Logistics and the Internet of Things

IoT International Forum
Berlin, November 2011

Prof. Dr. Michael ten Hompel
Data and Facts about Fraunhofer IML

- Founded in 1981
- About 200 scientists · 250 student assistants · 3 chairs at TU Dortmund
- Turnover > 20 million € · 50% from industry · trade and services
- Branches and project centers: Hamburg · Frankfurt · Prien (near Munich)
- Cooperation with: HSG St. Gallen (Switzerland) · Georgia Tech (USA) · Lisbon (Portugal) · Shanghai (China) · Rio de Janeiro (Brazil)
100 Mio. Euro for development and innovation in logistics and supply chain management!

40 Mio. founded by Federal Ministry of Education and Research

120 Companies

11 Research institutions

30 Joined projects

4 Associated projects

100 Innovations und Patents

4000 Jobs in logistics and SCM
Logistics as Industry in Germany

- Logistics is Germany’s third biggest industry
  - 2.8 million people work in logistics\(^2\) (7 % of total employees)
  - 220 billion Euro turnover in 2011
    First place in Europe with just about a third of the turnover
  - Approximately 5 % growth in turnover in 2011\(^2\)

- Education
  - 11,600 university graduates per year\(^3\)
    (BA and MA with logistics reference – mainly economists and engineers)
  - 1,300 of which with (main) studies in logistics.

- Germany is the world’s leading logistics market
Today, logistics is said to be a premium industry.

Germany is logistics world champion.
- World Bank study: «Connecting to Compete» 2010

Logistics analyzes and shapes economic systems based on the division of labor as objects in network flows.
- Position paper of BVL’s Scientific Advisory Board

The scramble for the world has begun! …and logistics is playing a decisive role.
- The container is the symbol of a globalized world. [Stefan Aust]
Actually, what is logistics?
To move human beings and things.

- All along, human kind has sought to set things in motion.
- Logistics endeavors to shape and organize this motion efficiently, reasonably and in a target-oriented way.
- Logistics conceives networks in the space of which things are set in motion. Places and human beings are connected by flows of information, commodities and goods.
- Logistics transforms things being thought into motion. It unites the virtual with the physical world.
Logistics is complex

- Over the past 10 years the amount of (intra)logistic information has increased by a factor of 1,000.
- In 2000 the entire internet data amounted to 21 Terabyte.
- At the same time the computer performance increased by a factor of 30-50.
Internet and social network

Much faster communication in much shorter time

- In 2010, 107 tr. mails were sent.
- This equals 15,000 mails for every person in the world.²
  - 2 billion people are able to receive mails
  - Spam-rate 89.1%³

- At the end of 2009, the number of users of social networks (800 Million) outreached the number of e-mail users.³

- The next generation:
  - 98% are members of studiVZ (German young)
  - 93% are online every day
  - 7.7 Million get a daily tweet of Lady Gaga

³MessageLabs Intelligence 2010
17% growth of e-commerce (Germany 2011)

\[
\frac{e-commerce}{mail~order~business} \times 100 \% \]

- 2006: 38,0%
- 2007: 39,5%
- 2008: 46,9%
- 2009: 53,3%
- 2010: 60,4%
- 2011: 66,4%

Infratest im Auftrag von BVH, Paypal; E-Commerce-Studie 2011
Pressekonferenz im Juni 2011
IoT Forum 2011
The result: The logistical triad
flexible · convertible · automated

- **Flexibility**
  - Modification of a system within the planned boundaries.
  - Flexibility of goods · of throughput · of layout

- **Changeability**
  - Modification, variation and expansion of a system beyond the planned boundaries².
  - Awareness of environment
  - Active, purposeful response (e.g. adaptation)
  - Independent acting (artificial intelligence)
  - Real time capability
  - Evolution into an indefinite future based on incomplete information

- **Versus automation**

Exponential Growth
Just some bits of information:
That’s how we see our world
How we should see our world
RFID combines virtual and material world
smaRTI – smart reusable transport items
Smart air freight containers (smartULD)

- DyCoNet smartULDs…
- …use energy harvesting
- …collect environmental data with sensors
- …trigger alarms autonomously
- …build local networks of charge carriers via short range wireless (SRW)
- …interact with IT-networks (e.g. ULD management)
- …order transports to a destination (loading devices, aircrafts)
Philosophy of the Internet of Things

- The trend is going from hierarchical to mesh-like structures
- Modularization of mechanical components
- Distribution of control functions over the system
- Every entity is represented by a software agent

This leads to:
- decentralization
- internet of things (not only) in logistics
Evolution – learning from nature
The cellular intralogistics anticipates individualization and elevates it to a method. The philosophy of the "Logistics on Demand" is transferred to the physical material flow:

- Stiff and conventional materials handling systems are dismantled.
- Autonomous vehicles and modules (cells) substitute conveyors and cooperate like the cells of an organism.
- Each cell provides a service – e. g. transporting a container from a source to a destination.
- The classic material flow system will be replaced by cooperating cells (entities).

This leads to a maximum of flexibility and dynamism.
The ideal logistic space is empty

the warehouse - logistical “anthill”

the workstations - logistical “feeding grounds”
There is a method to individuality!
Internet of Things - Cellular Intralogistics
Individuality is methodical!
Internet of Things-Cellular Intralogistics
Video Individuality is methodical!
Internet of Things-Cellular Intralogistics

Multishuttle Move
Multishuttle™ – Cellular intralogistics

- Agent-based control system
  - Decentralized control concept using autonomy and swarm intelligence
  - Autonomous access towards a destination
  - Communication with sensor nodes and WiFi by IEEE 802.15.4 and IEEE 802.11
  - Hybrid sensor concept including radio detection and ranging sensors
  - Intelligent decentralized localization and collision detection

- Save interaction with
  - People and non-automated vehicles like fork lift trucks etc.

- Order management by Logistics Mall + SAP
Particle filters for positioning · navigation · tracking

- Way by Odometry
- Way by MC particle filter
- Real position

Fraunhofer IML

LogiMAT 2011 - Dipl.-Ing. Andreas Kamagaew
sequ. Monte Carlo and Kalman filter for Gaussian distribution
IoT Forum 2011
Modelling a new world

Internet of Things
Cellular Intralogistics
  Operational level
  Real time capabilities
  Self-control
  MultiShuttle™

Internet of Services
logistics mall
  Normative level
  Batch execution
  Self-organization
  Software as a Service & SOA
Logistics Mall
Service-oriented architectures in logistics
Logistics Mall
Service-oriented architectures in logistics

logistics mall
TEIL II
Intelligent ULDs

Realtime interbranch processes, based on smart reusable transport items (smaRTIs)

Logistics Mall
Cloud Computing

Cloud-based event repository, to gather comprehensive supply chain information

Intelligent carriers for FMCG

REWE

Hybrid AutoID-processes, that support simple barcode scans, up to complex RTLS-Systems or end-user devices like the iPhone.

Swarm of Cellular Transport Systems

Autonomous Vehicles

Intelligent mail bins
Logistics and the Internet of Things

IoT International Forum
Berlin, November 2011

Prof. Dr. Michael ten Hompel