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Service-based architectures in production systems: Challenges, solutions and experiences

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Industrie 4.0

The fourth industrial revolution

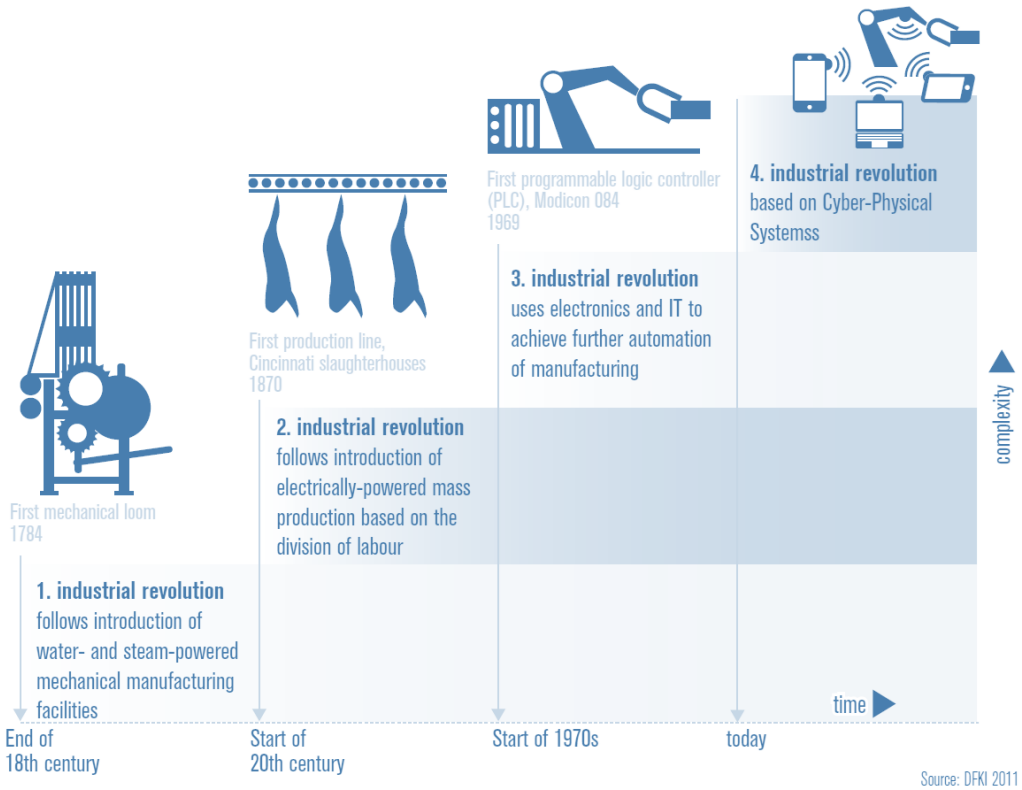
Previous industrial revolutions:

- Mechanical power
- Conveyor belt
- Automation / PLC controllers

Business models did not change

4th industrial revolution:

- End-to-end digitalization
- End-to-end connectivity
- **Efficient production** and **digital business models**



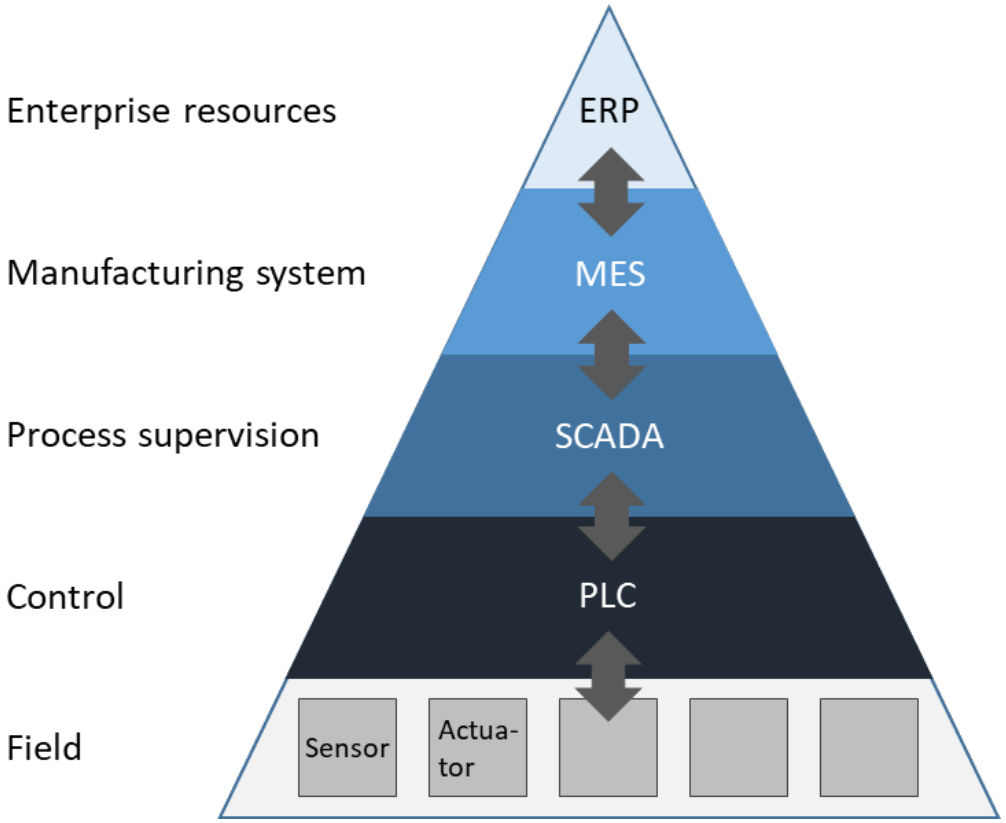
Automation Today

"Connectivity crisis"

We have already connectivity in production, but:

- Numerous protocols and technologies
- Tailored (i.e. not-standardized) data models
- Proprietary communication

Communication is organized as layers, which yield the automation pyramid

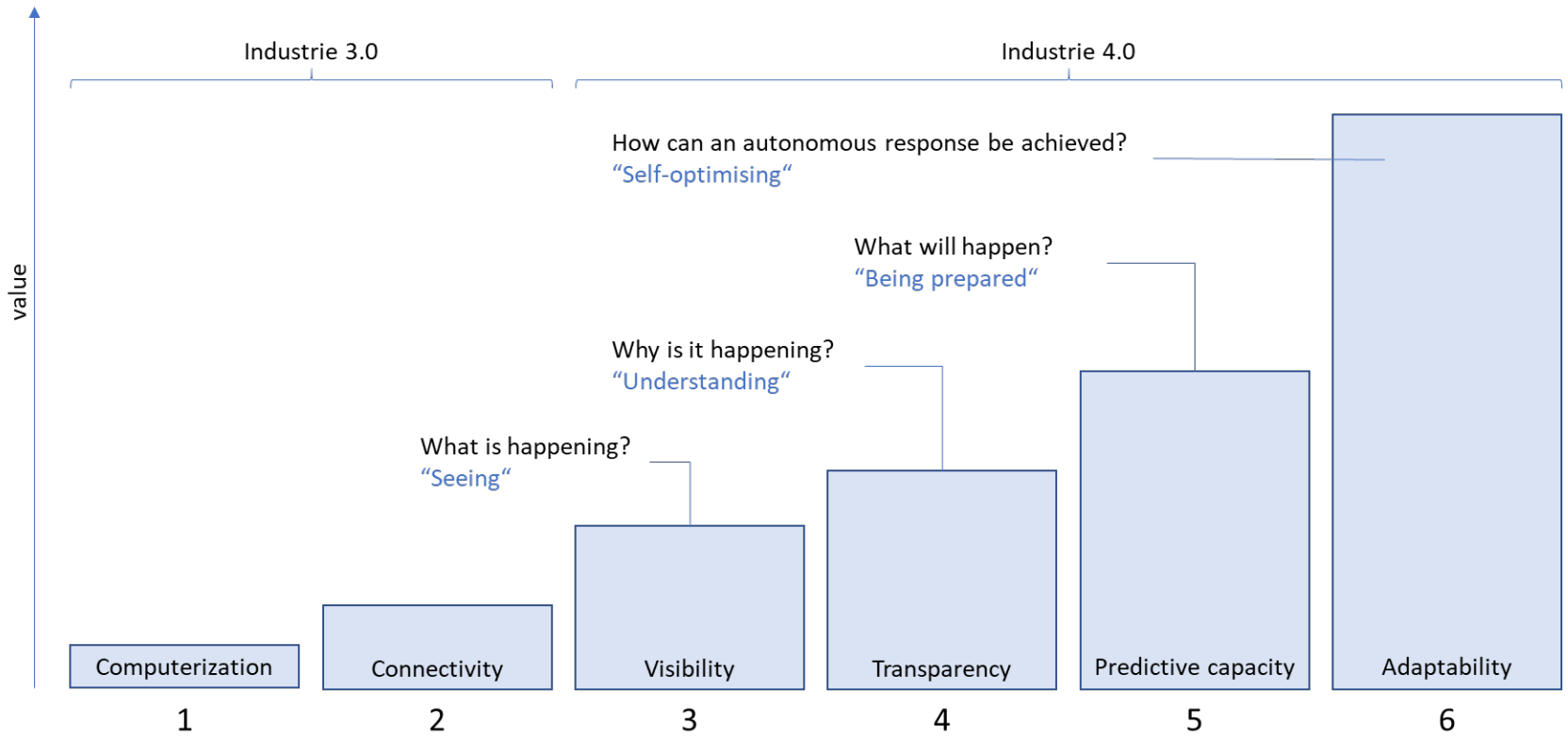


Levels of Digitalization
Maturity model

Self-optimizing production

- Rapidly change and adapt to
  - Market demands
  - Process changes
  - Product changes

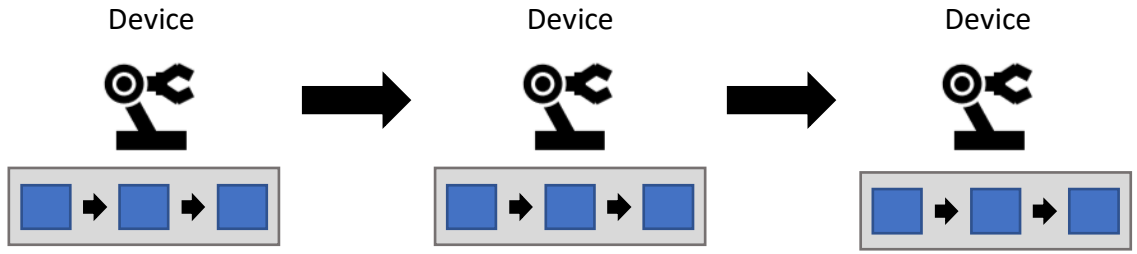
- Today, automation is a major limiting factor when changing a production



Service-Oriented Production
Today

Today: PLC controllers control production steps

- Totality of communicating PLC controllers yield production process
- No explicit process model, changes often cause unwanted side-effects
- This architecture limits changeability of production processes



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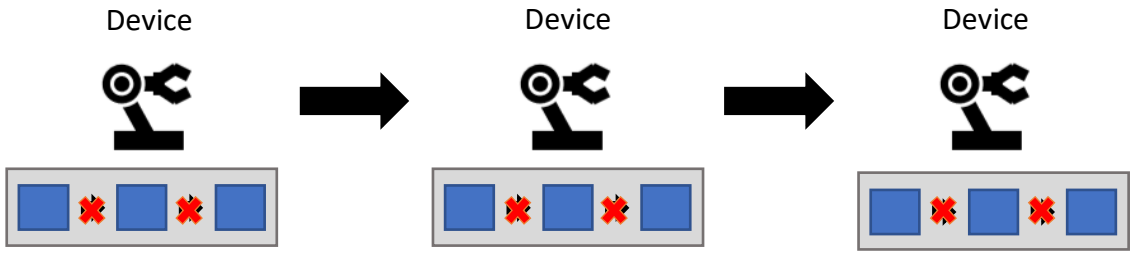
Service-Oriented Production
Tomorrow

Service-Oriented Architecture

- PLC controllers provide callable real-time services
- They do not implement complete process steps
- Service orchestration is performed by another component



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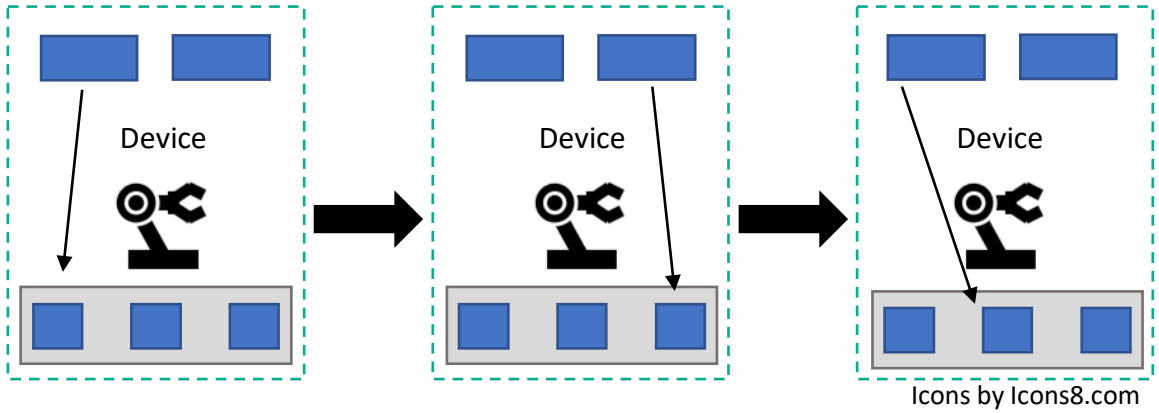
Service-Oriented Production
Service Interfaces

Devices provide defined service interfaces

- Callable
- No context knowledge

Separation between service implementation and service invocation

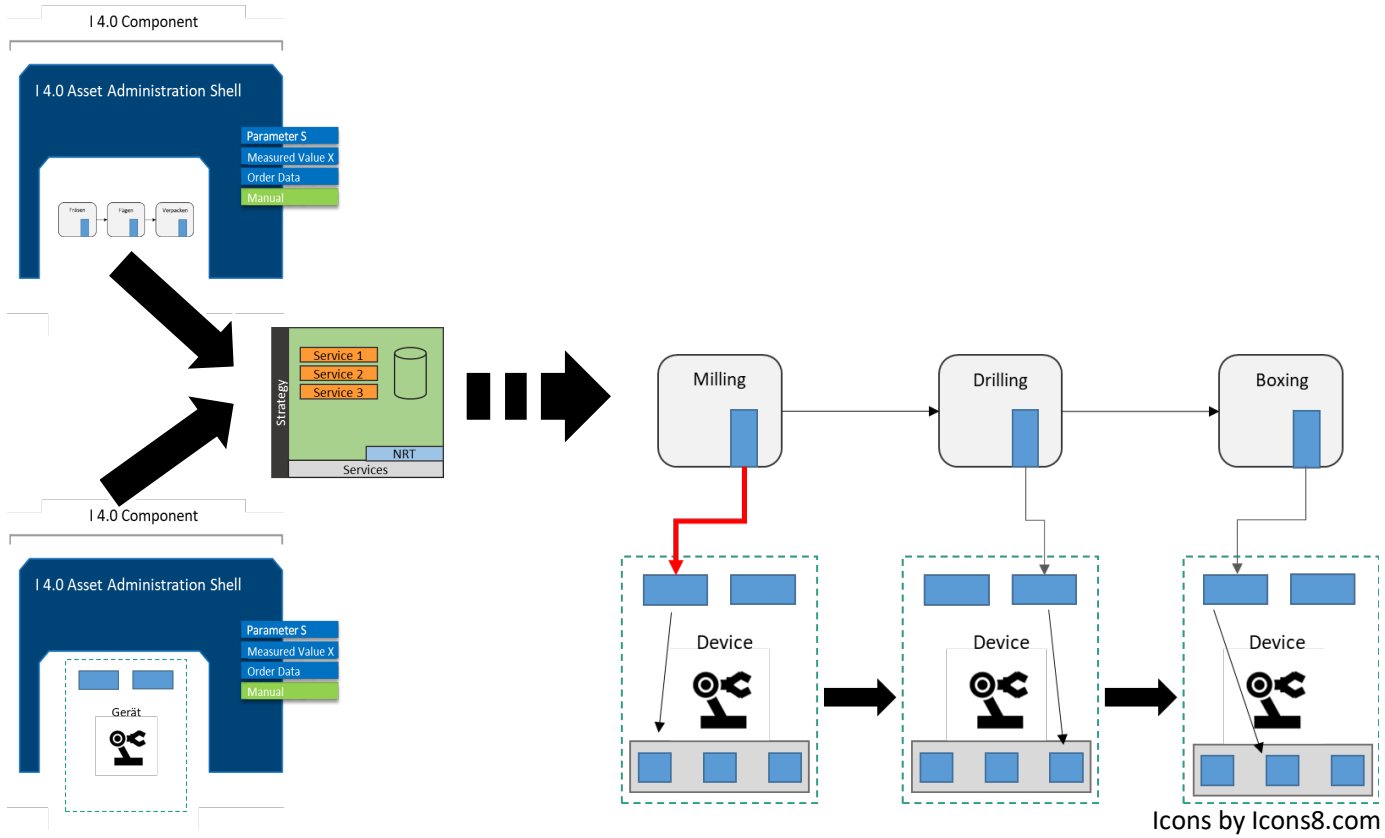
- Orchestrator knows about “which” services
- Has no details regarding implementation



Service-Oriented Production
Orchestration

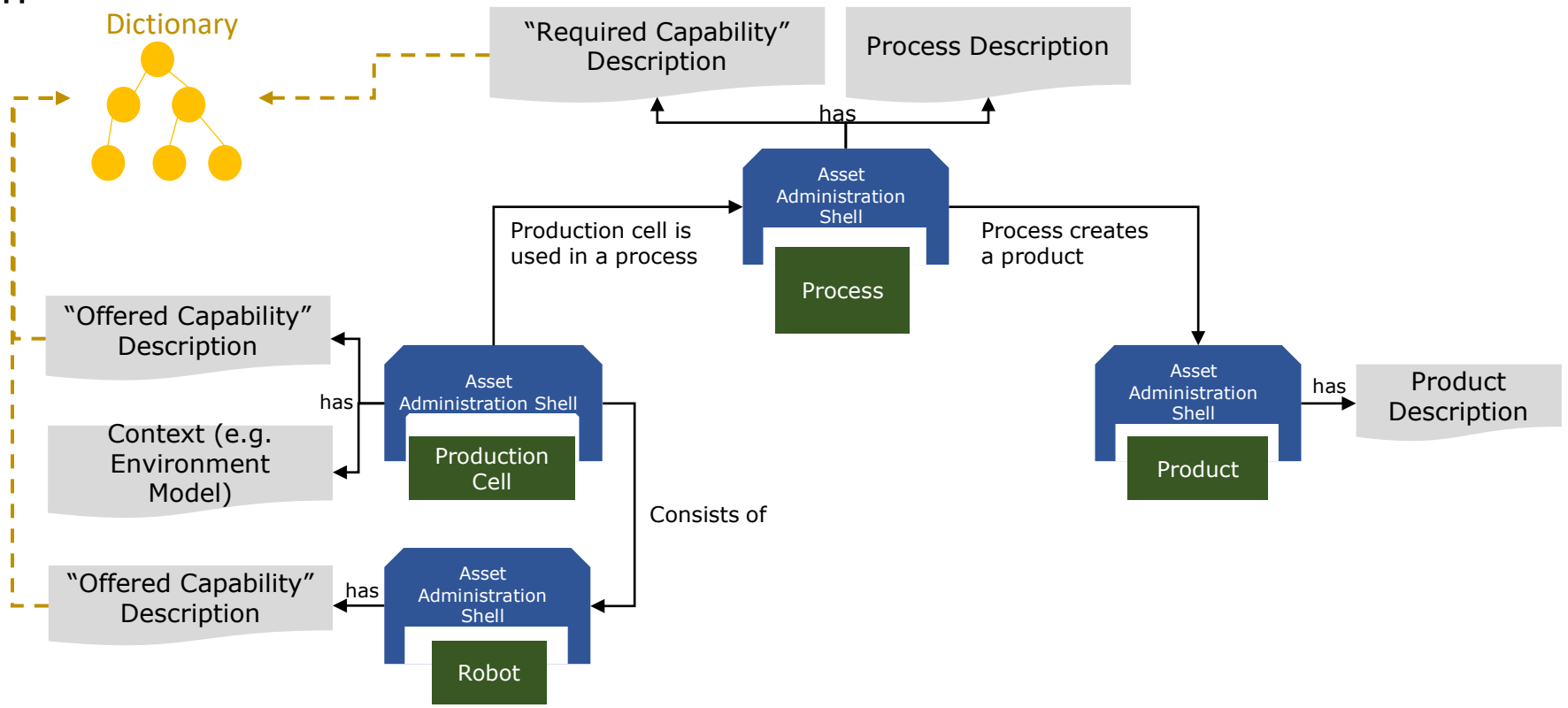
Service orchestration determines plan based on:

- Required production steps from product Asset Administration Shell
- Possible production steps from manufacturing line Asset Administration Shell
- Only the orchestrator knows when which production step will be executed
- But: How to describe required and provided manufacturing steps?



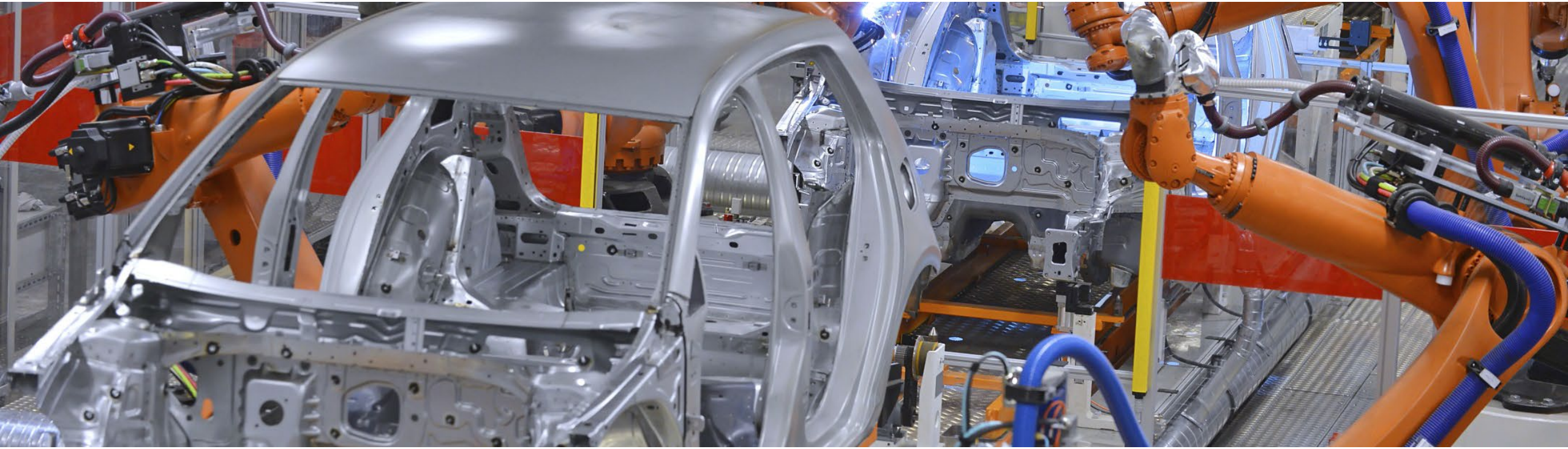
Service-Oriented Production
Capabilities

- Capability models describe required and offered production steps
- These descriptions are never fully complete
  - E.g. “can we drill a hole into metal plates or cheese?”
- They are valid only within a single domain
  - E.g. “Will this software always work?”
  - Testing and human assessment of recepies



Examples

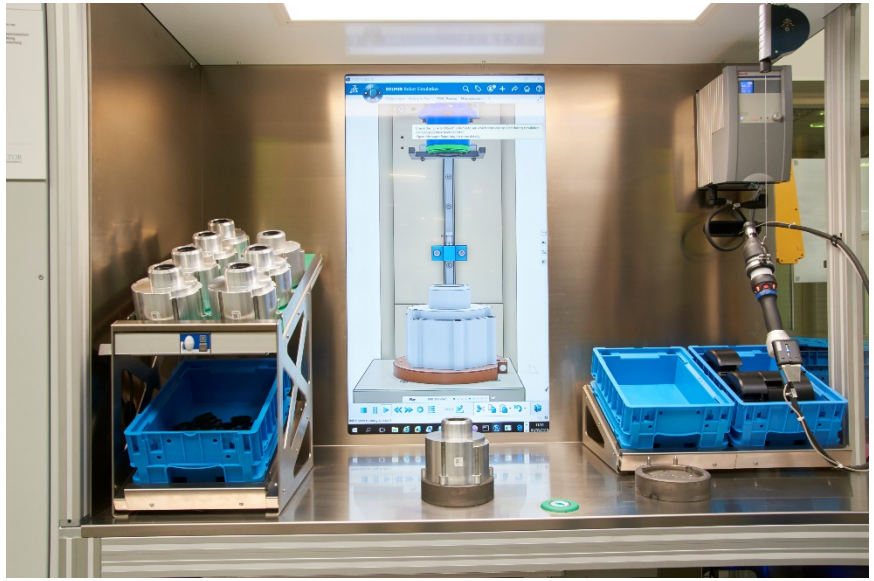
Service-Oriented Production Deployments



Service-Oriented Production

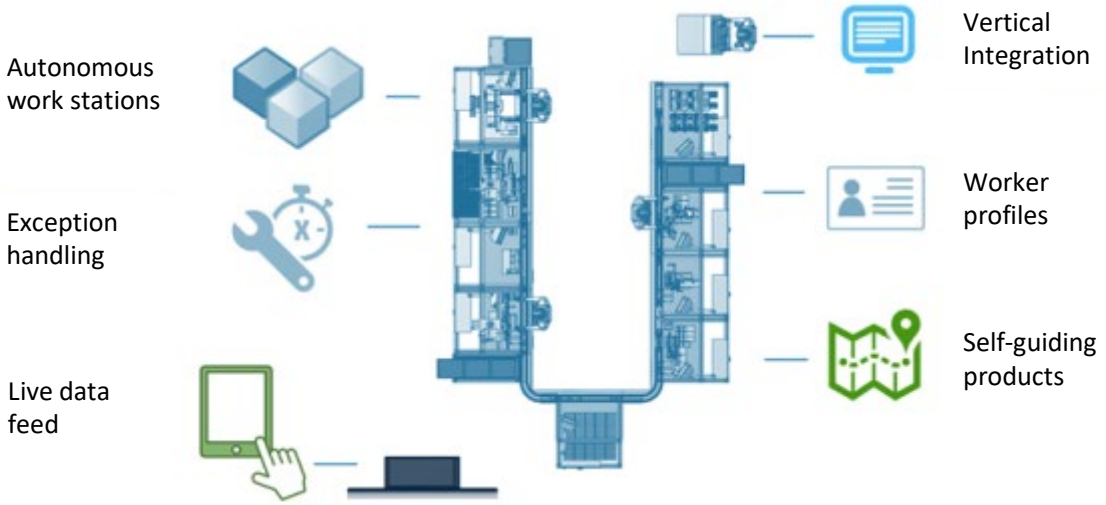
Manual Assembly Station

- Service-Based manual assembly station
- Equipped with state-of-the art control technology
- Receives orders from MES system
- Integrated new NEXO Screwdriver station within 15 minutes into BaSys Service-Oriented Architecture



Service-Oriented Production
Dynamic Task Scheduling

- Dynamic job scheduling for manufacturing line greatly improves throughput
- Scheduling is based on worker skills and predicted job completion times
- Asynchronous job scheduling without fixed cycle times
- Product tracking and exception handling
- Dynamic briefing of workers based on profiles
- Live data feeds provide overview on manufacturing at all times



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Thank you!