INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

SG8: Strategic Group 8

Sao Paulo, 2015-03-26

Industrie 4.0 /
SmartManufacturing

IoT

Ludwig WINKEL–Co-Convenor IEC SG8

What does it mean „Industrial automation“ (IA)

Machine and Plant Construction

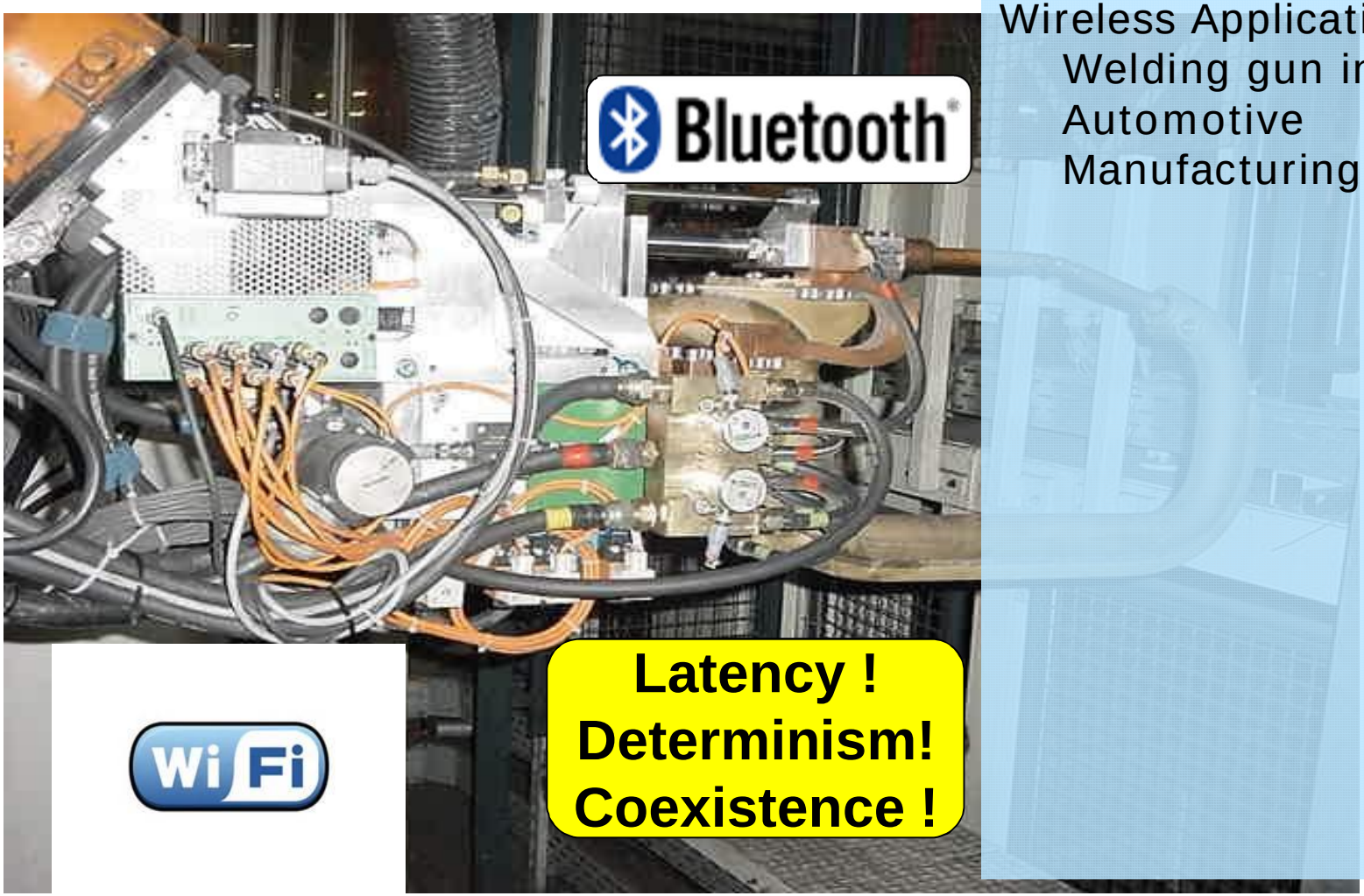
Factory Automation comprises machines that are used for production of goods

- Mechanics
- Automotive (car production)
- Clothes
- Phones
- Chip (electronics)
- Etc.

There are general requirements for Factory Automation that makes the difference to other application domains.

What does it mean „Industrial automation“ (IA)

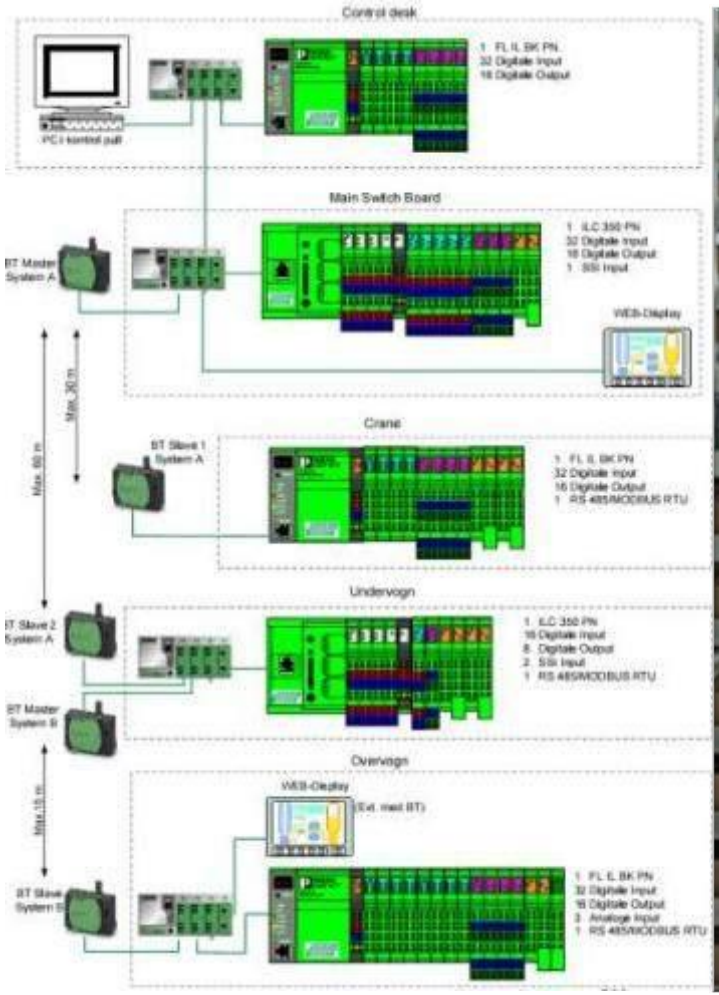
Machine and Plant Construction

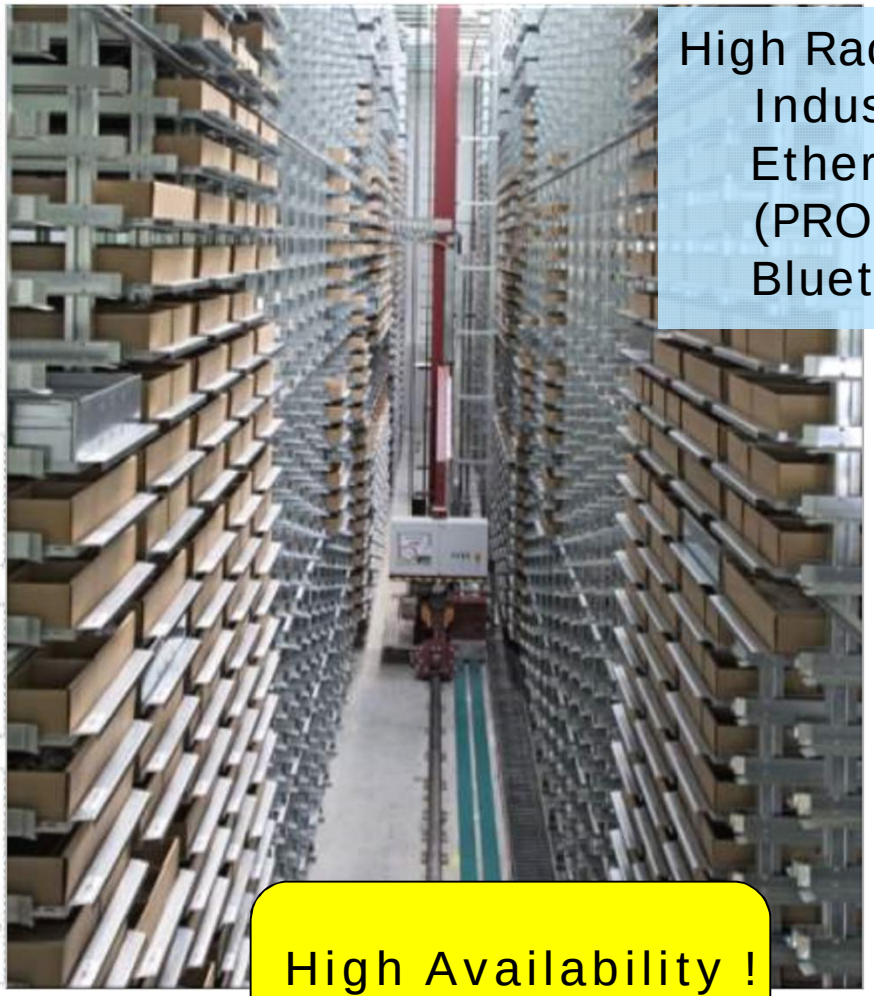


Wireless Application –
Welding gun in
Automotive
Manufacturing

What does it mean „Industrial automation“ (IA)

Machine and Plant Construction





High Rack Control; Industrial Ethernet (PROFINET) via Bluetooth

High Availability !
Coexistence !

Machine and Plant Construction

Process Industry;

Measurement & Control

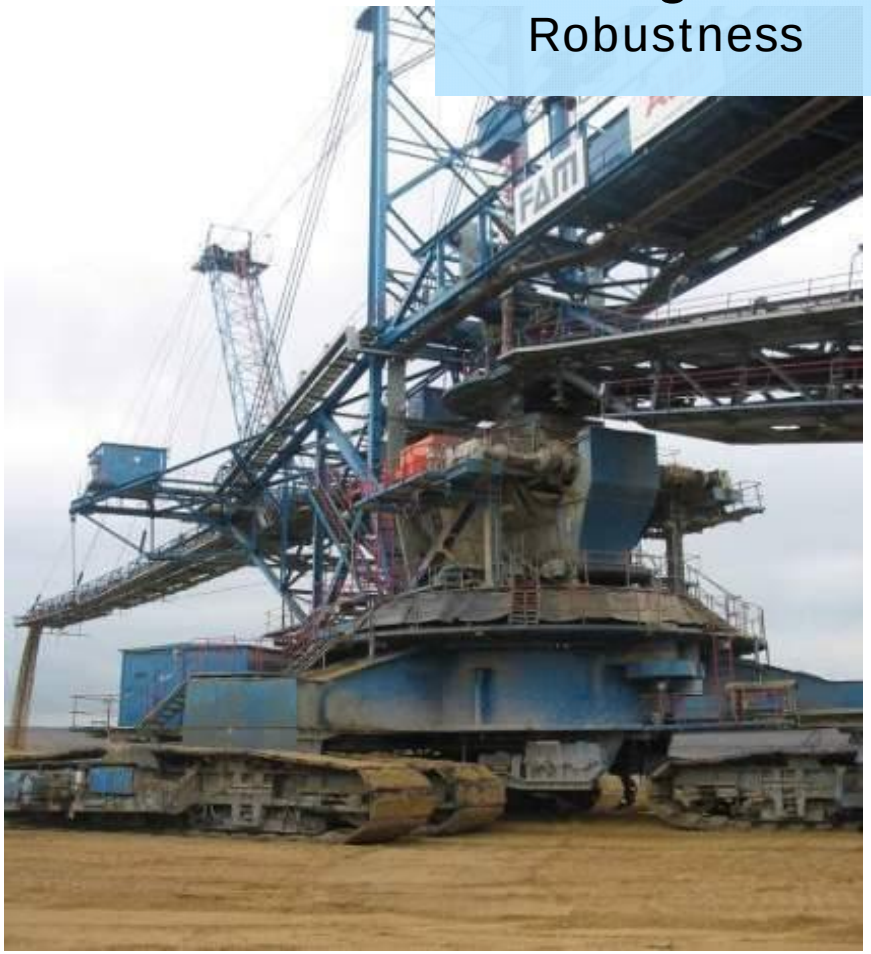
- Large plant expansion (100m …5km),
- High Availability, intrinsic safety and functional safety are extremely important
- Sensors without power supply
- Coexistence using radio
- Slow signal change (100ms…1s/Min.)

What does it mean „Industrial automation“ (IA)

Machine and Plant Construction

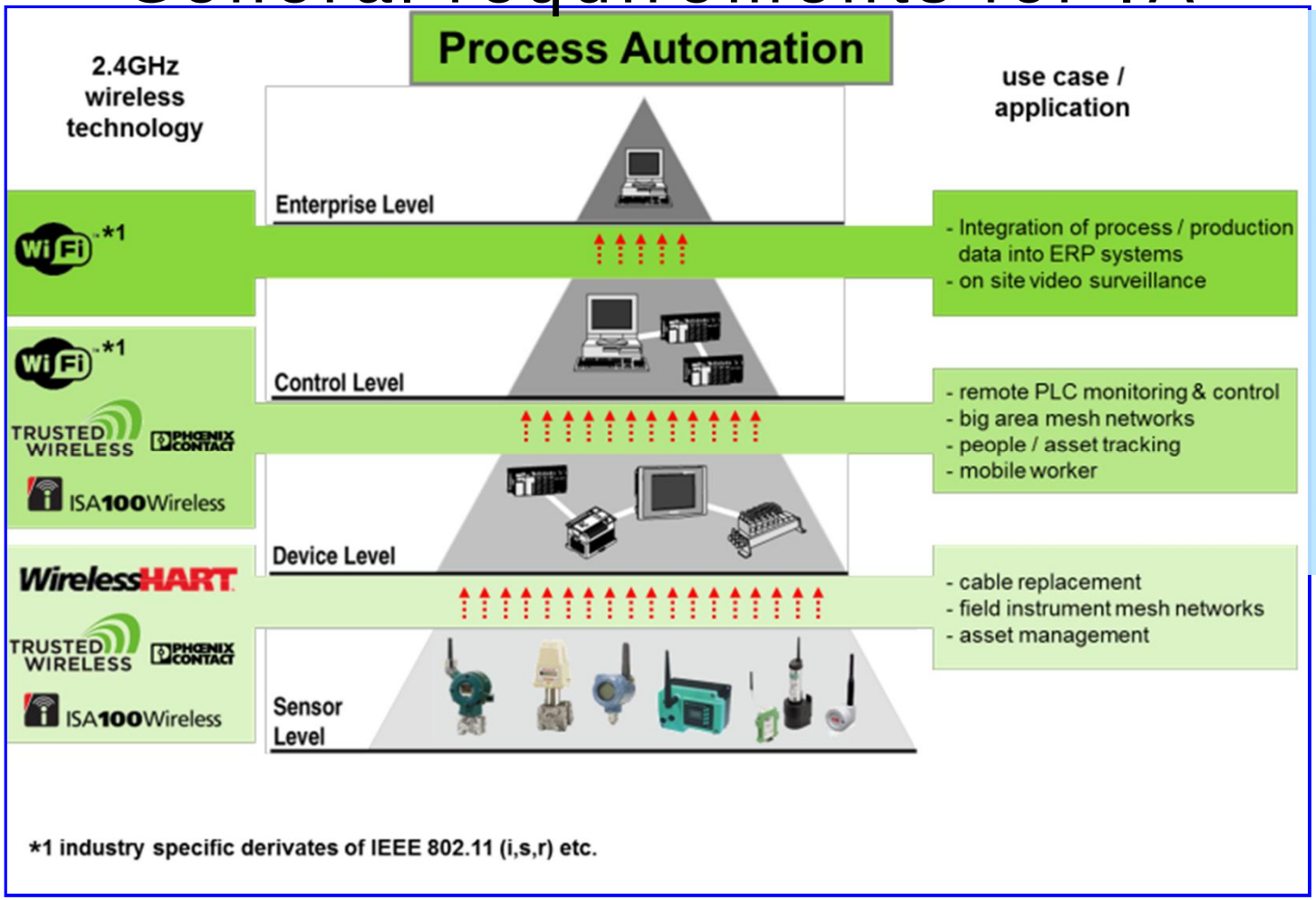
Mining Industry;

Robustness



What does it mean „Industrial automation“ (IA)

General requirements for IA



Automation pyramid

Decomposition of IA communication networks and components associated to levels.

What does it mean „Industrial automation“ (IA)

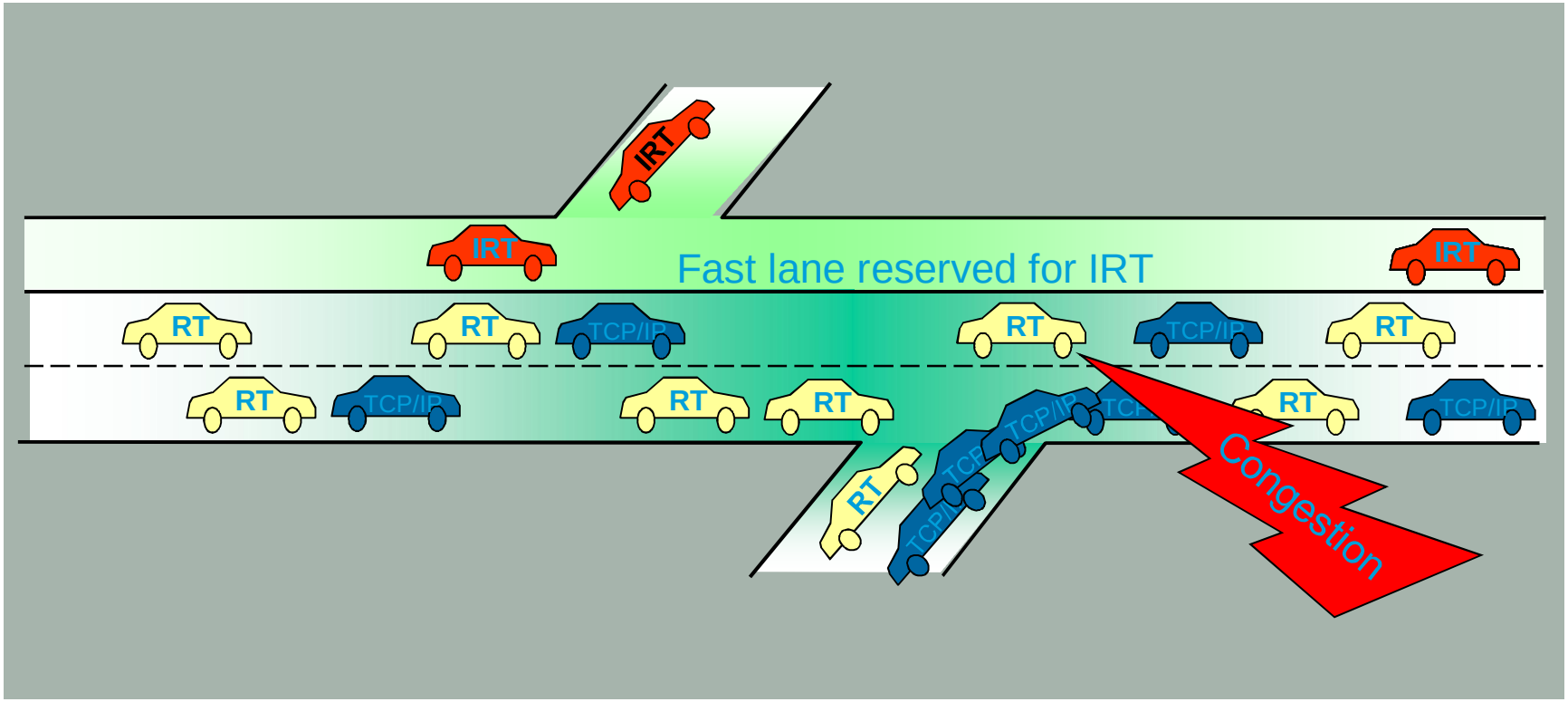
General requirements for IA

Requirement	Explanation
Short Latency	Fast response
Determinism	Temporal certainty, low jitter
Robustness	Mechanical and high availability of transmission link
Range	Extensive plants and NLOS (no line of sight)
High availability	Resilient communication, redundancy
Coexistence	Radio Management to achieve wireless coexistence
Cyber Security	the prevention of illegal or unwanted penetration, intentional or unintentional interference with the proper and intended operation, or inappropriate access to confidential information in an IA system. Cybersecurity includes computers, networks, operating systems, applications and other programmable configurable components of the system; not physical protection.

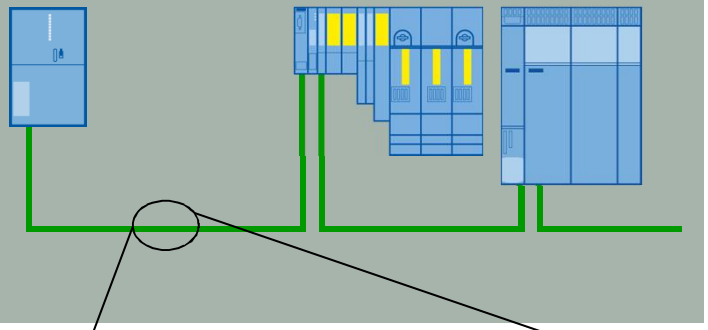
General requirements for IA; Real-time

Reserved fast lane for IRT

- Guaranteed real-time independent of network load
- TCP/IP data traffic takes place quasi parallel to this



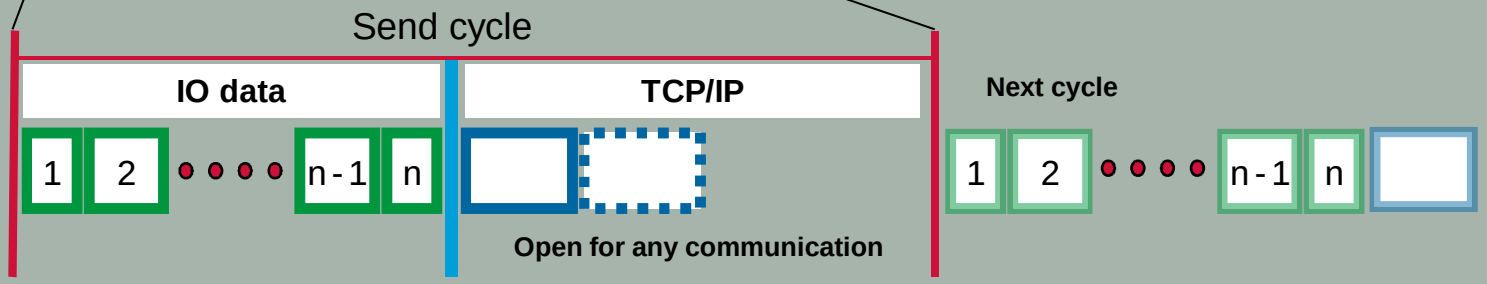
General requirements for IA; Real-time



parate channels for IO data and TCP / IP

- Performance and deterministic behavior through priority assignment of I/O data
- Openness for every type of Ethernet communication
  - TCP, UDP, IP, etc.
  - Integration of Ethernet devices in machines and systems (Webcam, network printer, etc.)

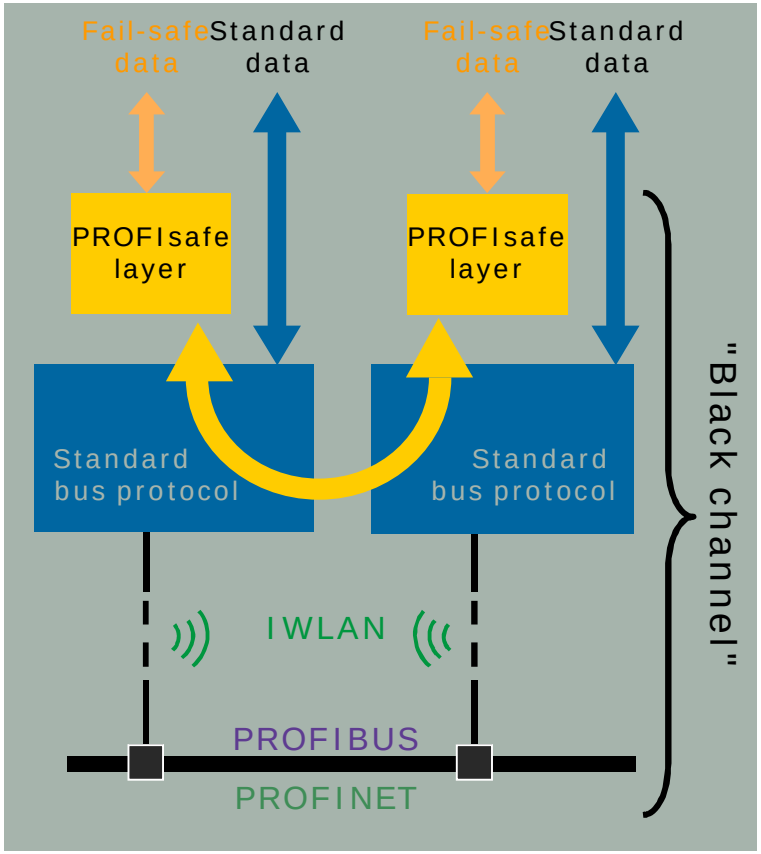
Time scheduling



Real-time and standard on one cable = totally integrated uniformity

What does it mean „Industrial automation“ (IA)

General requirements for IA; Functional safety

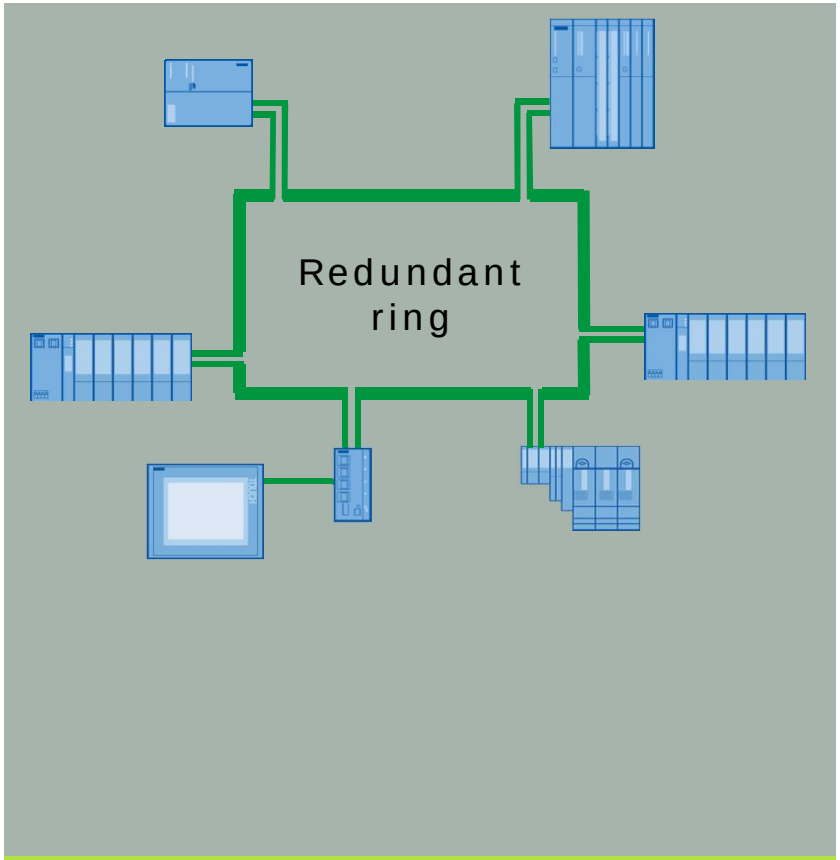


Functional safety can be used without the need of separated communication cables. Even wireless communication can be used

- Up to PL e acc. to ISO 13849-1
- Up to SIL3 acc. to IEC/EN 62061

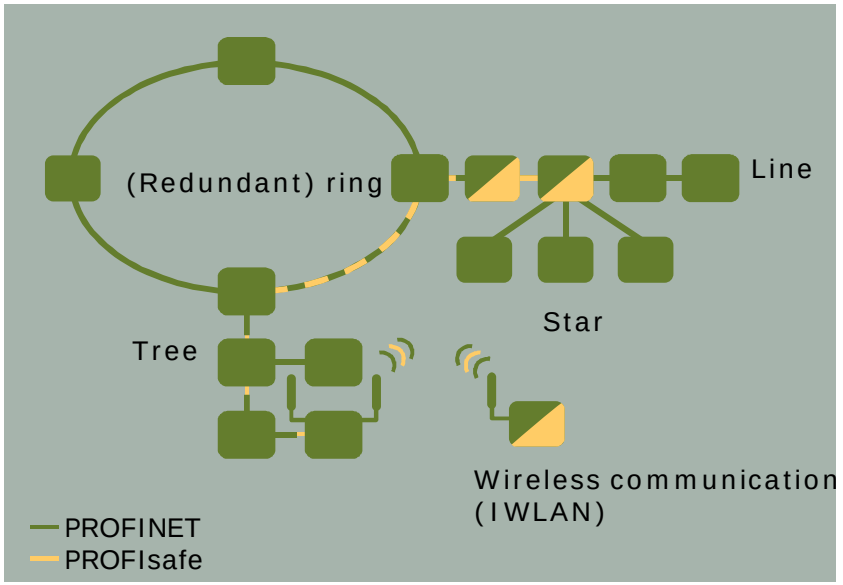
The “black channel” technology is standardized in IEC 61784-3-x and approved by several certification bodies.

General requirements for IA; Redundancy



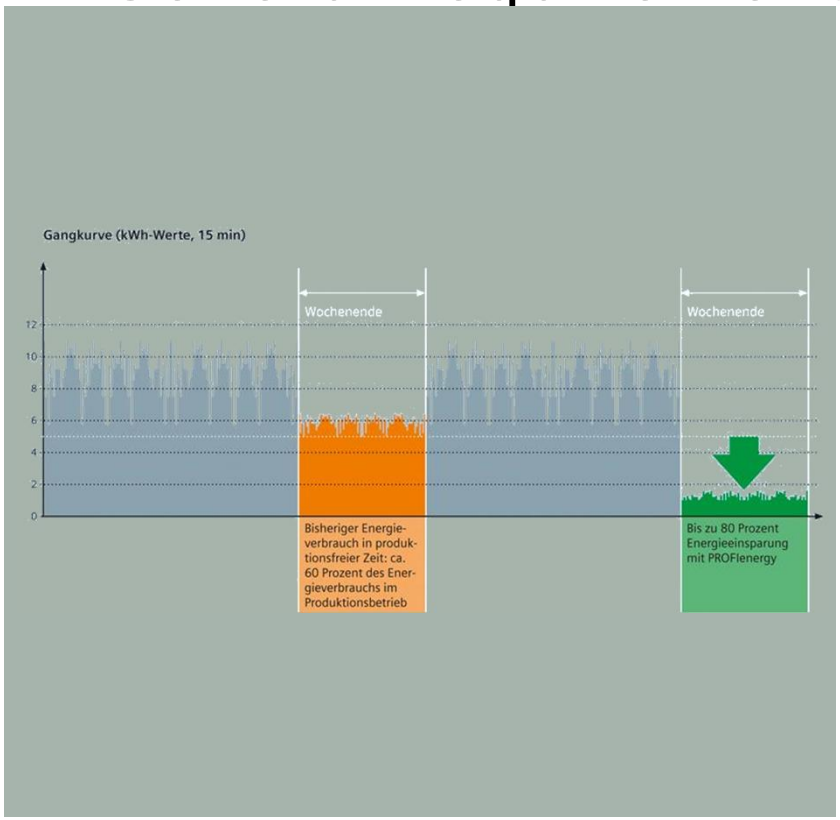
High plant availability due to media redundancy or High-availability Seamless Redundancy

As Rapid Spanning Tree Protocol (RSTP) does not fulfill the required recovery times, several different redundancy approaches are defined in IEC 62439-series.



What does it mean „Industrial automation“ (IA)

General requirements for IA; Energy Efficiency



PROFIenergy significantly reduces the energy consumption during idle times, and allows intelligent energy management

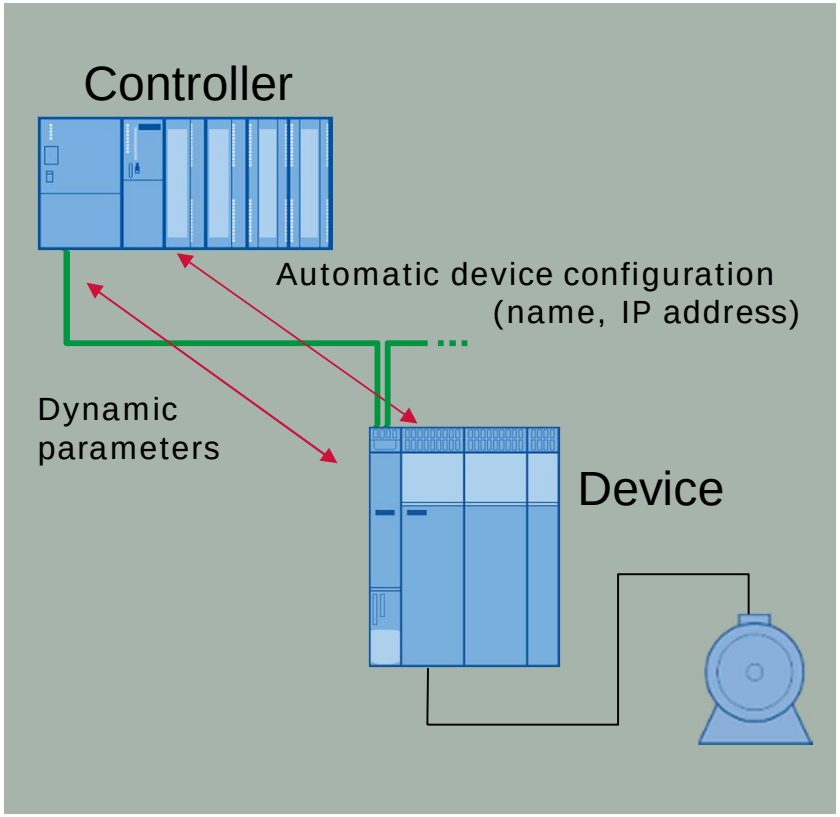
PROFIenergy:

PROFINET-based data interface for switching off consumers centrally and with full coordination during idle times regardless of the manufacturer or device type.

Defines:

- Handling of communic. protocols
- Transport mechanisms
- Control interface (Start_Pause and End_Pause)
- Status functions (Device_Identify; Query_Modes; PEM_Status; Query_Measurement)

General requirements for IA; Fast device replacement



Automatic reconfiguration following device replacement without engineering and without memory card

- During servicing and maintenance, no programming tools or engineering personnel are needed for replacing devices
- Reduction in downtime because only a new device from the warehouse must be used to put a machine or plant back into operation
- No more settings necessary on the device

What does it mean „Industrial automation“ (IA)

General requirements for IA; **industrial networks compared to office networks**

Fundamentals	- Guaranteed operation in rugged environments - networks are customized to applications/machines - Sparse density of devices; many switches with low number of ports - High rate of changing connections between switches and devices	- Operation in air-conditioned environments - Infrastructure considered during building phase - High density of devices, switches with high port count - Site-wide preconfigured infrastructure and cabling including patch-panels and sockets; clients are moving with low effort
High Availability	- high requirements like 7/24h - Network recovery times <200ms required to avoid impact to production - “seamless” (no packet loss, no failover time) - Different redundancy protocols e.g. MRP, HSR, PRP, ...	- Medium requirements - Network recovery times within seconds or minutes are accepted
Robustness	- Temperatures up to -20 … +70 degrees celsius - In and out of rack mounting is supported (IP65/IP67) - Universal mounting - DC 24V power supply	- Temperatures usually 0 … +45 degrees celsius - Distribution rooms - Planned infrastructure - 19” rack mounting - AC 110/230V power supply

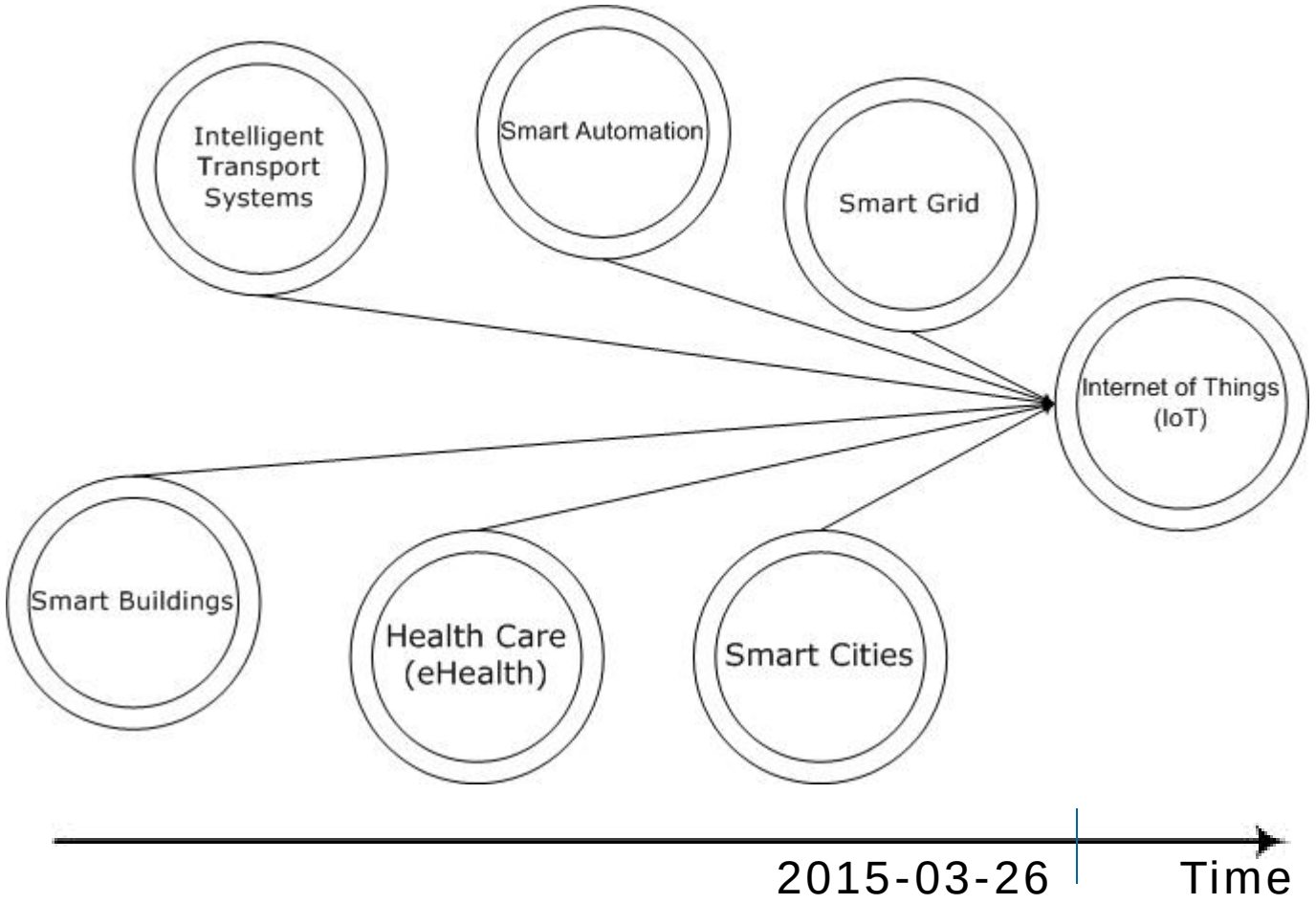
What does it mean „Industrial automation“ (IA)

General requirements for IA; **industrial networks compared to office networks**

		
Flexibility	- Changing production layouts in the shop floor - Tree-, star-, line- and ring-topologies are common - Together with higher level networks, control-rooms and wireless networks	- No changing layouts and cabling - Structured star-topologies are common - Together with site-, building- and floor-areas
Security	- Secure remote administration, e.g. for machine- and device-vendors - Major goal is availability	- Major goal is confidentiality
Moving Units	- E.g. automated guided vehicles, monorails with network connections - Forklifts, wireless scanner, ...	- No requirements
Safety	- Immediate response, e.g. emergency stop	- No requirements
Deterministic	- Guaranteed reaction times - e.g. Synchronisation of drives within a machine	- Best effort reaction times

How does „Industrial automation“ fit into IoT

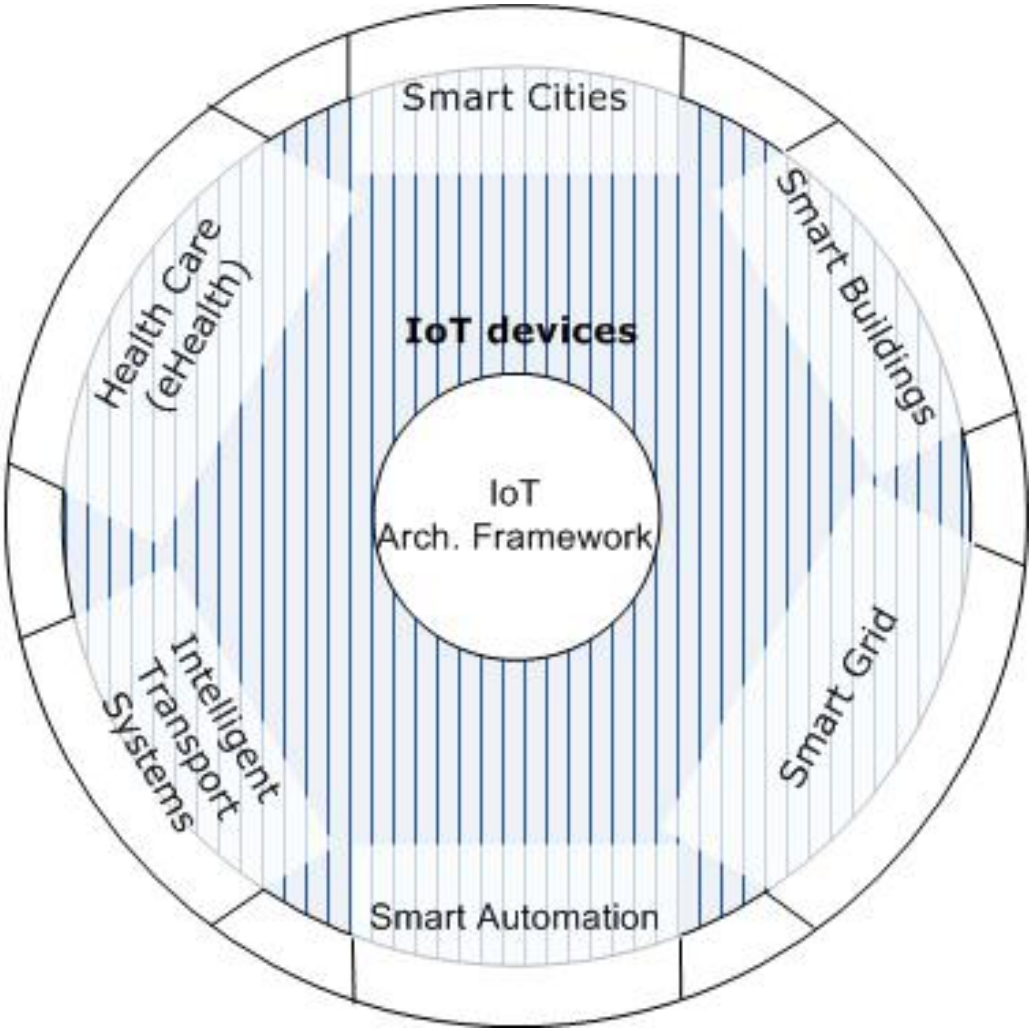
Today



Existing application domains could claim to be part of IoT, but …

How does „Industrial automation“ fit into IoT

Based on IEEE P2413



... the benefit of IoT shall be that IoT-devices and -phys. Entities can be used in different application domains with a certain compatibility level!

IA standardization relevant to IoT
Levels of device compatibility

Needed feature	Compatibility level: Incompatible	Coexistent	Interconnectable	Interworkable	Interoperable	Interchangeable
Dynamic performance						♥
Application functionality					♥	♥
Parameter semantics					♥	♥
Data types Data Access				♥	♥	♥
Communication interface			♥	♥	♥	♥
Communication protocol		♥	♥	♥	♥	♥

Interoperability requires Semantic and context knowledge.

There are certain levels of compatibility when devices have to cooperate together. The levels are dependent on well-defined communication and application features.

How does „Industrial automation“ fit into IoT

Hypothesis

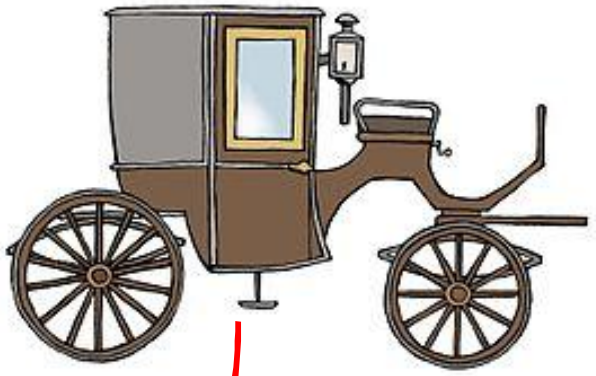
Semantics of things becomes the most crucial issue to use IoT devices in different application domains. In the worldwide IoT a real thing must be *uniquely identified*. The characterization of things must follow the Property Principle (PP) which postulates that each thing must have

- an unique standardized identifier (ID);
- a semantically standardized name;
- a standardized data format for its value.

A lot of International Standards (or drafts) of IEC, ISO and IEEE invented by IA may be the basis for the future IoT devices.

A combination of two simple things...results in a new product type

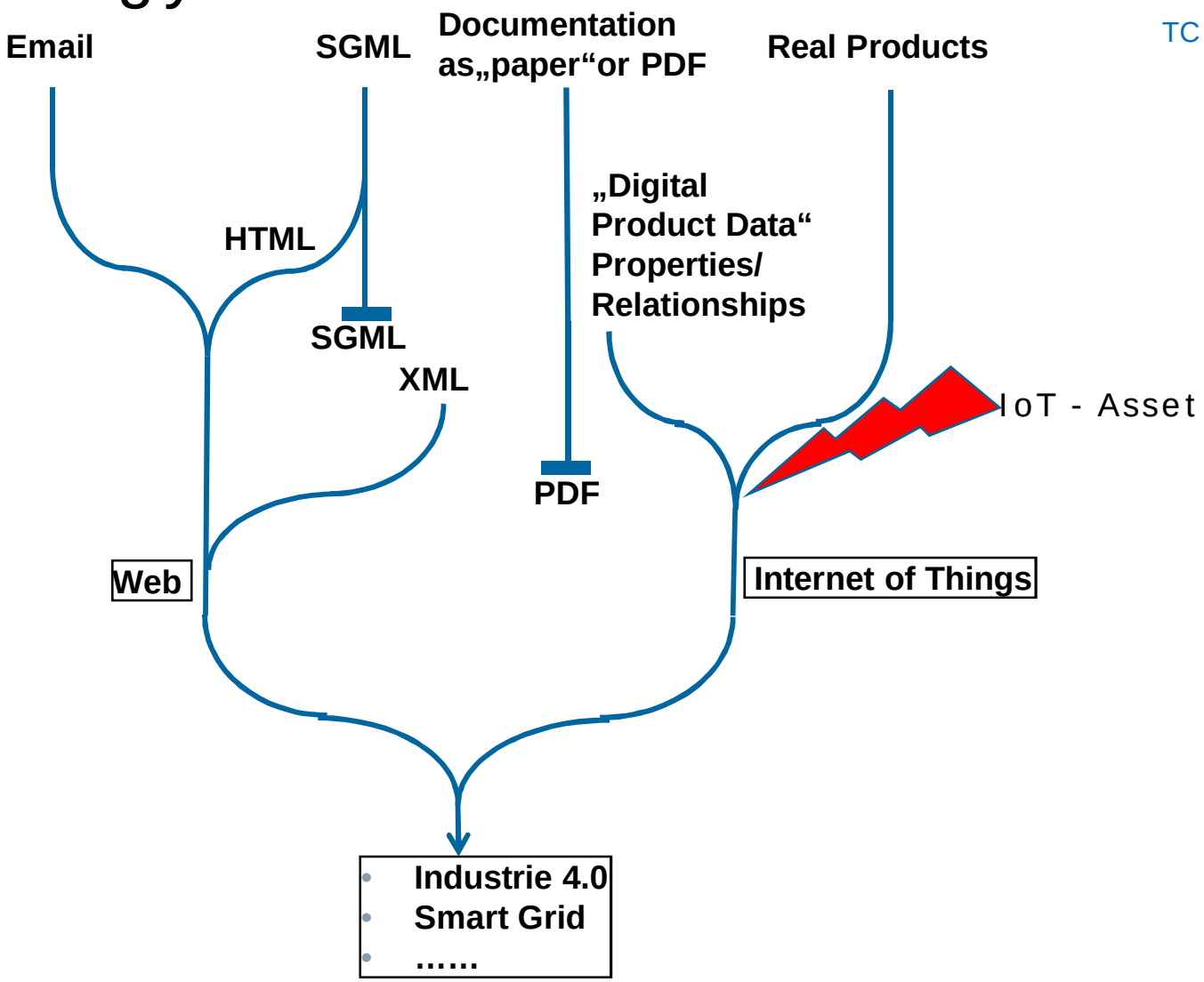
TC 65



Gottlieb Daimler:
There will be 5000 cars maximum. The reason is there are not more car drivers.

Henry Ford:
"If I had asked people what they wanted, they would have said faster horses."

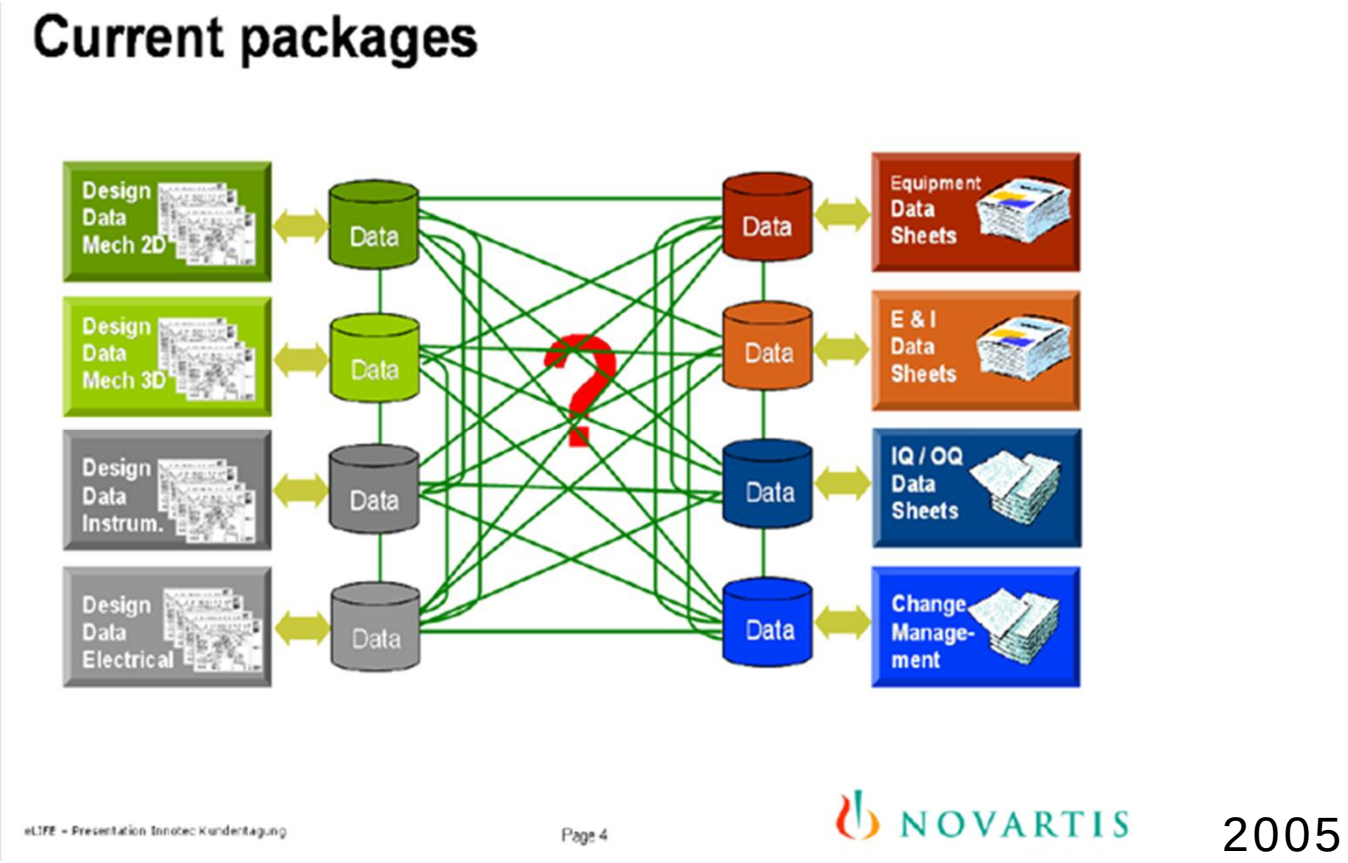
Technology Trail



Today: Each tool has ist own data model

TC 65

- Each tool has its own data model

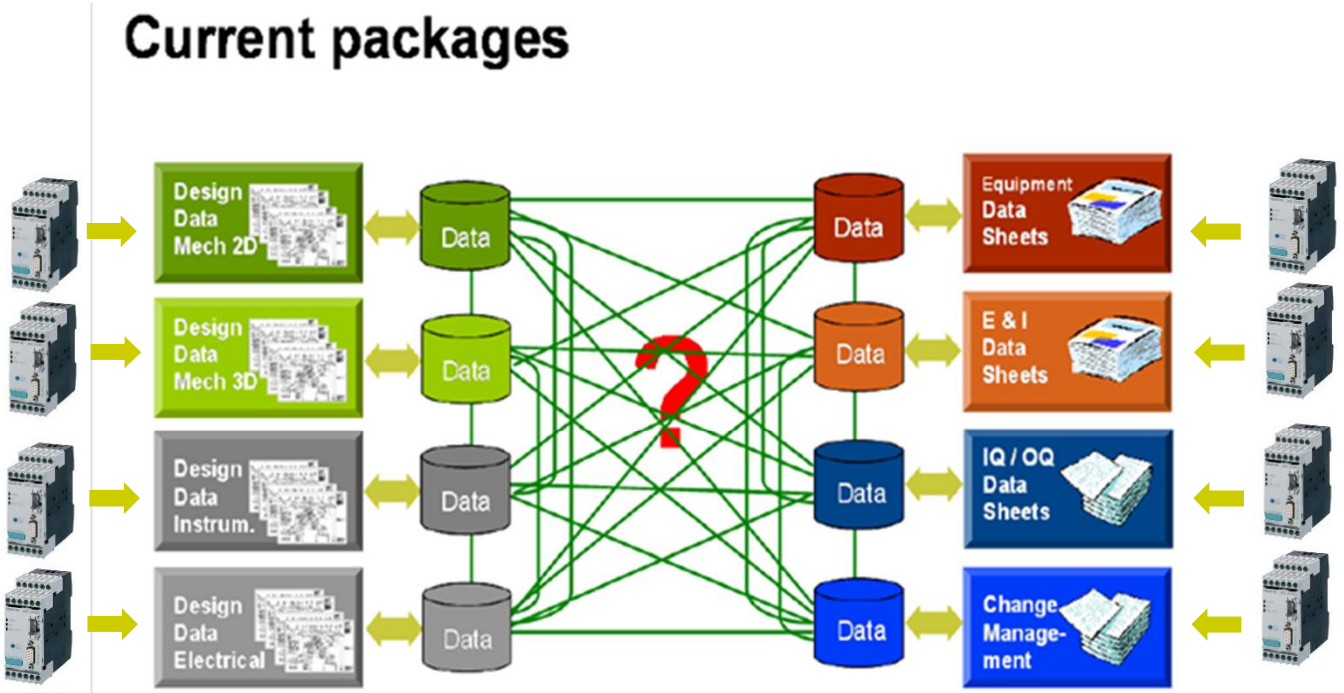


Freigegeben von NAMUR (H.Dr. Tauchnitz)

Each tool converts product data model into ist own one

TC 65

- Each product has its own data model
- Each tool has its own data model

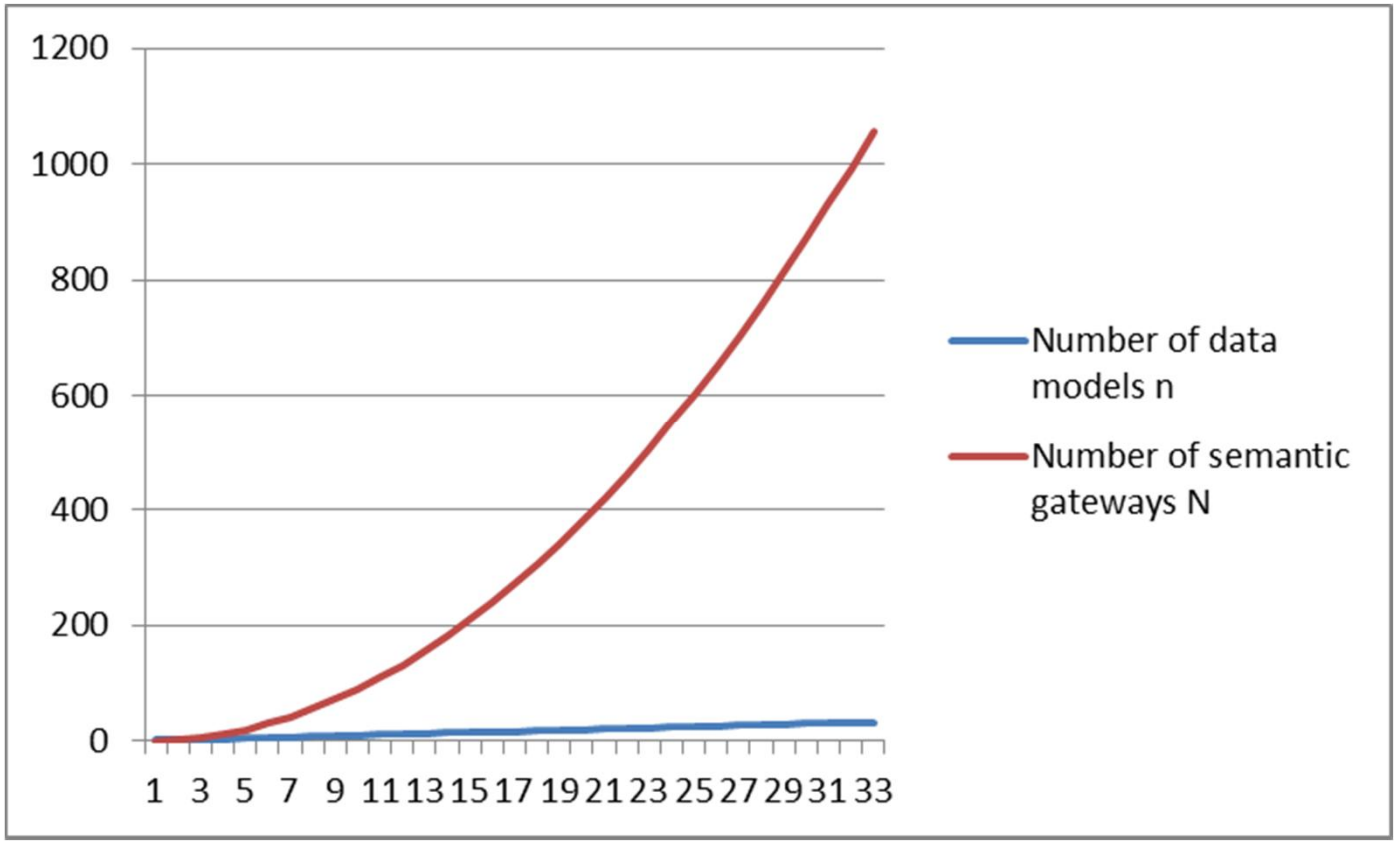


Numer N of semantic conversions with n instances: N=n(n-1)

2005

TC 65

A kernel problem of computer science: The number of required data conversions increases quadratically with the number of data models

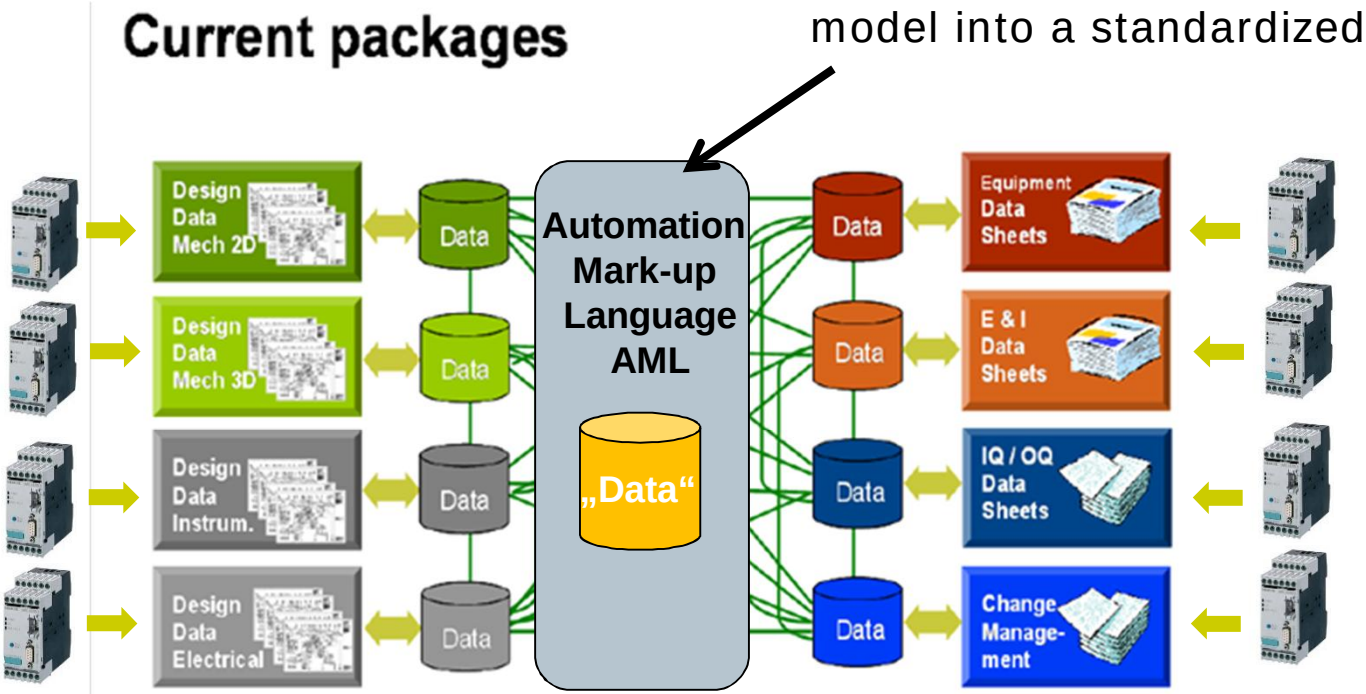


N=n(n-1)

The standardized data model „Automation ML“ reduces complexitiy

TC 65

- Each tool converts its data model into a standardized-one



Numer N of semantic conversions

with n instances: N=2n

Page 4

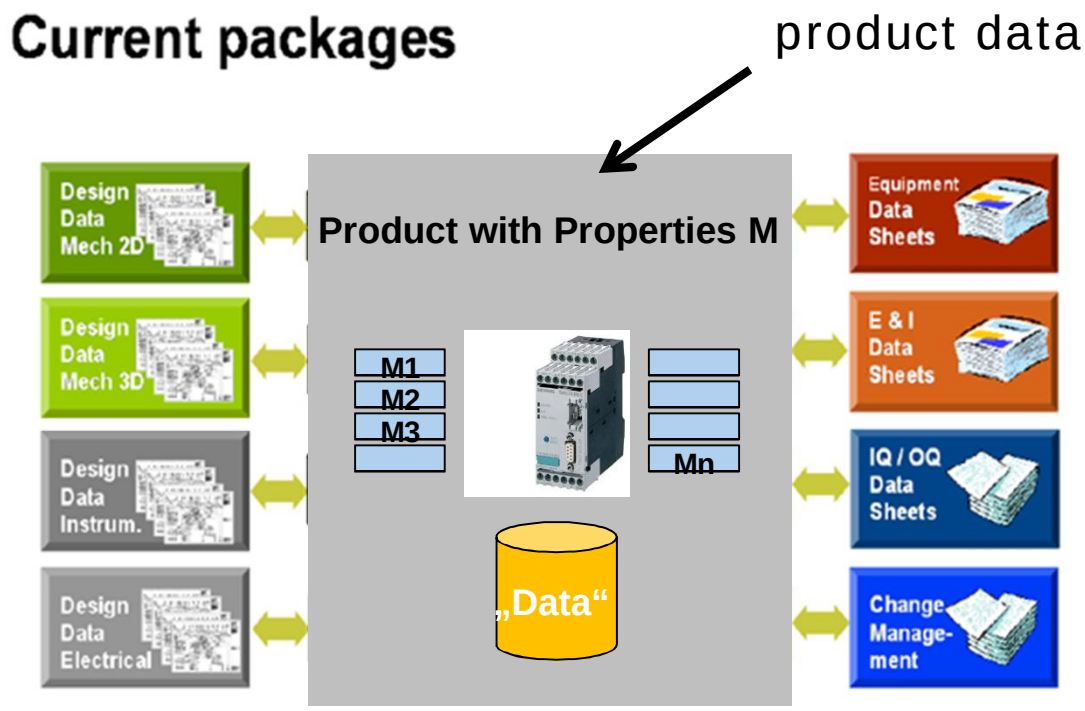
NOVARTIS

2005

Properties uniquely specified following one single rule reduces the number of conversions to zero

TC 65

- Each tool uses the common product data model

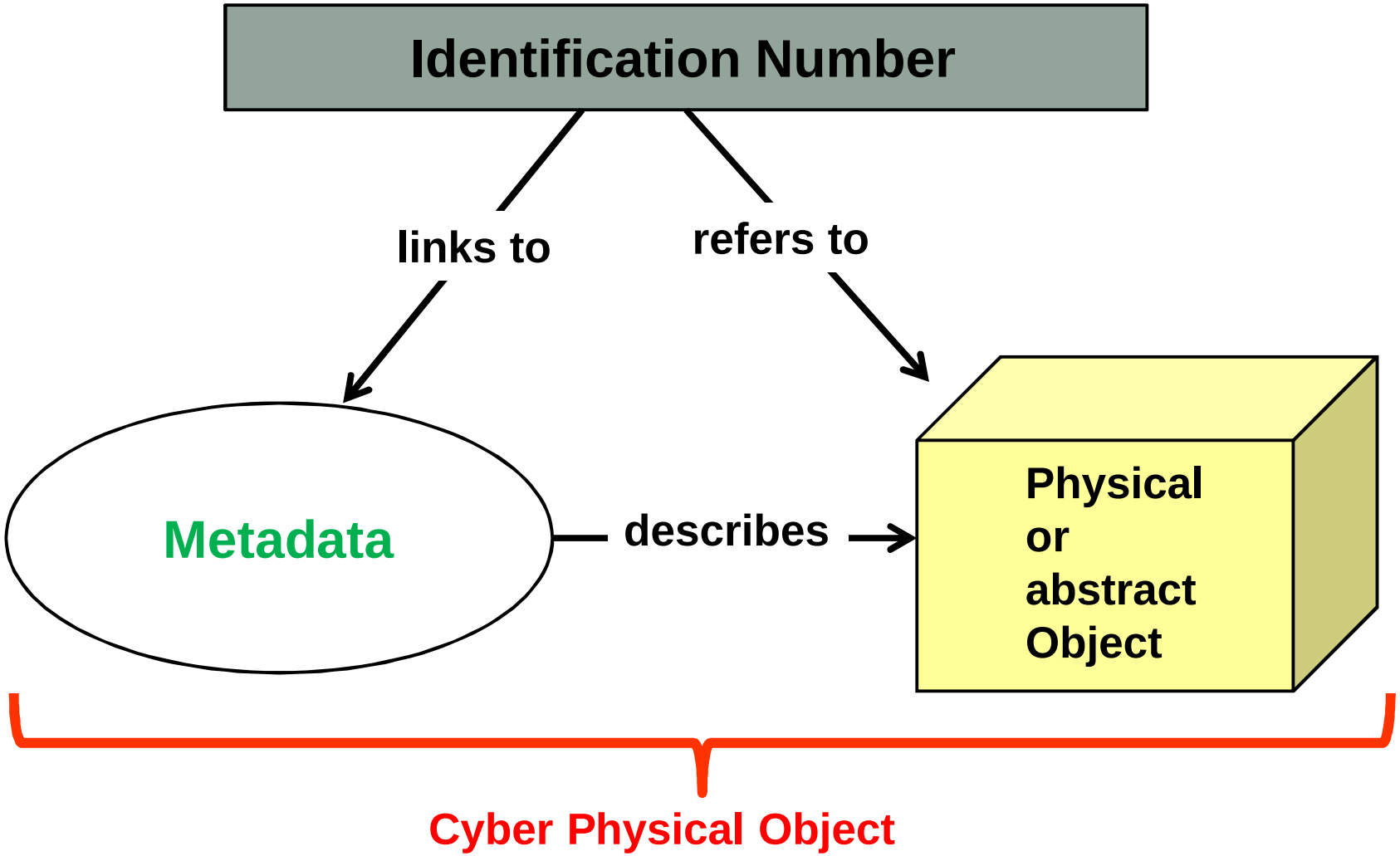


Numer N of semantic conversions with n Instances: N=0

NOVARTIS

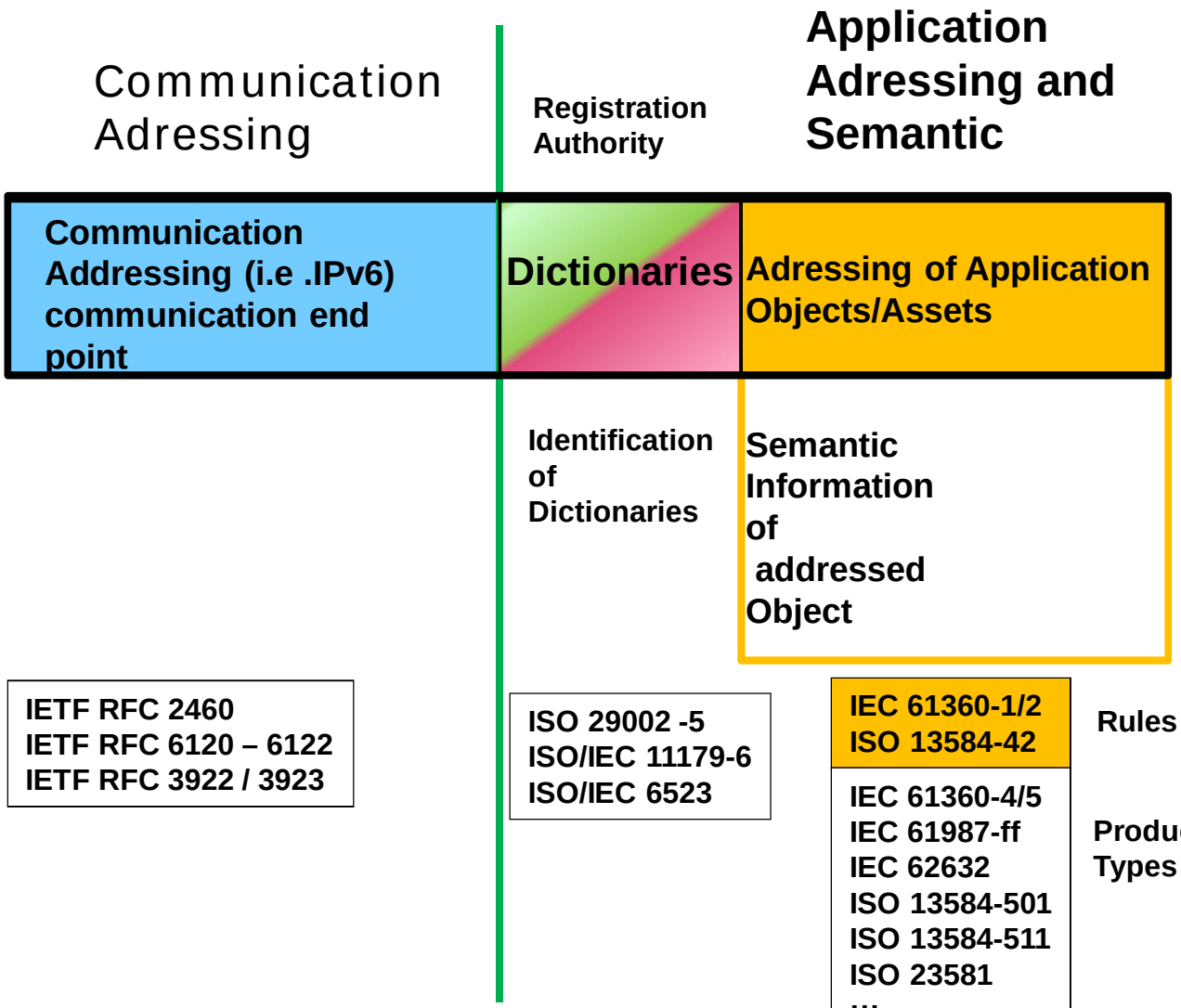
2005

Asset Model: Creation of a Cyber Physical Object (IEC 62507)



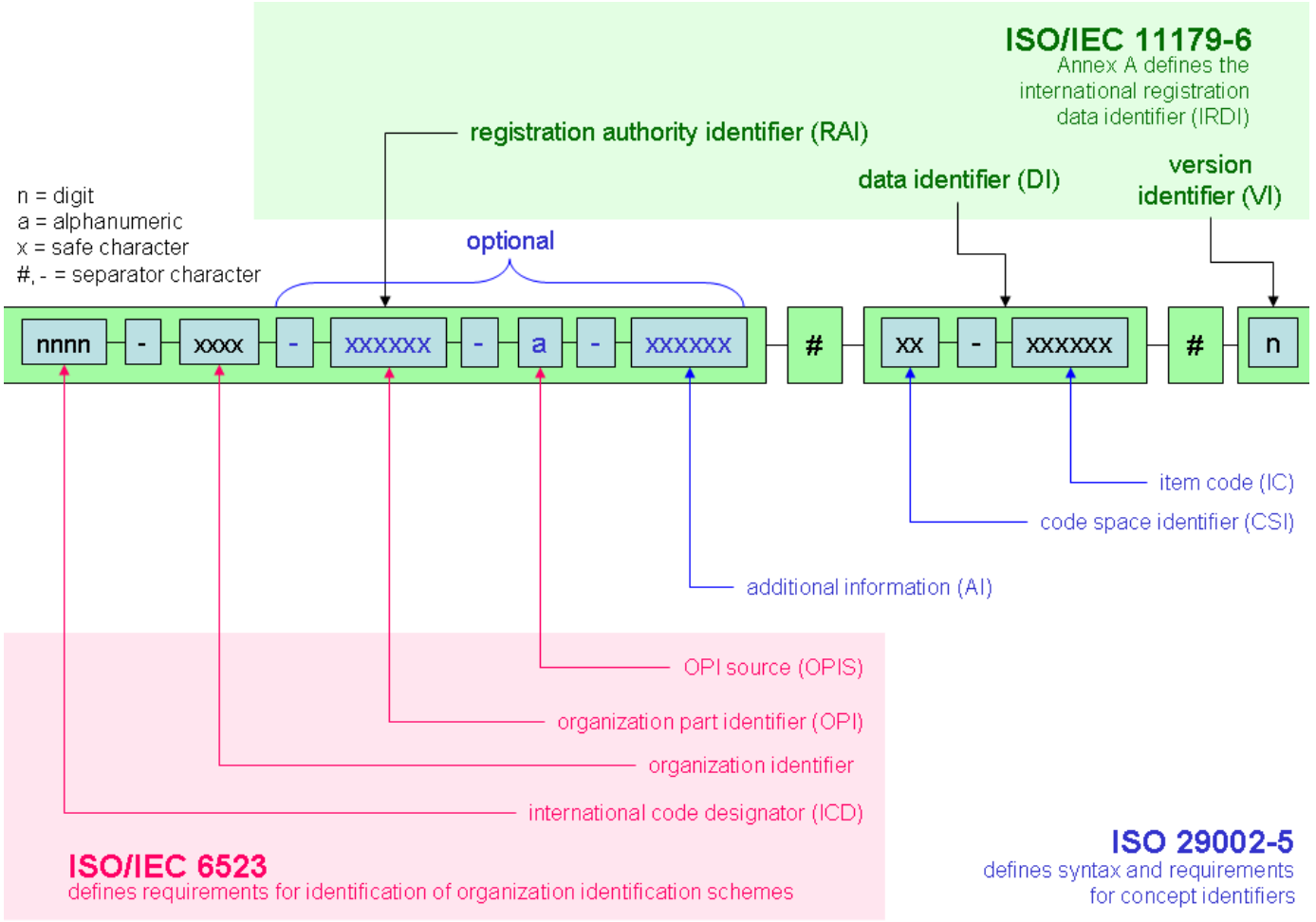
Identification of IoT-assets

TC 65



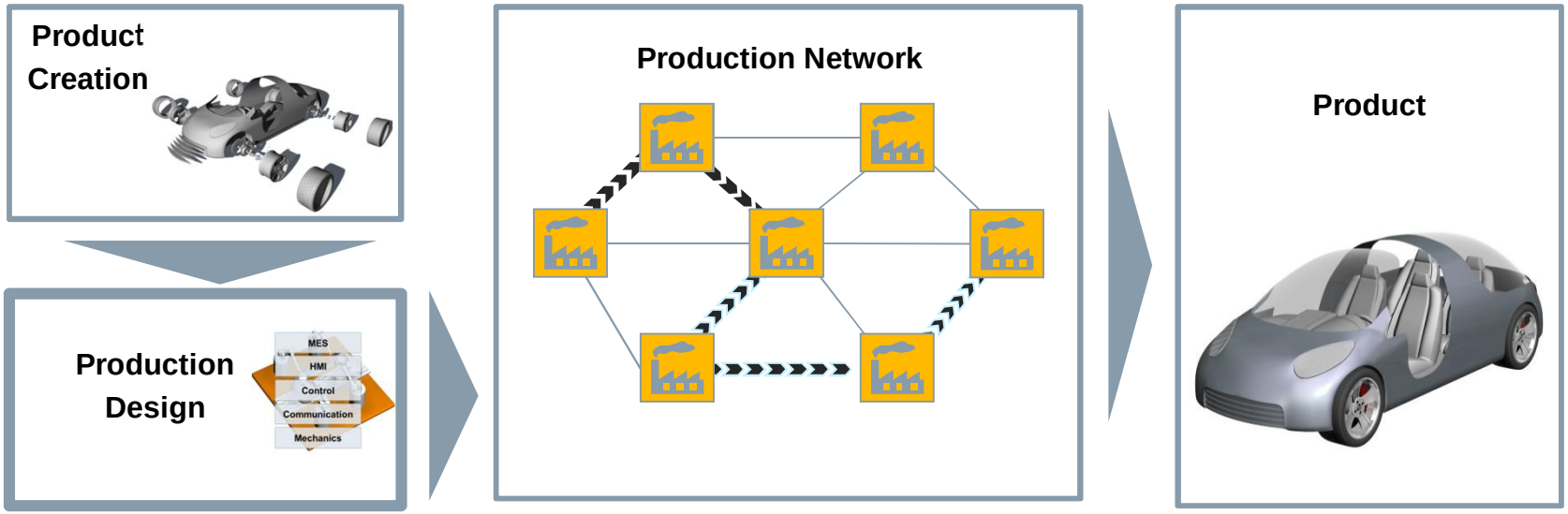
Addressing of Application Objects (ISO 29002)

TC 65



Example: Areas of concentration in Industry

TC 65



Similar areas and requirements are expected for

- Connected Cars
- Smart Grid
- .....

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Forum Industrial IT, Hannover, 07. April 2014

Industrie 4.0 – on the way to a new production environment – step by step

Prof. Dr. Dieter Wegener, Head of Technology, Industry Sector

Challenges:
Manufacturing changes are needed faster than ever before

Increase the ability to compete

1 Raise efficiency	2 Reduce time-to-market	3 Increase flexibility
• Energy and resource efficiency as decisive competition factors	• Shorter innovation cycles • Ever more complex products • Larger data volumes	• Individualized mass production • Volatile markets • High productivity

Industrie 4.0 will help manufacturing overcome the challenges it faces

Industry is once again considered the motor for growth and stability worldwide

USA

"Manufacturing Renaissance"

- Formation of a "National Network for Manufacturing Innovation"
- Use of national shale gas and oil deposits (fracking)

Germany

Maintain leading industrial position

- Sustainable investment in innovative strength
- High level of exports
- **Industrie 4.0 as new guiding principle**

China

Higher product quality by use of high-end technology

- Rising wages
- Need for quality driven demand for automation
- Energy efficiency legislation

Japan

Focus on growing exports

- Manufacturing industries generate about 20% of GDP
- Governmental activities to support export businesses
- Among the most innovative high-tech countries in the world

Industrie 4.0 impacts all branches of industry, from discrete manufacturing to the process industry

I4.0 facility

Future plant 2030

Future factory 2030

Process — Hybrid — Discrete

Energy
Water & wastewater
Chemicals
Oil & gas
Pulp & paper
Metals & mining
Pharmaceutical
Glass & solar
Food & beverage
Consumer products
Marine
Automotive
Aerospace
Machinery
Electronics

I4.0 plant

I4.0 factory

The Industrie 4.0 vision:
Self-optimization of Cyber Physical Systems (CPS)

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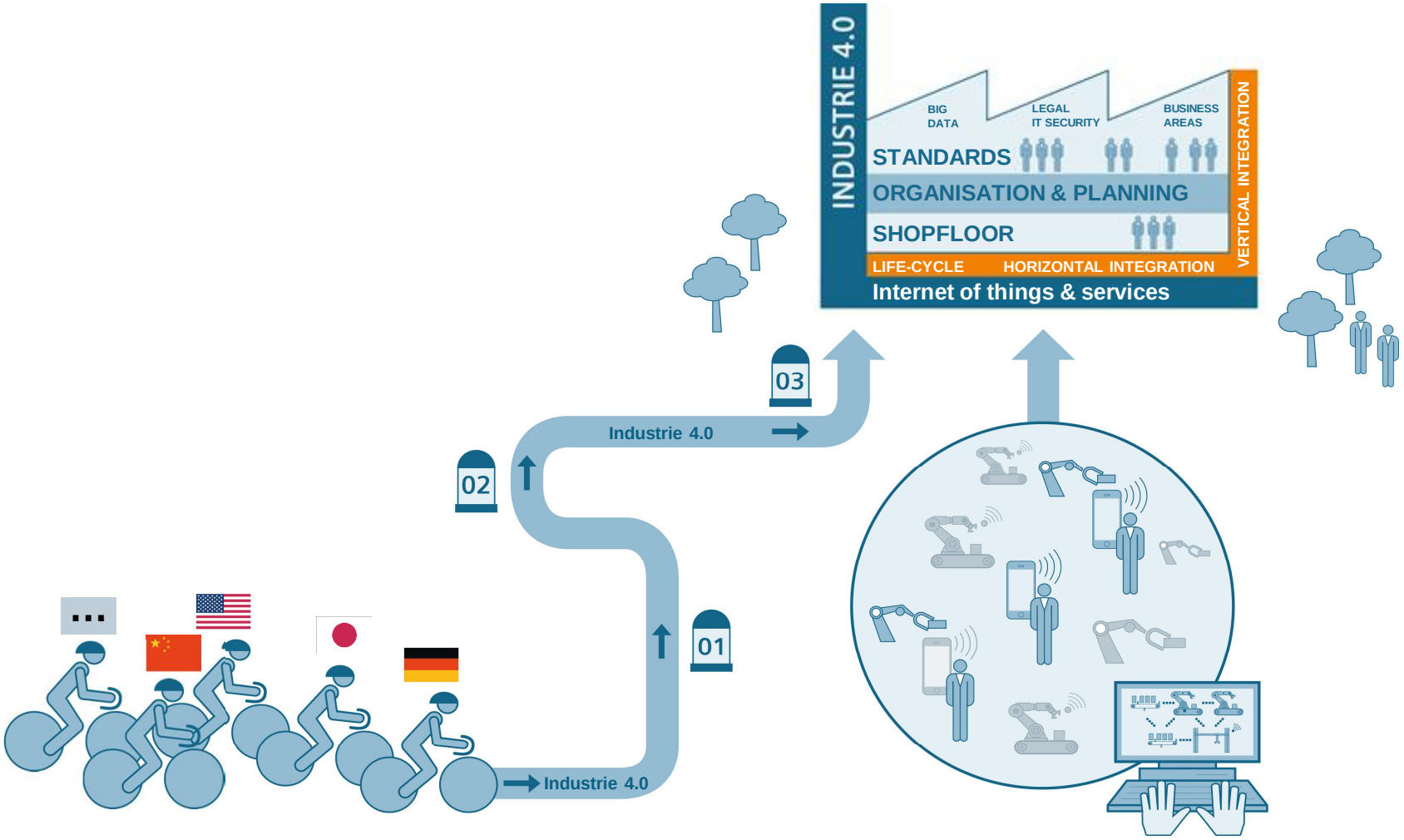
The Industrie 4.0 vision

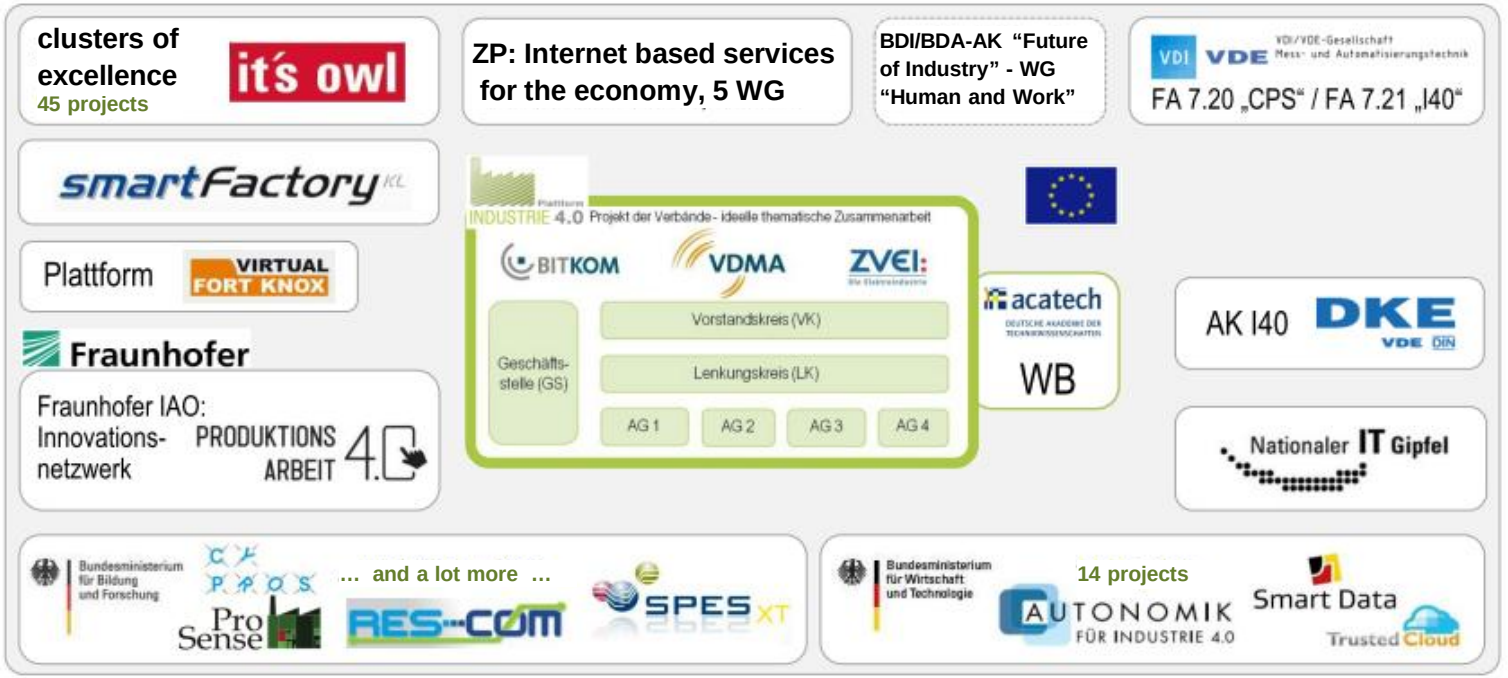
- The **product** to be manufactured **has all the data necessary** for its manufacturing requirements
- **Self-organization** of **networked manufacturing equipment**, taking into account the entire value added chain
- **The manufacturing sequence** is **determined on a flexible basis**, depending on the current situation
- **The human remains essential as the creative planner, supervisor and decision-maker**

The future of industry
Many teams are poised on the starting line



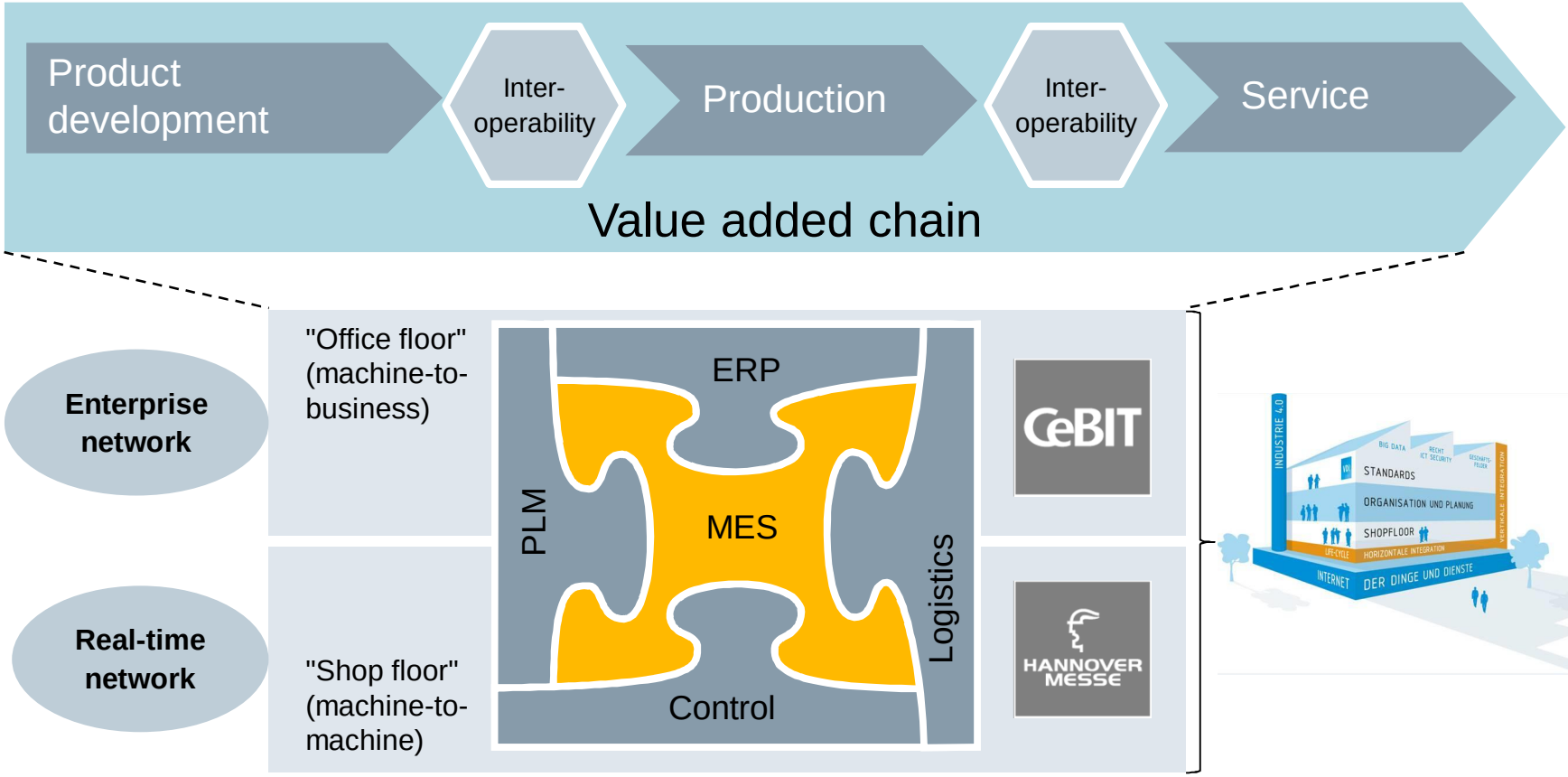
Germany has formed a worling group which is off to a good start...

The Platform “Industrie 4.0” and its environment.



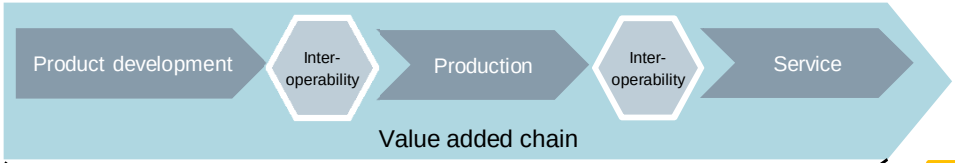
Areas of activity:

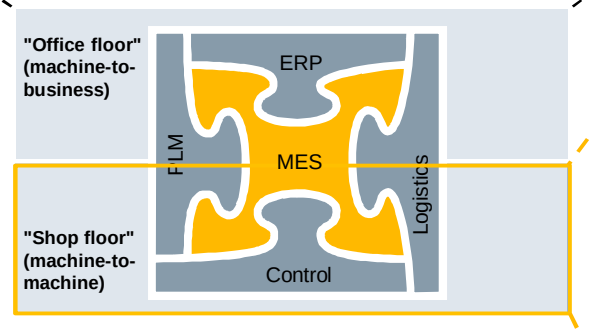
Secure interoperability of the system landscape throughout the entire value added chain



*Source: ZP2 (Future Project 2) working party, "Internet of services"

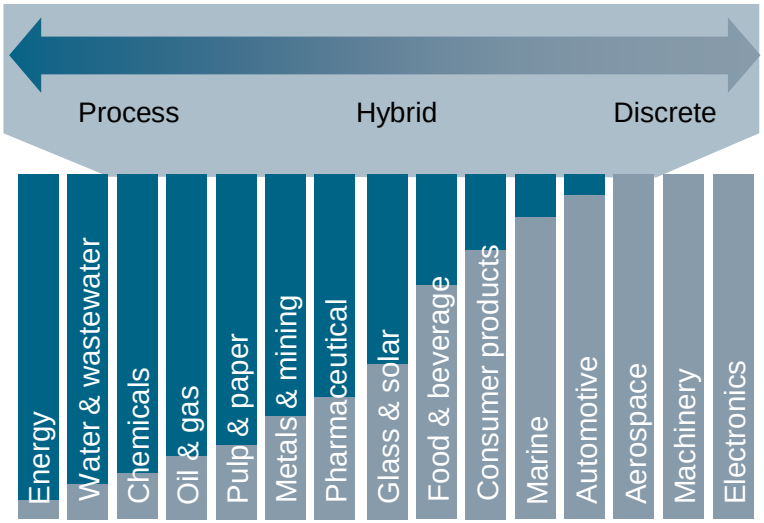
The challenges:
A common understanding of the shop and office floors



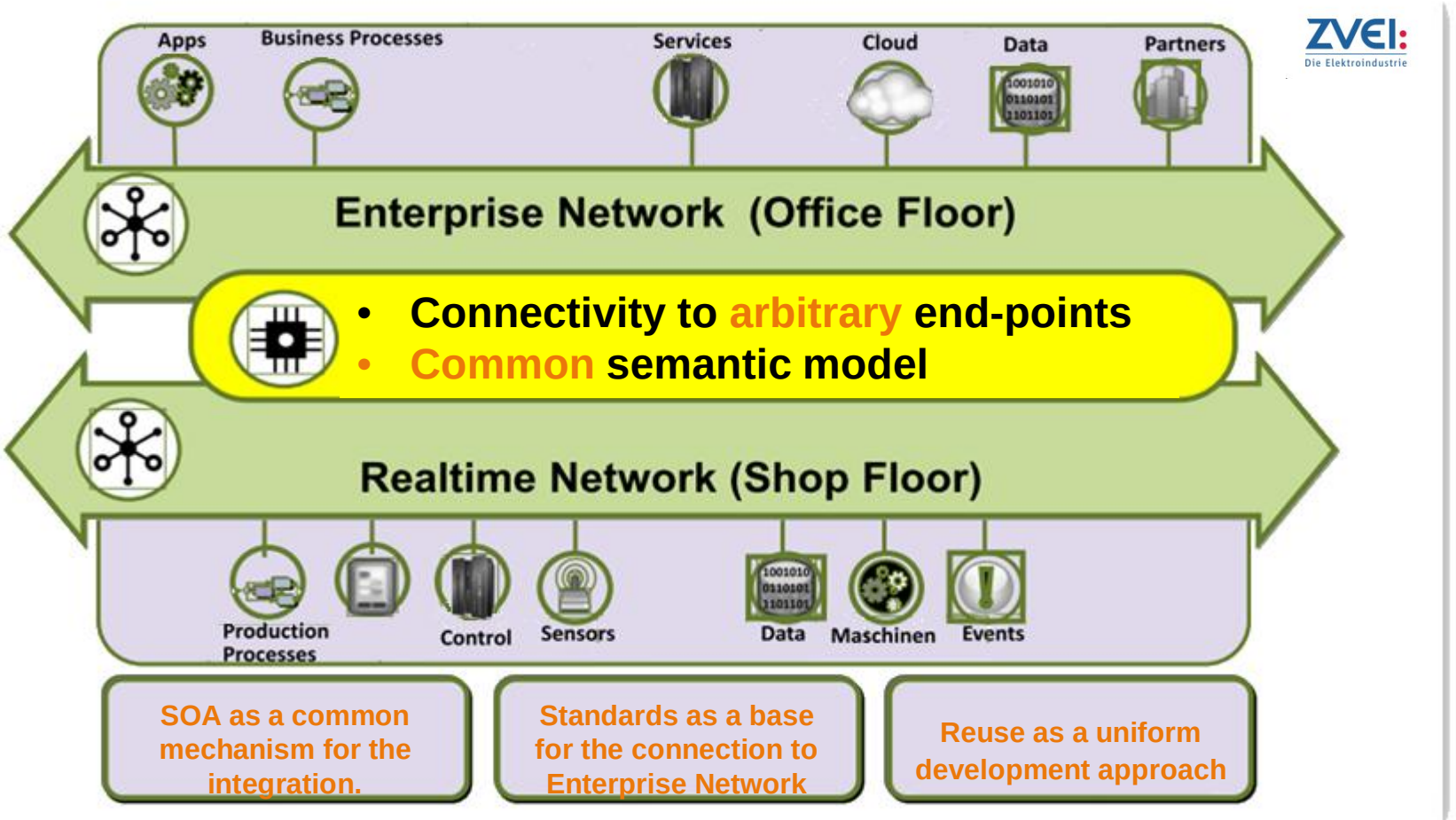


At the shop floor level take note of:

1. **High level of branch dependency, detailed in the norms & standards**
2. Reference architectures dependent on use case



SOA* implementation by way of semantic linkage of the office and shop floors



Source: ZVEI Industrie 4.0 steering group; Jan. 14, 2014

* SOA: Service-Oriented Architecture

Service aspects are currently being developed in the ZP2* Industrie 4.0 platform working group

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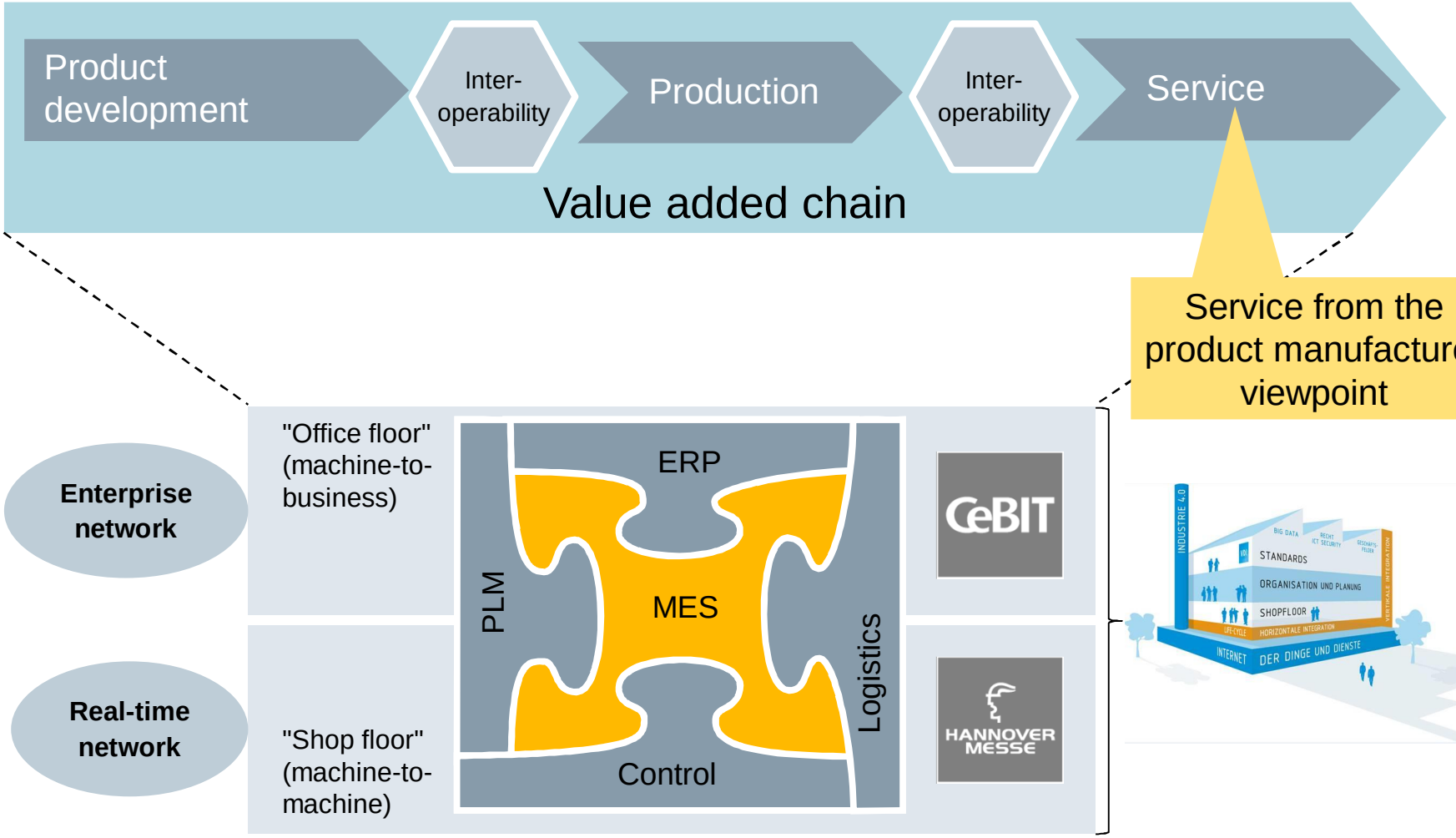
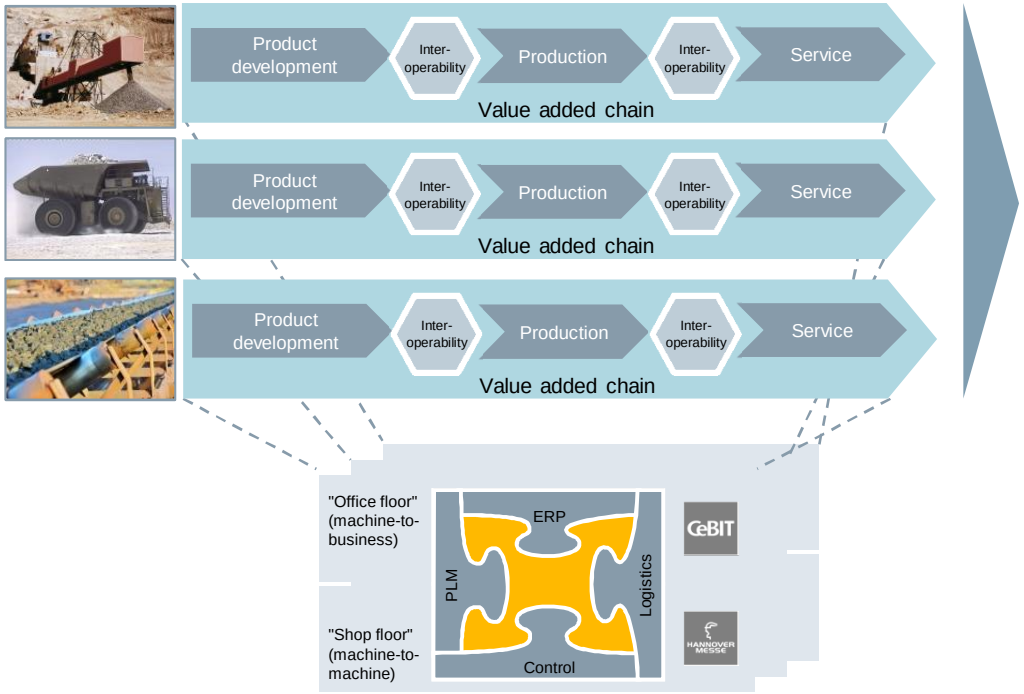


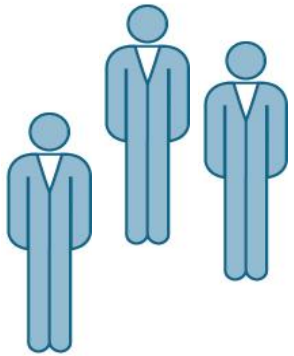
*Source: ZP2 (Future Project 2) working party, "Internet of services"

Expansion of Industrie 4.0 into the Service area from the product user viewpoint (Example: Mining)

New digital infrastructures and business models



Service from the user viewpoint



*Source: ZP2 (Future Project 2) working party, "Internet of services"

Siemens – Roadmap to Industrie 4.0
Evolution, not revolution

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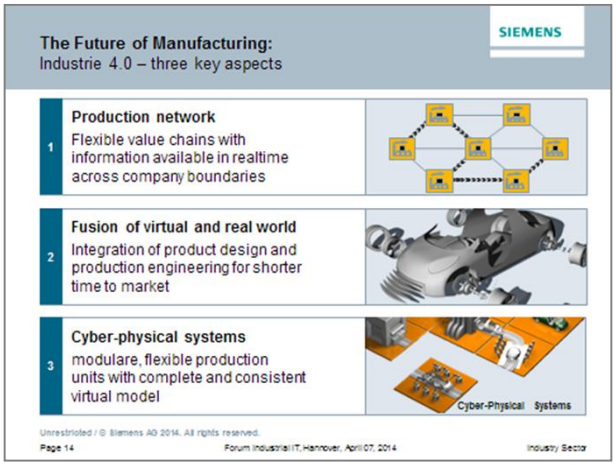
Yesterday and today	Today and tomorrow: Evolution	2030

Characteristics

- Preplanned processes
- Adaptable environment created
- Any deviation from plan is an error



Three key-aspects:

- Production network
- Fusion of virtual and real world
- Cyber-Physical Systems

Characteristics

- Flexible processes
- Situation dependent environment
- Ad-hoc decisions

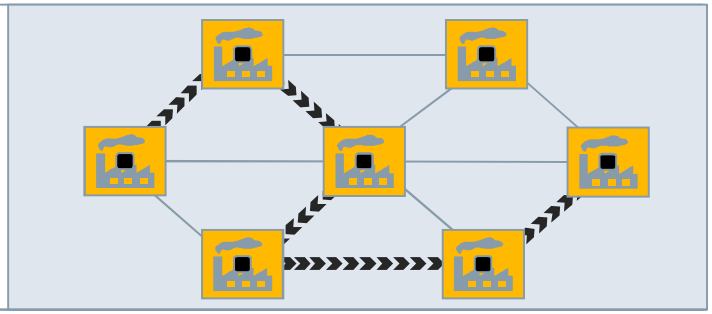
The Future of Manufacturing:
Industrie 4.0 – three key aspects

SIEMENS

1

Production network

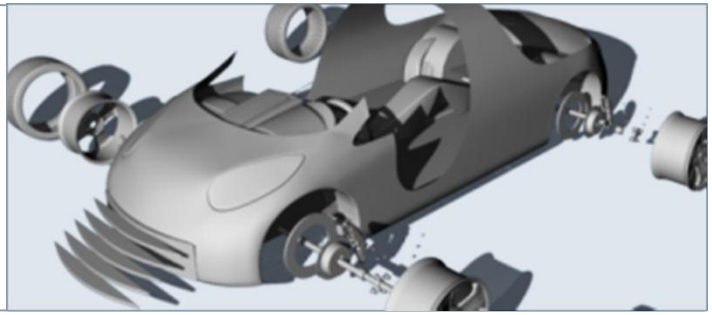
Flexible value chains with information available in realtime across company boundaries



2

Fusion of virtual and real world

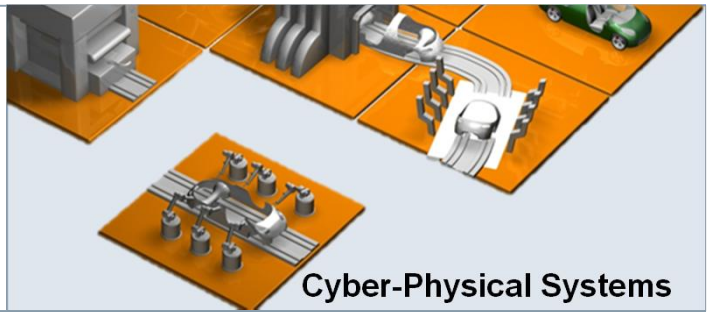
Integration of product design and production engineering for shorter time to market



3

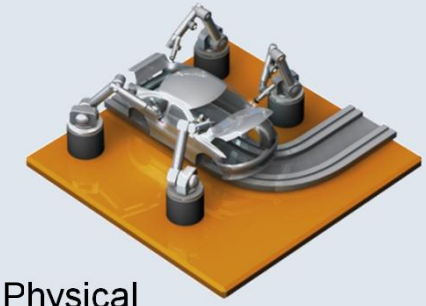
Cyber-physical systems

modulare, flexible production units with complete and consistent virtual model



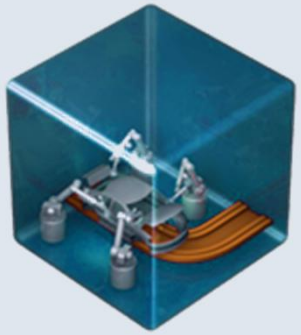
Key aspect 3:
Cyber-Physical-Systems (CPS)

Cyber Physical System (CPS)



Physical manufacturing equipment

+



Digital model

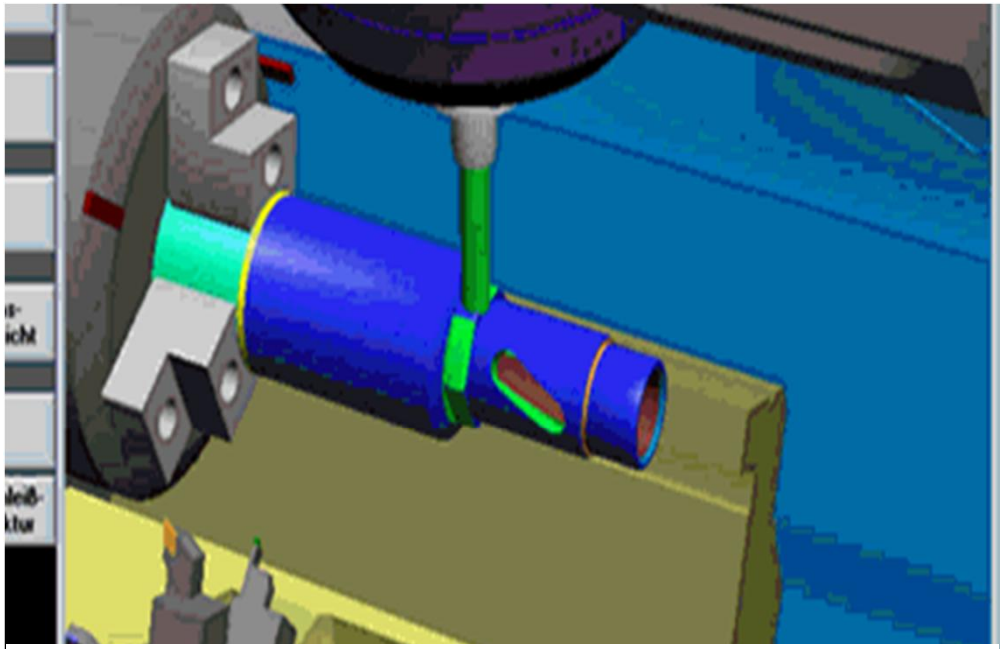
Contains all the information relating to…

- Software, informatics
- Mechanics
- Electrical, electronics
- Automation, HMI
- Safety, security
- Maintenance
- Site location, identity
- Status
- SW version
- Interfaces
- …

The digital model is always up-to-date and is extended throughout the entire life cycle

Product design → **Production planning** → **Production engineering** → **Production execution** → **Services**

"Virtual machine" – Increase in productivity through simulation of the manufacturing process



- Digital "twin"
- Simulated manufacture of a workpart
- Calculation of manufacturing times

10% increase in productivity during manufacturing and time savings of as much as 80% when installing and setting up the actual machine.

Key aspect 2:
Merging together the virtual and real manufacturing worlds thanks to our Digital Enterprise Platform

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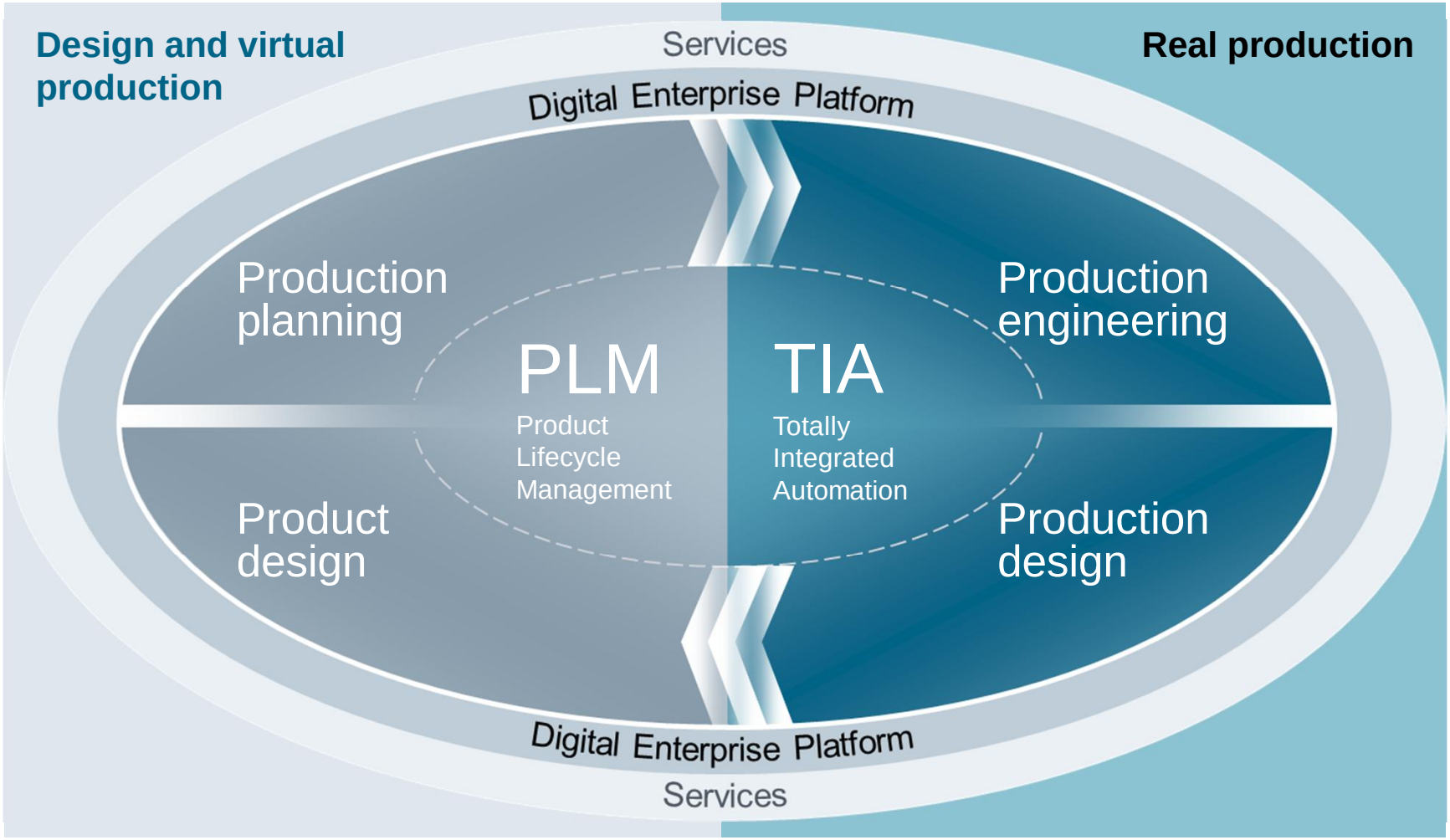

Key aspect 2: Integration of the product design and the manufacturing processes

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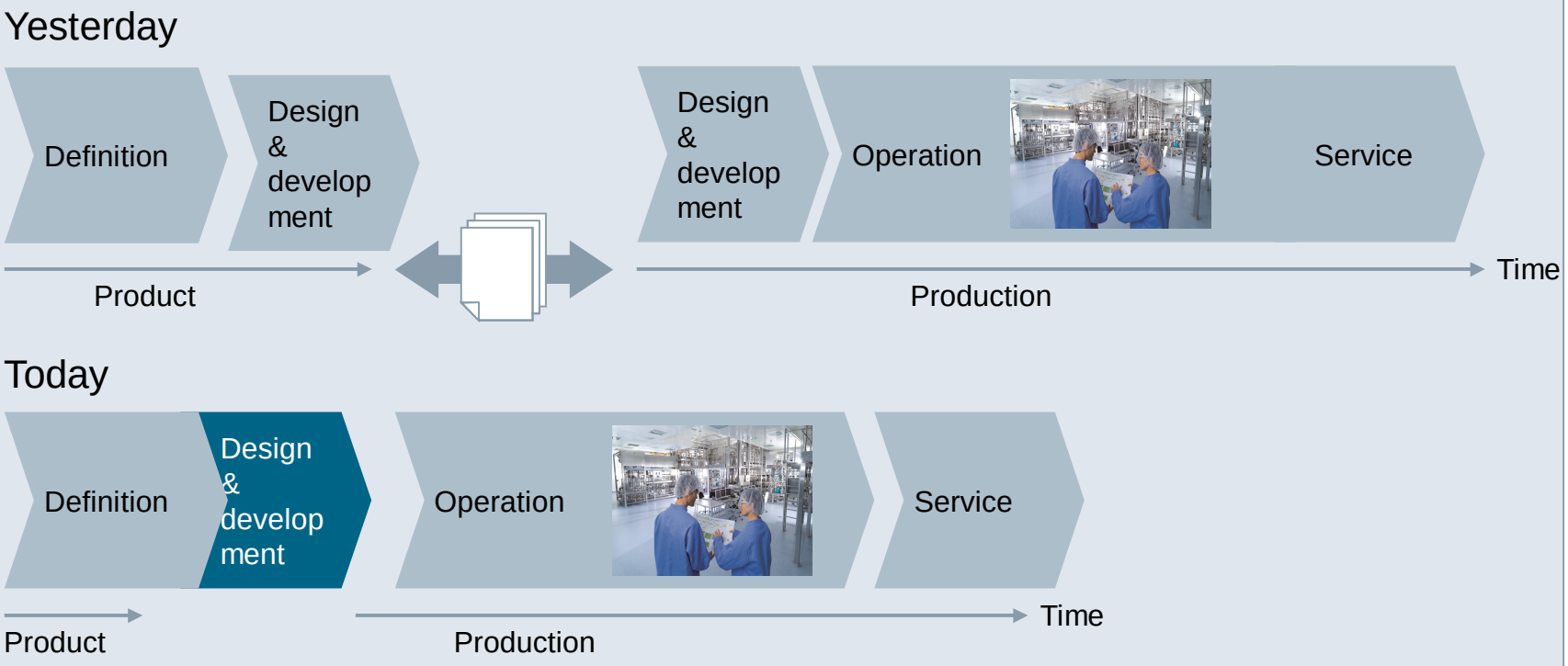
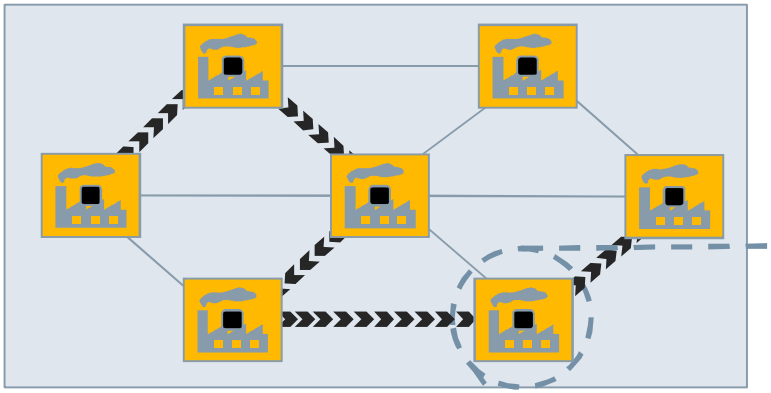
Example: Product design and manufacturing processes

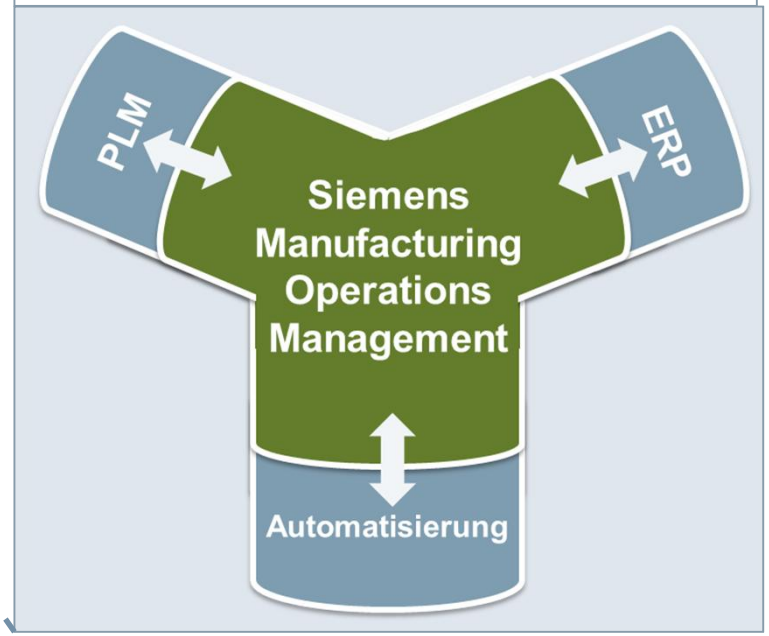


Raise efficiency, reduce time-to-market, increase flexibility

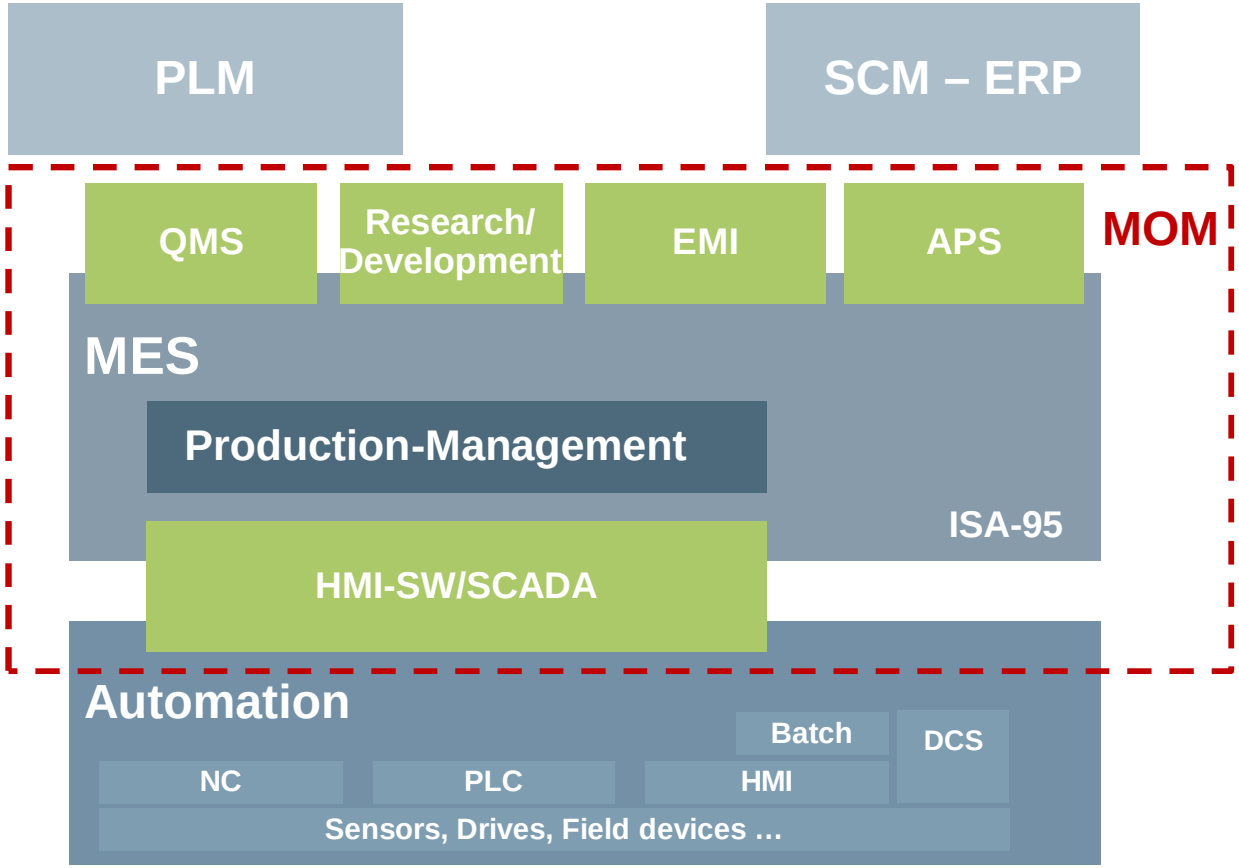
Key aspect 1:
Flexible production network based on
MOM (Manufacturing Operations Management)



Flexible value added chains with company wide available information on a real-time basis.



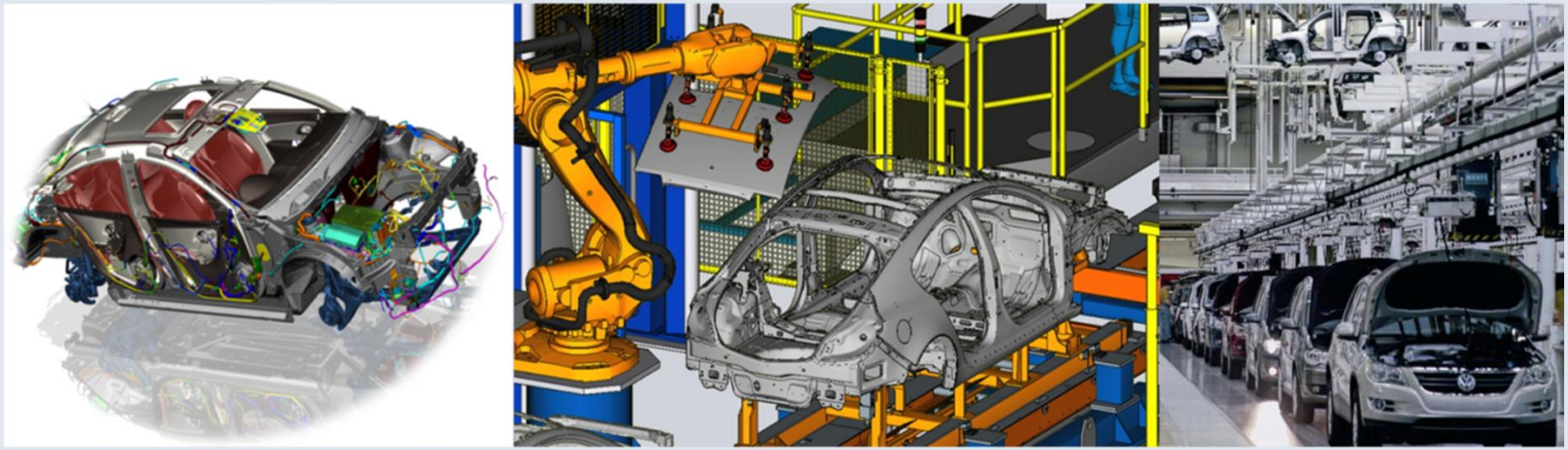
Siemens expands its portfolio to MOM (Manufacturing Operations Management)



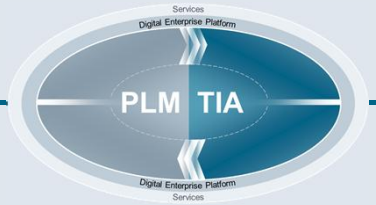
QMS: Quality Management System EMI: Enterprise Manufacturing Intelligence APS: Advanced Planning & Scheduling

Example: Manufacturing industry

Consistency throughout the entire value added chain



Product design → **Production planning** → **Production engineering** → **Production design** → **Services**

PLM software — 

— Totally Integrated Automation

Our automation offering
for the manufacturing industry

SIEMENS

Enterprise level

ERP PLM

Management level

MES

Operator level

SCADA

Control level

Field level

PLM

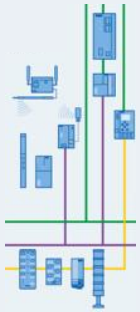
NX
Product Development

TEAMCENTER
Collaborative PDM

TECNOMATIX
Digital Manufacturing

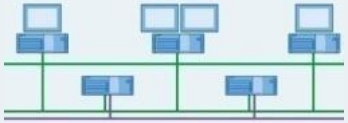
SIMATIC IT Production Suite

SIMATIC IT Intelligence Suite



SIMATIC NET
Industrial Communication

SIMATIC WinCC SCADA System



TIA PORTAL
Engineering Framework for Automation Tasks

SIMATIC
Controllers

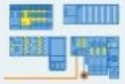
SIMATIC
HMI

SINUMERIK
CNC

SIMOTION
Motion Control

SIRIUS
Industrial Controls

SIMATIC IDENT
Industrial Identification



SIMATIC
Distributed I/O

SINAMICS
Drive Systems

Example: Process industry
Consistency throughout the entire plant lifecycle



Plant design → **Process planning** → **Plant engineering** → **Production** → **Services**

Plant engineering — PLM TIA — Totally Integrated Automation

Our automation offering
for the process industry

SIEMENS

Enterprise level

Integration with ERP Level

Management level

SIMATIC IT Intelligence Suite

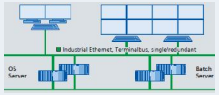
SIMATIC IT R&D Suite

SIMATIC IT Production Suite

COMOS Plant Engineering

Operator level

SIMIT Simulation



SIMATIC PCS 7 Operating System

SIMATIC PCS 7 Engineering

Control level

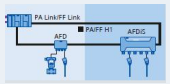
SIMATIC PCS 7 Controller

SIMATIC HMI

Field level

SIMATIC NET Industrial Communication

SIMATIC Distributed I/O



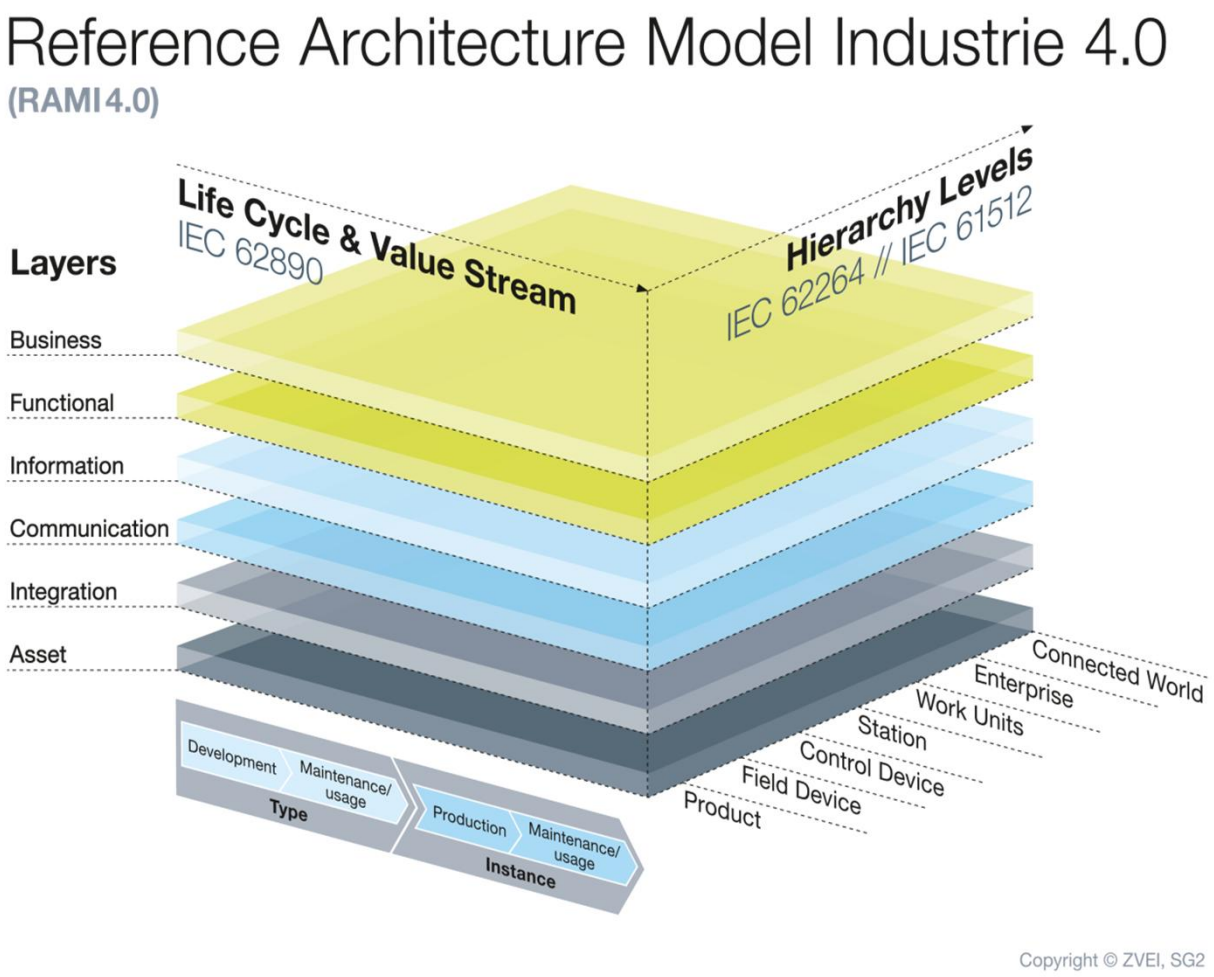
SIMATIC Field Bus

SITRANS/SIPART Instrumentation

SENTRON Power Control

SINAMICS Drive Systems

Reference Architecture Model Industrie 4.0 (RAMI4.0)



The Industrie 4.0 tour

Don't wait for Industrie 4.0, join the challenge now and help to shape it!