»Quo Vadis Logistik 4.0«
Changes and Future Trends in Transportation and Logistics

IDC Seminar
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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. The main competences of Logistics 4.0
   - Digitalization
   - Network collaboration
   - Service-level extension
   - Automation of supply chain

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

- **Embedded systems**
  - miniaturization

- **Semantic technologies**
  - information integration

- **Watson**
  - 2011

- Google Car
  - 2012

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

**Breakthroughs - Everybody and everything is networked**

**Communication technology**
bandwidth and computational power

**Semantic technologies**
information integration

**Embedded systems**
miniaturization

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

**Remark:** Leading to the 4th industrial (r)evolution... Breakthroughs - Everybody and everything is networked.
The terms’ definition and its “relatives”...

### Internet of Things, Cyber-Physical Systems & Industry 4.0

<table>
<thead>
<tr>
<th>Cyber-Physical Systems</th>
<th>OR</th>
<th>Internet of things</th>
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<td><strong>Shared</strong></td>
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<td><strong>Vision</strong></td>
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<td>- large-scale distributed computing systems of systems</td>
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<tr>
<td>- computation and “intelligence” is not decoupled from environment</td>
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<td><strong>Core Technology</strong></td>
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<td>- internet as large-scale network</td>
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<td>- embedded systems (= intelligent components)</td>
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<td><strong>Distinct</strong></td>
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<td><strong>Scientific Community</strong></td>
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<td>- Internet of Things driven from computer sciences, Internet technologies driven by EC</td>
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<td>- Cyber-Physical System driven from engineering aspects driven by the NSF</td>
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<td><strong>Philosophy, focus</strong></td>
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<td>- Internet of Things focusing on openness and on the network - virtuality</td>
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<td>- Cyber-Physical System focusing on the physical process behind, often a closed-loop system</td>
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#### For all practical purposes:
- Today: more or less synonym
- Industry 4.0: often also used as a special field of application
... 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)

“local” to “global”

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”
... 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

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

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

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

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

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

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

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

Digital revolution
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!

- 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?

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

User Interaction

- **Availability of information**
  Information available through powerful web services

- **Client Access**
  Access to information from anywhere and at any time

- **Omnichannel Management**
  Data access through various ways for heterogenous systems

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.](image)

In particular in logistics, the complexity is extreme due to the very heterogeneous players, that act globally.

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

- 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?
- ...

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**.
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?

What is the role of traditional logistics companies, and how / to which degree do IT- and cloud providers enter the scene?

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

(New) Cloud and IT companies
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)”

[Woolridge 2002]
Network collaboration

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

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**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**

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- expected improvements:
  - beyond safety, reduction of fuel consumption and gained road space
Network collaboration

Horizontal coupling (manufacturing/logistics) – to lot size 1

→ Organization 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
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.

**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?

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

- Synchronize all supply chain actors and their different single services: **local optimization**
Network collaboration
On the way to synchromodal network management

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
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
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 ...

Expert systems losing ground: Experts and service providers lose their unique selling proposition

Management of services: The new business model

Informed Customer

Profound Decisions
The customer 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

Sales

Marketing

Customer Support

Business Customer

"No, you weren't downloaded. You were born."
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!”

Managing Platforms

Cloud Service Request

Delivery Information

Carrier Request

Delivery Customer

Delivery Service

End Consumer

Requests and Status Updates

B2B relations still lacking generic services like in B2C relations

Mobile Apps
Service Innovations

A lot of new ideas are entering the field – fast!

DHL business model enables personalized delivery service, from delivery trucks into the trunk of a car.

Amazon: emerging to global dominance in the B2C market, enhancing its influence worldwide. Also: the more services platform cover, the more they have the capability to cover even more (“platform dilemma”) ...
Service Innovations

Lateral thinking - what’s next?

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?

GILD: “Roboter Recruiting”; selecting employees on a purely algorithmic basis

23.09.2016
S. Jeschke

*GILD*
The traditional division between logistics, intralogistics and production is outdated.

What’s more: the whole differentiation between “inside” and “outside” is subject of debate.

1. Real-Time reaction on external events
2. Algorithms and data are “the same”!
Advantage of decentralized control structures

Intralogistics goes mobile: The Festo Logistics League

**Mobile transportation robots from flexible routing**

<table>
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<th>Competencies:</th>
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<td>localization &amp; navigation</td>
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<tr>
<td>computer vision</td>
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<td>adaptive planning</td>
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<tr>
<td>multi agent strategies</td>
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<tr>
<td>sensory &amp; hardware</td>
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**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/
Automation of supply chain
Lateral thinking - what’s next?

Integrated Intra-Logistics

Drones as part of inner supply-chains

To which degree will the supply chain automate itself?

Will the product organize its transport on its own?

In case of a car, it may even drive itself to its new owner...

Cargo from the factory to the consignee

Autonomous Delivery

Towards intelligent parcels

Credit: Kobi Shikar

Credit: Still
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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

“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.

“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]
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)

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

• IT driven
• characterized by “everything is connected to everything anywhere anytime”

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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