Logistics 4.0 – The impact of IoT and Big Data on the industry

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Düsseldorf, Germany

IfU IMA ZLW RWTH AACHEN UNIVERSITY

Outline

I. Industry 4.0 – Definition and Context

- Definition
- Genesis and Foundations
- Key Technologies and Design Principles

II. Logistics 4.0 – Examples from Research and Development

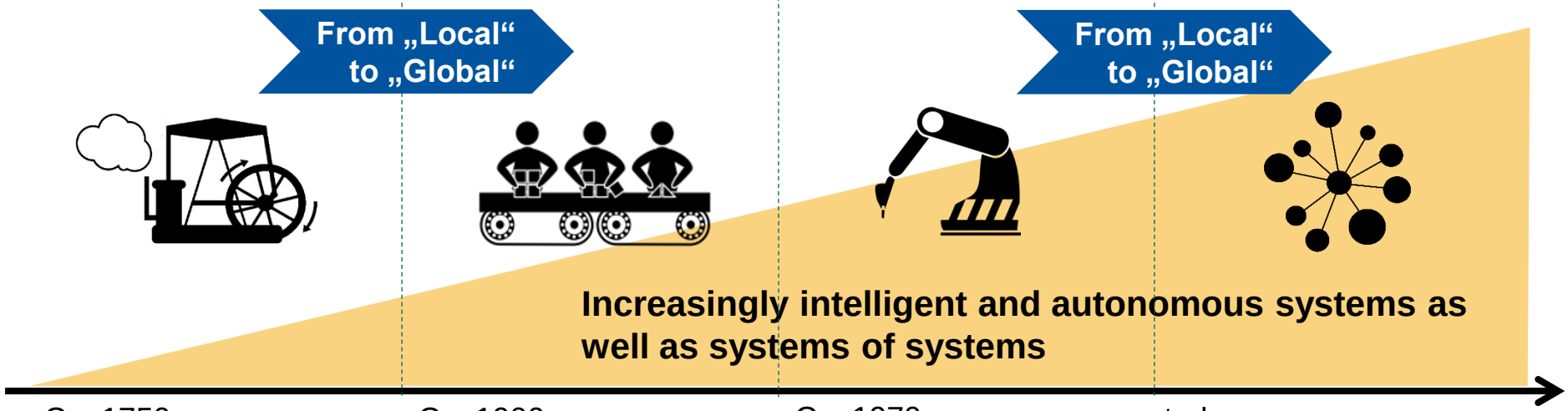
- Interconnection
- Information Transparency
- Decentralized Decisions
- Technical Assistance

III. Future Development

- Interconnection Across System Boundaries
- Changes in Commodity Flows through new Production Processes
- Decentralized Decision in (semi-)automated Systems

The 4th Industrial Revolution

1st Industrial Revolution	2nd Industrial Revolution	Digital Revolution	Industry 4.0
– Mechanization of manual labor through the of water and steam power – Transition from the agricultural to the industrial society	– Extensive electrification – Development of the communication infrastructure – Mass production and division of labor	– Digitalization – Information and communication technology – Increasingly intelligent systems	– Internet of Things & Cyber-Physical-Systems – Systems of Systems – Decentralized decisions – (Semi-)Autonomous Systems



Definition

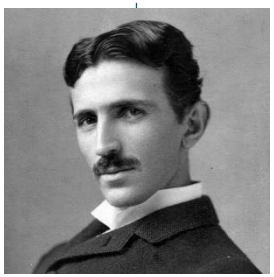
- The foundations of Industry 4.0 are…
  - …the **real-time availability of all relevant information**
  - …the **networking of all entities involved in the value chain**
  - …the **ability to derive the optimal value stream from data at any time**

- Emergence of **dynamic, real-time optimized and self organized cross-company value networks** through the **networking of people, objects and systems.**

- Lenkungskreis I40

Genesis and Foundations – Teleautomation

"When wireless is perfectly applied **the whole earth will be converted into a huge brain**, which in fact it is, […] and **the instruments through which we shall be able to do this will be amazingly simple** compared with our present telephone. **A man will be able to carry one in his vest pocket**." – *Nikola Tesla „Teleautomation"*

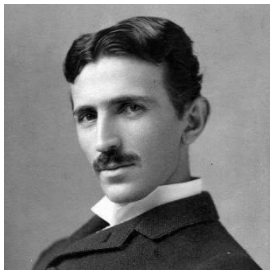


Nikola Tesla

1926

Genesis and Foundations – Ubiquitous Computing

"Most of the computers that participate in **embodied virtuality** will be invisible in fact as well as in metaphor. Already computers in light switches, thermostats, stereos and ovens help to activate the world**. These machines and more will be interconnected in a ubiquitous network.** " – Mark Weiser "Ubiquitous Computing"



Nikola Tesla

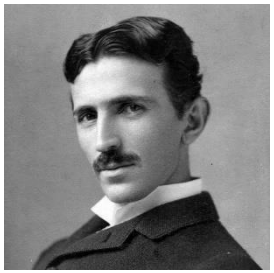
1926

Mark Weiser

1991

Genesis and Foundations – Internet der Dinge

"We're physical, and so is our environment. **Our economy, society and survival aren't based on ideas or information—they're based on things.** You can't eat bits, burn them to stay warm or put them in your gas tank. **Ideas and information are important, but things matter much more.** Yet **today's information technology is so dependent on data originated by people** that our computers know more about ideas than things." – *Kevin Ashton*



Nikola Tesla

1926

Mark Weiser

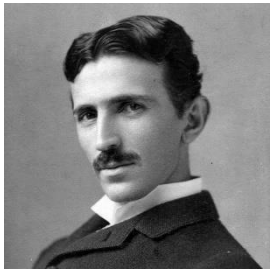
1991

Kevin Ashton

1999

Genesis and Foundations – Cyber-Physical-Systems

"Cyber-physical systems are **physical, biological, and engineered systems** whose operations are **integrated, monitored, and/or controlled by a computational core**. Components are networked at every scale. **Computing is `deeply embedded´ into every physical component**, possibly even into materials. The computational core is an **embedded system**, usually **demands real-time response**, and is most often **distributed**. The behavior of a cyber-physical system is a **fully-integrated hybridization of computational (logical) and physical action**. " - *Helen Gill*



Nikola Tesla

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Helen Gill

2006

Industry 4.0
Design Principles

Interconnection	Information transparency	Decentralized decisions	Technical assistance
▪ Vertical and horizontal networking of everything with everything ▪ New services and business models	▪ Continuous flow of information ▪ Virtualization ▪ Context sensitivity ▪ Big Data analytics	▪ Artificial Intelligence ▪ Learning systems ▪ Multi-agent systems	▪ Decision assistance and physical support ▪ Semi-autonomous systems

Based on: Hermann et al. 2016

Short-term

- Data driven
- Networking of processes and actors

Medium-term

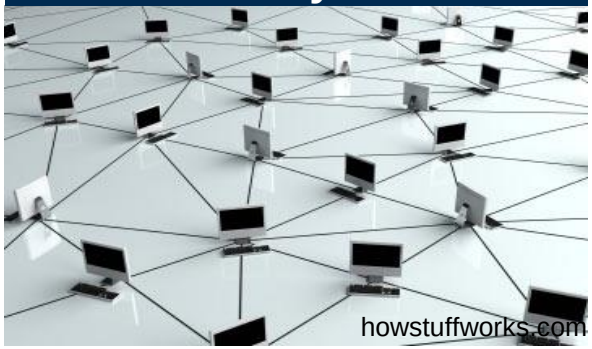
- Decentralization
- Autonomous systems
- Self-organizing systems of systems

Industry 4.0
Key technologies

Communication Networks

postscapes.com

Distributed Systems


howstuffworks.com

Embedded Systems

www.siemens.com

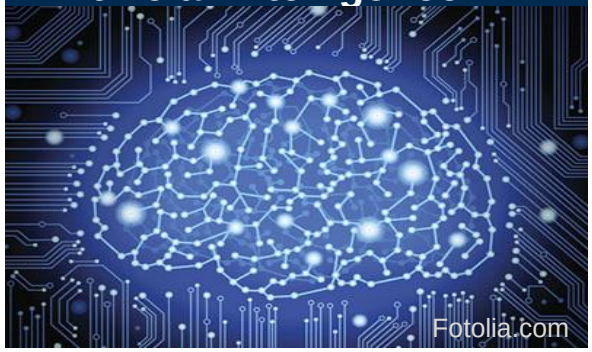
Big Data Analytics


Fotolia.com

Semantic Technologies

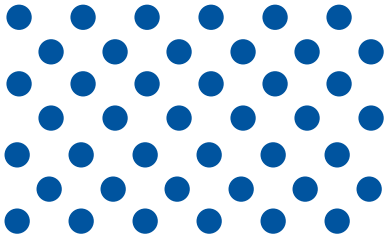
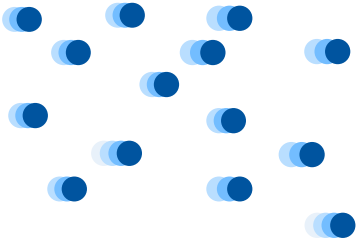
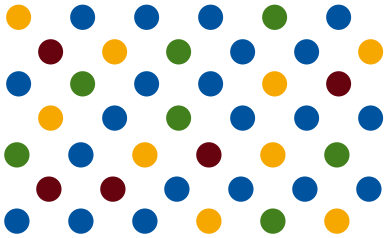

shutterstock.com

Artificial Intelligence


Fotolia.com

Big Data

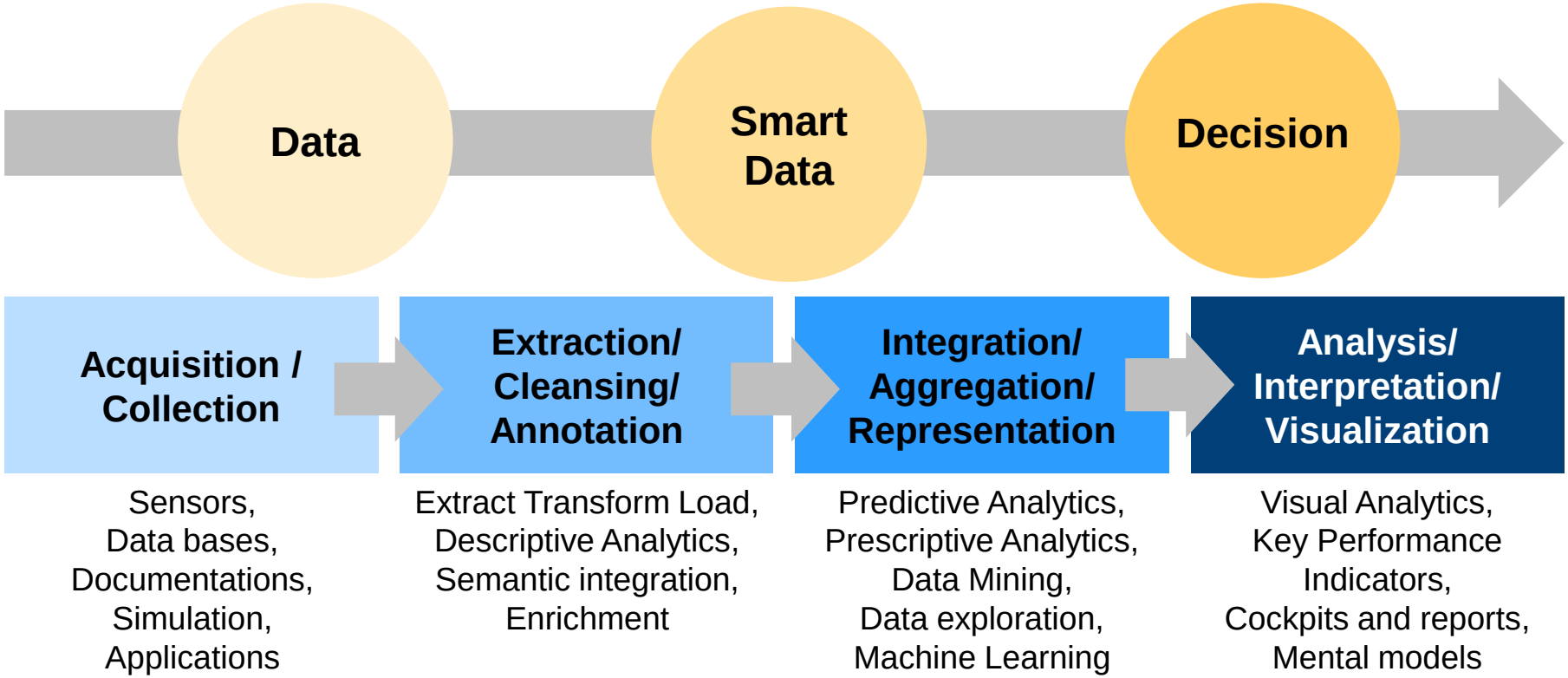
- **“Information is the oil of the 21st century, and analytics is the combustion engine”** – Peter Sondergaard, Gartner
- Big Data describes data sets that cannot adequately be processed with traditional data processing methods
- The four V´s of Big Data:

Volume	Velocity	Variety	Veracity
			
The volume of available data increases daily	Processing time is critical for many applications	Different forms, degree of organization, formats etc.	Inconsistencies, incompleteness, ambiguity

Based on: www.datasciencecentral.com

From Big Data to Decision

- **“At the end of the day, it's not about how much data you have, it's about how well you use it.”** – Tjeerd Brenninkmeijer, CMSWire



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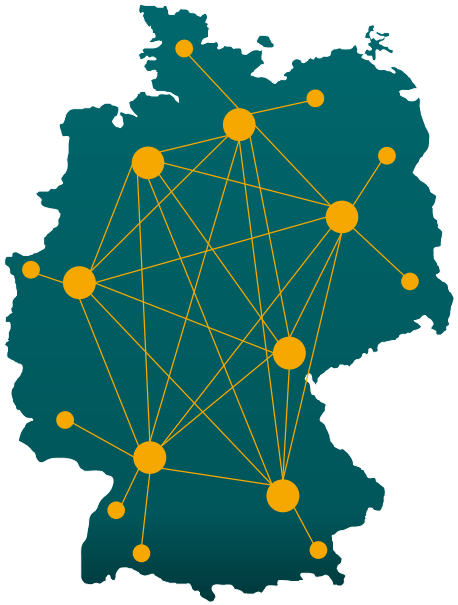
Cross-company networking and cooperation

- **Intelligent logistics management and networking** of heterogeneous actors **through cross-company cooperation platforms**
- **Optimization of local and global resources** (capacity utilization, CO_2-emissions, overall utilization of transport network etc.)
- **Decision support** for the selection of cooperation partners, routes etc.

- Example: **Part Load Alliance** (www.partload.com) offers **freight cooperation** for part load transports



Interconnection of Transport Modes

Project TelliSys (2012 – 2015)

Decentralized decisions in Transport

- **Highly automated, autonomous and cooperative driving** are a hot topic for all transport modes
- **Decentralized decision and control** on different levels
- „**European Truck Platoon Challenge**“
- "I reckon that we will be able to drive fully automatically in large parts of our rail network in 2021, 2022 or 2023” - Rüdiger Grube (FAZ, 2016)

KONVOI (2005 – 2010)

- This will not only change the working place of drivers but the whole transport system. **New actors, services and business models will drastically change the existing market.**

Decentralized Decisions in Intralogistics

RoboCup Logistics League 2016

Technical Assistance through Context-Sensitive User Interfaces

- **Natural User Interfaces (NUI)** are the next evolution step in Human-Machine-Interaction
- **“**Computers that will interact naturally and intelligently with humans **need the ability to at least recognize and express affect.”**
  - Rosalind Picard (MIT)
- Example: The project **IMOTION (2014 – 2015)** developed a system that is capable to **detect human emotions in spoken language**
- With the **analysis of additional vital signs**, the results can be further improved

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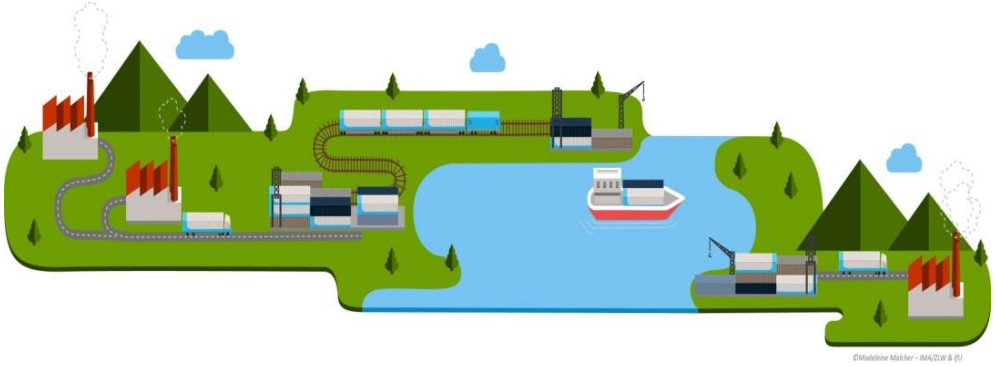
Cross-system interconnection

- **Seamless information flow and interconnection across the complete value chain**
- The **complete vertical und horizontal integration of all systems, processes, devices and people** offers a higher flexibility and the potential for a better **prediction of needs, prevention of bottlenecks and the real-time optimization of resources**
- In addition to potentials for **local optimization (**e.g. freight forwarders, shippers, terminal operators…) **new potentials can be exploited on global optimization level** (e.g. traffic management, synchromodal transport…)



Changes in Commodity Flows through new Production Processes

- **Additive manufacturing** becomes more important in the context of the increasing individualization of products
- In addition to **rapid prototyping** and the **manufacturing of small quantities** additive manufacturing is applied in the **local manufacturing of spare parts**
- **Additional applications and materials will develop** with the increasing maturity of AM
- The increased use of AM will **change existing commodity flows** and lead to the **emergence of new business models**

Decentralized Decision in (semi-)automated Systems

- Driven by the increasing automation and Big Data, **decentralized, learning systems** emerge along the value chain
- This not only offers **new opportunities** but also presents **new challenges:**
  - **Reduced predictability and transparency of the system behavior** through decentralized decision and action
  - **Anticipation of decisions and actions** of highly automated systems
  - **Trust** in all actors (human and machine) is a **key requirement for distributed responsibility**
- To meet these challenges a **paradigm shift and learning process** involving all stakeholders is required

Summary

- Logistics and transport are going to change on all levels in the context of a 4th industrial revolution:
  - **Interconnection of everything with everything in real-time**
  - **Context and user sensitive system using semantic technologies**
  - **Distributed artificial intelligent systems of systems**
  - **Automated systems**

- In addition to the development and adoption of new technologies, **organizational and social change are the key challenges** in a rapidly changing market:
  - **New, data driven services and business models**
  - **Formation of new cross-company networks**
  - **Emergence of new stakeholders**

Thank you for your kind attention!

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