CISTER - Research Center in
Real-Time & Embedded Computing Systems

The Industrial Internet of Things

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INESCTEC

Summary

- What is the **Industrial IoT**
- IIoT challenges
  - Adaptability and scalability
  - Security
  - Real-time and QoS
  - Programmability
  - New business models
- Conclusions

The Industrial Revolutions

- First Industrial Revolution (1781):
  - Invention of the (patented) steam engine by James Watt
  - Mechanical production
- Second Industrial Revolution / Technological Revolution (1874):
  - Invention of the incandescent light bulb
  - Electricity, moving assembly line, division of labour
  - Mass Production
- Third Industrial Revolution (1969):
  - Invention of the microprocessor
  - Electronics, IT
  - Automated production
- Fourth Industrial Revolution / Industrie 4.0 / Digitizing Industry (today)

Digitizing Industry

- Digitizing Industry: European name for an initiative to maximize the benefit of the information
  - machine and product sensorization (Cyber Physical Systems)
  - machine-to-machine (M2M) communications and automation technologies on a global scale
  - machine learning and big data technology crunching sensor data
  - ubiquitous fruition of the information

- Automated data analysis can enable companies to
  - detect inefficiencies and problems when/before they happen,
  - saving time, money and
  - supporting business intelligence efforts

The Industrial IoT

IIoT ⇒ Use of IP

- The Industrial Internet of Things (IIoT)
  - is the use of Internet of Things (IoT) technologies in manufacturing
  - is an enabler for the Digitizing Industry
- All devices have an IP address
- Devices are accessible through the Internet
  - It complements the custom technologies used in manufacturing (fieldbuses, etc)

Main Application Areas

- IIoT has a great potential for:
  - quality control
  - sustainable and green practices
  - supply chain traceability
  - overall supply chain efficiency
  - user in the loop.

(Some) IIoT challenges

- Adaptability and Scalability
- Security
- Real-time & QoS
- Programmability
- New business models

Adaptability and Scalability

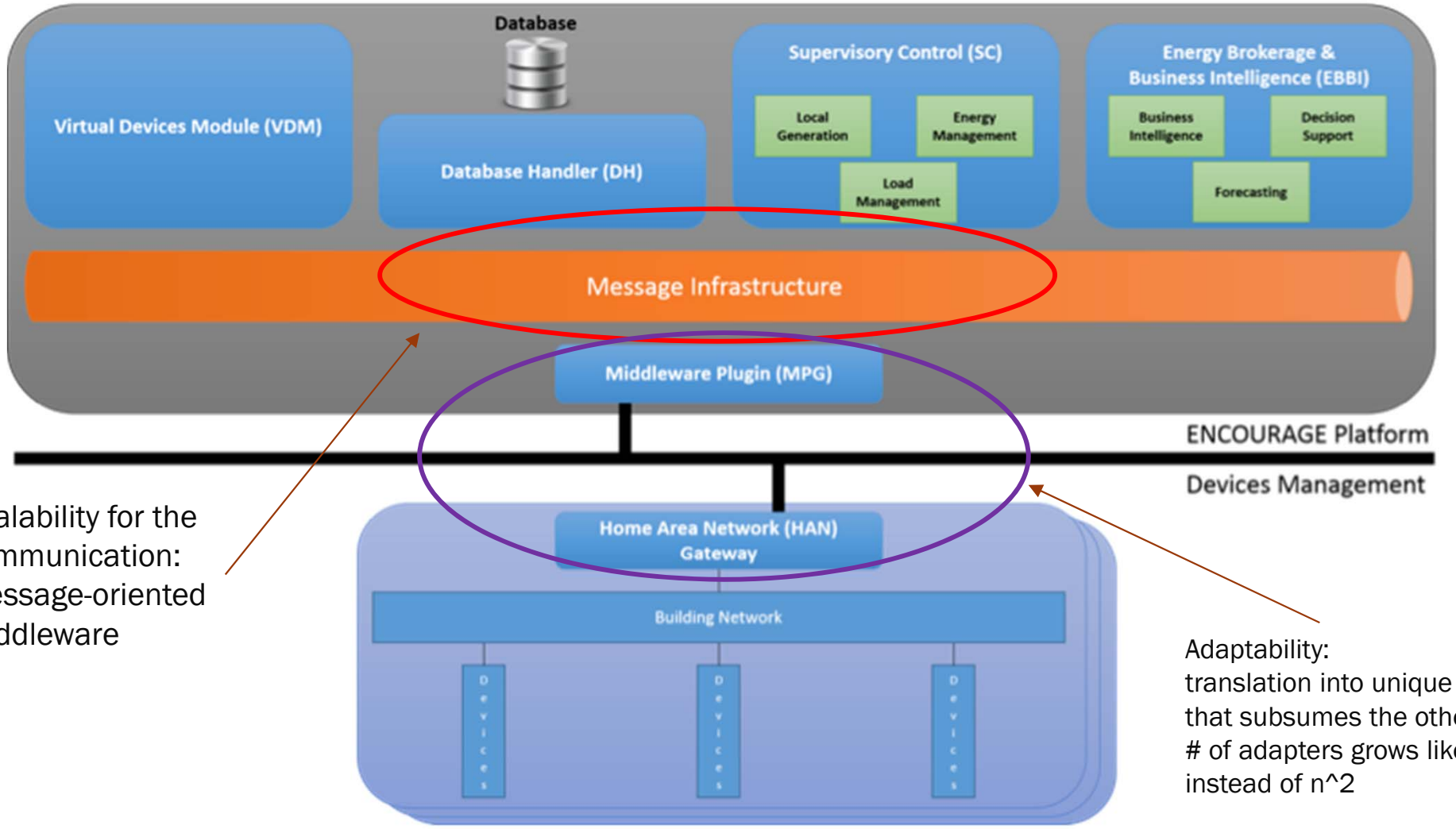
- Thousands of connected devices, high churn (set of active devices constantly varying)
- Multiple protocols and data formats imply the use of translator systems
- Big data analysis requires dynamic servers, whose computing power can scale with the load
  - But the scalability is hard to test and verify

Adaptability and scalability: possible implementation

Possible solution for adaptability and scalability:

- Communication Middleware
  - Provide most of the required functionalities “out of the box”
  - Both adaptability and scalability can be studied “once and for all”, and then applied to the business case

The ENCOURAGE Smart Grid



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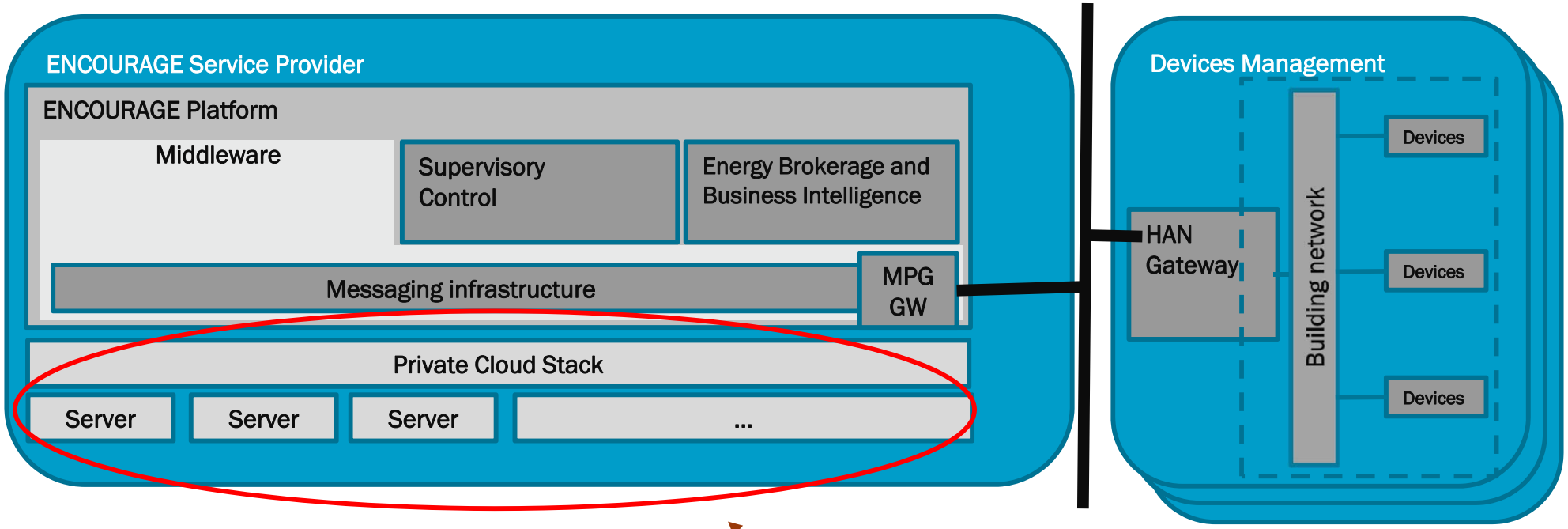


Scalability for the computation: Cloud & elasticity

Security

- Tiny devices cannot cope with compute intensive security functionalities
- How to balance between security and
  - Configurability
  - Dependability
  - Usability
  - Performance
  - Maintainability
- How to audit the system security
- How to program it

Security: implementation

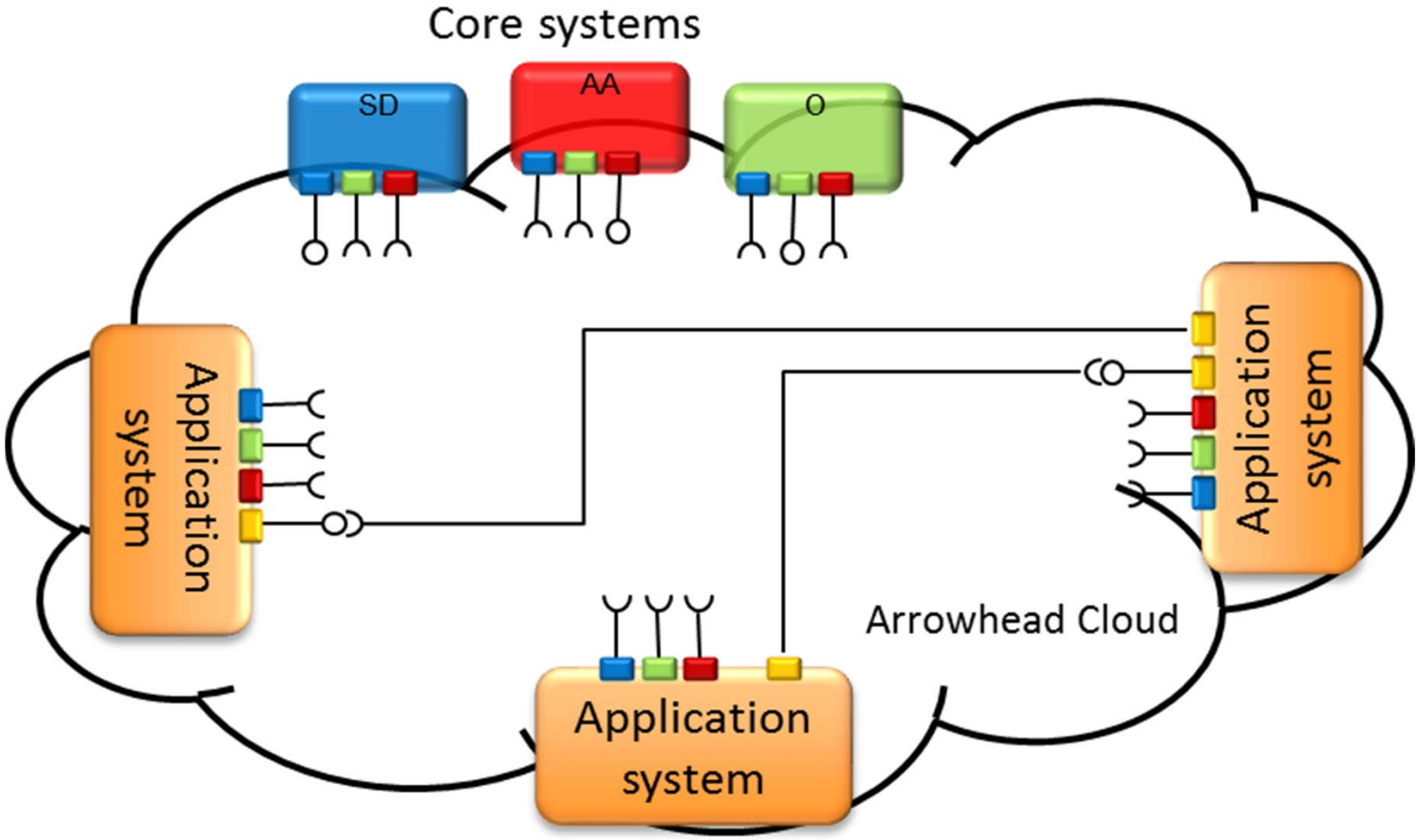
Possible solution to easy out the implementation of security:

- SOA Frameworks
  - Apply SOA principles to the system
  - Provide security as a set of main services

The Arrowhead Framework

- Service Oriented Architecture (SOA) approach for embedded automation and IIoT
- Offers a set of services that ease application development
- Mandatory services:
  - Service Discovery;
  - Orchestration;
  - **Authorization and Authentication**
- A set of optional services:
  - QoS Manager
  - Configuration Manager
  - Event handler
- A detailed documentation system

The Arrowhead Framework

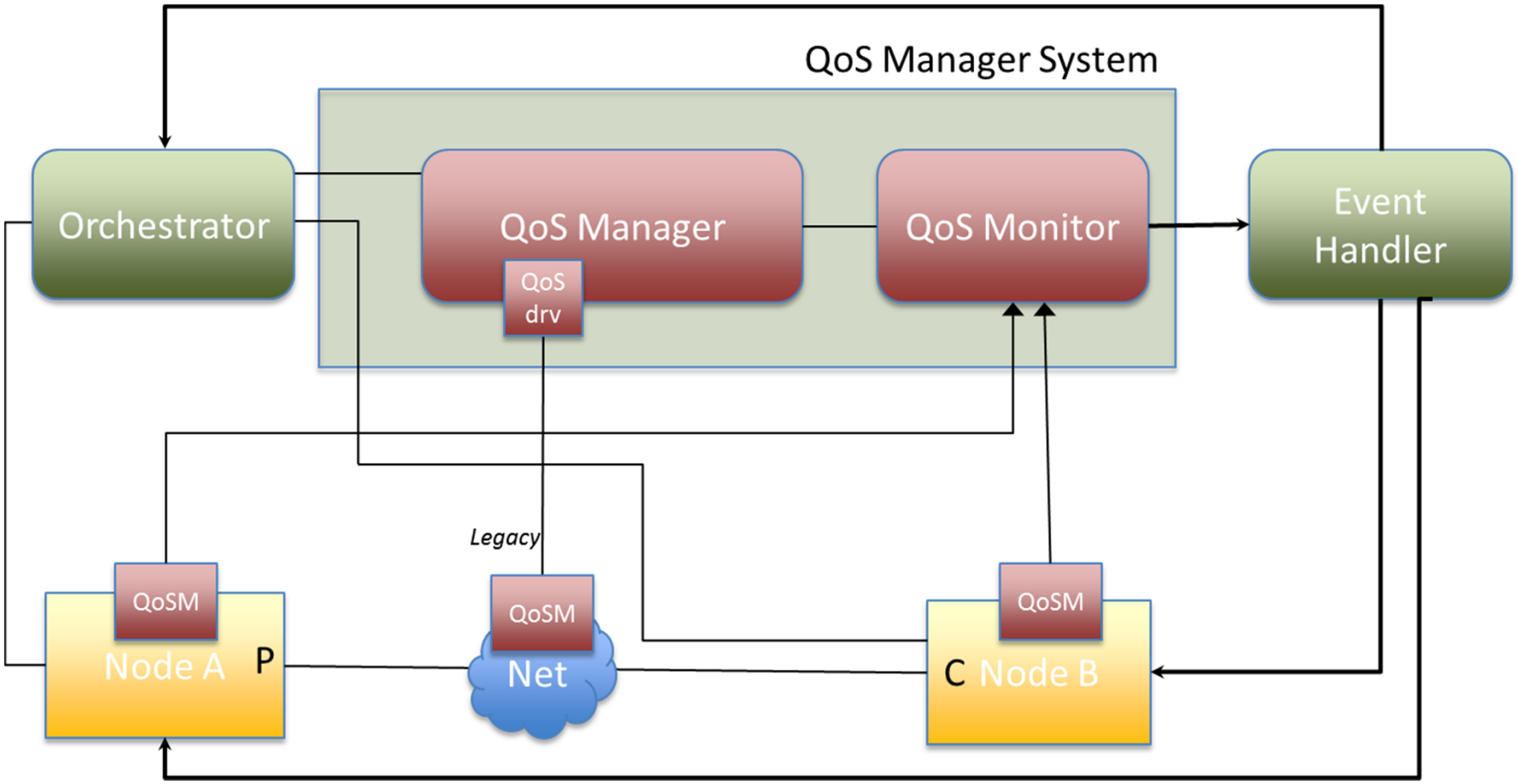


Orchestration (O) and Service Discovery (SD) Core Systems are only available after Authentication & Authorization (AA) of the Application Systems

Real-time & QoS

- IIoT application must access sensors and actuators used on automation applications
  - How is it done?
    - PLCs provide interfaces to hierarchically superior devices (dedicated networks)
    - IIoT devices operate on different wired/wireless networks
      - Shared with other applications / functions
  - QoS needed on applications using IoT devices
    - To extend the communication control over the shared networks

Real-time & QoS: solution from Arrowhead



Programmability

- How to program such large and highly distributed systems?
- What are the main primitives to be used by each application domain?
  - Application domains are too different, but there are obvious communalities: communication, resource management, code deployment, etc

A solution for programmability

- An obvious solution is to use a middleware.
  - Leverage on the commonalities
- Still, the set of common primitives are unknown
  - Low-level send/receive?
  - Publish/subscribe?
  - Distributed data structures?
- Do we provide primitives for resource management, QoS, translation systems, code deployment, etc?
  - Common mechanisms for different business cases?

- Visual programming tools will help on building simple applications
  - What about the complex ones?

New Business Models

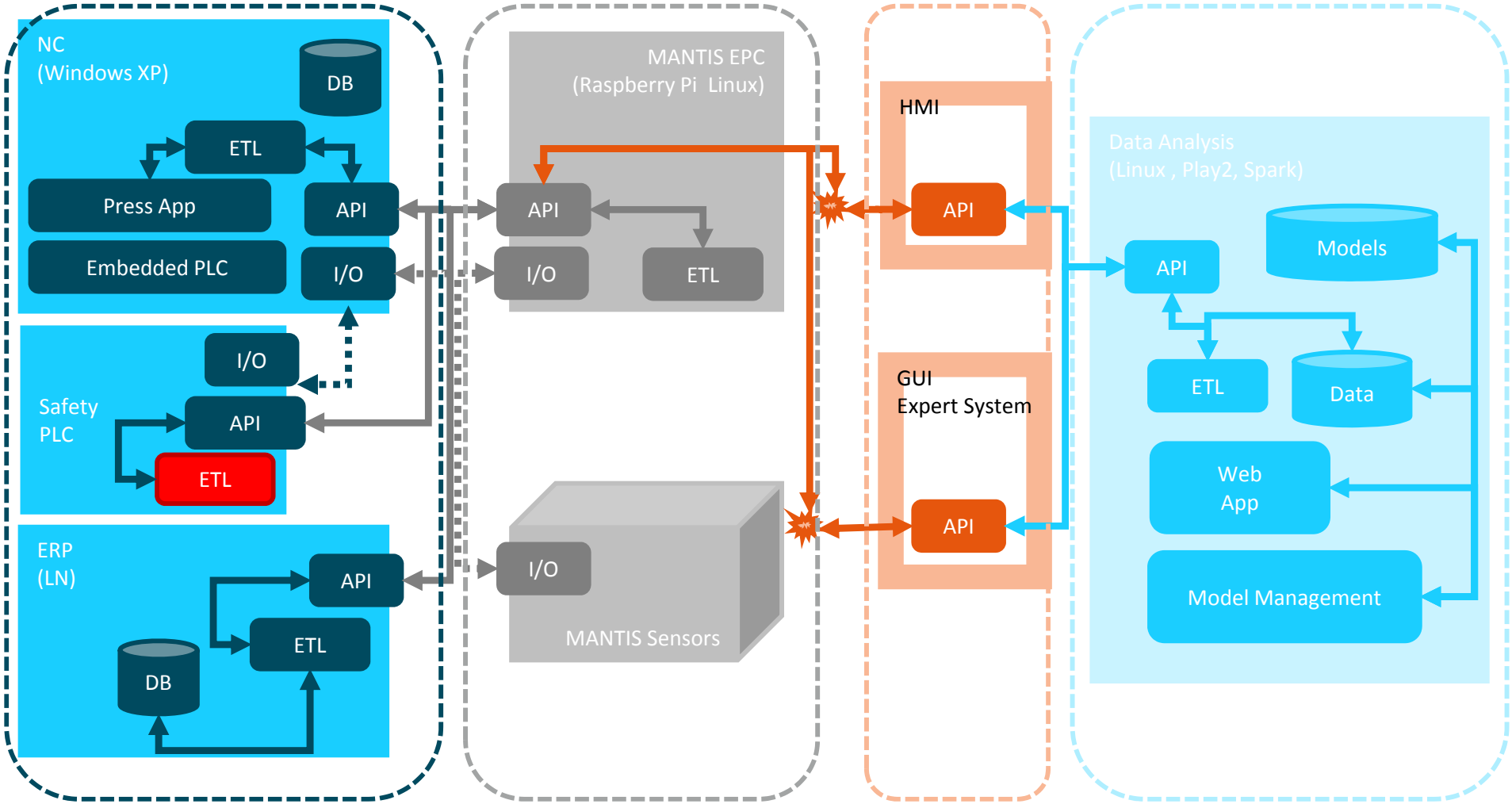
- IIoT enables a large set of new applications and consequently new business models
- Example of novel business area: proactive maintenance of industrial machine
  - Downtimes are very expensive to the factories
    - Makes sense to invest big money, to save on the downtimes
  - Reactive -> Preventive -> Predictive -> Proactive

New Business Models: Industrial maintenance

- Data is collected by sensors on the machine
  - Existing sensors + maintenance specific + virtual sensors
  - To detect component failures
- Data is gathered from multiple machines
  - To improve supply chain for maintenance operations
- Analysed on the cloud, with support from the machine vendor, to provide:
  - Profiles of machines with different health state
  - Thus, prediction of component failures

Press brake example

New Business Models: Industrial maintenance



Conclusions

1. IIoT can enable the revolution of the Digitized Industry: Information
   - Ubiquitous collection and fruition of information
   - Joining of Industrial Automation with IT and Big Data technologies
2. Most solutions are mediated by middleware
3. IIoT is still full of challenges

Acknowledgments

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Thank you for your attention

Questions?