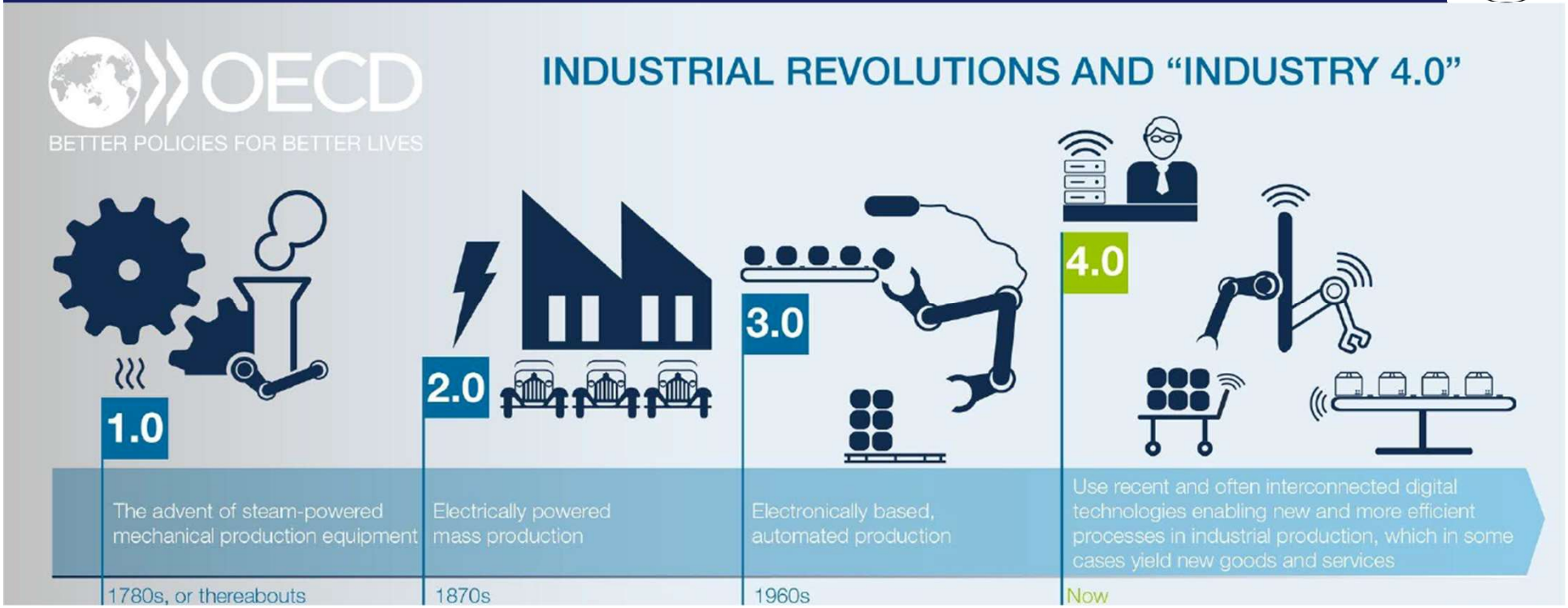
Big Data, Analytics and Industrial IoT - Enablers for the next industrial revolution

Prof. Andreas Kassler
CS Department
Karlstad University

Before we begin…

Go to www.menti.com and use the code 46 92 27

ICT Is Enabling the Industry4.0



- Industry4.0
  - Confluence of new technologies
  - Pace and scale
  - Unified by ICT

- New&Customized
- Safer
- Faster
- Greener
- More Efficient

New ICT Architecture and a New Ecosystem

Apps

Real-time Cloud Control

Apps

Smart Manufacturing

Online production

Real-time collaboration

Big Data

analytics platform

Cloud

Offline analysis

Decision-making support

5G IoT/TSN

Mission Critical Programmable Network

Everything is connected

Industrial devices

Devices

User devices

> > >

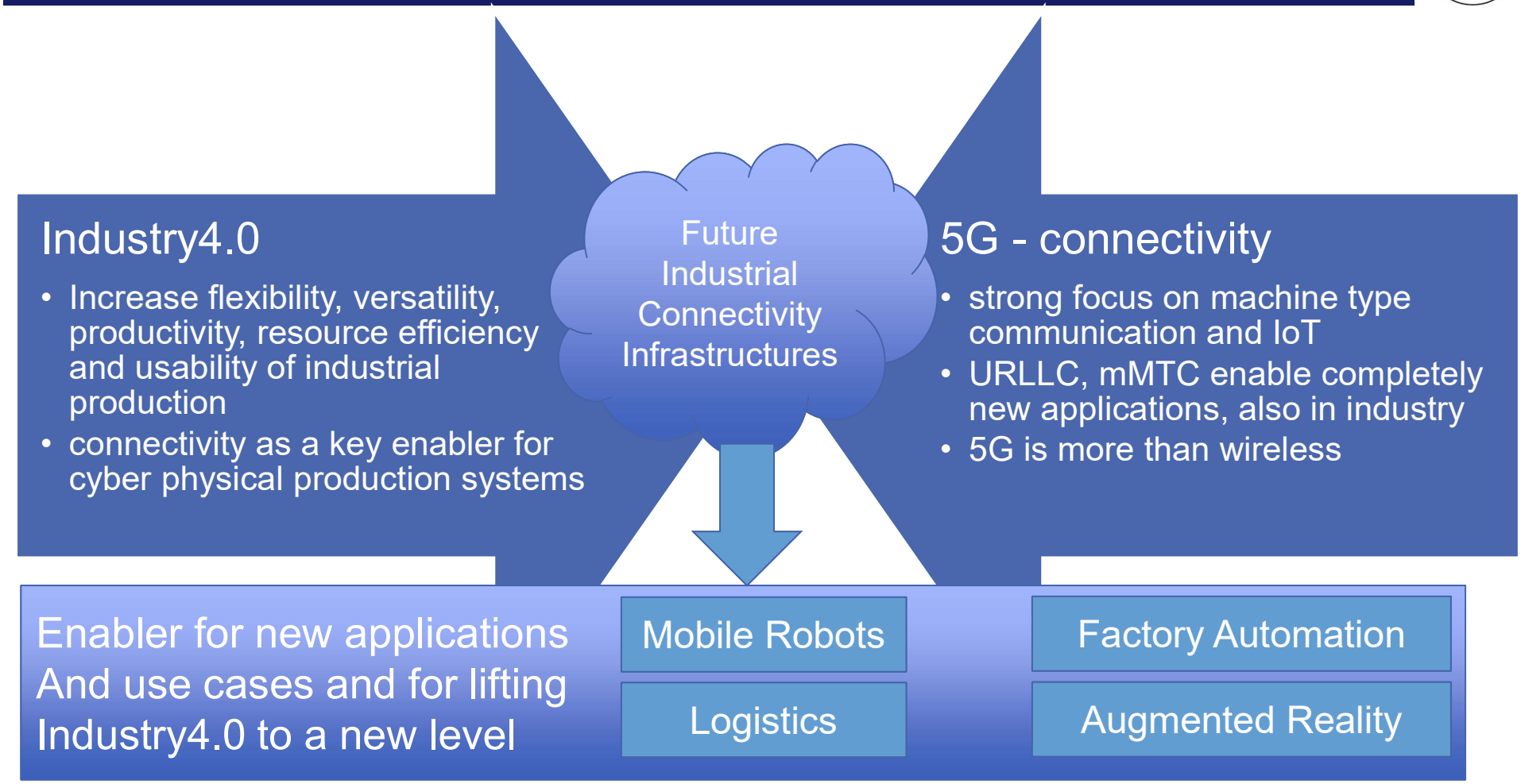
Intelligenti-zation

Business-Driven

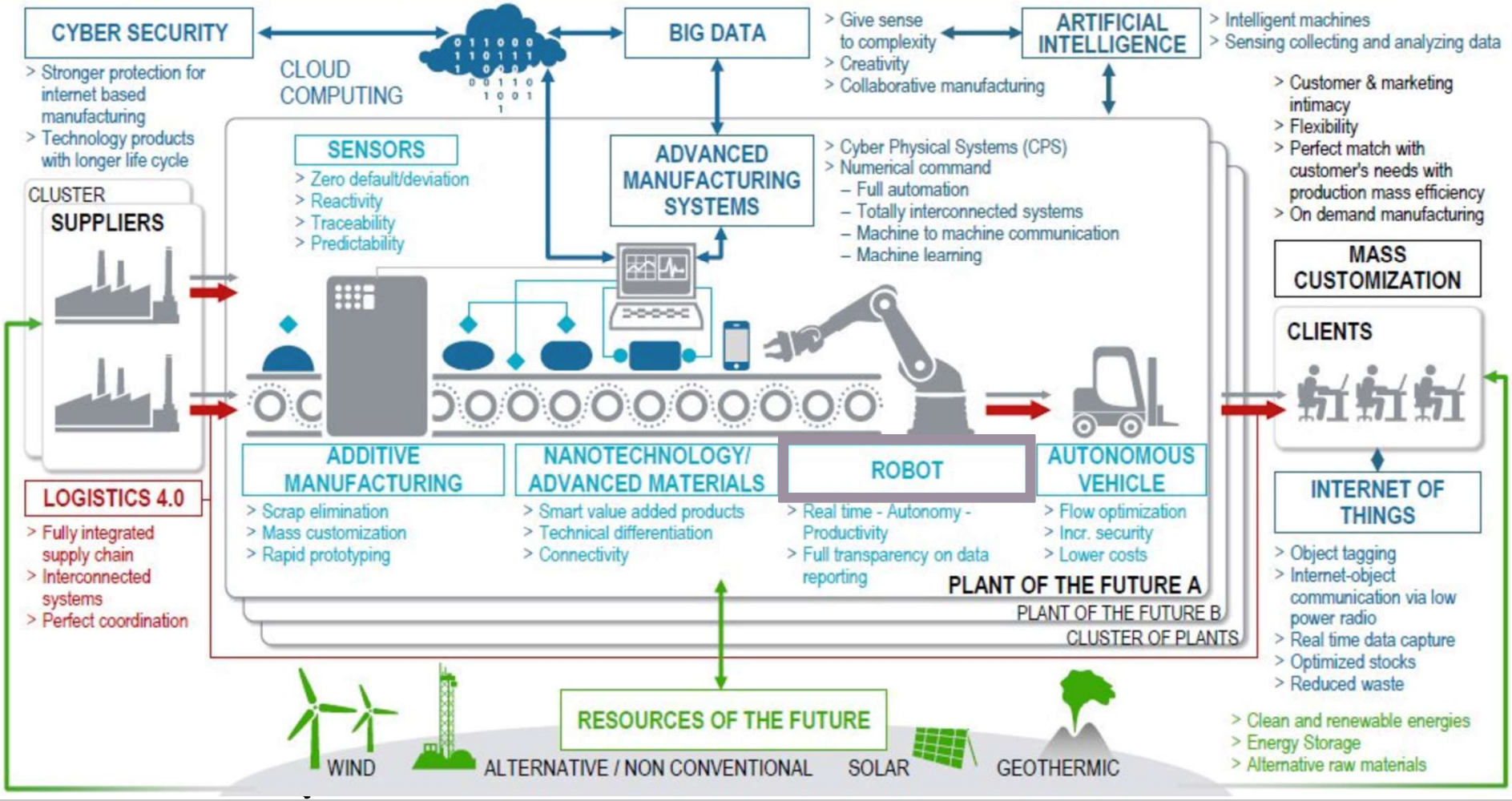
New Ecosystem

Agile Innovation

5G enabler for industry4.0

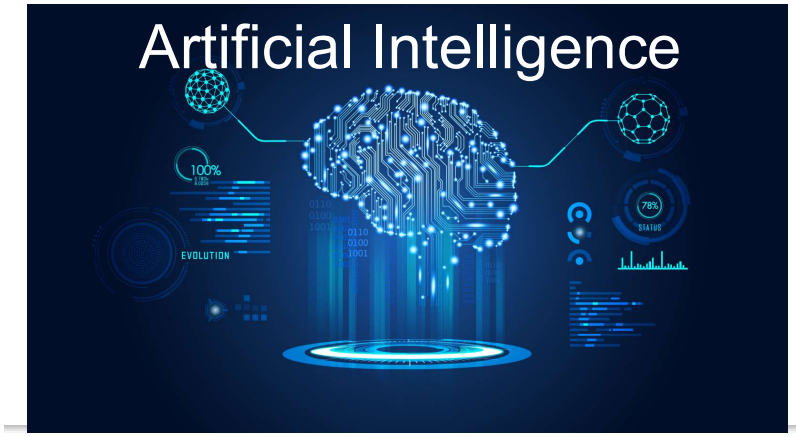


Industry 4.0 Ecosystem



Tonights Program…

Threat? Opportunity?



What is Big-Data?

What is Data Analytics?

Relationship between BD, Analytics &AI

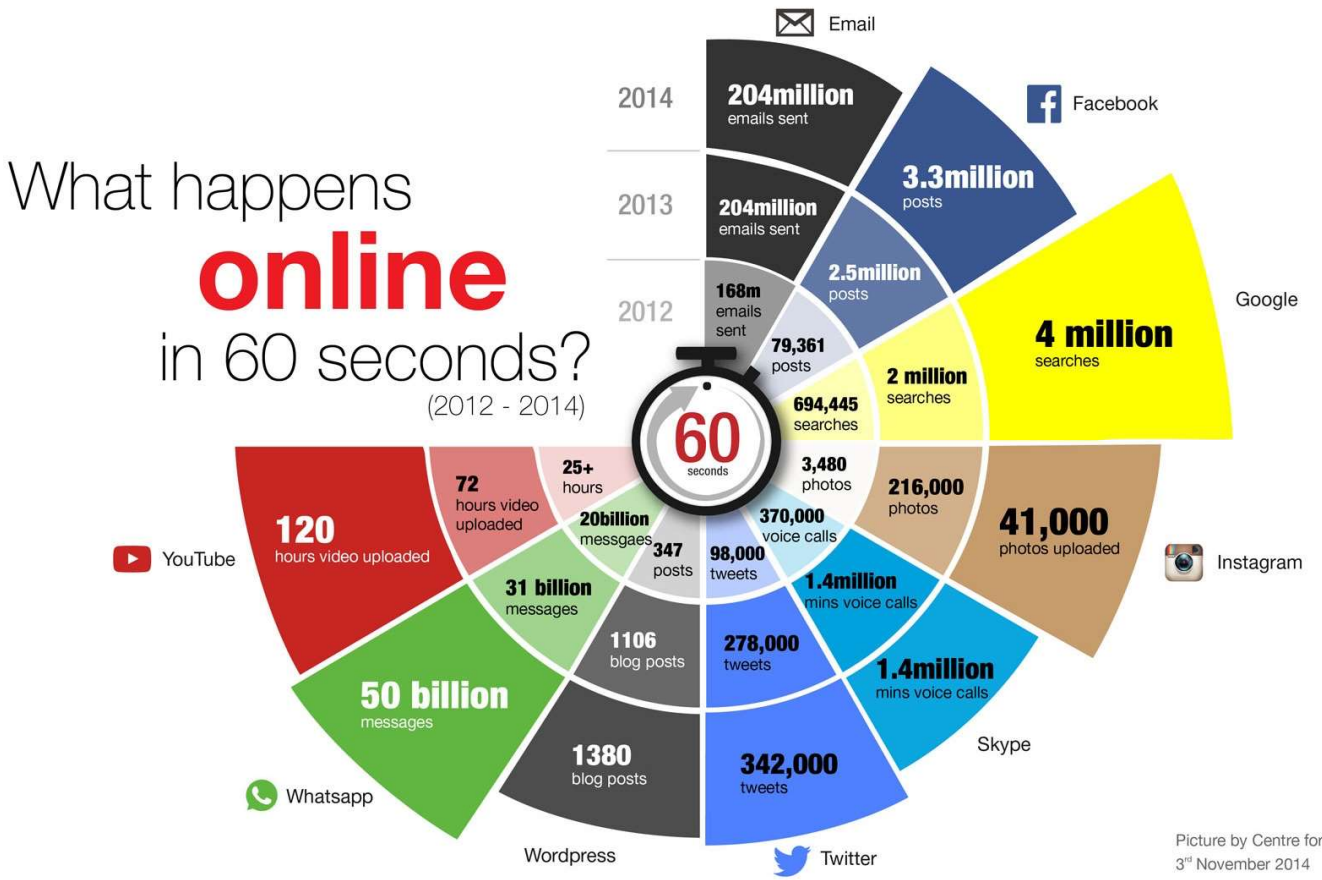
What is the role of analytics in IIoT

What is the value of analytics in IIoT

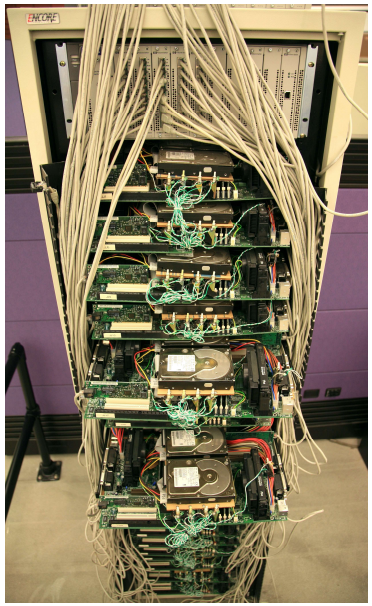
Architectural Issues

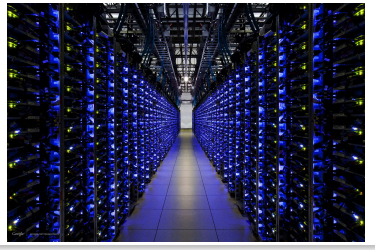
Case studies

10 years ago…the rise of data centers



Picture by Centre for Learning and Teaching
3rd November 2014

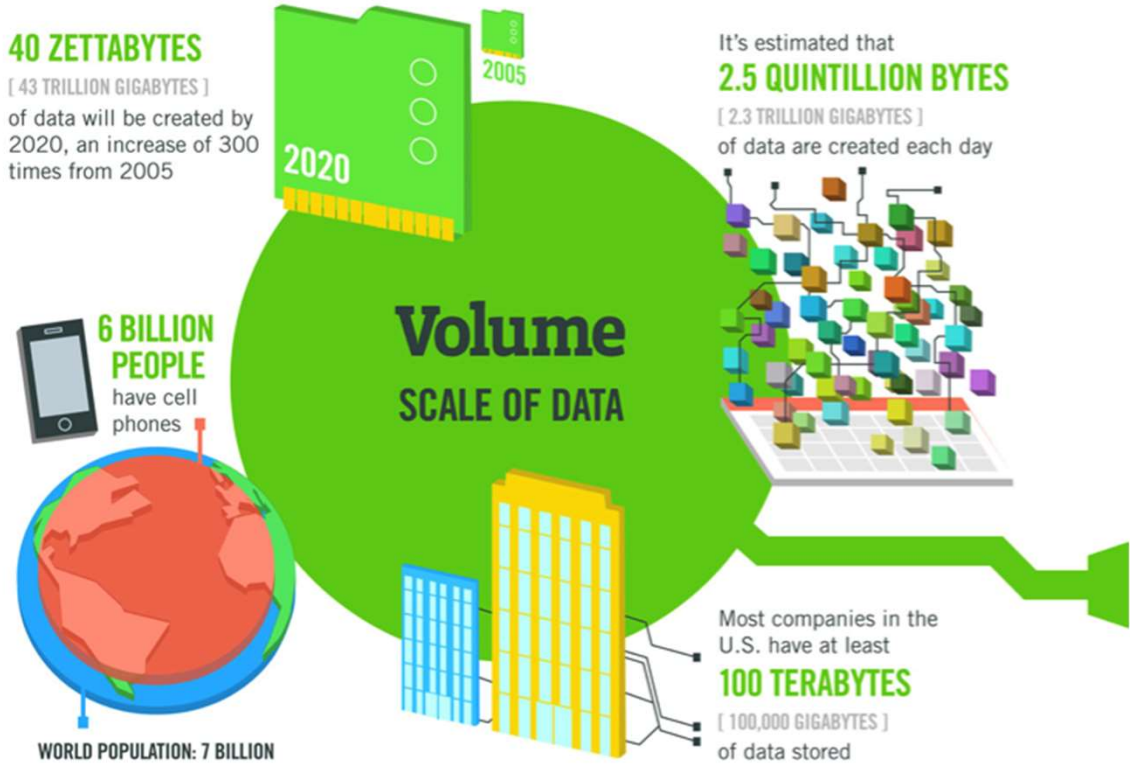




The rise of data centers

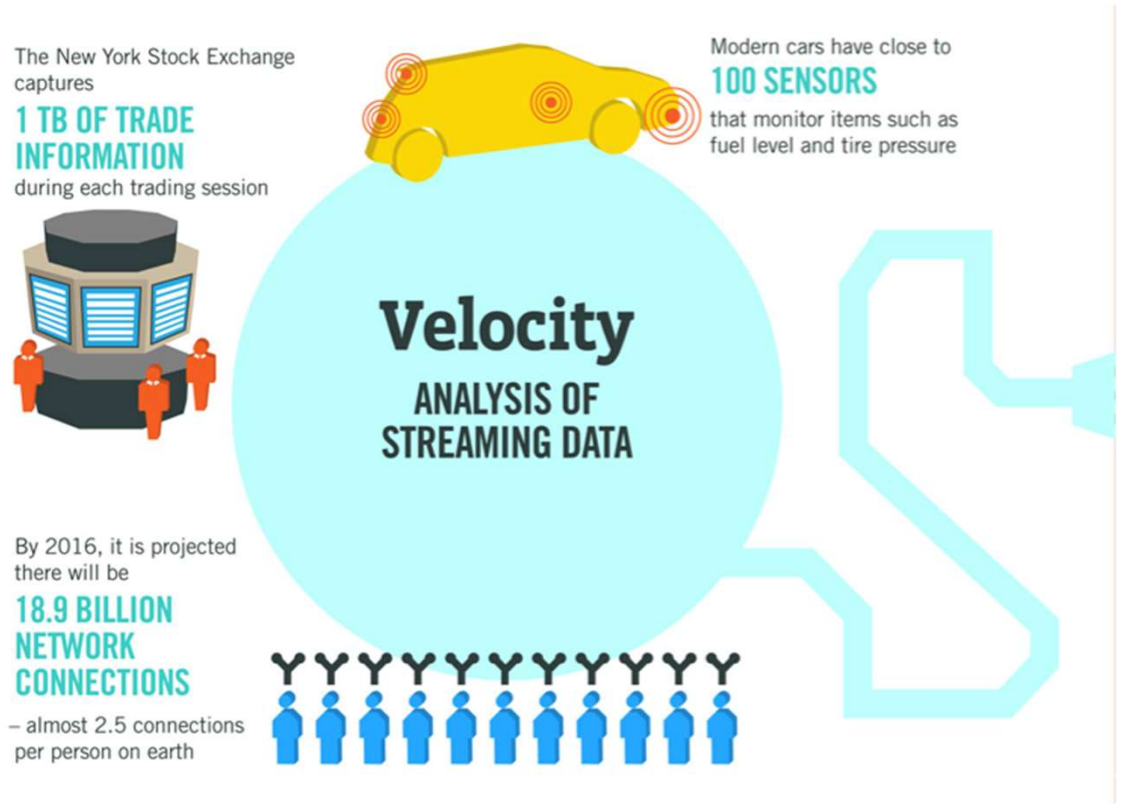
The 4 V: Volume

- Terabytes to exabytes of data to process



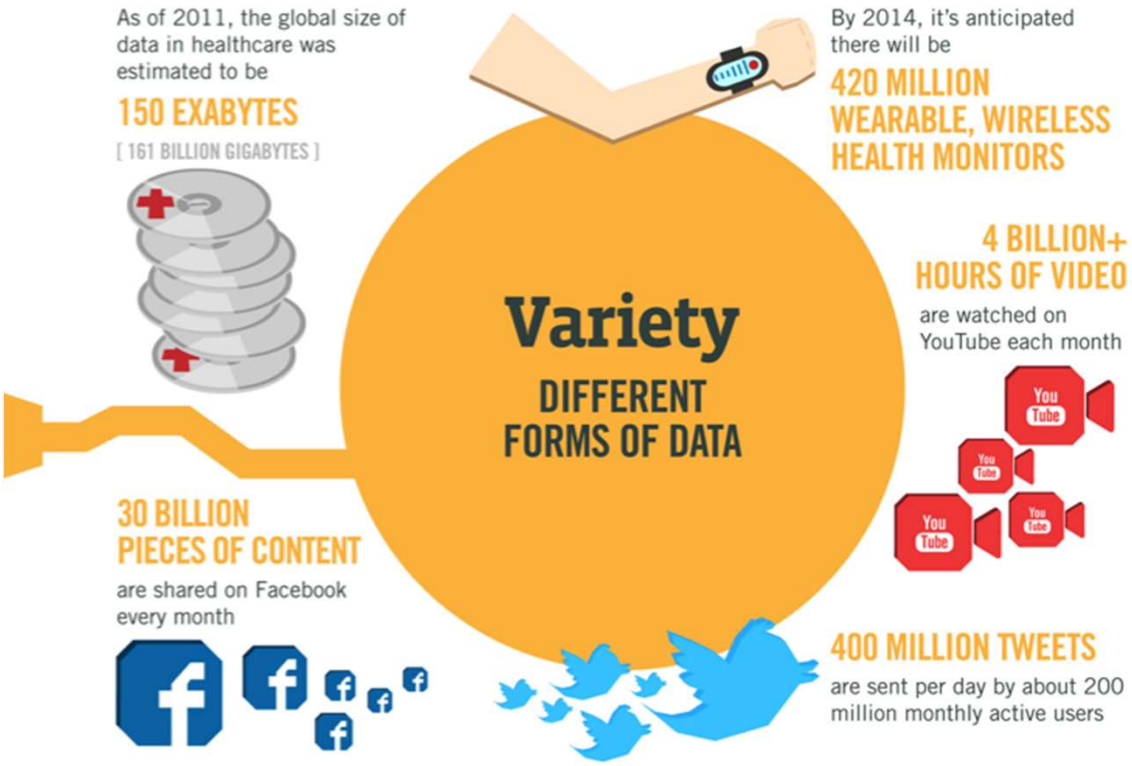
The 4 V: Velocity

- Streaming data
- ms to respond



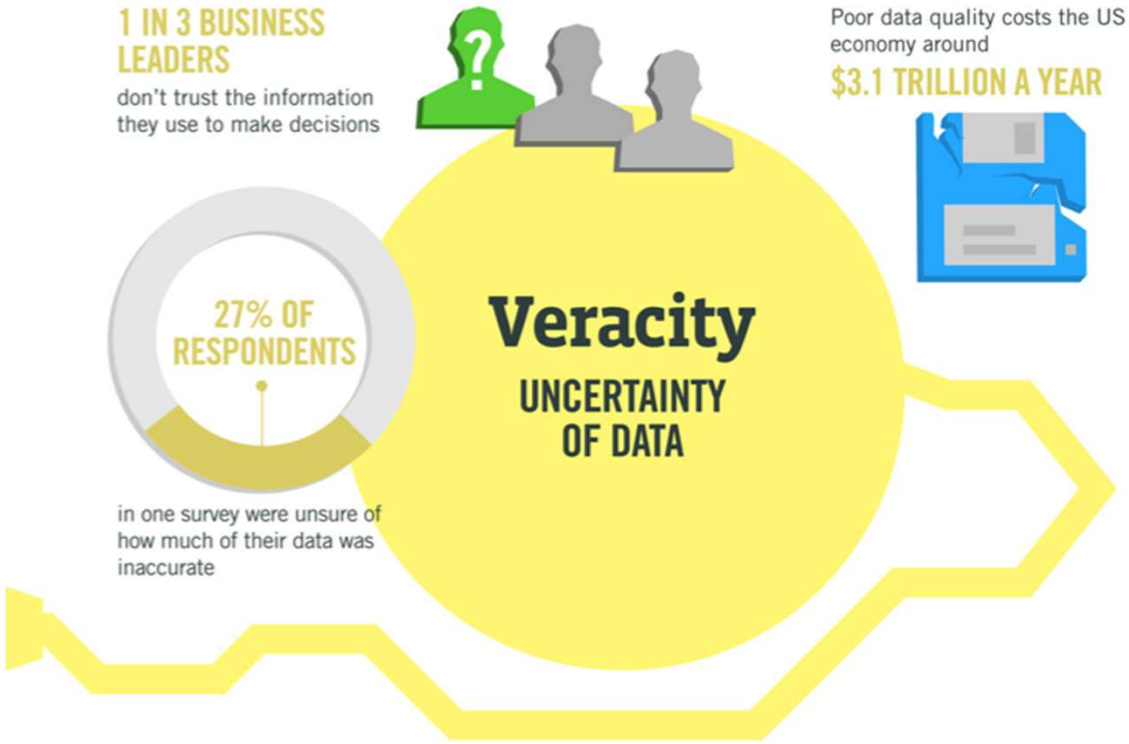
The 4 V: Variety

- Structured
- Unstructured
- Text
- Multimedia
- Video
- …



The 4 V: Veracity

- Due to data inconsistency, incompleteness, ambiguities, latency, deception, model approximation



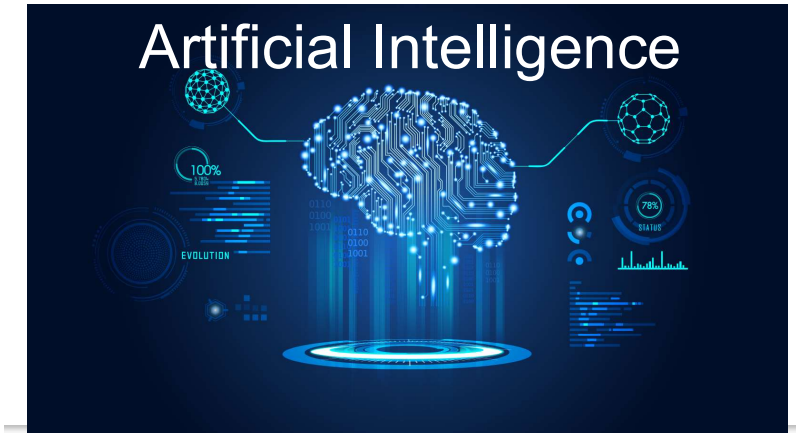
Big Data vs traditional DB

- Traditional
  - Structured/relational
  - Cost increase with size/growth
  - Well defined models and DB schema
  - ERP, CRM, SCM, App Data

- Big Data
  - Unstructured data
  - Scaling at low cost
  - Flexibility and complex analytics
  - Massive amounts of data
  - Distributed processing

Tonights Program…

Threat? Opportunity?



What is Big-Data?

What is Data Analytics?

Relationship between BD, Analytics &AI

What is the role of analytics in IIoT

What is the value of analytics in IIoT

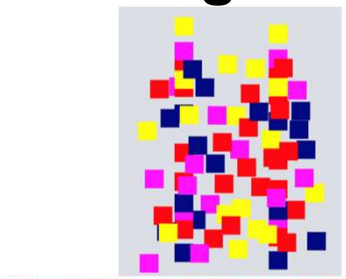
Architectural Issues

Case studies

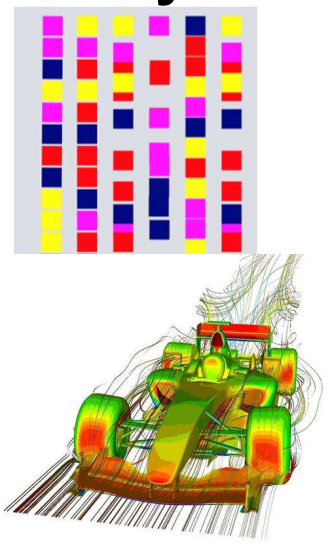
What is Data Analytics ?

Data analytics applies statistical techniques to large data sets to obtain actionable insights for making smart decisions. It tries to uncover hidden patterns, unknown correlations, trends and any other useful business information

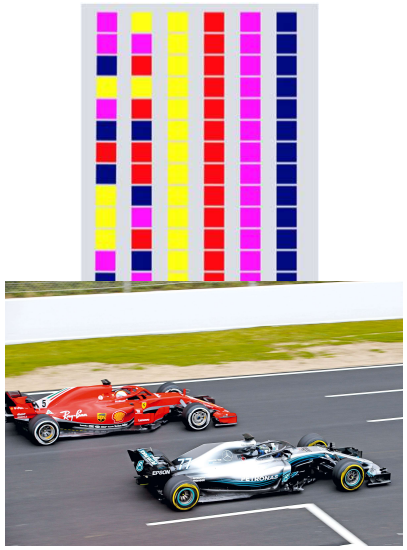
Big Data



Analytics

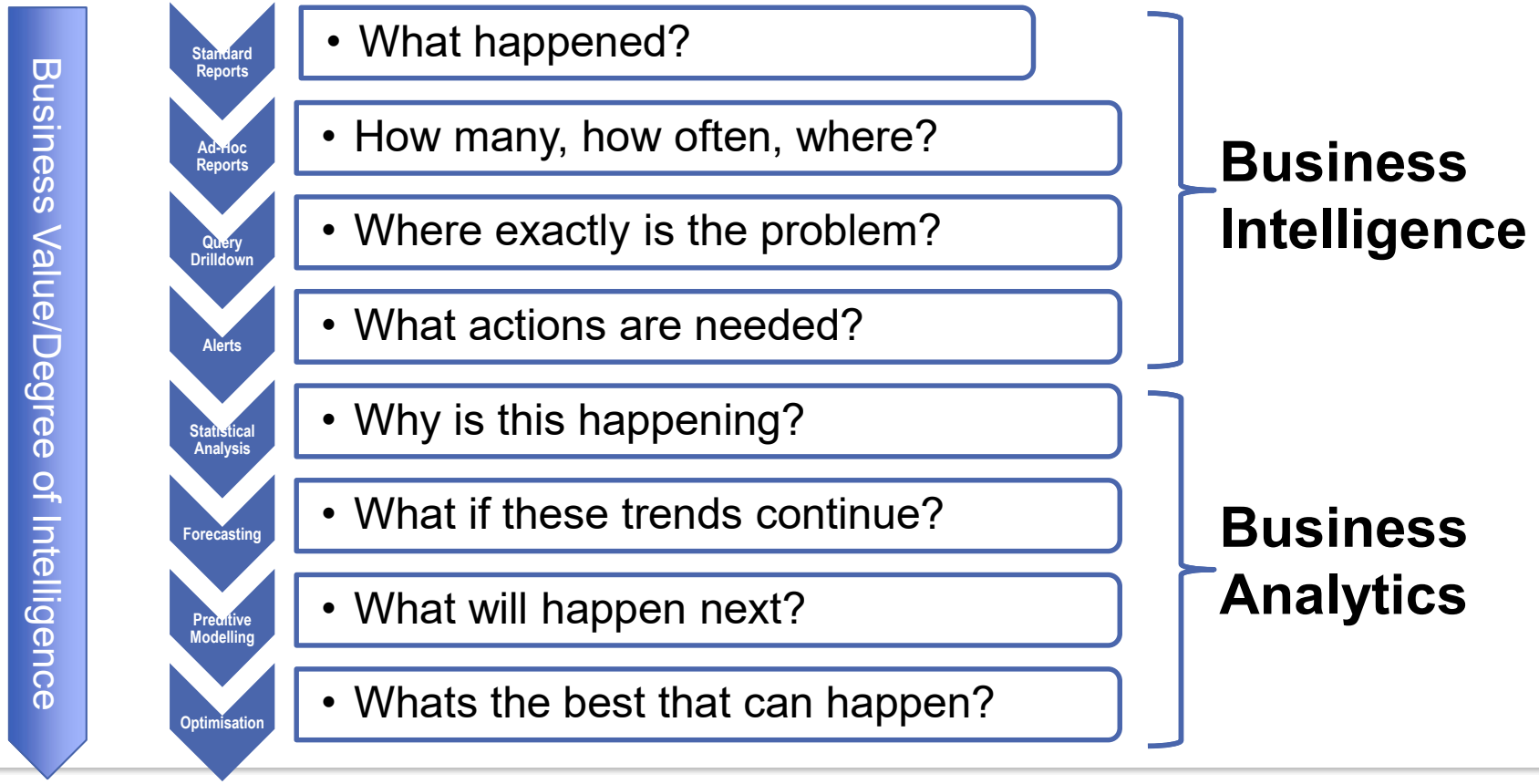


Decisions



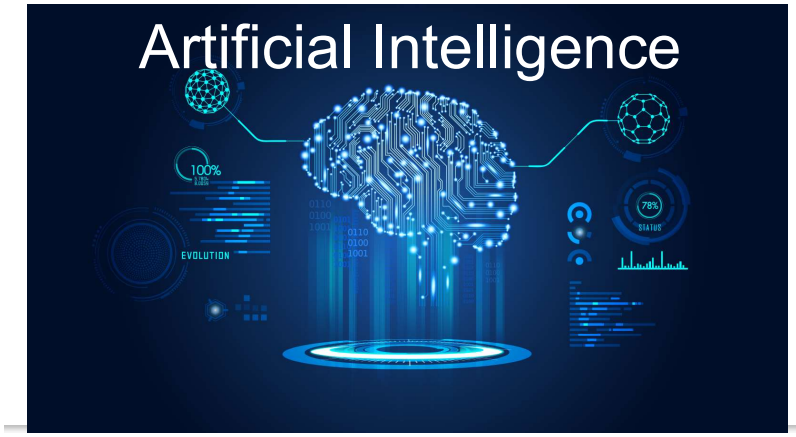
Business Analytics

Analytics and Data Science is the discovery and communication of insights and patterns from the data to solve business objectives



Tonights Program…

Threat? Opportunity?



What is Big-Data?

What is Data Analytics?

Relationship between BD, Analytics &AI

What is the role of analytics in IIoT

What is the value of analytics in IIoT

Architectural Issues

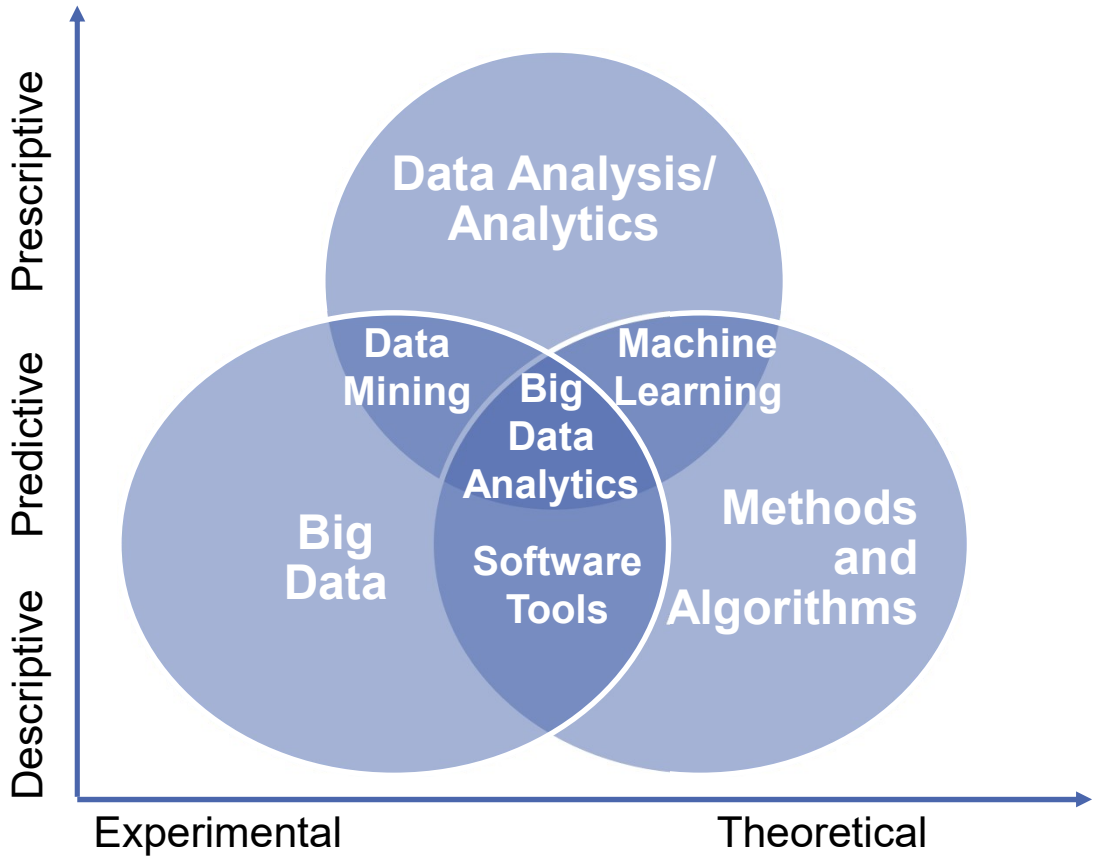
Case studies

Analytics (Descriptive/Predictive)

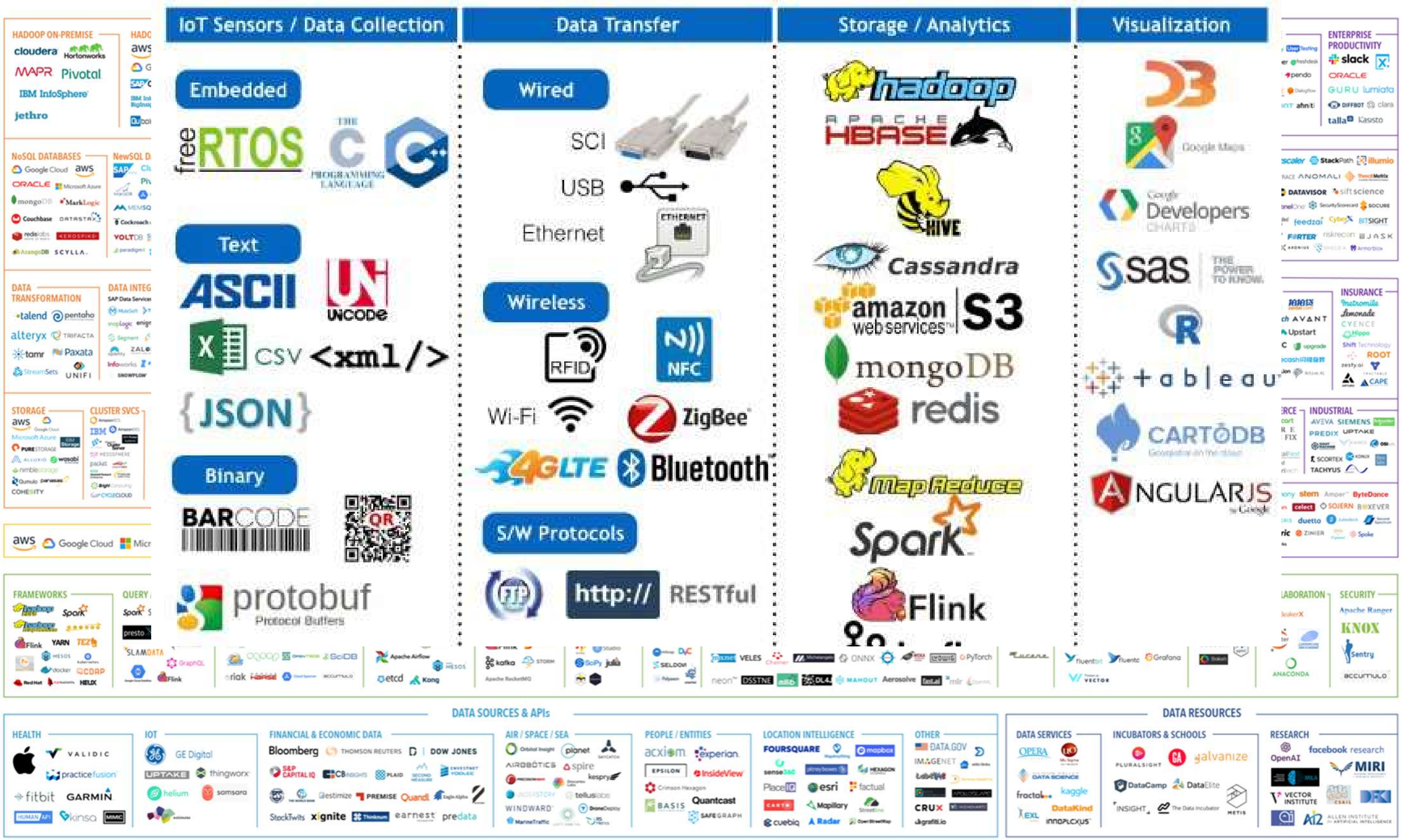
Helps you to advise on possible outcomes. "What should we do?"

Helps you to understand the future and answer: "What could happen?"

Helps you to understand your data. "What has happened?"

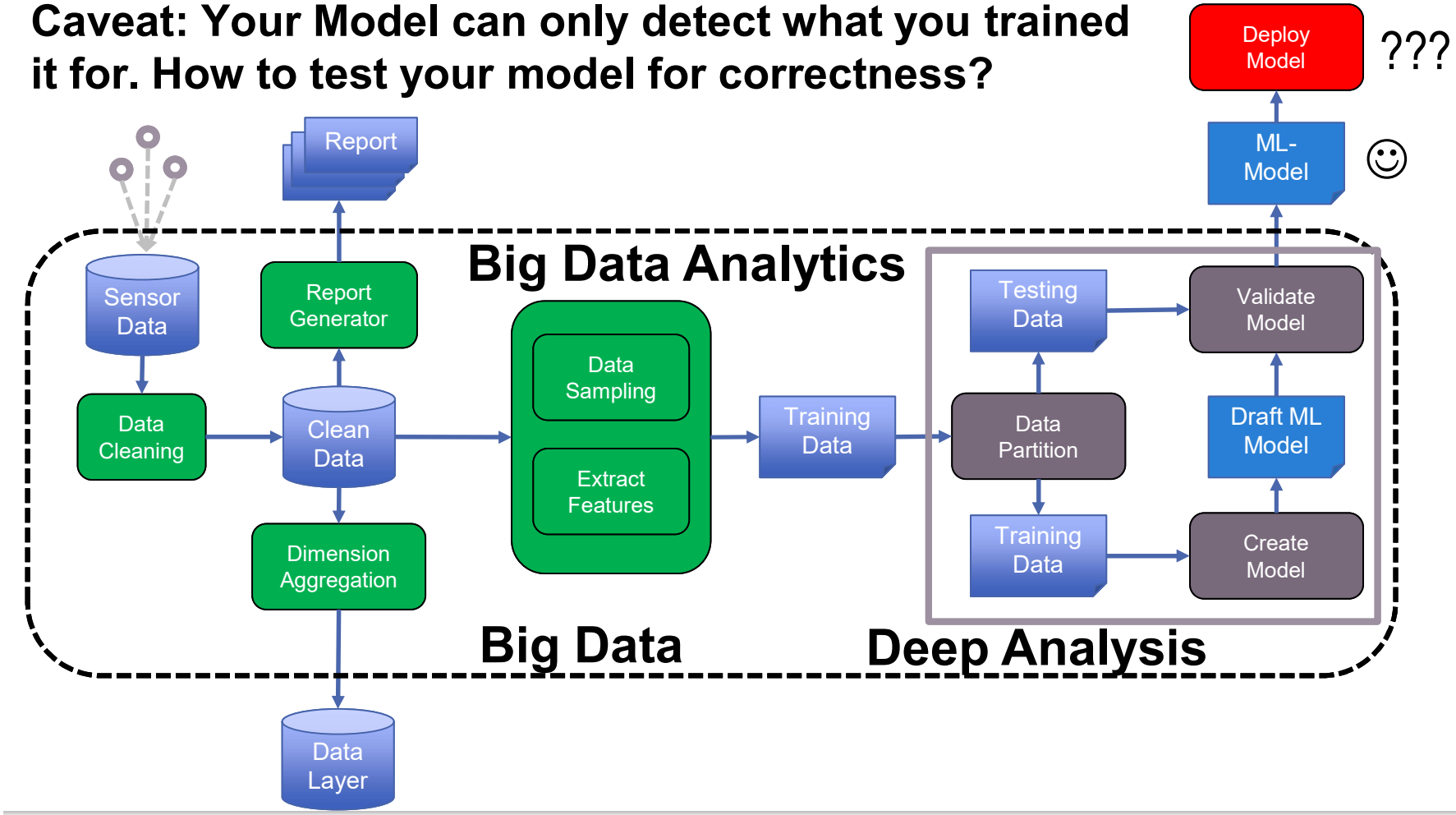


DATA & AI LANDSCAPE 2019



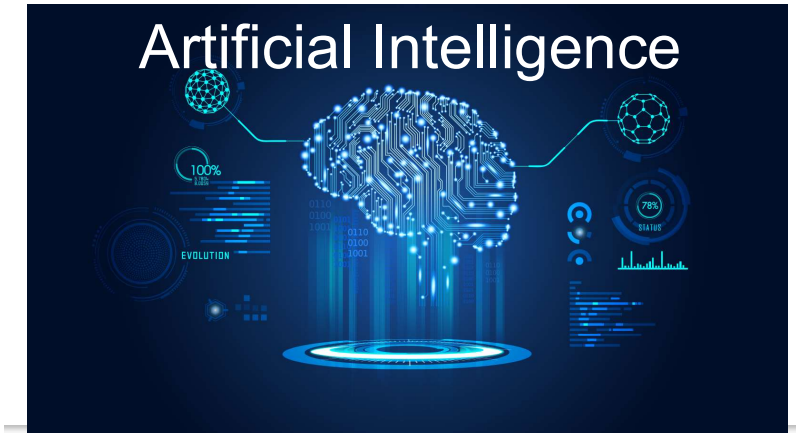
Big Data Analytics

Caveat: Your Model can only detect what you trained it for. How to test your model for correctness?



Tonights Program…

Threat? Opportunity?



What is Big-Data?

What is Data Analytics?

What is the role of analytics in IIoT

Relationship between BD, Analytics &AI

What is the value of analytics in IIoT

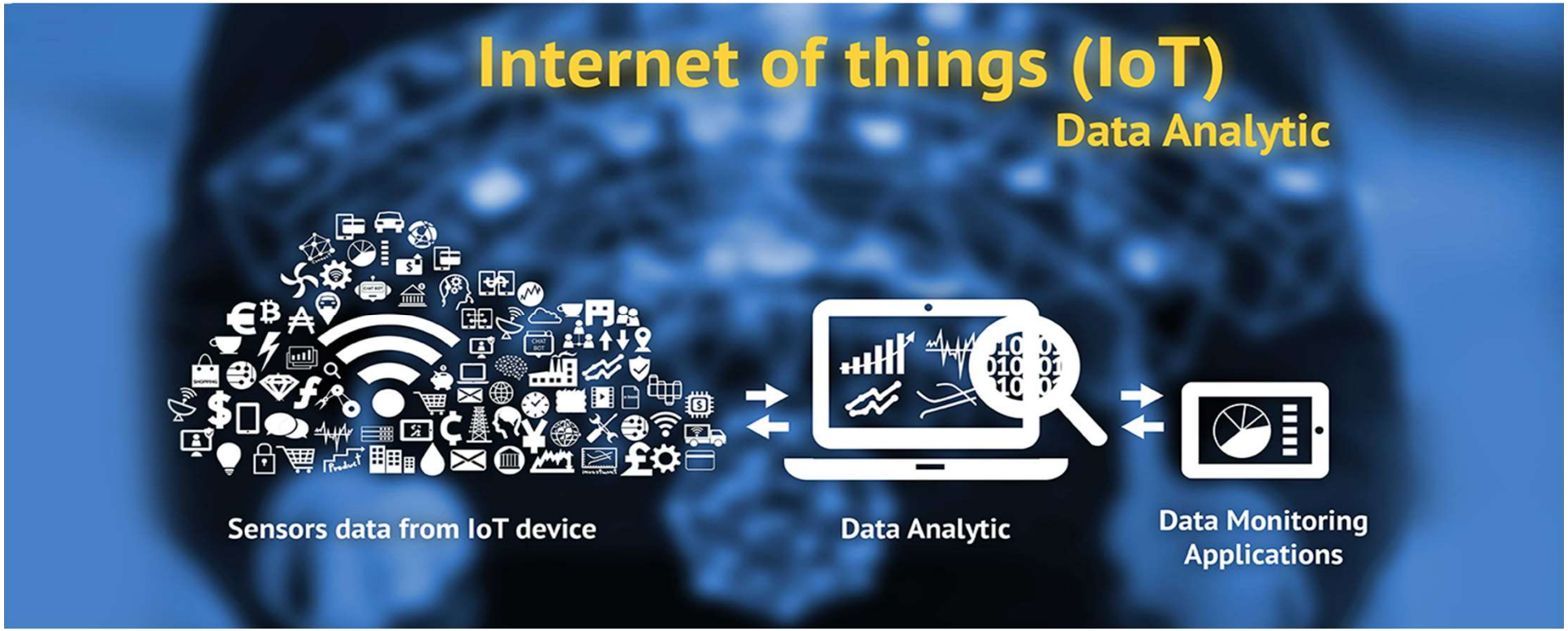
Architectural Issues

Case studies

Why Analytics in IIoT?

We need analytics to make sense of large sensorial data streams and volume to

- Automate decision making
- Increase operational efficiency
- Detect faults in machinery beforehand
- Optimize supply chains
- Give businesses a competitive edge
- Save OPEX



Analytics in IIoT - Usecases

Go to www.menti.com and use the code 46 92 27

Predictive Maintenance

- Using anomaly detection algorithms and machine models for predicting and optimizing machine runtime windows.
- Real-time remote condition monitoring
- Real-time analytics and Machine Models
- Fragmented Stack of Protocols
- Remote Updates and Version Control
- Notifications and Messaging

Remote Condition Monitoring

- Change the business model to machine-as-a-service and charge for usage and consumables
- Streaming Analytics for the connected assets
- Send notifications and updates to service engineers and manufacturers
- Enhanced Security

Connected Machines

- Globally connected machines with the purpose of analyzing data for predictive maintenance and enhanced service programs
- Collect and compute data from machines in the field
- Reduce bandwidth
- Deadband handling (loss of connectivity)
- Anomaly Detection

Machine AI Testing

Factory owner and manufacturer jointly evaluate different AI-algorithms for the process industry

Apply multiple AI-algorithms for real-time use-cases

Sandbox, testing, and comparison of AI-functions

Organizations constraints due to many stakeholders within the project

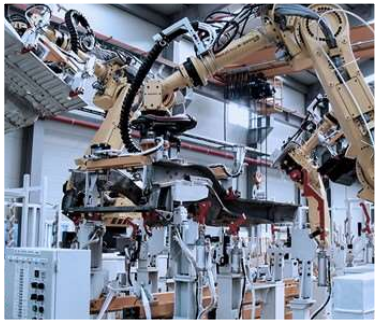
Analytics in IIoT - Usecases

Go to www.menti.com and use the code 46 92 27

Process Control Loops

- Process automation control loops connected to cloud service for global IoT analytics
- Need to filter data and move functions and analytics to the edge
- Combine the cloud providers IoT-offer with independent edge provider increases the level of independence

Image Recognition



- Optimizing process by using AI for detecting product errors and poor quality at high speed
- Real-time image analysis
- Take action (send action) to sorting mechanism in real time
- Collect data for historical usage
- Train AI-algorithm

Streaming Analytics

- County environment department is overviewing and controlling water buoys for pollution and water flow statistics and alerts.
- Statistics are compared to historic environmental data
- Anomalies are stored and put on a watch list
- Combine event information from the whole deployment to find patterns and find the origin of detected anomalies

On-Premise IoT

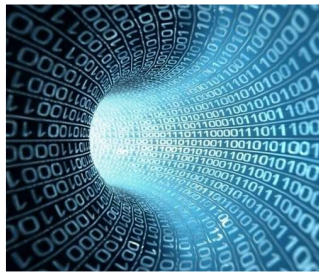
Global factory owner that needs to remotely deploy and run machine models on-premise without internet connectivity due to advanced security architectures. Specific requirements in terms of cloud services and providers

IoT behind factory firewalls

Real-time analysis to trigger actions in other machines

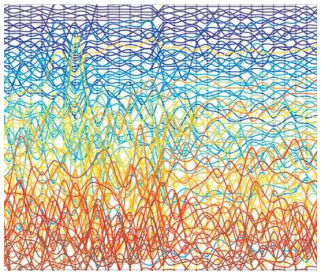
Analytics in IIoT - Difference

More data



- High Volume, continuous data in motion from multiple sensors
- Store, blend and manage time-series data

More complexity



- Using multiple analytics techniques
- Distributed analytics at edge

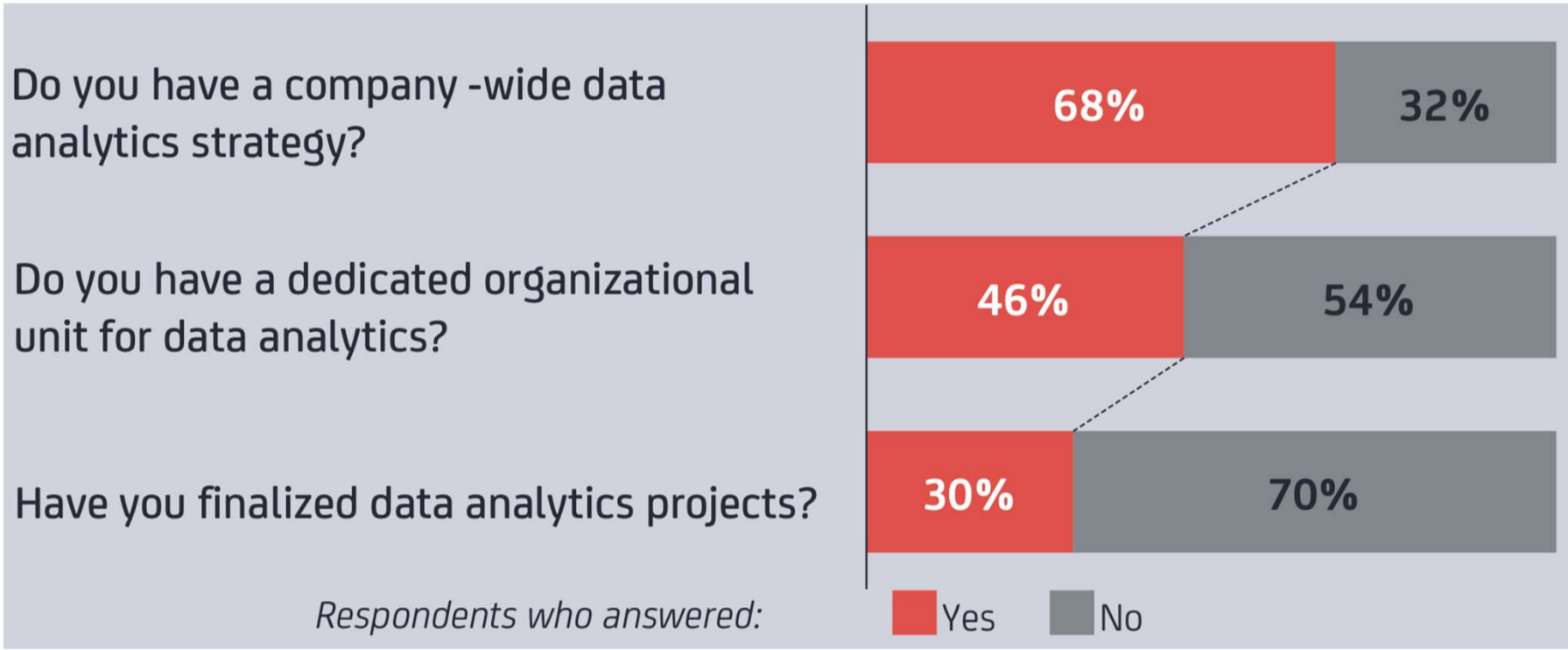
More automation

- Integration with operation systems and BPMS
- Bidirectional communication and control endpoints

- Millions of Sensors producing lots of data
  - Have limited processing capacity → Prohibitive to ship everything to Cloud, also due to security concerns
  - Localized Compute, Storage and Networking close to data source → Edge, Fog

Status in Industry?

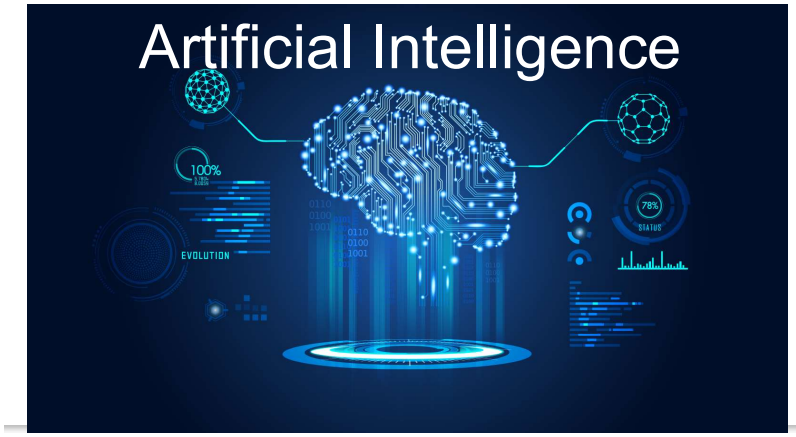
Go to www.menti.com and use the code 46 92 27



https://iot-analytics.com/wp/wp-content/uploads/2016/10/Industrial-Analytics-Report-2016-2017-vp-singlepage.pdf

Tonights Program…

Threat? Opportunity?



What is Big-Data?

What is Data Analytics?

Relationship between BD, Analytics &AI

What is the role of analytics in IIoT

What is the value of analytics in IIoT

Architectural Issues

Case studies

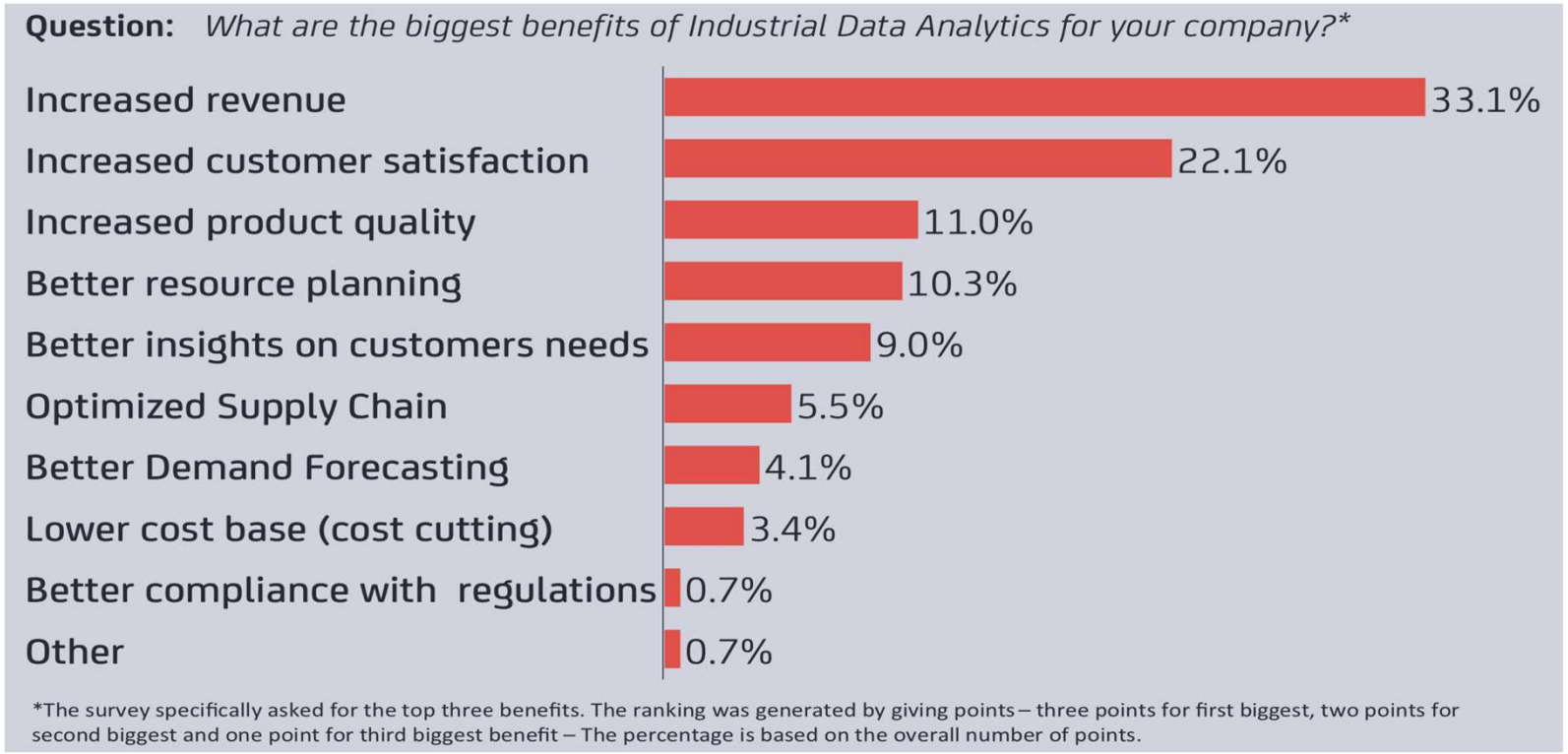
Value of Data Analytics in IIoT

Operations Efficiency	Maintenance Efficiency	Service Efficiency	Information Efficiency	Energy Efficiency
• Production Optimization • Production Planning and Scheduling • Productivity modelling • Statistical quality control • Inventory optimization	• Predictive Maintenance • Condition Monitoring • Maintenance Planning and Scheduling • Reliability-Centered Maintenance • Anomaly Detection	• Remote Management/ Services • Field Service Management • Materials management (inventory) • Service Lifecycle management • Supply Chain analytics	• Information modelling • Data quality framework • Asset life cycle information model • Machine borne data management and analytics • Knowledge management	• Energy management • Resource efficiency • Asset sustainability index • Safety performance (Alarm management) • Regulatory/ standards compliance

In the industrial space, there is a great deal of interest in using analytics to optimize asset maintenance, production operations, supply chain, product design, field service and other areas (Industrial Internet Consortium)

Analytics in Industrial IoT?

Go to www.menti.com and use the code 46 92 27



https://iot-analytics.com/wp/wp-content/uploads/2016/10/Industrial-Analytics-Report-2016-2017-vp-singlepage.pdf

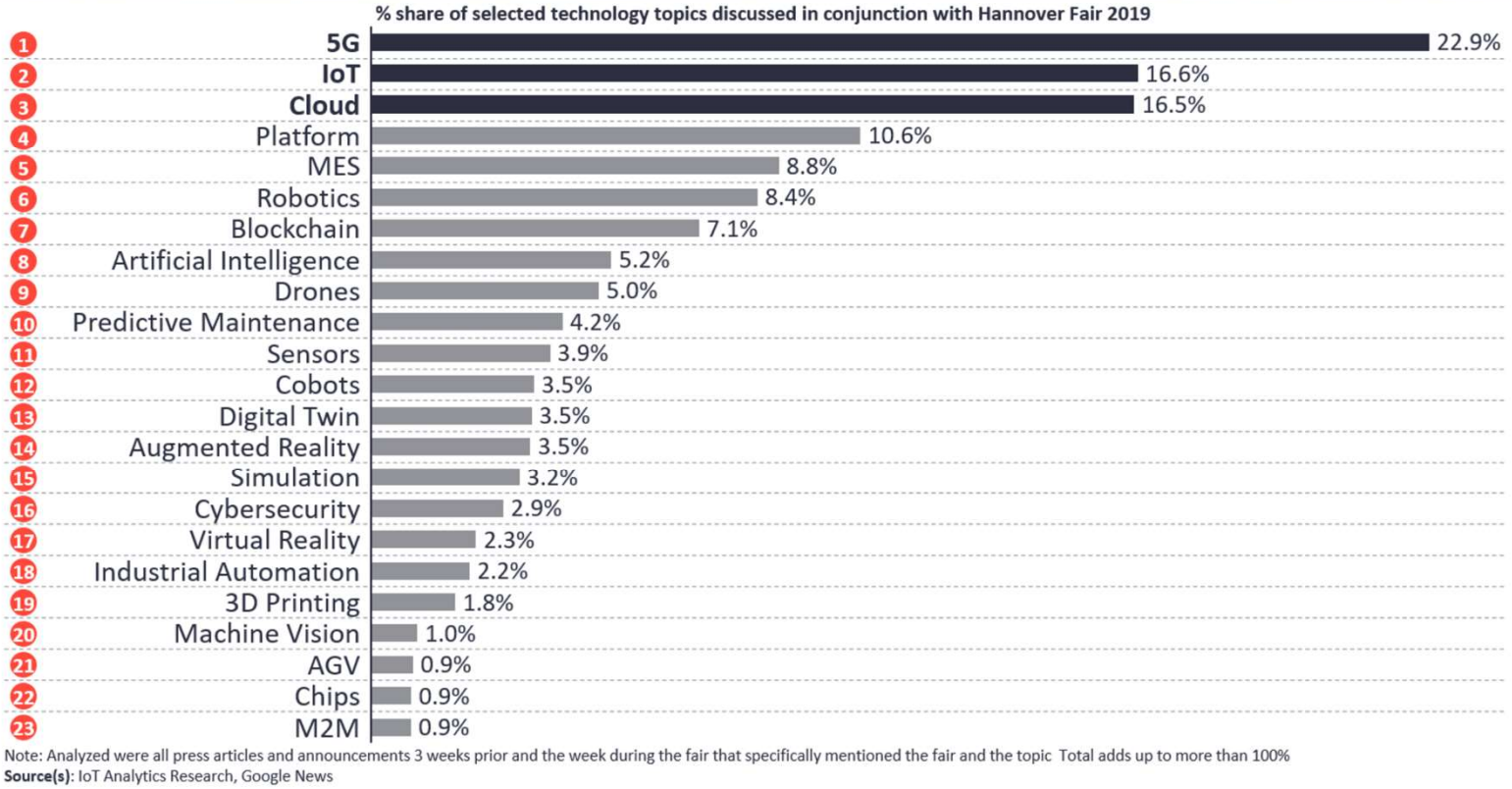
Industry4.0 value drivers

[1]Maintenance, repair, and operations.

McKinsey&Company

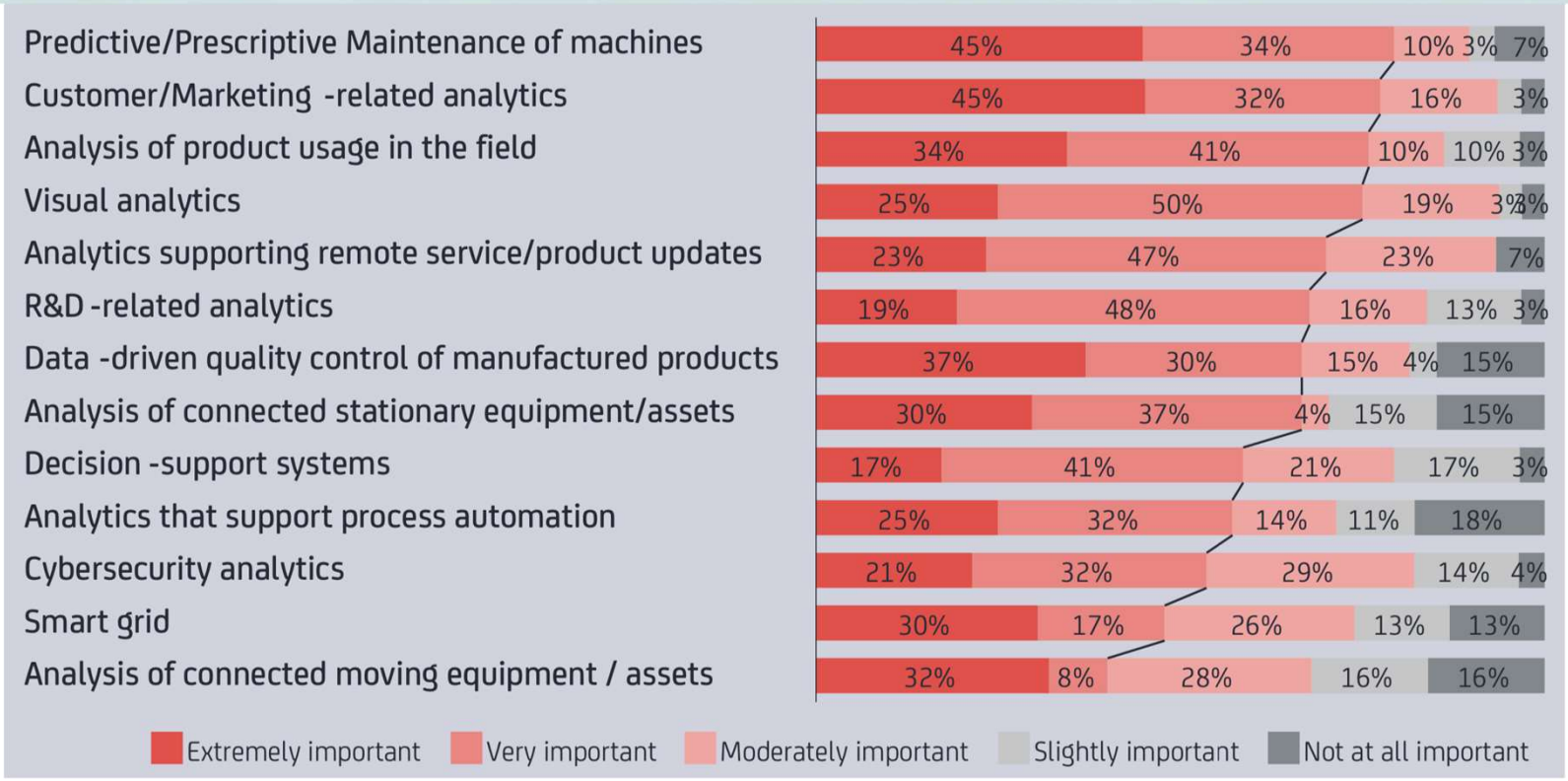
Technologies

Go to www.menti.com and use the code 46 92 27



How important are the following applications?

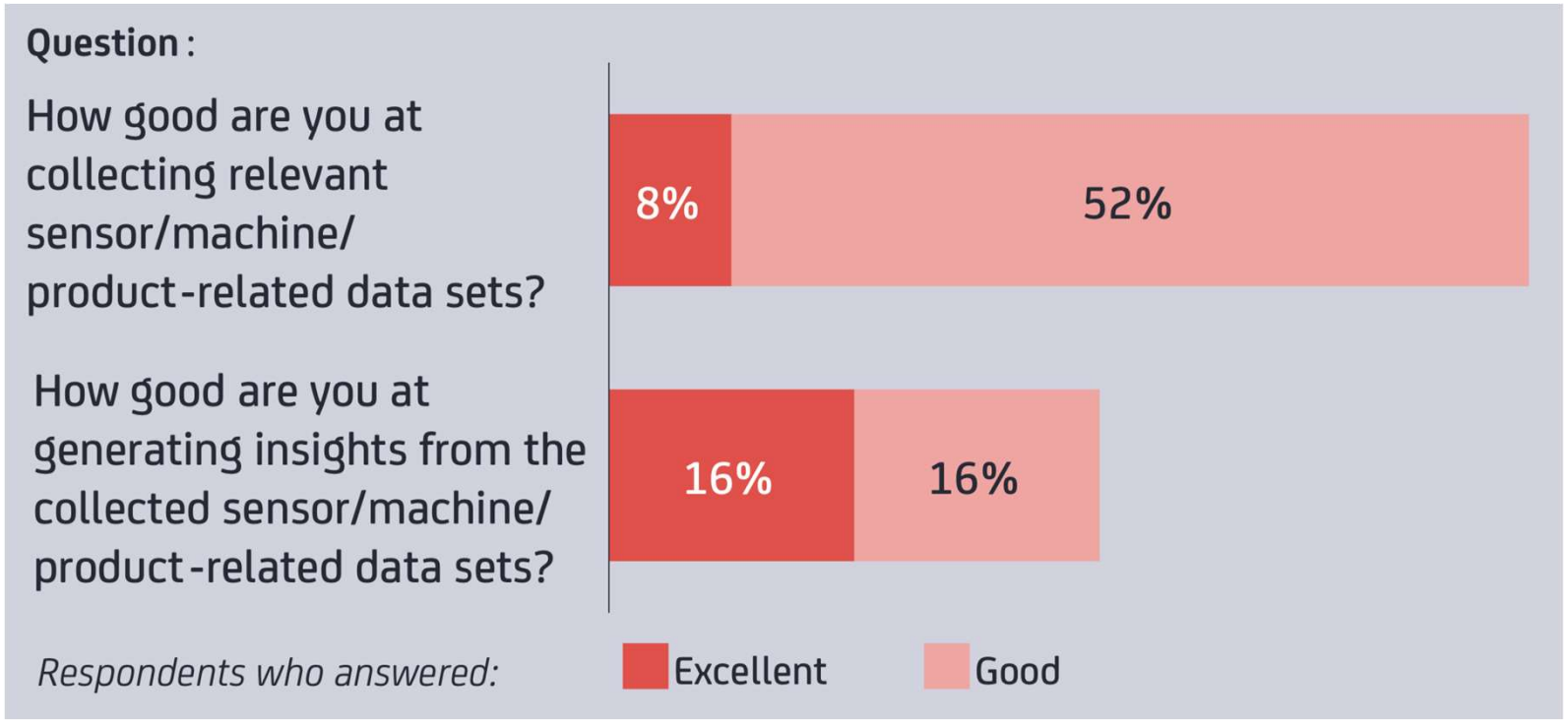
Go to www.menti.com and use the code 46 92 27



https://iot-analytics.com/wp/wp-content/uploads/2016/10/Industrial-Analytics-Report-2016-2017-vp-singlepage.pdf

Companies struggle generating insights

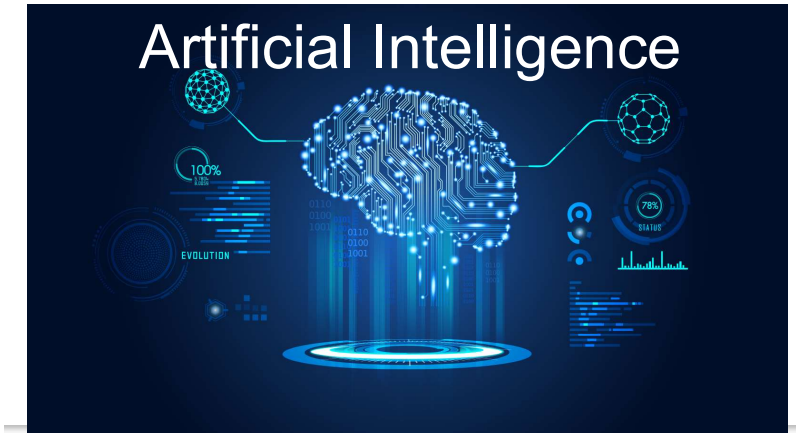
Go to www.menti.com and use the code 46 92 27



https://iot-analytics.com/wp/wp-content/uploads/2016/10/Industrial-Analytics-Report-2016-2017-vp-singlepage.pdf

Tonights Program…

Threat? Opportunity?



What is Big-Data?

What is Data Analytics?

Relationship between BD, Analytics &AI

What is the role of analytics in IIoT

What is the value of analytics in IIoT

Architectural Issues

Case studies

IoT Reference Model

Levels

7 **Collaboration & Processes**
(Involving People & Business Processes)

6 **Application**
(Reporting, Analytics, Control)

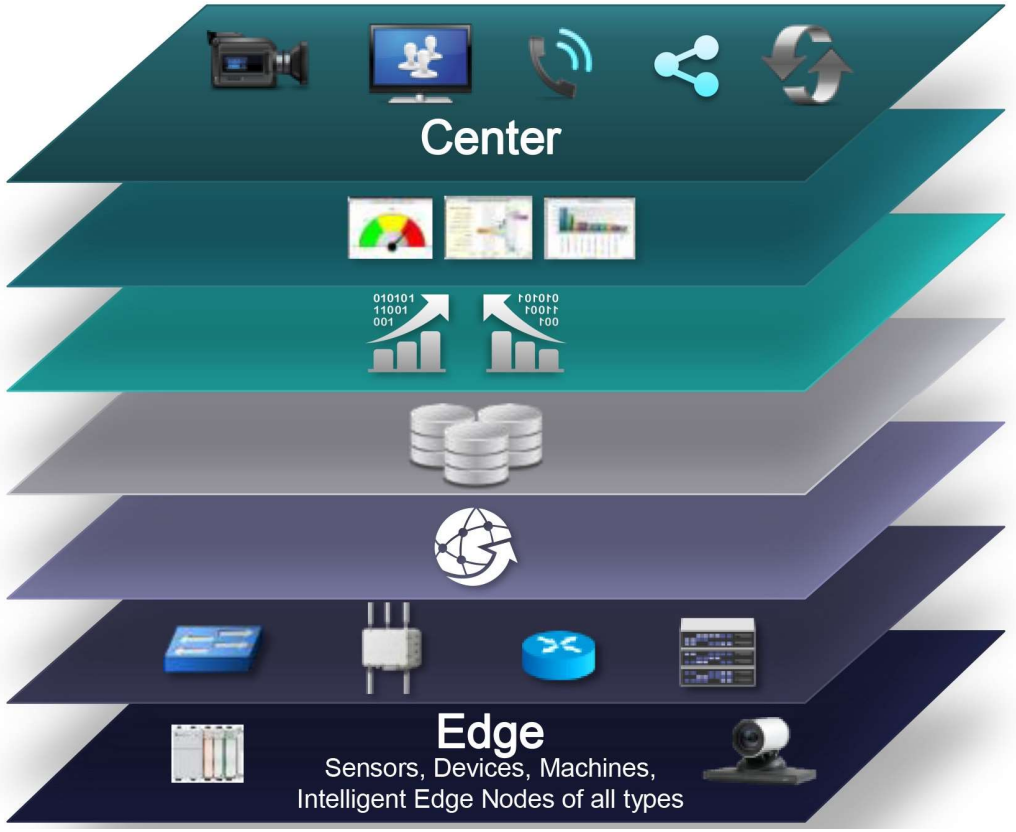
5 **Data Abstraction**
(Aggregation & Access)

4 **Data Accumulation**
(Storage)

3 **Edge Computing**
(Data Element Analysis & Transformation)

2 **Connectivity**
(Communication & Processing Units)

1 **Physical Devices & Controllers**
(The "Things" in IoT)



Source: IoT World Congress (IBM, Cisco)

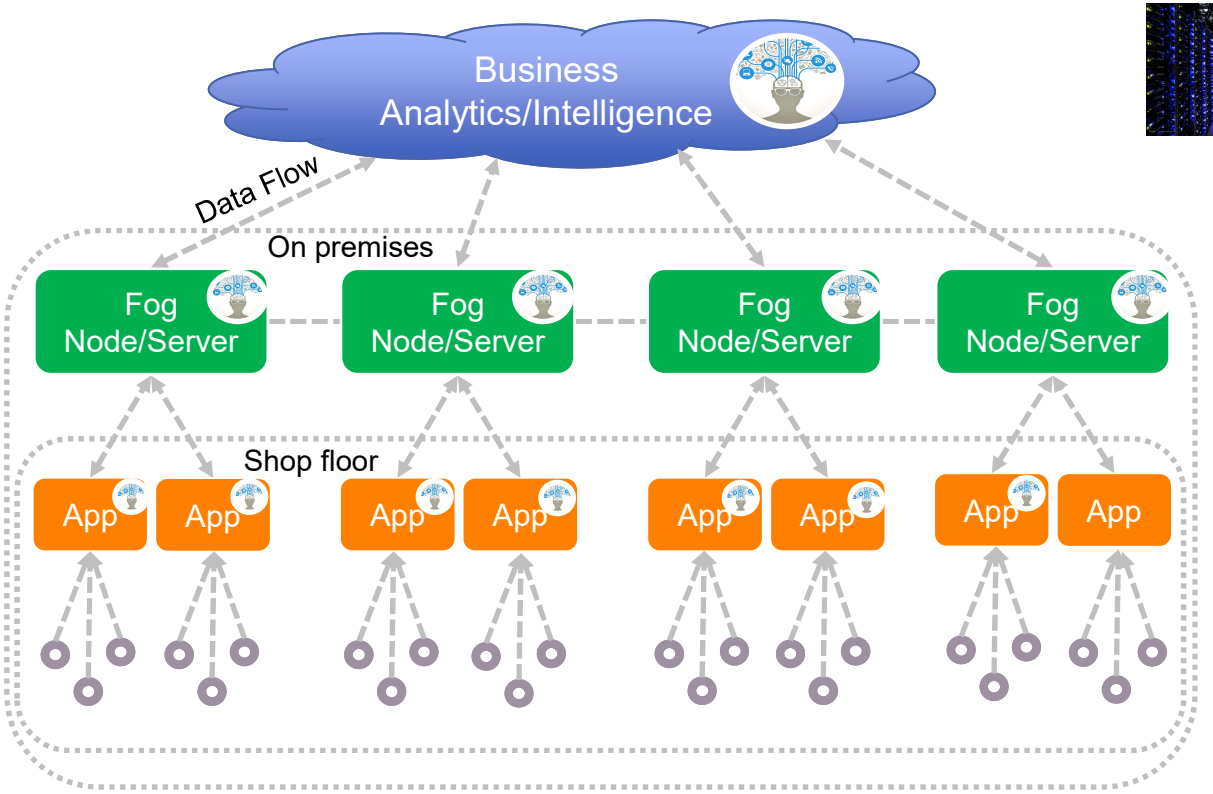
Industrial IoT Data Processing Layers

Cloud Layer
Big Data Processing
Business Logic
Data Warehousing

Fog Layer
Local Network
Data Analytics and Filtering
Control Response
Virtualization/Standardization

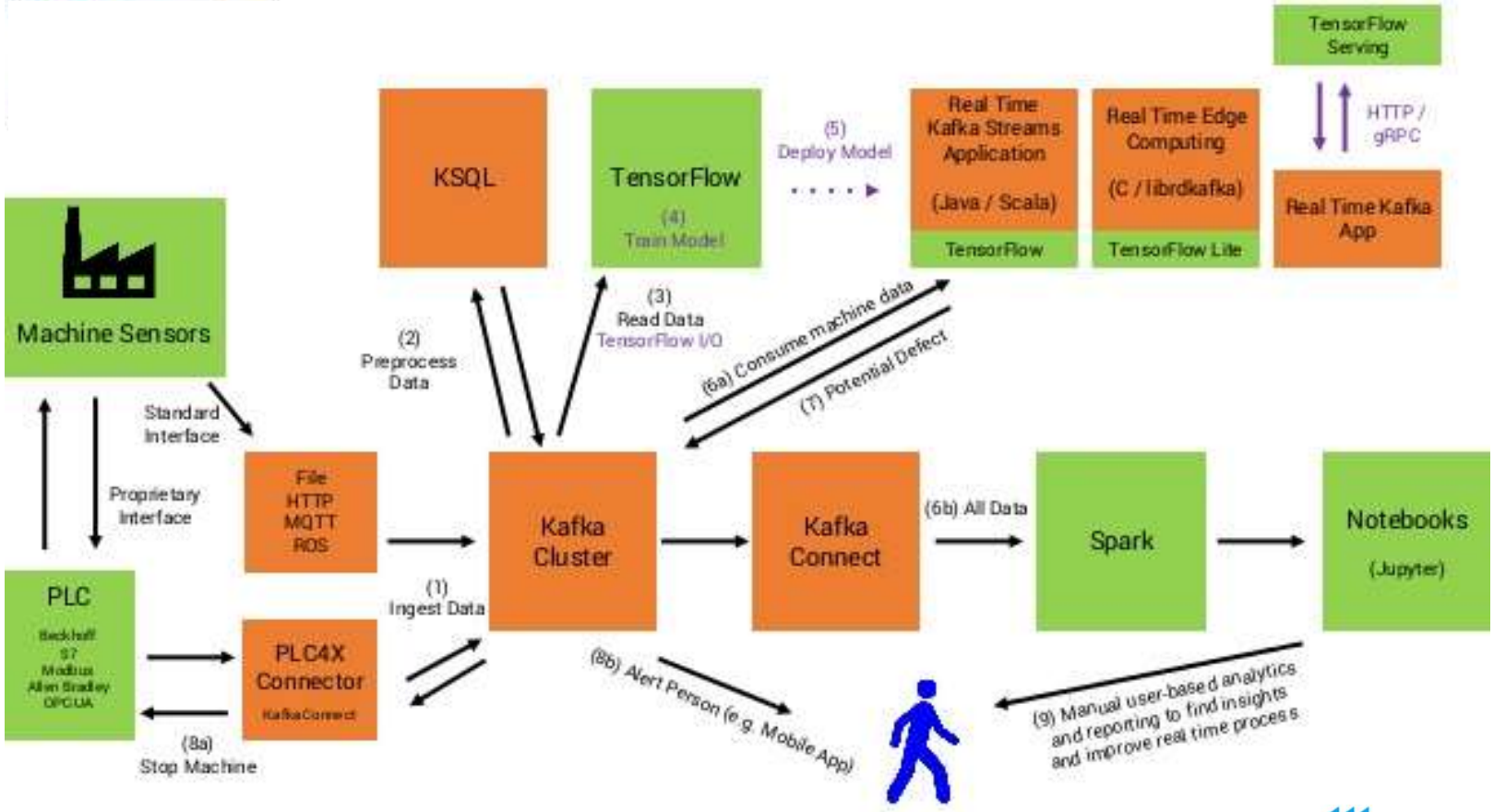
Edge Layer
Large Volume Real-Time Processing
On Premises Visualization
Industrial PCs
Embedded Systems
Gateways
Micro Data Storage

Sensors and PLC
create data

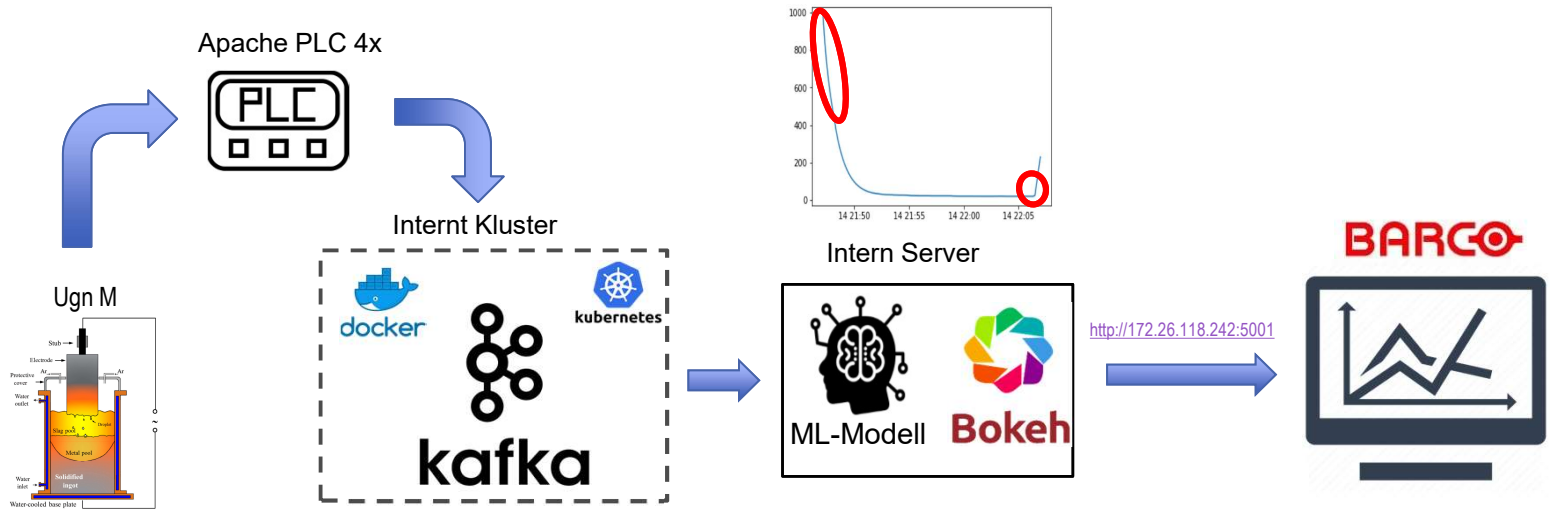


Slower — Processing Speed / Response Time — Faster

Industrial IoT Data Streaming Prototype



Industrial IoT Data Streaming Prototype

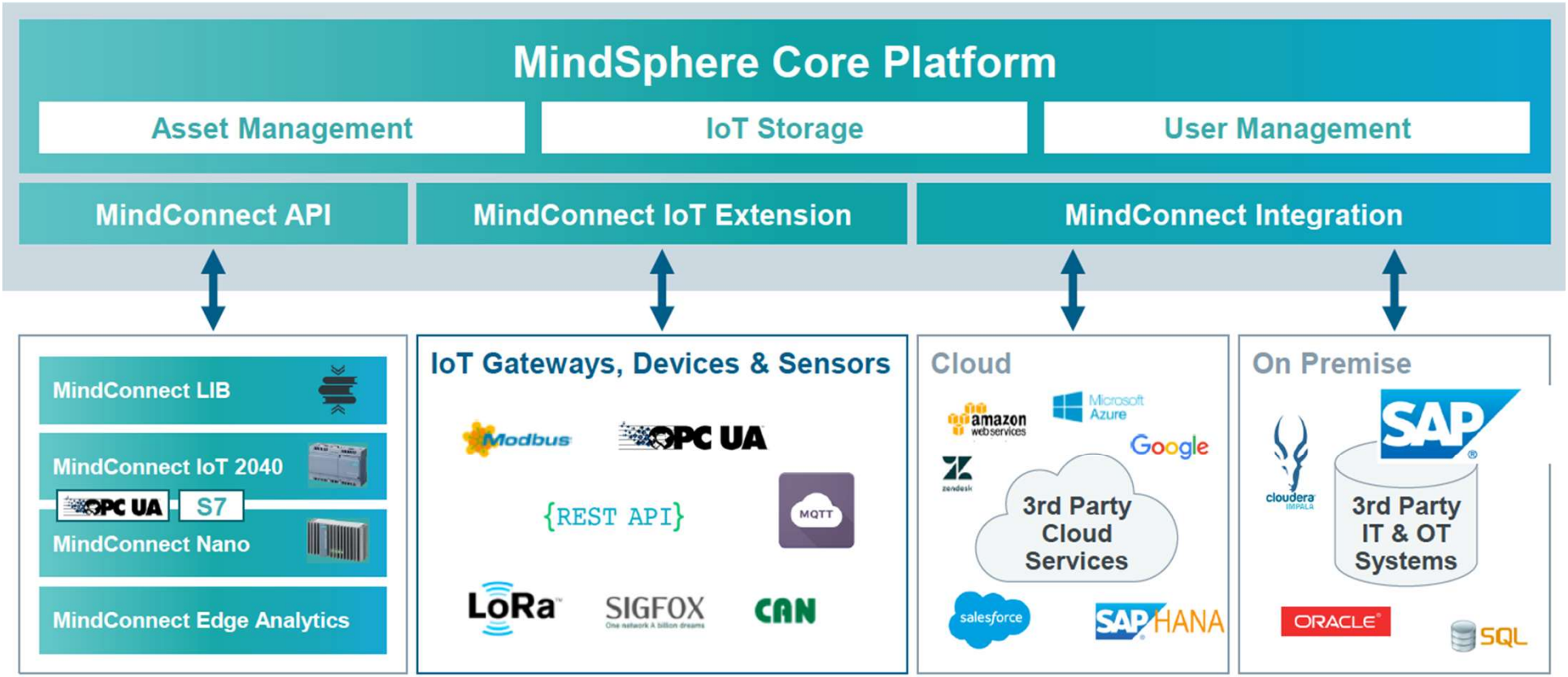


Lesson Learned

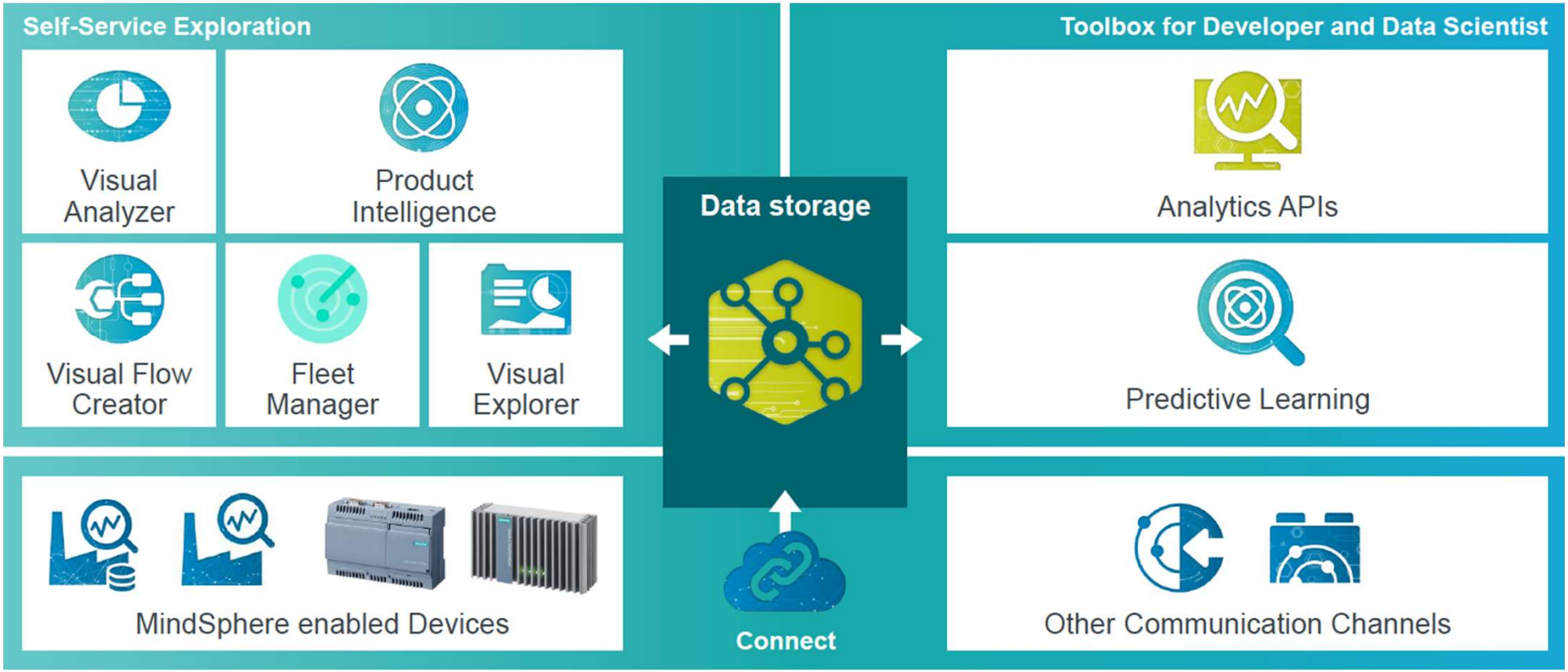
- Infrastructure
  - Networks
  - Cloud/Edge/Fog and RealTime Streaming integration
  - Backups and location of computers
  - System owners
  - Old equipment's
- Standardization
- Project methodology and project owners
- Take-over – No dedicated responsibility

Industrial IoT / Cloud Integration Example - MindSphere

Industrial IoT / Cloud Integration Example - MindSphere

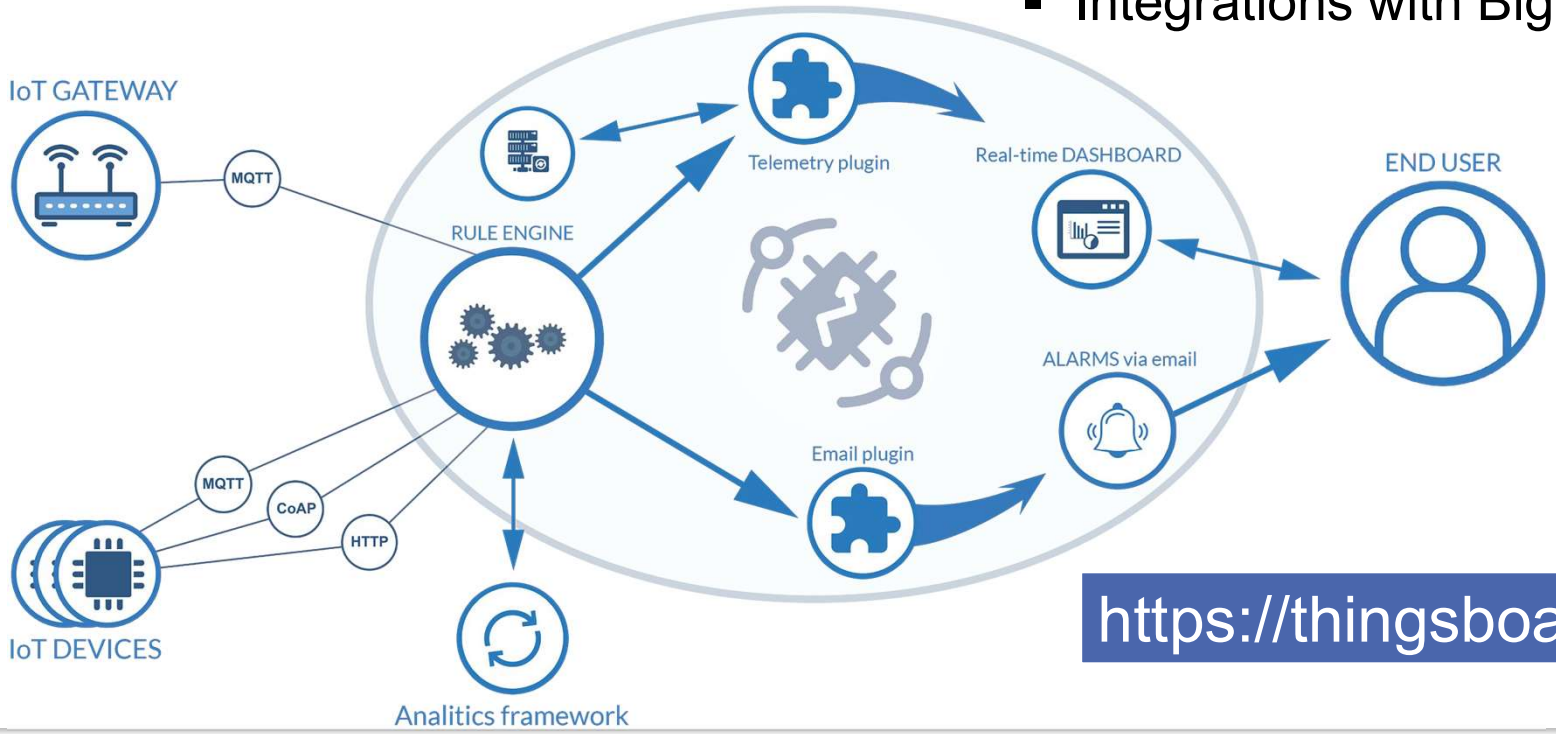


MindSphere Analytics – Ready-made Apps + APIs



ThingsBoard

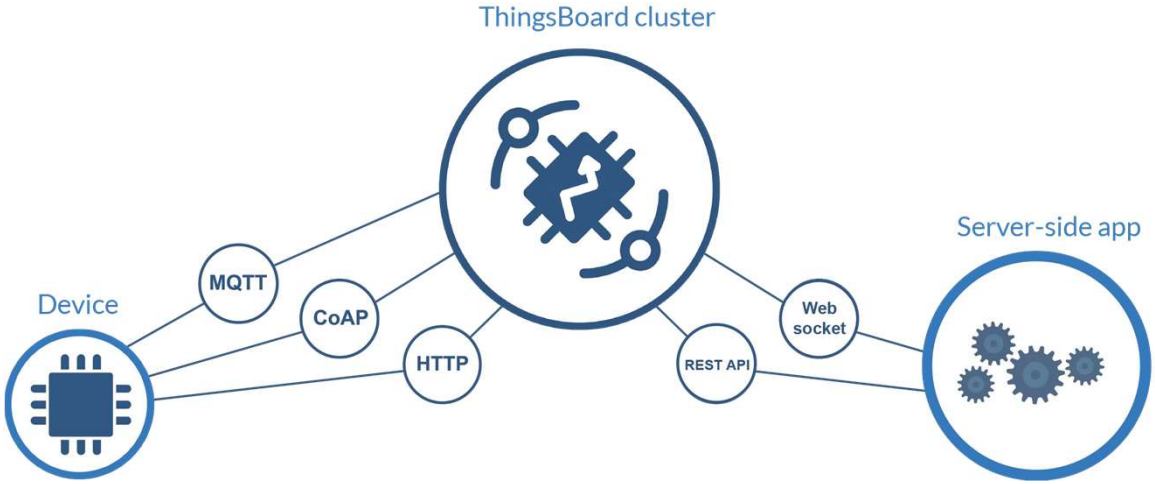
- IIoT Device management & RPC
- Encryption and Multi-Tenant
- 100% open-source under Apache 2.0
- Data processing rules, Customizable rules, dashboards, widgets
- Integrations with BigData

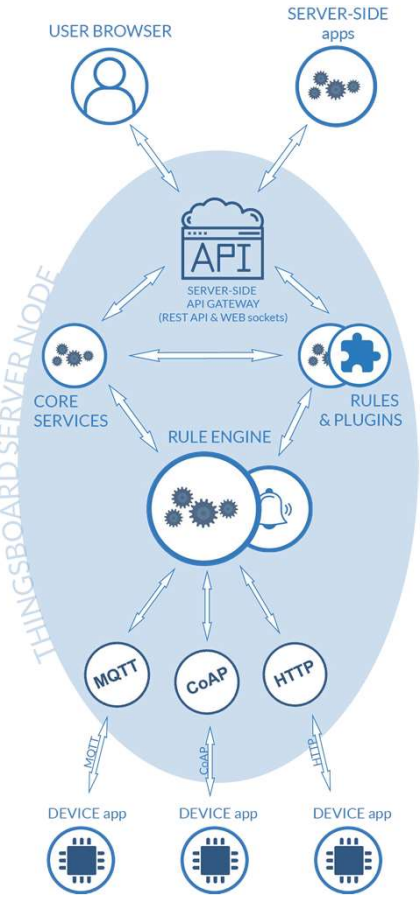


https://thingsboard.io

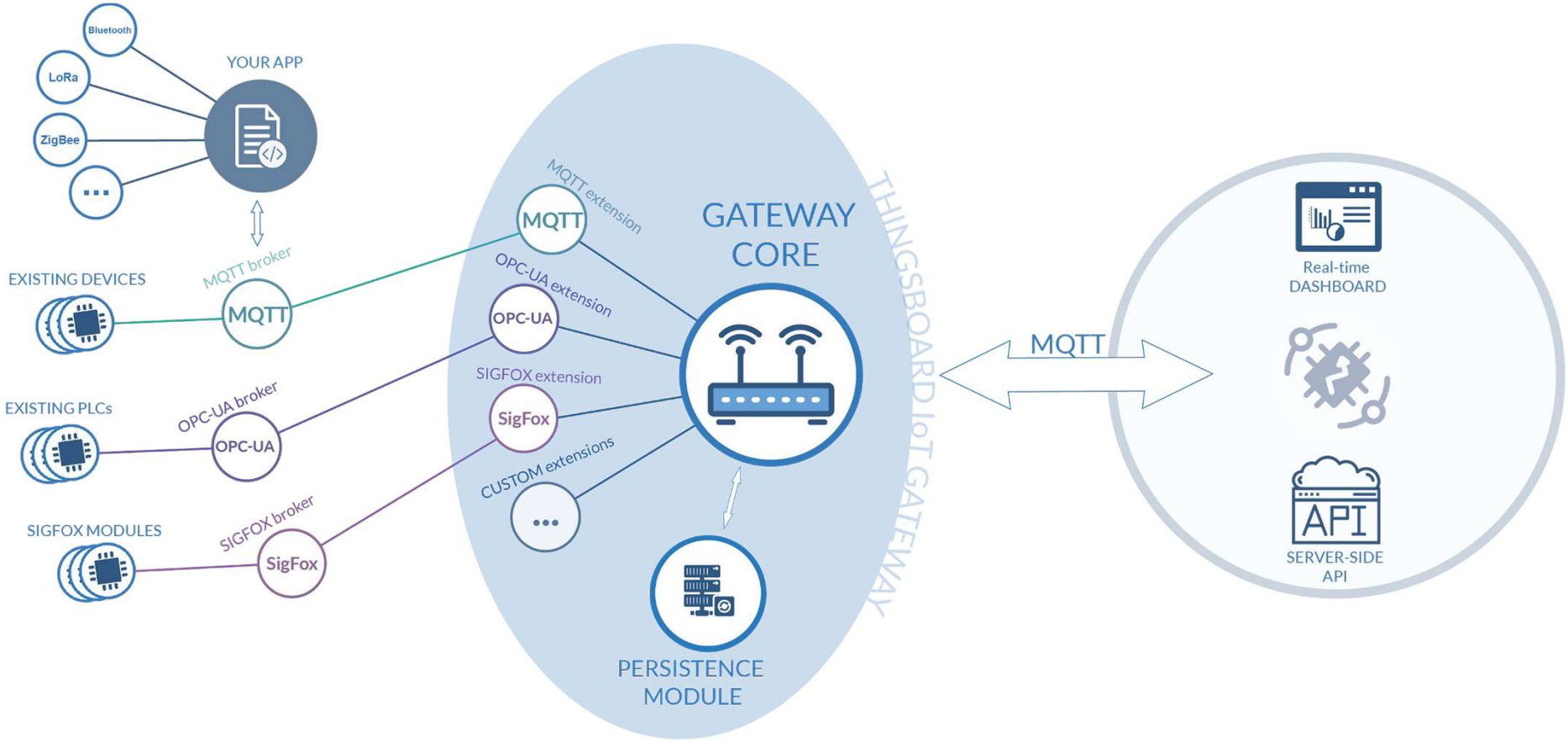
ThingsBoard Architecture

- horizontally scalable platform, build using leading open-source technologies → Kubernetes
- no single-point-of-failure
- ThingsBoard cluster can handle millions of devices.
- adding new functionality is easy with customizable widgets, rule engine and plugin system





ThingsBoard IoT Gateway

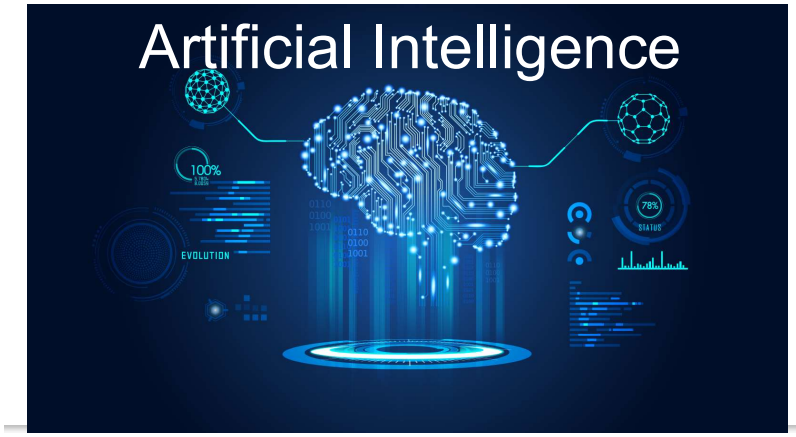


Technologies and Frameworks

- **Client-side:** Angular.js/React
  - **Server-side:** Java 8, Spring, Akka, gRPC, Zookeeper
- **Databases:** Cassandra or PostgreSQL
  - **Big Data integrations:** Apache Spark, Kafka
- **Protocols:** HTTP(S), MQTT, CoAP
  - **IoT Gateway Protocols:** OPC-UA, MQTT, Sigfox
- **Deployment:** AWS, Google Cloud, Docker, Kubernetes, on-premises

Tonights Program…

Threat? Opportunity?



What is Big-Data?

What is Data Analytics?

Relationship between BD, Analytics &AI

What is the role of analytics in IIoT

What is the value of analytics in IIoT

Architectural Issues

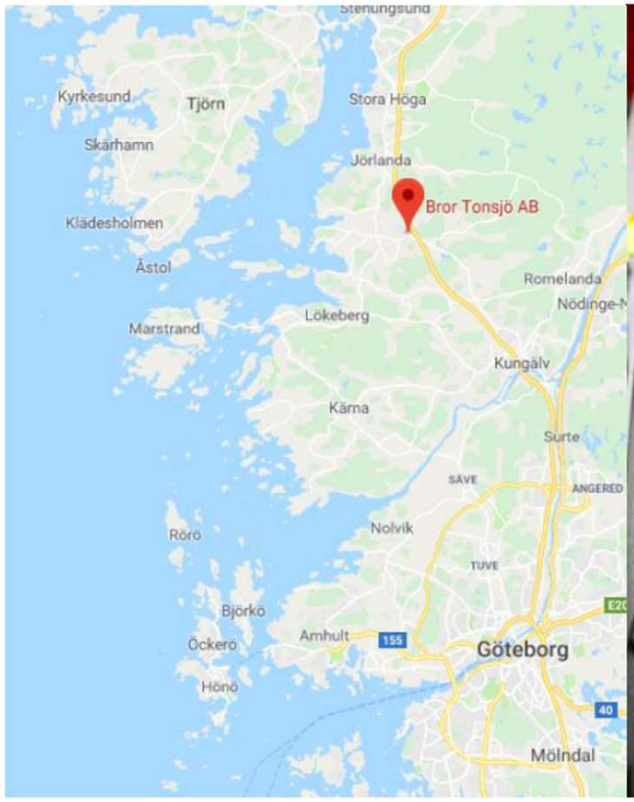
Case studies

MindSphere Usecase

MindSphere

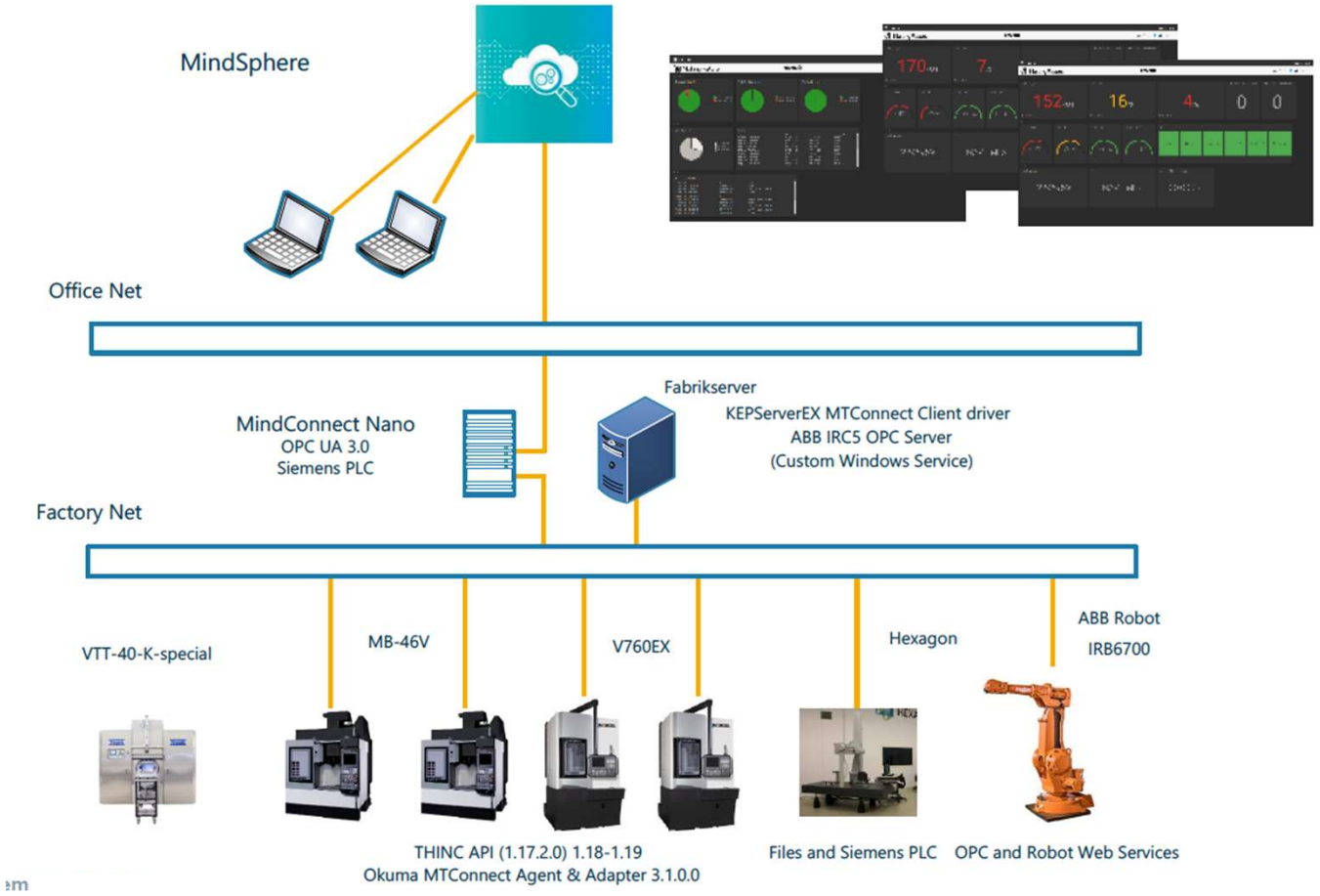
TONSJÖ

Founded in 1962
Family owned by the 3rd generation Tonsjö
100 employees

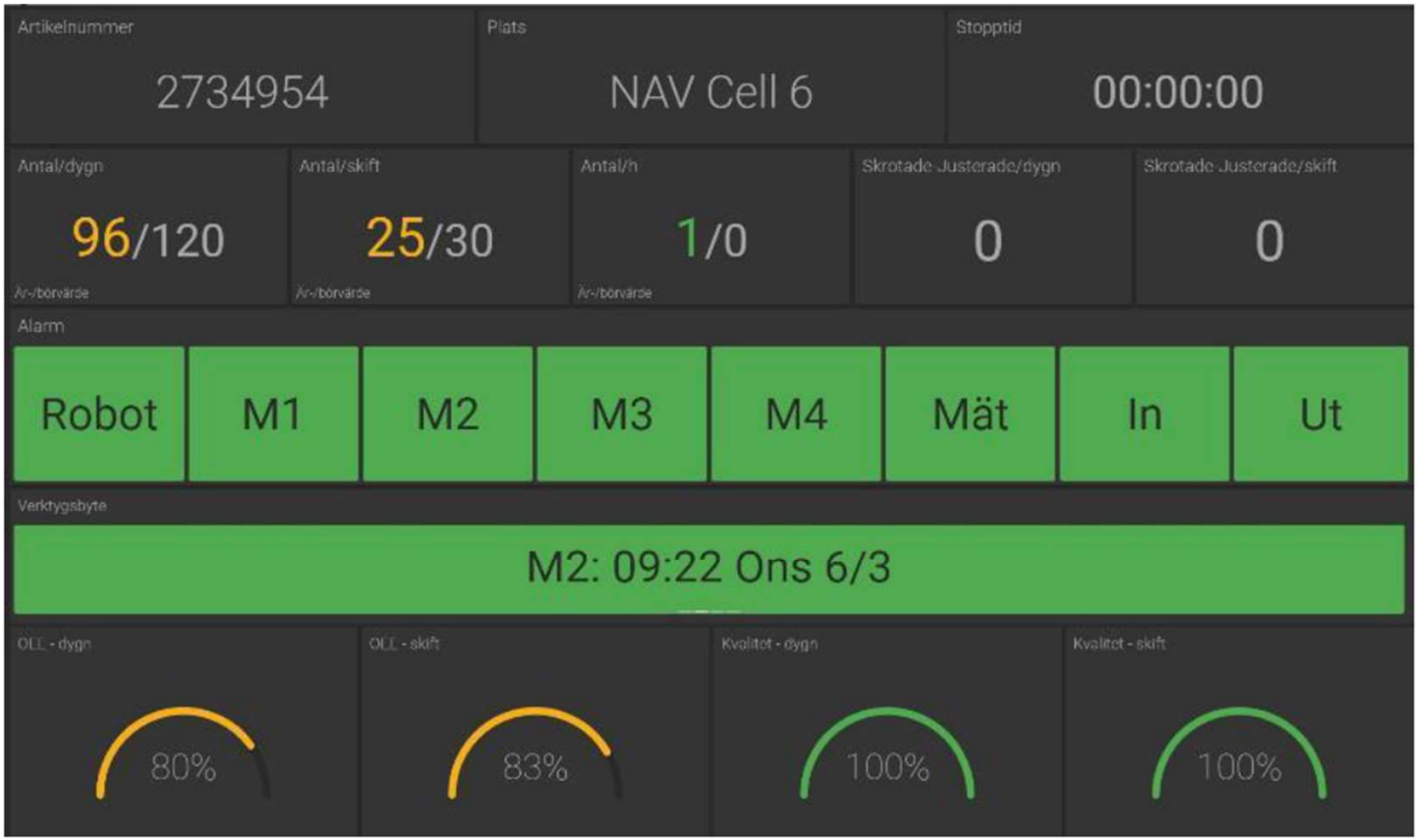


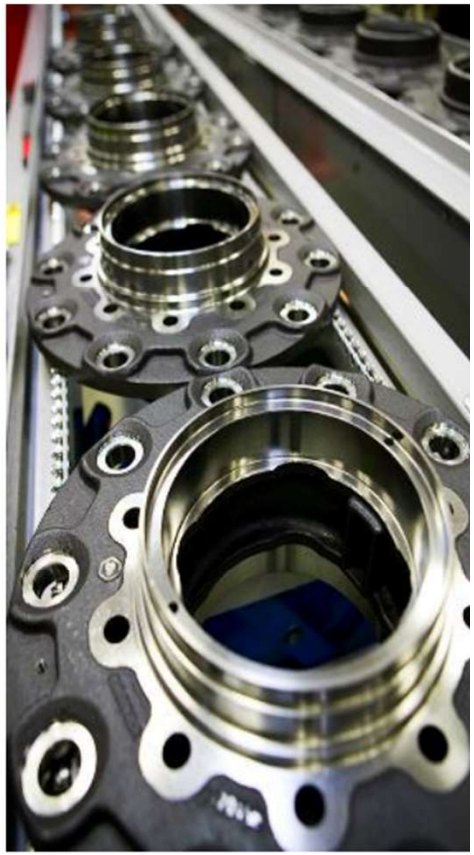
MindSphere Usecase – Status Quo

MindSphere Usecase – Connectivity

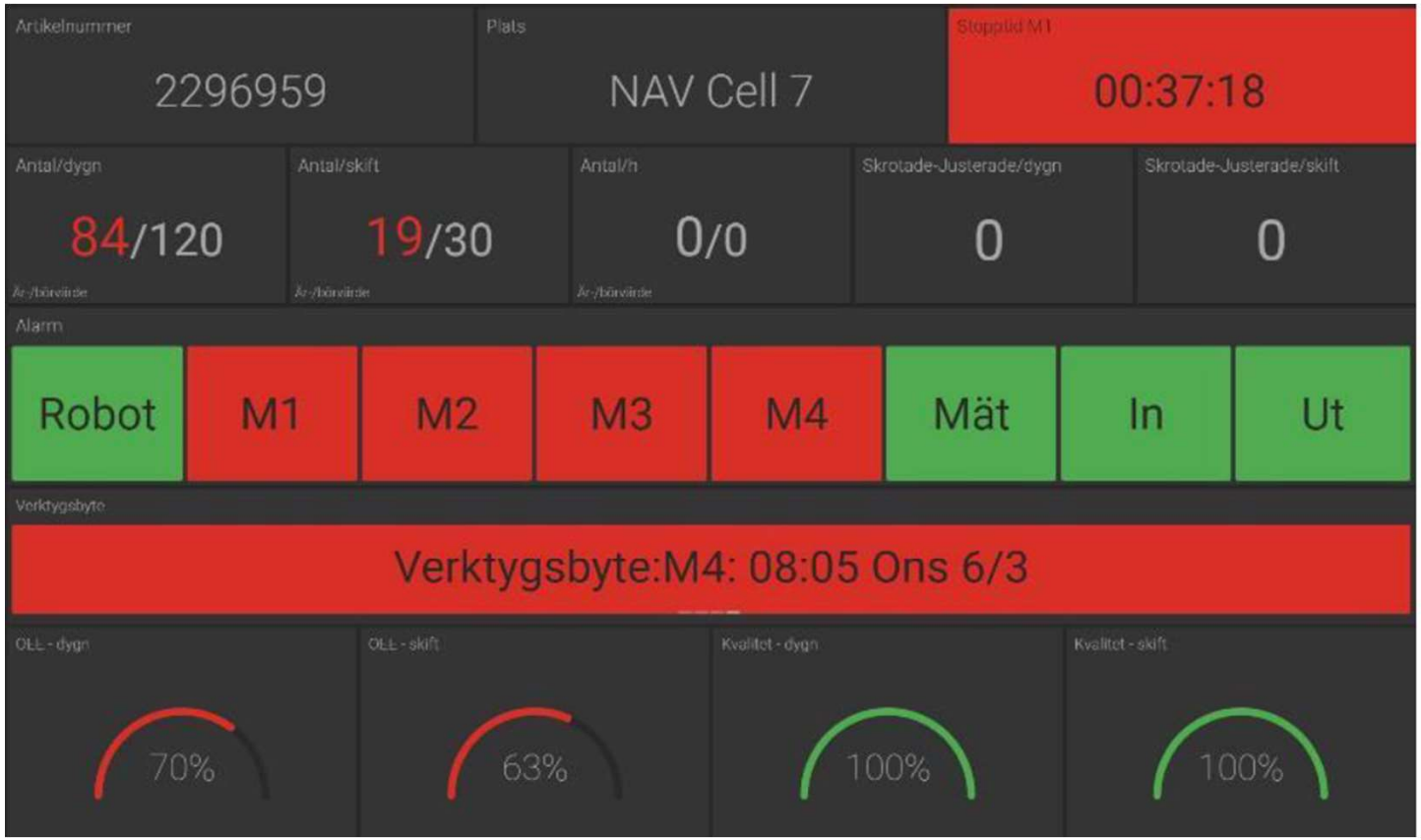


Dashboard NAV Cell 6 (wheel hub cell 6)



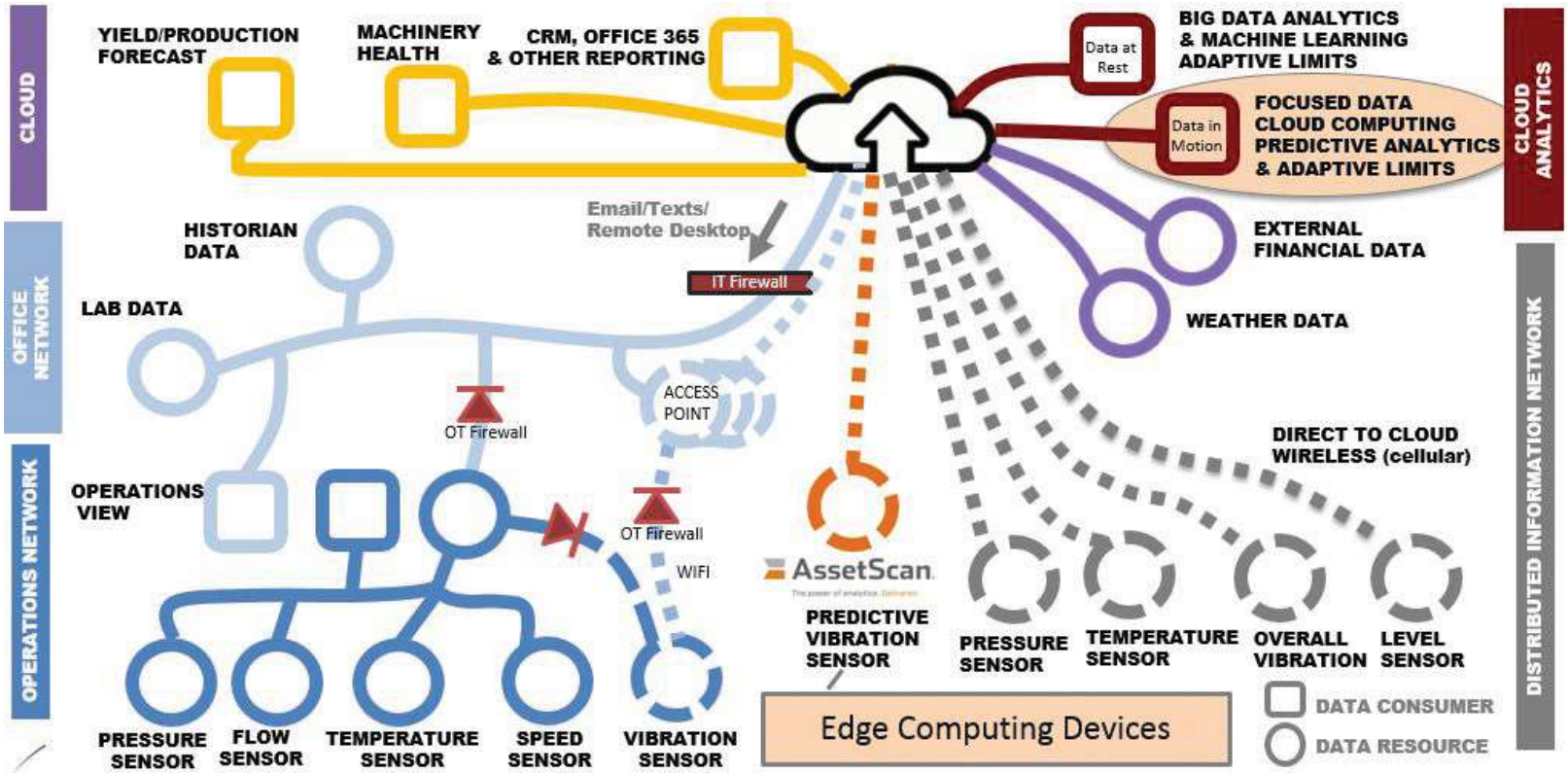


Dashboard NAV Cell 7 (wheel hub cell 7)



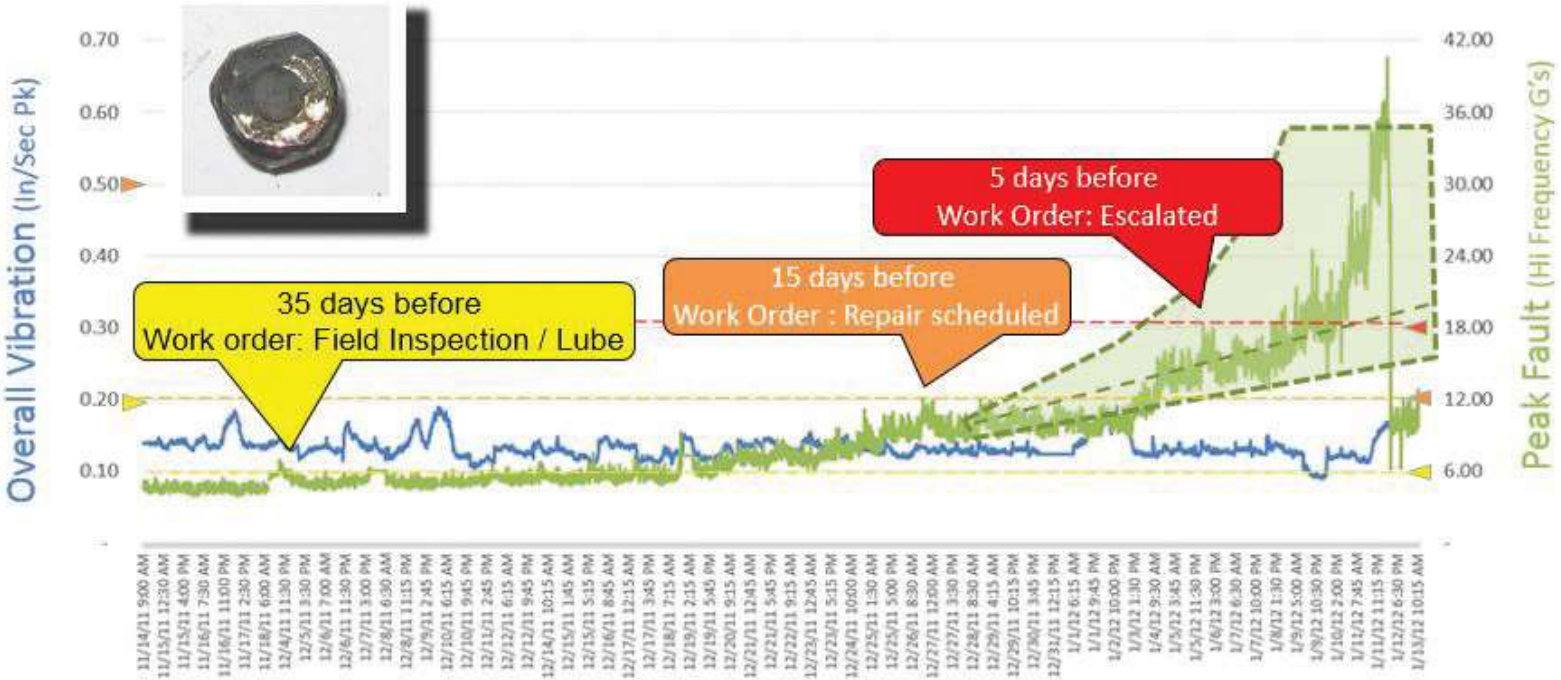
Increased Efficiency

Use case: Predictive Maintenance



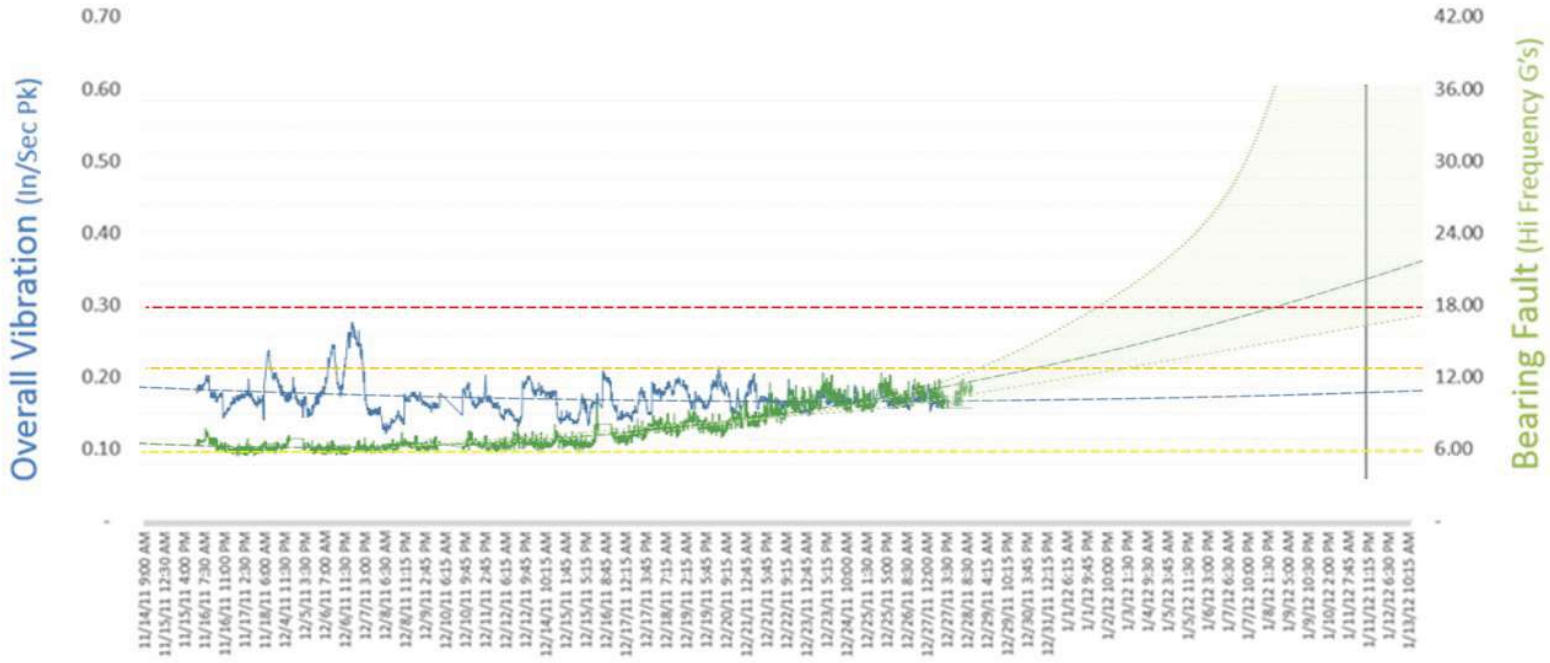
https://www.datascience.com/blog/predictive-analytics-in-industrial-iot

Use case: Predictive Maintenance



https://www.datascience.com/blog/predictive-analytics-in-industrial-iot

Use case: Predictive Maintenance



https://www.datascience.com/blog/predictive-analytics-in-industrial-iot

Digital Twin - Rolling assistance system

Background

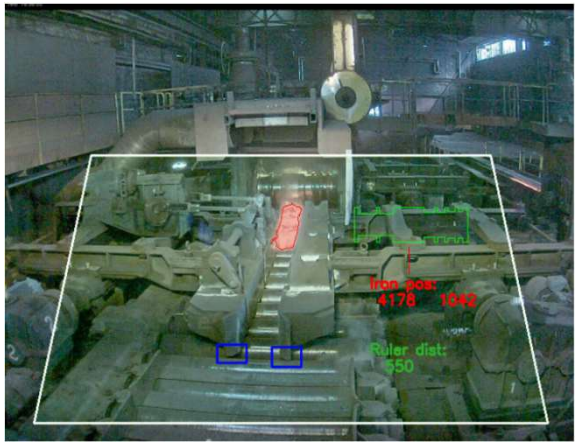
- Educate and train operators
- Hard to keep whole work process in mind
- Needs for flexible and updated stick series

Solution

- Operator simulation education
- Visual support using transparent screen
- Database that documents stick series

Potentials

- Fast operator learning outside of production
- Knowledge transfer
- Helps operators to do the right thing
- Dynamic stick series through ML



UDDEHOLM
a voestalpine company

Control room

Background

- Uddeholm AB have a growing number of machines, which requires a wide variety of increasingly complex maintenance processes
- There is a need to simplify troubleshooting, analysis of data, development of processes and quality improvement

Solution

- Consolidate a centralized control room
- Implement a video wall solution
- Complete the installation of essential sensors
- Visualized the monitored data
- Integrate horizontal and vertical systems

Advantages

- Increase the system availability
- Increase the ability to analyse, identify, and classify opportunities to improve processes
- Less unexpected maintenance
- Boost the collaboration
- Foundation of future digital development

Step 1
Inventory
Ramp-up

Step 2
Data collection
Integration

Step 3
Complete
Dashboards

Image analysis of samples

Background

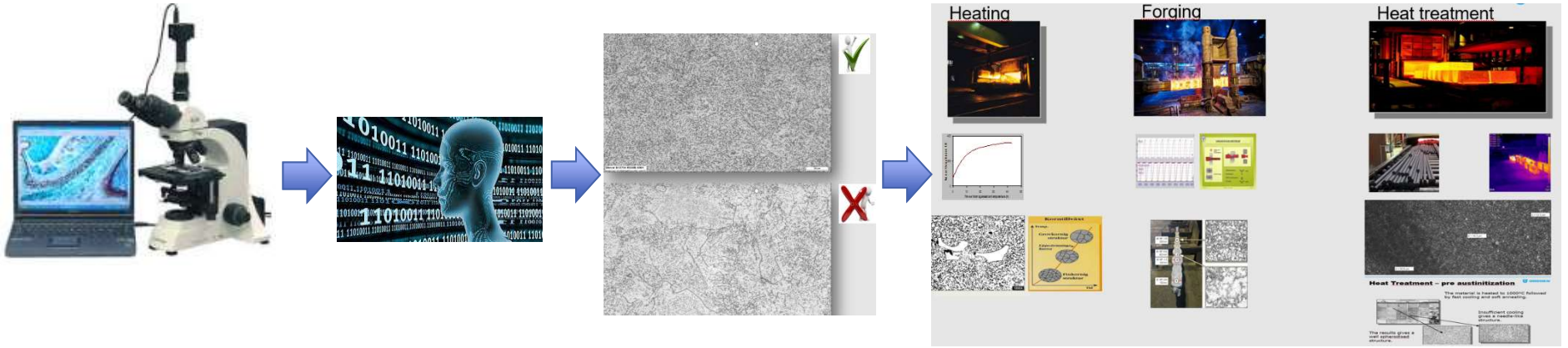
- Variations in quality ratings
- Several manual steps
- Need for increased capacity
- A lot of stored data

Solution

- Automate sample analysis
- Apply image analysis for quality ratings
- Use AI-techniques for continuous learning

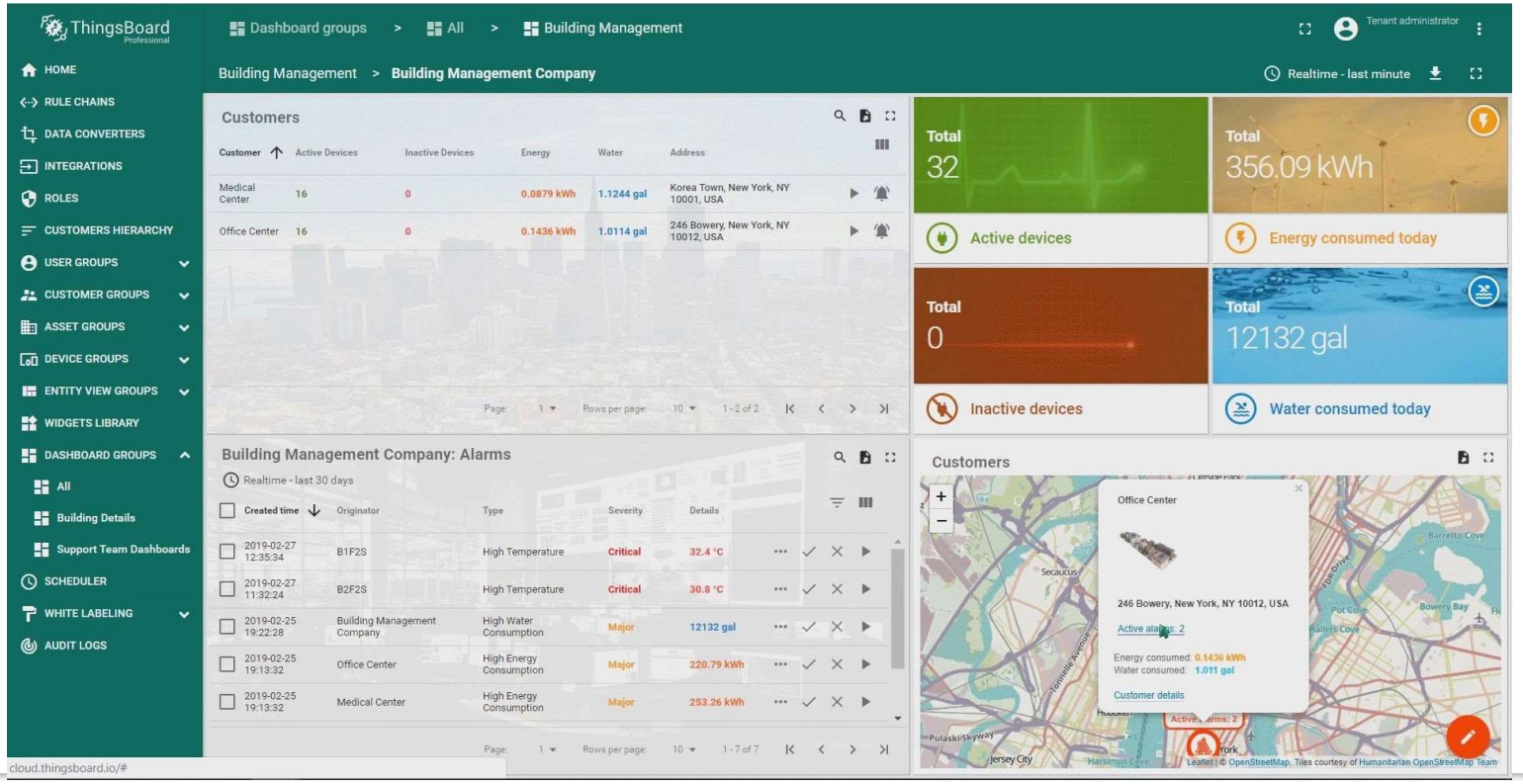
Potentials

- -0.5 FTE
- Quality feedback to and tracking of production
- No human quality ratings



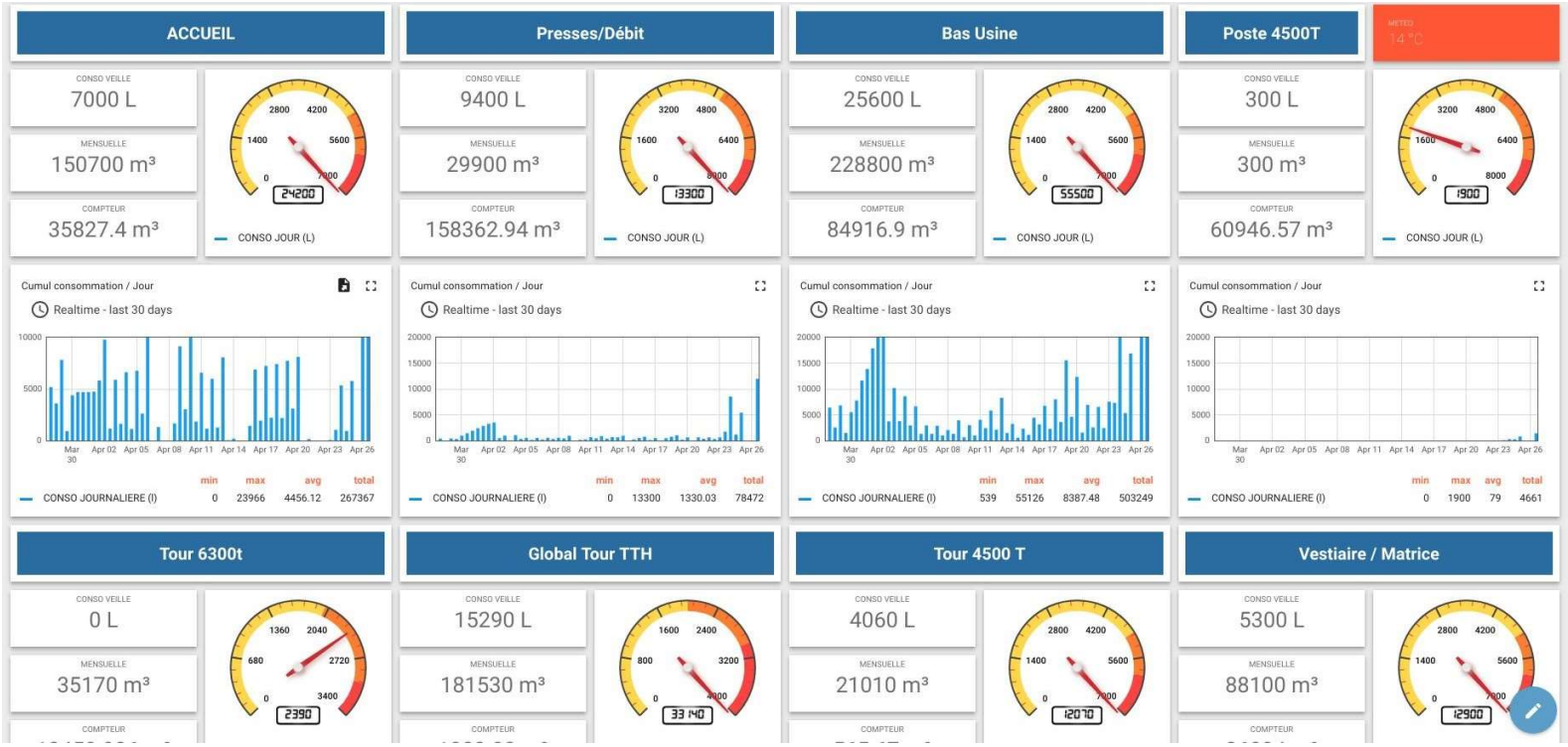
Use cases: Building management

Access to this use case
on https://cloud.thingsboard.io
login: smart-building-spectator@thingsboard.io password: demo123!



Use cases: Smart water metering

- Enterprise size water consumption supervision and management
- Reduce operational costs and rise efficiency

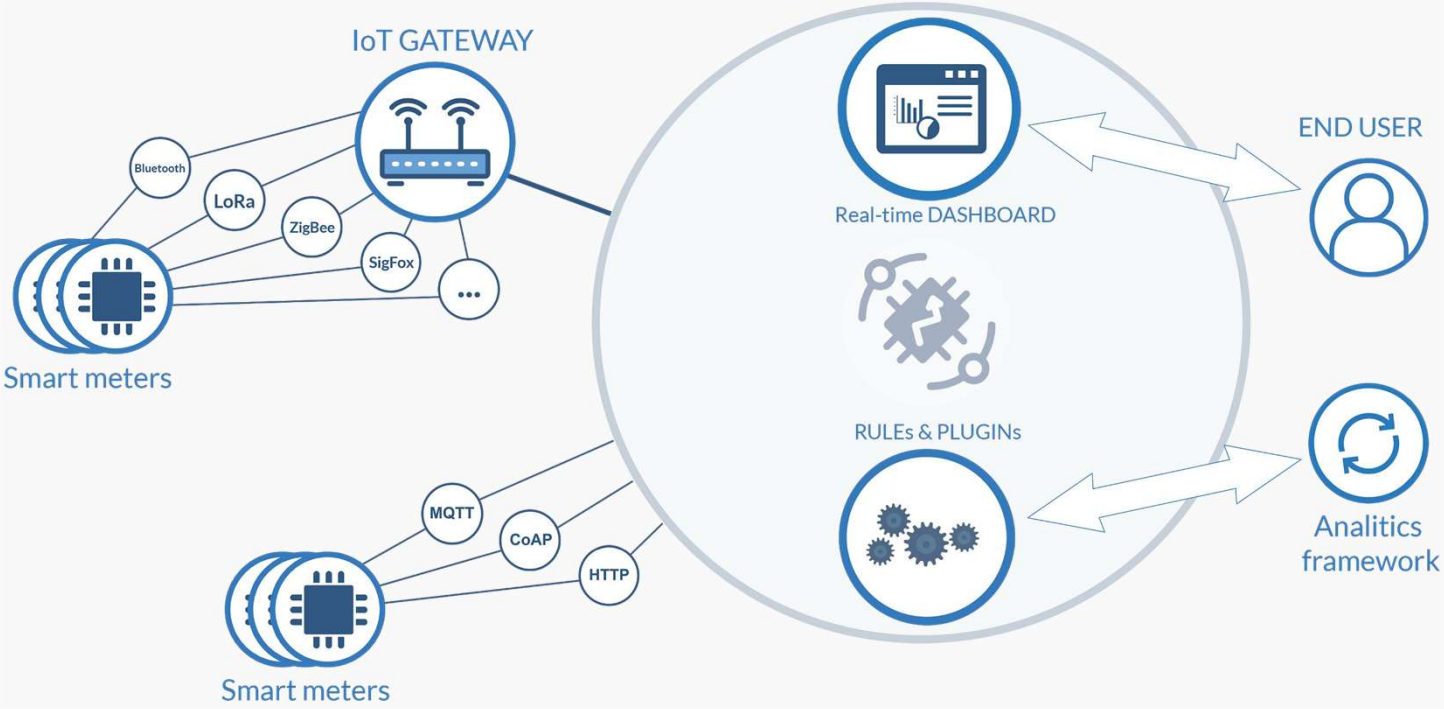


Use cases: Smart Energy

- Reliable and fault tolerant data collection
- flexible data visualization for real-time and historical smart energy monitoring
- Multitenancy and end-user dashboards

Use cases: Smart Energy

- Flexible connectivity options to connect devices, store and analyze collected IoT data.
- Integration with third-party analytics frameworks and solutions for advanced analytics and machine learning

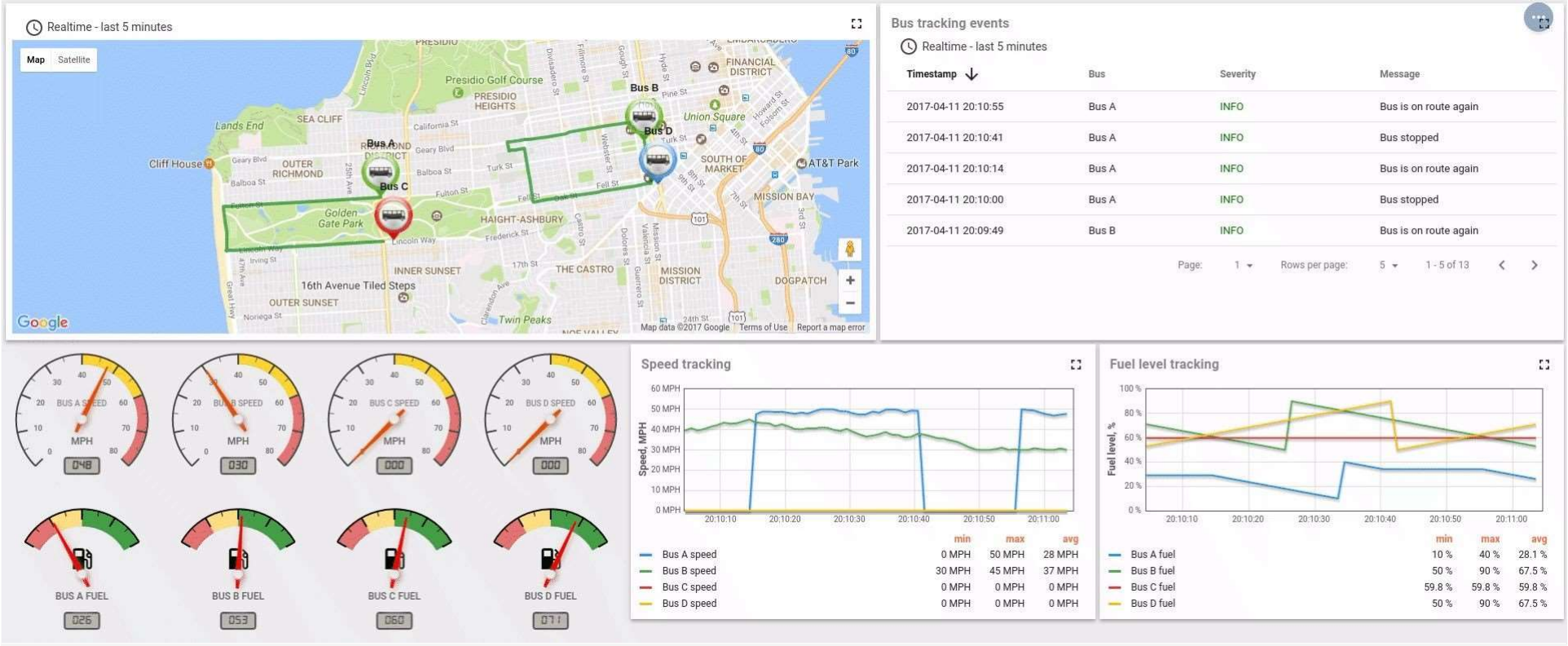


Use cases: Smart Farming

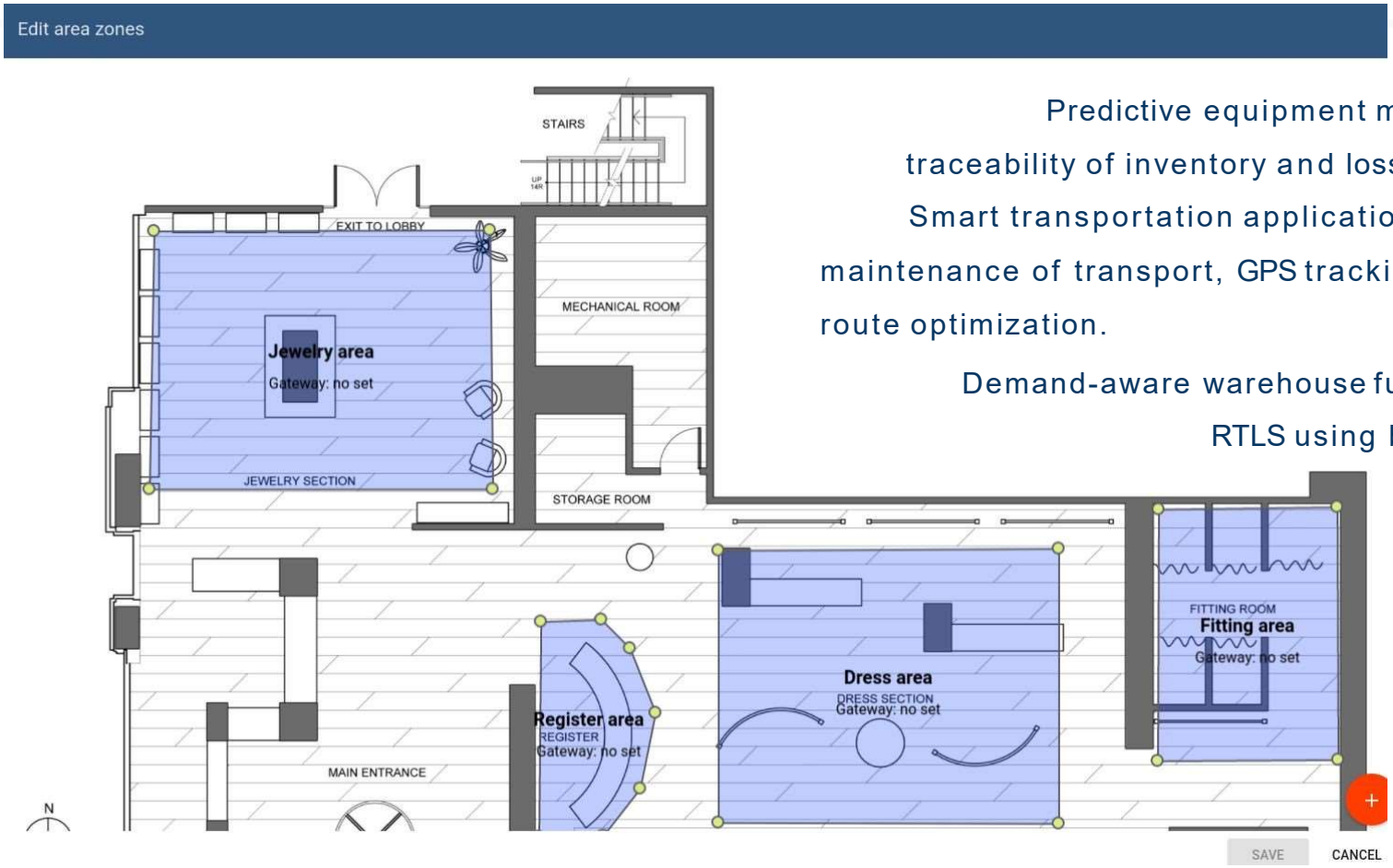
- Reliable and fault tolerant data collection from IoT devices and sensors
- monitor facilities state, crop growth characteristics, humidity level, etc.
- Flexible deployment options: at the farm, in the cloud, mixed

Use cases: Fleet Tracking PoC

- flexible IoT data visualization for both real-time and historical vehicle data
- Remote control over secure, encrypted connection



Smart Retail



Predictive equipment maintenance, traceability of inventory and loss prevention.

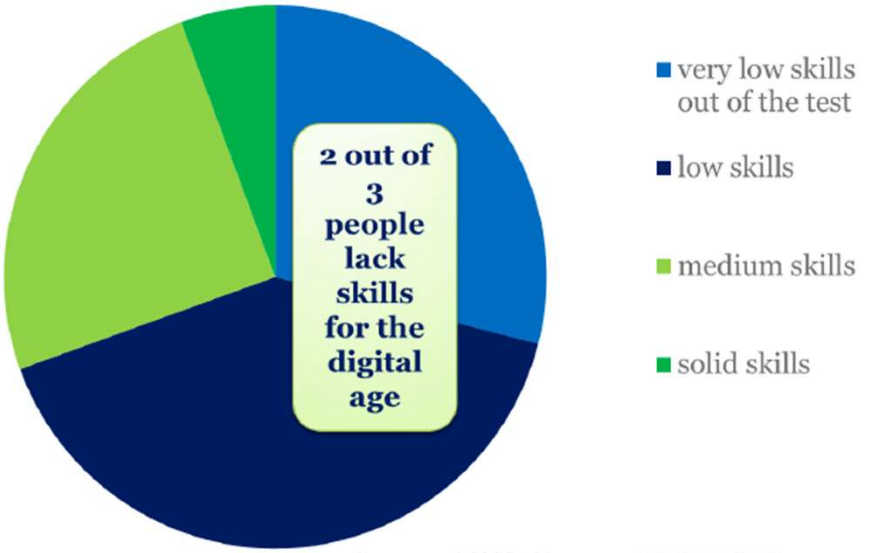
Smart transportation applications with the maintenance of transport, GPS tracking and route optimization.

Demand-aware warehouse fulfillment.

RTLS using beacons (UK)

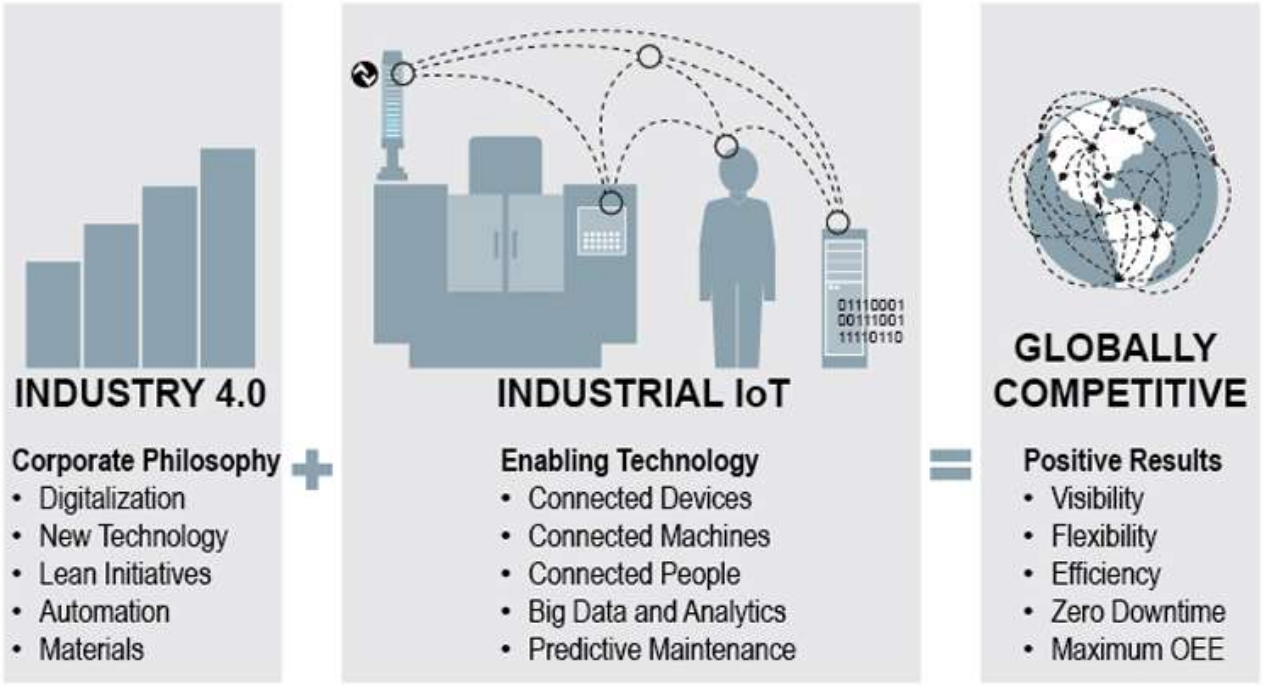
Implications and issues

- Future Job Market?
  - What talent? (data scientists, plant technicians, CS specialists,..)
- Job destruction?
  - We no longer differentiate between manual and intellectual tasks
- Skill implications?
  - More skills, more interdisciplinary education, more industry interaction
  - Generic skills to support learning in fast-changing environment
  - Digital skills and skills that complement machines

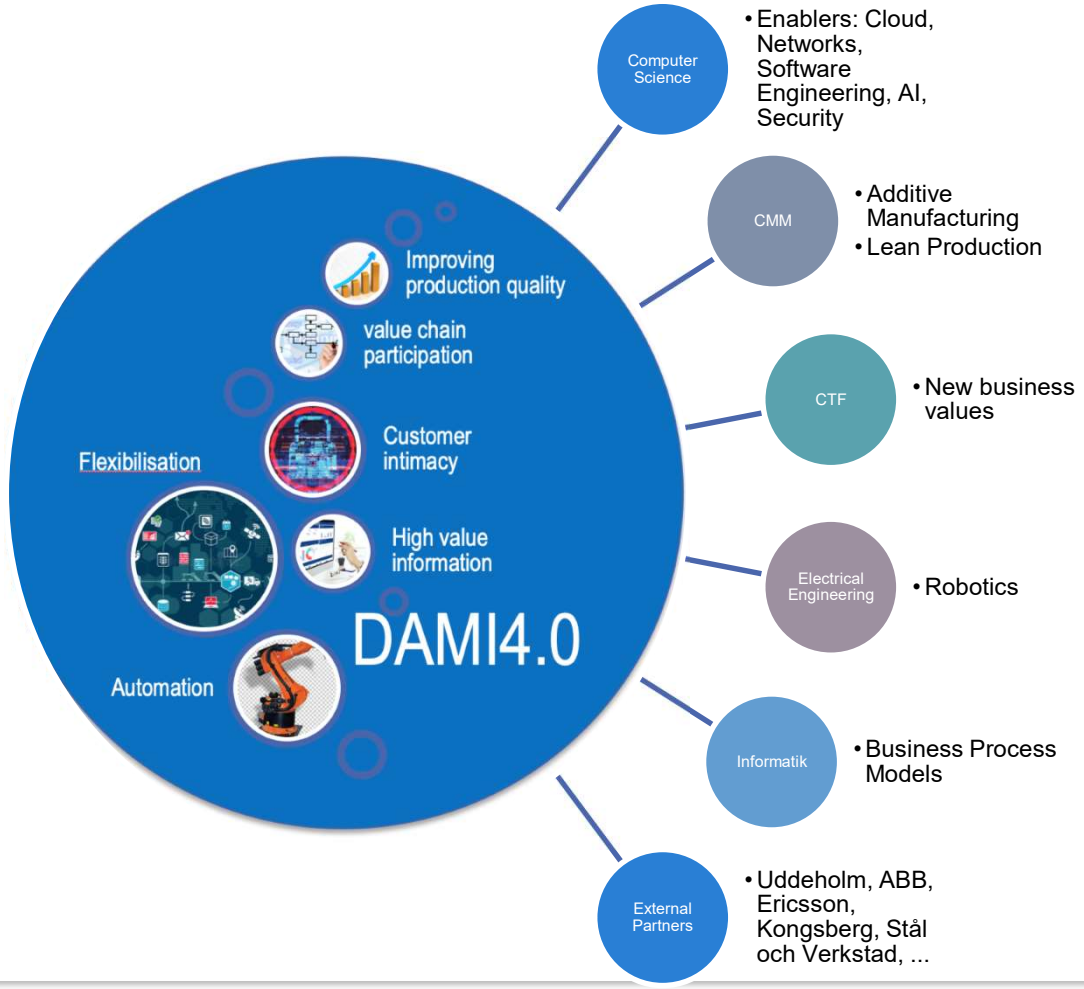


Source: OECD Survey of Adult Skills, 2015.

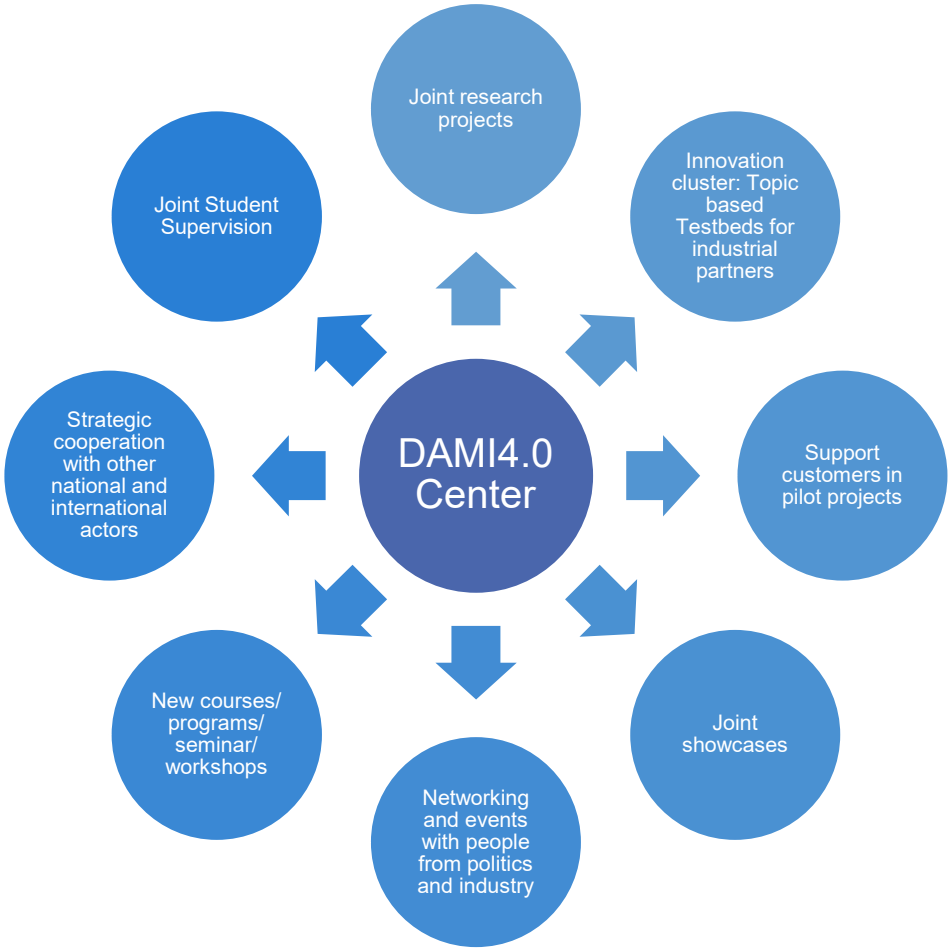
Summary


INDUSTRY 4.0
Corporate Philosophy
• Digitalization
• New Technology
• Lean Initiatives
• Automation
• Materials
INDUSTRIAL IoT
Enabling Technology
• Connected Devices
• Connected Machines
• Connected People
• Big Data and Analytics
• Predictive Maintenance
GLOBALLY COMPETITIVE
Positive Results
• Visibility
• Flexibility
• Efficiency
• Zero Downtime
• Maximum OEE

DAMI4.0 Center



DAMI4.0 Center



Wrap up

Go to www.menti.com and use the code 46 92 27

- Andreas Kassler
  - Email: andreas.kassler@kau.se
  - Cellphone: 070-684 19 01