


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

The background of the slide is a photograph of an industrial factory floor. In the center, a small white autonomous mobile robot (AMR) is moving along a track. On either side of the track, there are several large, orange industrial robotic arms, likely from a company like KUKA, which are positioned to perform tasks. The scene is brightly lit, and the focus is sharp on the central robot, with the robotic arms in the foreground and background slightly blurred.

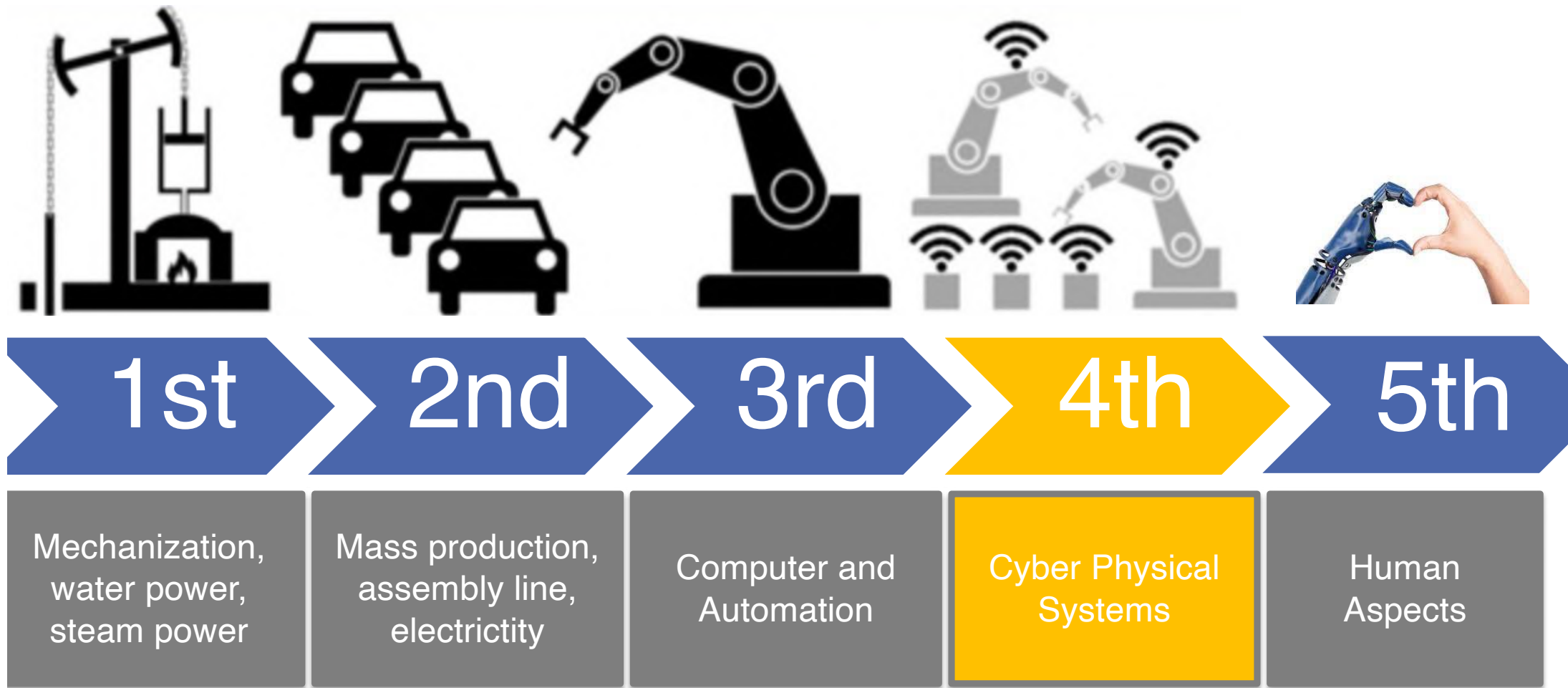
Prof. Andreas Kessler

CS Department

Head of research center DAMI4.0

Karlstad University

Road towards Industry5.0



New ICT Architecture and a New Ecosystem



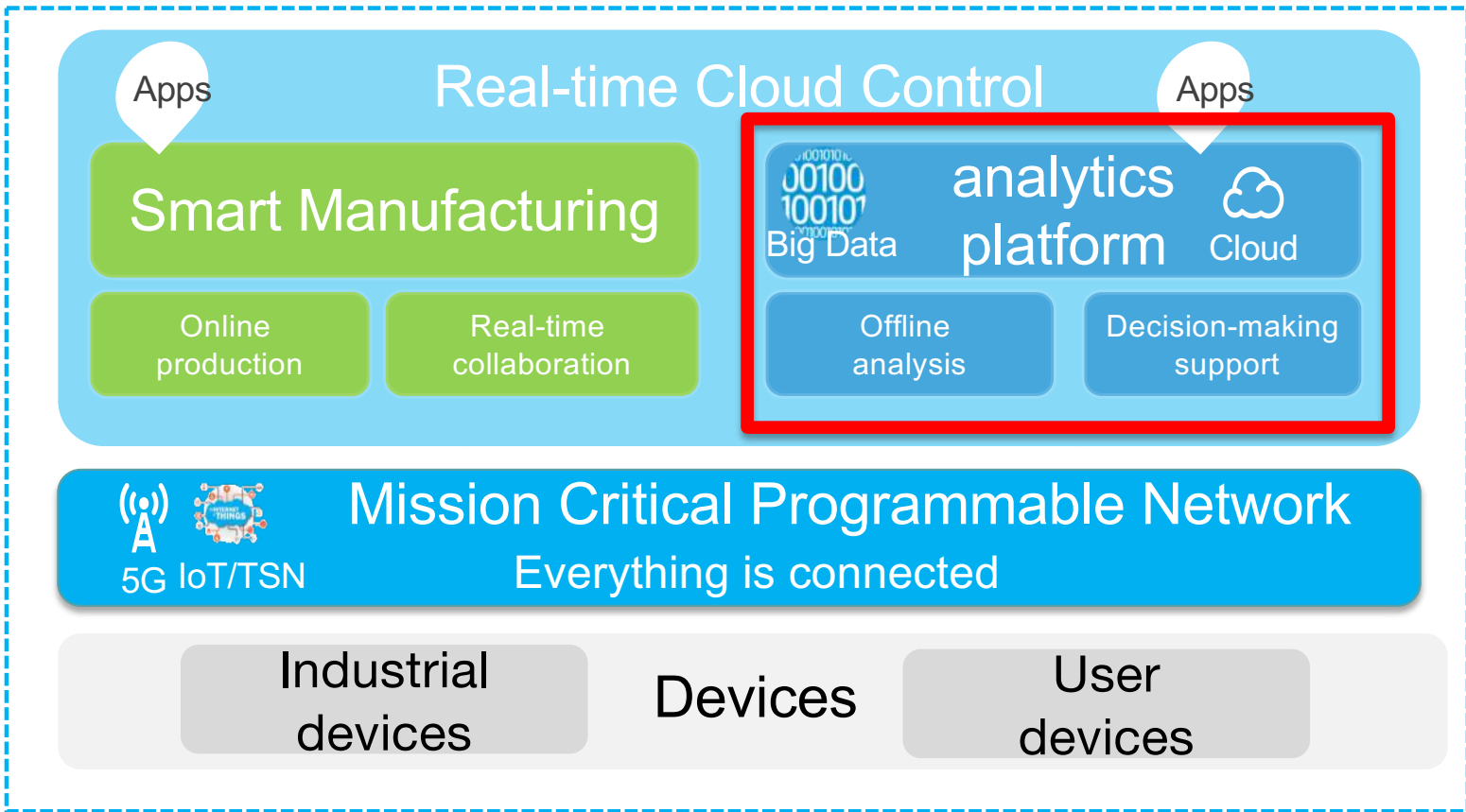
Everything becomes intelligent

Intelligenti-
zation

Business-
Driven

New
Ecosystem

Agile
Innovation



Tonights Program...



What is Big-Data?

What is Data Analytics?

Relationship between BD, Analytics & AI

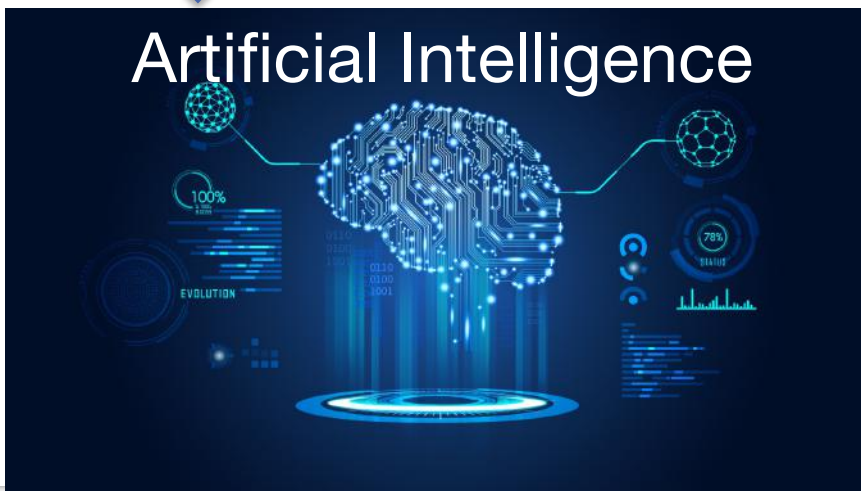
What is the role of analytics in IIoT

What is the value of analytics in IIoT

Architectural Issues

Threat? Opportunity?

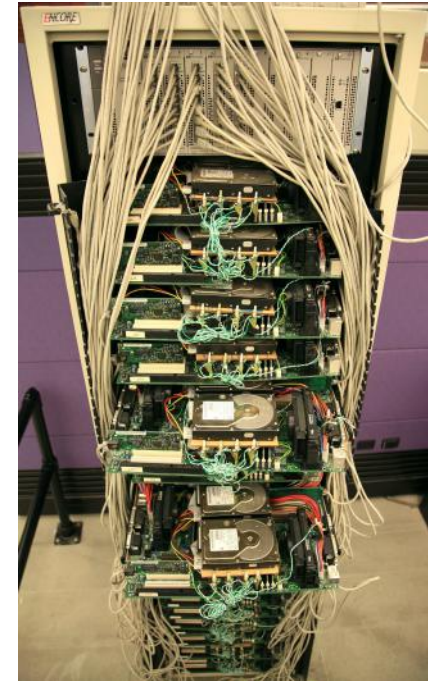
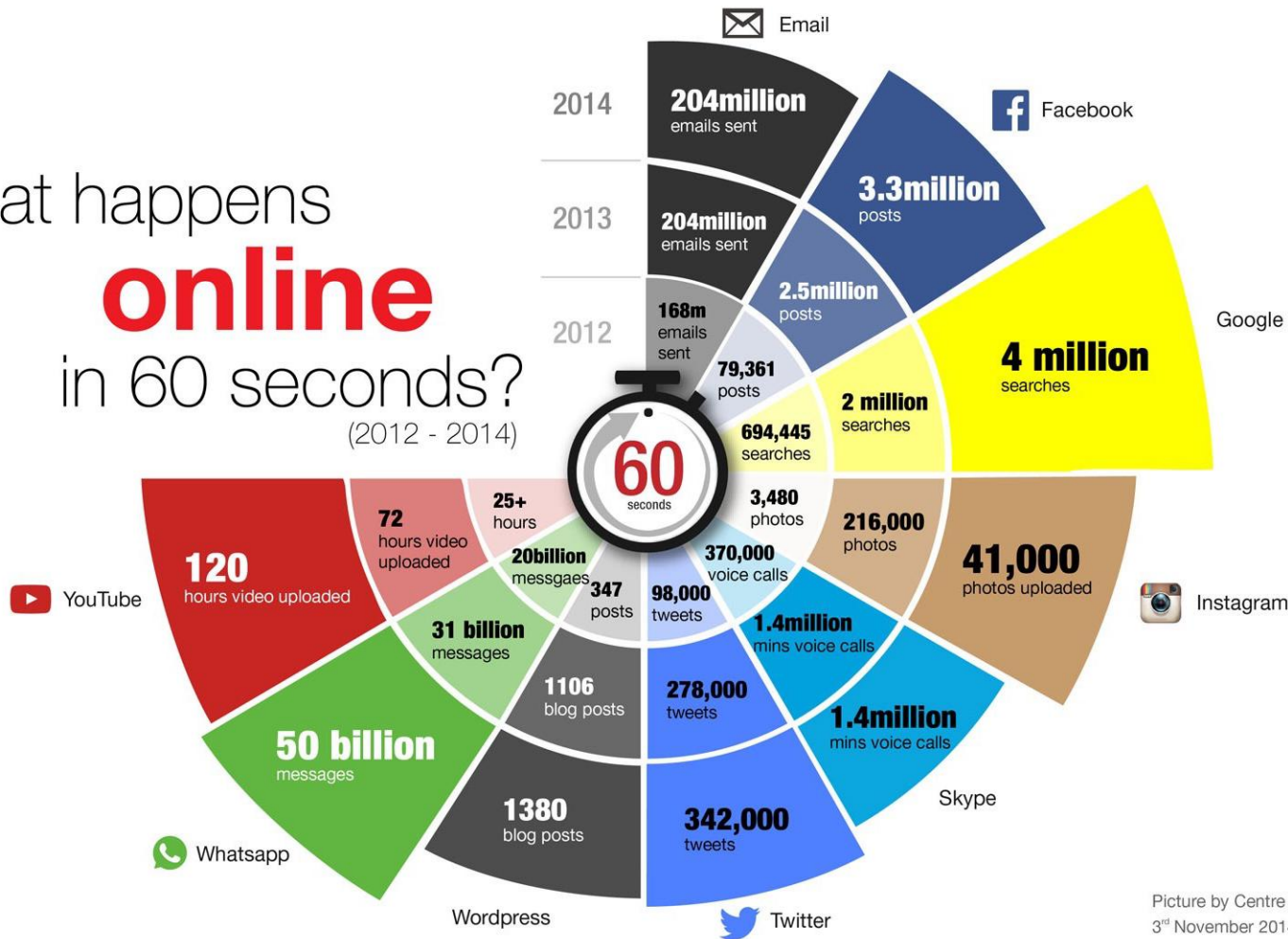
Case studies



10 years ago...the rise of data centers



What happens
online
in 60 seconds?
(2012 - 2014)

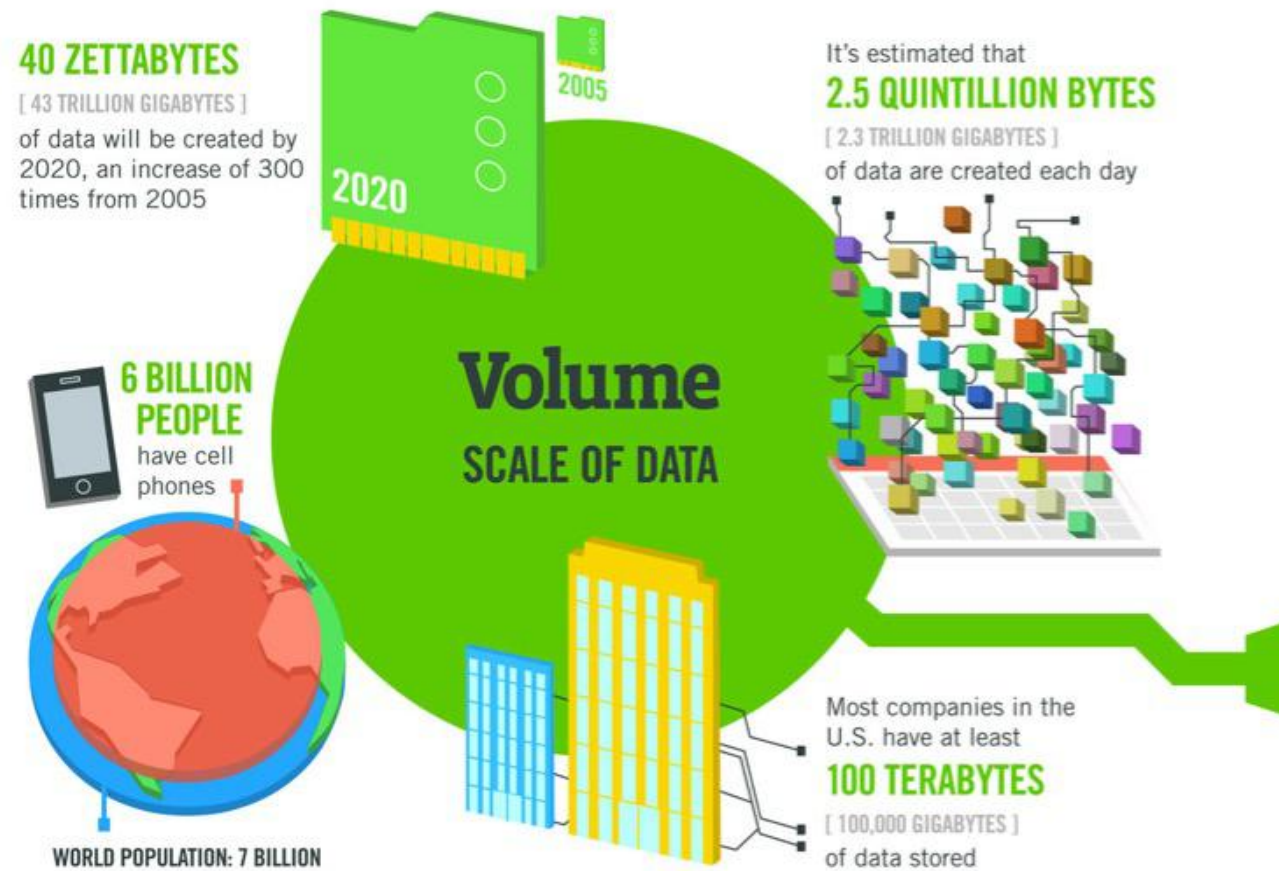


Picture by Centre for Learning and Teaching
3rd November 2014.

The 4 V: Volume



- Terabytes to exabytes of data to process



The 4 V: Velocity



- Streaming data
- ms to respond

The New York Stock Exchange captures
1 TB OF TRADE INFORMATION
during each trading session



Modern cars have close to
100 SENSORS
that monitor items such as
fuel level and tire pressure

Velocity
ANALYSIS OF
STREAMING DATA

By 2016, it is projected
there will be

**18.9 BILLION
NETWORK
CONNECTIONS**

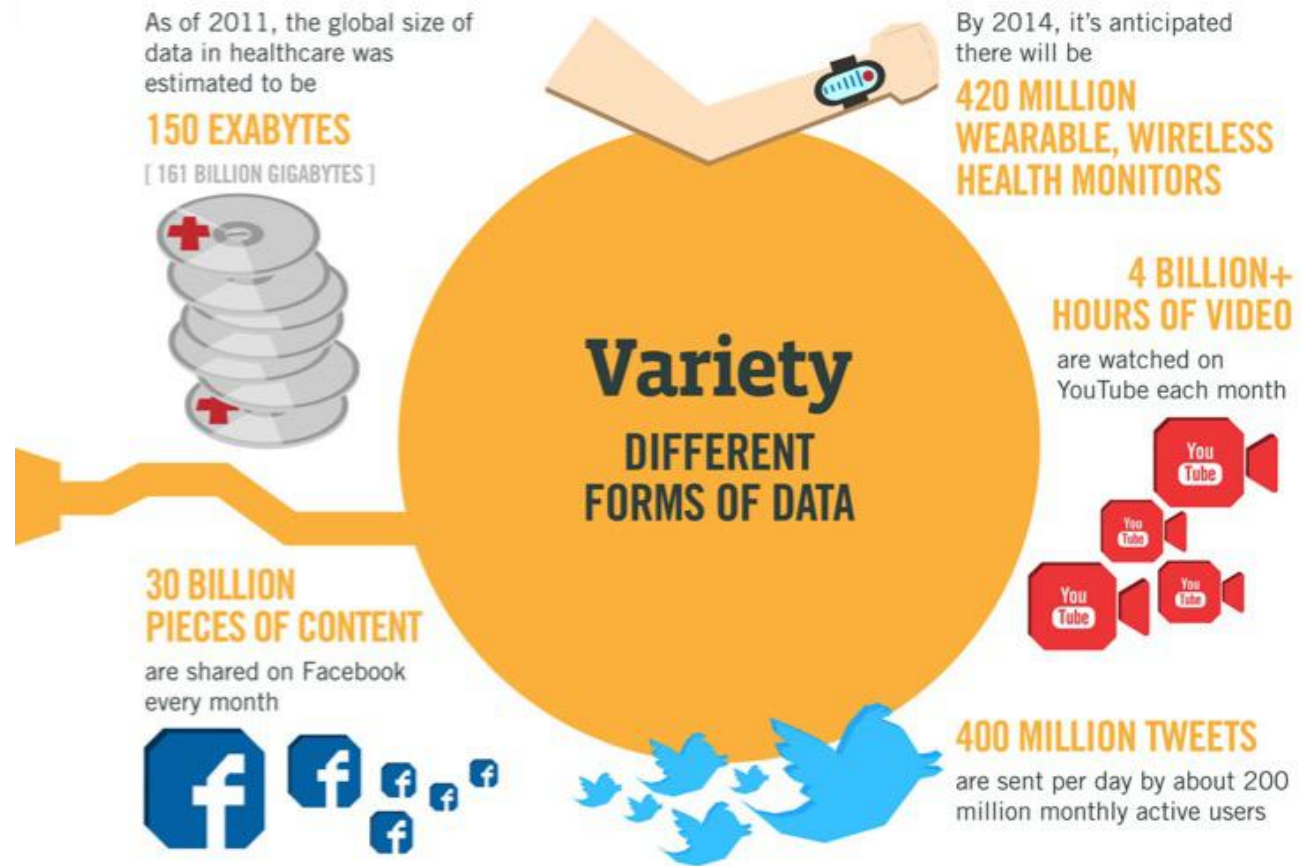
– almost 2.5 connections
per person on earth



The 4 V: Variety



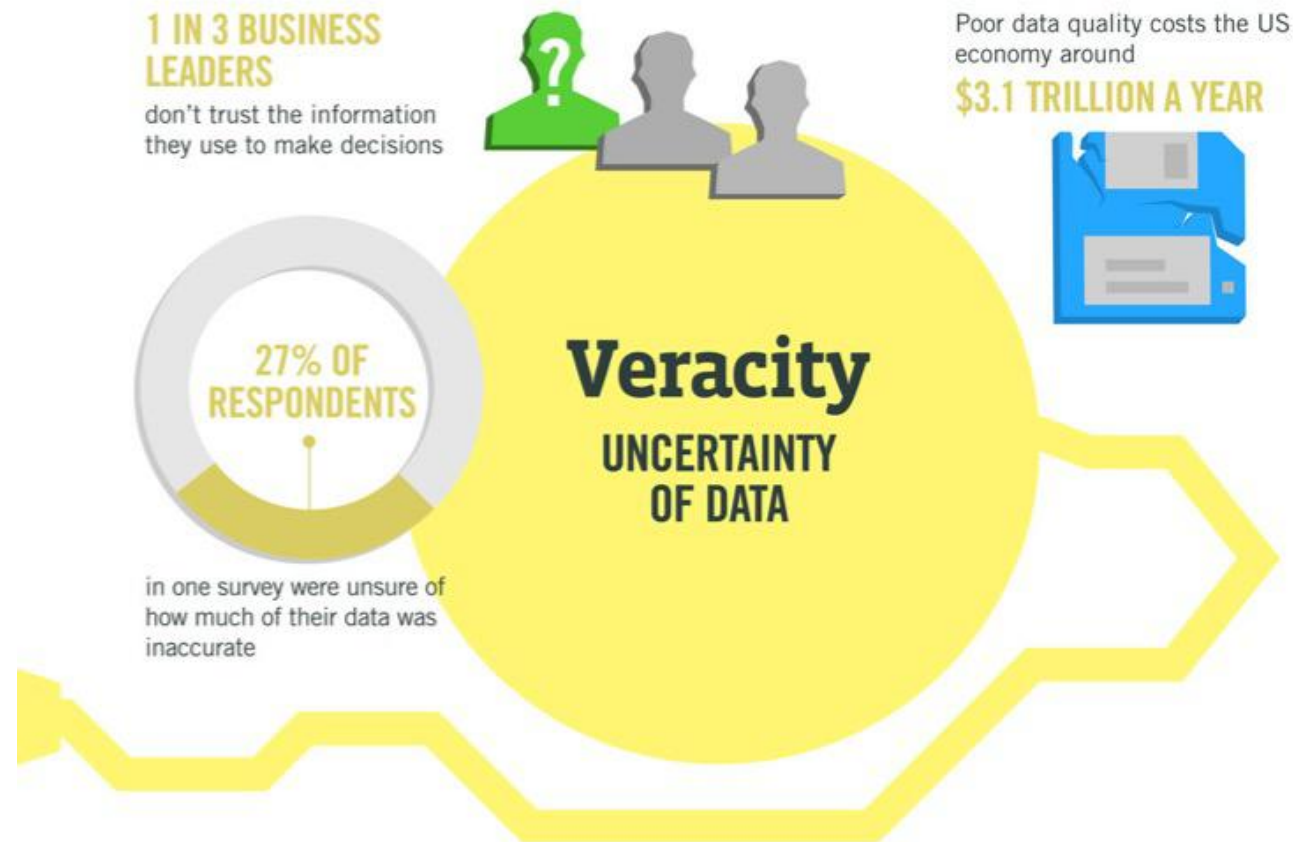
- Structured
- Unstructured
- Text
- Multimedia
- Video
- ...



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

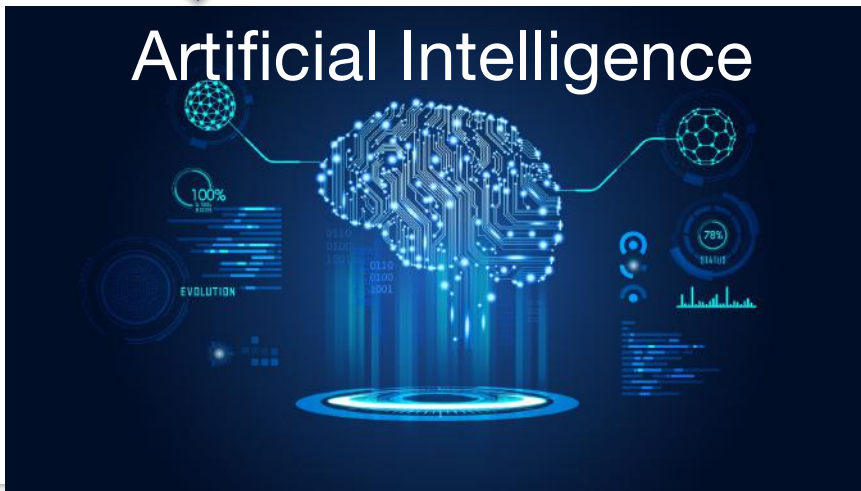
■ Big Data

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

Tonights Program...



Threat? Opportunity?



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What is the value of analytics in IIoT

What is the role of analytics in IIoT

Architectural Issues

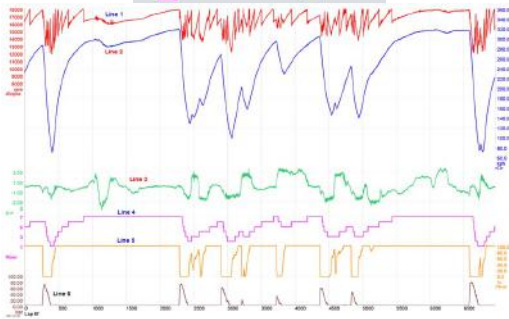
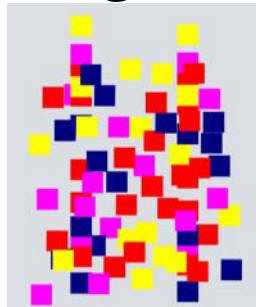
Case studies

What is Data Analytics ?

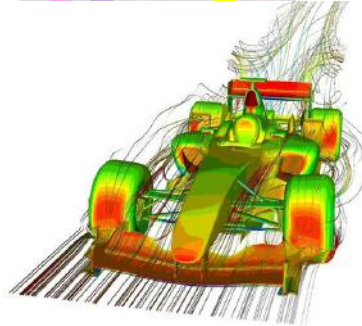
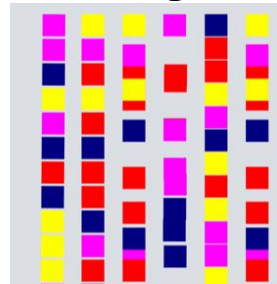


Data analytics applies statistical techniques to large data sets to obtain actionable insights for making smart decisions. It tries to uncover hidden patterns, unknown correlations, trends and any other useful business information

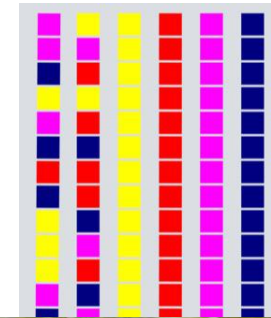
Big Data



Analytics

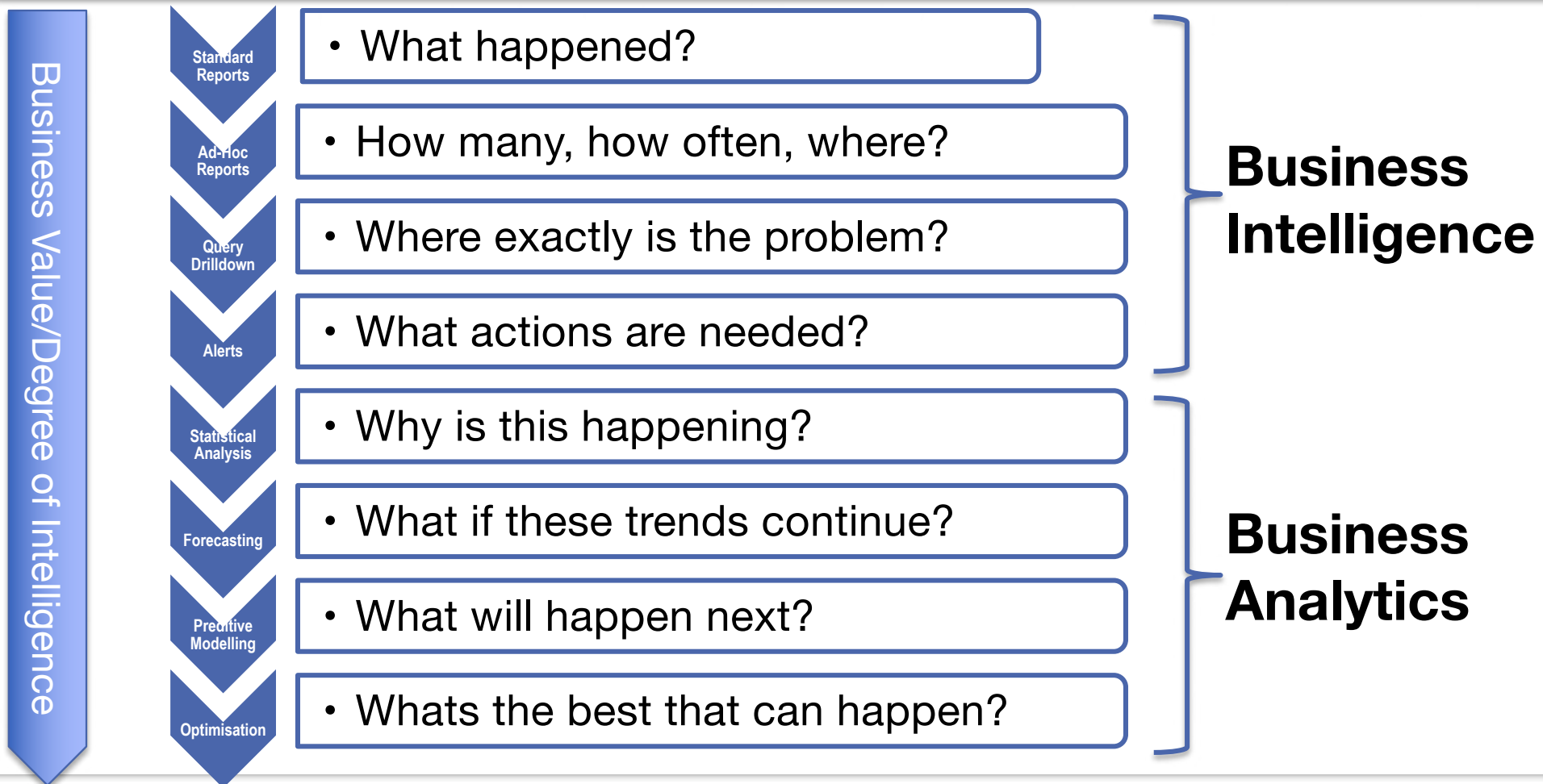


Decisions



Business Analytics

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



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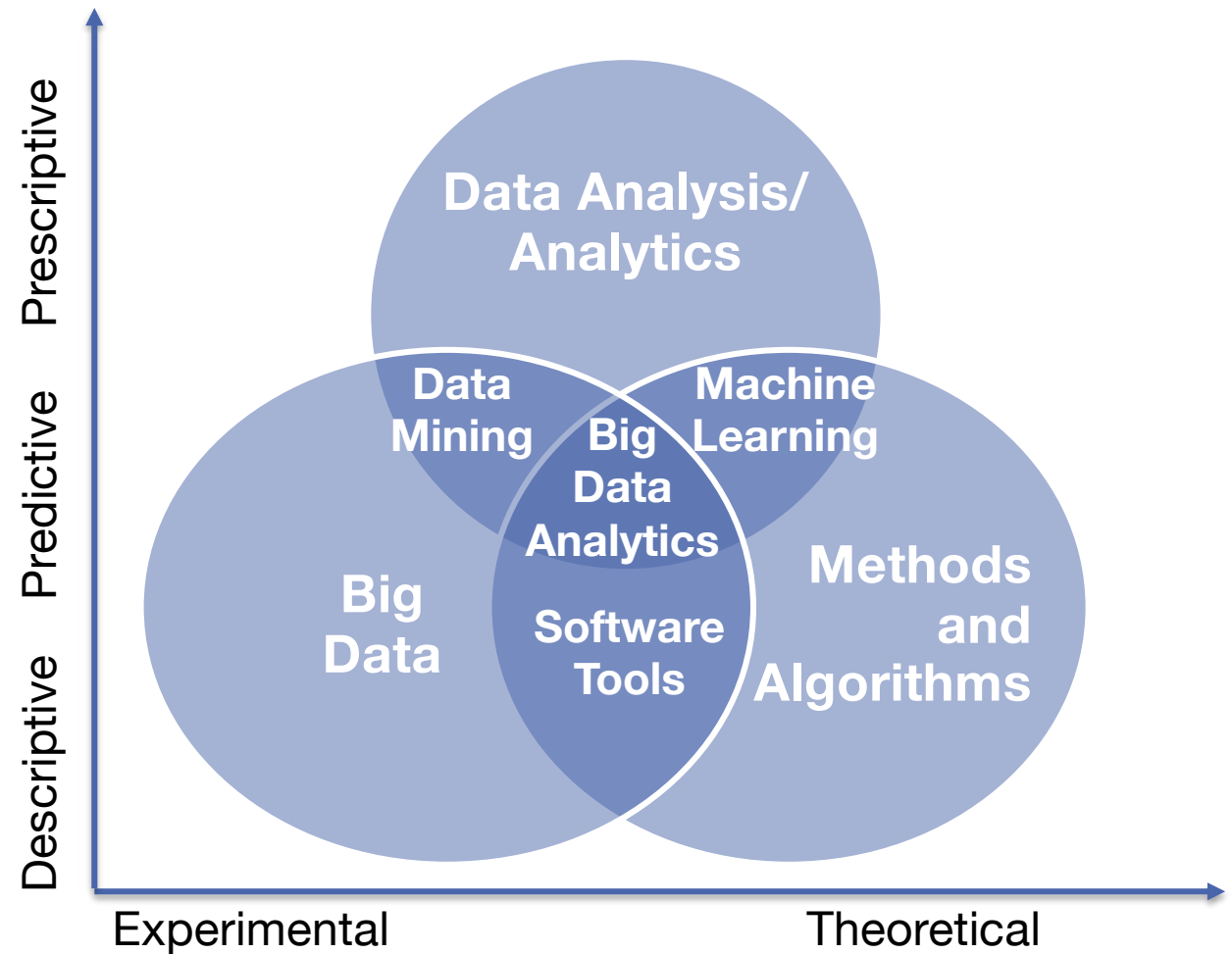
Analytics (Descriptive/Predictive)



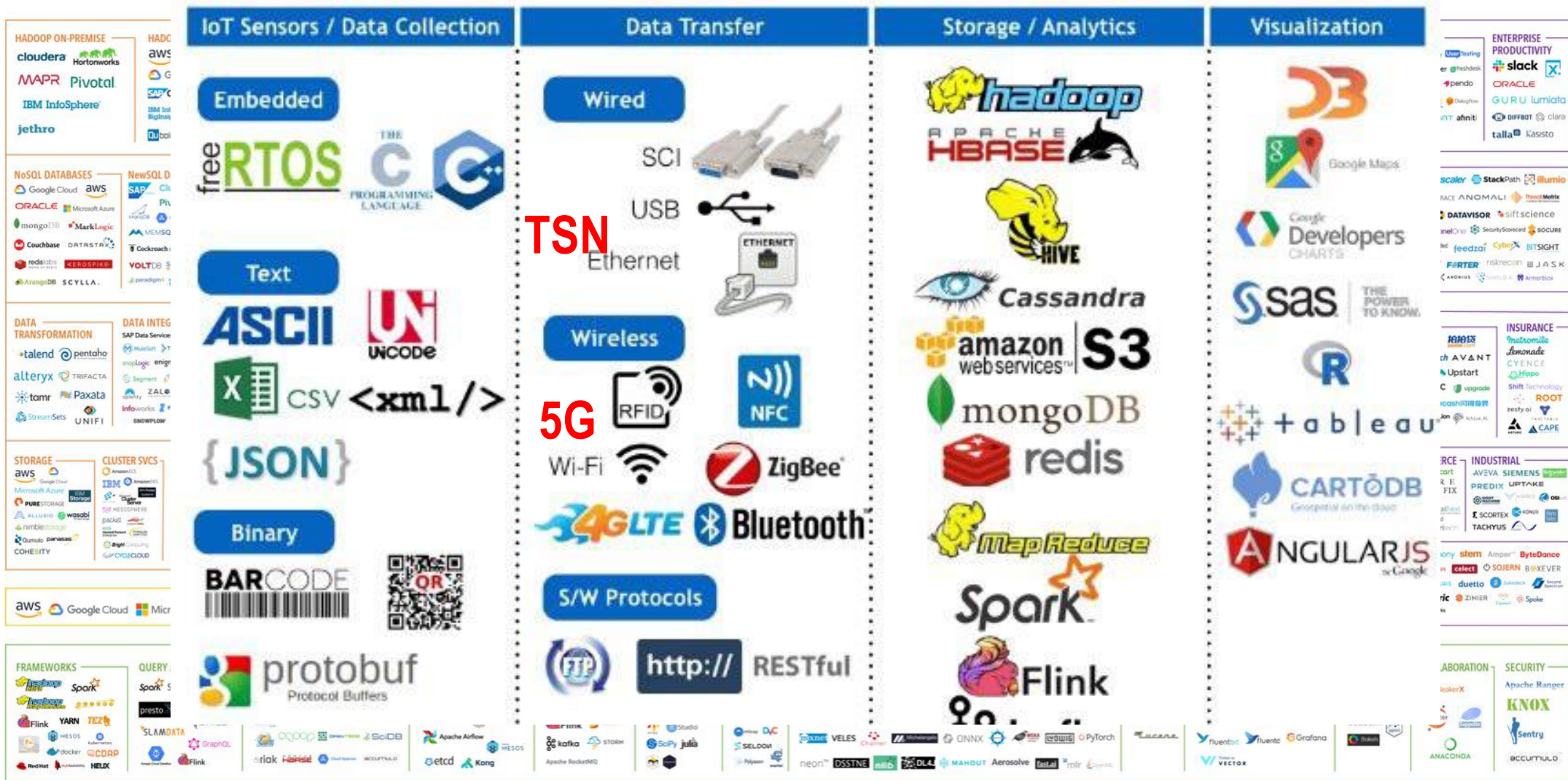
Helps you to advise on possible outcomes.
“What should we do?”

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

Helps you to understand your data. “What has happened?”



DATA & AI LANDSCAPE 2019



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Analytics in IIoT - Usecases



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



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 overseeing 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

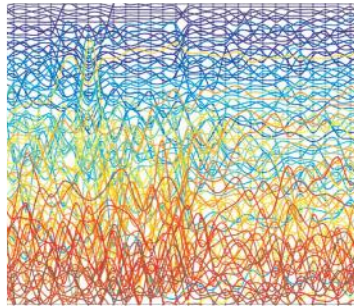


More data



- 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



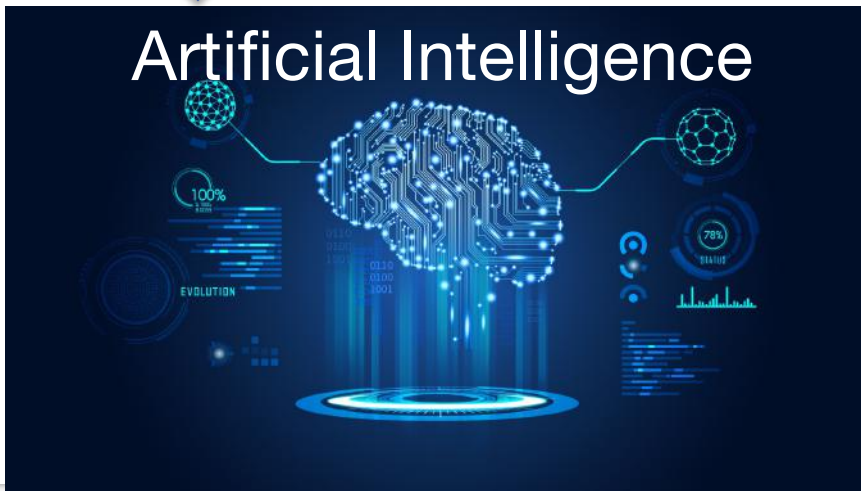
- Integration with operation systems and BPMS
- Bidirectional communication and control endpoints

- 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

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Value of Data Analytics in IIoT



Operations Efficiency

- Production Optimization
- Production Planning and Scheduling
- Productivity modelling
- Statistical quality control
- Inventory optimization

Maintenance Efficiency

- Predictive Maintenance
- Condition Monitoring
- Maintenance Planning and Scheduling
- Reliability-Centered Maintenance
- Anomaly Detection

Service Efficiency

- Remote Management/ Services
- Field Service Management
- Materials management (inventory)
- Service Lifecycle management
- Supply Chain analytics

Information Efficiency

- Information modelling
- Data quality framework
- Asset life cycle information model
- Machine borne data management and analytics
- Knowledge management

Energy Efficiency

- 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?



Question: *What are the biggest benefits of Industrial Data Analytics for your company?**



*The survey specifically asked for the top three benefits. The ranking was generated by giving points – three points for first biggest, two points for second biggest and one point for third biggest benefit – The percentage is based on the overall number of points.

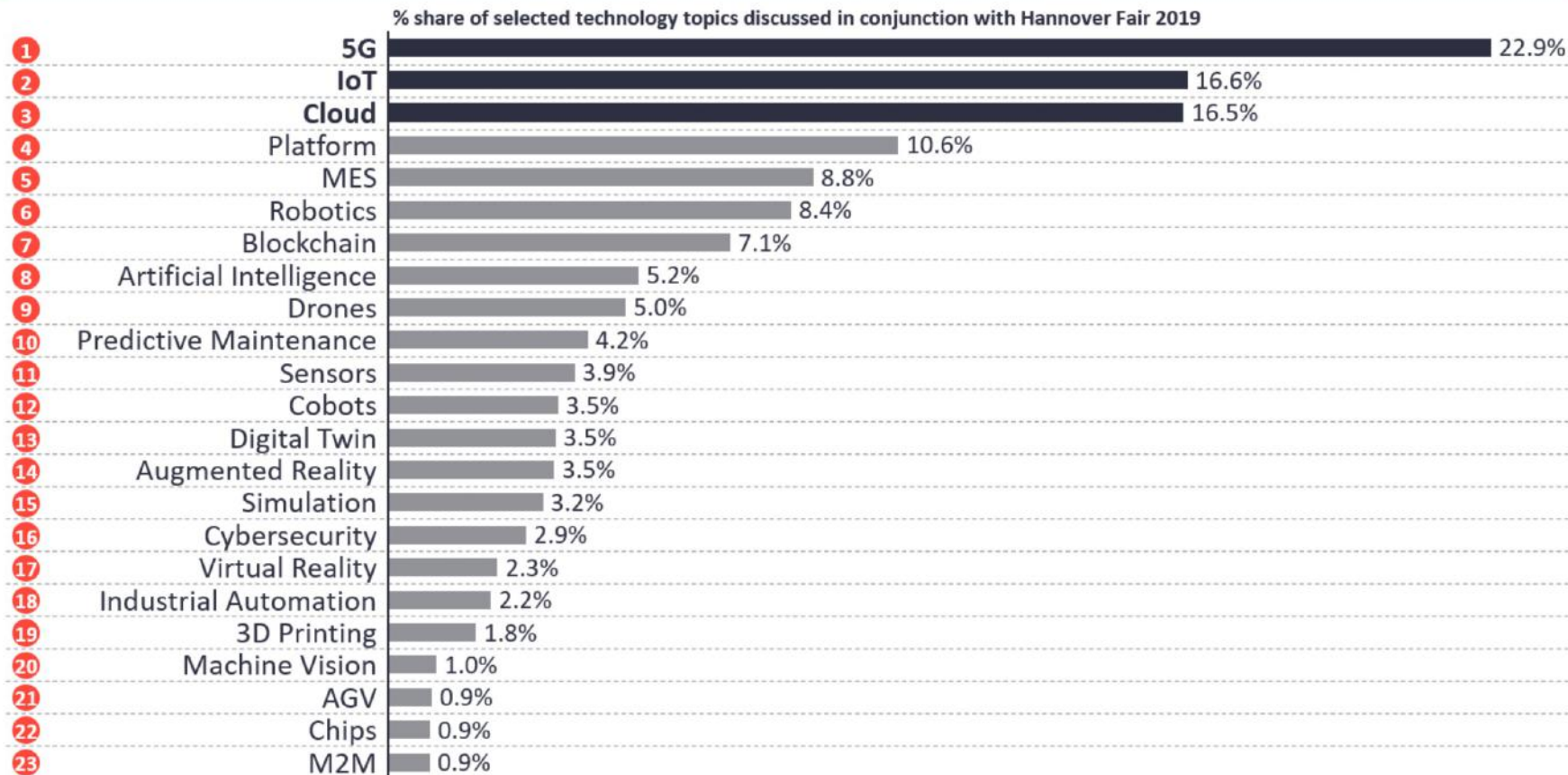
<https://iot-analytics.com/wp/wp-content/uploads/2016/10/Industrial-Analytics-Report-2016-2017-vp-singlepage.pdf>

Technologies



Hannover Fair 2019: Top technologies

Share-of-voice in the media



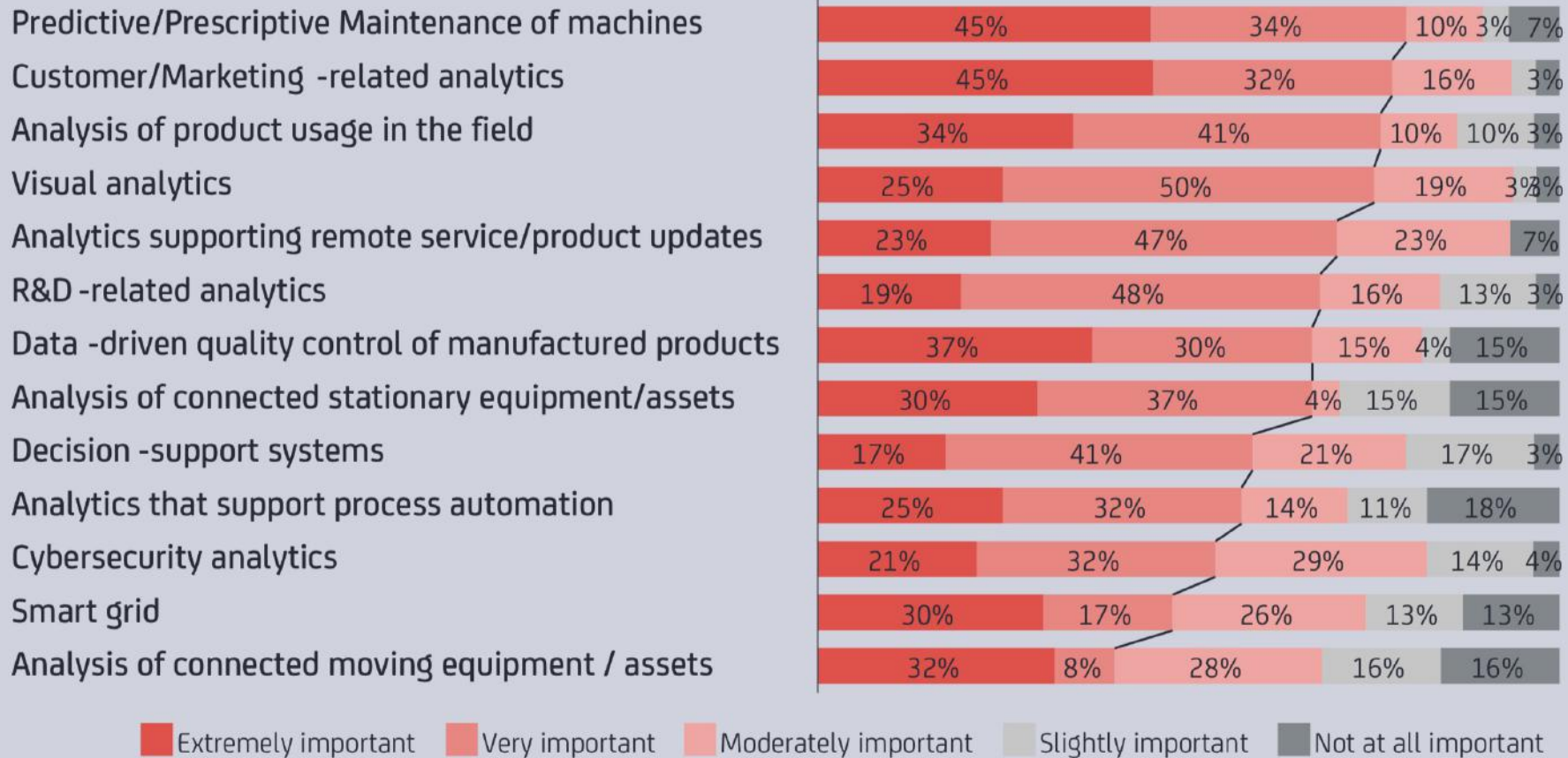
Note: Analyzed were all press articles and announcements 3 weeks prior and the week during the fair that specifically mentioned the fair and the topic. Total adds up to more than 100%

Source(s): IoT Analytics Research, Google News

How important are the following applications?



Question: How important are the following Industrial Data Analytics applications for your company in the next 1-3 years?



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

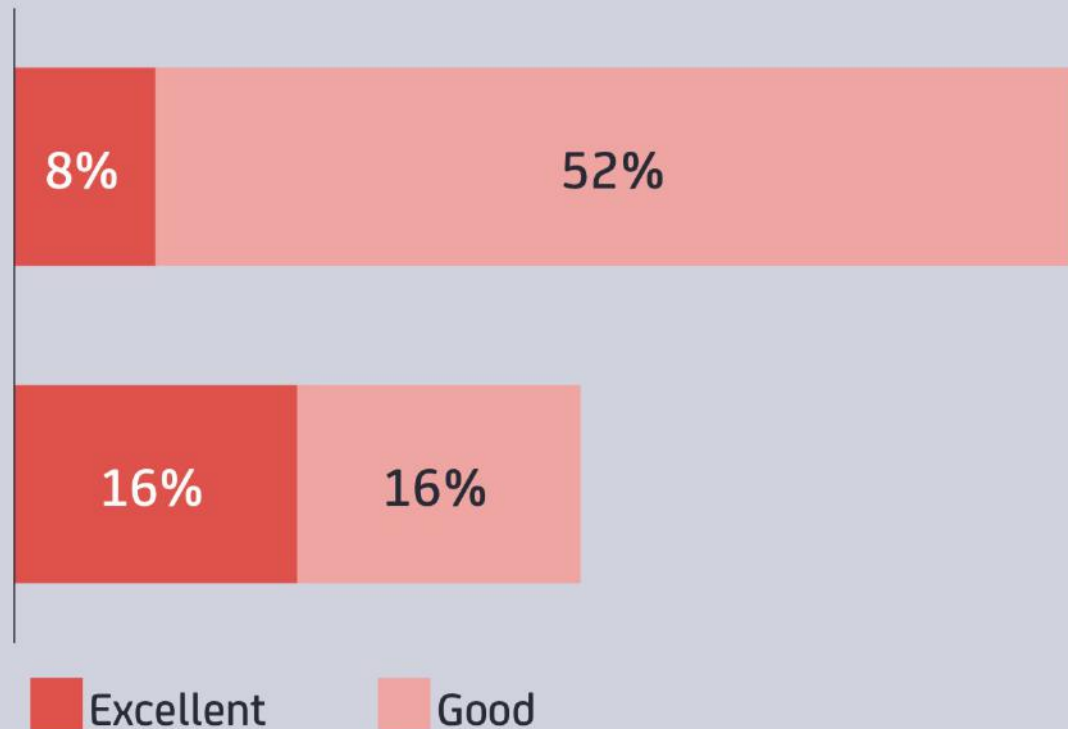
Companies struggle generating insights



Question :

How good are you at collecting relevant sensor/machine/product-related data sets?

How good are you at generating insights from the collected sensor/machine/product-related data sets?

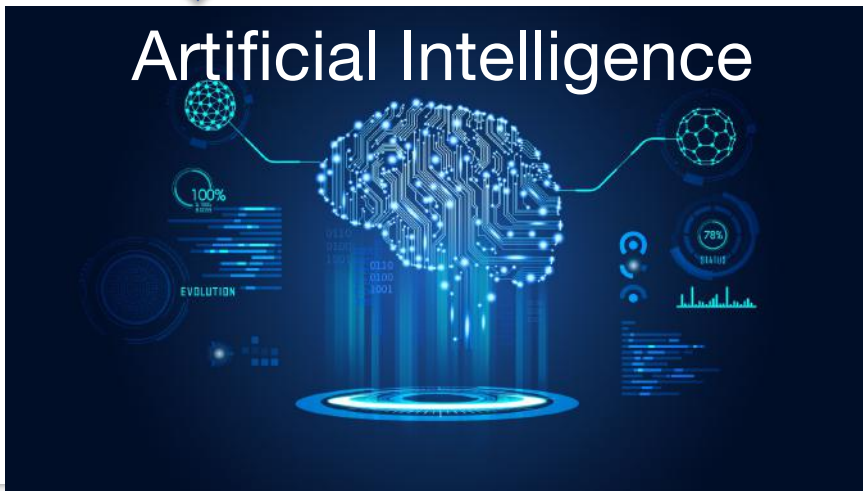


Respondents who answered:

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Industrial IoT Data Processing Layers



Cloud Layer

Big Data Processing
Business Logic
Data Warehousing

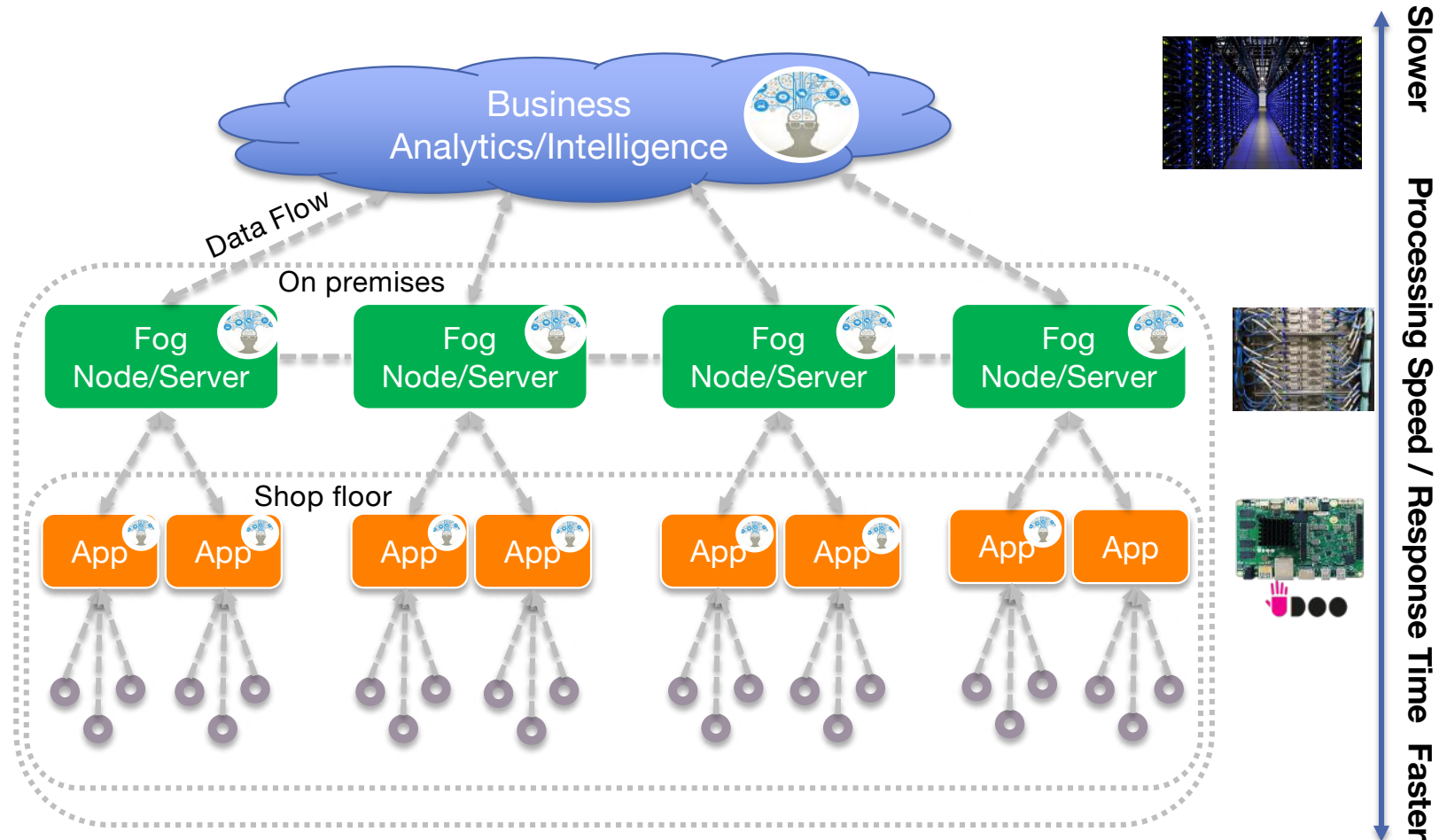
Fog Layer

Local Network
Data Analytics and Filtering
Control Response
Virtualization/Standardization

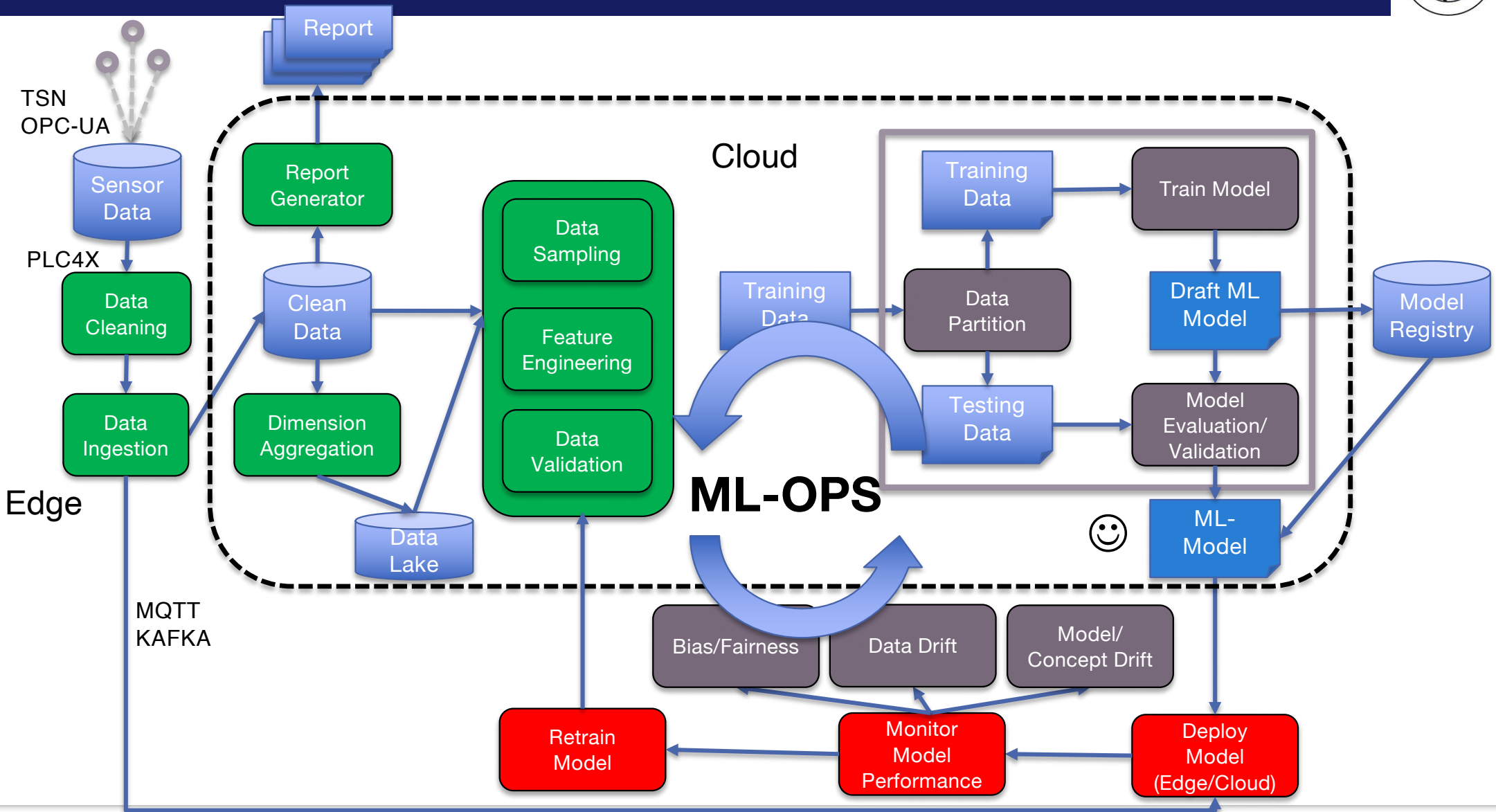
Edge Layer

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

Sensors and PLC
create data



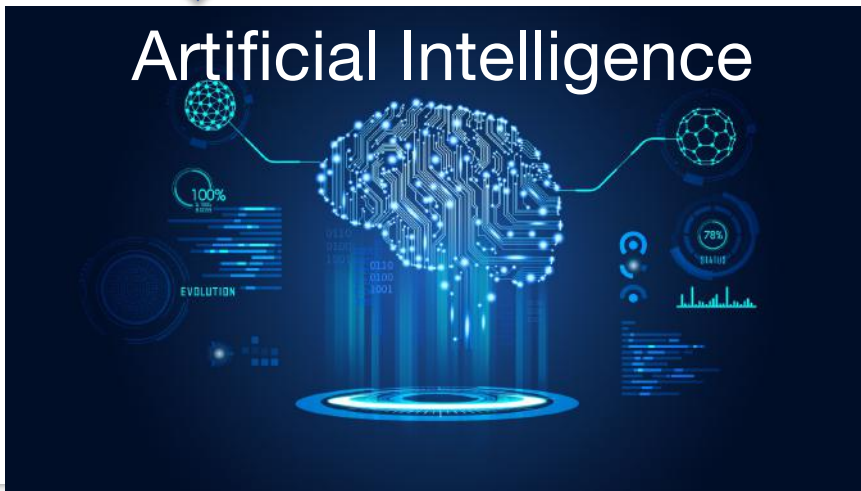
ML-OPS Cycle



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Threat? Opportunity?



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Research Center for Digital Adaptive Manufacturing for Industry 4.0

Vision

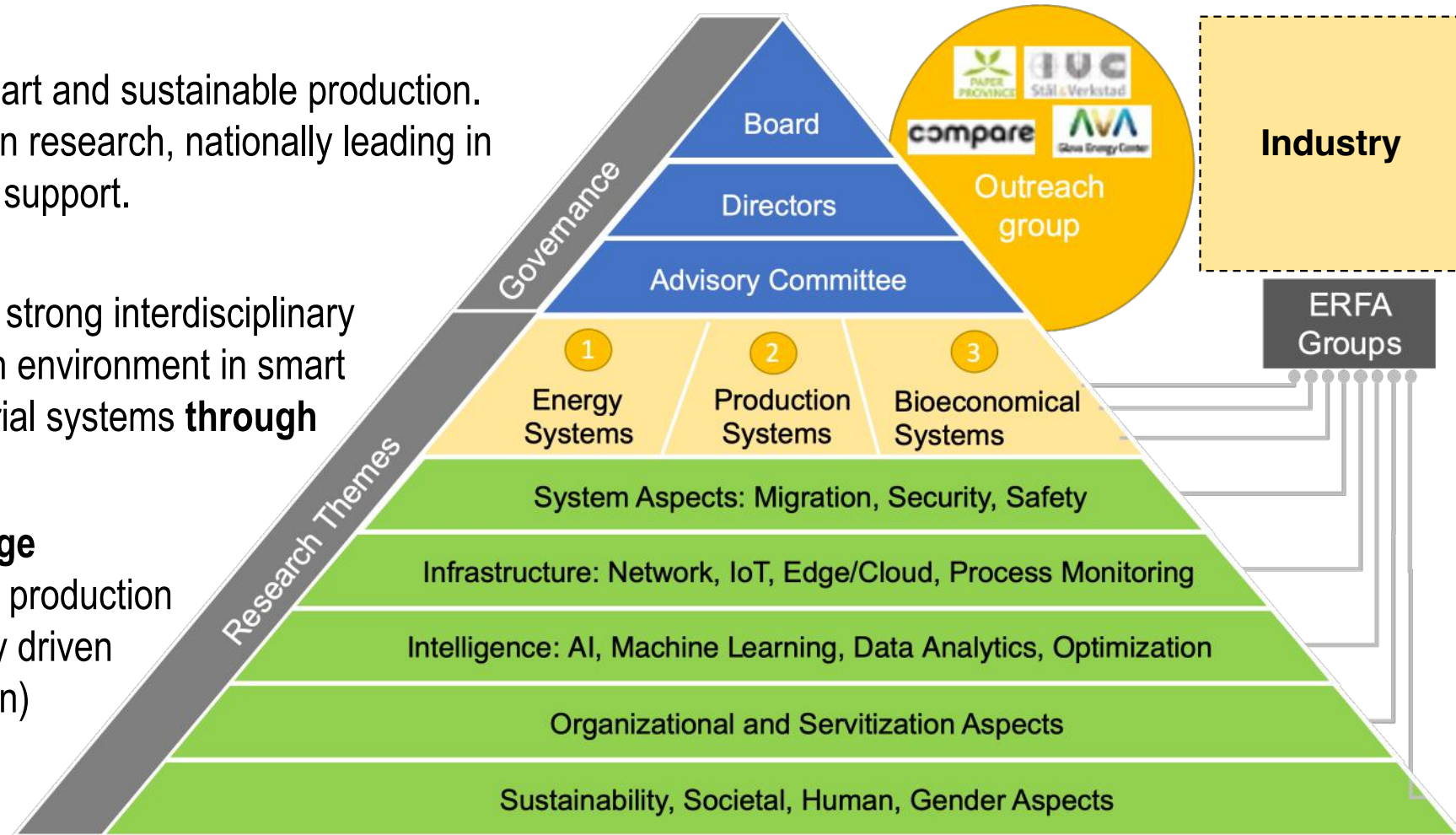
One-stop center for smart and sustainable production. Internationally leading in research, nationally leading in education and industry support.

Main strategic goal

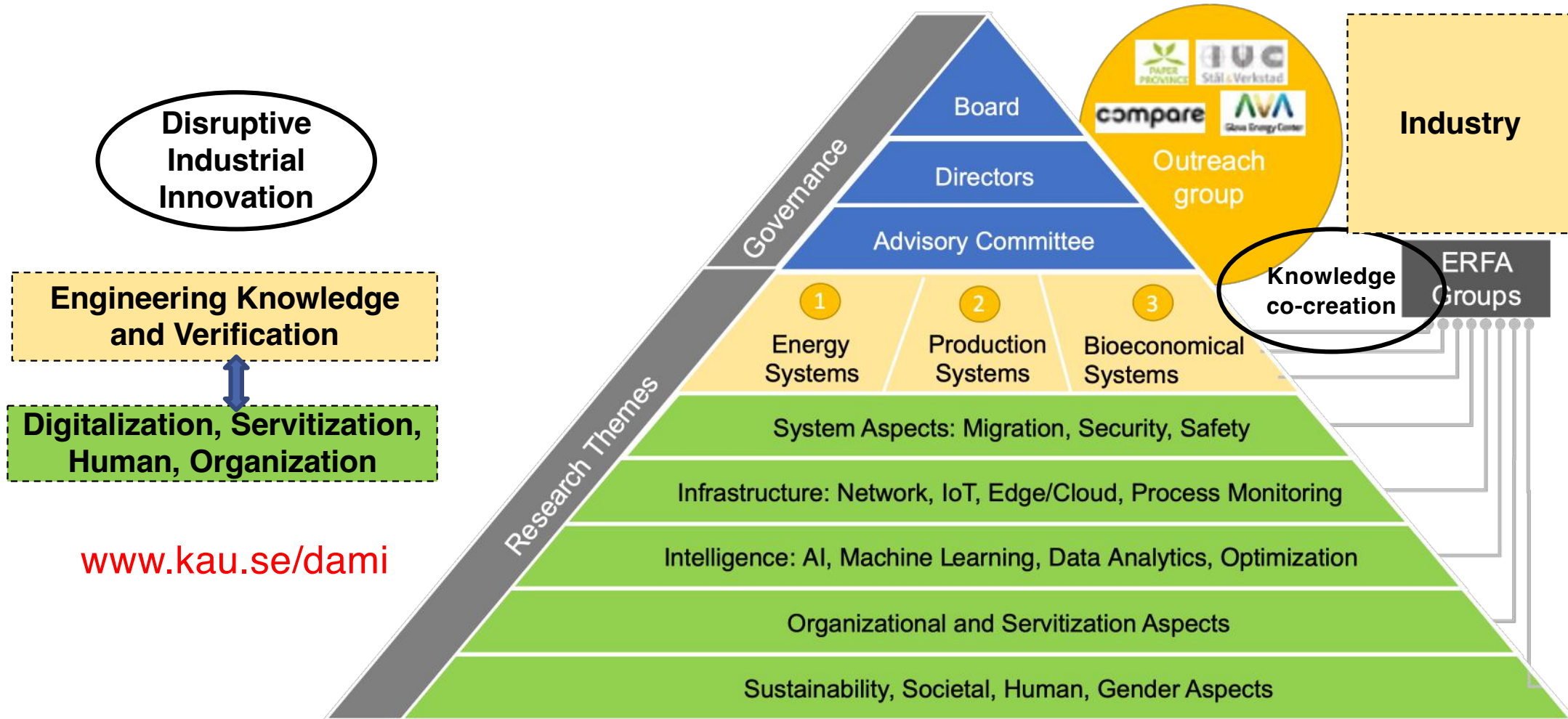
Establish a unique and strong interdisciplinary research and education environment in smart and sustainable industrial systems **through digitization.**

Main societal challenge

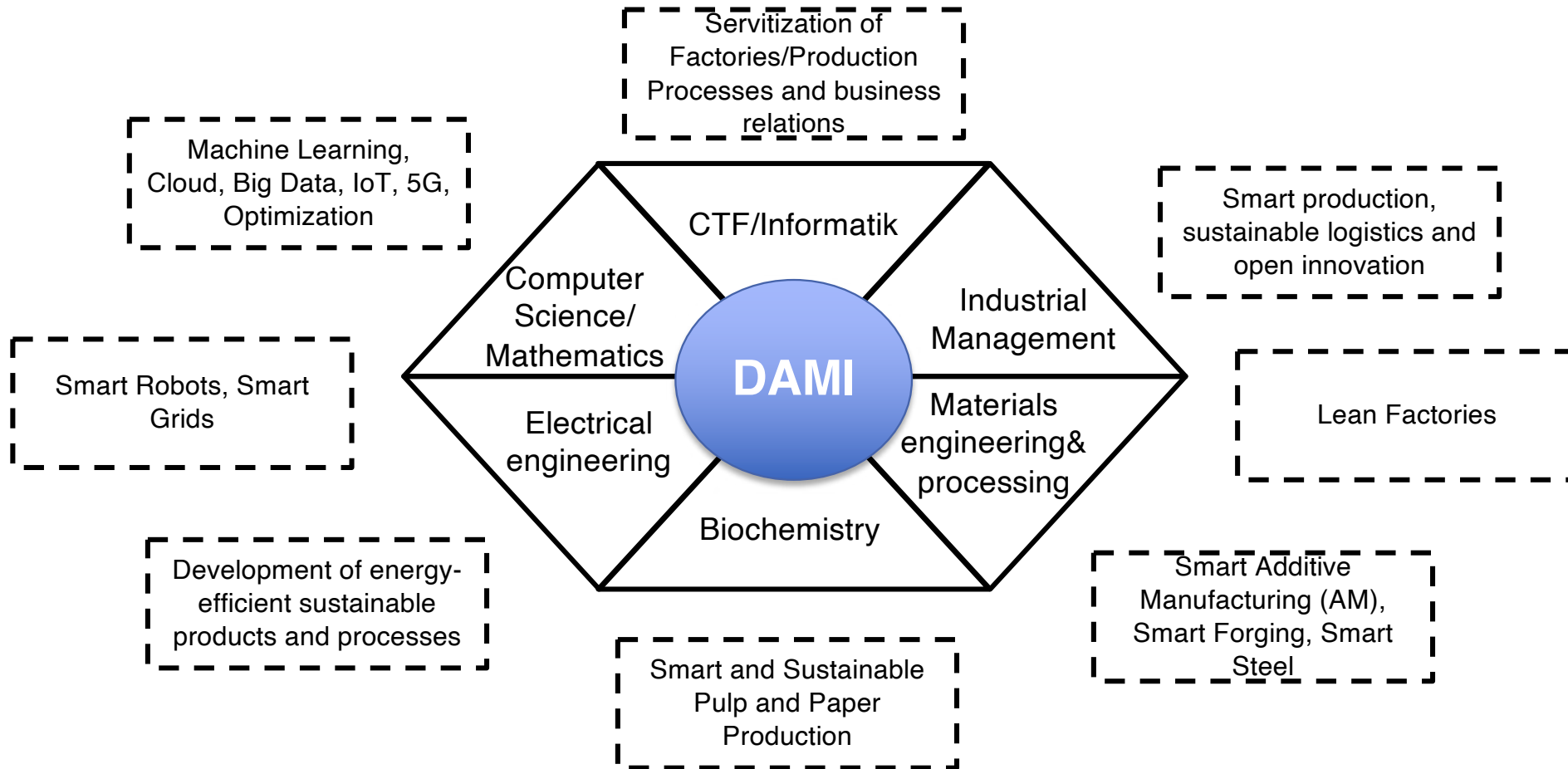
Sustainable and Smart production (people and technology driven industrial transformation)



Research Center for Digital Adaptive Manufacturing for Industry 4.0



Internal Operation



Collaboration Forms



- Industriforskaraskolan
– hig.se/inspire



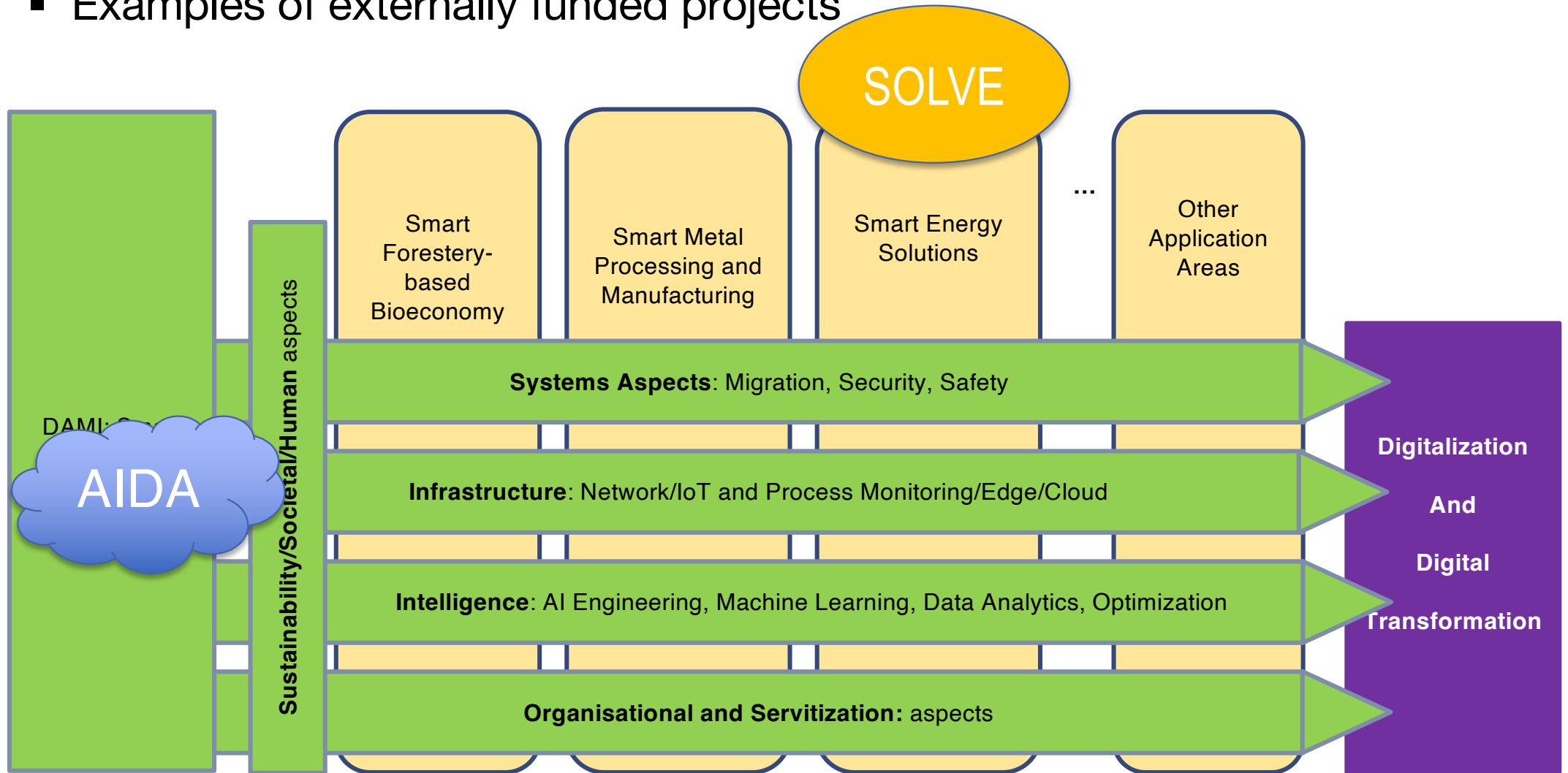
Save the Date



- Workshop on: “How can AI and Industrial IoT lead towards more sustainable industrial production processes?”
- Date: 13th September 2022, kl 13:00 – 17:00
- Venue: Karlstads Universitet
- Confirmed Speakers, among others
 - Jan Bosch, Sweden Software Center: AI in the age of DevOps
 - Daniel Gillblad, AI Sweden: Industrial Strength AI - Challenges and Opportunities
- Announcement soon on

www.kau.se/dami

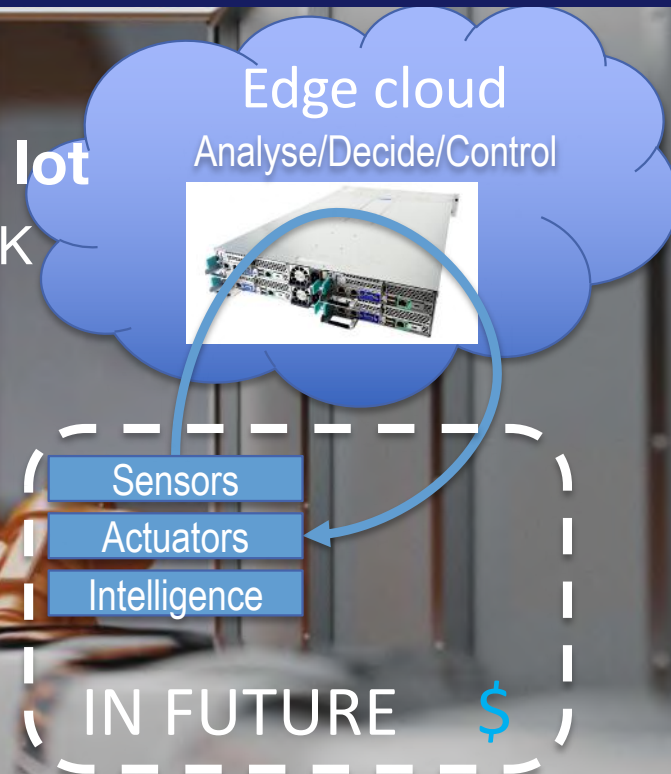
- Examples of externally funded projects



AIDA



- **AIDA: A holistic AI-Driven networking and processing framework for Industrial IoT**
 - KKS Synergi: 3 years (2020-2023) → 12 MSEK
 - sola.kau.se/aida
 - Partners. Ericsson, Tieto, Uddeholm, TCN, Karlstads EI& Stadsnät
- Support for data-driven trustworthy Industrial IoT applications



- **Characteristics and Benefits**

- In software, virtualized, programmable, upgradable, commodity infrastructure, open, interoperable, customizable
- Increase flexibility, reduce deployment time and cost

3 Main Pillars



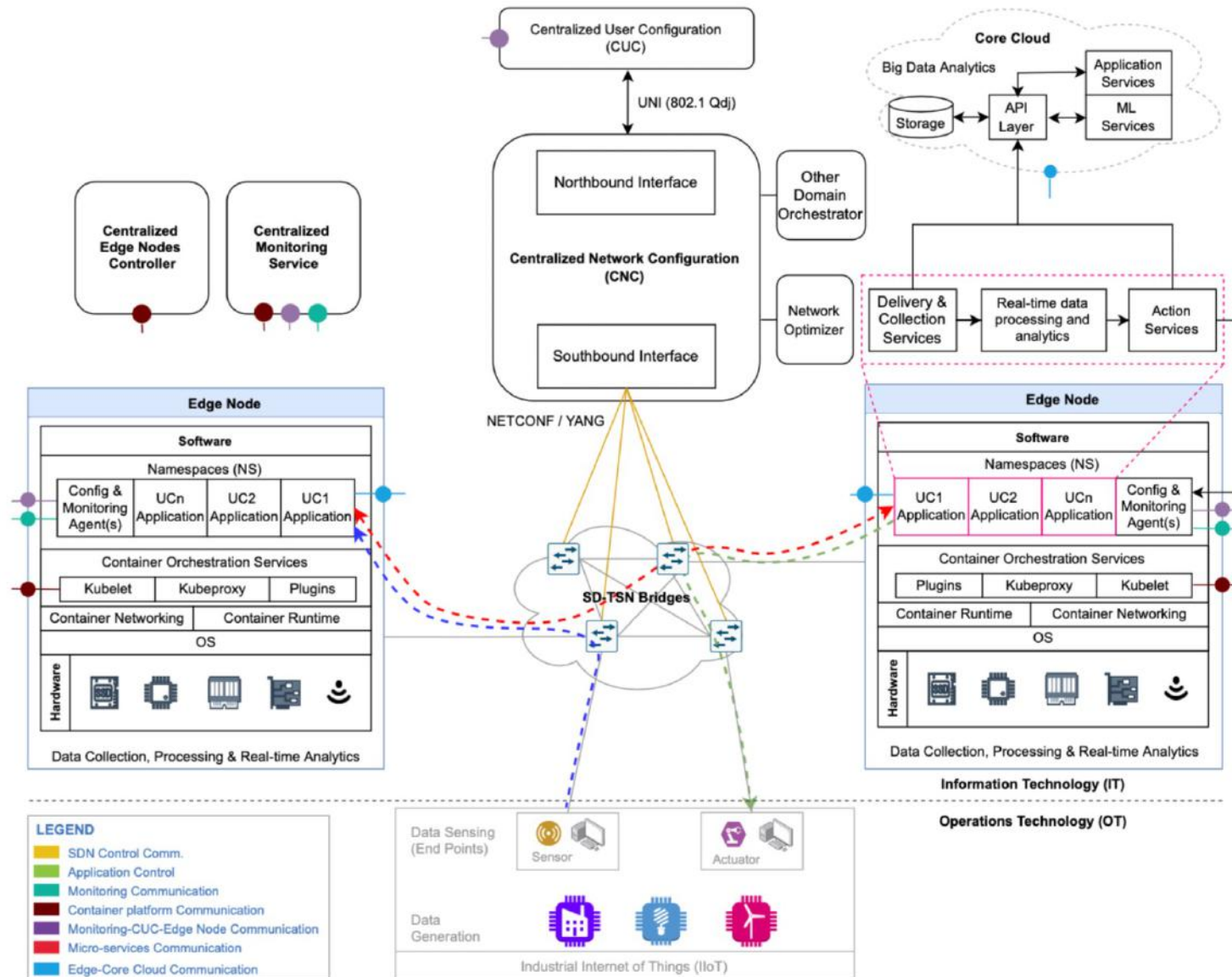
Data-Driven, Trustworthy
Industrial IoT applications

**Getting
The
Data
Fast,
Under
Guarantees**

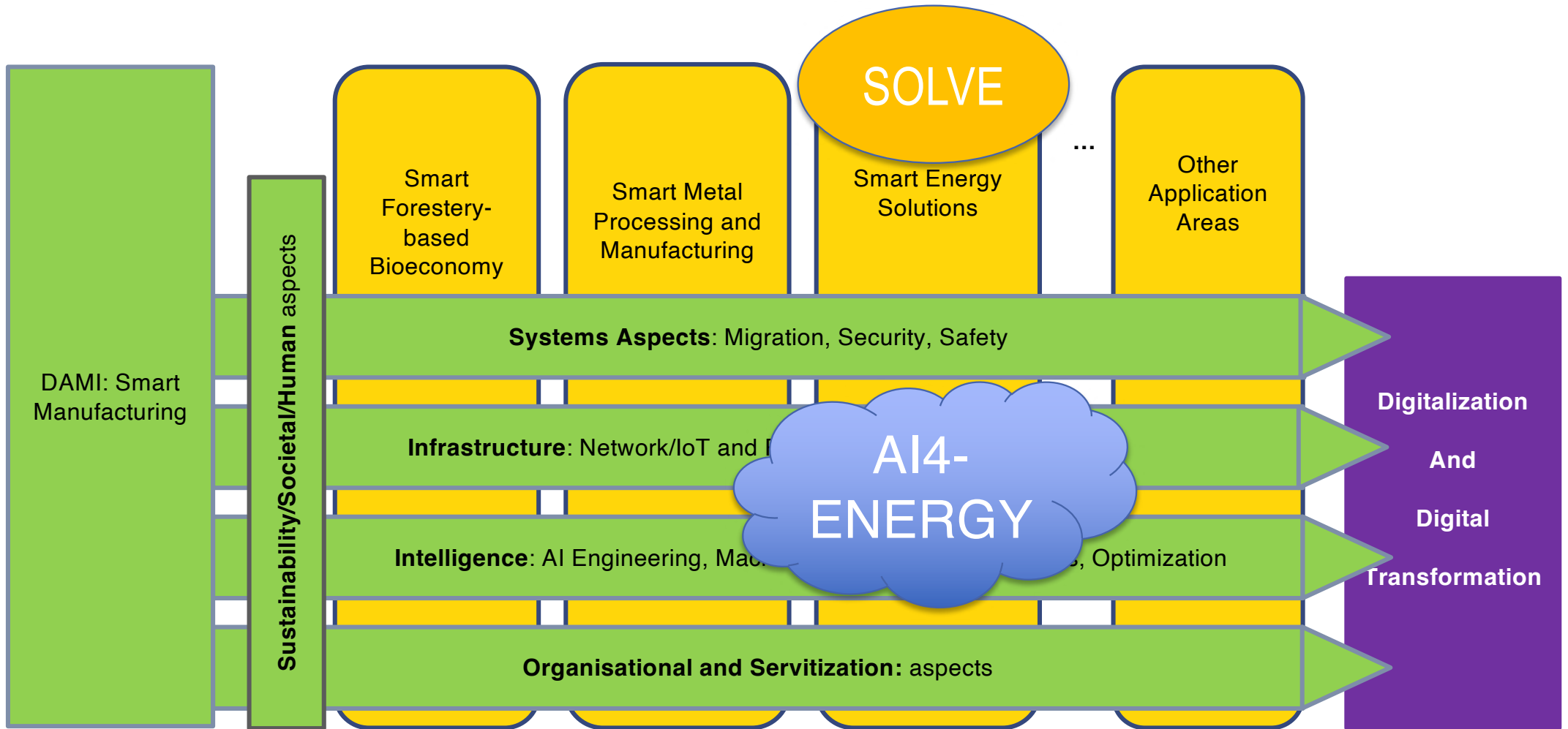
**Processing
the
Data
Fast,
under
guarantees**

**Making
Sure, Data
and
Decisions
are Correct**

AIDA: Trustworthy Industrial IoT Framework



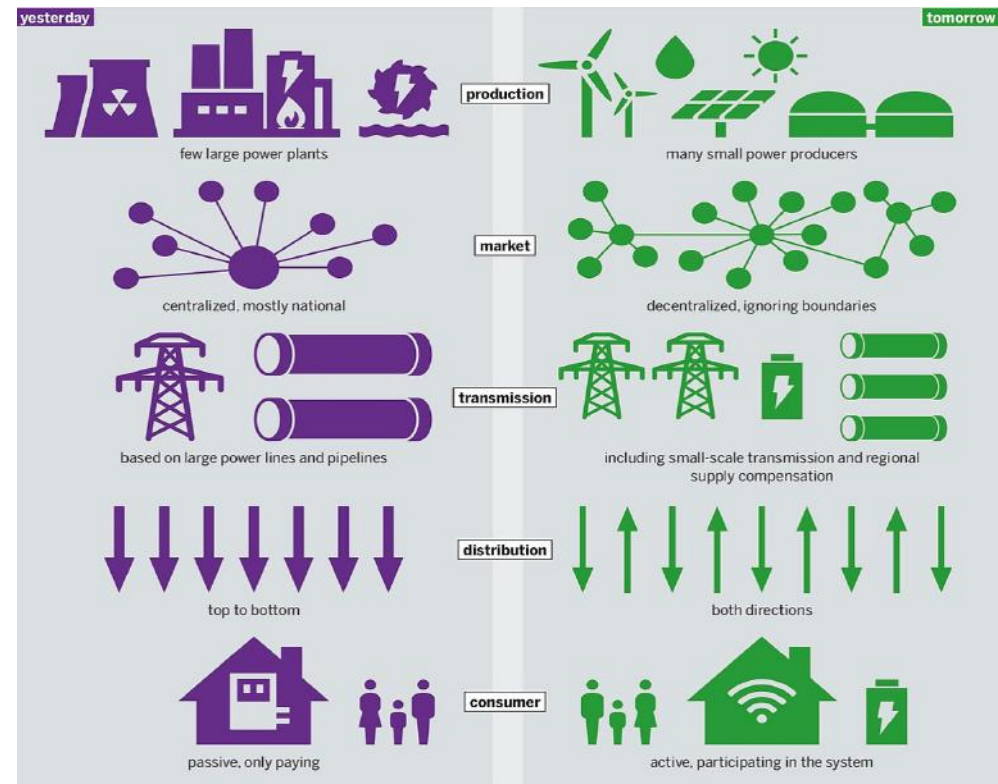
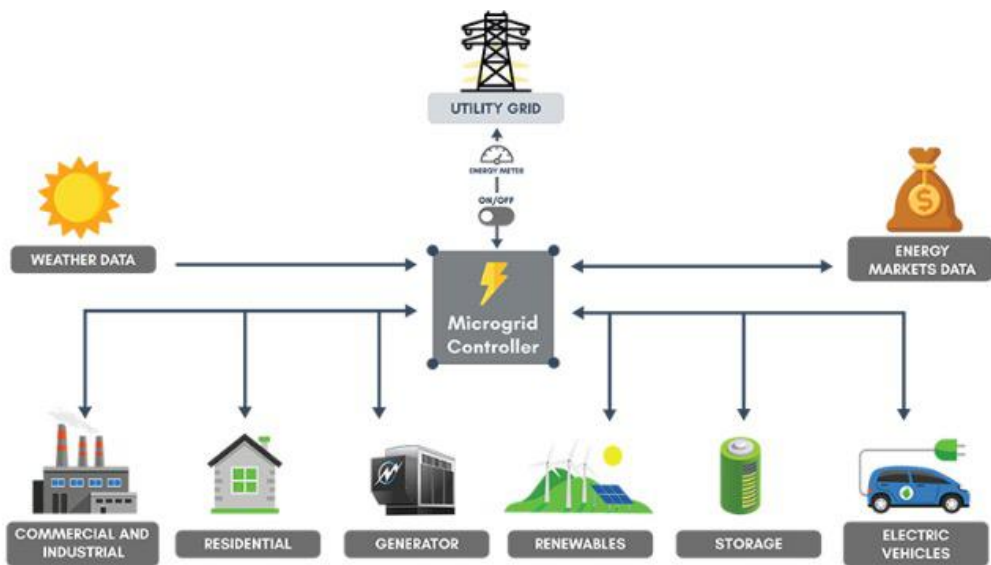
Ongoing Projects



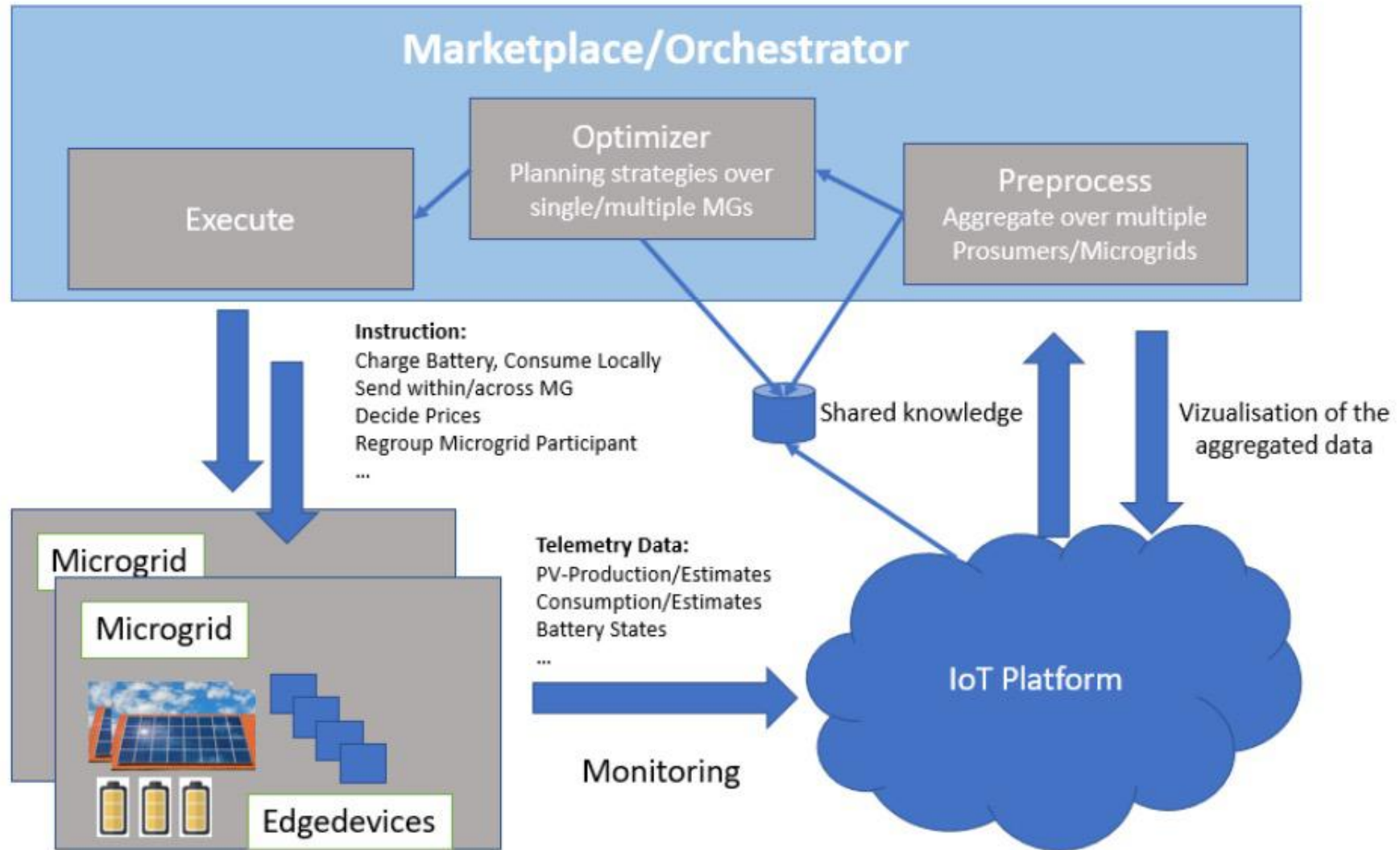
AI4ENERGY



- Integration of Machine Learning, Edge and IoT Cloud Computing for RE based Smart Grids → sola.kau.se/ai4energy
- Funded by Energimyndigheten, 3 years, 7 MSEK
- Together with Glava Energy Center



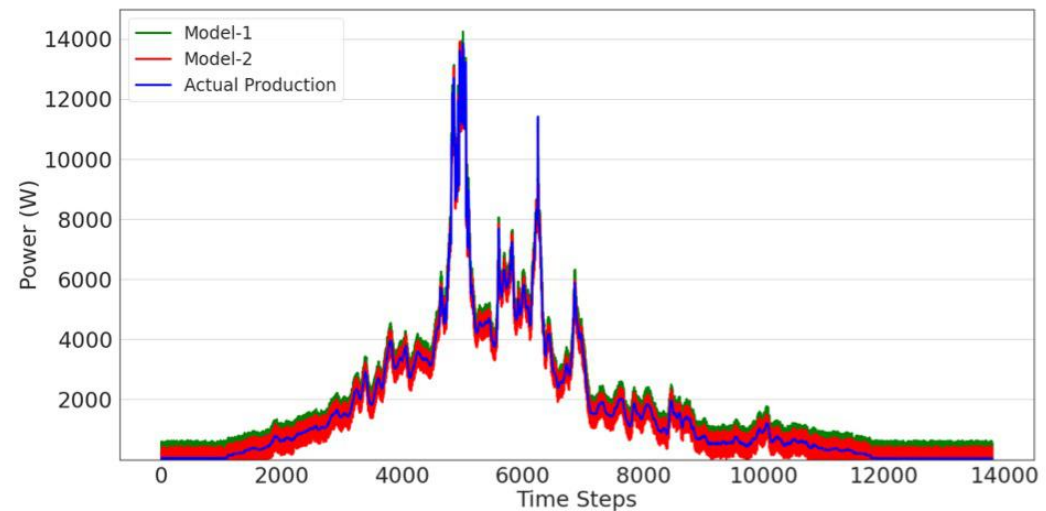
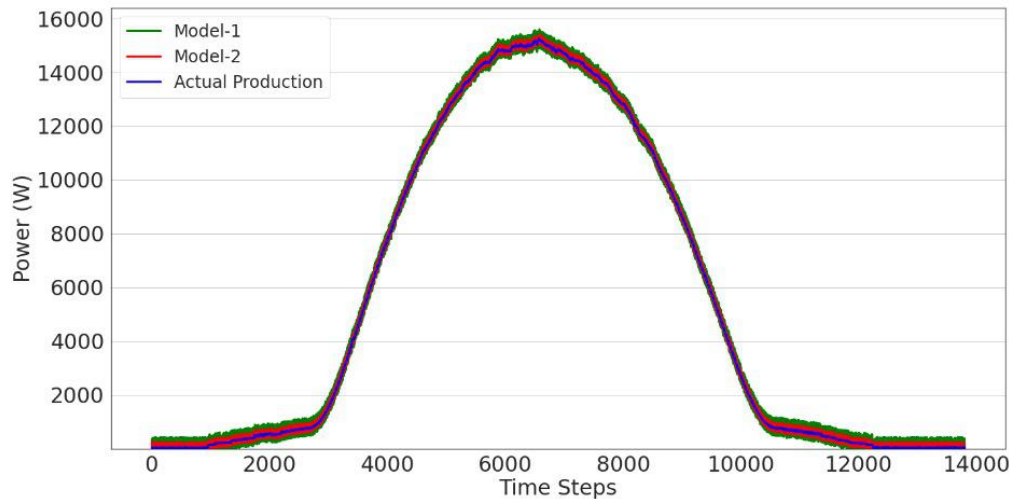
Architecture



ML-based prediction of Supply and Demand



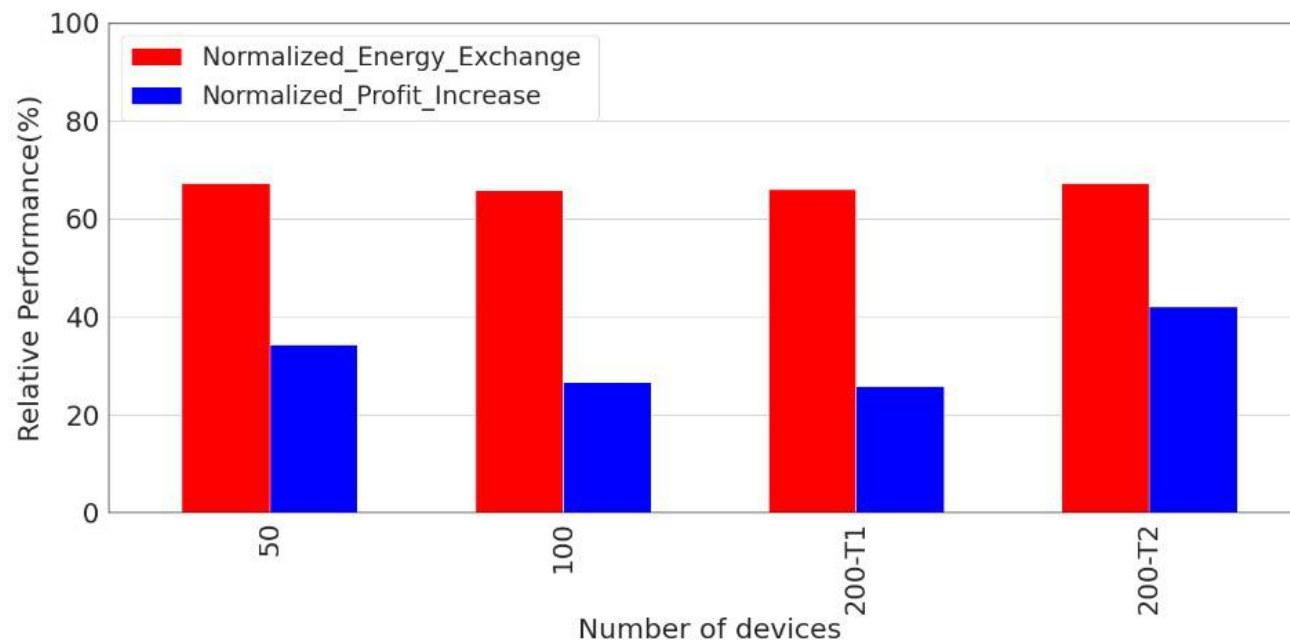
- Energy Supply and Demand is uncertain
 - Weather phenomena, consumption patterns,..
 - For optimized energy exchanges, need good estimates
- ML based timeseries prediction at Edge Devices
 - LSTM, Facebook prophet, XGBoost
 - Clustering for model accuracy improvement → sunny, rainy, overcast,..
 - 5 year dataset, quantifying prediction accuracy and uncertainty



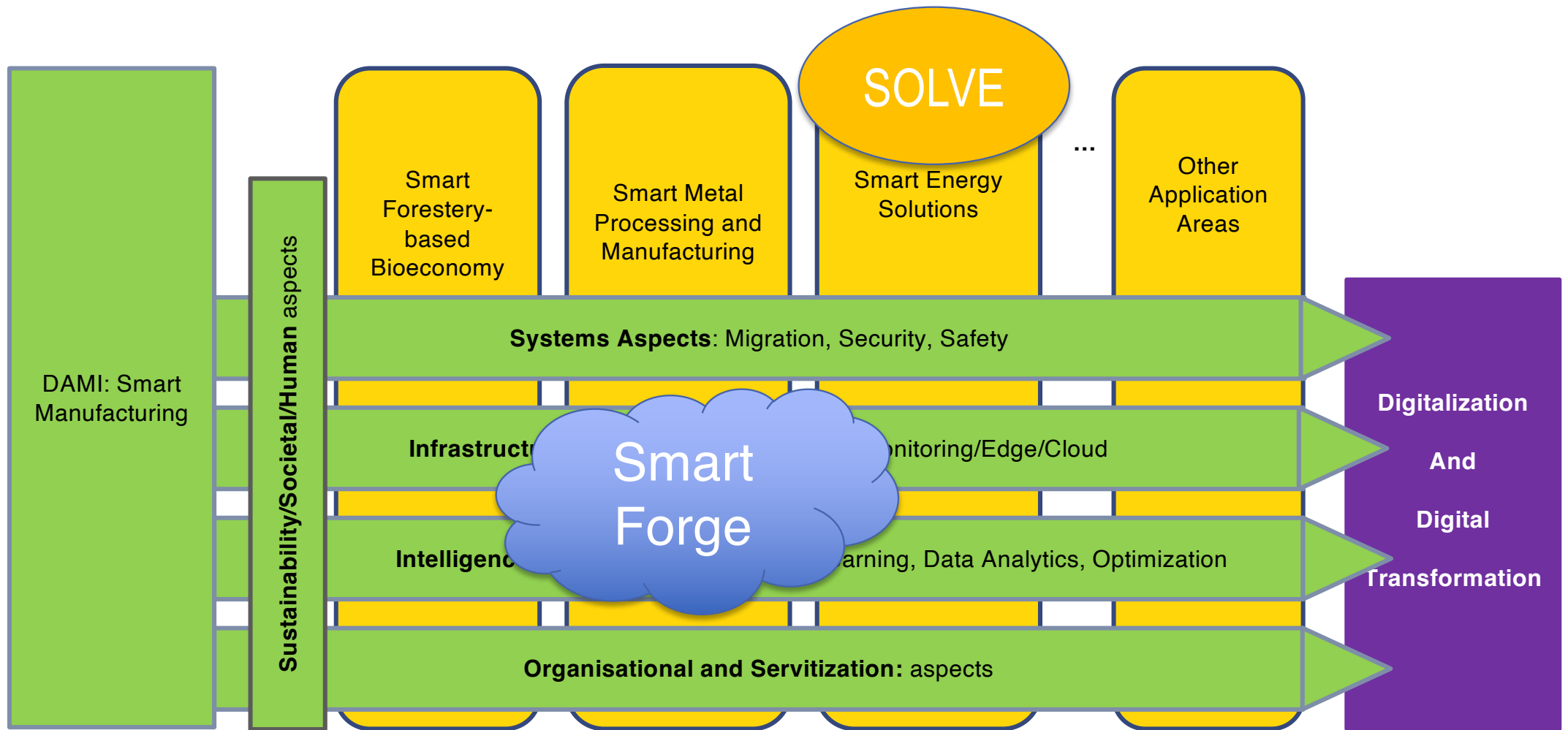
Optimizing Energy Exchange Schedules



- Complex optimization problems to solve
 - Complex decision making under uncertain and dynamic systems
 - Exact Solutions that are robust against parameter deviations, Heuristics, Cost of Robustness
 - Coordinating energy exchanges within Microgrid reduces global CO2 and costs



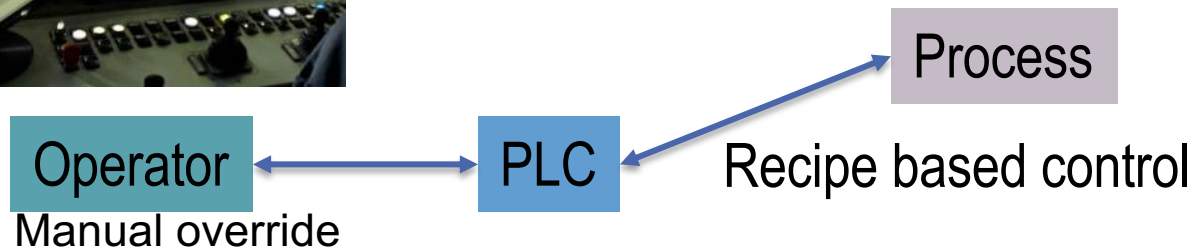
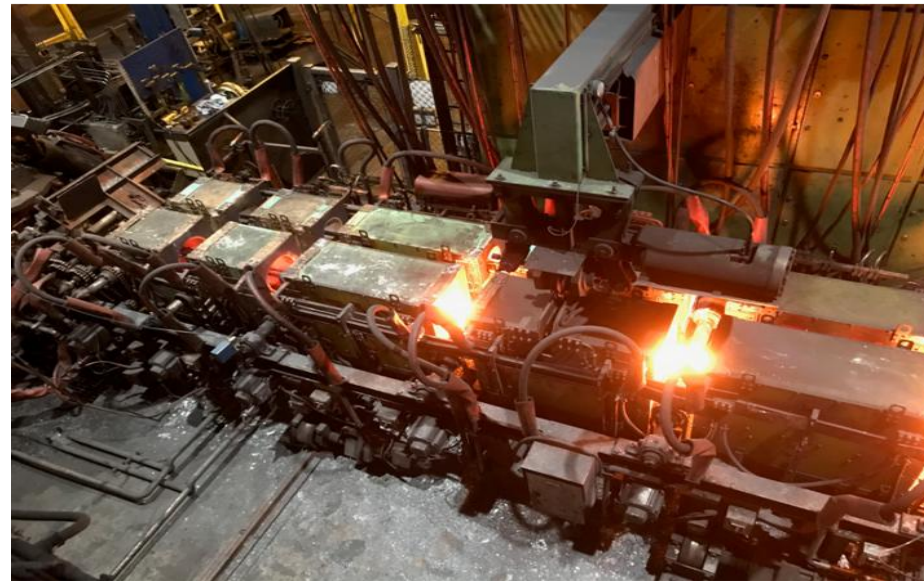
Ongoing Projects



SmartForge



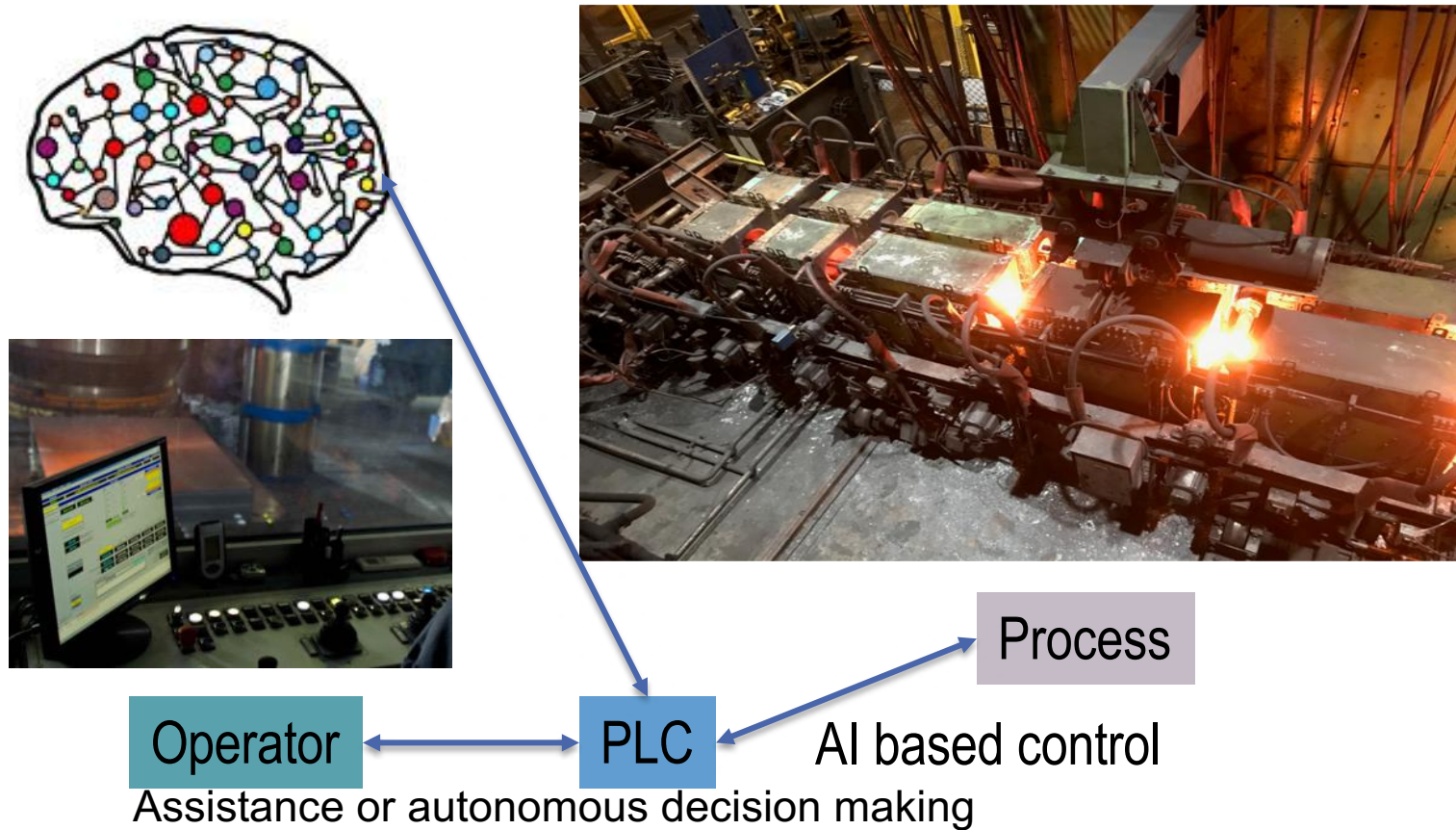
- Funded by Vinnova within PiiA, 2 y., Bharat Forge, RISE, Viking Analytics
 - Induction Heating for Forging Line
 - Operator assistance
 - Reduce scrap and material waste
 - How can AI assist?



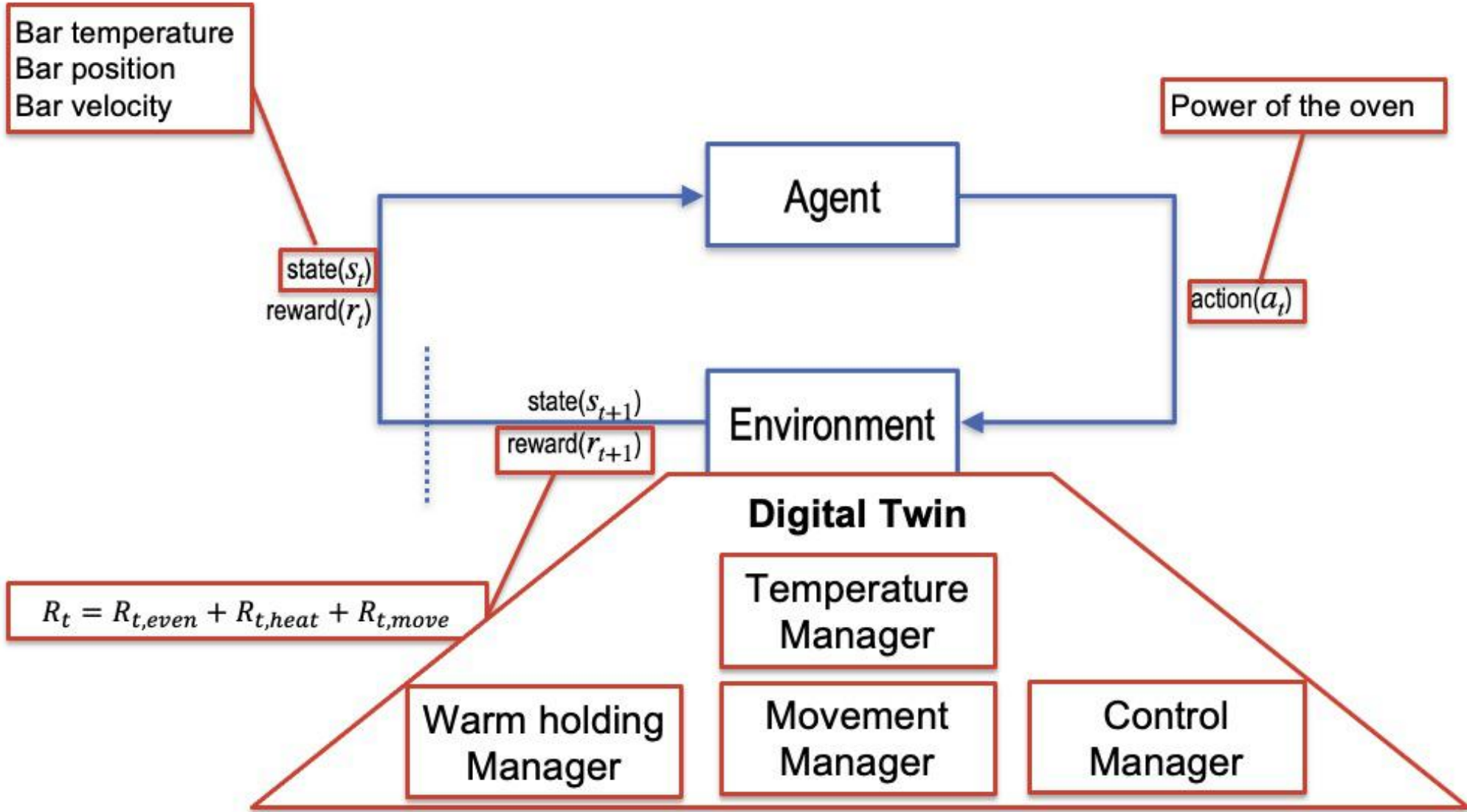
Main idea



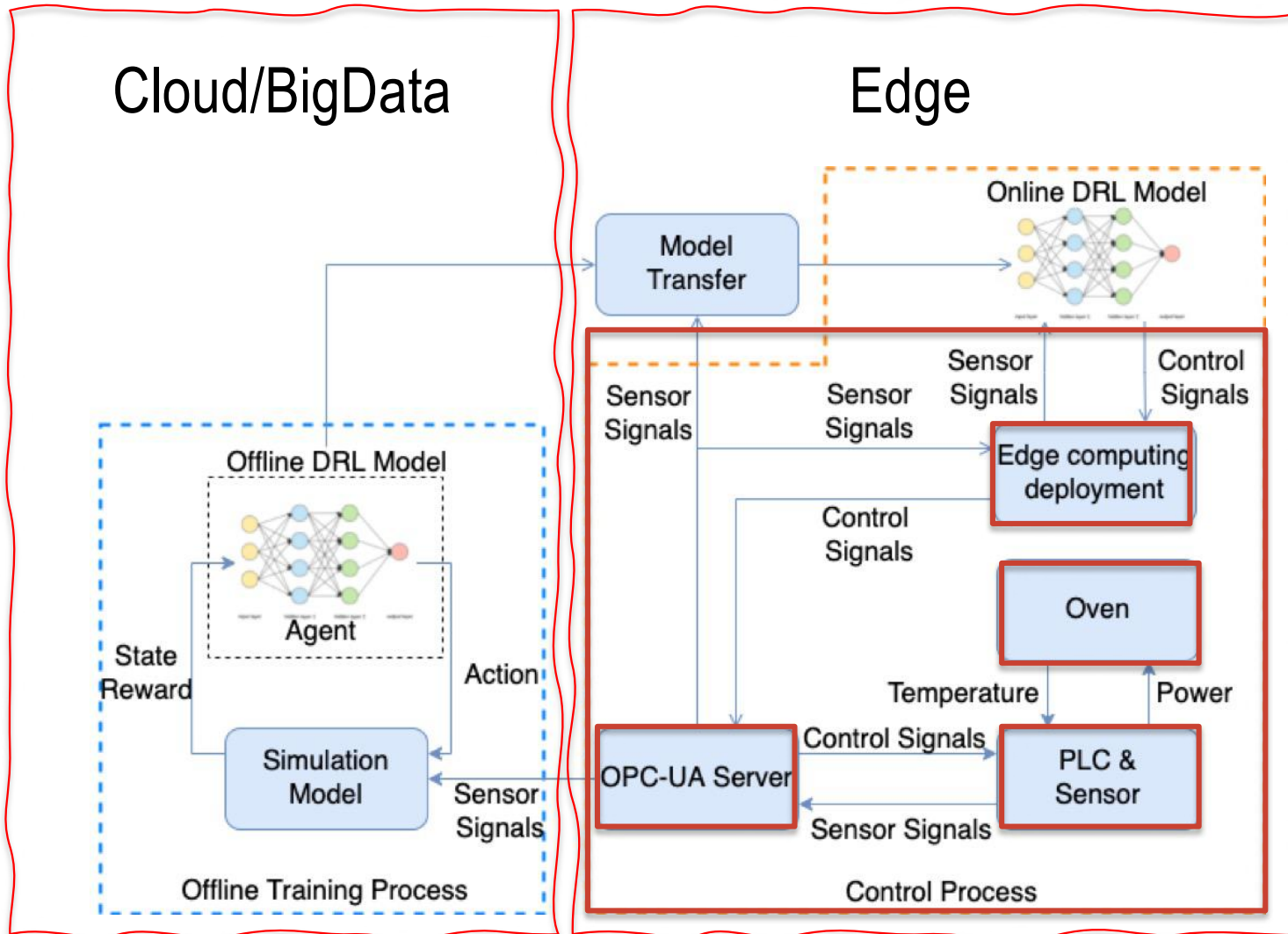
- AI-based control/assistance



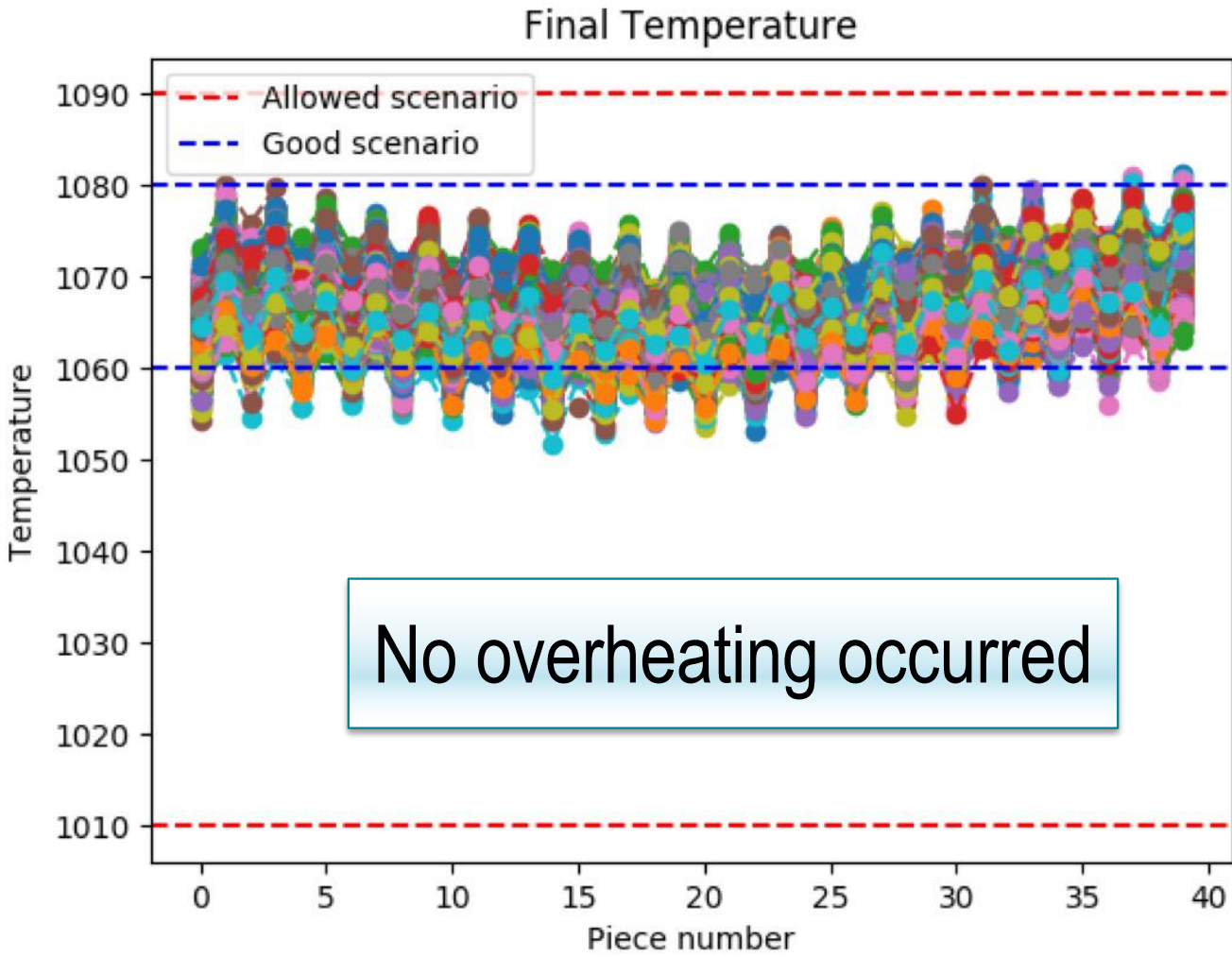
Digital Twin based Deep Reinforcement Learning



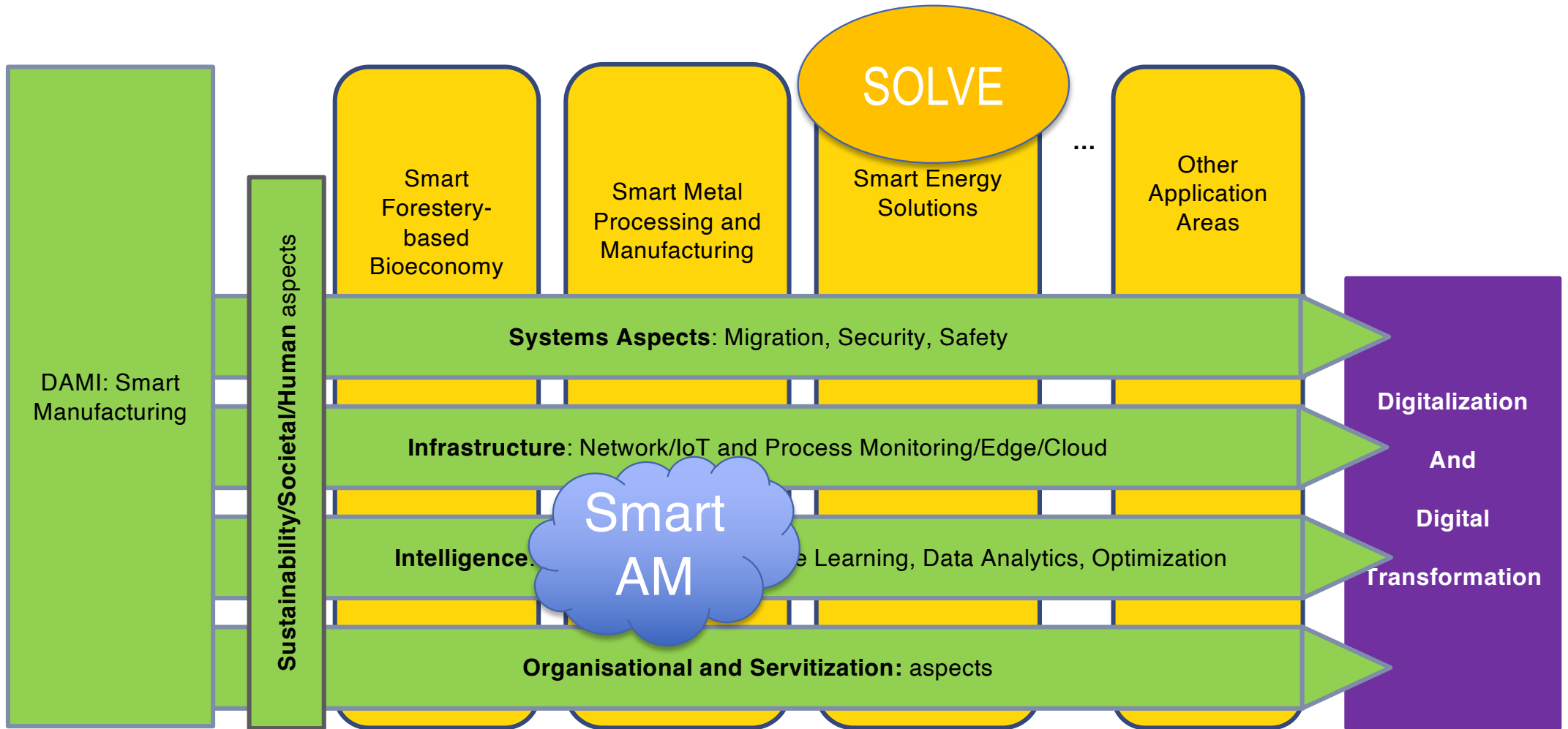
Digital Twin based Deep Reinforcement Learning



Evaluation



Ongoing Projects



Smart Additive Manufacturing



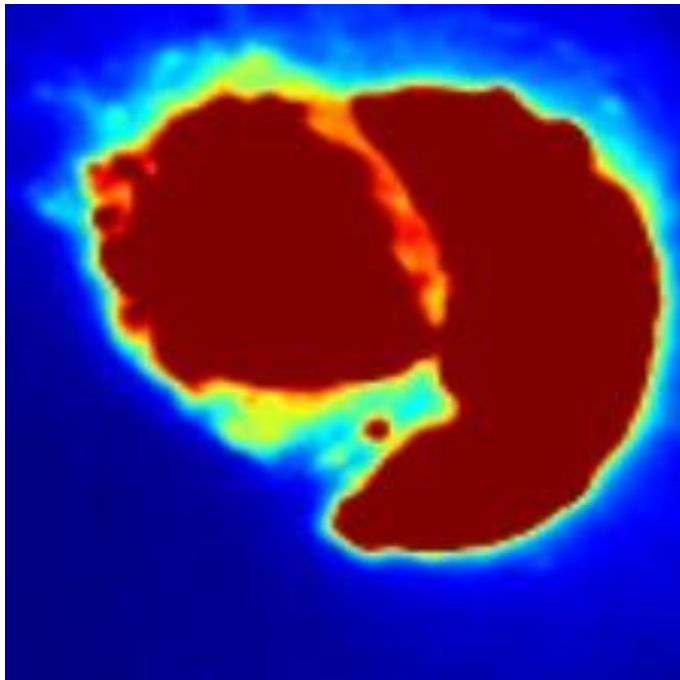
- Additive Manufacturing - AM
 - E.g. Laser Powderbed Fusion (LPBF), but also polymere, lignin,..
 - Sustainability, small series, customized production
 - Process Parameter Optimization, Defects Classification and Quality Control → AI for Smart Agile Production and Services towards Environmental Sustainability



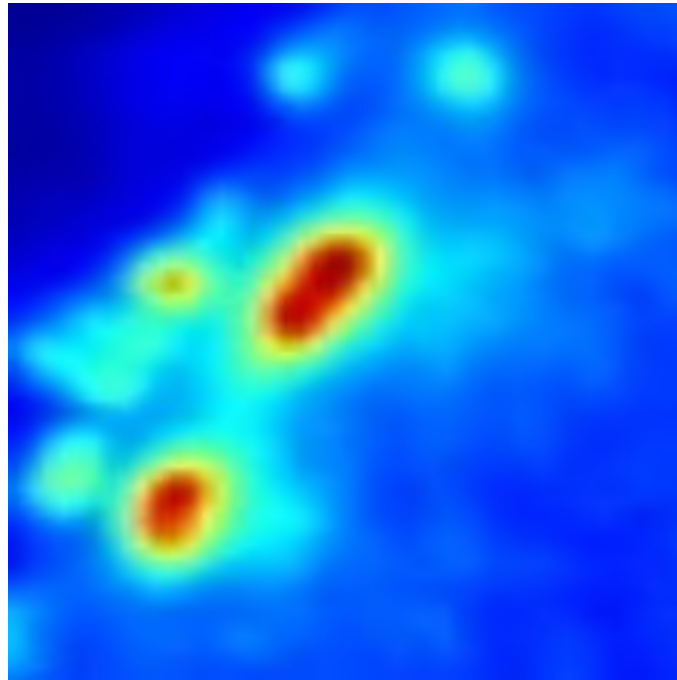
AI for AM Defect Classification



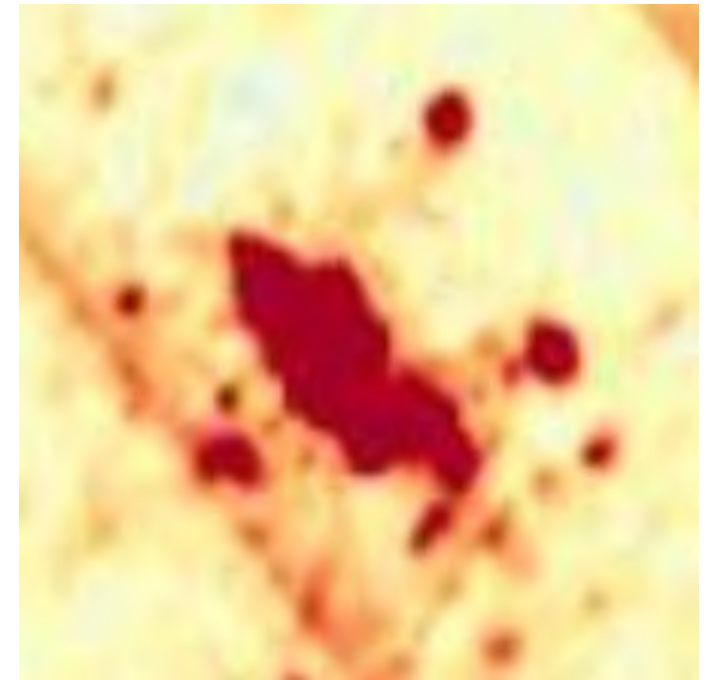
- Anomalies during AM printing process
 - Together with Uddeholm, Amexci
 - Quality Control → impact on final product quality?
 - Defect detection → AI based image classification



Delamination



Hotspot

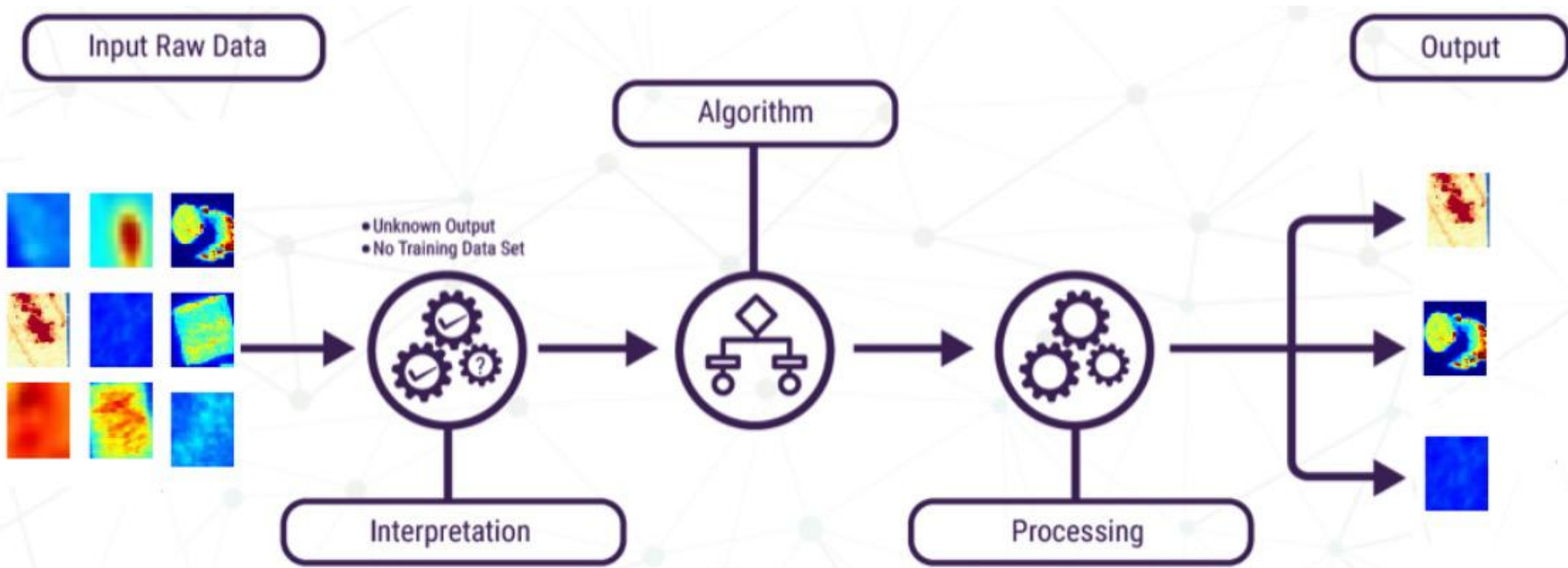


Spatter

AI for AM Defect Classification



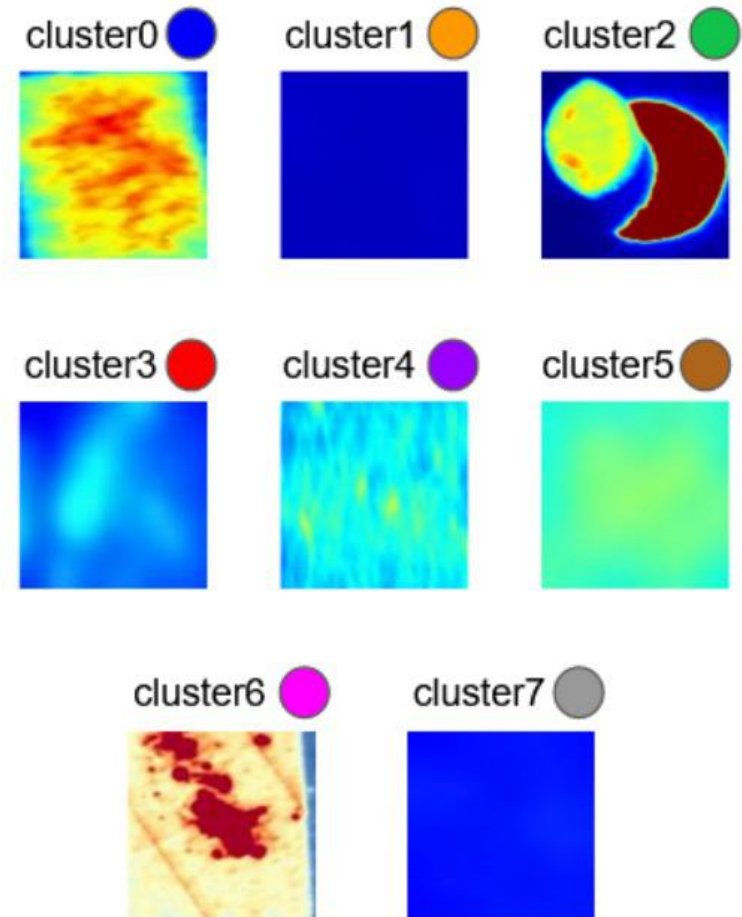
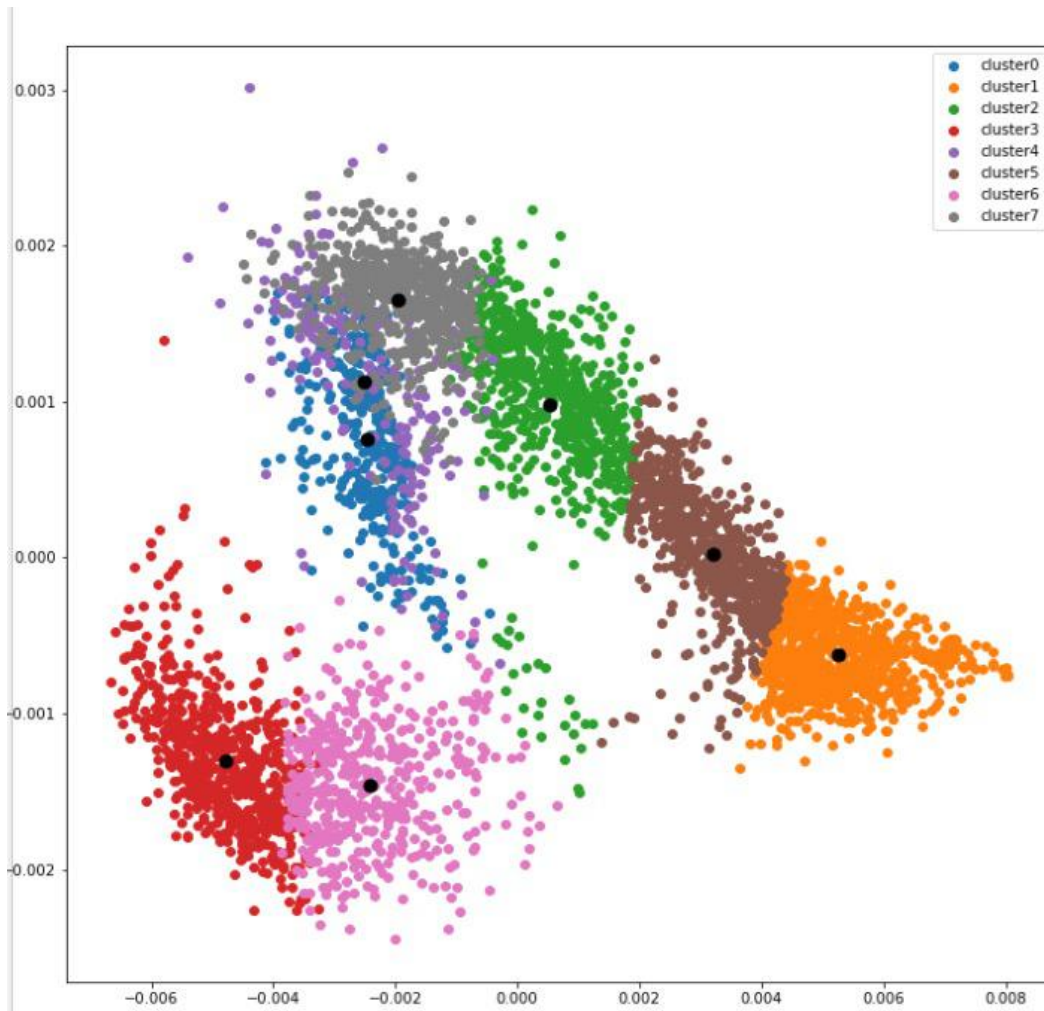
- Unsupervised Learning



AI for AM Defect Classification



■ K-Means Clustering



Summary

