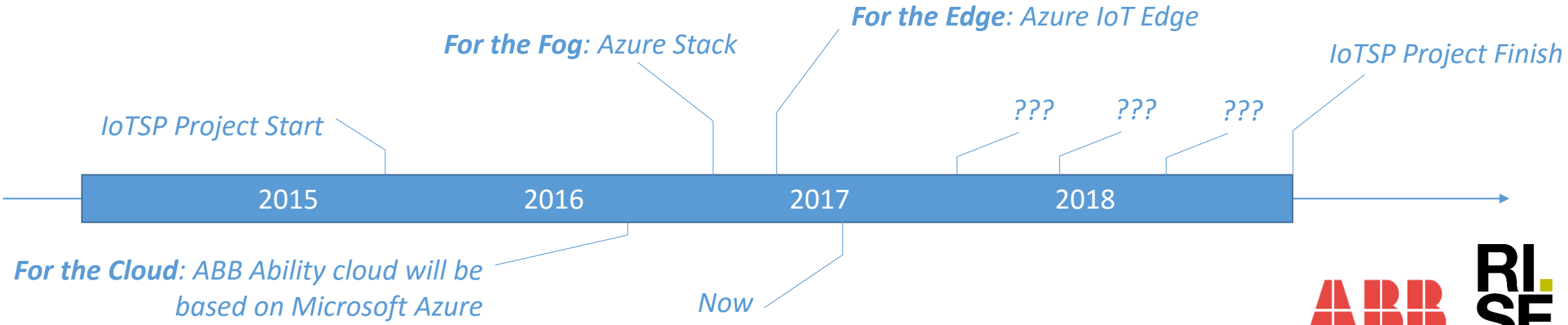
Cloud I/O

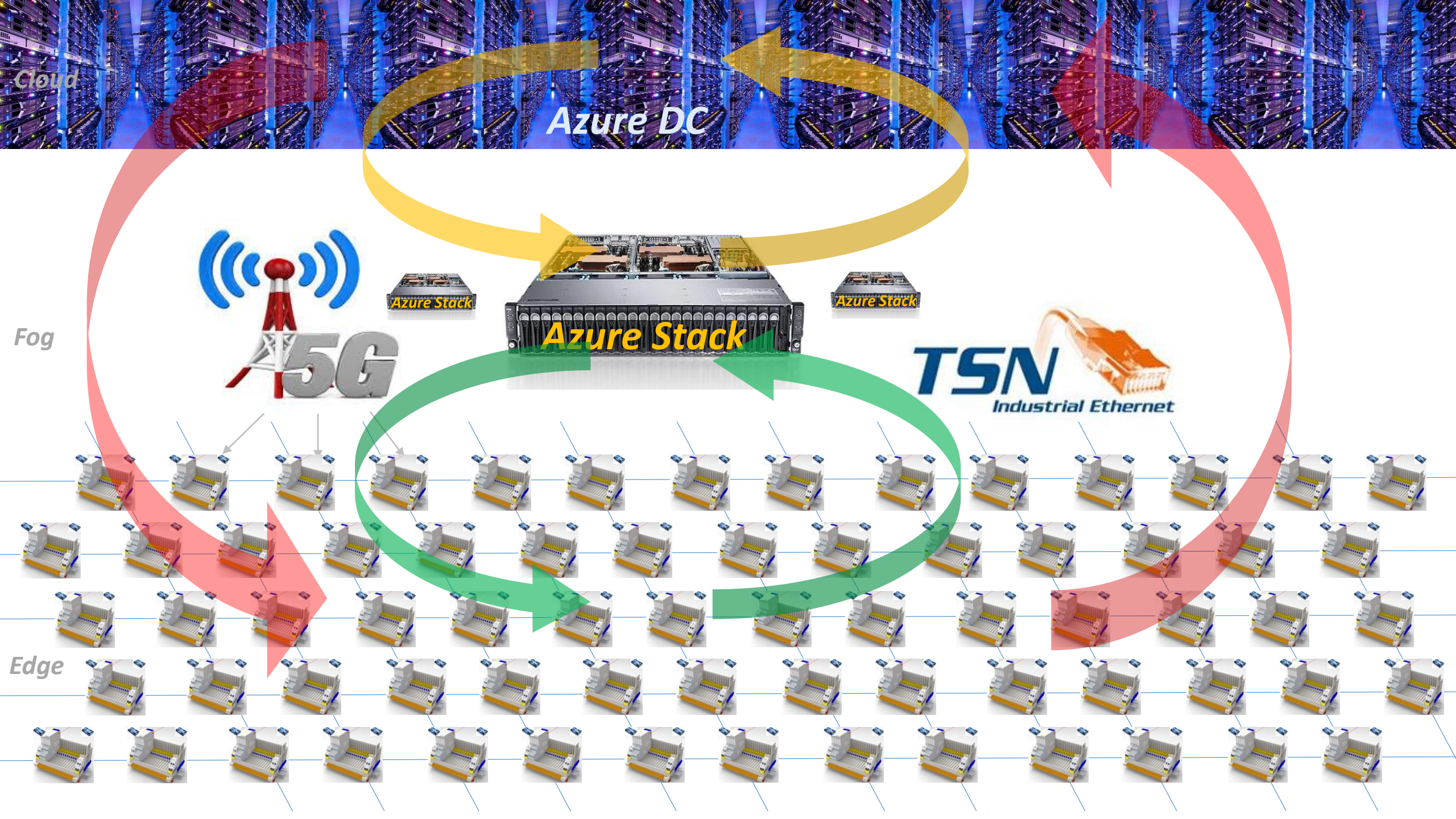
IoTSP

CloudIO

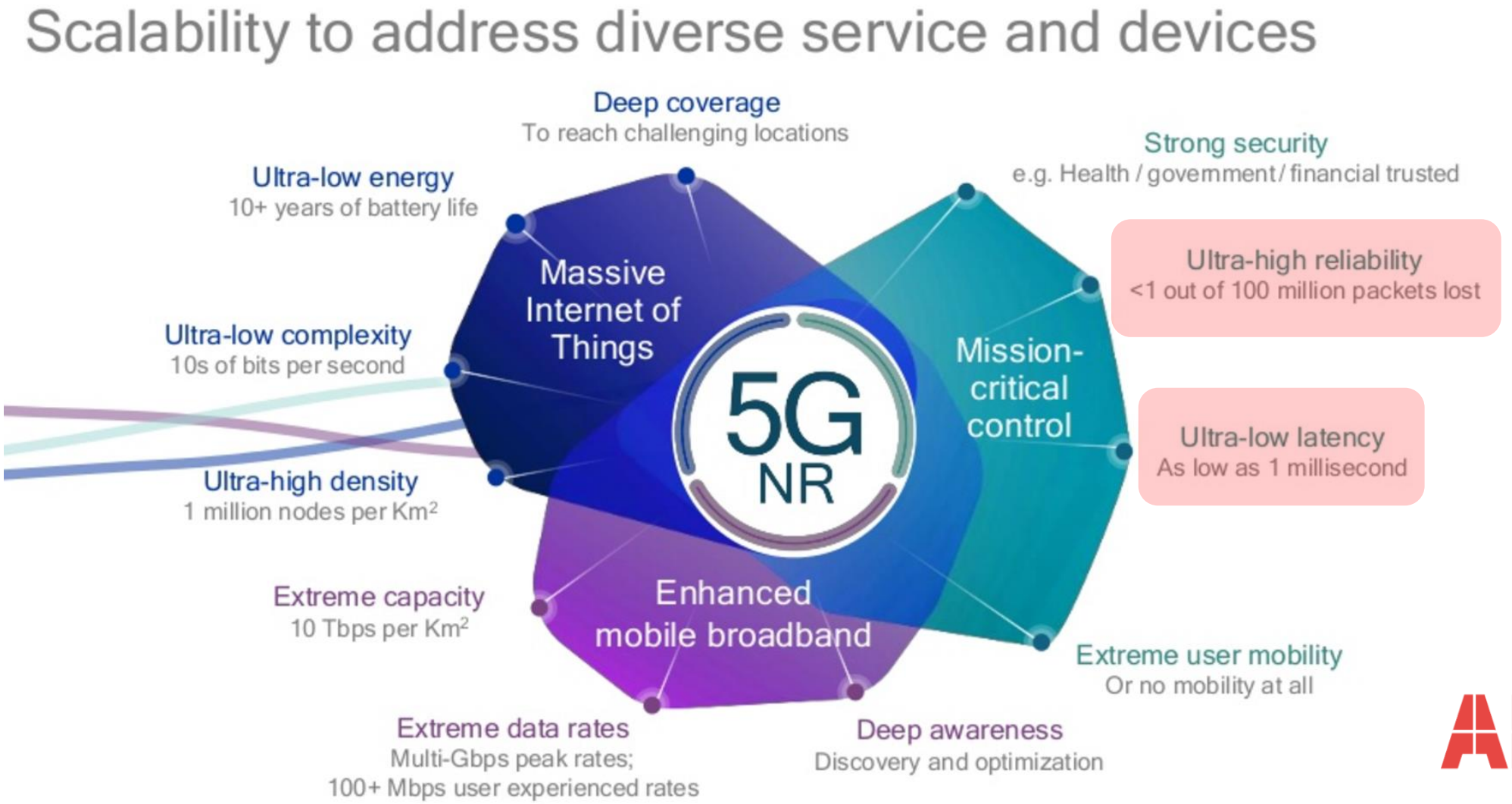
Vision of an easy-to-use, infinitly scaleable industrial IO system connected to Cloud Computing

Wayne Gretsky: ”*A good hockey player plays where the puck is. A great hockey player plays where the puck is going to be*”




Cloud
Azure DC
Azure Stack
Azure Stack
Azure Stack
Fog
5G
TSN
Industrial Ethernet
Edge

What is 5G?


Scalability to address diverse service and devices
Deep coverage
To reach challenging locations
Ultra-low energy
10+ years of battery life
Strong security
e.g. Health / government / financial trusted
Massive Internet of Things
Ultra-high reliability
<1 out of 100 million packets lost
Ultra-low complexity
10s of bits per second
5G NR
Mission-critical control
Ultra-low latency
As low as 1 millisecond
Ultra-high density
1 million nodes per Km²
Extreme capacity
10 Tbps per Km²
Enhanced mobile broadband
Extreme user mobility
Or no mobility at all
Extreme data rates
Multi-Gbps peak rates;
100+ Mbps user experienced rates
Deep awareness
Discovery and optimization

What is TSN

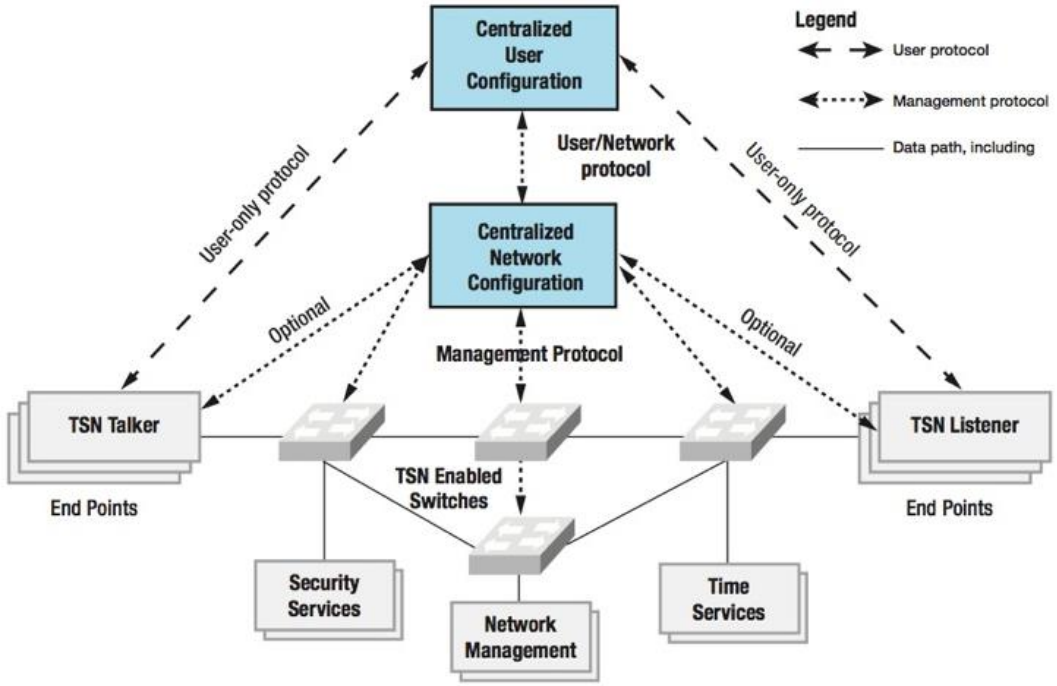
- Updates to the Ethernet standards through IEEE 802 to improve latency and performance while maintaining interoperability and openness

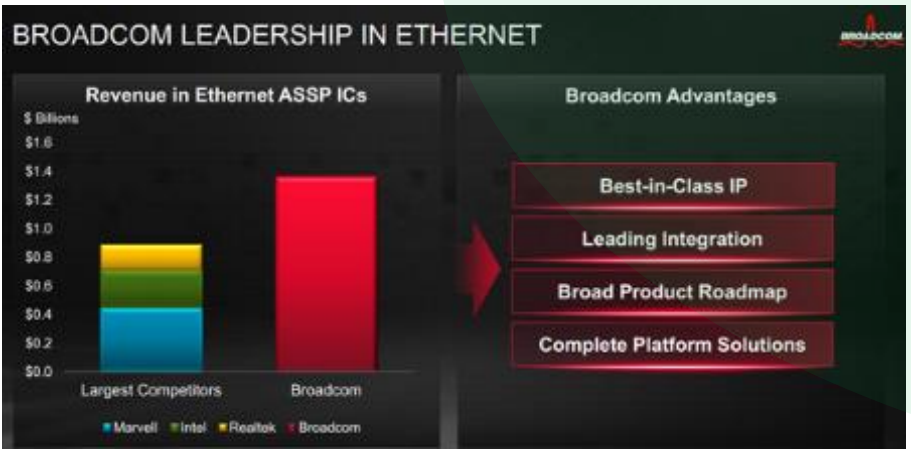
- Time Sensitive Networking (TSN) will provide:
  - Time synchronization
  - Bandwidth reservation and path redundancy for reliability
  - Guaranteed bounded latency
  - Low latency (cut-though and preemption)
  - Bandwidth (Gb+)
  - Routable to support complex networks and wireless

- Imagine…:
  - 1000 bits of data/SELECT IO channel @ 100 ms
  - A TSN Ethernet network with ”10 G” bandwitdh
  - This network could fit 1 million SELECT IO channels!
  - 10.000 SELECT IO channels would consume just 1 % of this 10G bandwidth
  - There would be lot’s of bandwidth left for Video cameras, Netflix, other OT traffic and other IT traffic.

TSN-based Protocols – “Sharing the Wire”

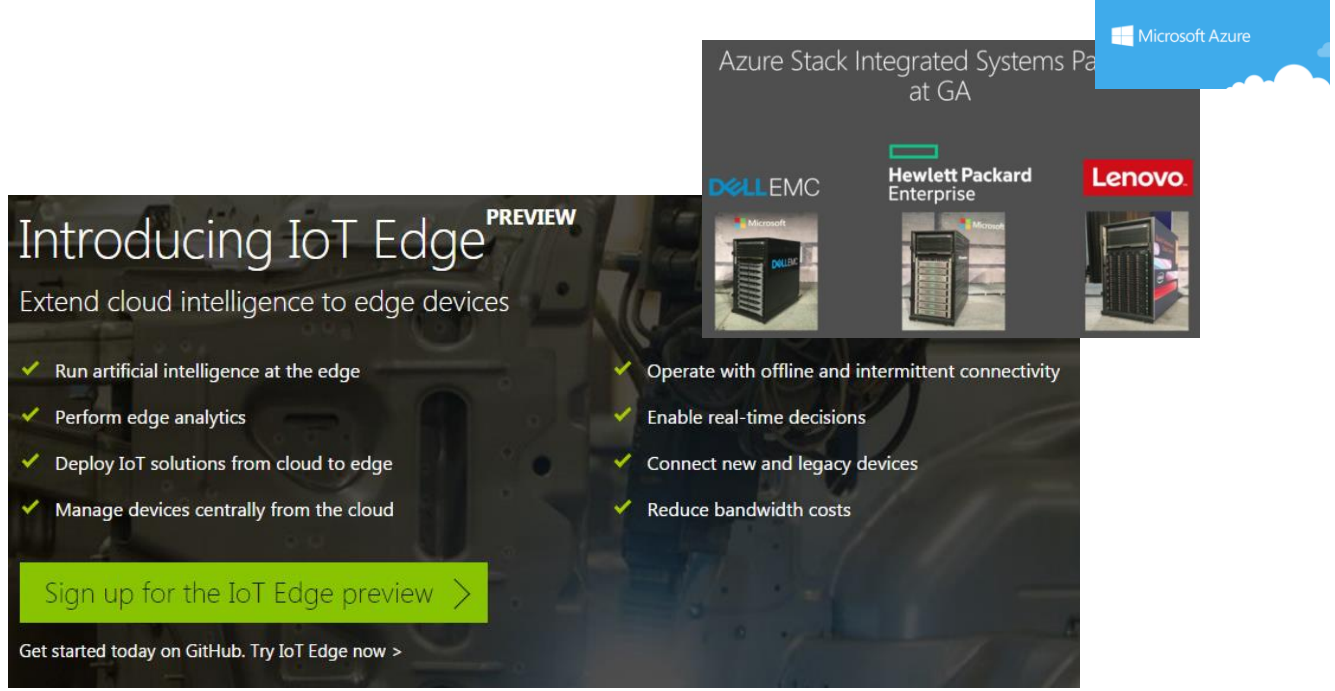
Roles in the TSN System

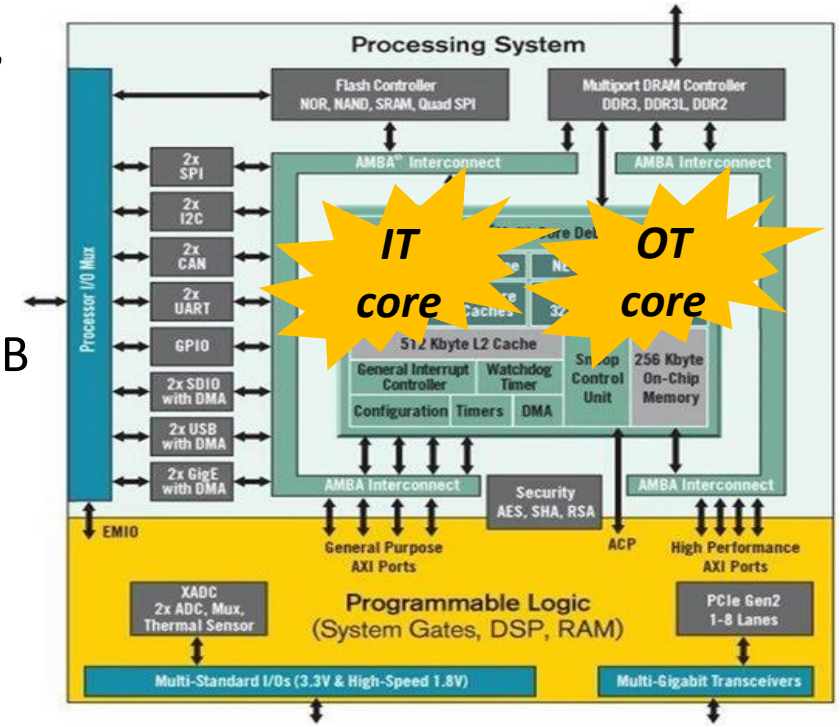


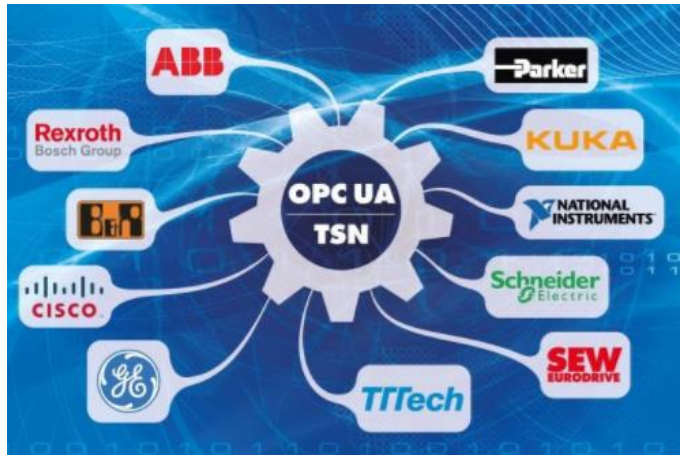


Everyone working with TSN

- Complete and Secure Cloud-Fog-Edge Platform
- OPC UA PubSub communication enables Device2Device communication with Publish/Subscribe communication technologies via Ethernet, 5G, ..
- Low hardware requirements:
  - Single core and min 128 MB RAM







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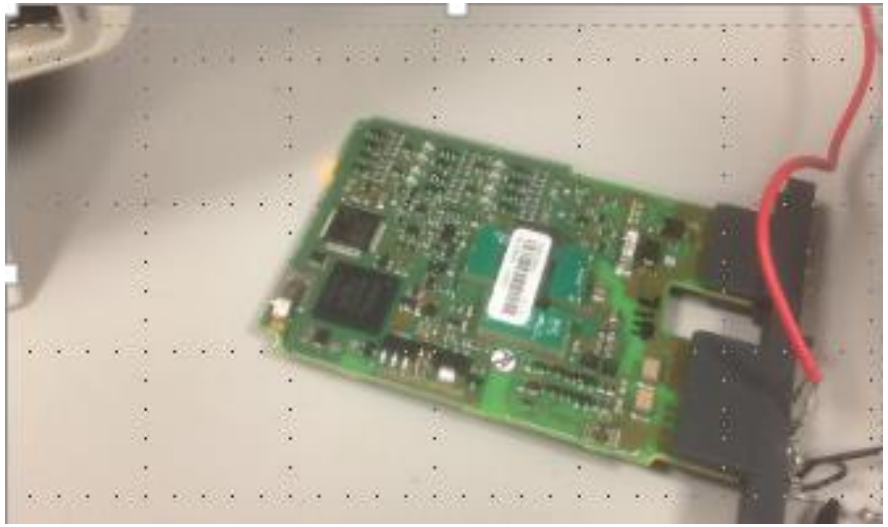
So what have we done so far?

1. **Cloud**: Large portions of IoTSP has worked with Azure functionality
   - **Cloud2Fog2Edge Connectivity**: Internet and IoTHUB communication evaluation
2. **Fog**: We've configured an Azure Stack Machine @SECRC
3. **Fog**: We have access to 5G BaseStation from Ericsson @SECRC
4. **Edge**: We've aquired CloudIO Edge Computers with Ubuntu (Azure IoT Edge capable) suitable for TSN and more
5. **Edge**: We've developed a SELECT IO Scanner IP and a simple linux application using UIO driver to do 1 ms SELECT IO scan



Internet Connectivity

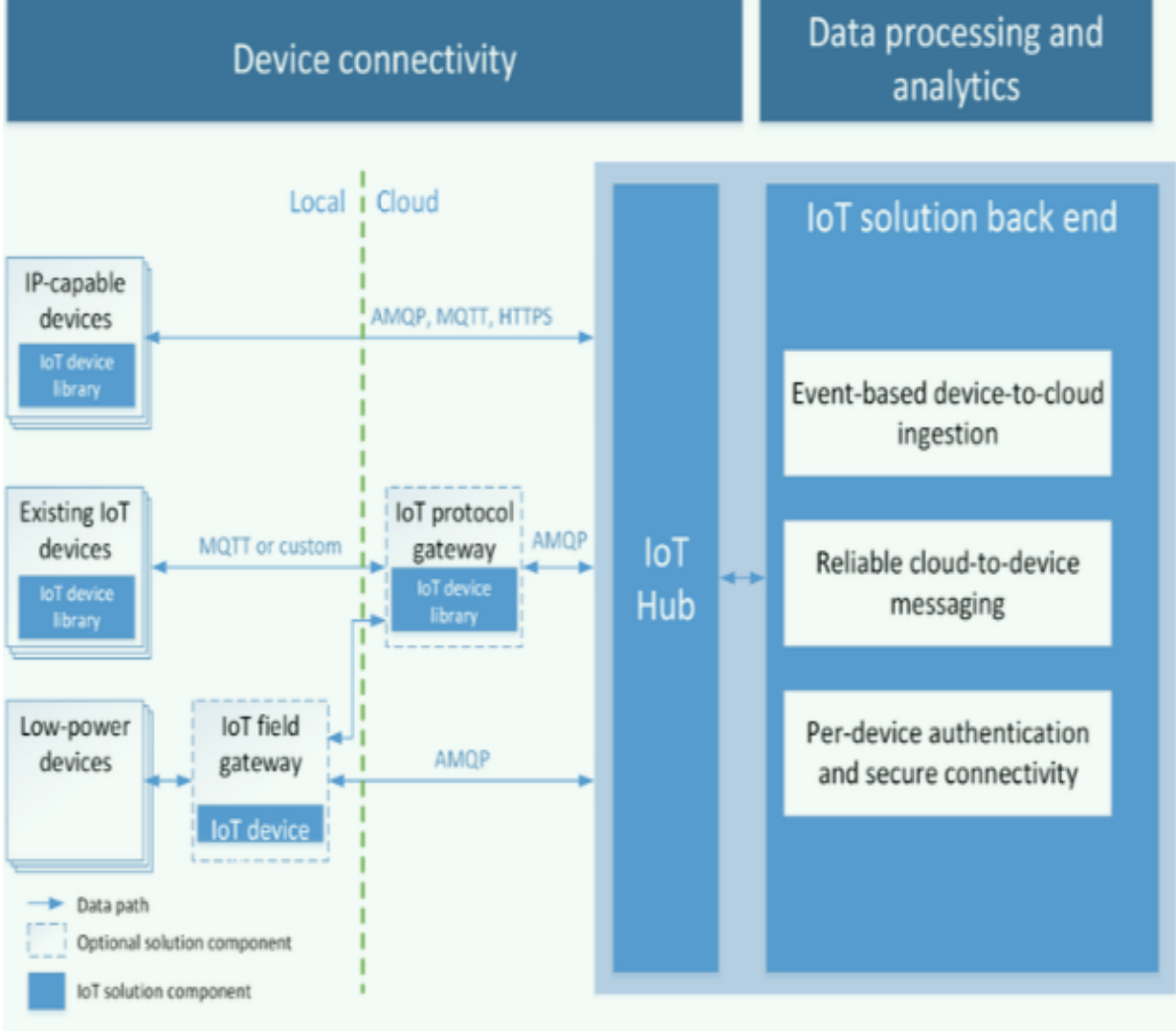
Fog

Edge

SELECT IO scan provided by ABB

Click

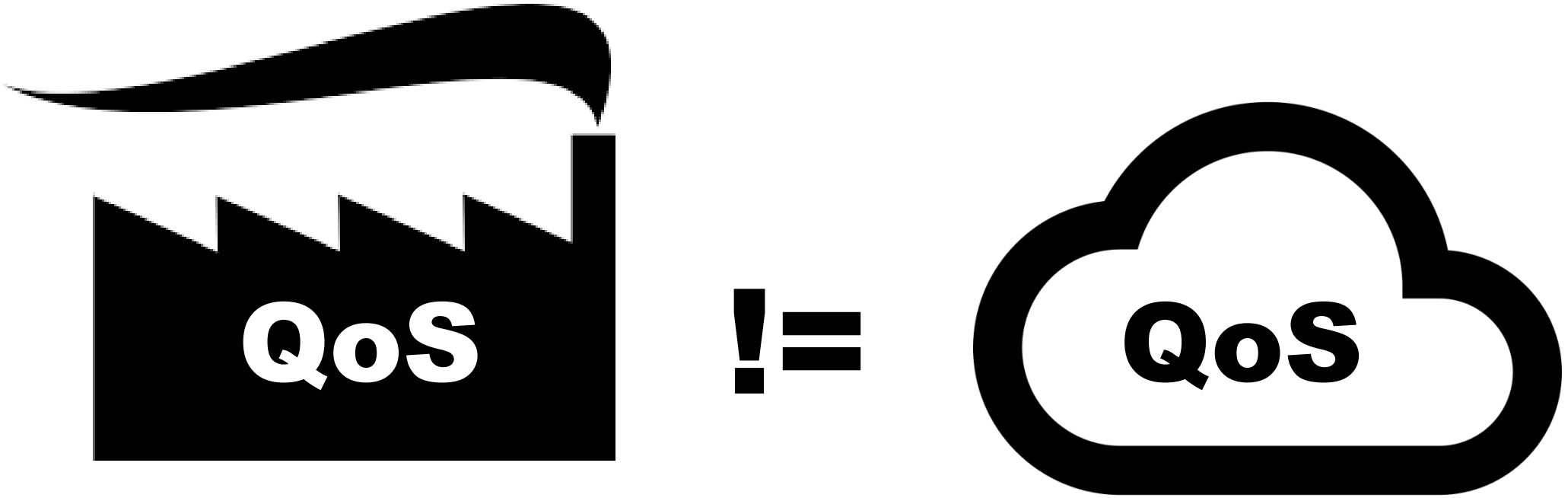
ABB Confidential



IoTSP project demonstrates potential with IoTHUB communication from Ubuntu applications at the Edge to Azure (in Cloud and Fog) via 5G and Ethernet

ABB RISE

Industrial Cloud



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Microsoft Azure SLA => 10-25% Service Credit

- https://azure.microsoft.com/en-us/support/legal/sla/summary/
  - Analysis Services
    - A **minute** is considered unavailable for a given Server if **more than 1%** of all Client Operations completed during the minute return an Error Code.
  - Event Hub/IoT Hub
    - A **minute** is considered unavailable for a given Event/IoT Hub if all continuous attempts to send or receive Messages or perform other operations on the Event/IoT Hub throughout the minute either return an Error Code or do not result in a Success Code within **five minutes**.
  - Express Route
    - A **minute** is considered unavailable for a given Dedicated Circuit if all attempts by Customer within the minute to establish IP-level connectivity to the Virtual Network Gateway associated with the Virtual Network fail for longer than **thirty seconds**.
  - Scheduler
    - We guarantee that **at least 99.9%** of the time all scheduled jobs will initiate **within 30 minutes** of their planned execution times.

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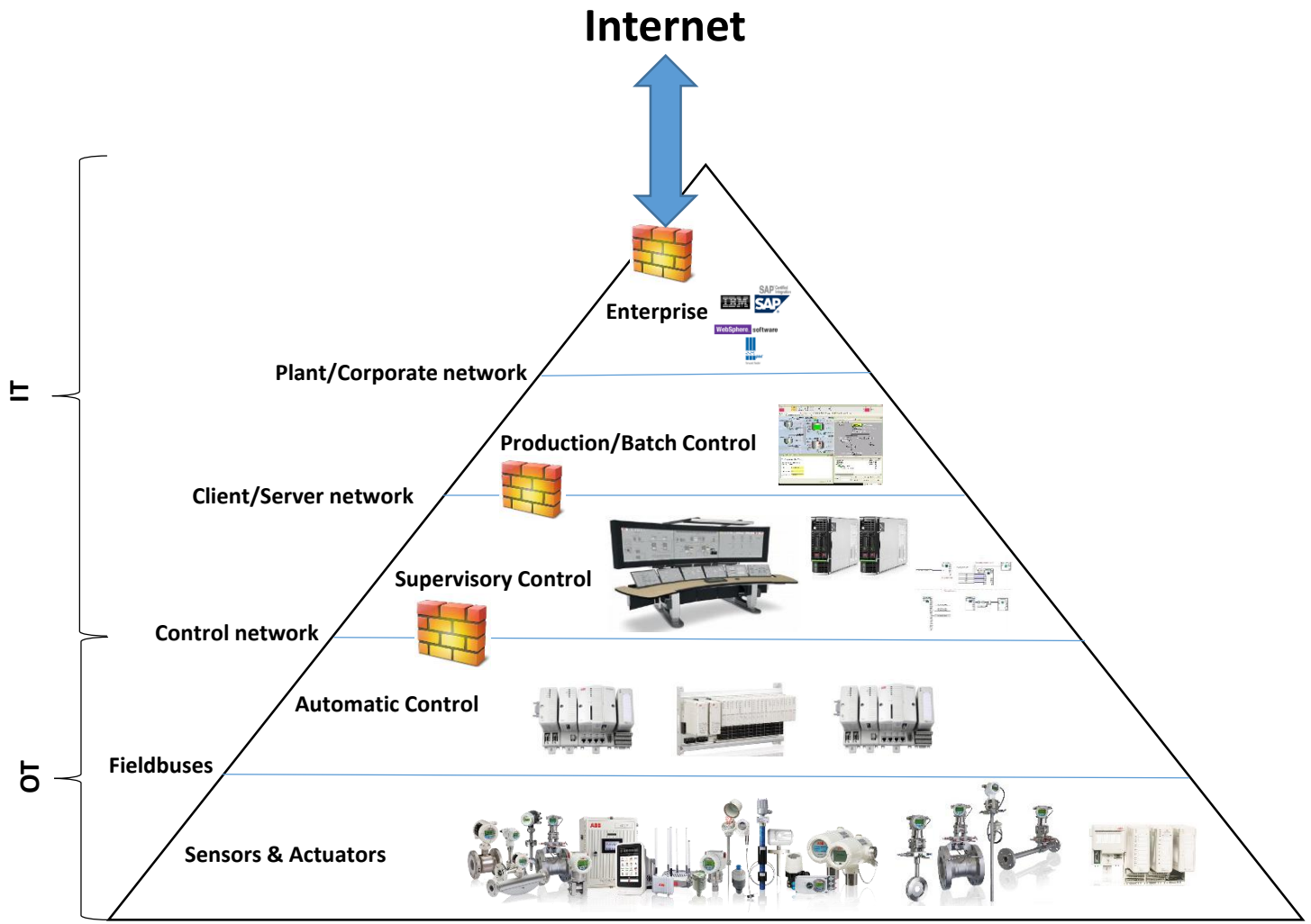
Amazon S3 Service Level Agreement

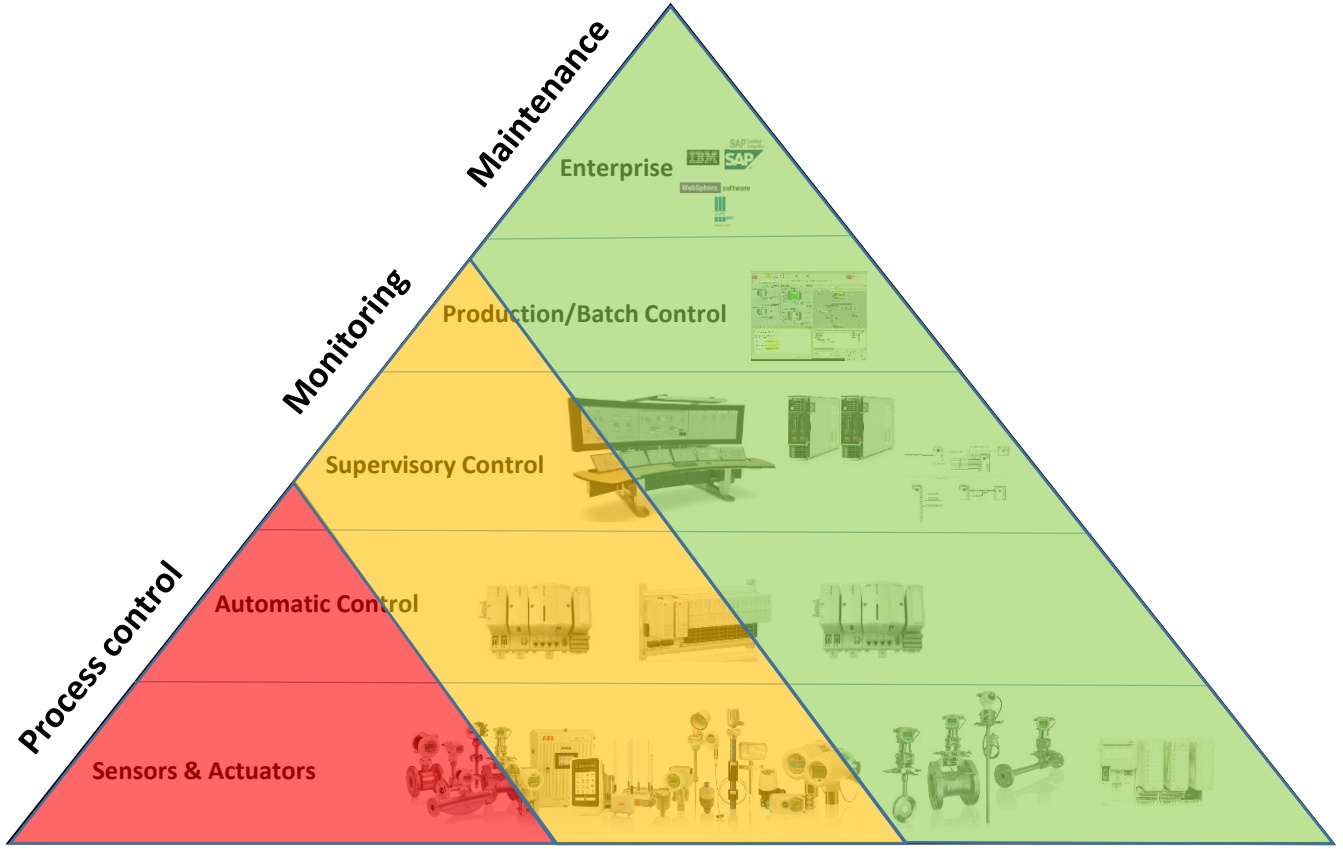
- https://aws.amazon.com/s3/sla/
  - “Error Rate” means: (i) the total number of internal server errors returned by Amazon S3 as error status “InternalError” or “ServiceUnavailable” divided by (ii) the total number of requests for the applicable request type during that **five minute** period. We will calculate the Error Rate for each Amazon S3 account as a percentage for each five minute period in the monthly billing cycle. The calculation of the number of internal server errors will not include errors that arise directly or indirectly as a result of any of the Amazon S3 SLA Exclusions (as defined below).
  - “Monthly Uptime Percentage” is calculated by subtracting from 100% the average of the Error Rates from each **five minute** period in the monthly billing cycle.
  - A “Service Credit” is a dollar credit, calculated as set forth below, that we may credit back to an eligible Amazon S3 account.

Industrial automation



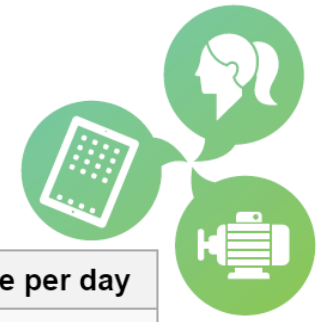
Process and machines

Industrial automation (crictial to less sensitive)



Process and machines

Availability



Availability %	Downtime per year	Downtime per month	Downtime per week	Downtime per day
90% ("one nine")	**36.5 days**	**72 hours**	**16.8 hours**	**2.4 hours**
95%	18.25 days	36 hours	8.4 hours	1.2 hours
97%	10.96 days	21.6 hours	5.04 hours	43.2 minutes
98%	7.30 days	14.4 hours	3.36 hours	28.8 minutes
99% ("two nines")	**3.65 days**	**7.20 hours**	**1.68 hours**	**14.4 minutes**
99.5%	1.83 days	3.60 hours	50.4 minutes	7.2 minutes
99.8%	17.52 hours	86.23 minutes	20.16 minutes	2.88 minutes
99.9% ("three nines")	**8.76 hours**	**43.8 minutes**	**10.1 minutes**	**1.44 minutes**
99.95%	4.38 hours	21.56 minutes	5.04 minutes	43.2 seconds
99.99% ("four nines")	**52.56 minutes**	**4.38 minutes**	**1.01 minutes**	**8.66 seconds**
99.995%	26.28 minutes	2.16 minutes	30.24 seconds	4.32 seconds
99.999% ("five nines")	**5.26 minutes**	**25.9 seconds**	**6.05 seconds**	**864.3 milliseconds**
99.9999% ("six nines")	**31.5 seconds**	**2.59 seconds**	**604.8 milliseconds**	**86.4 milliseconds**
99.99999% ("seven nines")	**3.15 seconds**	**262.97 milliseconds**	**60.48 milliseconds**	**8.64 milliseconds**
99.999999% ("eight nines")	**315.569 milliseconds**	**26.297 milliseconds**	**6.048 milliseconds**	**0.864 milliseconds**
99.9999999% ("nine nines")	**31.5569 milliseconds**	**2.6297 milliseconds**	**0.6048 milliseconds**	**0.0864 milliseconds**

Cloud & Edge SLA

Industrial Automation

* System 800xA Solutions Handbook, ABB,

IoTSP QoS measurements

- Availability
  - Cloud Service Response time (i.e., RTT) is compared to application deadline requirement
  - $\textbf{Availability} = 1 - \frac{\#failed/late\ cloud\ service\ responses}{\#total\ cloud\ service\ requests}$
- Latency & Jitter
  - Round-Trip-Time (RTT) measurements (avg., max, min, jitter = σ)
- Error Rate
  - The percentage of errors detected by a device within a predefined period of time.

Inspired by NAMUR NE133 KPIs for communication a “User Association of Automation Technology in Process Industries”, 140+ member companies, http://www.namur.net

Azure IoT Suit: popular solutions

Remote monitoring

Connect and monitor your devices to analyze untapped data and improve business outcomes by automating processes.

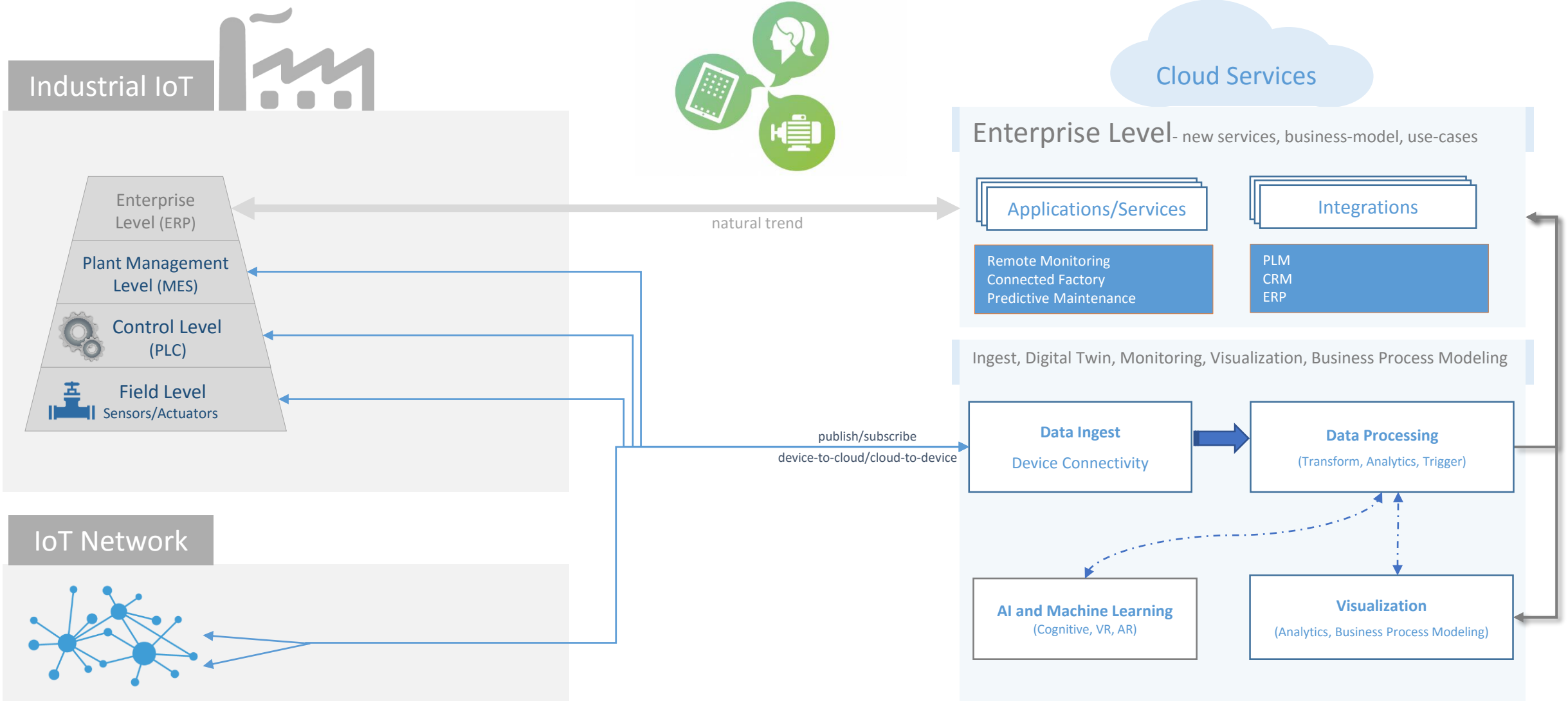
Connected factory

Accelerate your journey to Industrie 4.0 – connect, monitor and control industrial devices for insights using OPC UA to drive operational productivity and profitability.

Predictive maintenance

Anticipate maintenance needs and avoid unscheduled downtime by connecting and monitoring your devices for predictive maintenance.

https://www.azureiotsuite.com/#solutions/types



Challenges

- Quality of Service, Data Privacy (Reliability, Availability, Big Data)
- Data Acquisition Challenges (Frequency, Format, Filtering)

Research Areas

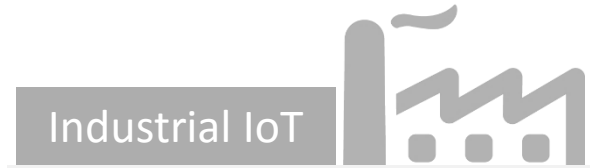
- Industrial Cloud Reliability and Latency
- Cloud Services Availability

POC Architecture and Experiment Approach

- **Objective;** find latency and calculate availability
  - Latency between device and cloud services
  - Latency between cloud services

- **Challenge**; time sync issue between IoT devices and cloud services

- **Approach**; perform device round-trip measurements, find Availability



IoT - Device Simulated

1.3 send measurement to QoS Reporter

QoS Reporter

1.1 send device-to-cloud message

1.2 send acknowledgment for device-to-cloud

1- Device-To-Cloud Measurement

Cloud Services

Ingest, Digital Twin, Monitoring, Visualization, Business Process Modeling

Data Ingest, Device Connectivity

IoT Hub

Visualization

(Analytics, Business Process Modeling)

IoT - Device Simulated

2.6 send measurement to QoS Reporter

QoS Reporter

2.1 send device-to-cloud message

2.2 send acknowledgment for device-to-cloud

2.5 send command cloud-to-device

2- Device-To-Cloud Service Measurement

Ingest, Digital Twin, Monitoring, Visualization, Business Process Modeling

Data Ingest, Device Connectivity

IoT Hub

2.3 trigger

Data Processing

Azure App Function

2.4 send command to IoT-Hub for IoT-Device

AI and Machine Learning

(Cognitive, VR, AR)

Visualization

(Analytics, Business Process Modeling)

Industrial IoT

QoS Reporter

1- send QoS measurement

Cloud Services

Ingest, Digital Twin, Monitoring, Visualization, Business Process Modeling

Event Hub: Data Ingest

2- transform

Stream Analytics
:Data Processing
(Transform, Analytics, Trigger)

3- visualize and store QoS

Calculate **Availability**

4- calculate

Power BI: Visualization

Azure Storage
(Analytics, Business Process Modeling)

1- Measurement Reporter and Availability Calculations

Experiment Setup and Reports

- **Experimental Setup**
  - Running two devices for 4-5 days
  - Data-center in Ireland
  - Sending data ingest messages every second
  - Getting commands from cloud every 30sec

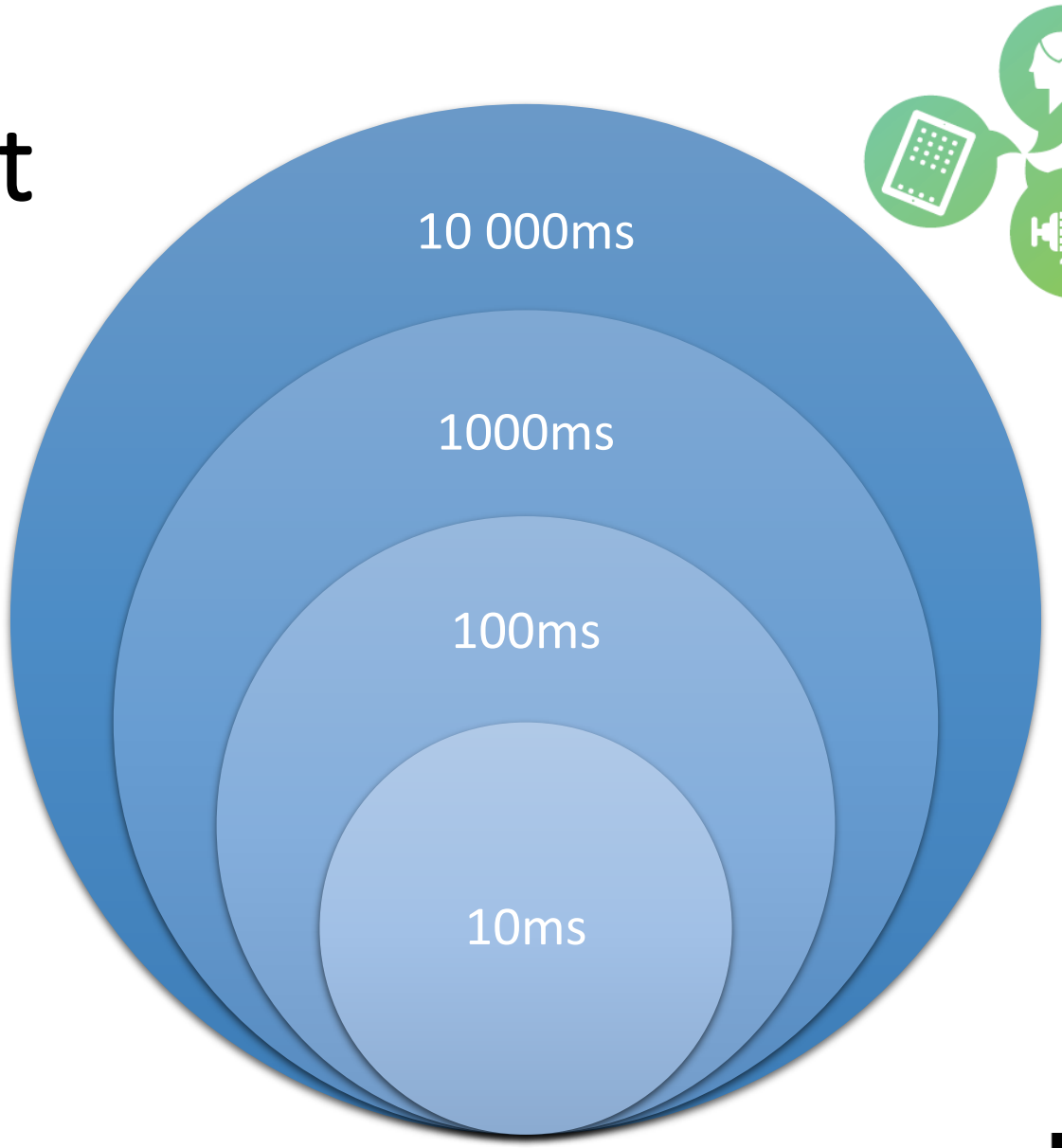
- **Reports**
  - Device-to-Cloud Measurements: Västerås device to Ireland data-center
  - Device-to-Cloud Measurements: Ireland device to Ireland data-center
  - Device-to-Cloud Measurements: Summary
  - Device-to-Cloud Service Measurements: Västerås device to Ireland data-center
  - Device-to-Cloud Service Measurements: Ireland device to Ireland data-center
  - Device-to-Cloud Service Measurements: Summary

Reference Latency Chart

- 10ms
  - **Motion Control**

- 100ms
  - A response time of 100ms is perceived as **instantaneous**
- 1000ms
  - Response times of 1 second or less are fast enough for users to feel they are **interacting freely with the information**
- 10 000ms
  - Response times greater than 10 seconds completely **lose the user's attention**

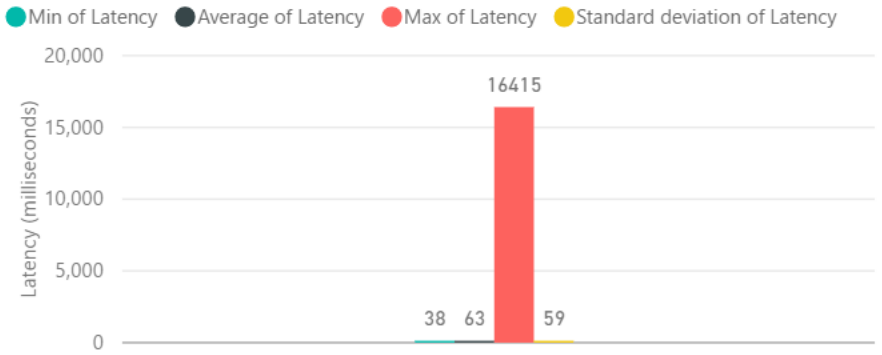
1968 Robert Miller classic paper; Response time in man-computer conversational transactions

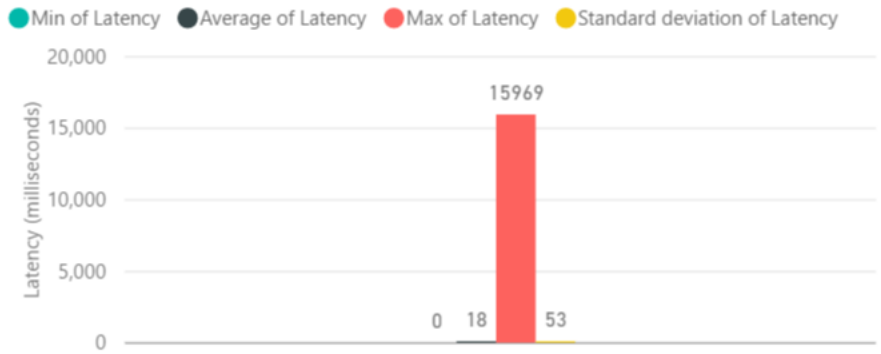


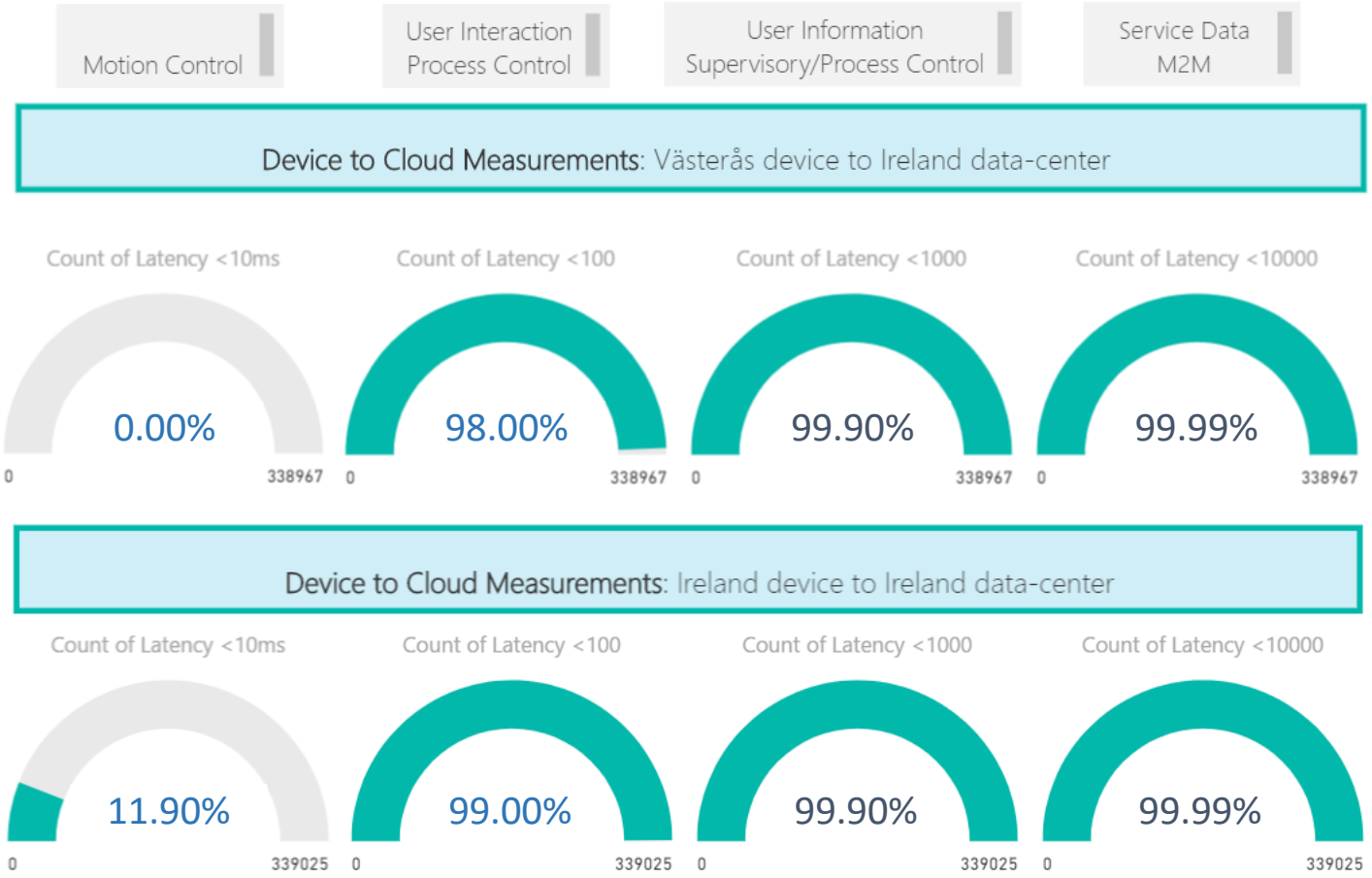
Results and Visualization

- Power BI Embedded
  - https://app.powerbi.com/groups/me/reports/485e64bf-cbbf-42b8-958c-54128512e9d0/ReportSection

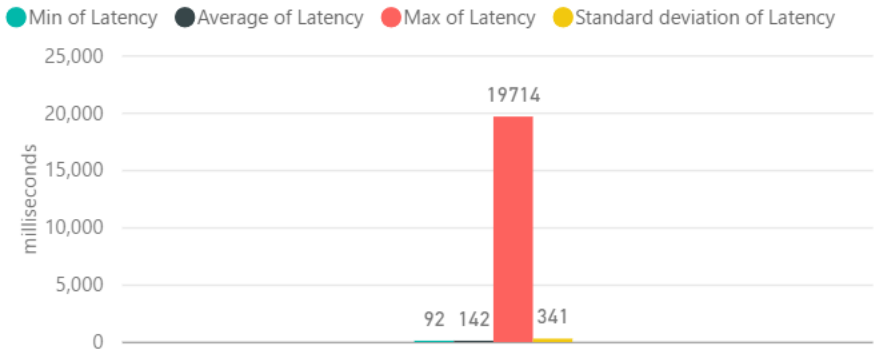
Experimental Results and Availability

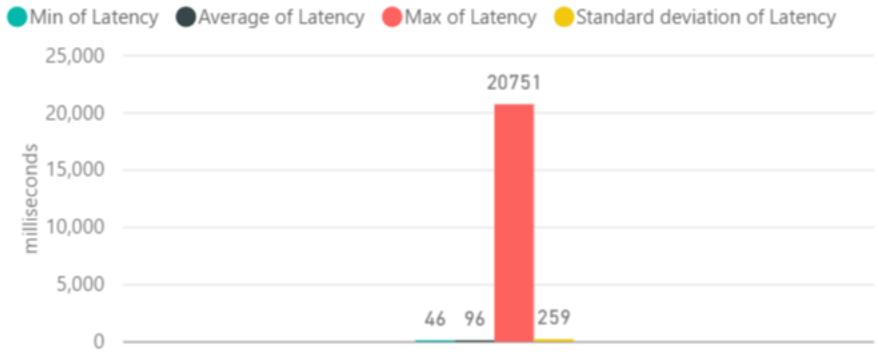


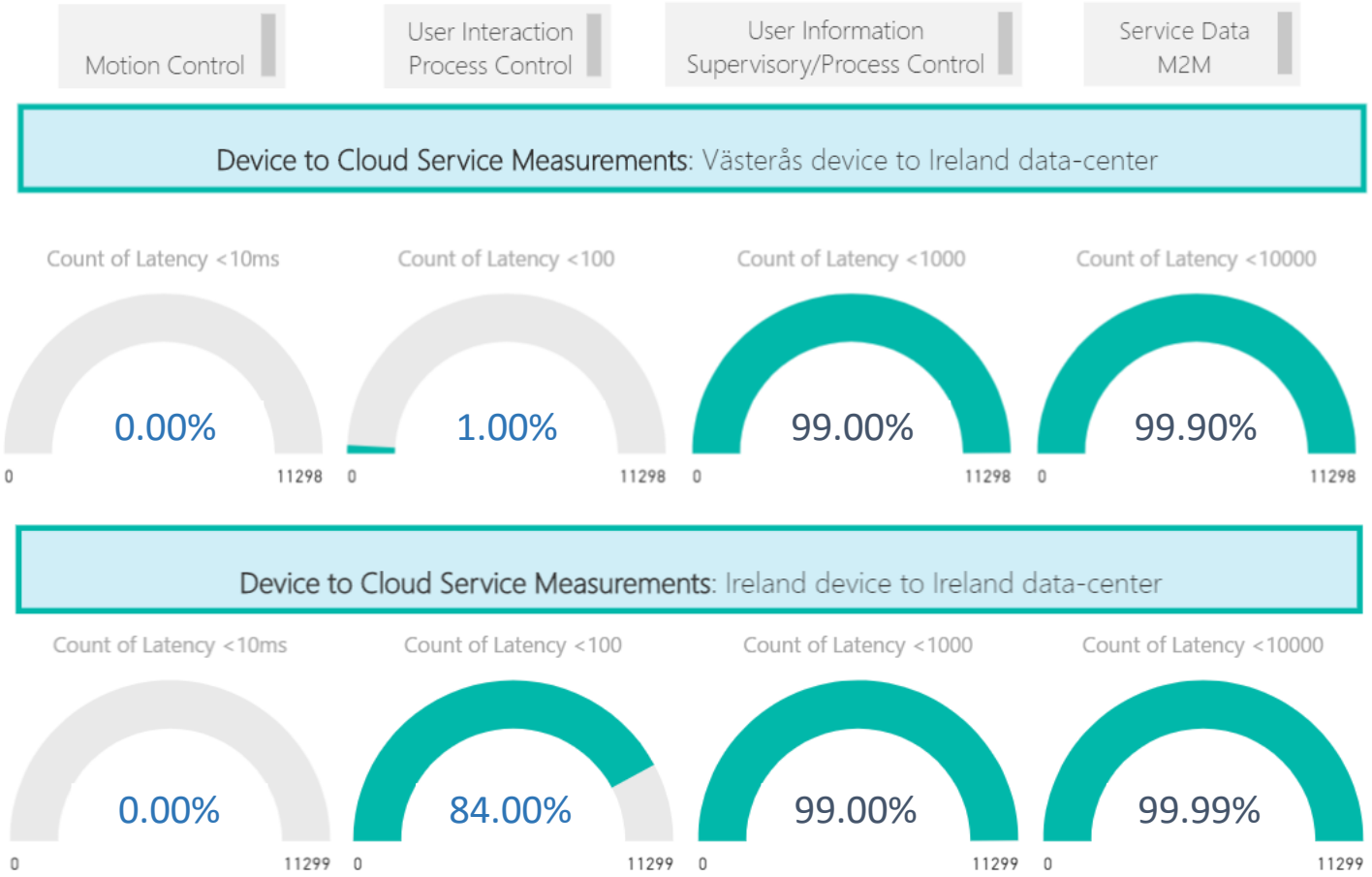




Experimental Results and Availability







Characteristics of Cloud Services

- Lack of time accuracy between device and cloud services
- Cloud services works as scheduled jobs and ASAP
  - Scheduled jobs can create predefined latency, e.g. Stream Analytics
- Throttling limits can increase latency
  - Requests placed in queue
- Throttling limits can stop services and create errors
  - Maximum queue limit encountered
- Application specific architecture design and test throttling limits
  - Worst-case works under limits or service scale accordingly

Next Steps

- Need more concrete use-cases to experiment IoT cloud services
  - Enhance architecture with more industrial services
  - Guidance for designing of application specific industrial SLAs

- Identify challenges and future work to improve QoS
  - Modular redundancy in cloud
  - Cloud Scalability and Replication
  - Dedicated network routing, e.g. express route
  - Edge Computing
  - Distributed Cloud

Business Models for the Internet-of-things

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THE IMPACT OF IOT

BILLIONS OF DEVICES

- More then 50 billion in 2020
- Heterogeneous architectures
- Big Dates and broadband communications

Source: Intel

MANY APPLICATION DOMAINS

- Consumers (i.e., wearable, home automation, wellness)
- Commercial (i.e., retail, building, logistics)
- Industrial (i.e., manufacturing, energy, transportation)
- Public Sector (i.e., Smart Cities and regions, public safety, security, healthcare)

Source: Beecham

DIFFERENT BUSINESS APPROACHES

- Intelligent services
- Open ecosystems
- Different value chains
- Many different business models
- New actors (e.g., Makers)

Source: Freescale

IEEE Internet of Things

A shift in focus to service and value

Data Collection

GIS

Mobility

Sensors

Visualization/
Monitoring

Stationary things

Production

People

Analytics - Optimization

Identify relation/
pattern

Virtual reality
models

Predict/Optimize
Next step

Actuation

Performance
footprint

Autonomous
systems

Predictive
Maintenance

Connectivity | **Intelligence** | **Creating value**

Business Model

Describes the rationale of how an organization creates, delivers, and captures value

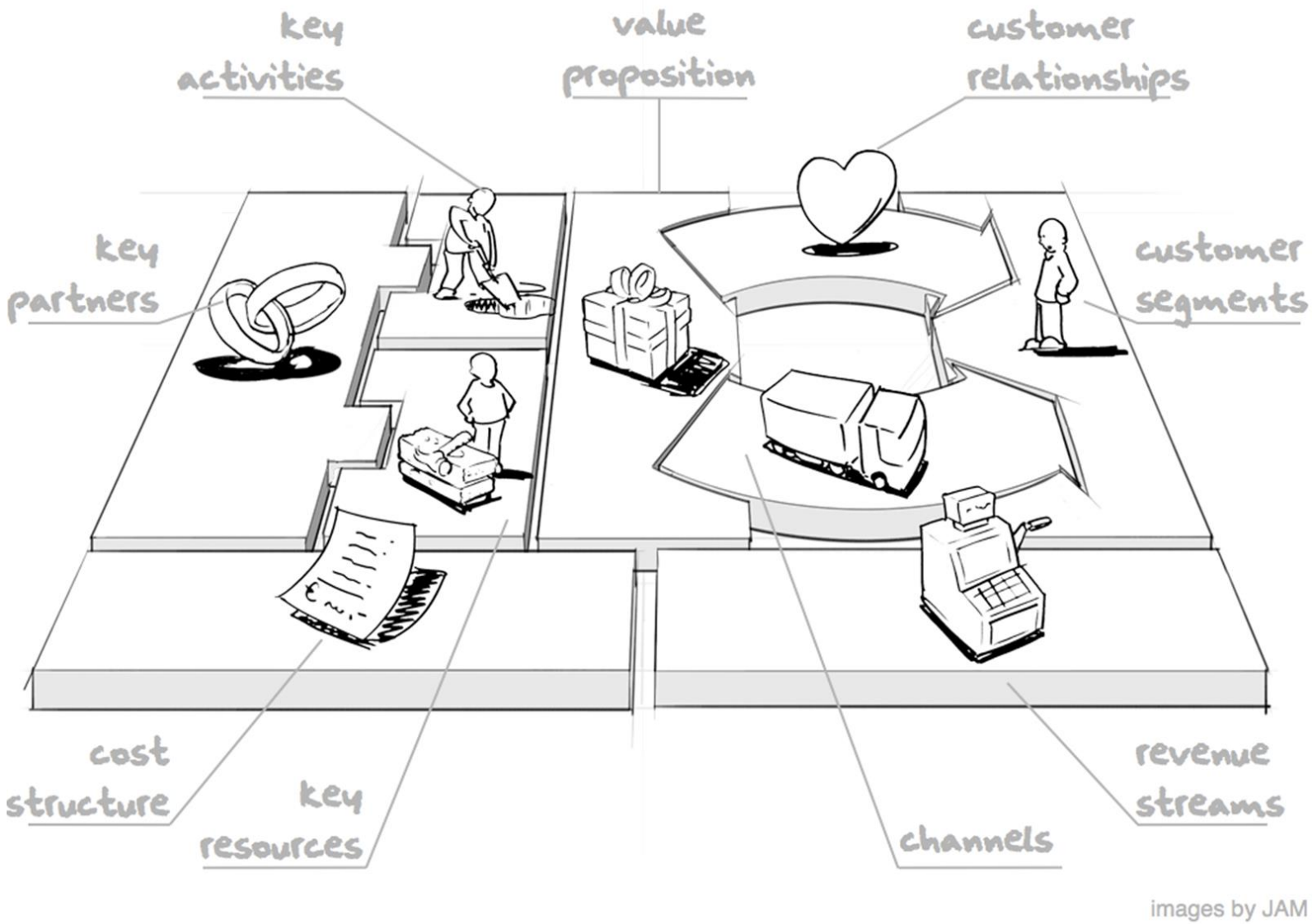
Value Creation

Perform activities that increase the value of a company's offering and encourage customer willingness to pay

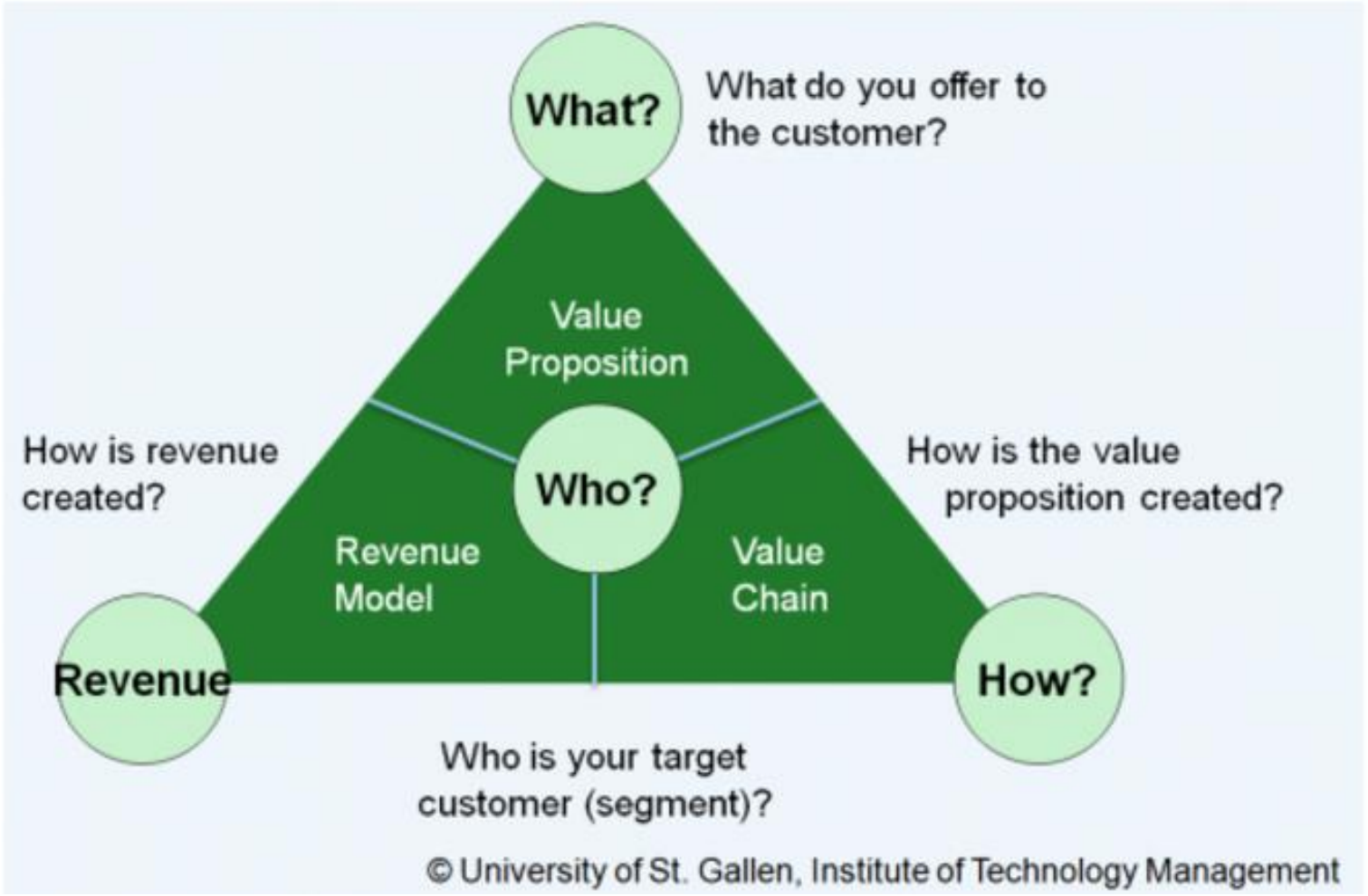
Value Capture

Monetization of customer value

Business Model Canvas



A business model is a blueprint of how a company creates and captures value



The Internet-of-things Requires a Mindset Shift (1)

Create value differently

		TRADITIONAL PRODUCT MINDSET	INTERNET OF THINGS MINDSET
VALUE CREATION	Customer needs	Solve for existing needs and lifestyle in a reactive manner	Address real-time and emergent needs in a predictive manner
	Offering	Stand alone product that becomes obsolete over time	Product refreshes through over-the-air updates and has synergy value
	Role of data	Single point data is used for future product requirements	Information convergence creates the experience for current products and enables services

SOURCE SMART DESIGN

HBR.ORG

The Internet-of-things Requires a Mindset Shift (2)

Capture value differently

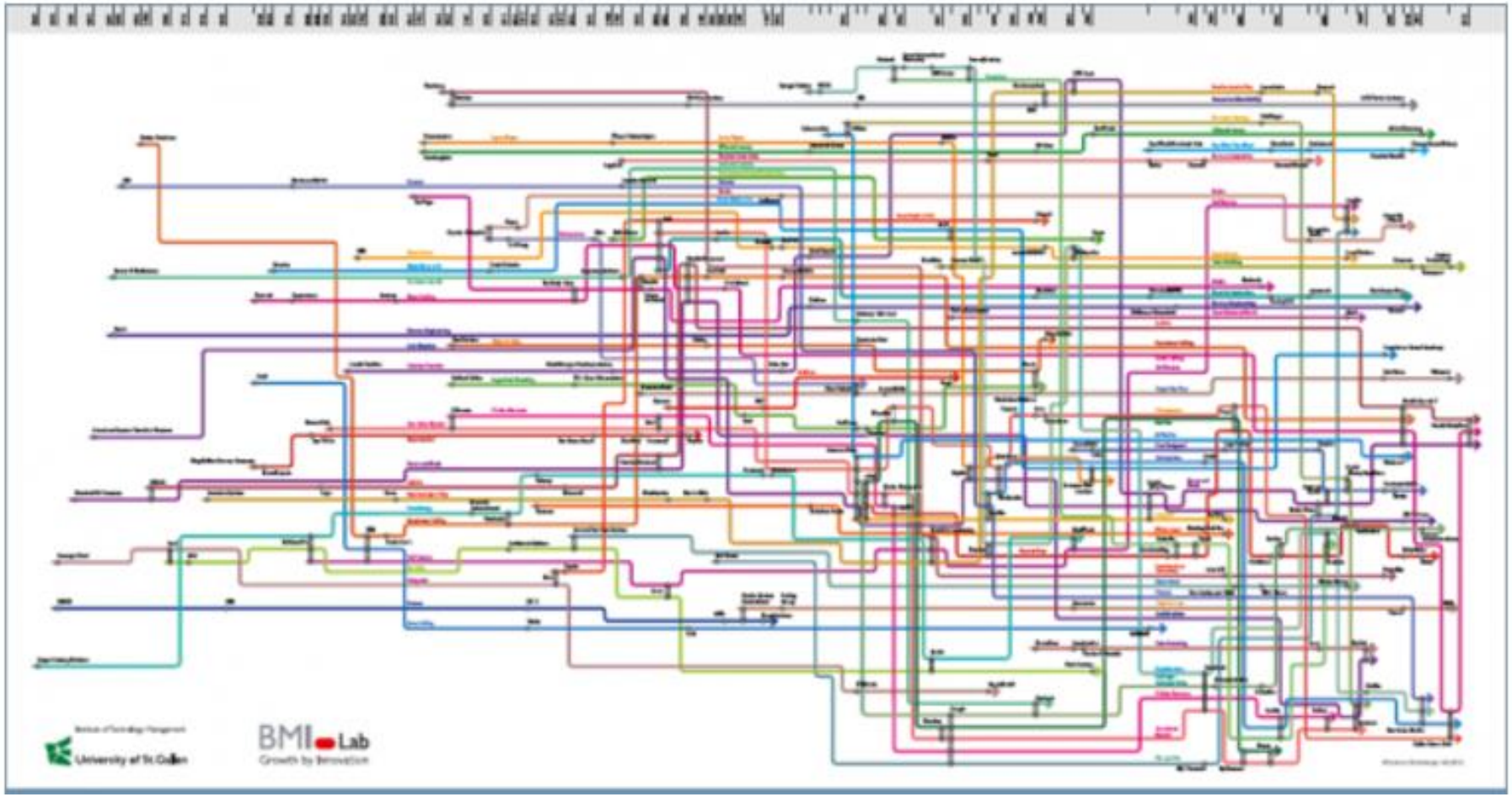
		TRADITIONAL PRODUCT MINDSET	INTERNET OF THINGS MINDSET
VALUE CAPTURE	Path to profit	Sell the next product or device	Enable recurring revenue
	Control points	Potentially includes commodity advantages, IP ownership, & brand	Adds personalization and context; network effects between products
	Capability development	Leverage core competencies, existing resources & processes	Understand how other ecosystem partners make money

SOURCE SMART DESIGN

HBR.ORG

Internet-of-things changes business models

St. Gallen Business Model Innovation Map



Business Model Patterns

Digitally Charged Products

Product as a point of sales
Digital add-on
Object self service
Remote usage and condition monitoring

Sensor as a Service

The data-generating products or the resulting services are no longer the central focus in this pattern but rather the data itself

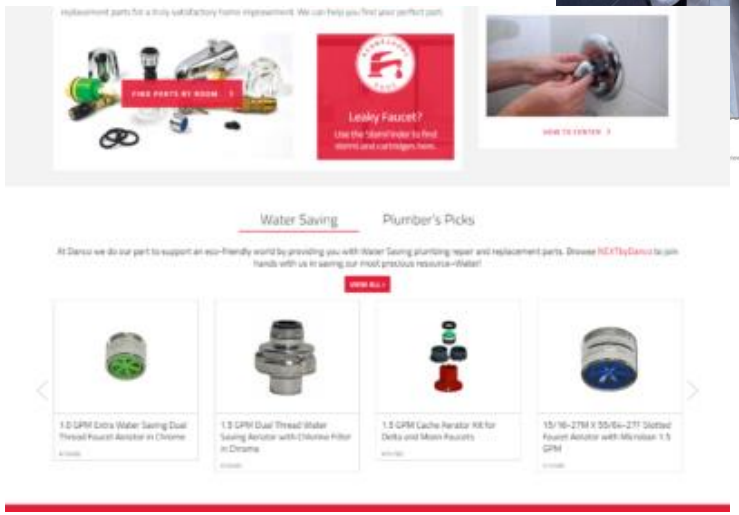
Experience selling

The value of a product/service is increased by an enhanced customer experience offered with it

Business Model Pattern “Digitally Charged Products”

Product as a point of sales

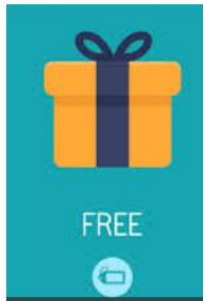
Physical products become sites of digital sales and marketing services

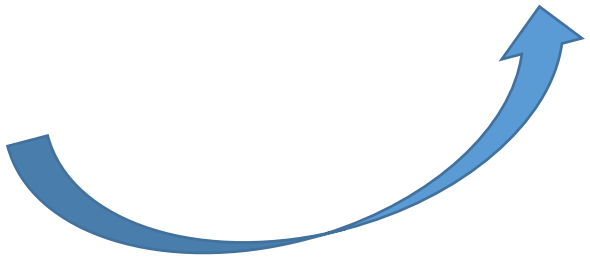


Business Model Pattern “Digitally Charged Products”

Digital add-on

A physical assets is sold together with a free digital service at no additional cost. Over time, the customer can purchase premium services and get invoiced.





Business Model Pattern “Digitally Charged Products”

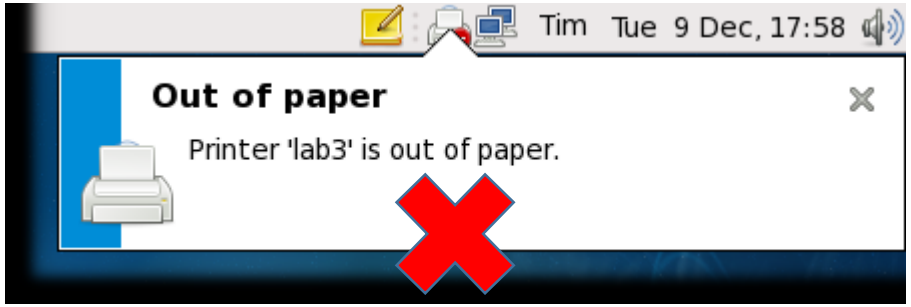
Digital add-on

The usability of a product/service or sub-functions can be restricted to the time span of a subscription.

Business Model Pattern “Digitally Charged Products”

Object self service

Physical assets have the ability to serve themselves by placing orders on the internet or from the storage, etc.



Business Model Pattern “Digitally Charged Products”

Remote usage and condition monitoring

The use and consumption of a product/service is measured and charged (pay per use)

Monitoring the status of production plants or equipment to guarantee performance and availability

Simple PAY AS YOU GO Business Model

Business Model Pattern “Experience selling”

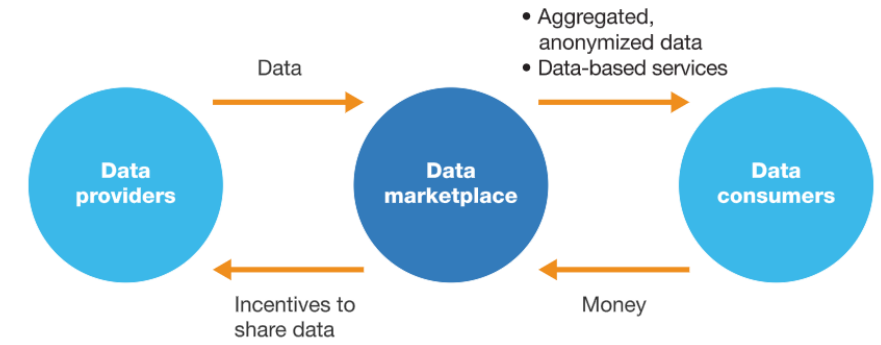
The value of a product/service is increased by an enhanced customer experience offered with it

Business Model Pattern “Sensor as a service”

Collecting, processing and selling the sensor data for a fee from one subsection to other subsections.

The data-generating products or the resulting services are no longer the central focus in this pattern but rather the data itself -> Data marketplace

Aggregated data can be an incentive for providers to share information.



McKinsey&Company

How is the marketplace best structured?

Mine Swish - A Future Mining Business Model

+ swish® = Sant ?

Mine Swish - A Future Mining Business Model (1)

Sensor as a Service

The data-generating products or the resulting services are no longer the central focus in this pattern but rather the data itself

Offering analytics and insights

Why the operation costs over a certain period is high?
Why the energy consumption is high last week?
How is the utilization rate of mining machines over a certain period?
What is the root cause of a too low mean-time-between-failure for the mining machines?

Mine Swish - A Future Mining Business Model (2)

Digitally Charged Products

Product as a point of sales
Digital add-on
Object self service
Remote usage and condition monitoring

Digital offerings

Predictive maintenance instead of reactive or time-based maintenance (maximize equipment availability)
Service updates and upgrades
Reporting (daily, weekly, monthly)
Integration with other services, e.g., mine safety, fleet management, mine ventilation, etc.

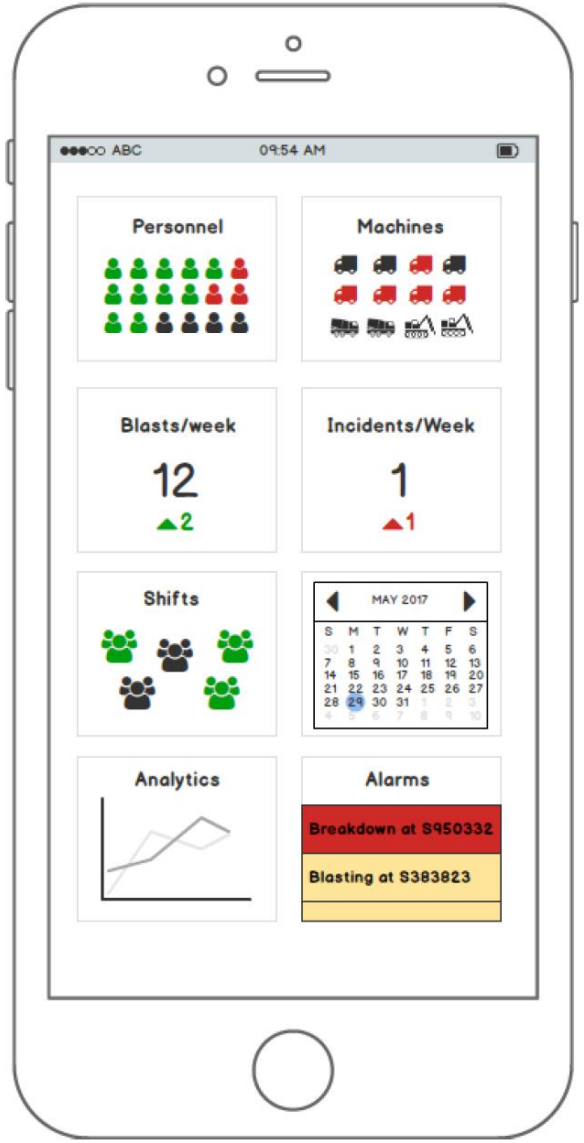
Mine Swish - A Future Mining Business Model (3)

Experience selling

The value of a product/service is increased by an enhanced customer experience offered with it

Convenience and increased accessibility by offering services in mobile devices:

Notifications to operator on events
Visualization of activity schemes on mobile devices
Video and voice communication
Visualization of KPIs for production status



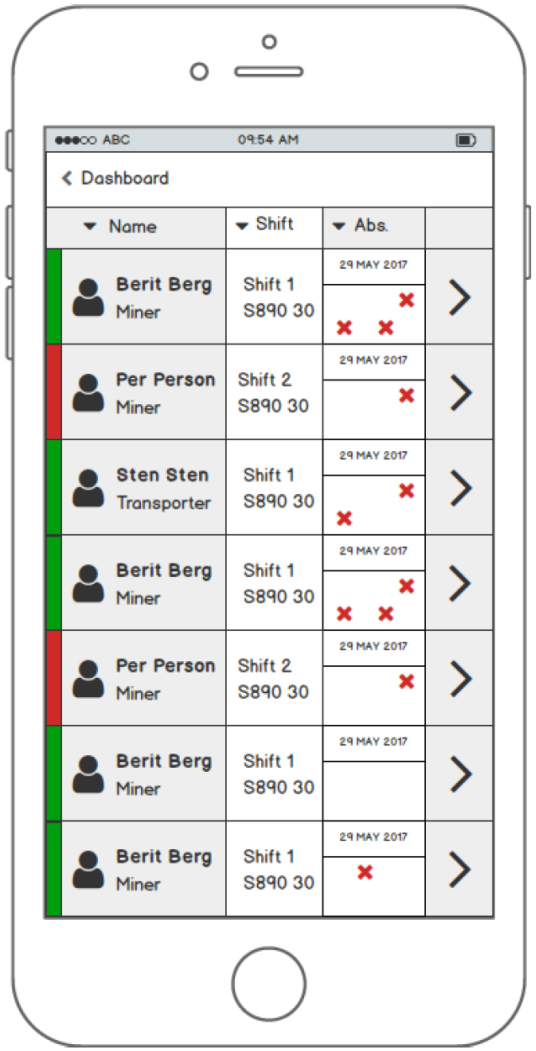
Mine Swish - A Future Mining Business Model (4)

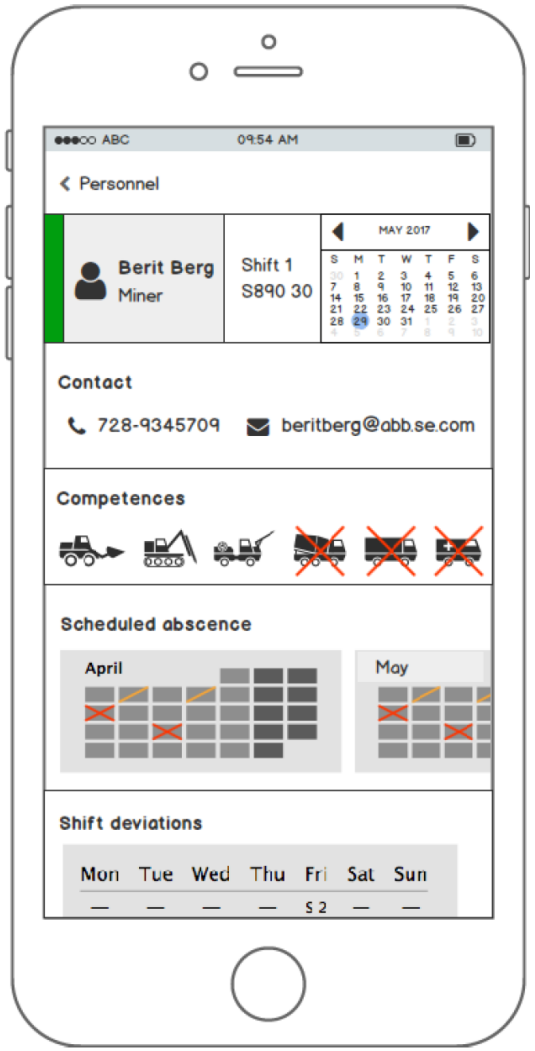
Experience selling

The value of a product/service is increased by an enhanced customer experience offered with it

Convenience and increased accessibility

Visualization of activity schemes on mobile devices





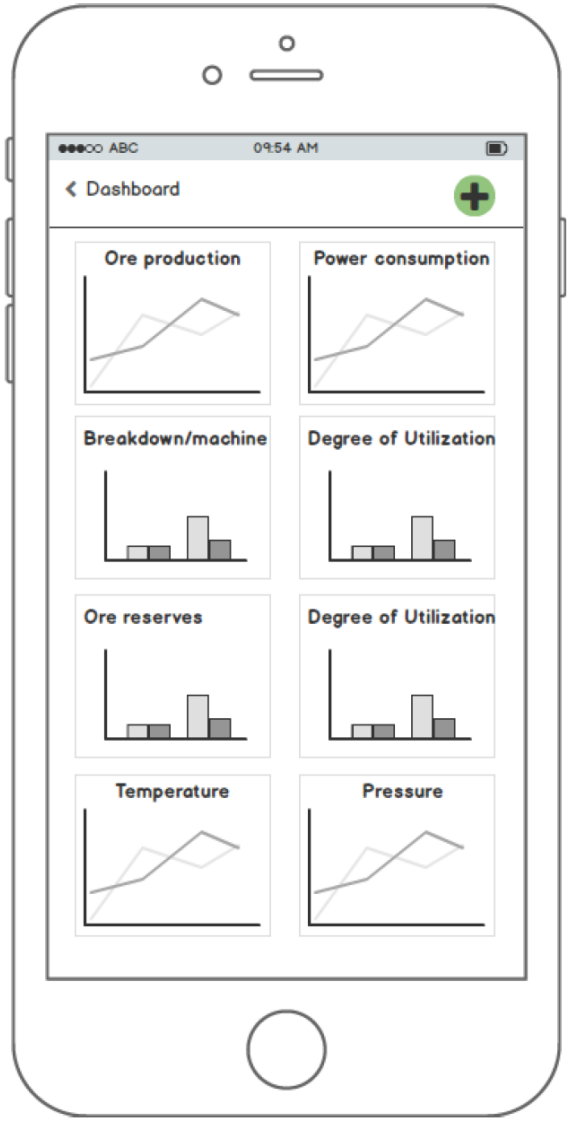
Mine Swish - A Future Mining Business Model (5)

Experience selling

The value of a product/service is increased by an enhanced customer experience offered with it

Convenience and increased accessibility

Visualization of KPIs for production status



Challenges

Data perspective

Data privacy, confidentiality, integrity, ownership, and traceability
Data quality and trust
Value co-creation through data sharing and integration
Who takes the role of data marketplace?

Service perspective

How to achieve recurring revenues?
Trust between service provider and service consumer
Quality of service
Ease of use

Transition perspective

How is the organization influenced due to the transition from product-dominant to service-oriented business model?
Step-wise transition from existing business model to adapt to Internet-of-things context

Legal perspective

Compliance with regulations
SLA legal aspects

Future Perspectives

Value design shifting from a firm to designing business models for ecosystems

- Integration of actors, various resource flows, and value exchange between them

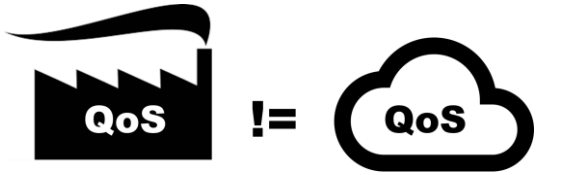
Value design shifting from data sharing to co-developing

- Greater level of collaboration and sharing - all actors collaborate and co-develop high value analytics solutions (creating value and wins for all actors involved)

Value design to embed sustainability thinking

- Make sustainable choices to reduce material consumerism and enhance product lifecycles

Reflections, Next steps


QoS
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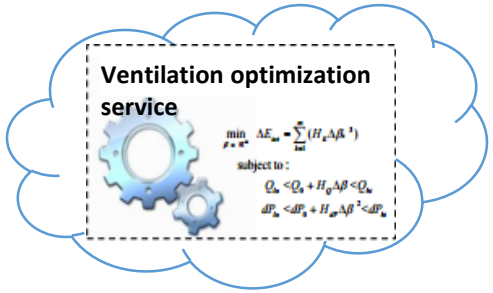
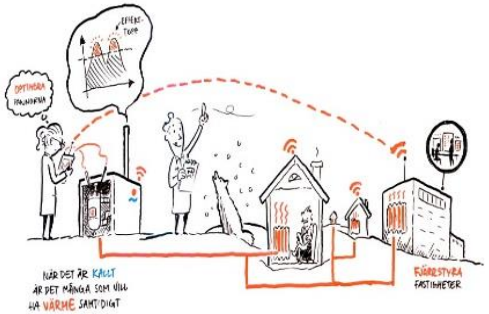
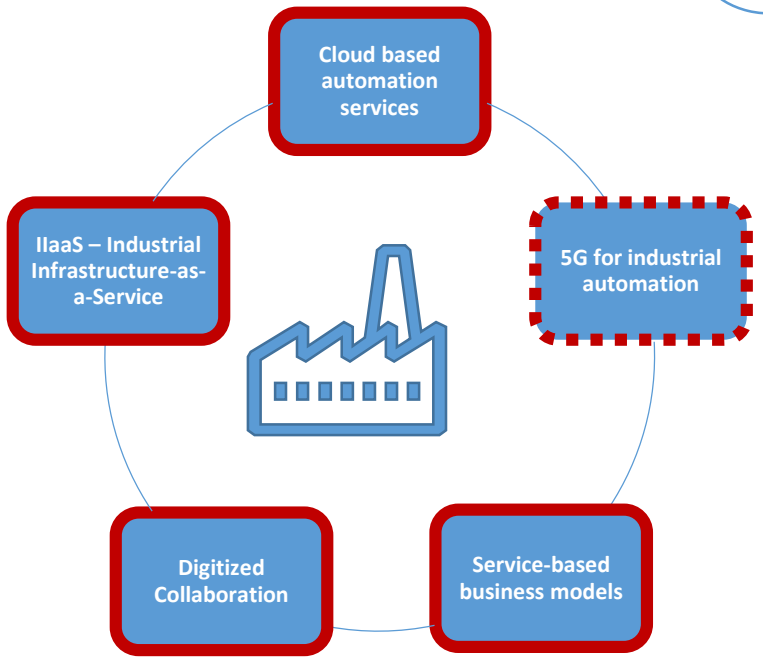
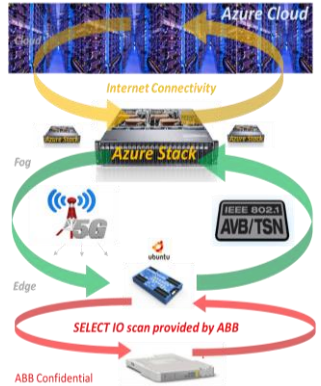
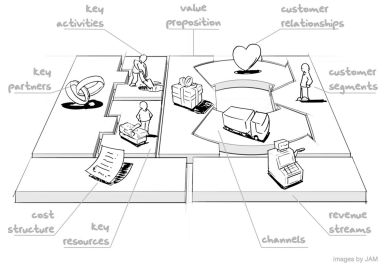
QoS


Ventilation optimization service



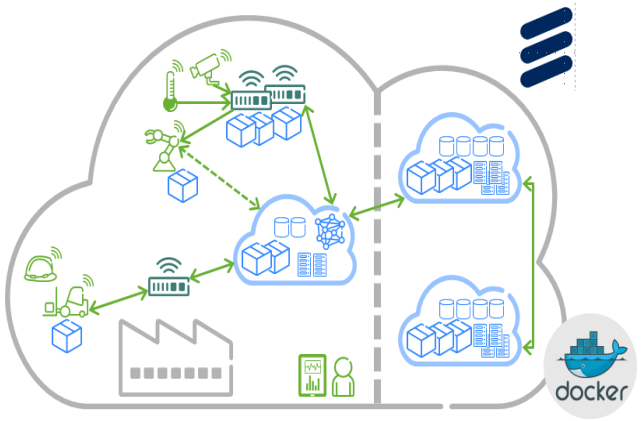

Cloud based automation services
IIaaS – Industrial Infrastructure-as-a-Service
5G for industrial automation
Digitized Collaboration
Service-based business models


Azure Cloud
Internet Connectivity
Azure Stack
Fog
Edge
IEEE 802.1 AVB/TSN
SELECT IO scan provided by ABB
ABB Confidential


key activities
value proposition
customer relationships
key partners
customer segments
cost structure
key resources
channels
revenue streams

Planning next sprints – Ideas/partners

Distributed Cloud



Machine learning in UC

Cyber security

FireEye and Mandiant Merger 01-08-2014-Forbes

Arla

storaenso

ERICSSON

LKAB

SANDVIK

NEW BOLIDEN

MälarEnergi

ABB

RI. SE

Concept demonstrators

Mine Ventilation Optimizer as a Cloud Service

ABB RI.SE

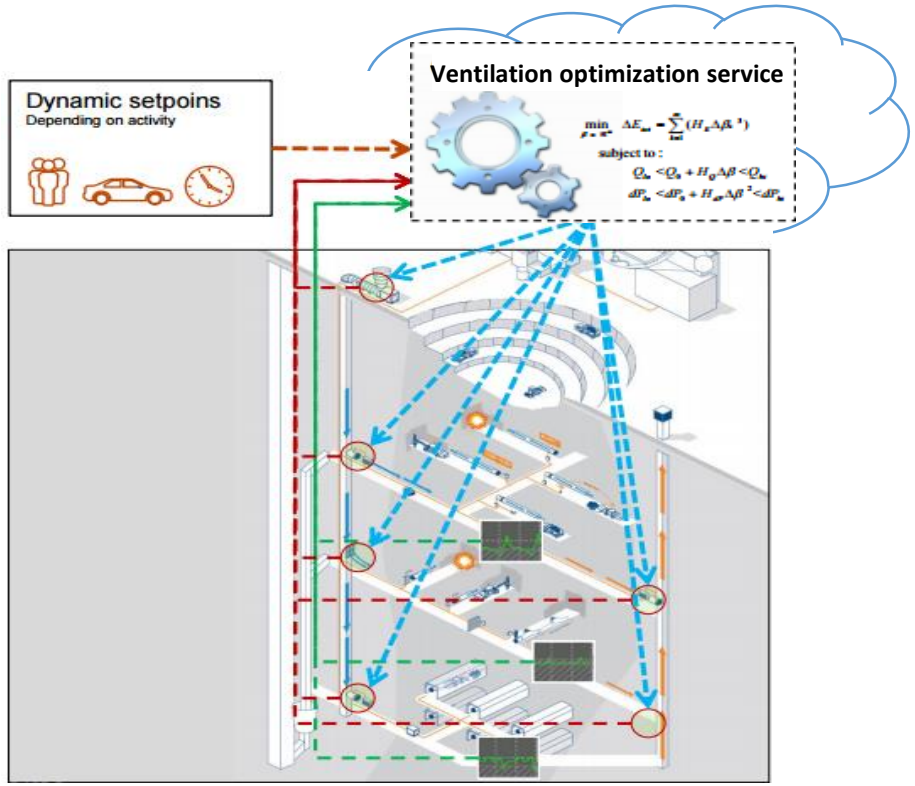
Enable new capabilities and services

- The service is managed from a central location
  - Flexibility to modify and improve the SmartAir™ Optimizer

- Customers use the service as needed
  - Easy upgrade and change to new levels of mine ventilation
  - Easy installation and maintenance
  - Easy to handle software upgrades and patches

- Monitor ventilation data from across different mine sites
  - Visualization of ventilation-related data to assist decision makings, e.g., historical data, real-time data, and KPI tracking, etc.

- Suggestion for optimization algorithm improvement based on machine learning



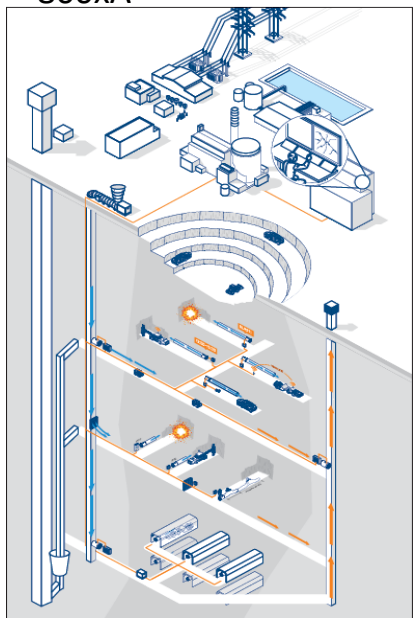
Architecture (based on Microsoft Azure cloud services)

Azure Function

Service Fabric

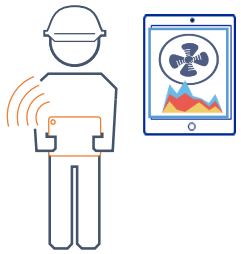
Virtual Machine

800xA



Vent. parameters

Setpoint



Production activities

Data collection

Ingestion

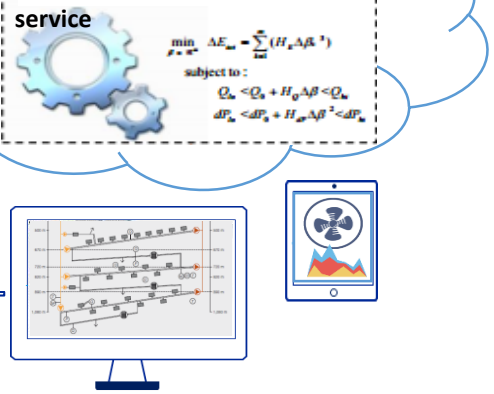
IoT Hub

Event Hub

Actual fan speed

Scheduled every X minutes

Ventilation optimization service



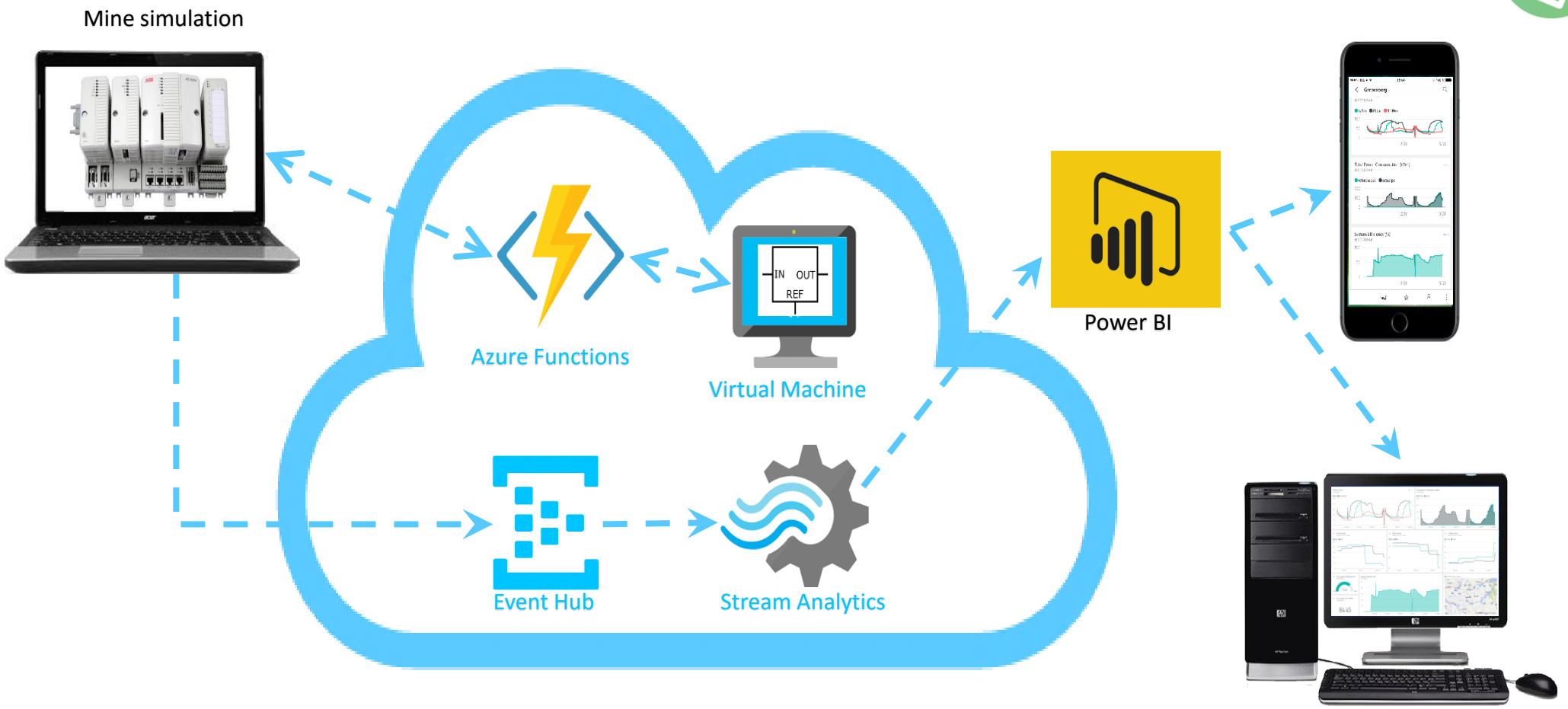
Event-based control

Other cloud services for decision support, e.g., planning and scheduling, etc.

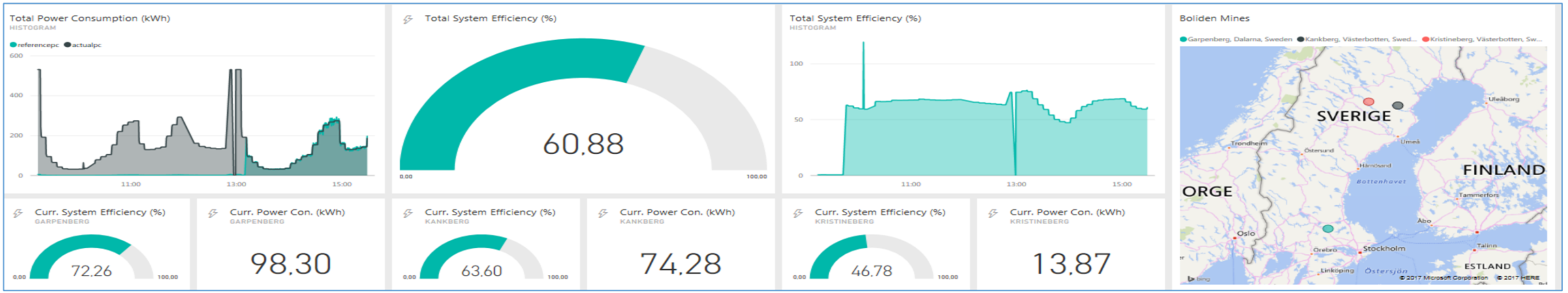
ABB

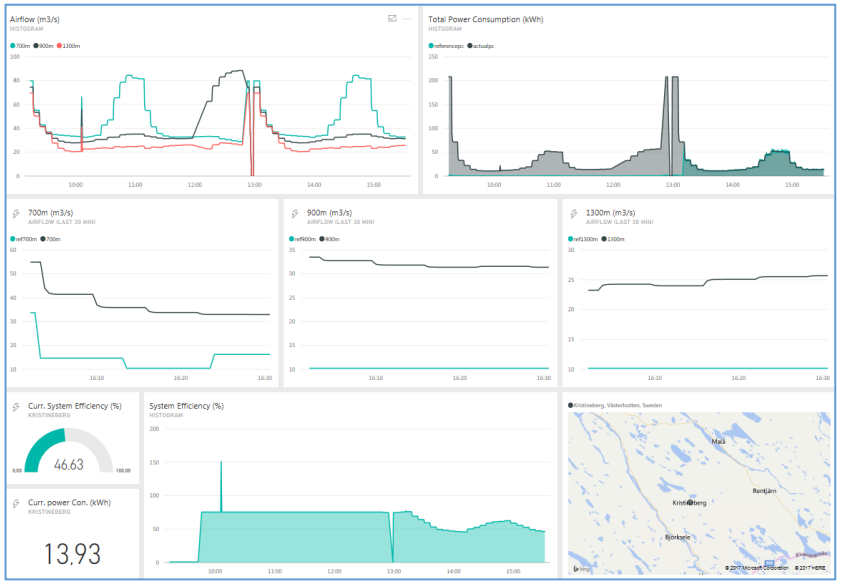
RI. SE

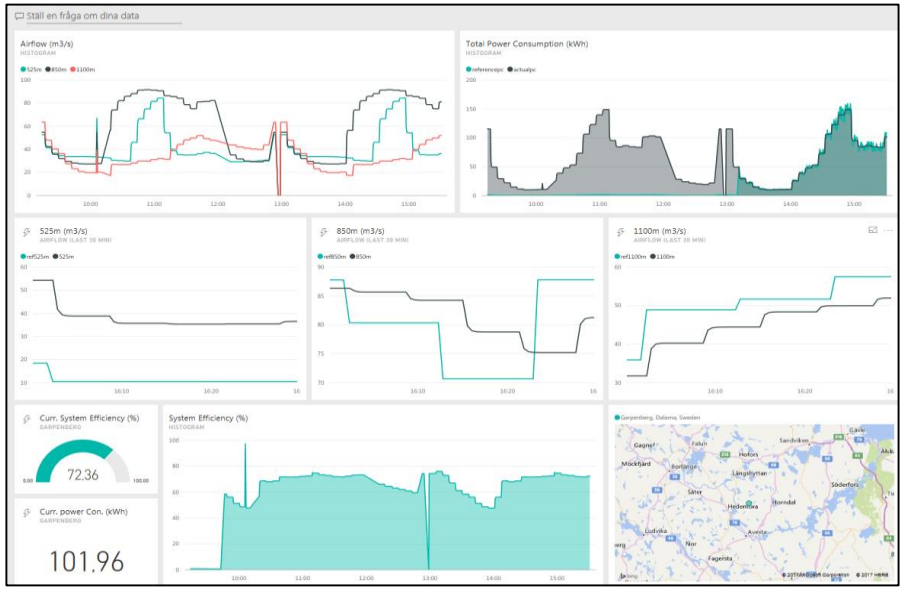
Demo set-up

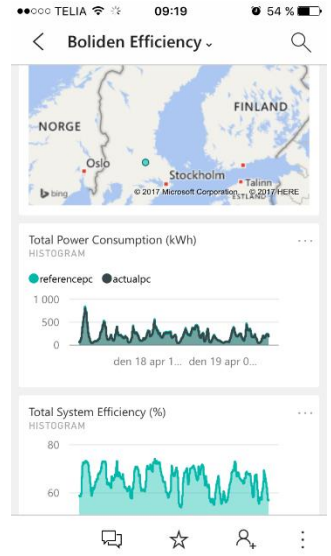

Mine simulation
Azure Functions
IN OUT
REF
Virtual Machine
Power BI
Event Hub
Stream Analytics

Power BI visualisering









IoT Hub connect