Smart Systems in Baggage Handling and Warehouse Automation

Smart Systems Integration 2009

March 10, Brussels

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Bundesministerium für Bildung und Forschung

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Overview

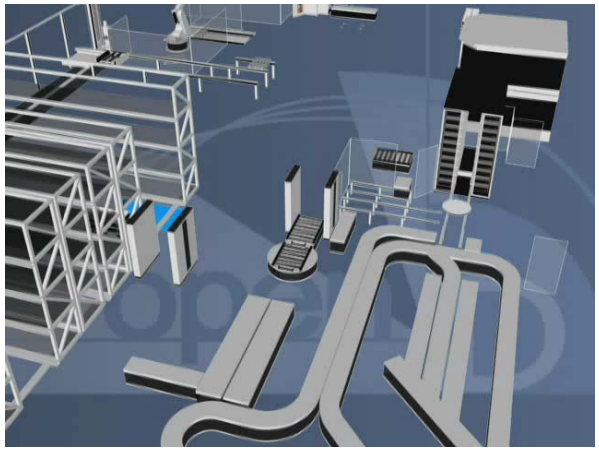
- Some real world examples
  - Baggage handling
  - Warehouse automation
- … How they could been solved
  - Software architecture
  - Hardware/Software/Control
- … And what comes next

Real World Challenges

- Logistics system are
  - Discrete
  - Complex
  - Often non deterministic
- Automated logistics systems have to be controlled in real-time
- The more accurate a process is forecasted or planned concerning future events, the more unlikely they occur within a determined time

- *If everything is under control you are just not driving fast enough*.
  Stirling Moss (race champion, born1929)

Internet of Things



- It will be the „things“ that control the processes and machines. Today it is the other way around.
  - Baggage finds its way through the transportation net of an airport “on its own”
  - The flow of consumer goods from the warehouse to the point of sale will be optimized according to customers needs
  - Automated supply of orders within eCommerce processes.
- Logistic entities (pallets, bins, baggage units, conveyors) get connected via RFID and software agents.
- **„Every pallet by itself“** (Prof. M. ten Hompel)

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Aims

- Material flow control
  - Standardized software and hardware entities
  - Flexible loading devices
  - Radio frequency identification (RFID)
- Universal software- and control architecture
  - Multi agent systems
  - Bio inspired algorithms
  - Robust, emergent behavior
  - Interfaces
- Tools
  - Simulation and test environment
  - Hardware

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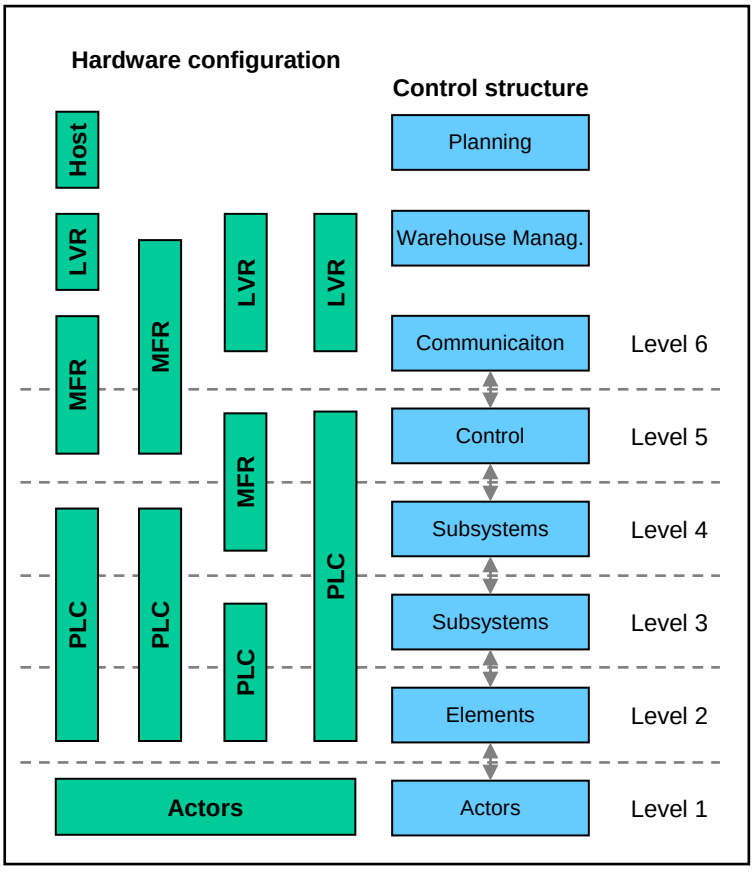
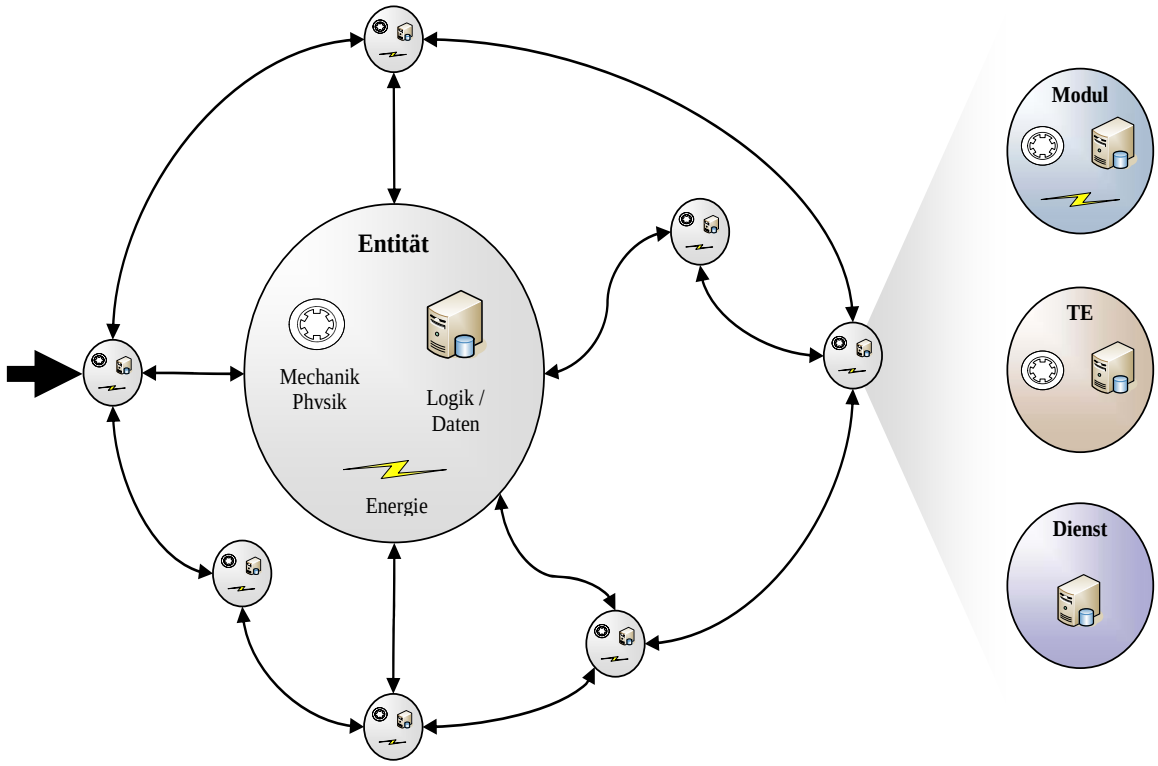
Classical Centralized System Architecture vs. Decentralized



Entities – the building blocks of the internet of things



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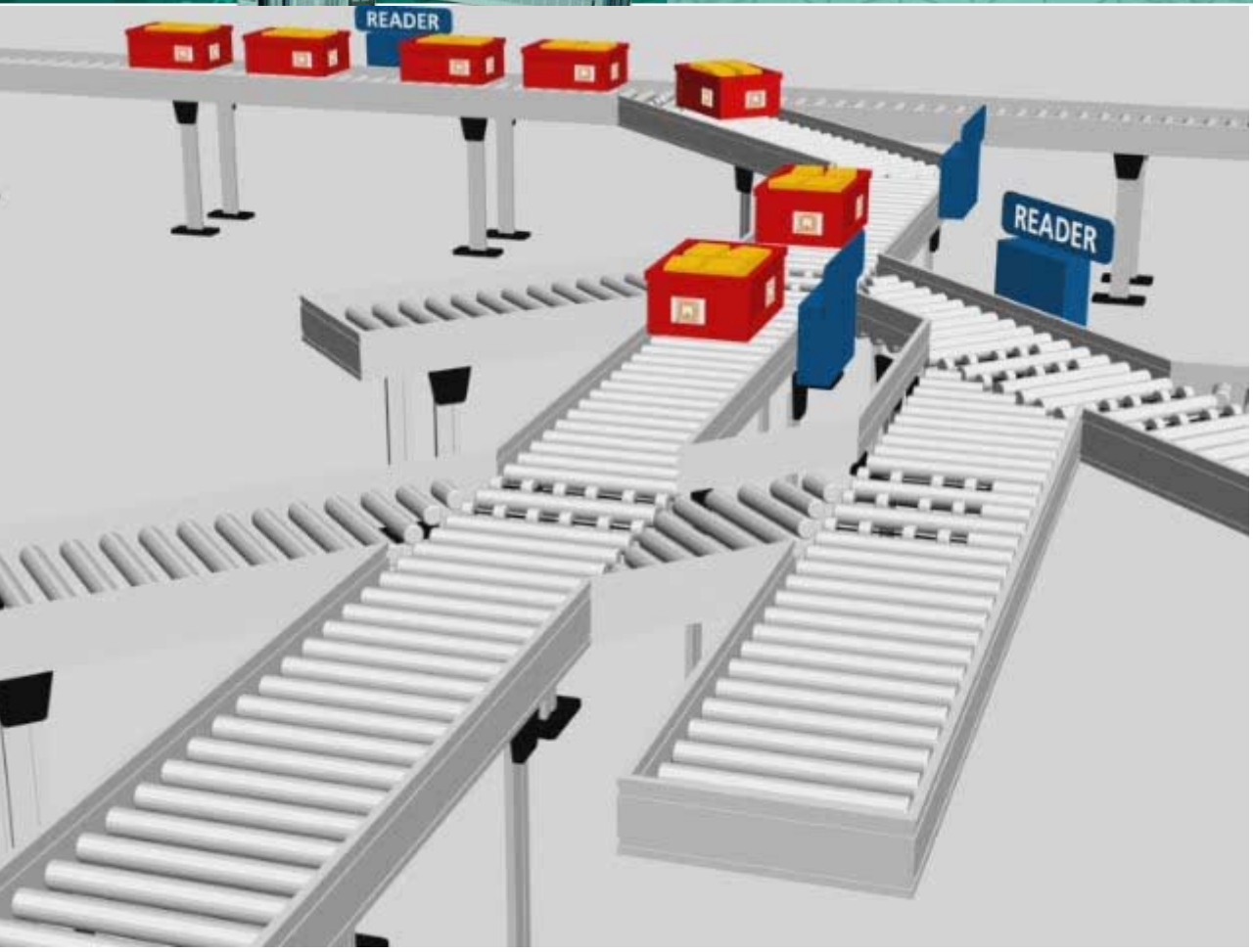
How does it work?



- Each bin has a RFID Tag 13,56 MHz
- Each bin has a software agent
- Cooperation with conveyor agents
- Deadlock/ congestion prevention

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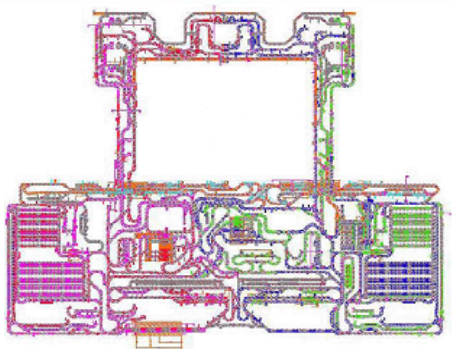
Baggage Handling

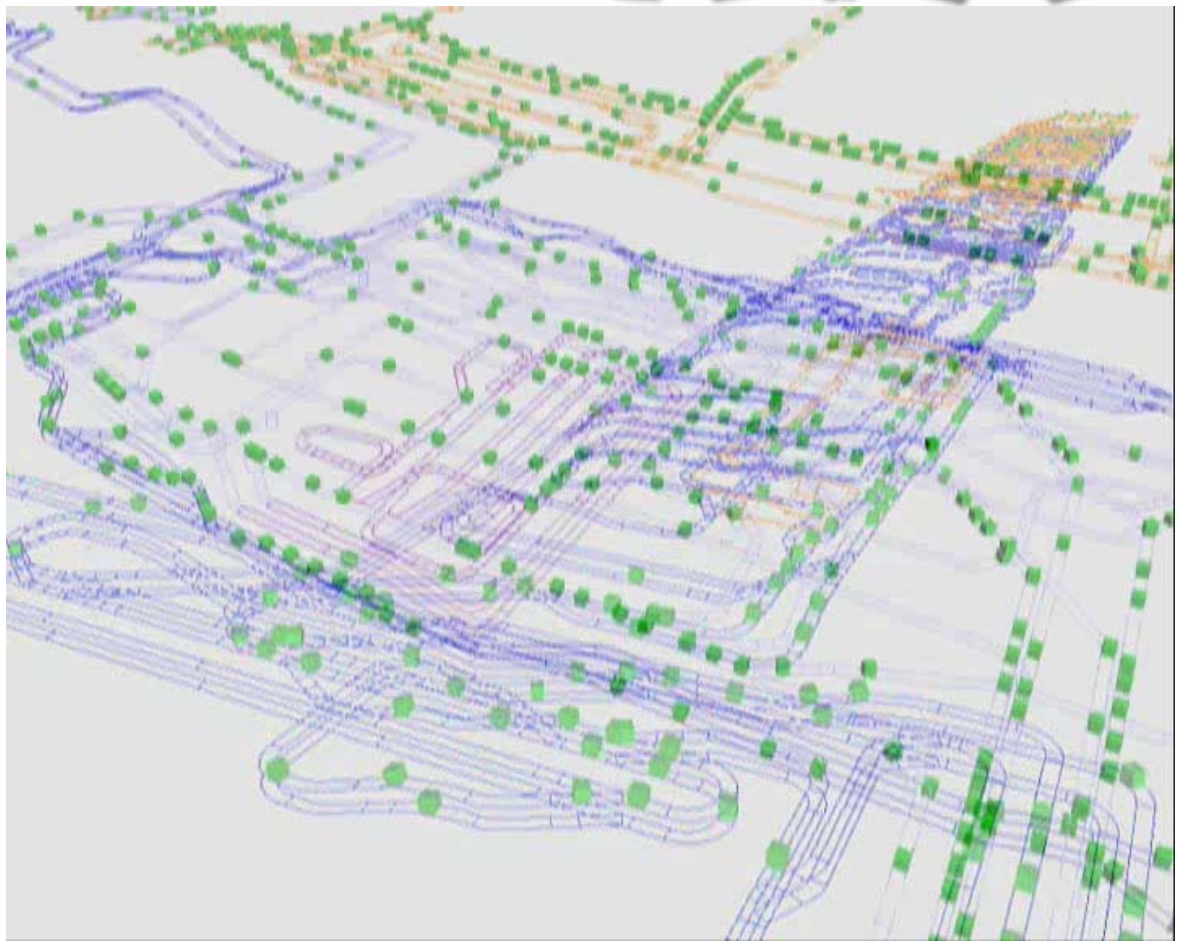
- Category A Airports
  - More than 20 Mio. passangers per year, Atlanta > 70 Mio!
  - Routing between check-in and baggage claim
  - More than 100 relevant source-destination-relations
  - > 40 km of conveyor technology, 12.000 single conveyor elements
  - > 10.000 units per hour
- Constraints
  - Minimum Connecting Time, Early baggage store
  - > 100 security control stations (automated or manually)

➔ That's quite a big and complex real life model

Bild: Siemens

Simulation of an existing Airport

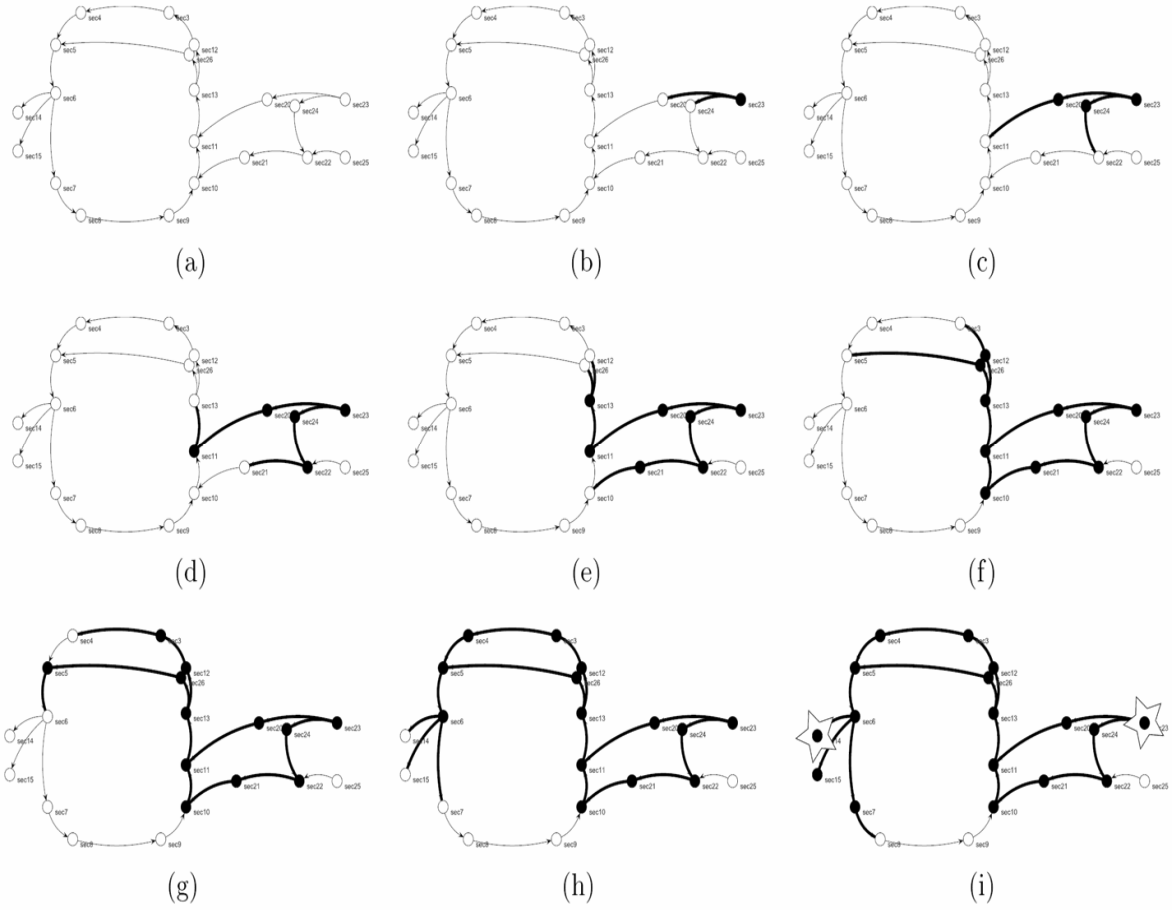




- > 2.000 Agents
- One agent consist of the same 400 loc that are multiple instantiated
- System load: 6 hours, 60.000 units
- **It works!**
- Throughput approx. 90% of centralized solution, but simplified dramatically

Bild: Siemens

Routing: Flooding vs. Ant Based Algorithm



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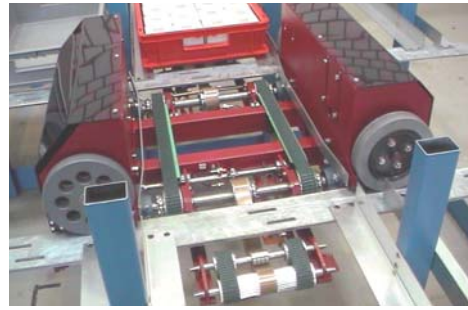
Warehouse Automation

- Higher frequency of deliveries, smaller picking units, more articles
- Dynamic order disposition and adhoc processing (e.g. E-Commerce)
- Layout flexible, automated systems for smaller load units (e.g. miniload)
- System components („construction kit“)
- Integration f emerging technology (e.g. WLAN, RFID, ...)
- More dependencies between IT-systems and to business processes
- Integration of intralogistics and transportation

→ **Higher demands on system adaptation**

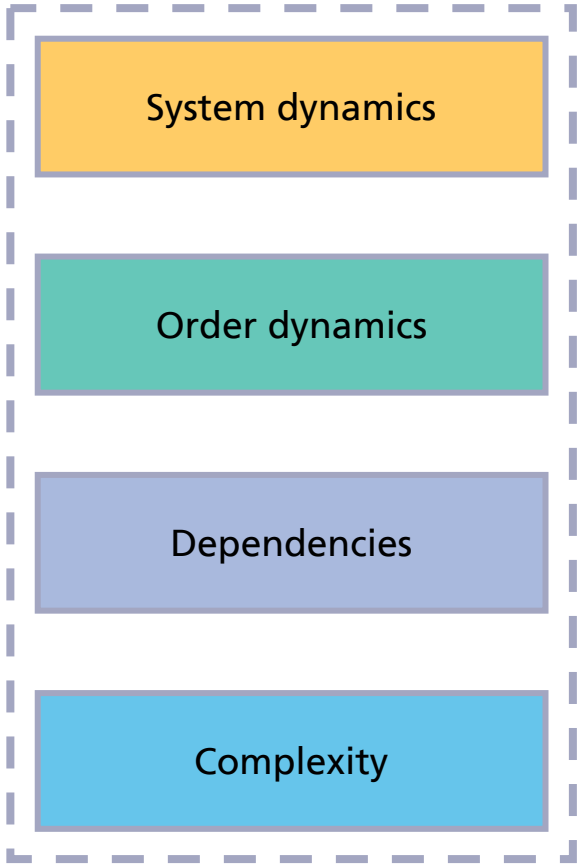
Multishuttle System

- Rail bounded, autonomous vehicles with onboard-controller and WLAN
- Flexible layout by construction kit principle. Components are: multifunctional rail, lift, turntable and transfer car
- Scalable throughput through variable number of vehicles



→ **HOW can a control system make use of that (mechanical) flexibility?**

(MAS) guarantee adaptation



- Autonomous agents [...] solve specific tasks in a distributed fashion, involving multiple agents of different capabilities. These agents will coordinate, cooperate and sometimes compete among themselves in order to most effectively accomplish a given task.
- A Software Agent is a computer program that acts autonomously, interacts with its environment according to its own agenda.

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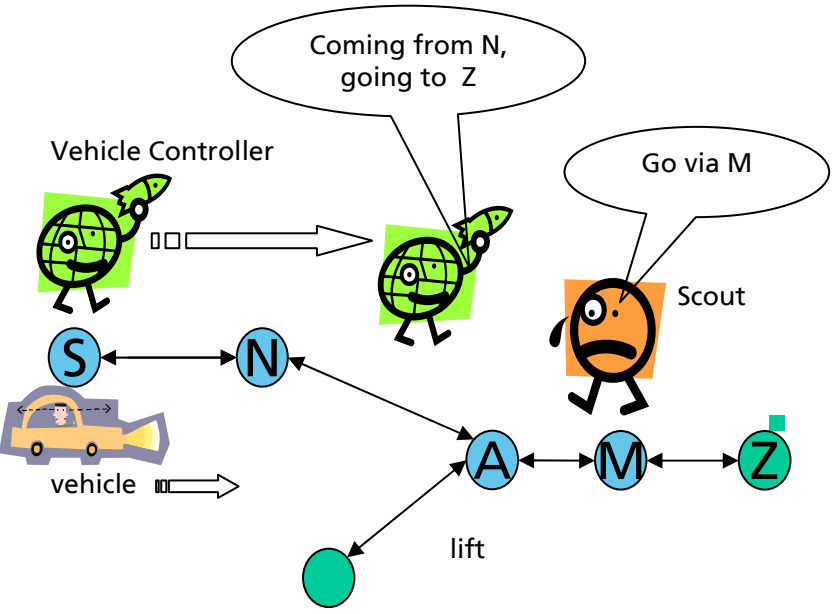
Liu J., Y. Y. Tang,
"Adaptive Image Segmentation With Distributed Behavior-Based Agents,"
GÖRZ, G. ; ROLLINGER, C.-R. ; (HRSG.), J. S.
Handbuch der Künstlichen Intelligenz

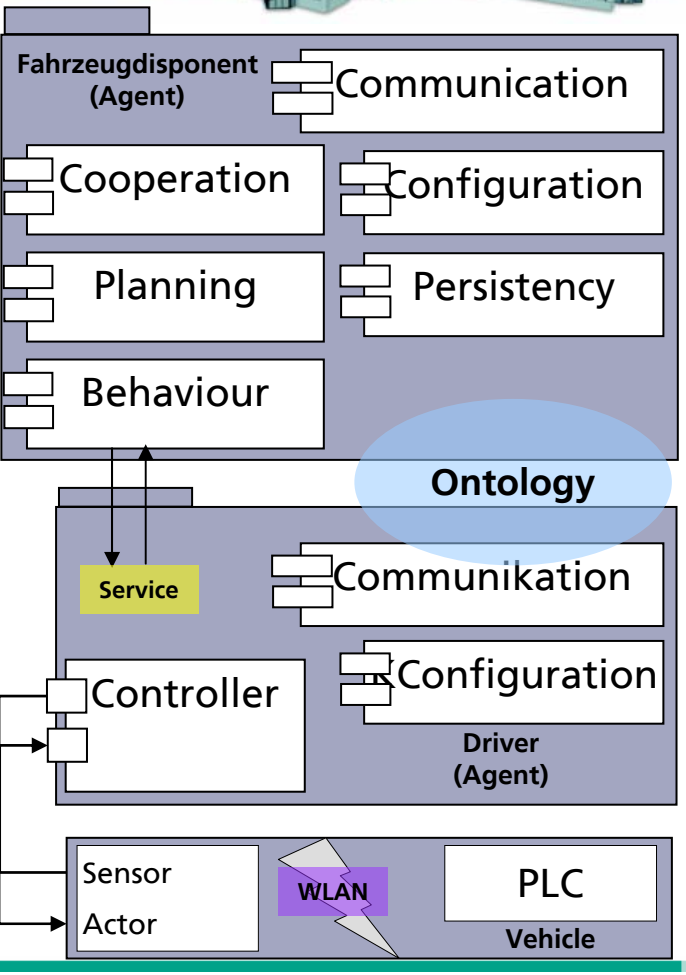
agent behavior and evolution



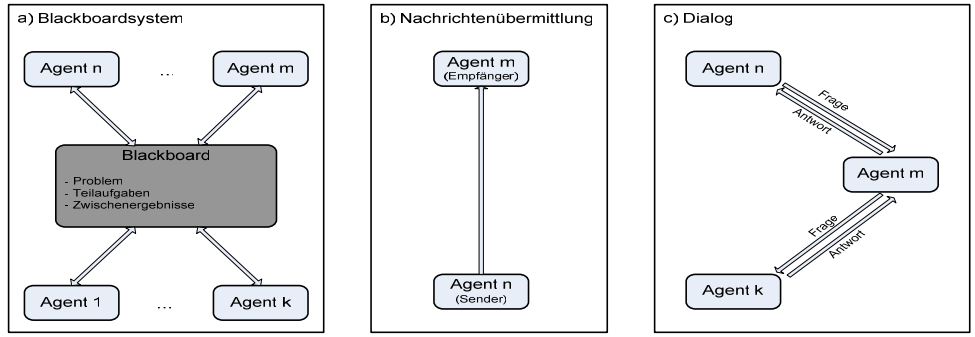
Easy to understand – easy to engineer!

- First: A robust system.
  That has been achieved by MAS design with very simple heuristics
  - Finding routes
  - Don't block other vehicles (Deadlock recognition and prevention)
  - Coordination of vehicle movement and elevator movement.
- Then: How can system behavior be optimized using evolutionary computing?
  - Using more sophisticated heuristics and meta-heuristics for known sub tasks, e.g. routing
  - Let the agents evolve by using evolutionary mechanisms.

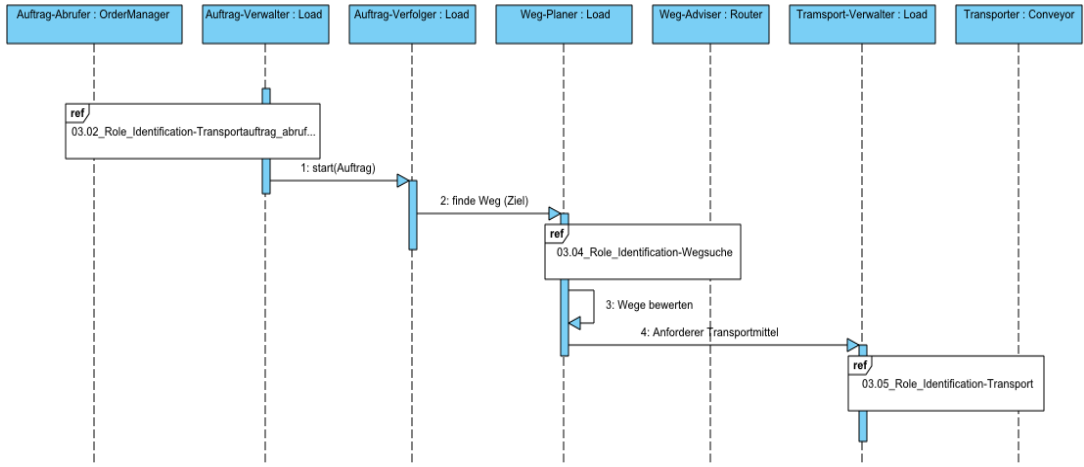
Softwarearchitektur



Communication in MAS



Protocol



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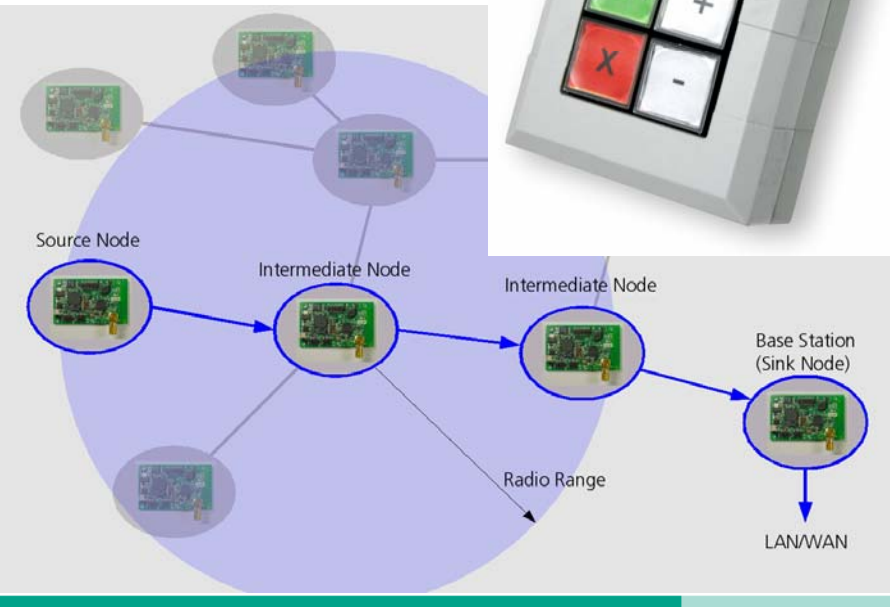
Sensor Networks

VITOL
Vernetzte Intelligente Objekte in der Logistik



- Networking
  - Self configurable
  - Self organized
  - locatable
- Communication
  - Air interface
  - WSN-Protocol stack
  - Dynamic net topologies
- Autonomy
  - Energy pack
  - Embedded operating system
  - Application logic

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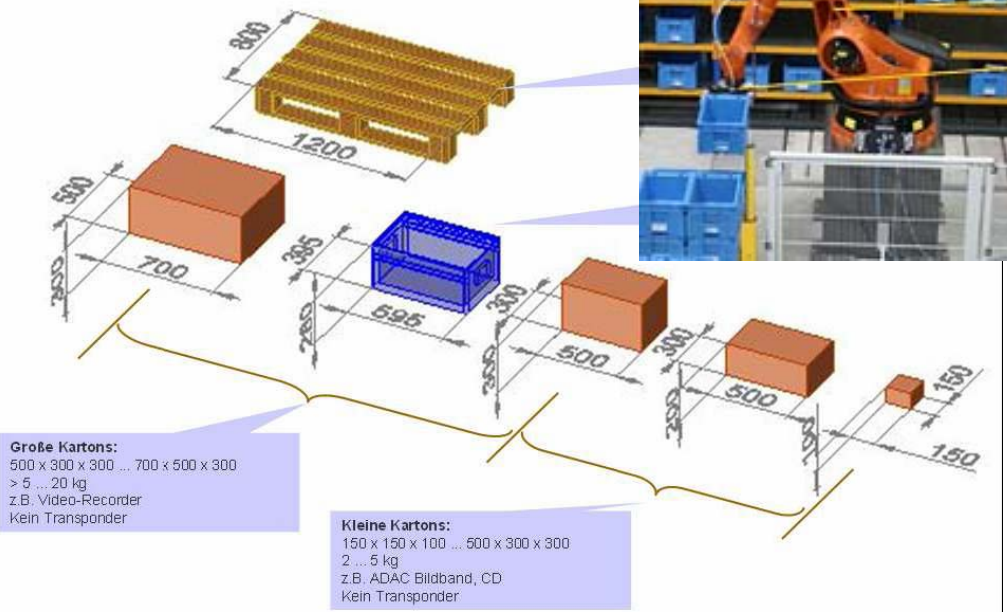
Picking & Handling



- Every bin carries information about how it has to be handled on a RFID tag
  - Weight, geometry
  - Surface
  - …
- The handling device adapts to the communicated parameters
  - Multifunctional device
  - Suction (vacuum)
  - Clamping
  - supporting

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Conclusion

It has been shown that the concepts of the internet of things within intralogistics systems work well

The building blocks for the internet of things

- Hardware (still too expensive??)
- Software (still too error prone??)
- Mechanical components (still too constricted ??)

- … have to work "hand in hand" to establish smart behavior in a complex environment
- Engineering and ramp-up have to become easier
- **Smart systems are the solution to cope with the increasing complexity of future logistics systems**

Thanks for your attention!