

# Industry 4.0: Software Hierarchy

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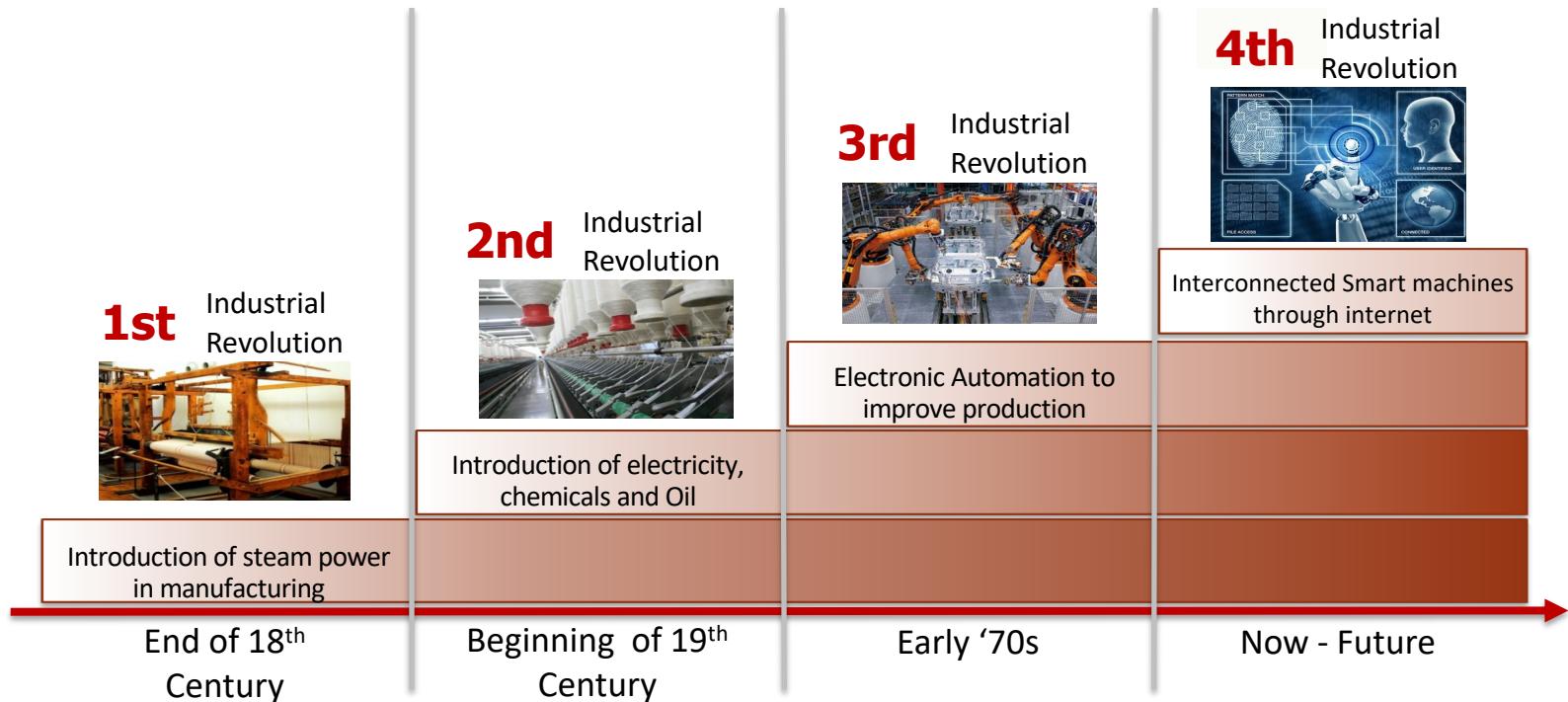
# Agenda

- Industrial Revolution
- The 4 industrial Revolutions
- Industry 4.0 Introduction
- Why Industry 4.0
- Software Hierarchy
- Six Design Principles
- Enabling technologies

# Industrial Revolutions

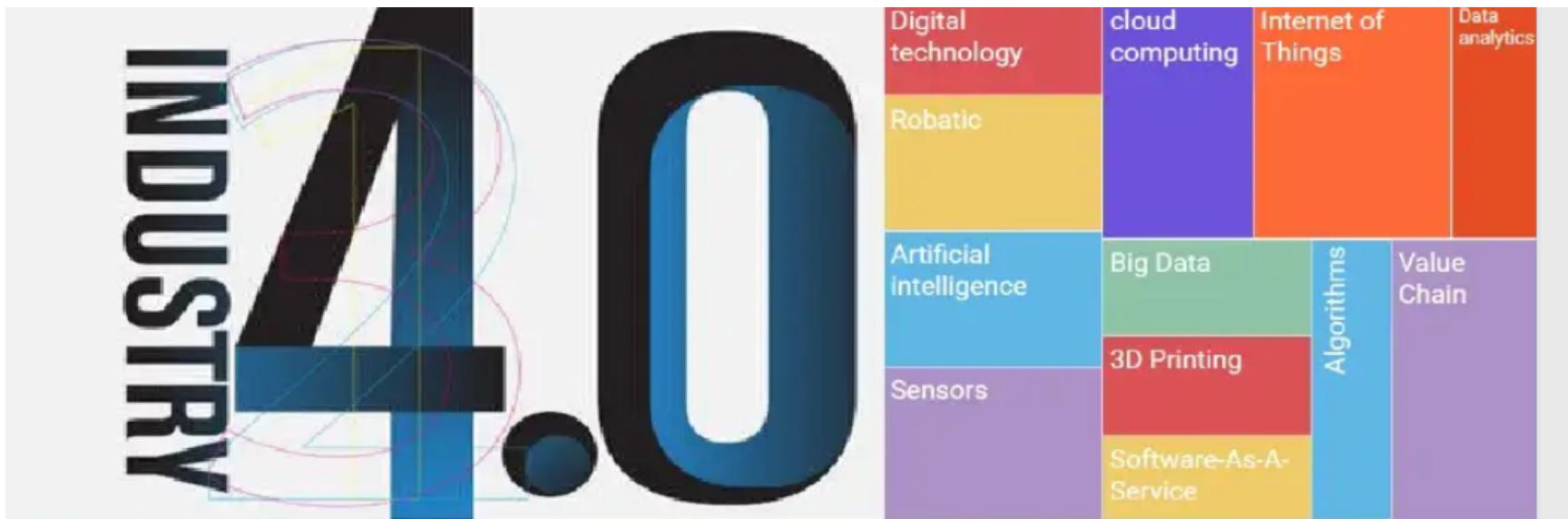
- The industrial revolution was a fundamental change in the way goods were produced ,from human labor to machines
- The more efficient means of production and subsequent higher level of production triggered far reaching changes to industrialized societies
- Phases of earlier 3 Industrial Revolutions:
  1. 1760 to 1840 - Ushered in Mechanical production; railways and steam engine
  2. 1870 to 1940 - Mass production; electricity and assembly line
  3. 1960 to 2010 - Computers; semi conductors, main frame computing, personal devices, internet

# The Fourth Industrial Revolutions



# Industry 4.0 Introduction

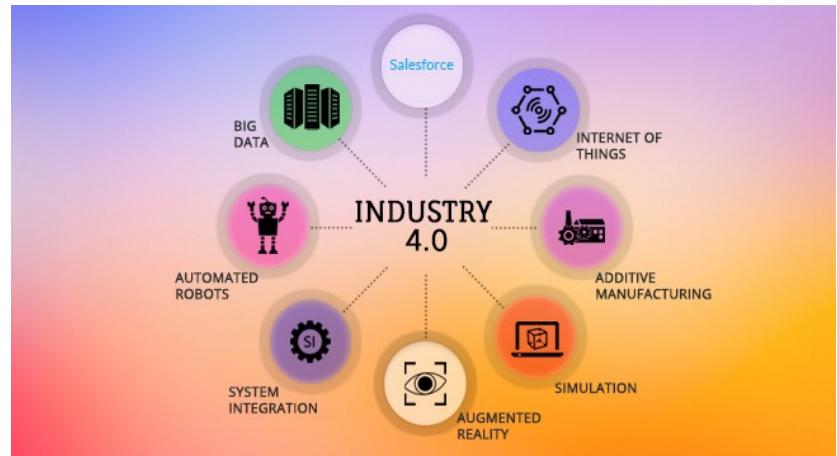
- The term Industry 4.0 refers to the combination of several major innovations in digital technology, all coming to maturity right now, all poised to transform the energy and manufacturing sectors.



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These technologies include

- Advanced Robotics
- Artificial Intelligence
- Sophisticated Sensors
- Cloud Computing
- Internet Of Things
- Data Capture And Analytics;
- Digital Fabrication (Including 3D Printing)
- Software As A Service
- And Other New Marketing Models, Smartphones And Other Mobile Devices



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- Platforms that use algorithms to direct motor vehicles (including navigation tools, ride sharing apps, delivery and ride services, and autonomous vehicles ) and the embedding of all these elements in an interoperable global value chain, shared by many companies from many countries.

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# What is Industry 4.0?(Another Definition)

A collective term for technologies and concepts of value chain organization.

Cyber-Physical Systems (**CPS**)

Internet **of T**hings (**IoT**)

Internet **of S**ervices (**IoS**)



Industry 4.0

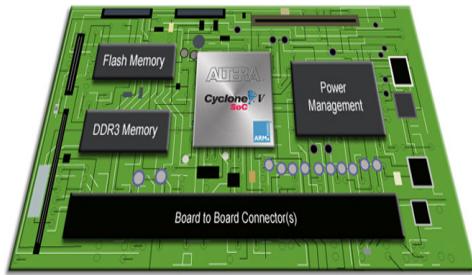
it facilitates the vision of the **Smart Factory**

*“Zukunftsprojekt Industrie 4.0” – Germany, April 2011*

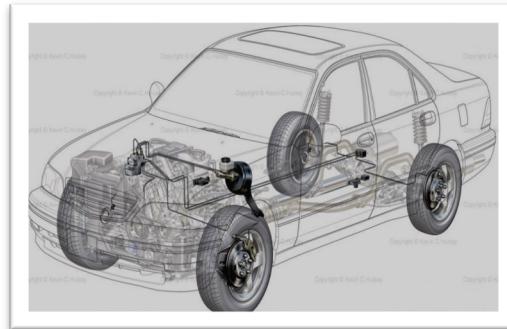
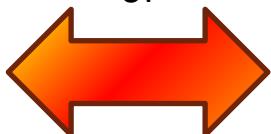
*“Made in China 2025” – China, May 2015*

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What are CPS? *Cyber-physical Production Systems*



Integration of



**Cyber System**

**Physical System**

**CPS** are an Integration of **Computation** and **Physical** processes

Behavior defined by both **Cyber** and **Physical** parts

**CPPS** are an Integration of **Computation** and **Physical** processes in a **Production** system

# Smart Factory

Within the modular structured **Smart Factories** of Industry 4.0, **cyber-physical systems** monitor physical processes, create **a virtual copy** of the physical world and make decentralized decisions.

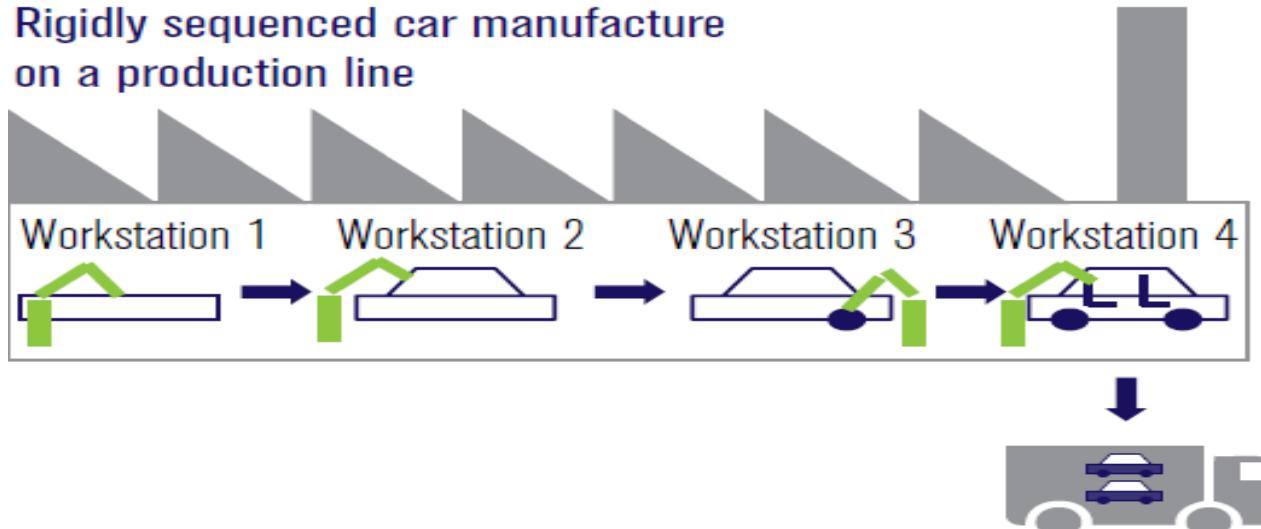
Over the **Internet of Things**, **Cyber-physical systems** communicate & cooperate with each other & humans in real time.

Via the **Internet of Services**, both internal & cross-organizational services are offered & utilized by participants of the value chain.

- Builds on the Digital revolution
- Smaller & powerful sensors
- Machine Learning
- Ubiquitous internet
- Artificial Intelligence (AI)
- Labor & Energy Cost

# Today's Factory

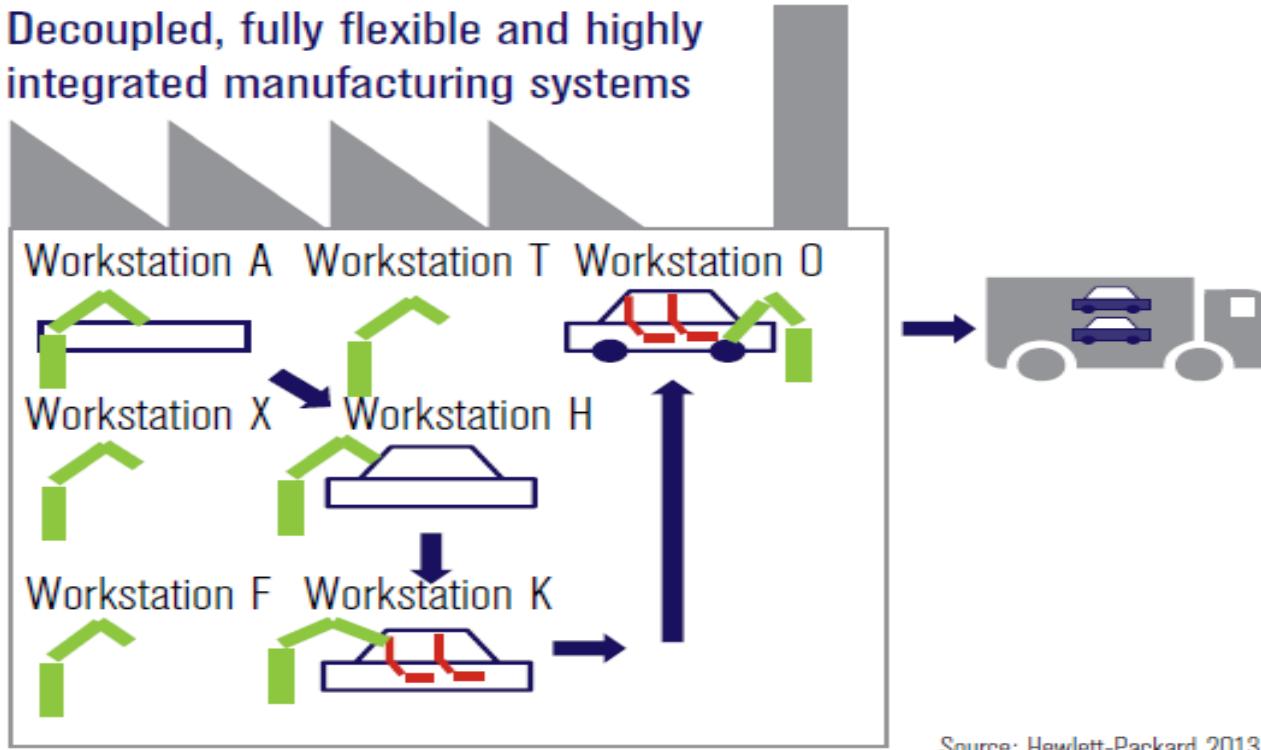
Rigidly sequenced car manufacture  
on a production line



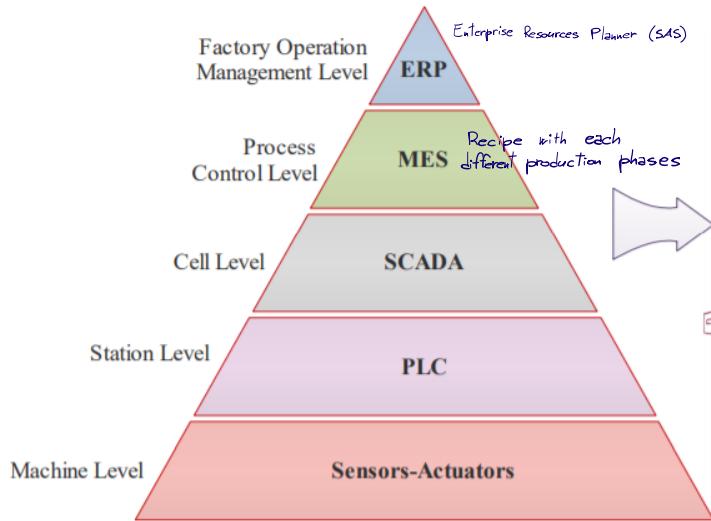
Source: Hewlett-Packard 2013

# Tomorrow's Factory

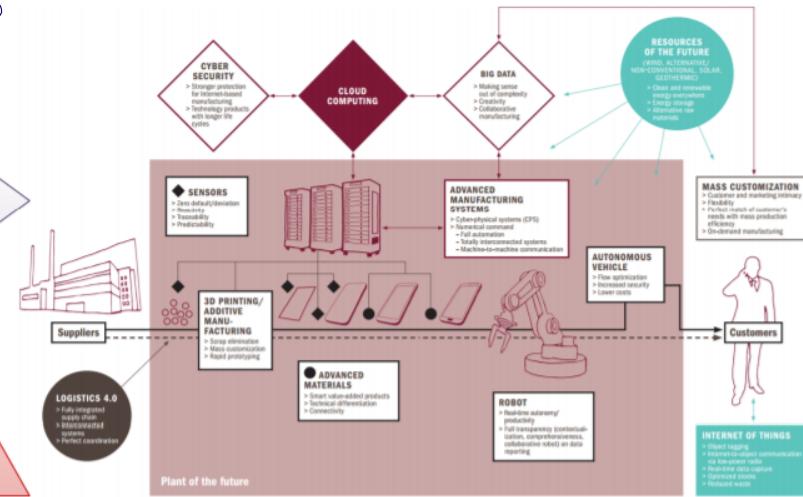
Decoupled, fully flexible and highly integrated manufacturing systems



# Software Hierarchy

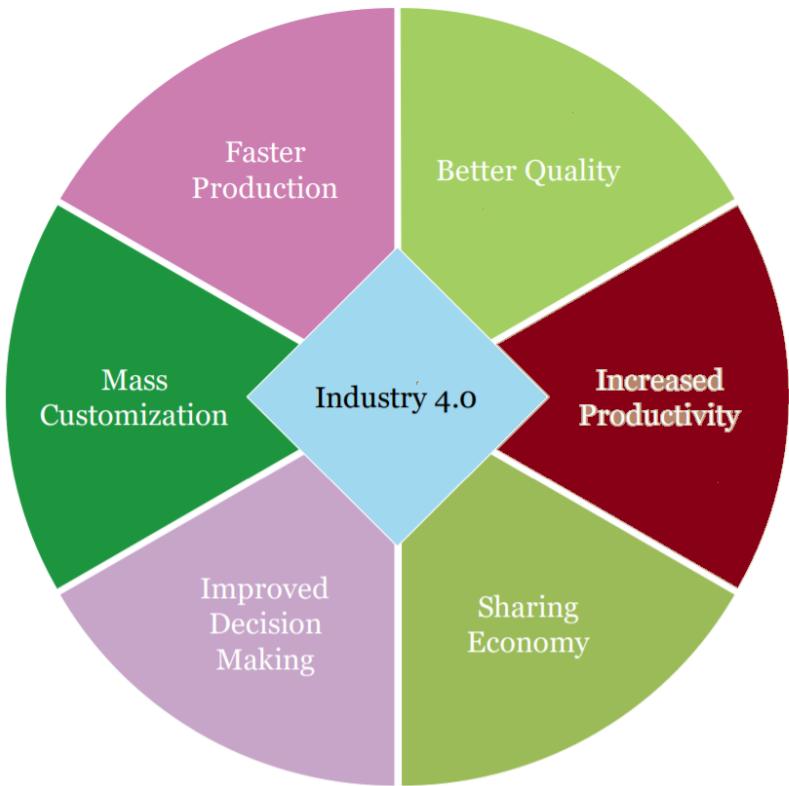


**Classical 5-Layer Automation Architecture**



**Emerging Cyber Physical System-based Automation**

# Why Industry 4.0



# Industry 4.0 Examples - 1

- German toolmaker **Trumpf**
  - an Industry 4.0 supplier and worldwide market leader of laser systems
    - has put the first "social machines" to work
  - Each component is "smart" and knows what work has already been carried out on it
    - Because the production facility already knows its capacity utilization and communicates with other facilities, production options are automatically optimized.

*These machines can interact with other ones*  
*↗*

## Industry 4.0 Examples - 2

- German manufacturing giant Siemens
  - an industrial user, is implementing an Industry 4.0 solution in medical engineering
  - For years, artificial knee and hip joints were standardized products, with engineers needing several days to customize them for patients
    - Now, new software and steering solutions enable Siemens to produce an implant within 3 to 4 hours

# Industry 4.0: Six Design Principles

- **Interoperability**: the ability of cyber-physical systems (i.e. work assembly stations), humans and Smart Factories to connect and communicate with each other via the Internet of Things and the Internet of Services
- **Virtualization**: a virtual copy of the Smart Factory which is created by linking sensor data (from monitoring physical processes) with virtual plant models and simulation models
- **Decentralization**: the ability of cyber-physical systems within Smart Factories to make decisions on their own
- **Real-Time Capability**: the capability to collect and analyze data and provide the insights immediately
- **Service Orientation**: offering of services (of cyber-physical systems, humans and Smart Factories) via the Internet of Services ⇒ Not only simple bits, but complete activities
- **Modularity**: flexible adaptation of Smart Factories for changing requirements of individual modules

# Top 10 Skills to be relevant in Industry 4.0

- Complex Problem Solving
- Critical Thinking
- Creativity
- People Management
- Coordinating With Others
- Emotional Intelligence
- Judgment And Decision Making
- Service Orientation
- Negotiation
- Cognitive Flexibility (Thinking About Multiple Concepts Simultaneously)

# Key Enabling Technologies

