»Quo Vadis Logistik 4.0«
Data Platforms, Control Structures and “Everything as a Service”
in Transportation and Logistics

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Outline

I. Introduction – What is Transport-Logistics 4.0?
   - 4.0 – a revolution of artificial intelligence
   - About 4.0 breakthroughs and emerging mega trends
   - From Industry 4.0 to Logistics 4.0

II. About the Main Trends of Logistics 4.0 in “Phase 1”
   - Digitalization – data platforms
   - Network collaboration – control structures
   - Service-level extension – everything as a service

III. Future Perspectives & Summary
   - Robotization
   - Urbanization
   - 3D fabrication
   - The End!!
... leading to the 4th industrial (r)evolution...

**Breakthroughs - A new era of artificial intelligence**

**Communication technology**
- bandwidth and computational power

**Semantic technologies**
- information integration

**Embedded systems**
- miniaturization

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Google Car 2012

Watson 2011

→ Systems of “human-like” complexity
... leading to the 4th industrial (r)evolution...

**Breakthroughs - Everybody and everything is networked**

**Communication technology**  
bandwidth and computational power

**Embedded systems**  
miniaturization

**Semantic technologies**  
information integration

- **Swarm Robotics**
- **Team Robotics**
- **Smart Factory**
- **Car2Infrastructure**
- **Smart Grid**

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... towards a networked world

The “Information Revolution”

Everybody and everything is networked. - Big Data & Cyber-Physical Systems

“Internet of Things & Services, M2M or Cyber Physical Systems are much more than just buzzwords for the outlook of connecting 50 billions devices by 2015.”

Dr. Stefan Ferber, Bosch (2011)

Vision of Wireless Next Generation System (WiNGS) Lab at the University of Texas at San Antonio, Dr. Kelley

Weidmüller, Vission 2020 - Industrial Revolution 4.0
Intelligently networked, self-controlling manufacturing systems

around 1750
1st industrial revolution
Mechanical production systematically using the power of water and steam

around 1900
Power revolution
Centralized electric power infrastructure; mass production by division of labor

around 1970
Digital revolution
Digital computing and communication technology, enhancing systems’ intelligence

today
Information revolution
Everybody and everything is networked – networked information as a “huge brain”

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... towards a networked world

And how do these systems work?

Communication technology
bandwidth and computational power

Embedded systems
miniaturization

Semantic technologies
information integration

?? Steering - Controlling ??

Towards intelligent and (partly-) autonomous systems AND systems of systems

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The connected world
Not restricted to industry: cyber physical systems in all areas

“Industry 4.0 will address and solve some of the challenges facing the world today such as resource and energy efficiency, urban production and demographic change.”

Henning Kagermann et.al., acatech, 2013

Power revolution
Centralized electric power infrastructure; mass production by division of labor

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Digital computing and communication technology, enhancing systems’ intelligence

Information revolution
Everybody and everything is networked – networked information as a “huge brain”
What is Logistics 4.0?

How will be the future of logistics or Logistics 4.0?

Definition along two different time scales:

1. short-term:
   data-driven, highly networked processes between heterogeneous players (optimization, efficiency, transparency of processes, ...)

2. medium-term:
   autonomous systems and self-organization of systems of systems
From Industry 4.0 to Logistic 4.0
... and a more detailed one!

Logistics 4.0

- Full digitalization
- Network collaboration
- Service innovations
- Big Data
- Artificial Intelligence
- Autonomous driving
- Automation of supply chain
- Synchro-modal transport
- Sustainable transport
- Green Logistics

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Digitalization

Where do the data live?

Data are around from everywhere. But – how to process them?

Big Data Processing through Intelligent Cloud Solutions

Here, the term “cloud” is used in a maximum liberal style, namely as a solution for data storage and analysis somewhere outside of the place where the data are originally generated.

Cloud Functionalities

- Information integration
  Complex data integrated and processed by platform services
- Cooperation
  Information exchange between cloud and teams
- Granularity
  Access to single data and aggregated information

The future of information access is service-oriented and omnipresent.

“No access” is neither an option nor is it an allowed excuse...
Digitalization

How is the access managed – who gets what?

Complexity of information is increasing exponentially.

Logistics: complexity is extreme due to the very heterogeneous players, that act globally.

Again, players are not restricted to “humans” or “companies” but include also technological entities as web agents, autonomous trucks etc.

Obviously, the concept of “platforms” plays in important role in managing and utilizing this complexity.

Here, the term “platform” is used in a maximum liberal style. Platforms can be centralized structures, but can also be federative-cooperative.

- How to know which information is available?
- Which quality?
- How to use all information to continuously optimize every process step (that is, to solve the algorithmic challenges)?
- How to restrict data against third parties?
- How to share information?
- ...

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Digitalization

Big Data induce “intelligence”: from Big Data to Smart Data...

Who the heck needs BIG data? - Let’s make sense out of them...

The Big Data analysis pipeline...

- transfers big data (many…) into smart data (meaningful data)
- accumulates intelligence from information fragments
- is a pipeline of aggregating (artificial) intelligence.

Acquisition / Recording → Extraction / Cleaning / Annotation → Integration / Aggregation / Representation → Analysis / Modeling → Interpretation / Prediction

BIG DATA + SMART DATA → INTELLIGENCE / DECISION / INSTRUCTION
Digitalization
Lateral thinking - what’s next?

Who is in the center of this development? Who is hosting the data?

What is the role of traditional logistics companies, and how / to which degree do IT- and cloud providers enter the scene?
Decentralized systems are usually modelled by concepts all close to “Multi Agent Systems”

“A multi-agent system (MAS) is a (usually) computerized system composed of multiple interacting intelligent (and potentially heterogeneous) agents within an environment.

... 3 important characteristics:

- **Autonomy**: the agents are at least partially independent, self-aware, autonomous
- **Local views**: no agent has a full global view of the system, or the system is too complex for an agent to make practical use of such knowledge
- **Decentralization**: there is no designated controlling agent (or the system is effectively reduced to a monolithic system)”

[Wooldridge 2002]
Network collaboration

2009: Truck robot platoons – **distributed** intelligence

The KONVOI project (several institutes from RWTH & industry partners)

- 2005-2009
- automated / partly autonomous transportation, e.g. by electronically coupling trucks to convoys
- several successful tests with trucks: Chauffeur, KONVOI, SARTRE (EU), Energy-ITS (Japan), ...

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- Adv. driver assistance system for trucks
- short distances between vehicles of approx. 10m at a velocity of 80 km/h
- Energy-ITS: 4m ! (2013)
- KONVOI:
  - Car2infrastructure components!
  - Model of multi agent systems
- expected improvements: beyond safety, reduction of fuel consumption and gained road space
Network collaboration

Organizations forms on demand – individualized by client - initialized by product

- Heterogenous player modeled as multi agent concept
- Models from biology and social sciences
- Basis on Autopoiesis & embodiment theory

Product agitates as “super-agent”:
- Plans production and transportation steps
- Requests service from agents
- Negotiates with other products for agent-resources

- Konvoi 2005-2009, RWTH with partners
- (partly) autonomous driving via convoys

© Daniel Ewert 2013
Advantage of decentralized control structures

Intralogistics goes mobile: The Festo Logistics League

Mobile transportation robots from flexible routing

Competencies:
- localization & navigation
- computer vision
- adaptive planning
- multi agent strategies
- sensory & hardware

Competitions robocup:
2012: 0 points in World Cup
2013: 4th in World Cup
2014: Winner of the GermanOpen

2014: Winner of the World Cup
2015: Winner of the World Cup
2016: Winner of the World Cup

Critical factors for success:
- Totally decentralized
- No “hard coded components”
- Strong cooperation
- Re-planning during tasks

http://www.carologistics.org/
From network collaboration to network integration: synchromodality

Synchromodal transport can be described as an “extended version” of intermodal transport. It allows for the most efficient and flexible connections between all different existing transport networks, usually represented by different modes and different providers at a given time.

Synchromodality:
Combining intermodal transport with chain and network management

The Multi Agent perspective:
Very heterogeneous players have to be combined and synchronized, not only in their actions but in their common goals
Network collaboration
Transfer of the agent idea to smart logistics

**Macroscopic society design**

Matching of local optimization goals of agent and global optimization goals. Altruistic vs. egoistic behavior.

- Managed as a global network;
- Community rules: global optimization

**Microscopic agent and service design**

How to build agents that are capable of autonomous action in order to successfully carry out the tasks that we delegate to them?

- Synchronize all supply chain actors and their different single services:
  - local optimization
- Managed as a global network;
  - Community rules: global optimization

Lead logistics providers

Logistic services

Carriers

Cargo owners

\( \rightarrow \)

Actors

Cargo Owners

Carriers

Logistics Service Providers

Lead Logistics Providers & Consultants

Services

Manufacturing, Retailing

Transportation

Logistics

Supply Chain Management

\( \rightarrow \)

Supply Chain Integration

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Network collaboration

Lateral thinking - what’s next?

I’m the BOSS

Will there be a net of federal networks or one dominant “octopus”?

And who makes the rules?

What is the intelligence of the single entity, what is the intelligence of a node, what is the intelligence of the whole system? – Thus, what are the different roles, respectively?

versus

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Services become available and experts become obsolete!

As information becomes more and accessible, experts lose information power. This observation is inline with all earlier changes along the information chain, starting with the book printing ...

![Diagram showing the transition from expert systems to informed customers.](image-url)
The costumer gets powerful.

And: he/she expects services in business (B2B) to work in the same comfortable way as at home (B2C).

And – more again: the digital native is entering the scene. This guy does not even know what a fax machine is used for. Everything outside the internet does not exist!

Business units – such as marketing, sales, customer support – communicate with each other, but also directly and autonomously with the customer.

Traditional enterprise Communication

Customer focused multi-channel communication

Internal communication becomes more efficient

Enabled by service-oriented business models
Service Innovations

... dealing to „Logistics as a Service“ (LaaS)

**Logistics 4.0 or „Logistics as a Service“ (LaaS)**

The terminology is based on concepts as Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) .... up to Anything-as-a-Service (XaaS). It is sometimes referred to as "on-demand XY", without hosting or owning the necessary infrastructures and tools.

The philosophy behind it is: “Just do it – I don’t care how!”
Service Innovations
Lateral thinking - what’s next?

- GILD: "Roboter Recruiting"; selecting employees on a purely algorithmic basis
- SAS: all types of reliability analysis, e.g. payment moral etc.

Which new business models are about to break through?

Will the product be delivered to customer before it has been ordered, "Anticipatory Shipping"?

- Send medicine before a disease spreads...
- Who is ordering?
- Which kind of foresight do Big Data Technology will come up with in the future?
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Some even more “out of space” concepts

The new driver

„My colleague the robot...“

Again more: In a few years, automated driving might outcompete human drivers. Security issues, the demographic change, and the decreasing attractiveness of the job may add to a fast change.
Some even more “out of space” concepts

The third dimension

“In 2030, 70% of all humans will live in cities. Already then, about 10% will live in megacities (i.e., more than 10 Mio people). Escalating…”

[freestyle translation, source pwc studies]

The megacities of the future

At a certain point, due to purely mathematical reasons, extended 3-dimensional building structures can not longer be served by purely 2-dimensional (street) networks.

Source: National Geographic Magazine

Source: Cargo sous terrain, CH

Cities

urbanization
Some even more “out of space” concepts

The new construction

„Digital warehouses are replacing physical spare parts storages“
[freestyle translation, source Logistik magazine]

„3D printing is on its way to leave the somewhat ‘restricted’ areas of spare part business, tool making etc. and is about to become a serious challenger for all traditional manufacturing models“.
[source Prof. Erman Tekkaya, TU Dortmund]

Water carbonators reaching high sales figures

3D printing of house (source Univ. of Southern California 2013)

3D print of pasta – Barilla (tests since 2015)

On-demand production

Harbor Rotterdam – 3D printer farm for metal printing (after piloting, now roll-out in 2016)

“plastics instead of parcels?” - UPS moving from logistics to 3D printing (tests since 2013)
Summary

... in four steps!

4.0: Revolution of a distributed artificial intelligence

We are right in the middle of a 4th Industrial Revolution.

“Green is beautiful”

... even if strict measures against “environmental bad guys” are rare today, there is an increasing pressure on everybody and all business models to cope with sustainability issues accordingly; and the “Generation Y” is adding to this effect!

Logistics 4.0 – I: Data-driven revolution

- New possibilities of optimization and business models are mainly data-driven.
- Globalization has its additional effects on speed and plurality...

Logistics 4.0 – II: Automation-driven revolution

- Autonomous carrier systems
- Fluent transition within logistics, intralogistics, and production
- New, intuitive intelligent interaction with humans...
Thank you!

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