Agent Technology in Agile Production and Product Support

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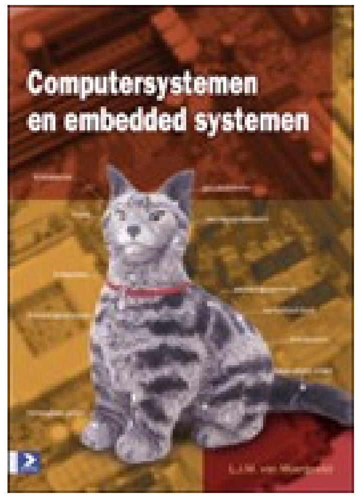
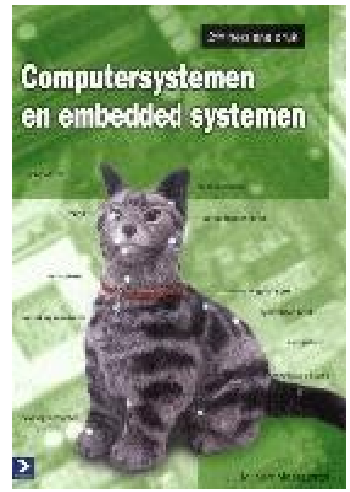
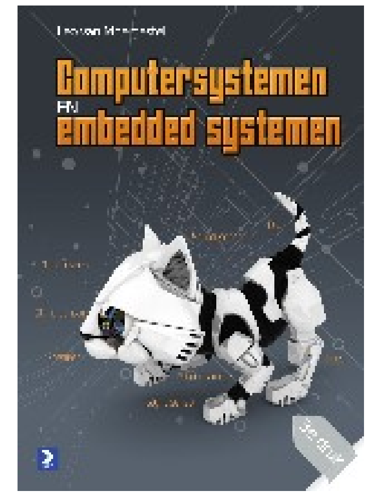
My books


COMPUTERSYSTEMEN
EN -NETWERKEN


Computersystemen
en embedded systemen


Computersystemen
en embedded systemen


Computersystemen
EN
embedded systemen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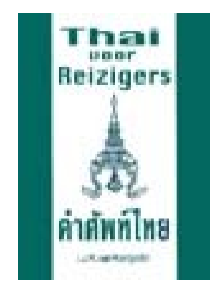
Woordenboek
Thai-Nederlands


Woordenboek
Nederlands-Thai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Overview

- Part 1: Manufacturing overview
- Part 2: Manufacturing 2.0
- Part 3: Agent-based manufacturing
- Part 4: Agent-based product support

Overview Part 1

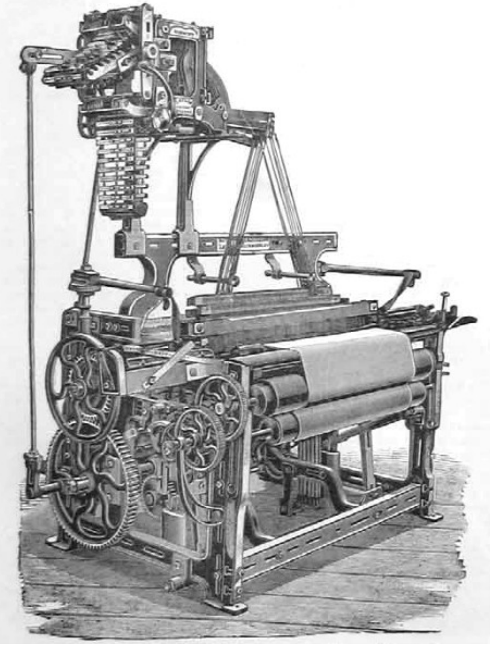
- Industrial revolutions
- Standard manufacturing
- Modern technologies
- Concepts and hot topics

Industrial revolutions

- Power driven systems (steam, waterpower)
- Electrical driven systems, production lines
- Automation with electronics and IT
- Cyber connected systems

Revolution 1

- Introduction of mechanical production facilities with the help of water and steam power
- The first power loom was designed in 1784 by Edmund Cartwright and first built in 1785.



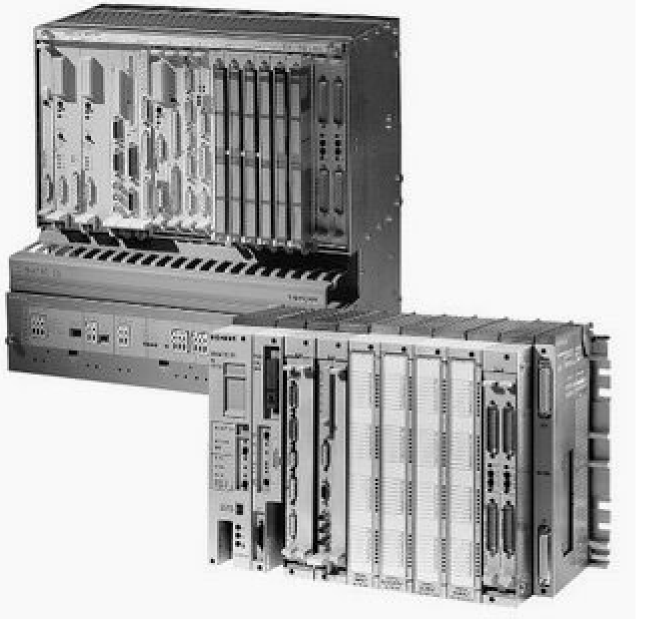
Revolution 2

- Division of labor, mass production, production lines
- Use of electric power
- First assembly line Cincinnaty slaughter houses (1870)
- Remember 'Modern Times' (Chaplin)

Assembly line

Revolution 3

- Automation by electronics, IT and advanced electro-mechanical systems like industrial robots
- First Programmable Logic Controler (PLC) Modicon 084



Revolution 4

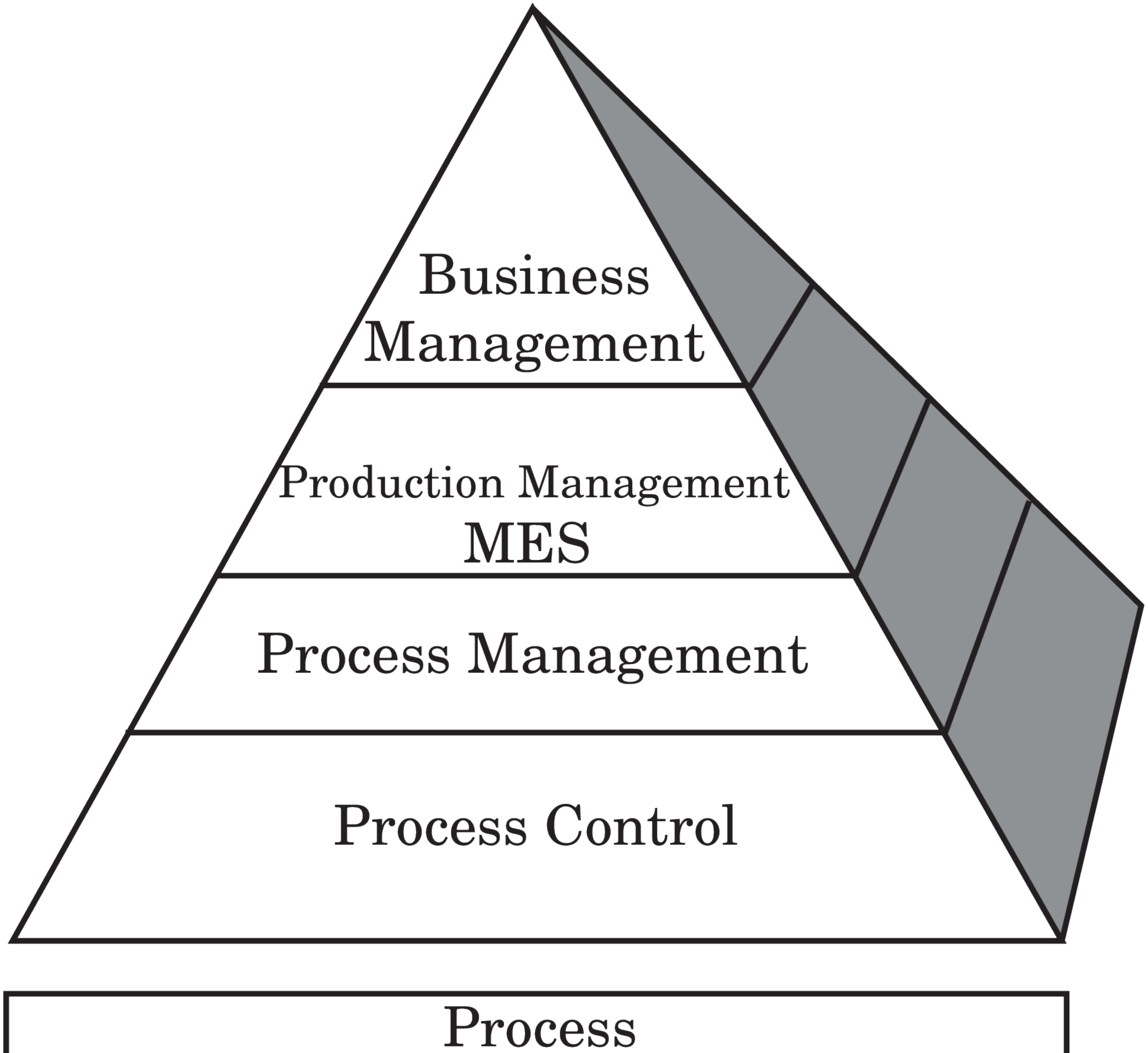
- Cyber-physical systems
- Smart interconnected systems communicating, sharing information, negotiating and making desicions

How things are made

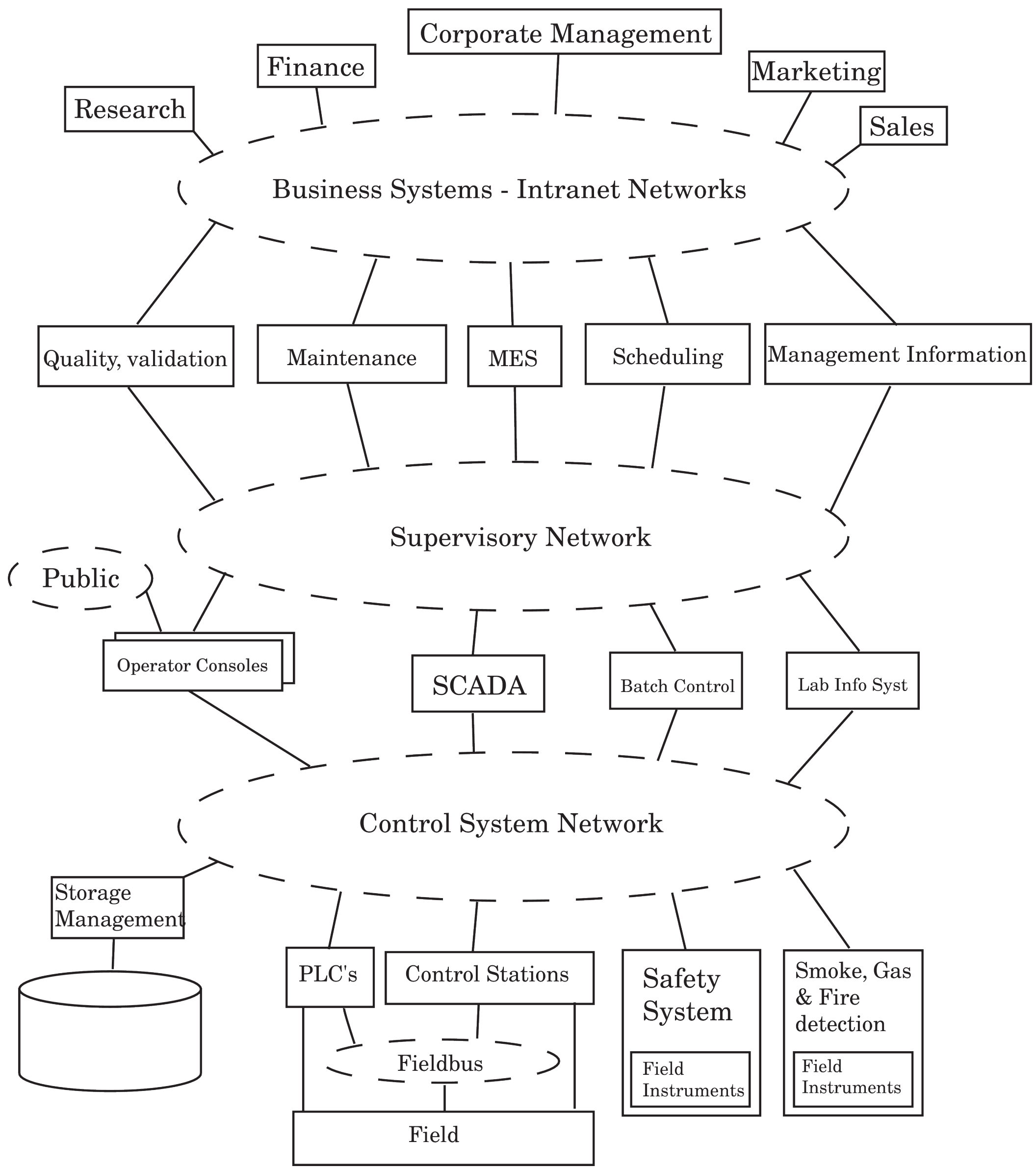
- Single product (unique, tailor made)
- Continuous production (chemical industry)
- Batch production (food, consumer products, industrial products)

- Both continuous and batch are considered industrial production

Automation piramid



Control layers

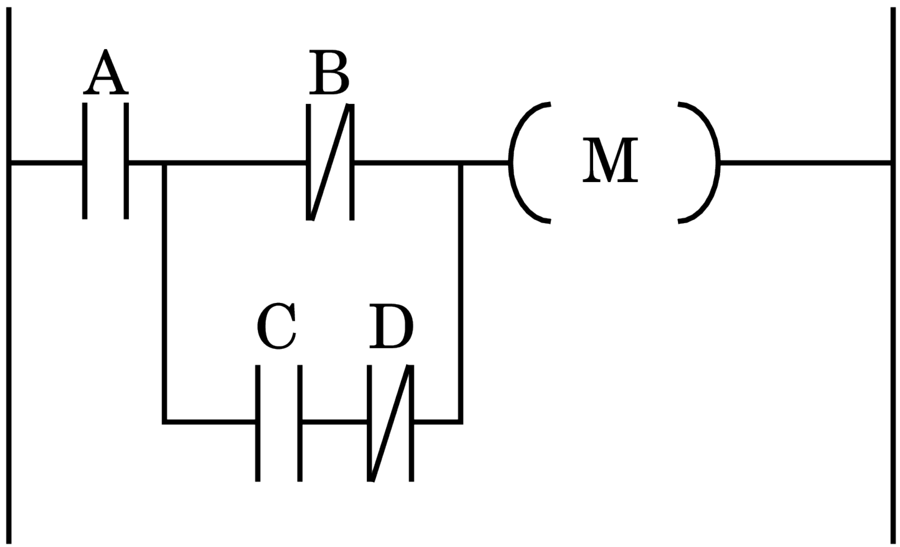


Intermezzo PLC

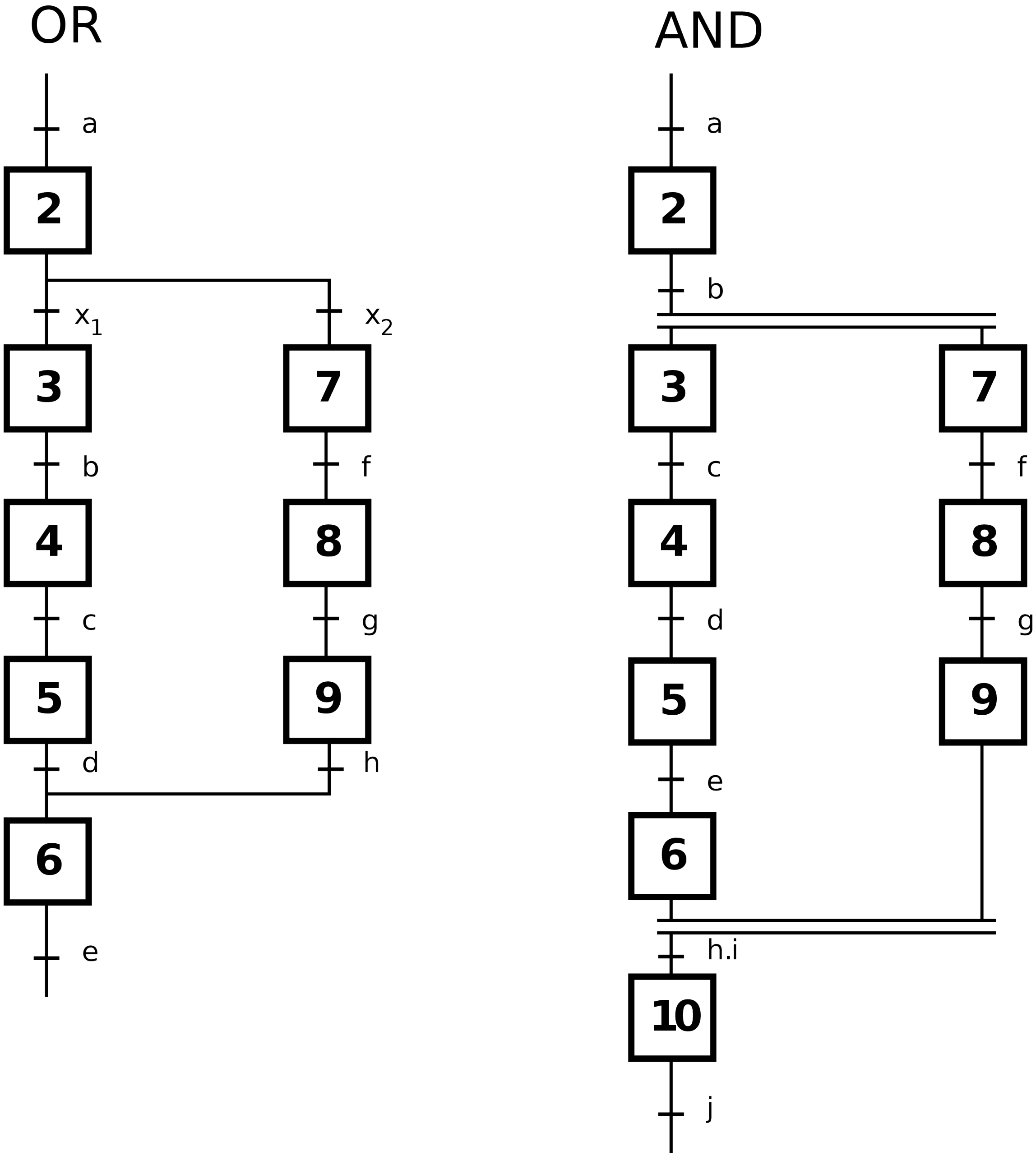
- Programmable Logic Controller
- Programming standards IEC 61131-3 (1993, third edition: 2013)
    - LD (graphical, relay logic)
    - IL (Textual, low level commands like assembler)
    - ST (Textual, Pascal-like procedural language)
    - FBD (graphical, logic diagrams)
    - SFC (graphical, state machine, GRAFCET)

Intermezzo PLC

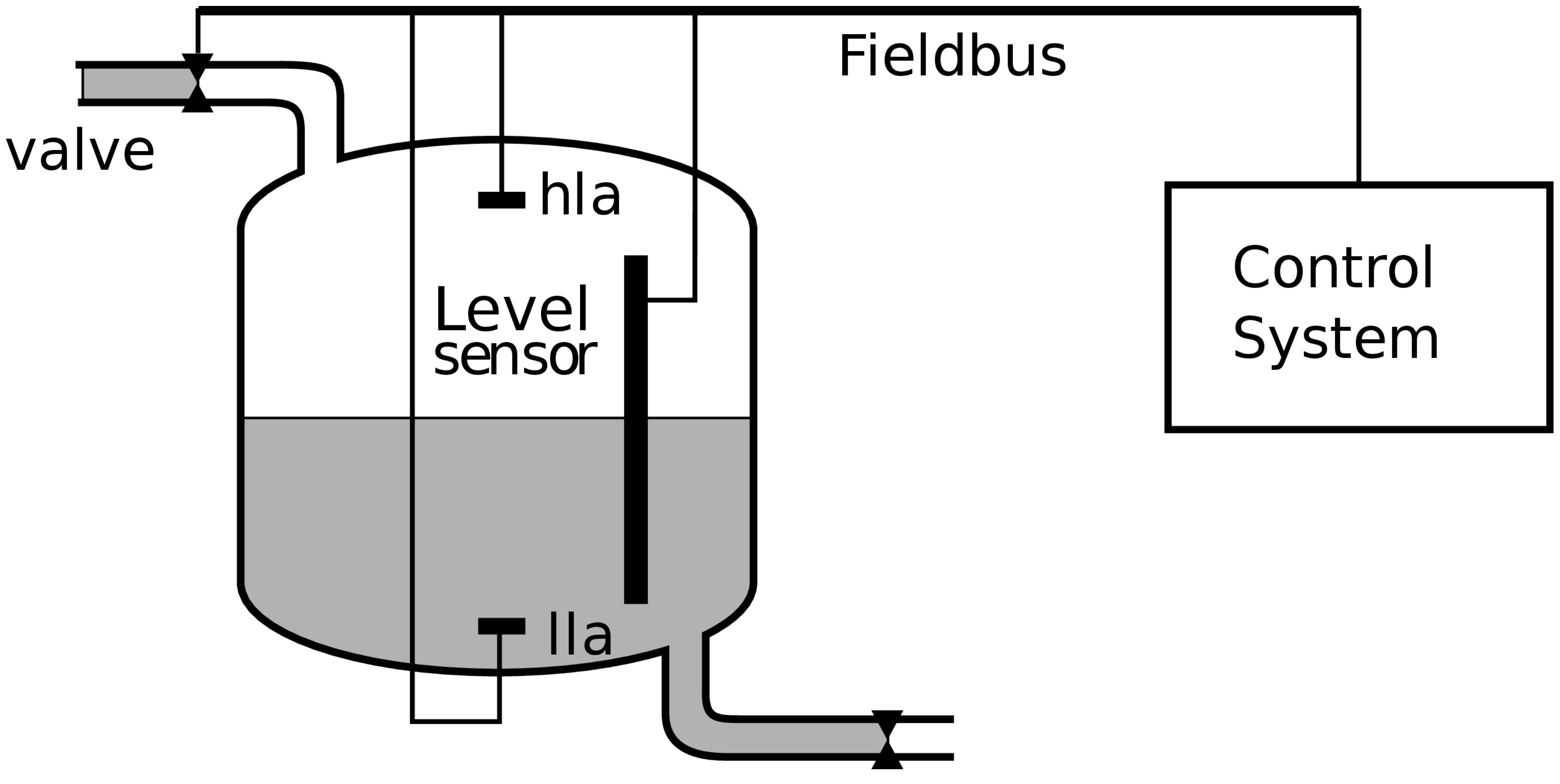
PLC programming 1(2)



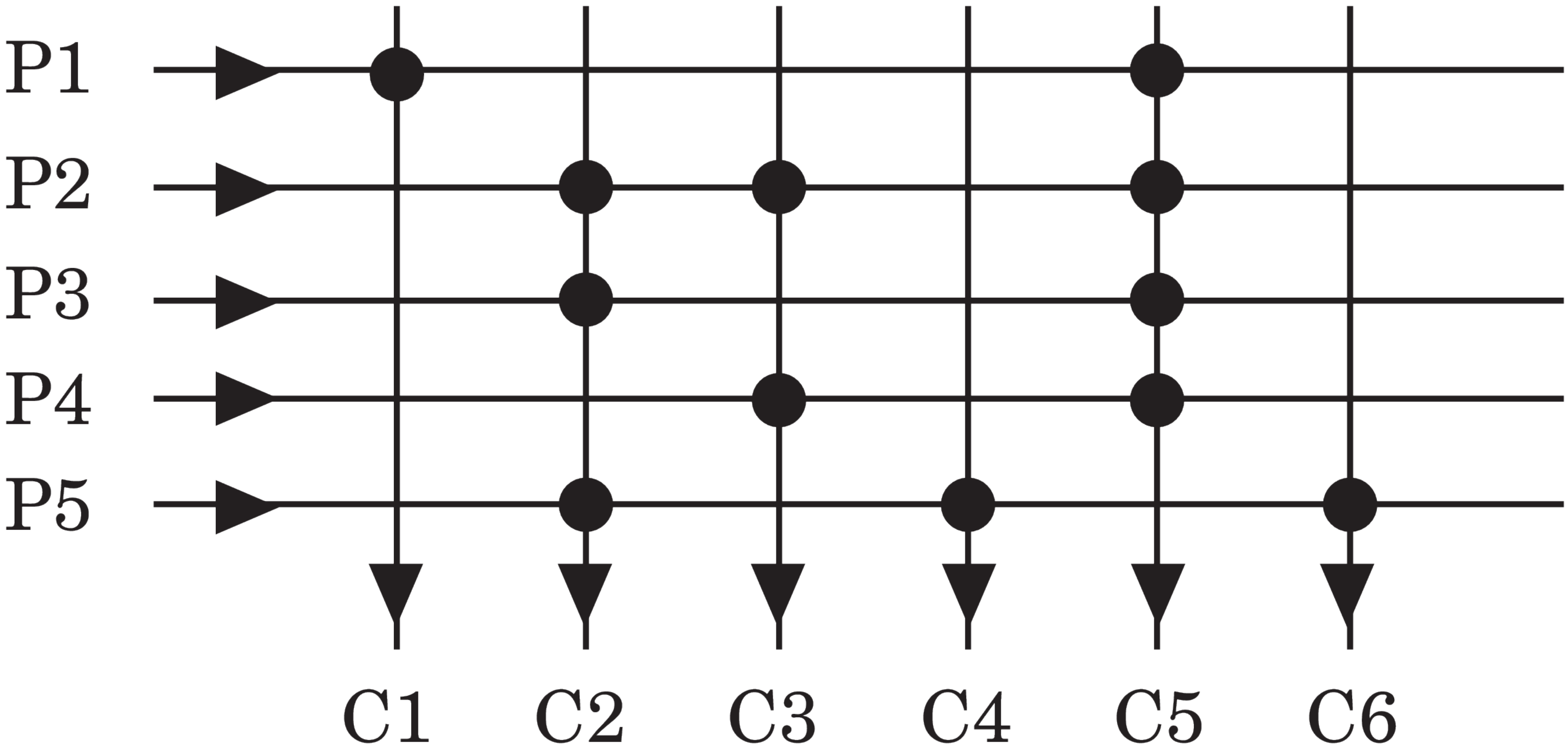
PLC programming 2(2)



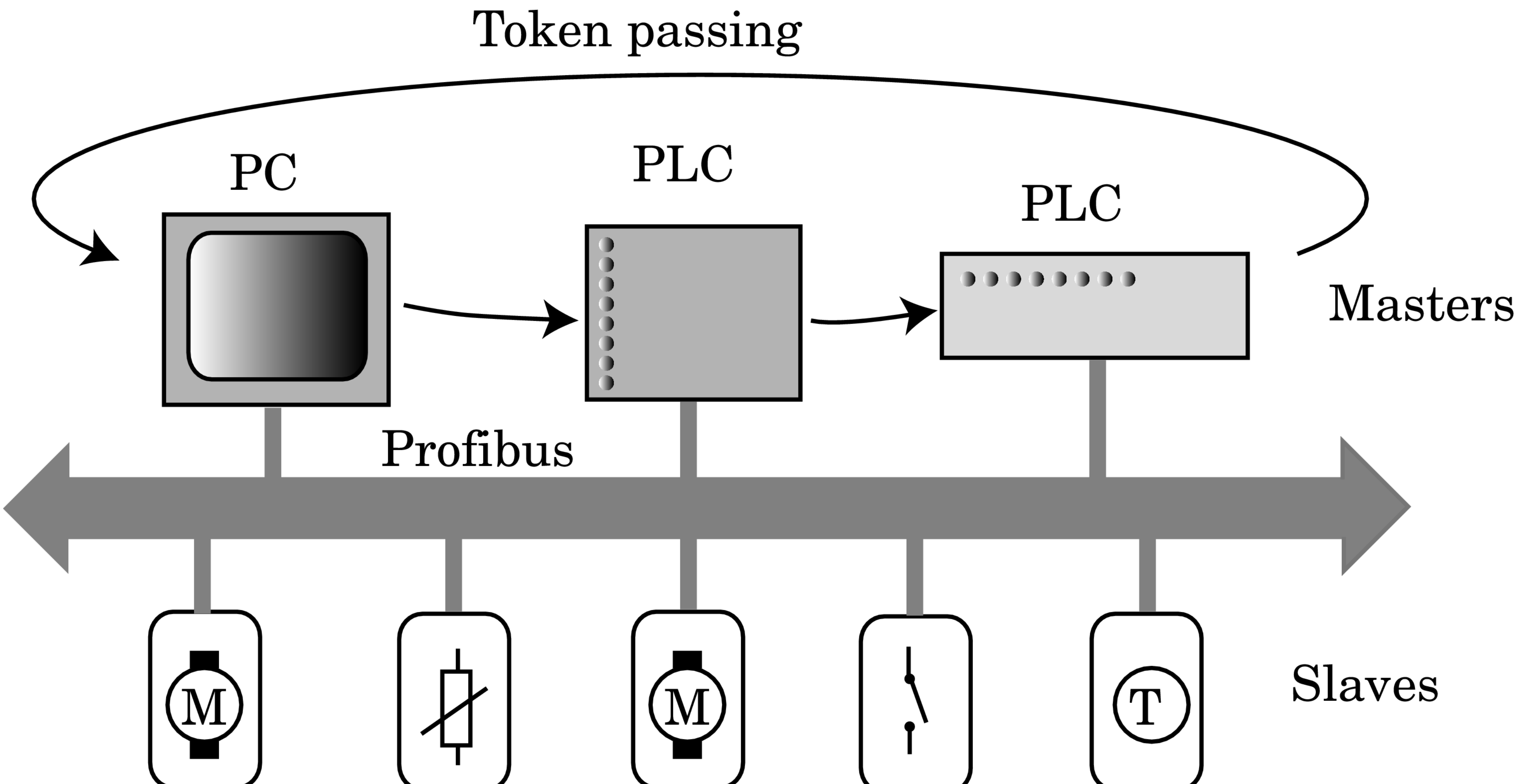
Intermezzo Fieldbus



Producer-consumer network



Profibus



SCADA

- Supervisory Control And Data Aquisition
- Operates at a lower level than tne Manufacturing Execution System (MES)
- Severel commercial solution providers
- Connection with production system generated data
- Control at operator level.

MES (11 tasks)

- Resource allocation
- Operations scheduling
- Dispatching production units
- Document control
- Data collection
- Quality management
- Labor management
- Process management
- Maintenance management
- Product tracking
- Performance analysis

Concepts and hot topics

- What are concepts and hot topics in modern manufacturing?
  - Lean manufacturing
  - Agile manufacturing
  - RMS
  - Personalsing products
  - Short time to market

Lean Manufacturing

- TPS
- What is the product value for the consumer?
- Discover where this value is added during production
- Determine waste in the process, remove it and shorten the duration of lead time
- Apply pull-driven production
- Keep the waste away

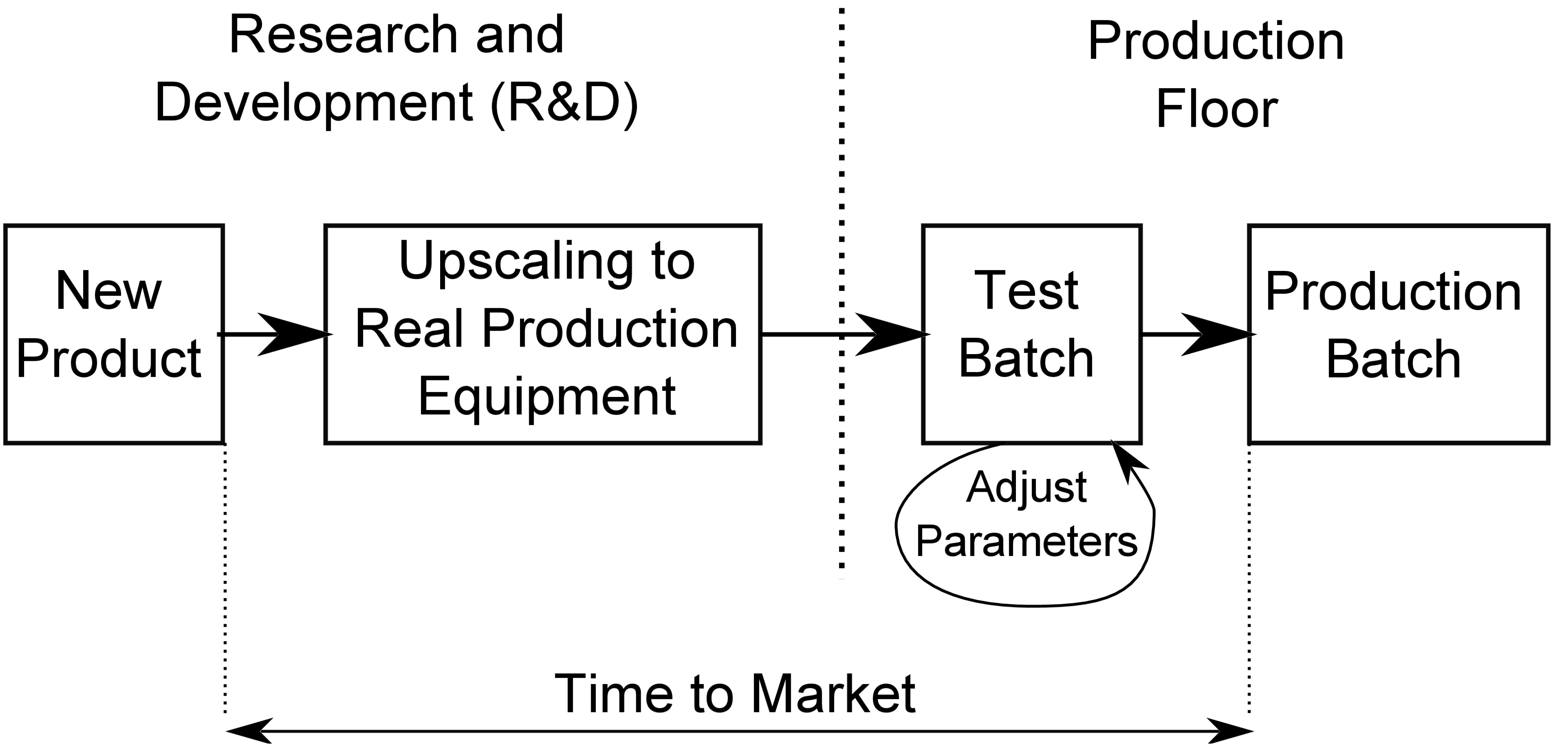
Agile Manufacturing and RMS

- Definition: An agile manufacturing system is a system that is capable of operating profitably in a competitive environment of continually and unpredictably changing customer requirements.
- Definition: A reconfigurable manufacturing system is a manufacturing system that is designed for fast changes, both in hardware as well as software components, in order to quickly adjust production capacity and functionality in response to sudden changes in market or in changes in requirements.

Personalising 1(2)

Personalising 2(2)

Time-to-market



Conclusion so far

- Standard manufacturing automation is mostly based on industrial production (batch processing and continuous processing).
- This kind of manufacturing will not disappear but other solutions might be useful.
- Why is there a need for other solutions?
  - Customers want personalised products
  - New technologies available
  - Short time-to-market needed

Manufacturing 2.0

Summary of presentation by Dr. Hsu-Pin (Ben) Wang, Georgia Tech

http://camls.utsa.edu/faim2014/data/FAIM2014-05-21-Keynote-Manufacturing2.0.pdf

Overview Part 2

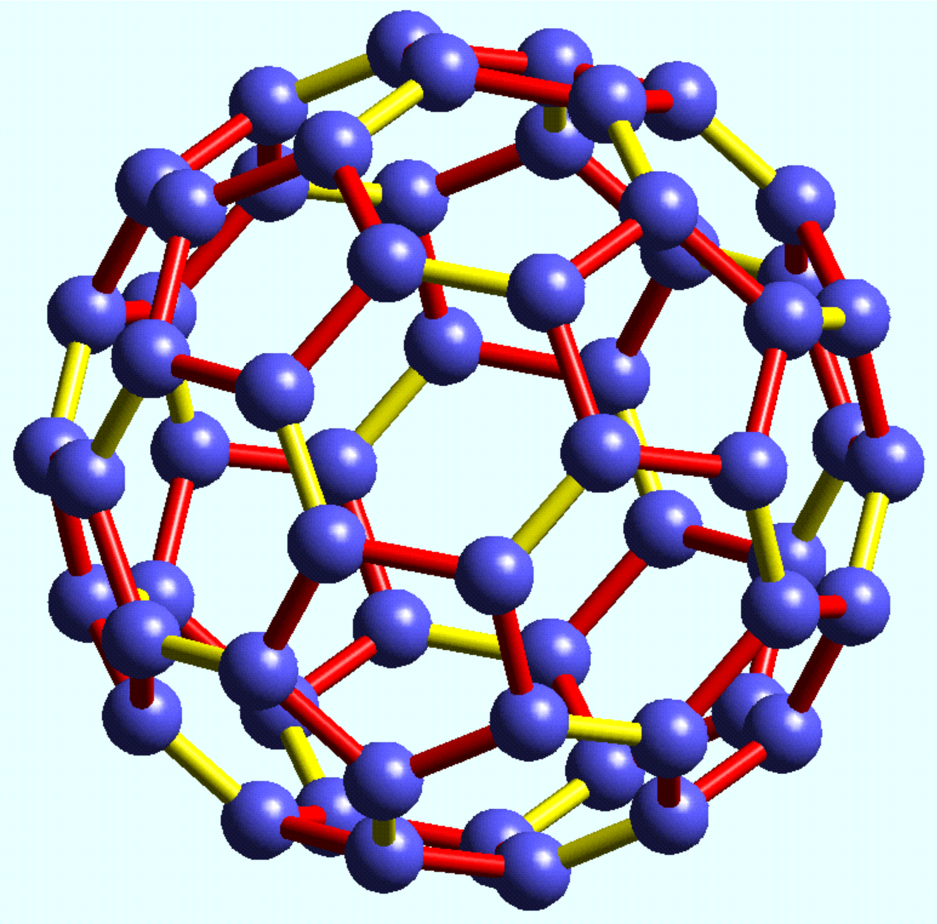
- Research and manufacturing
- New technologies
  - Materials
  - 3D printing
- Conclusion

Some problems

- Innovation chain is not producing results
- It takes too long before new discoveries and materials are introduced and accepted by the industry
- In the current innovation chain there is a gap between the academia and the industry. This so-called valley of death should be bridged by applied research and fast technology maturation.

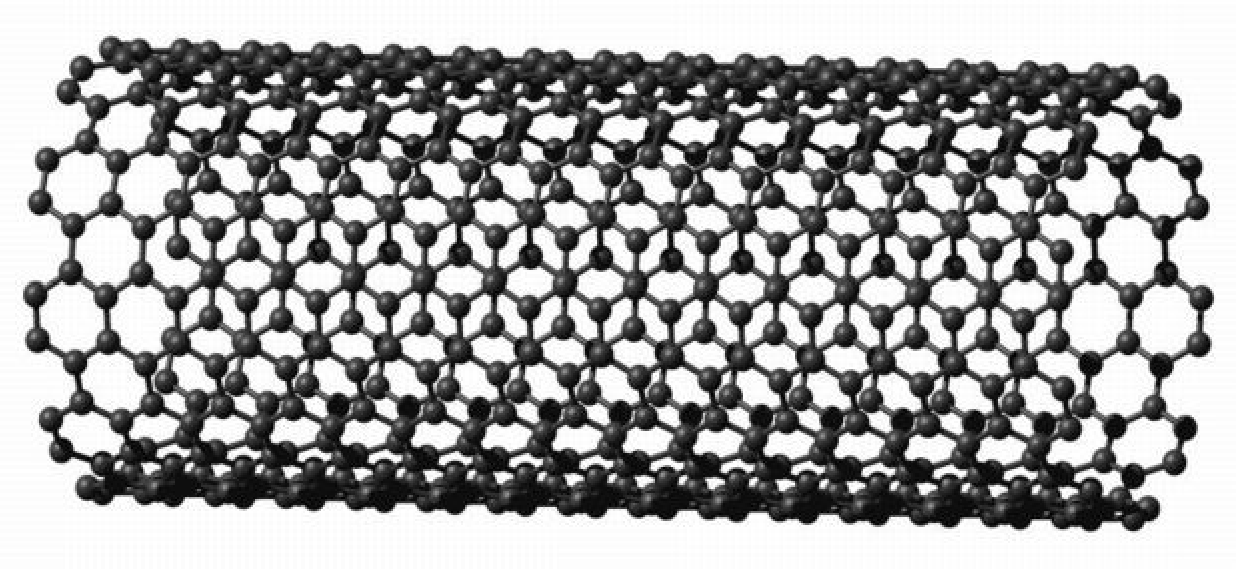
New matarials

- We focus on just one example: C60



Nanotubes

- Based on C60 nanotubes can be made
- Stronger than steel and amazing properties



Buckypaper

- Nanotubes can be used to make buckypaper
- This material will be used in cars, airplanes and many other devices to make them light while keeping them strong and less power consuming

Figure 2. Scanning electron microscopy image of buckypaper (left); 400 foot roll of CNT (right). Source: Nanocomp.

Additive manufacturing

- Additive manufacturing (also known as 3D printing) is one of the new revolutions in the production industry.
- Industrial 3D printers are still much more expensive than the 'toy' devices offered to the public, but they can produce amazing results.
- Plastic printing, ceramic printing, metal printing and printed electronics are possible.

New opportunities

- Mass customization
- Variable lot size down to one
- On demand manufacturing
- Tool-less manufacturing
- Expanded design space

Conclusion

- To make these opportunities possible, research has to be done.
- New manufacturing paradigms should be developed

Agile agent-based manufacturing

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Overview of part 3

- Agent-based manufacturing
- Production grid
- Product flow in the grid
- Grid adaption
- Results

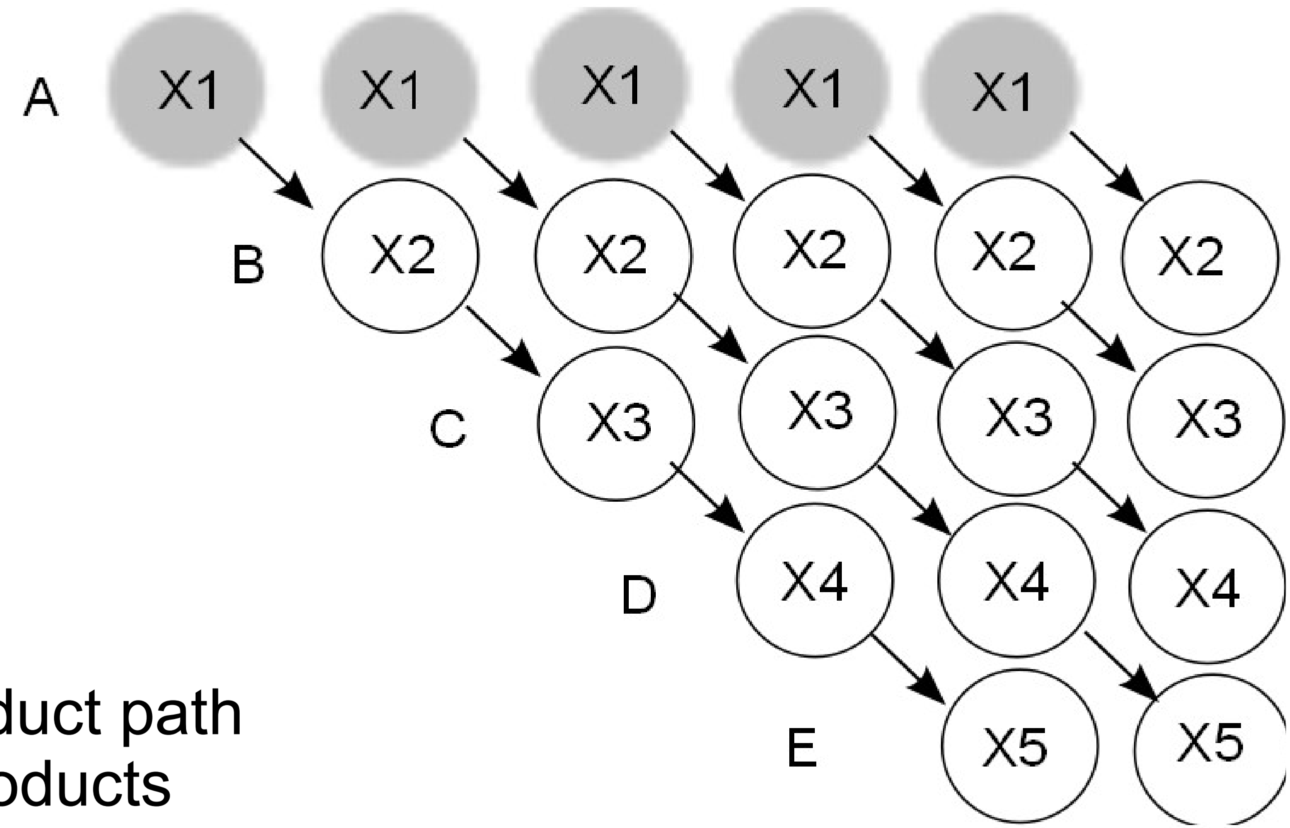
Manufacturing Challenges Resumed

- Short time to market
- Customer specific products
- Small quantities

Grid production

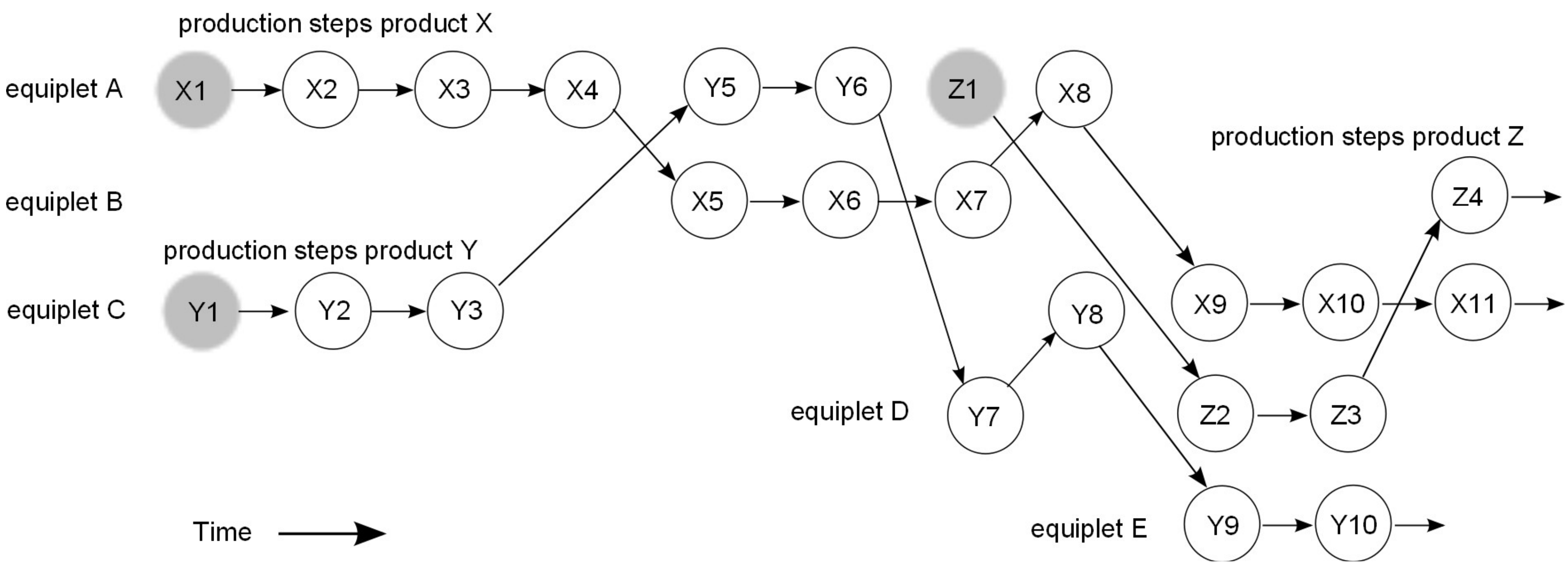
- Based on a grid of versatile production platforms (called equiplets)
- Agile and scalable software infrastructure

Classic pipeline production



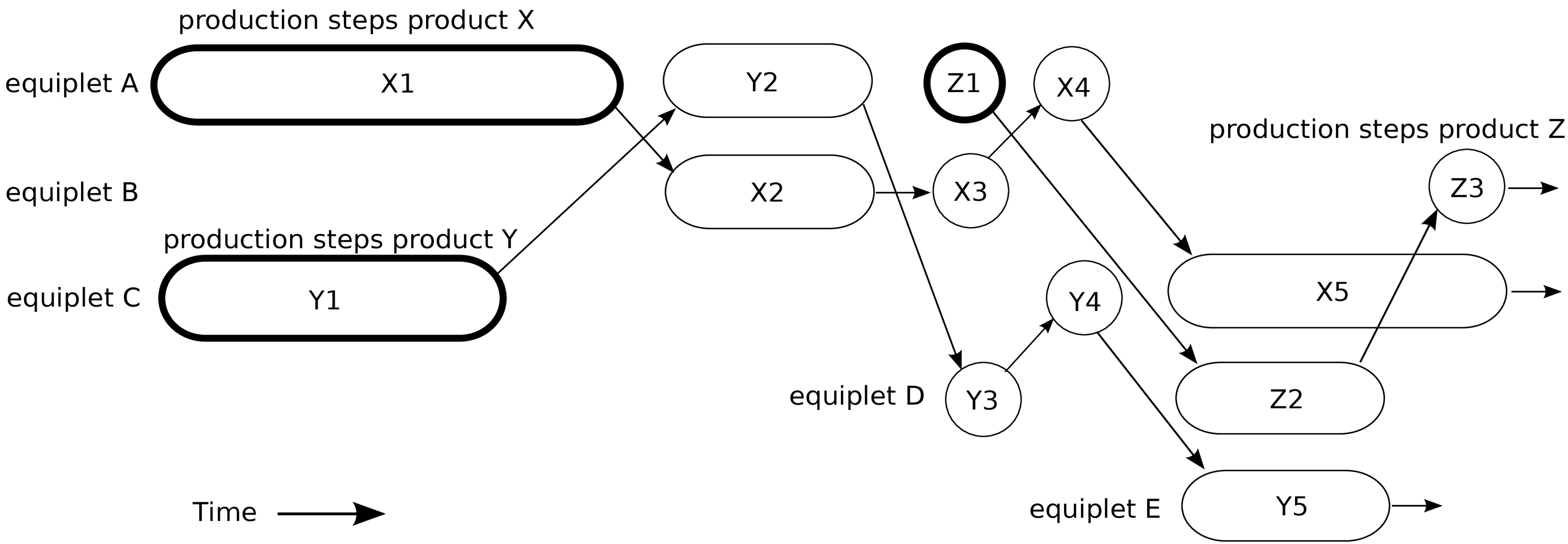
Fixed product path
Similar products
Huhge batch size

Grid production 1(2)

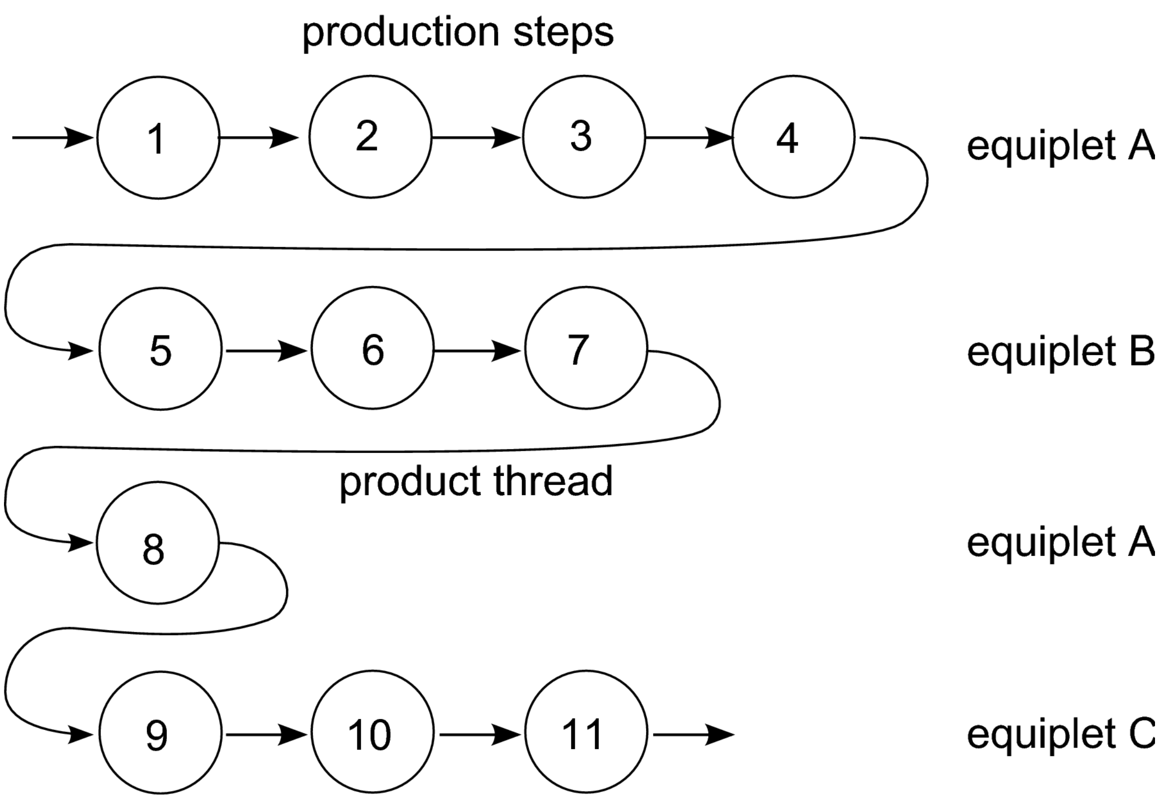


Different product paths (product threads)
Different products (multi parallel production)
Small batches or single product manufacturing

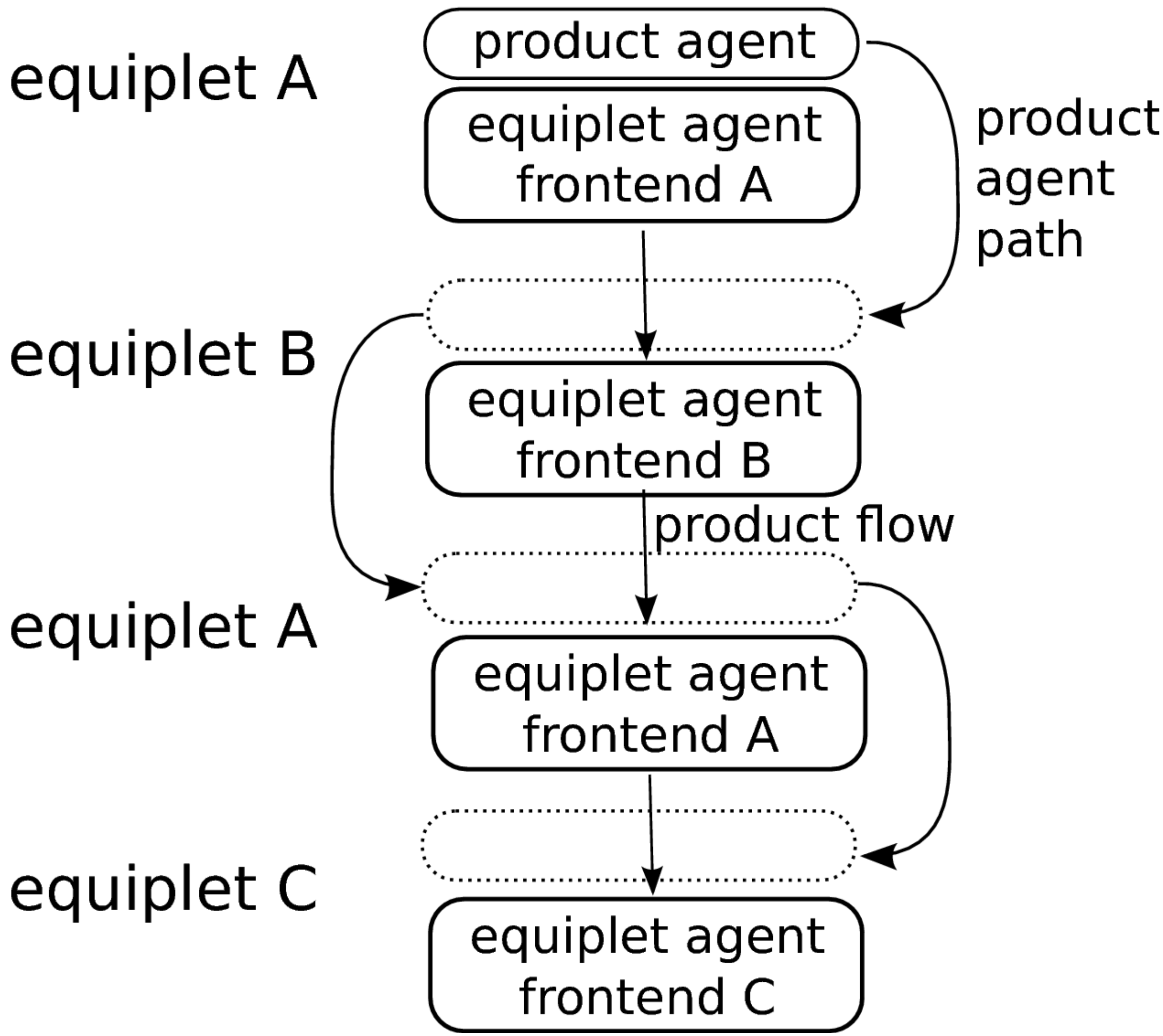
Grid production 2(2)



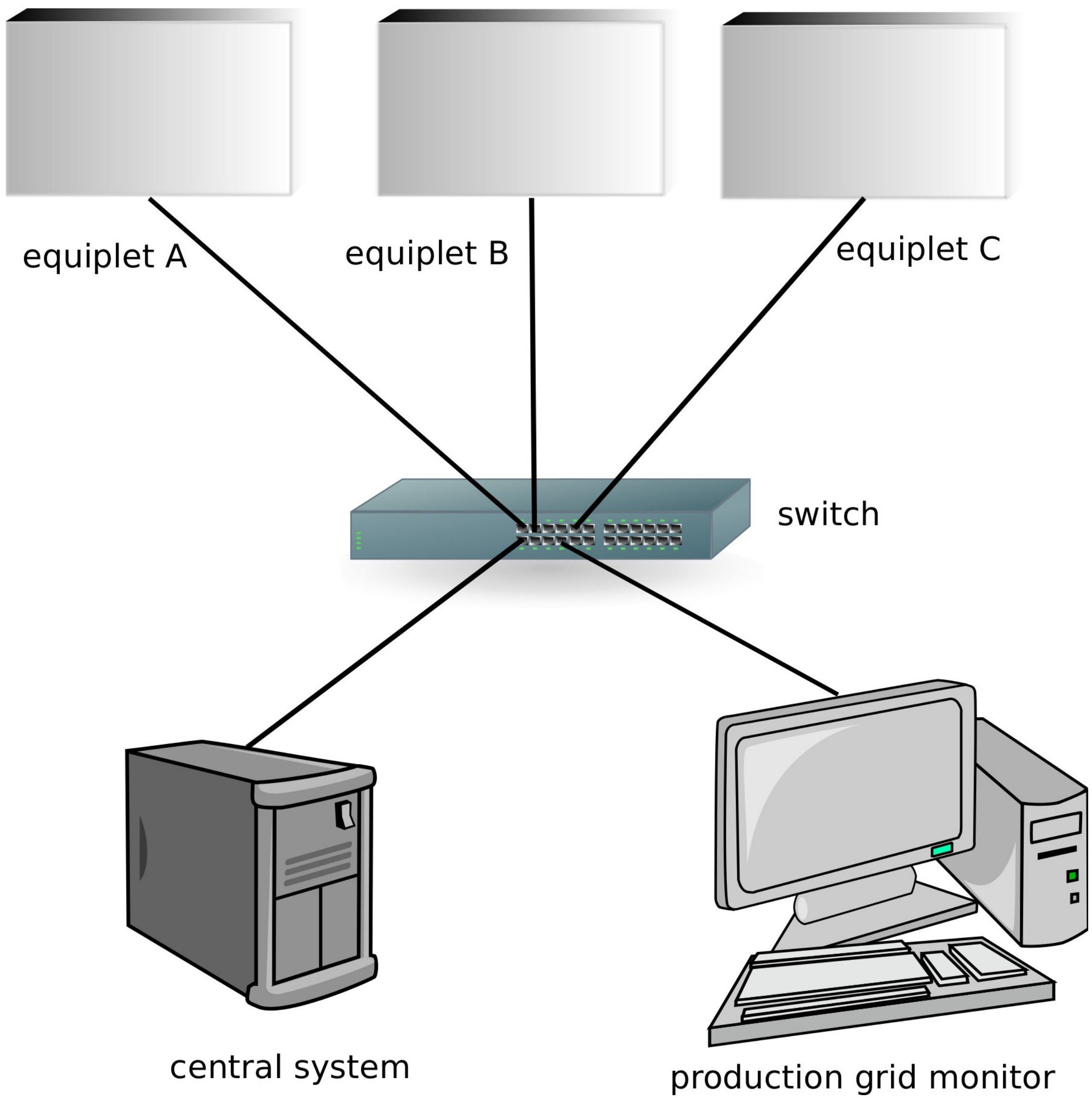
Example of a product path



Product agent and equiplet agents

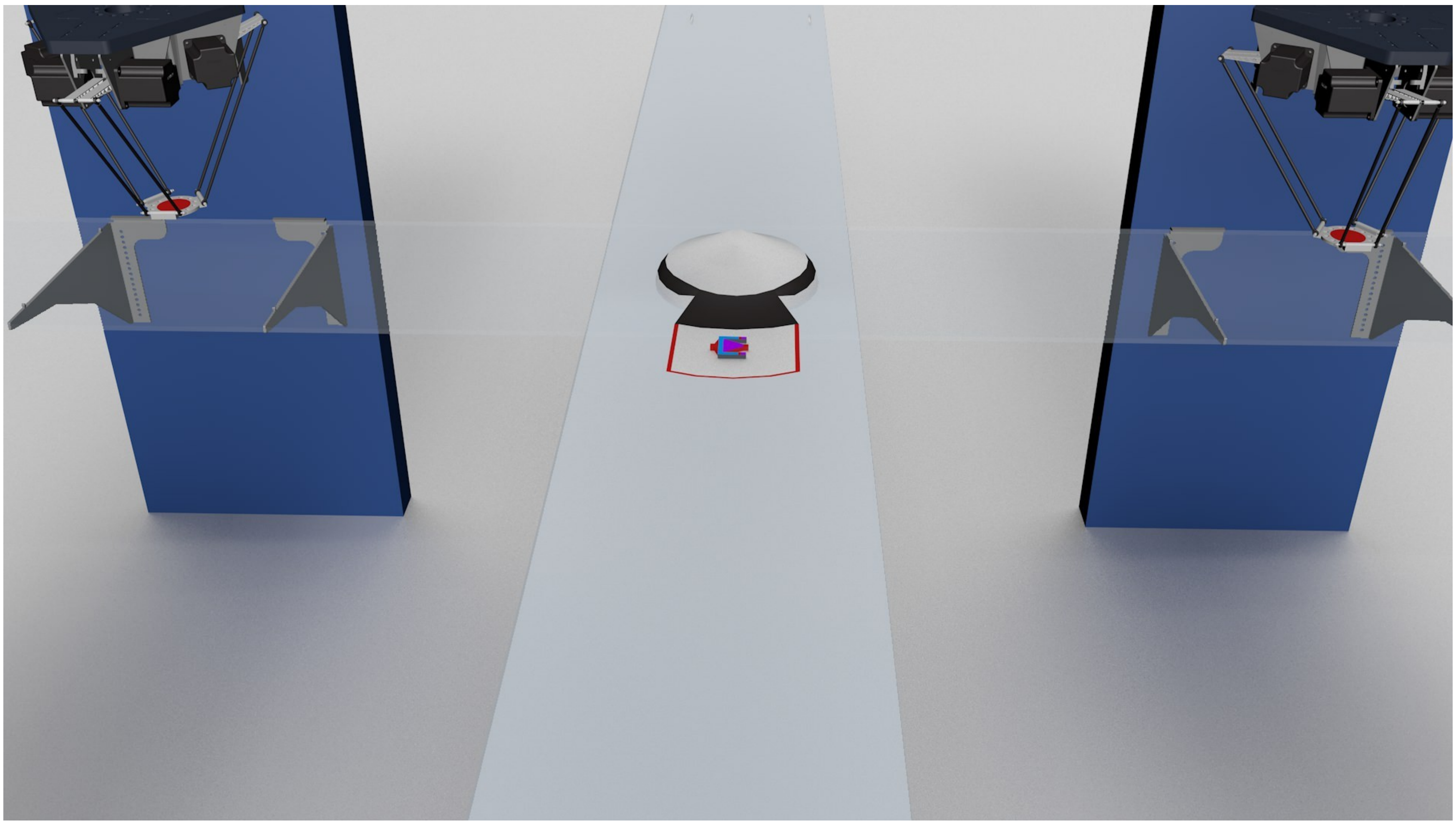


Grid production

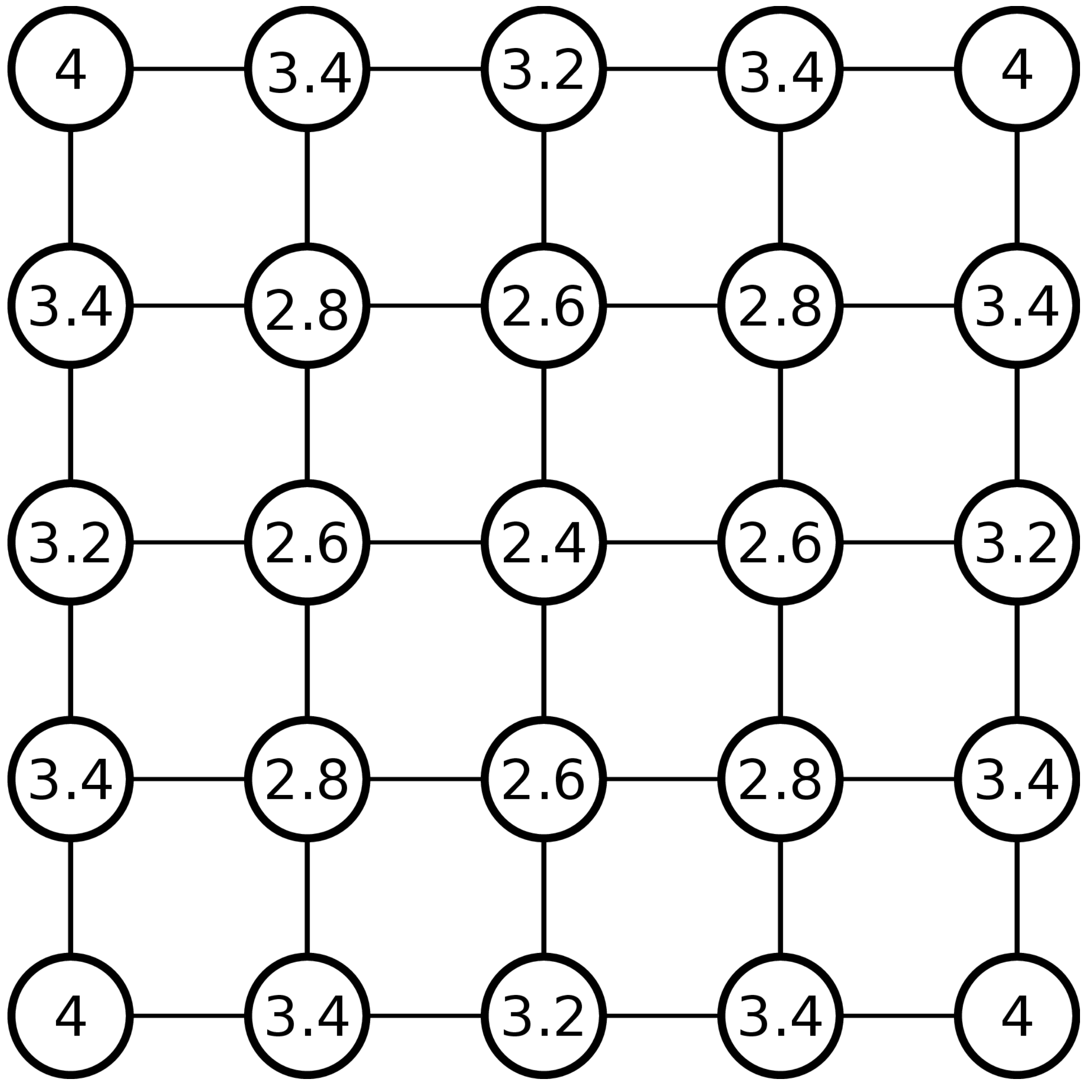


Equiplets with different frontends

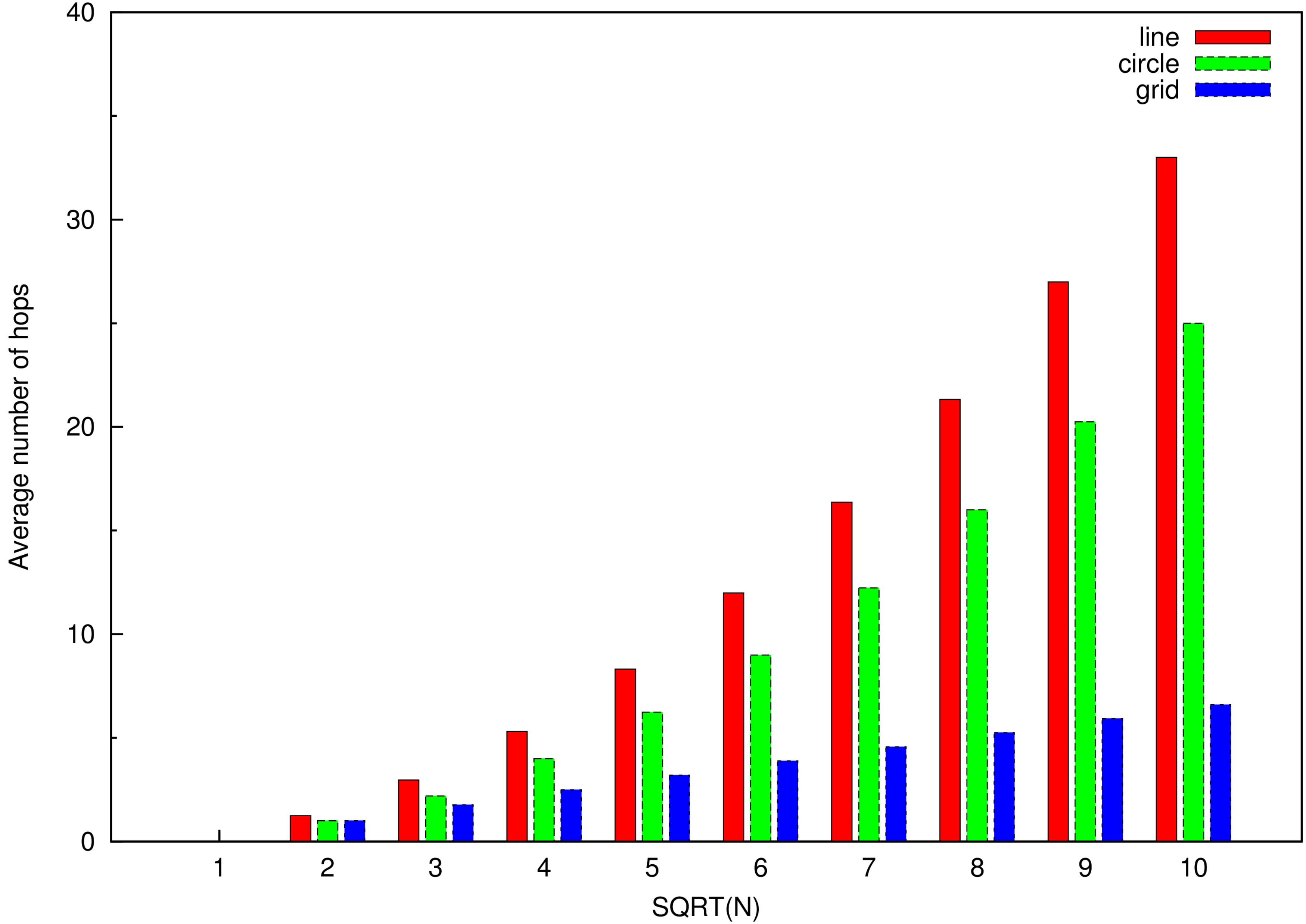
Impression of grid manufacturing



Grid with distances



Grid versus Line versus Circle



How things are made

- Single product (unique, tailor made)
- Continuous production (chemical industrie)
- Batch production (food, consumer products, industrial products)

- Both continuous and batch are considered industrial production

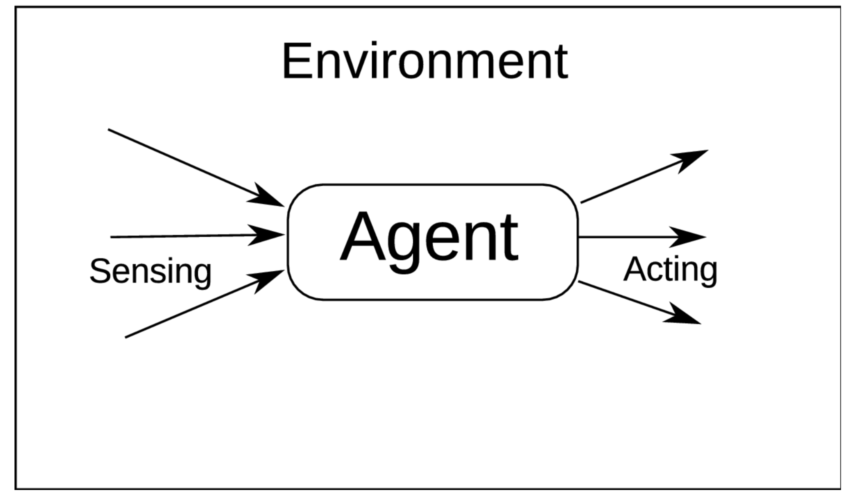
ICT infrastructure solution

- Every product is (possibly) unique
- Every product has its production steps
- Distributed system

- A product agent **represents the product** and knows **what** (production steps) to do
- An Equiplet agent **represents the equiplet** and knows **how** to do (certain production steps)

Agents

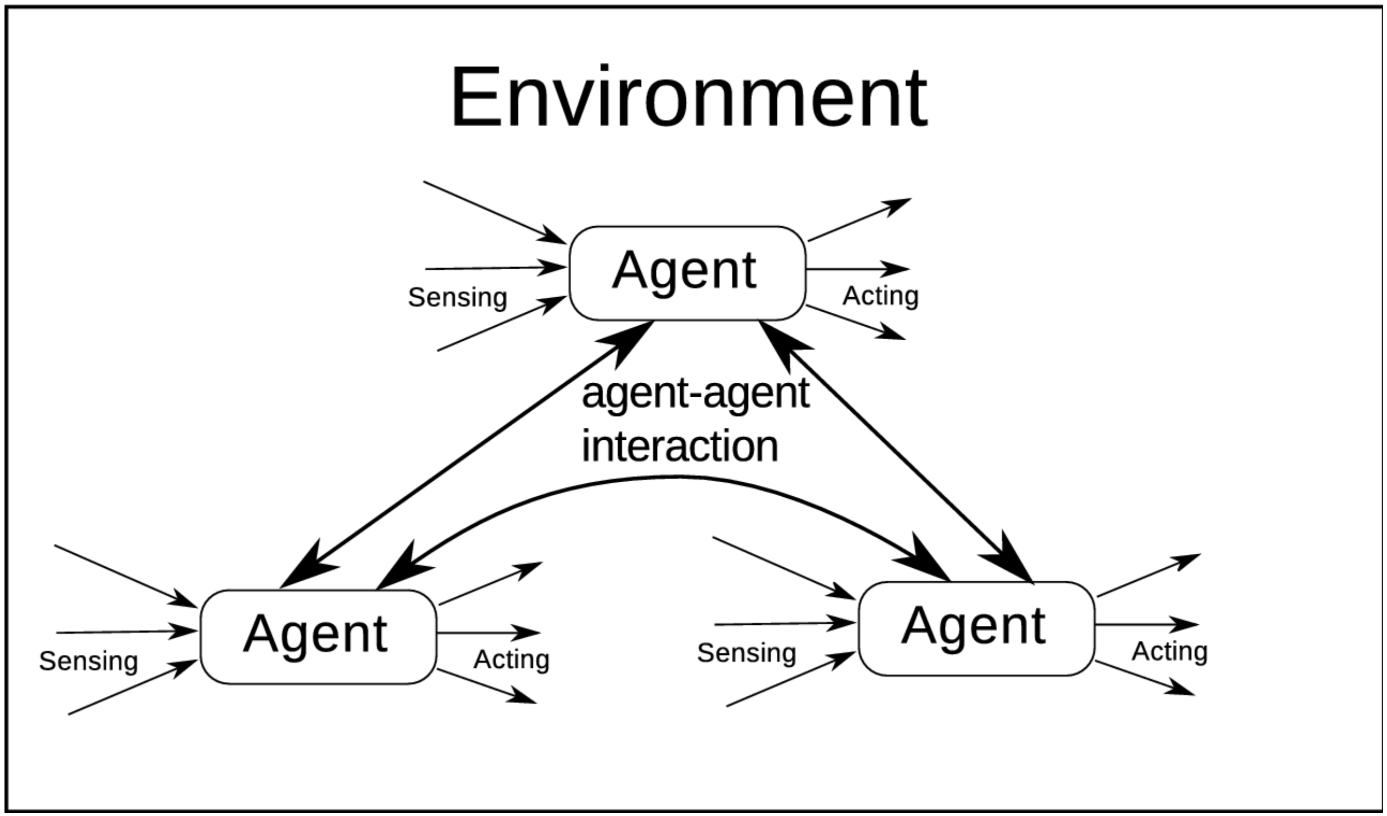
- Autonomous systems
- “Living” in an environment
- Sensing, acting, reacting



Definition by Wooldridge and Jennings:

“An agent is a computer system *that is* situated *in some* environment *and that is capable of* autonomous action *in this environment in order to meet its* design objectives*”*

MultiAgents



- Interacting agents
- Roles, communication
- Cooperation, negotiating

Multiagent production 1(2)

Equiplet agents publish their production steps on a blackboard

Product agents choose the equiplets and make reservations for these equiplets

Product agents negotiate to find a solution in case of scheduling problems

Product agents collect production information to build a product log.

Multiagent production 2(2)

Equiplet agents have a frontend (thus a set op production steps)

Equiplet agents publish these production steps on a blackboard

Equiplet agents wait for product agents to arrive

Equiplet agents send production information to product agents when performing a production step

Problems to be solved

Path planning

Production scheduling

Product logging

Transport (materials and products)

Error recovery

Software architecture

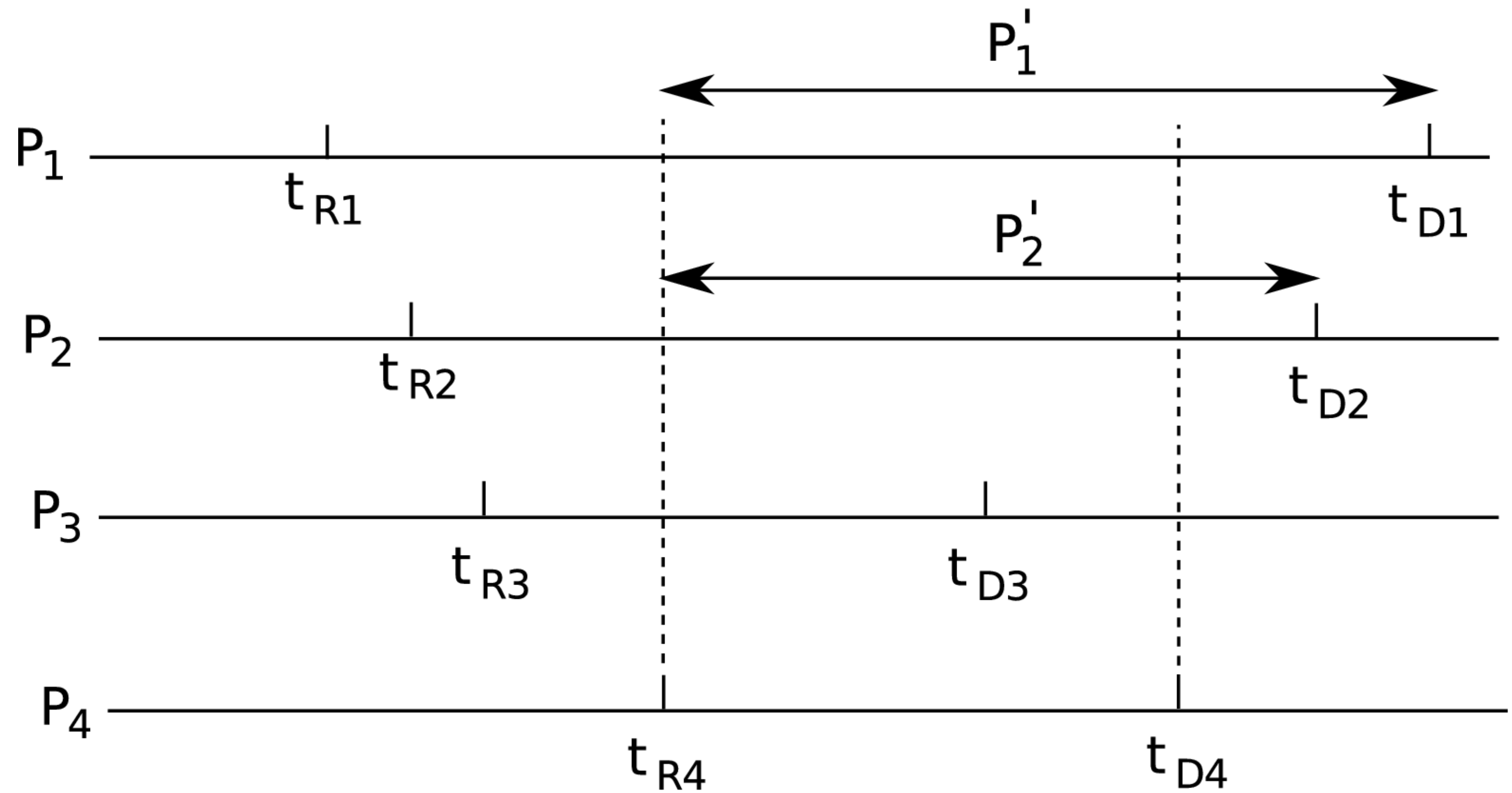
Path planning

- Choose a path with a minimum of hops
- Avoid overloaded equiplets
- Avoid erroneous equiplets

Scheduling

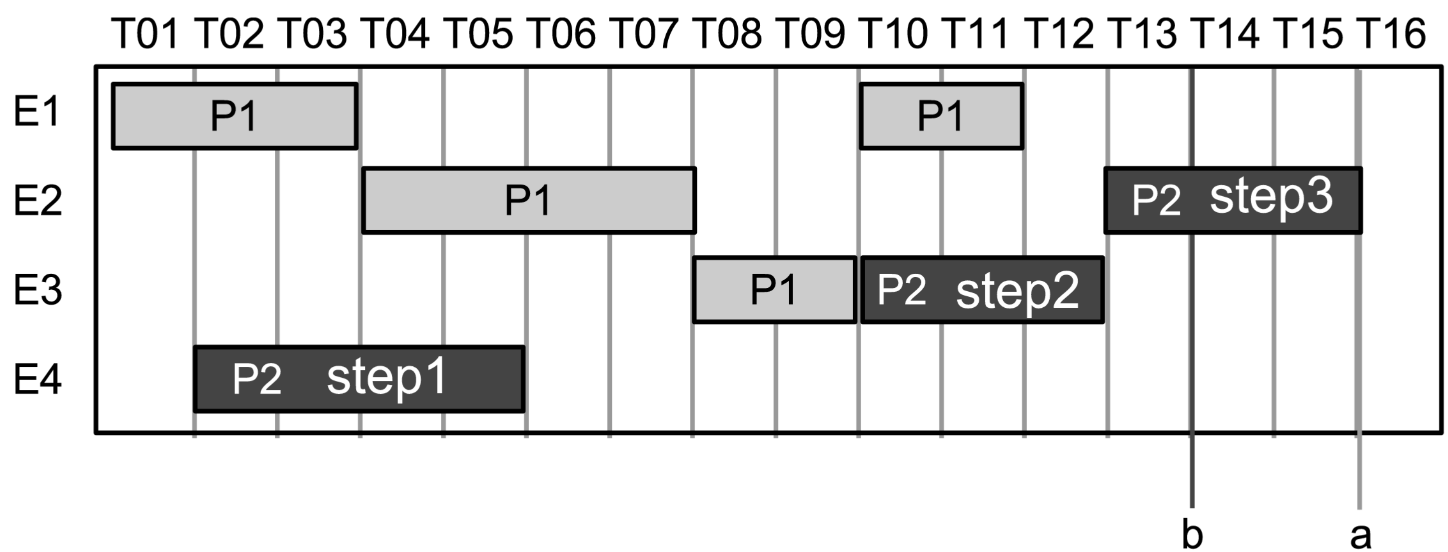
- Based on Realtime OS scheduling (single resource)
    - SPF (shortest process first)
    - EDF (earliest deadline first)
    - LSF (least slack first)
- Multi-agent based issues (multiple resources)
    - Weak versus strong
    - Low overhead / Fast
    - High grid load

EDF scheduling approach



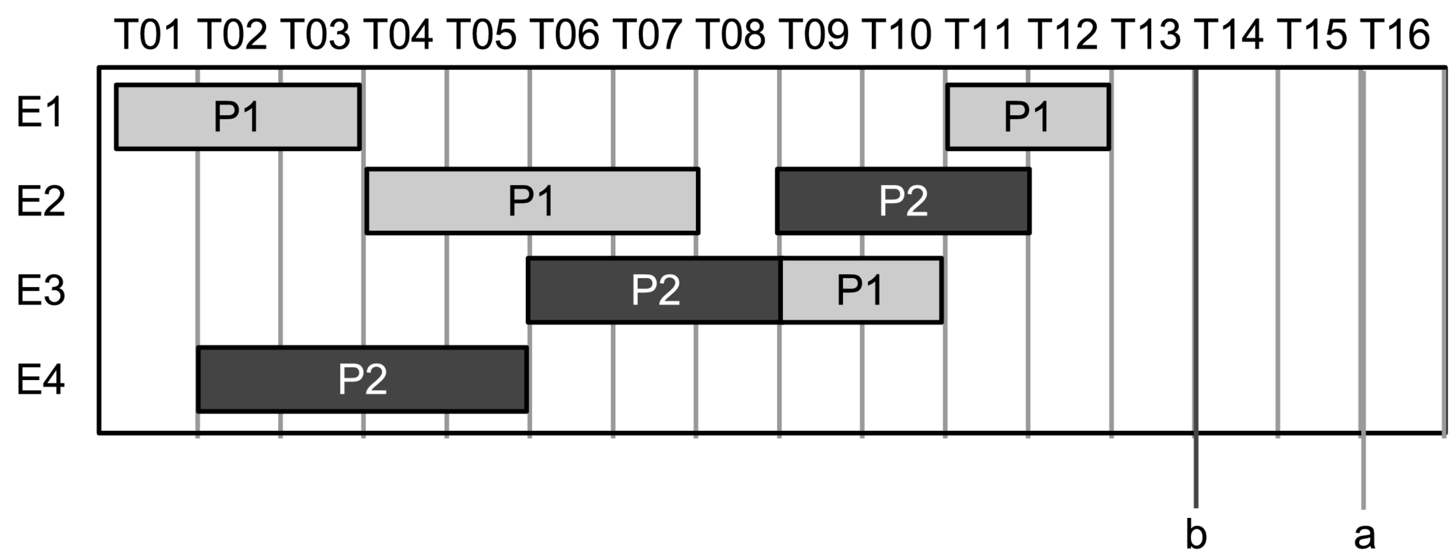
Example of a missed deadline

Missed deadline (b) for product P2

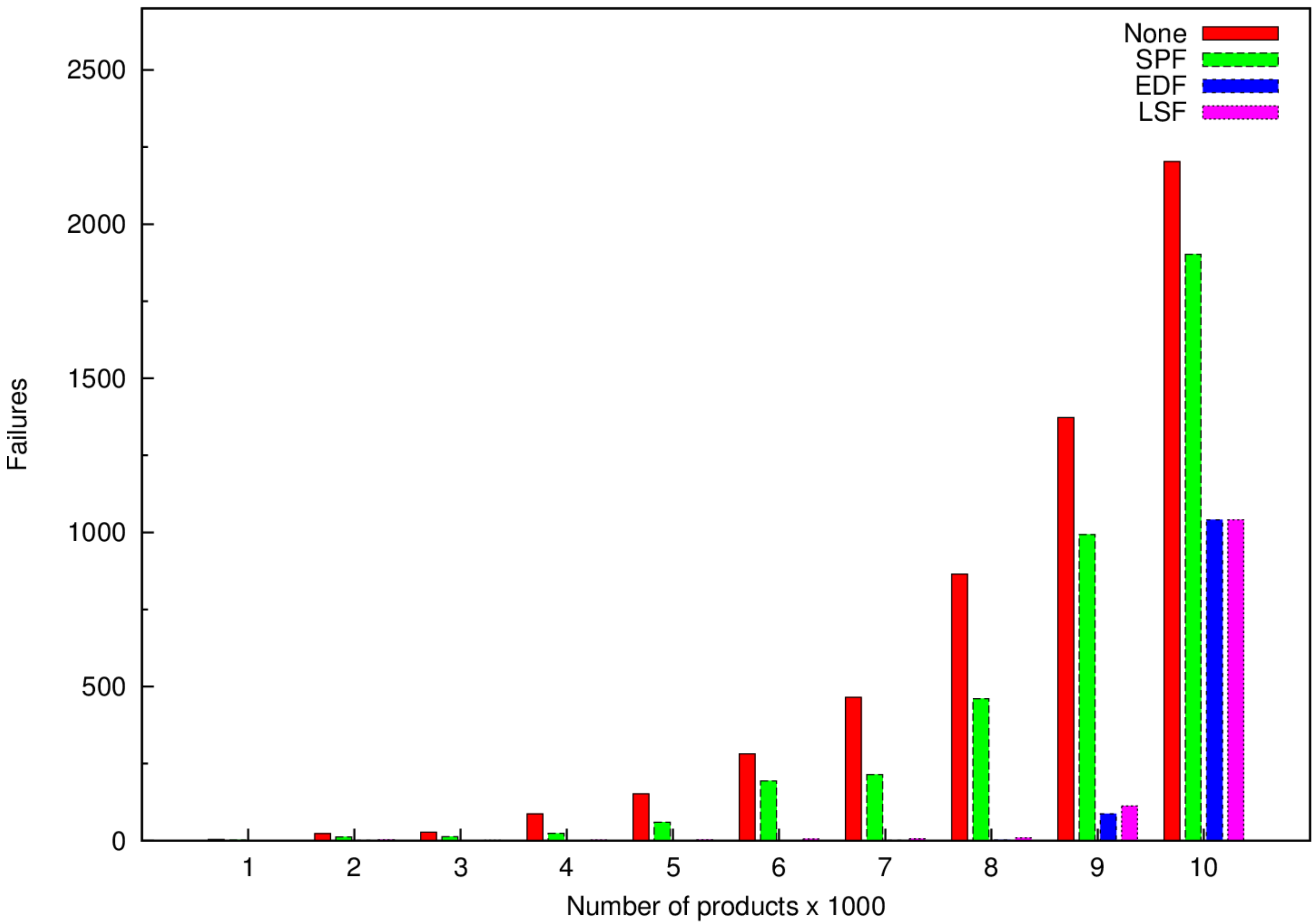


Solution using EDF

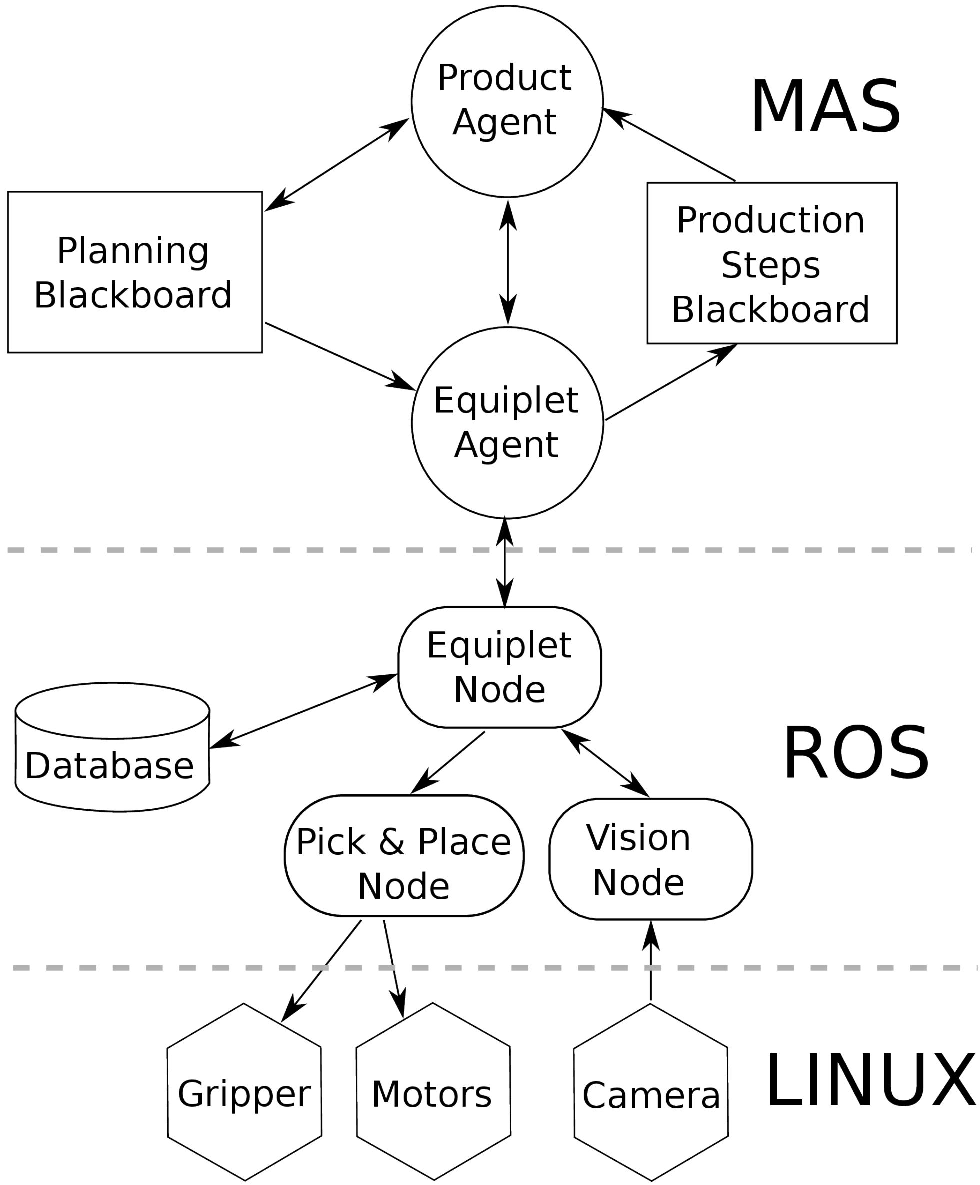
Feasible scheduling solution for both product P2 and P1 after rescheduling using EDF



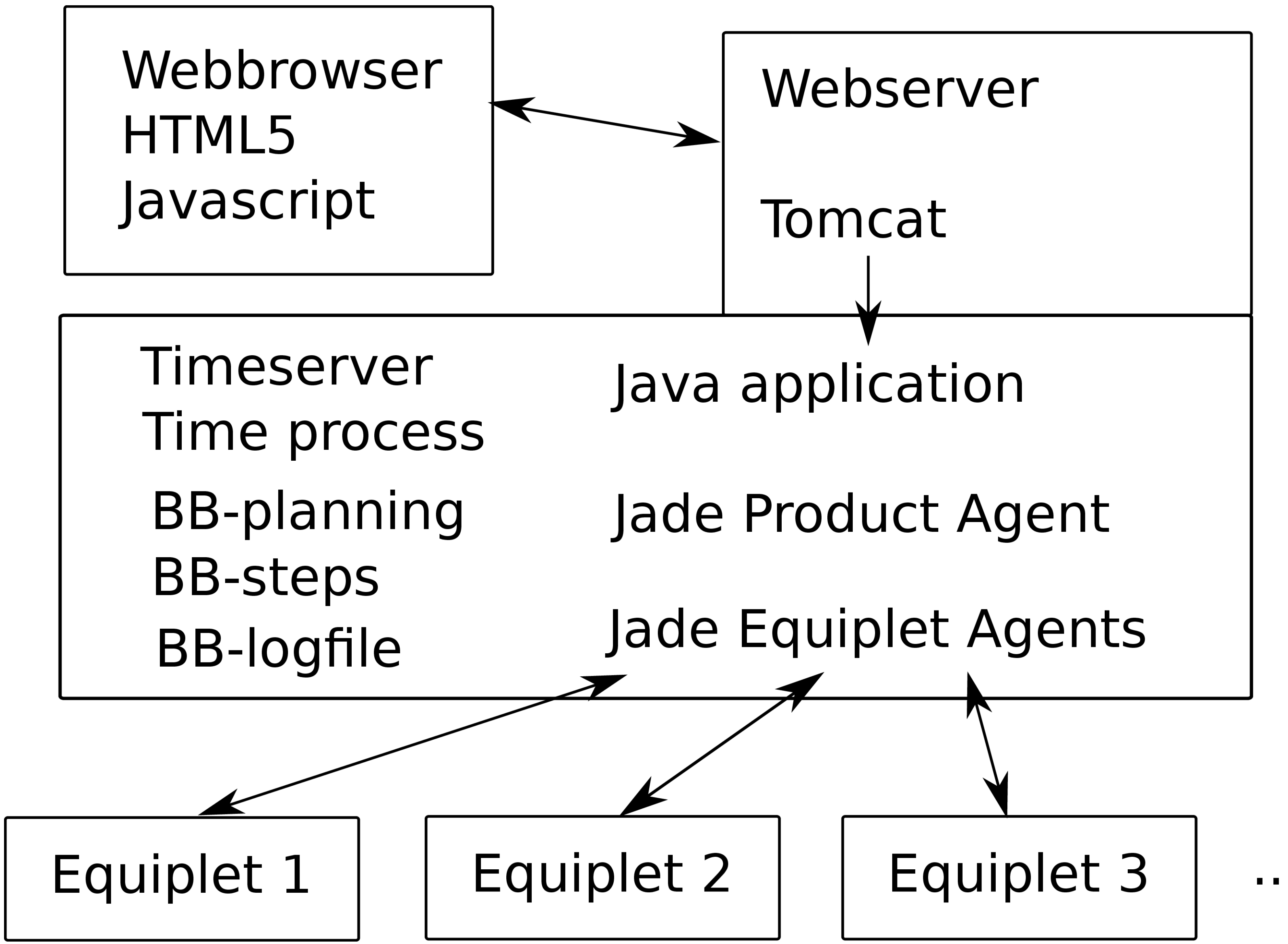
Comparison of different scheduling types



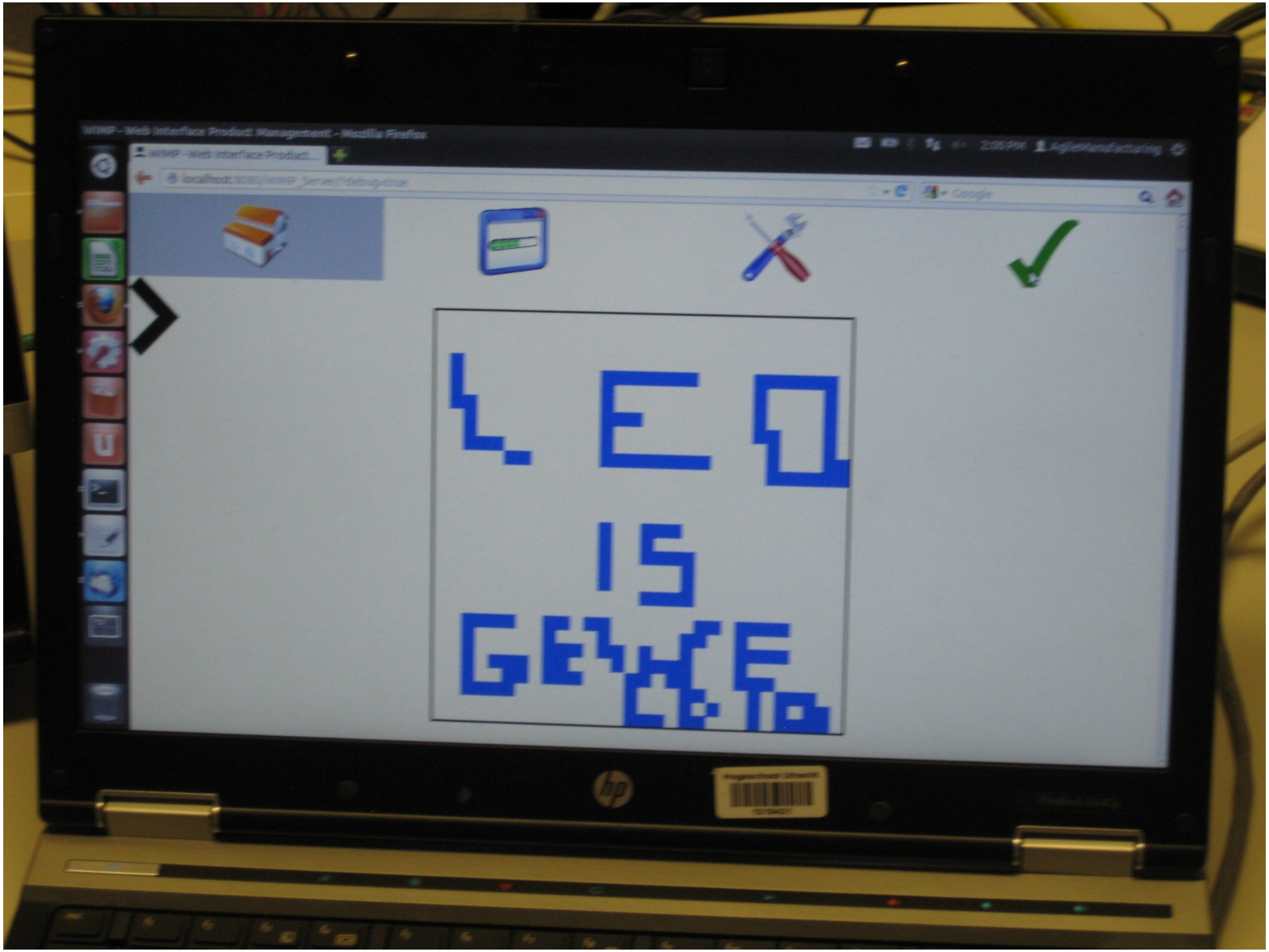
Architecture



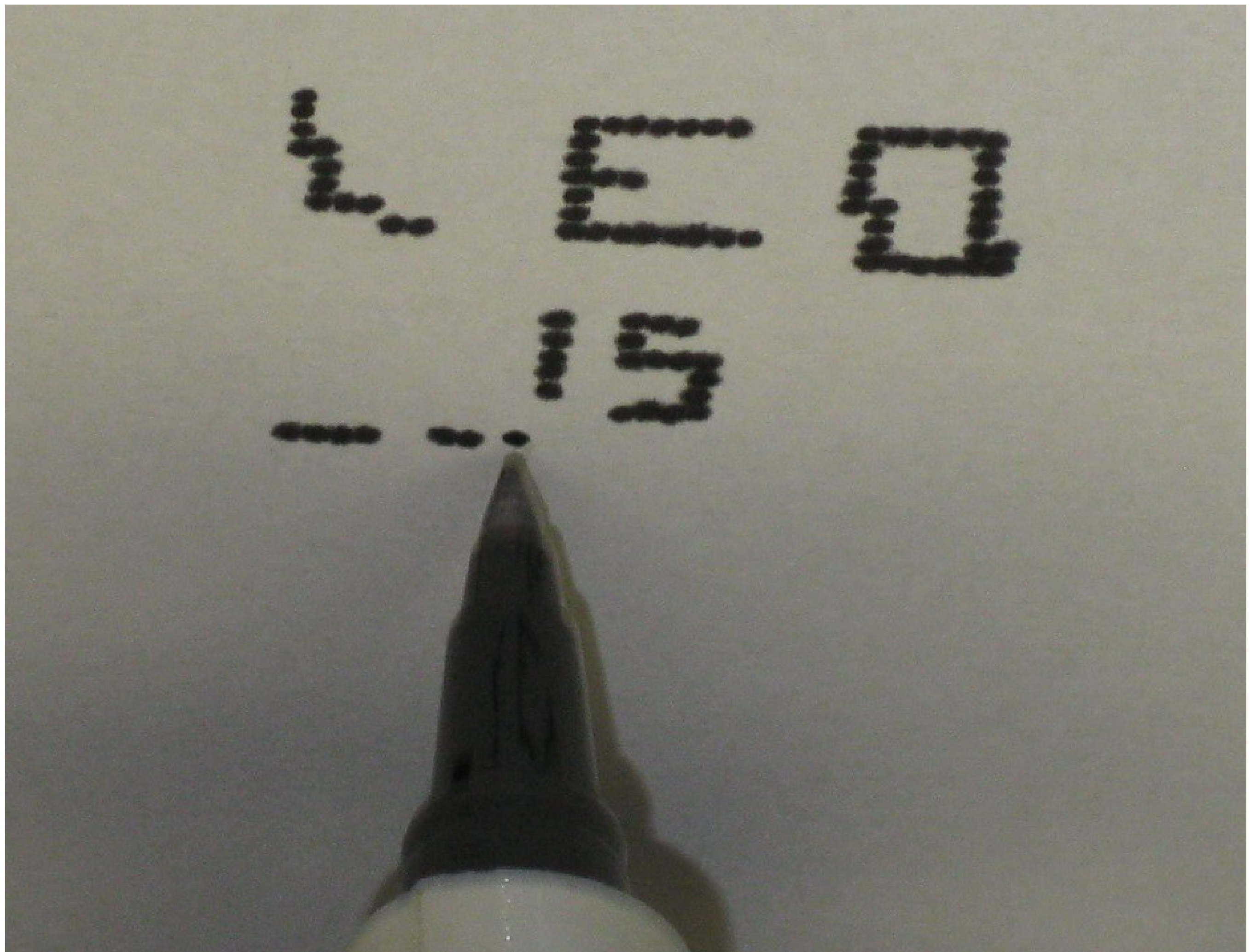
Implementation



Web interface



Result

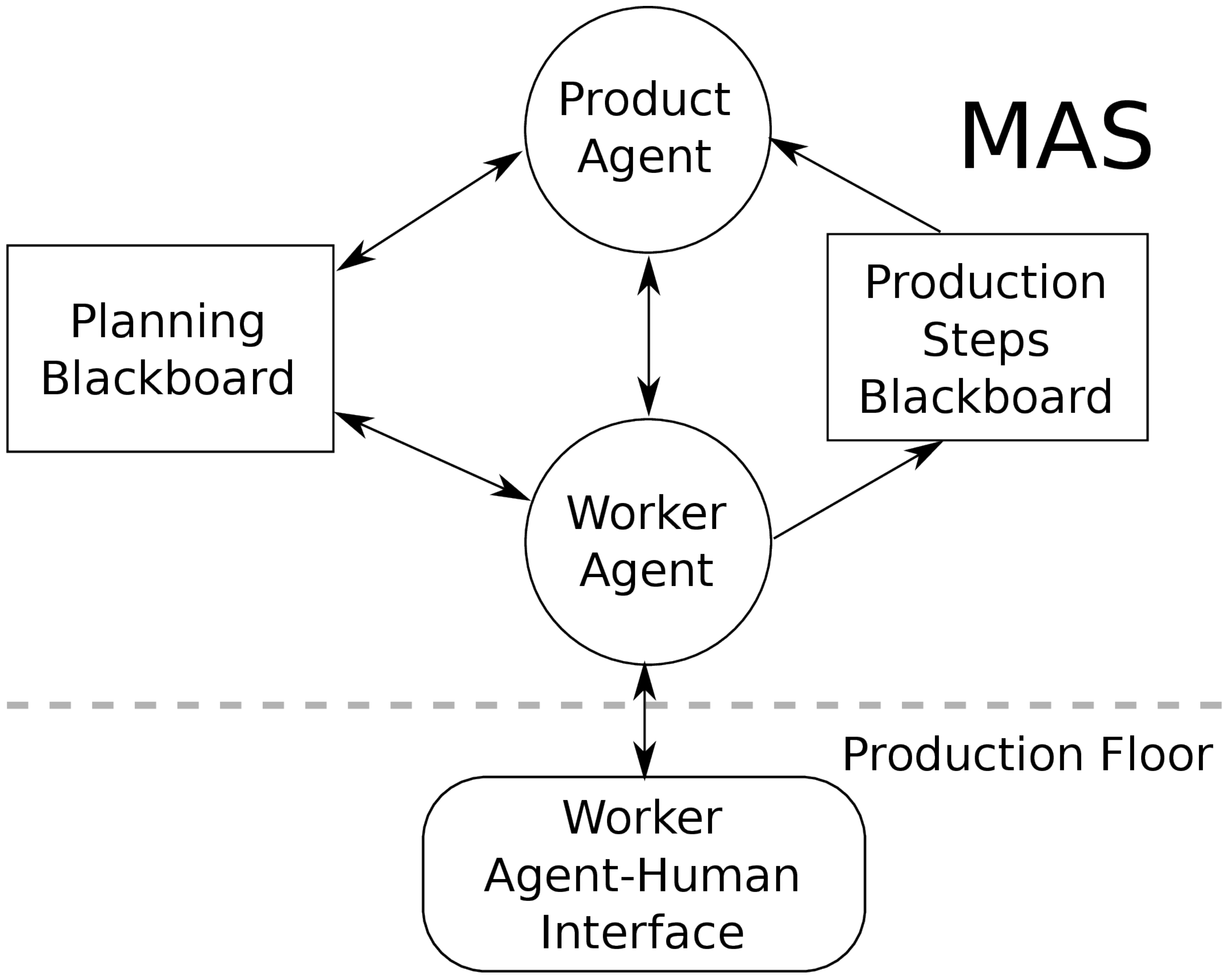


Using this model in a hybrid environment

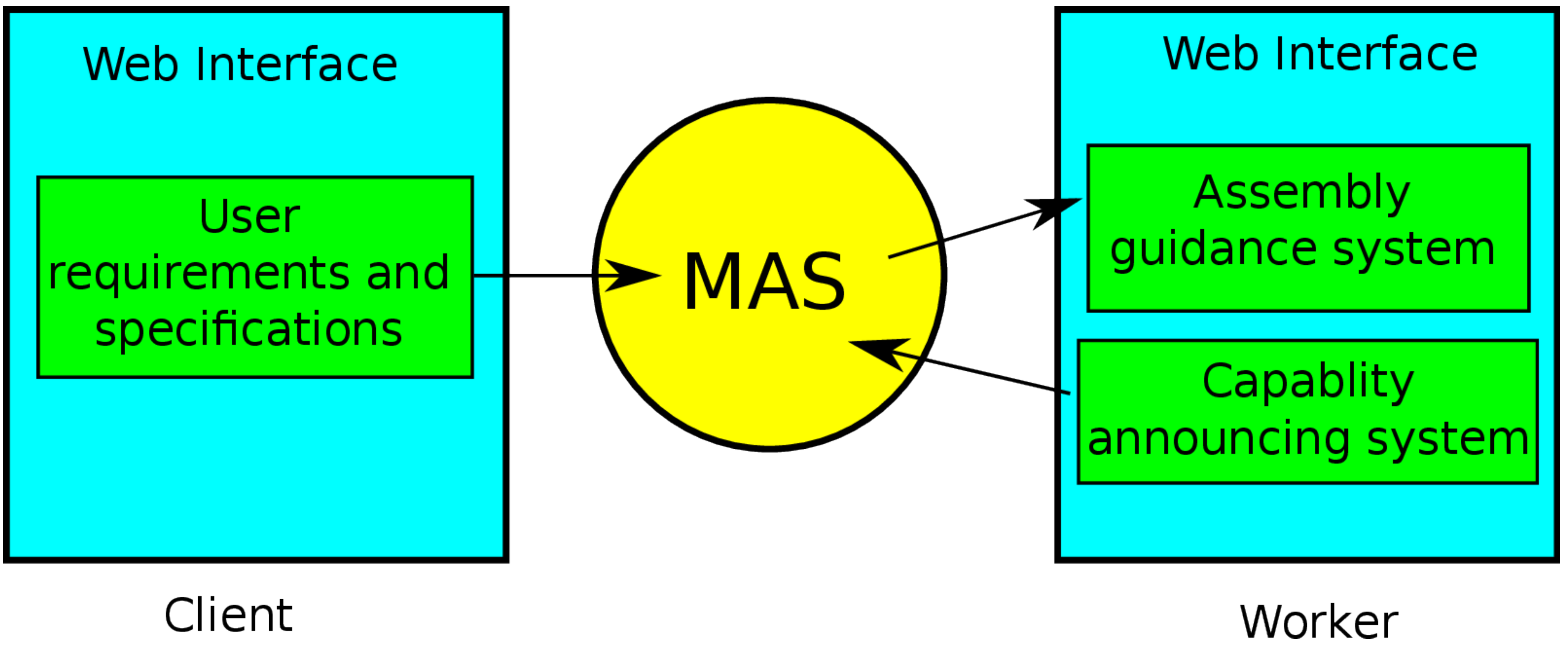
- **What to do** versus **how to do**
- This model can also be used in the situation of human workers instead of equiplets.

- A product agent **represents the product** and knows **what** (production steps) to do
- A worker agent **represents the human worker** and knows **how** to do (certain production steps)

Hybrid architecture



Implementation



Conclusion

The concept has been implemented in an experimental setup

Agent technology fits well to a distributed infrastructure

Concept can be the basis of product agents in the life cycle of a product

The product agent is a good candidate to represent the product in the Internet of Things

Agent-based Product Support

Leo van Moergestel

Overview part 4

- Life cycle of a product
- Roles of the product agent in different phases
- Implementation in a demo system
- Recycling and repair
- Conclusion

Life cycle of a product

- Design
- Manufacturing
- Distribution
- Usage
- Recycling

Note: the product life cycle is a different concept

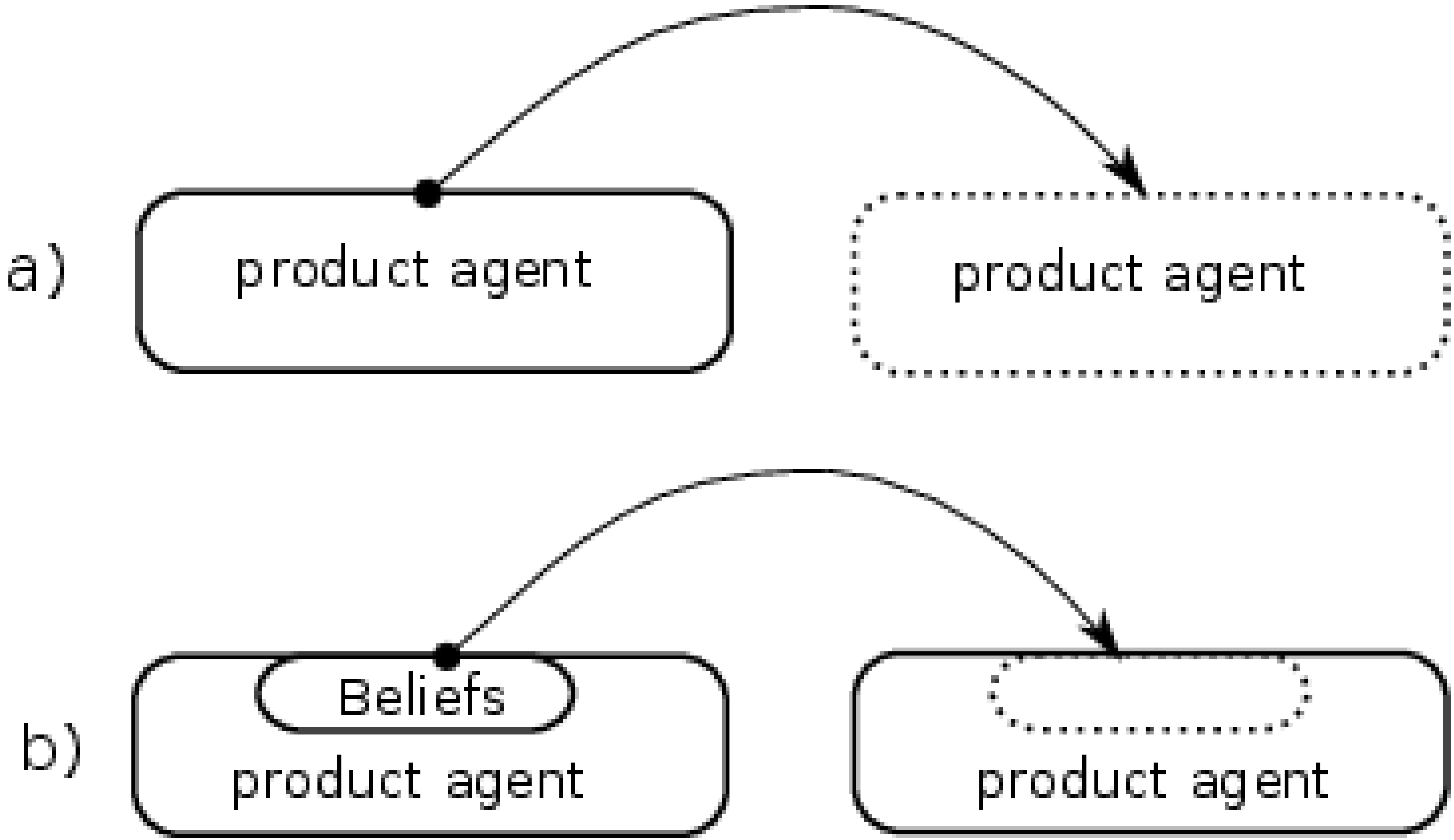
What to do with the product agent when the manufacturing is done?

- Embed the agent with its information in the product
- Or transfer the information to another embedded agent
- Keep the product agent alive in cyberspace

Benefits of embedded agents

- Depends on the phase in the life cycle
- All information about a specific product is availabe
- Basis for implementing the Internet of Things

Embedding a product agent



Logistics / Transport

- Monitor handling during transport
- Monitor temperature, humidity etc.
- Localize the product
- Arrange transport

Use phase

- Monitor the usage
  - Advice the end-user
  - User manual
- Alert end-user
- Check subsystems

- It all depends on the type of product, what should be done

Recycling

Show the re-usable subsystems

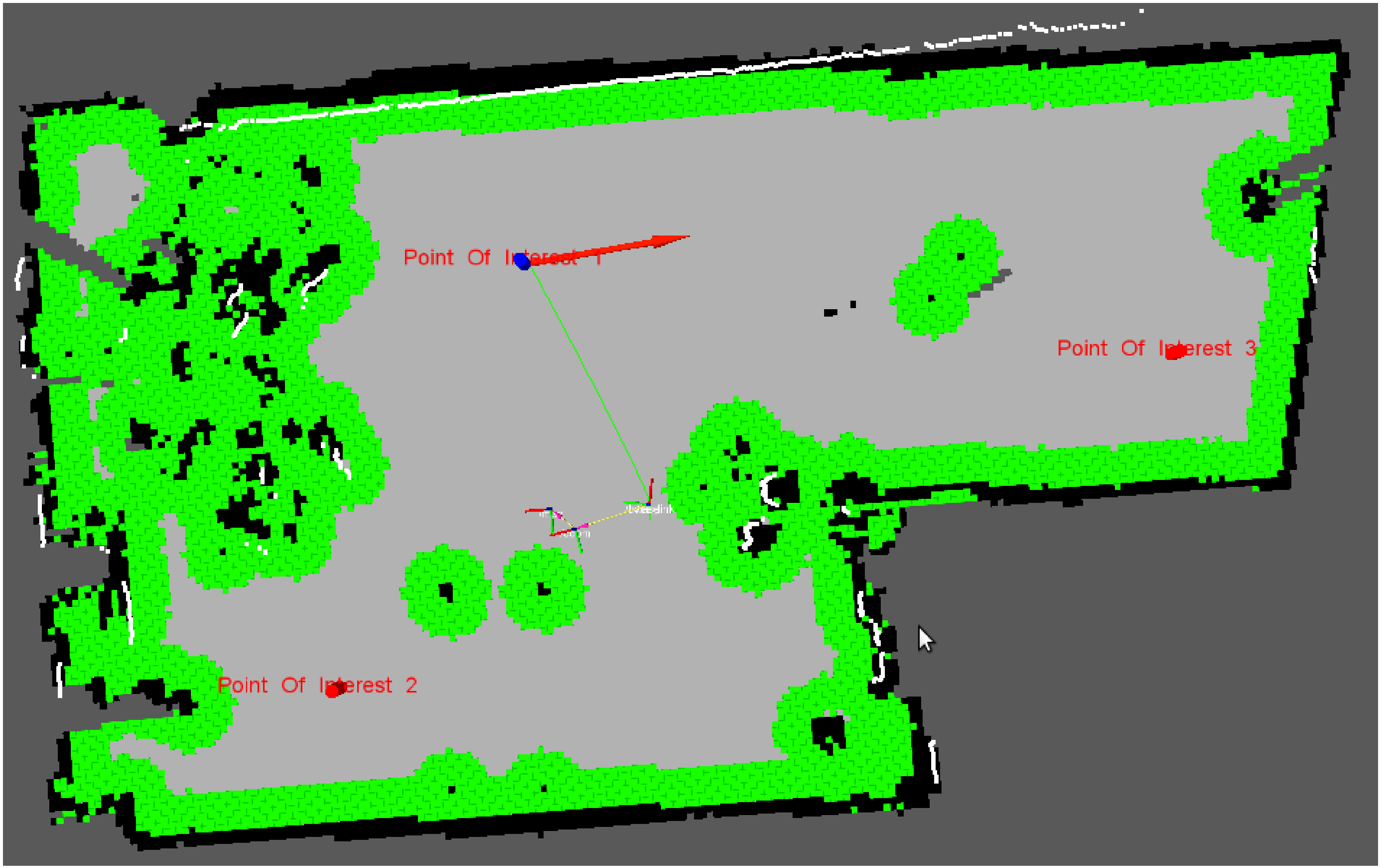
Show the position of re-usable materials

Participate in a trading market for used subsystems

ADRIE

Autonomous Discovery Robot for Indoor Environments

Mapping an indoor environment



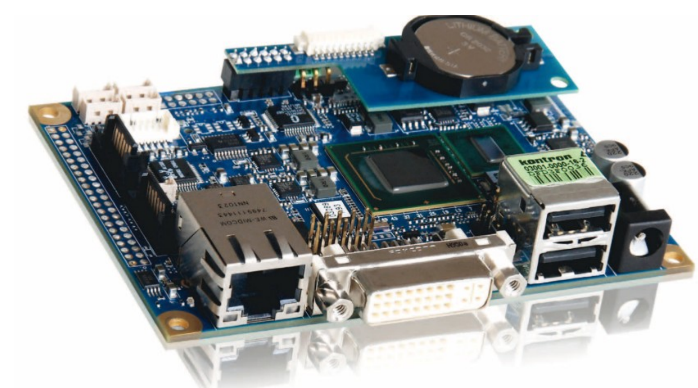
Layered Architecture

Global planning

Mapping

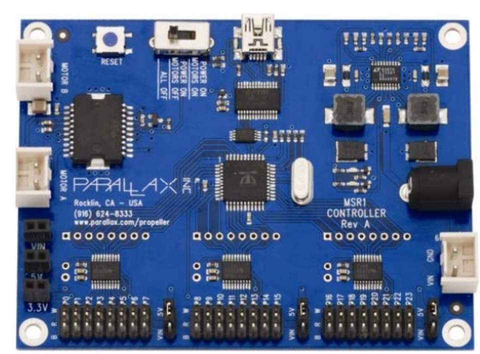
Local planning

Monitoring agent

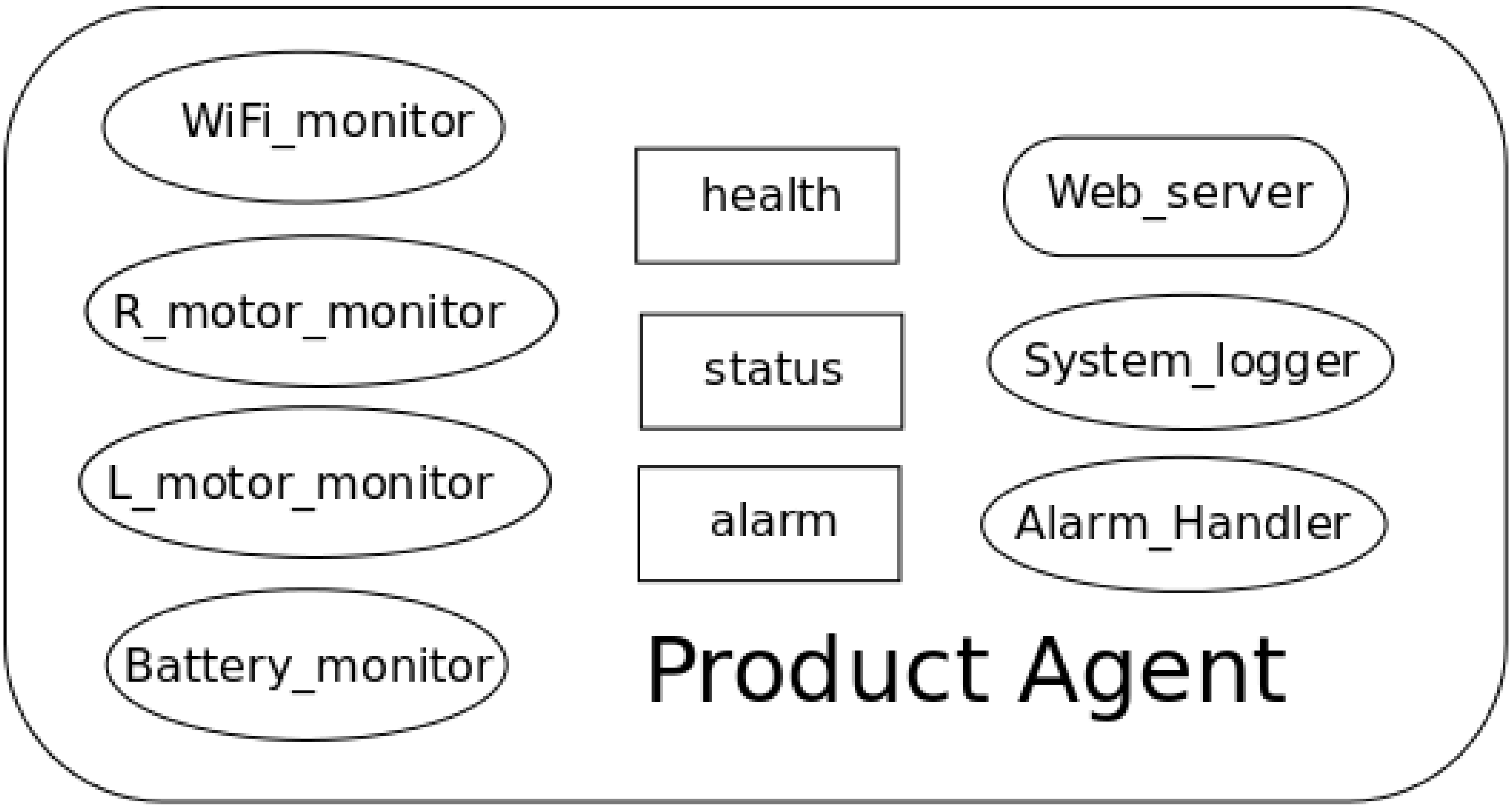


Calculate position

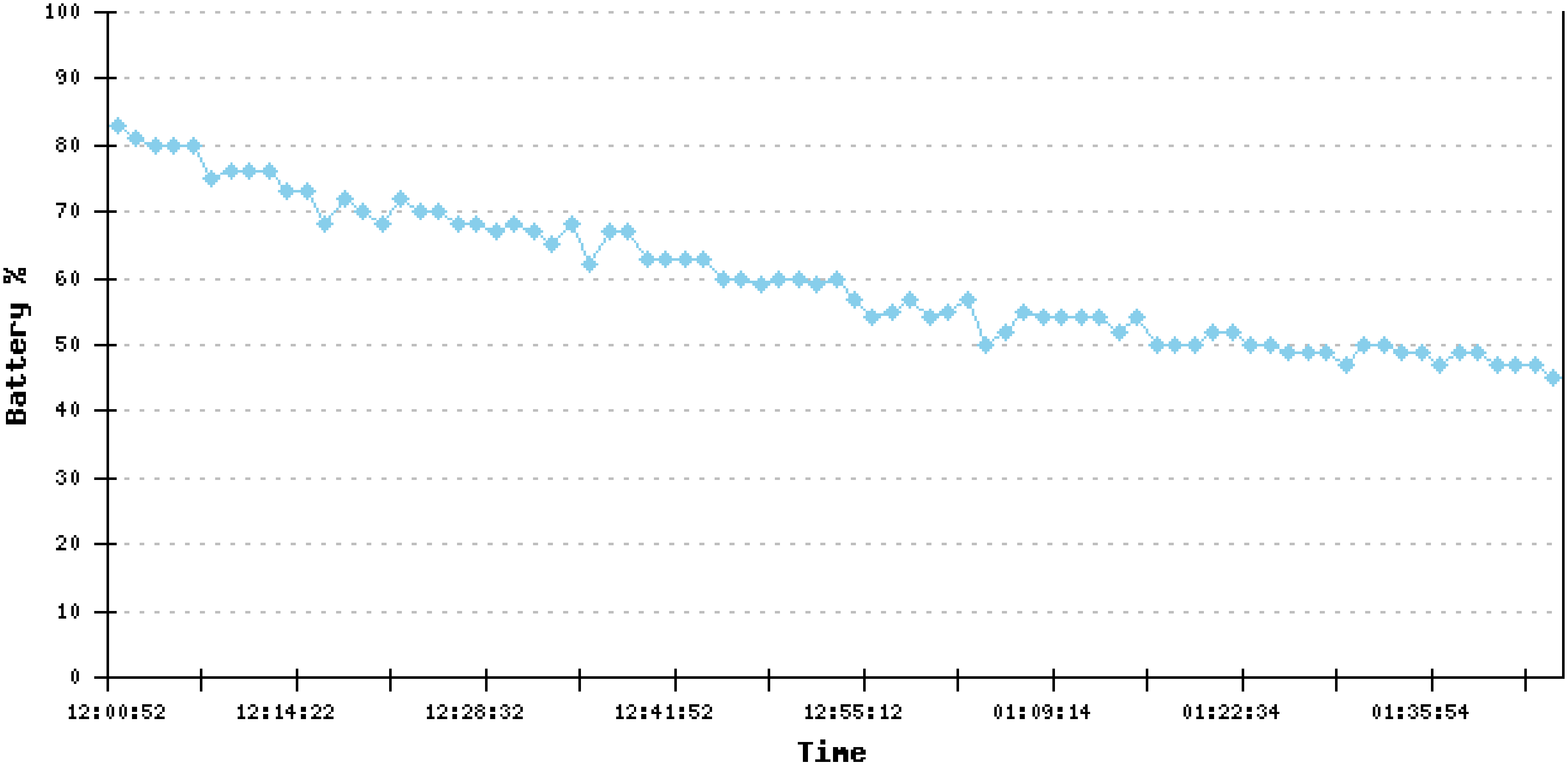
Motor control



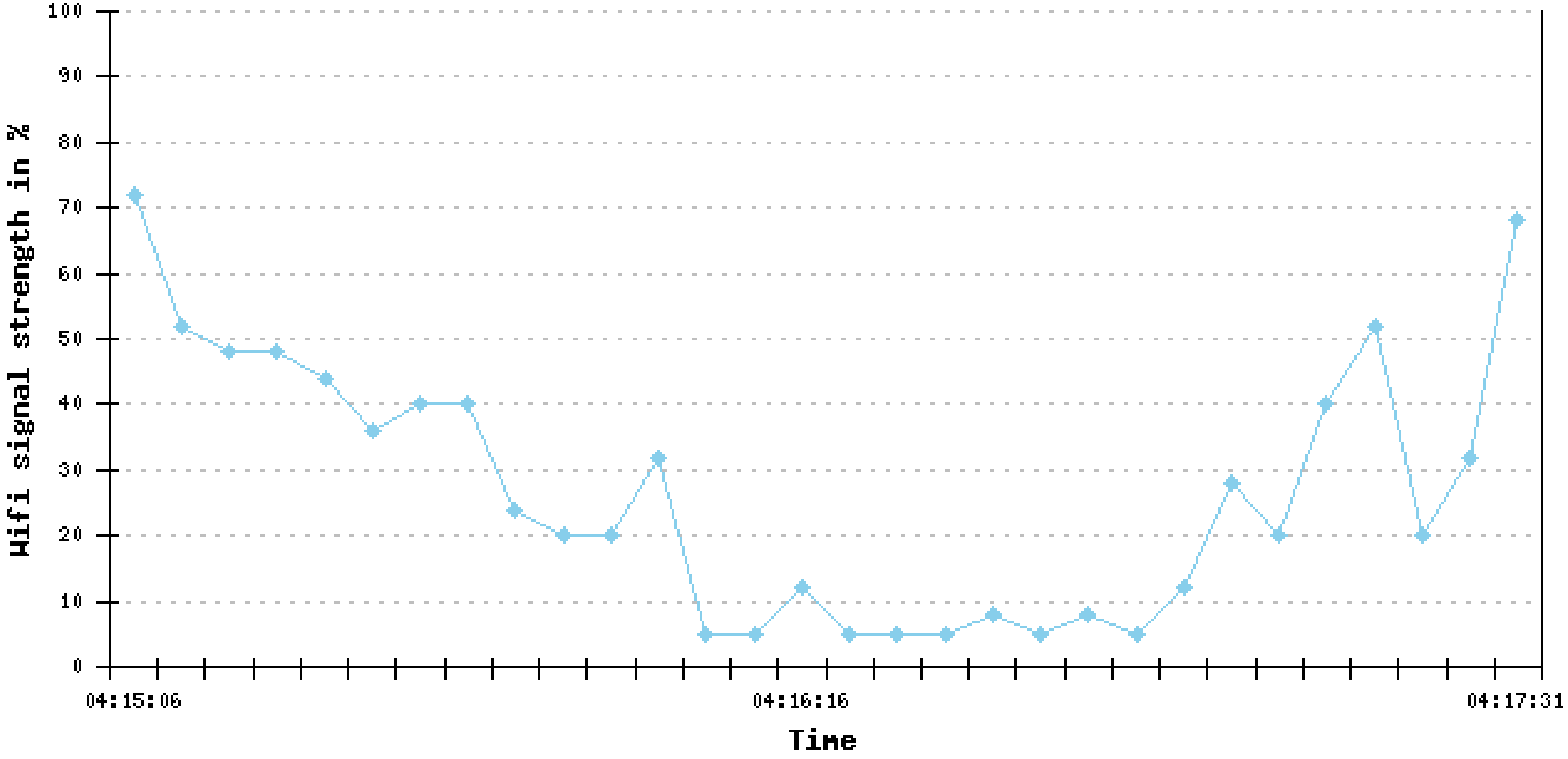
Monitoring Agent



Battery status



WiFi signal strength



Depletion of elements

Element	Symbol	Years available
Silver	Ag	29
Indium	In	13
Antimony	Sb	30
Hafnium	Hf	10
Tantalium	Ta	116

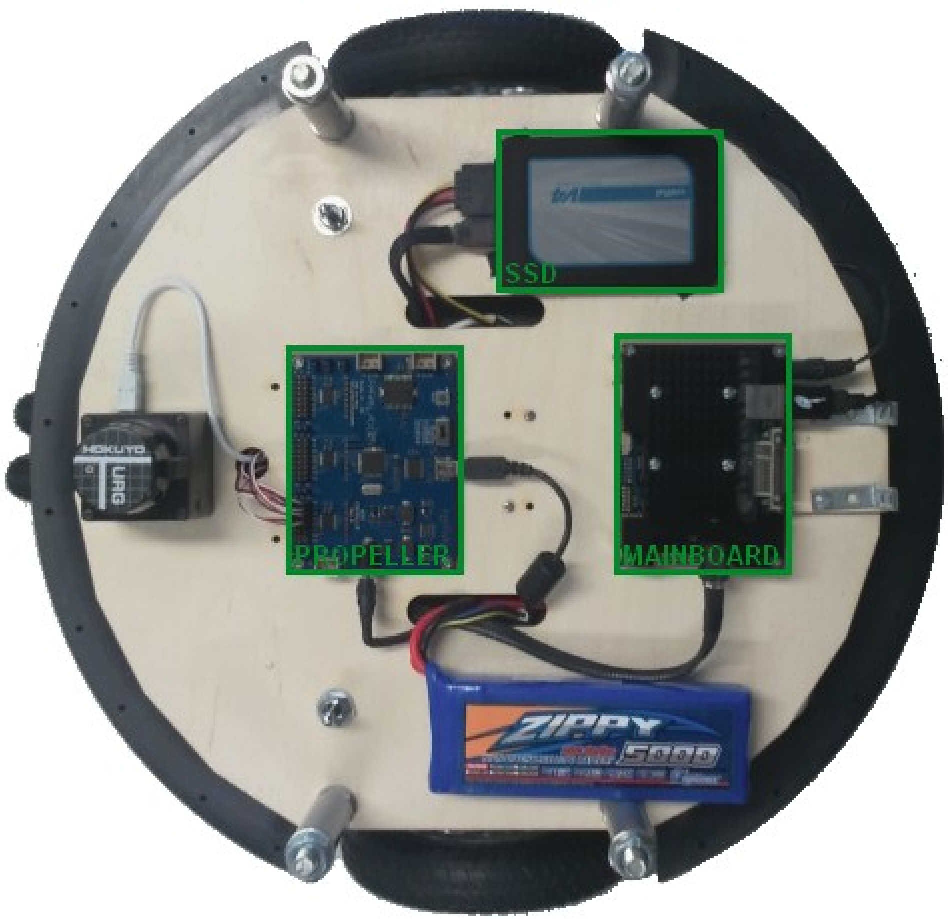
Discovering materials

ADRIE :: Materials

This is a list of materials that the robot uses. Click on a material to see in which components it is used.

- rubber
- aluminium
- gold
- polymer
- copper
- platinum
- rhodium
- lithium
- indium

Material used: **gold**

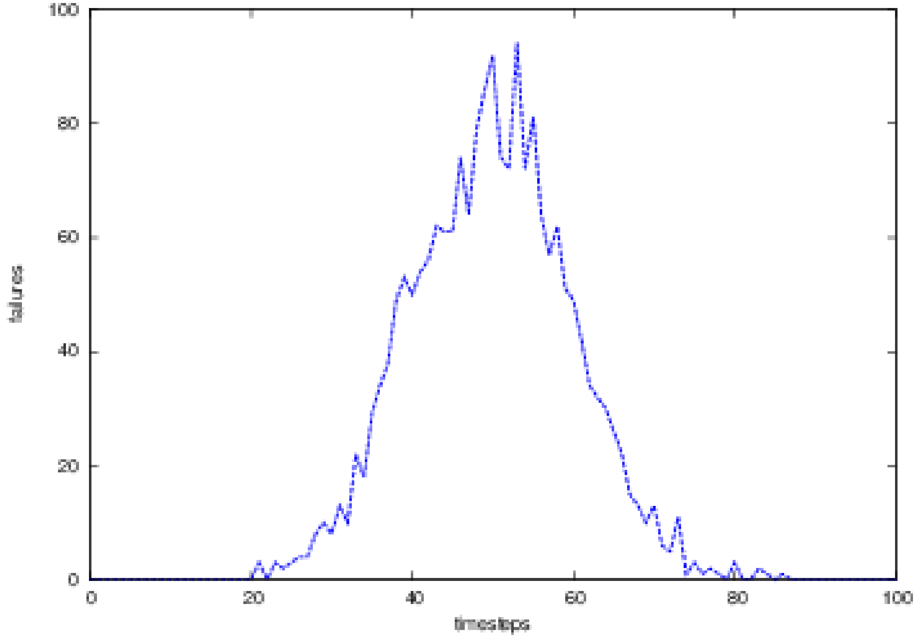


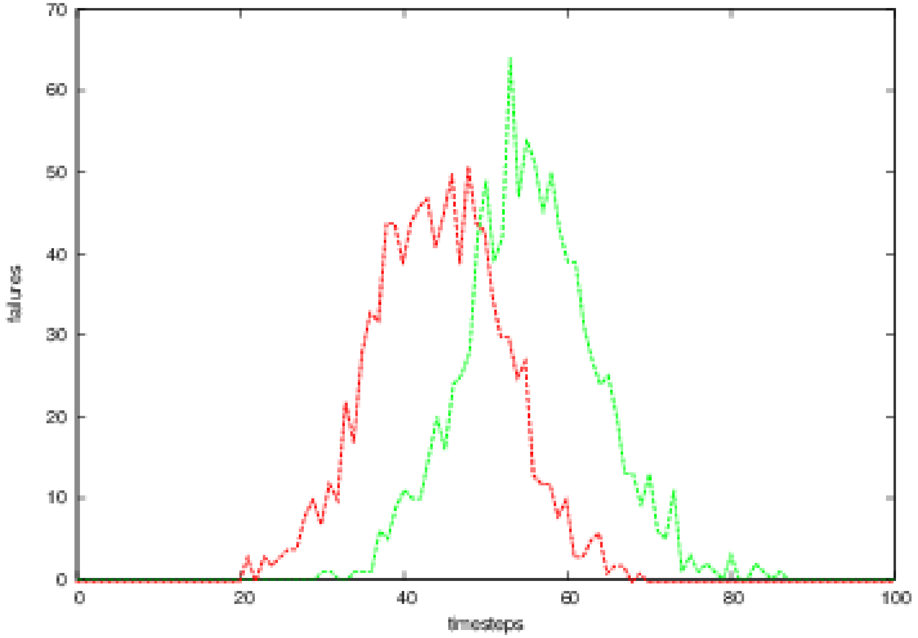
Agent-based recycling

Supplement Facts Serving Size 8.0 fl.oz. (240 ml) Serving Per Container 3		
Calories	100	
Total Carb	27g	9%
Sugars	27g	
Vitamin B2	1.7mg	100%
Vitamin B3	20mg	100%
Vitamin B6	2mg	100%
Vitamin B12	6mcg	100%
Sodium	180mg	8%
Taurine	1000mg	
Panax Ginseng	200mg	
Energy Blend 2500mg L-Carntine, Glucose, Caffeine, Guarana Inositol, Glucuronolactone, Maltodetrin		
Percent Daily Values are based on a 2000 calorie diet.		

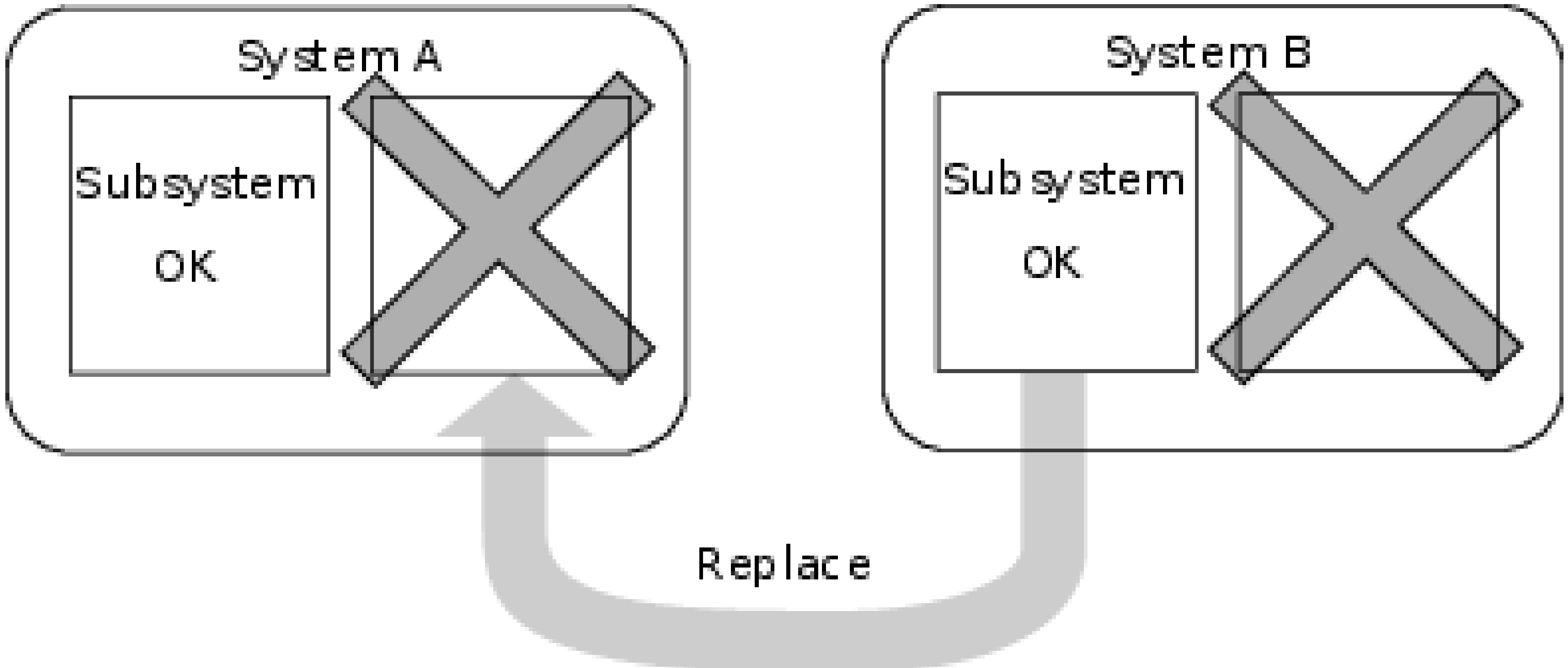
- Recycling can be much easier if a list of "ingredients" is available (probably with its usage)
- Position of the "ingredients" is also important information
- Both features can be provided by a product agent

Agent-based repair

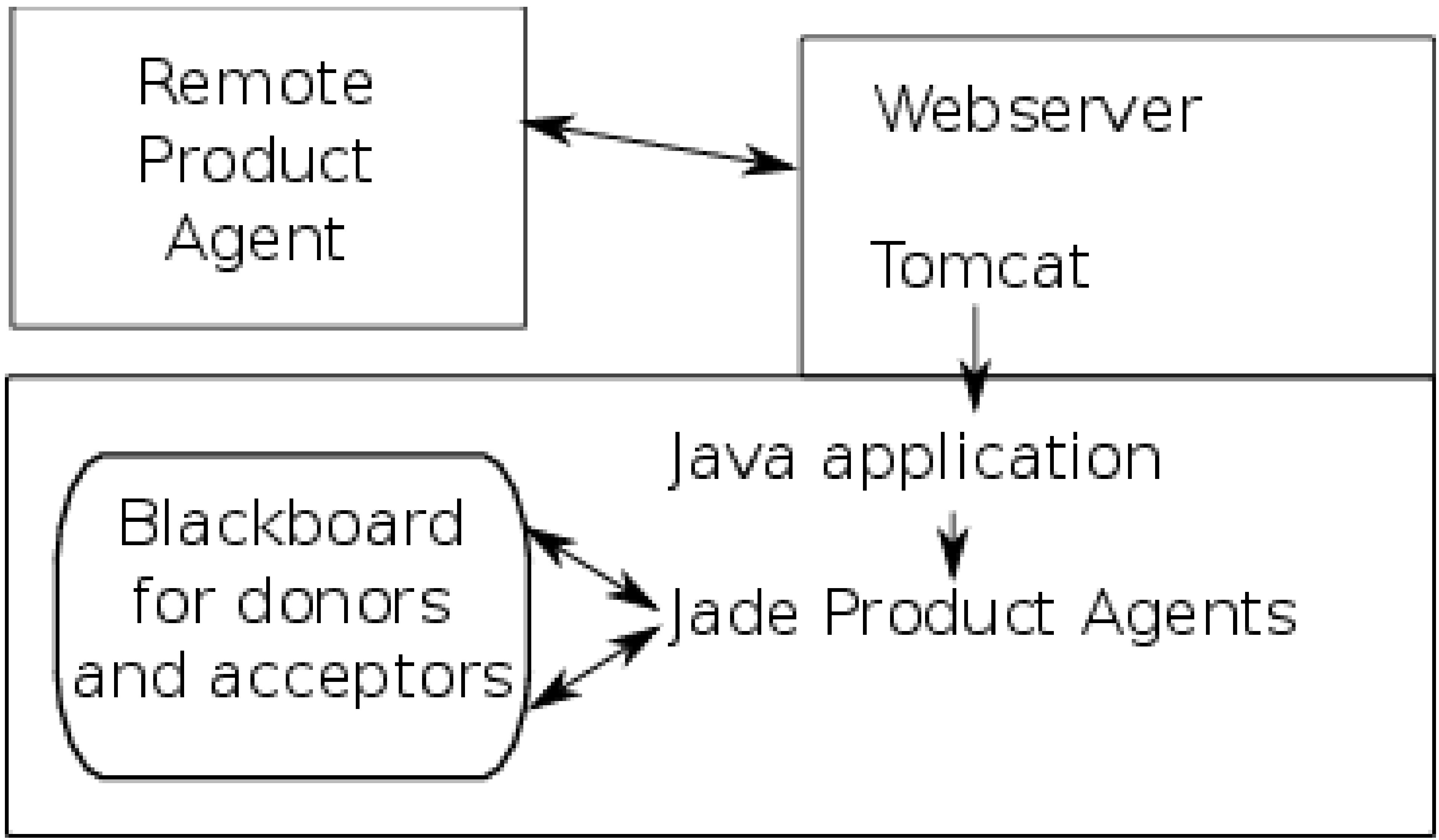




Agent-based repair (2)



Agent-based repair (3)



Donor or acceptor?

- Owner decides in the first place
- Number of working subsystems
- Expected lifetime of subparts

Conclusion

Agents can play an important role in all parts of the life cycle of a product

A product agent is a good basis for the Internet of Things (IoT)

An aspect of IoT can be recycling and repair support

A product agent acts like a guardian angel (except for the spiritual aspects)

Thank you!
Questions?