An Automation Approach Based on Workflows and Software Agents for IPS²
by

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Agenda

- Motivation of research
- Concept for modelling, simulation and execution of IPS² business processes
- Modeling with process fractals
- Simulation of business processes
- Execution of business processes through a process engine and an agent system
- Summary and future work

Motivation
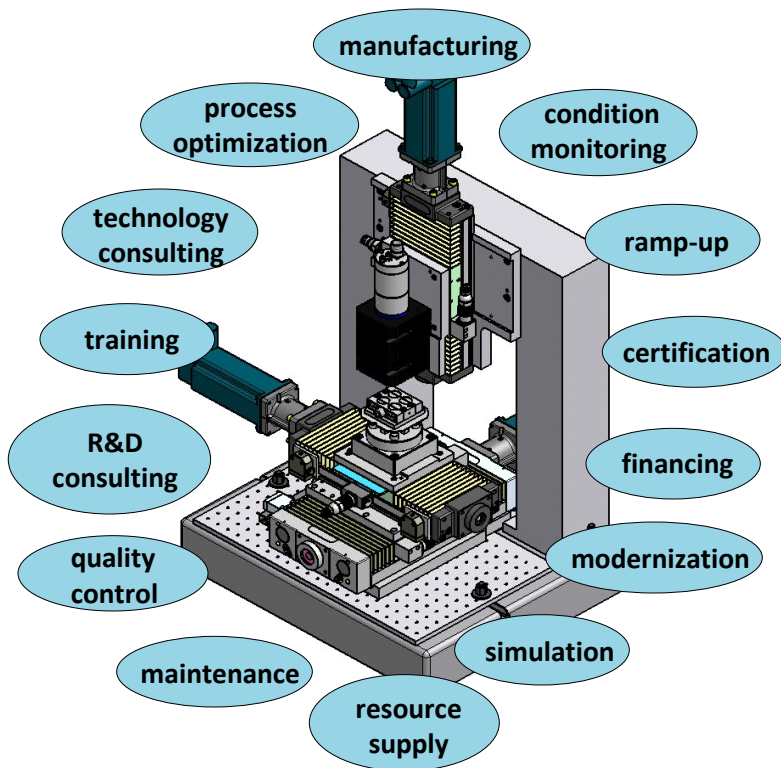
- IPS² in the industrial sector highly customer individual
- High dynamics over the entire lifecycle necessary to fulfill customer needs
- Responsibility of IPS² provider for processes in the delivery phase
- Arising risks by guaranteeing availability or production output
- Interaction between processes and products to deliver IPS²

→ Challenge: How can the IPS² provider efficiently model, simulate and execute IPS² business processes?

Concept
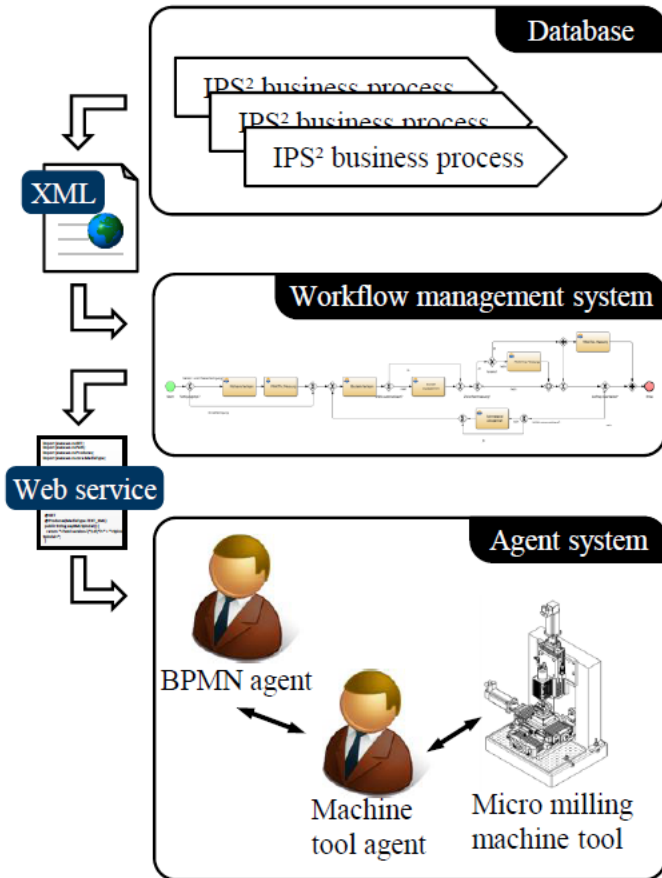
- Every customer receives an individual IPS² business process
  - Modeling and simulation in the development phase
  - Execution in the delivery phase
- Process modeling and simulation in a workflow management system
  - BPMN2.0 based modeling language
  - Tool: IYOPRO of the company intellivate GmbH
- Interaction between processes and physical products by means of web services and software agents during execution

Concept

P – IPS² planning
D – IPS² development
I – IPS² implementation
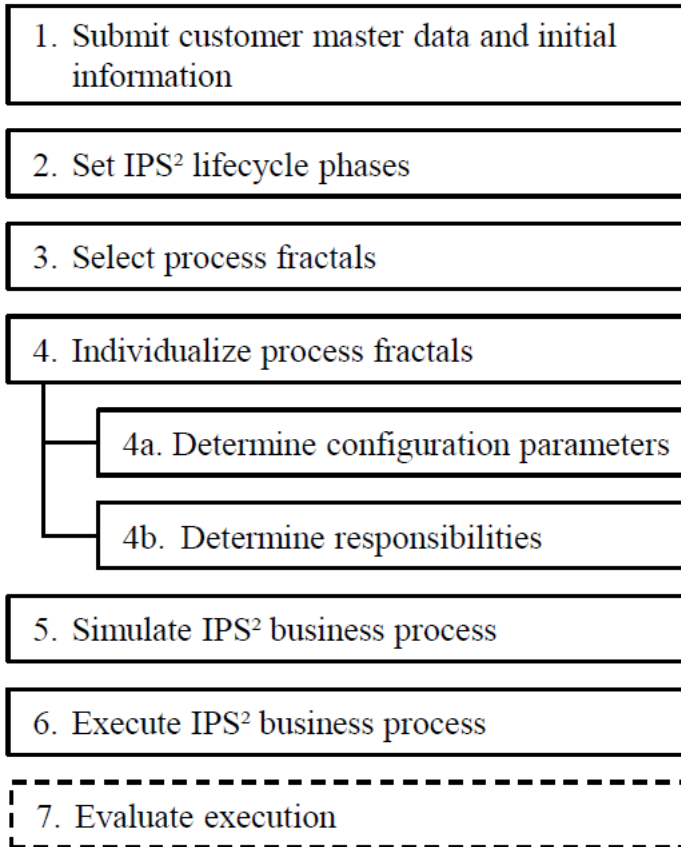O – IPS² operation
C – IPS² closure
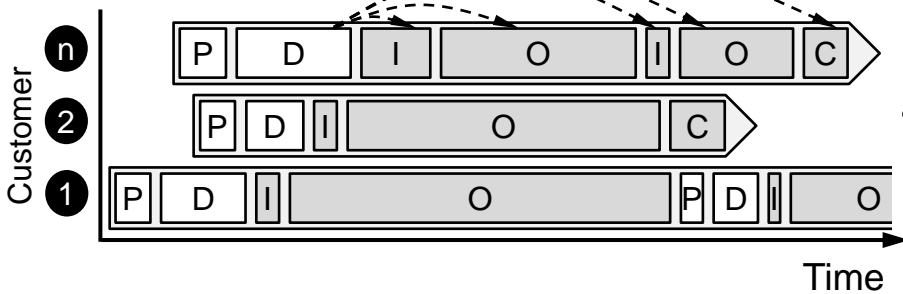
- IPS² business processes
  - Customer individual modelling
  - Covering whole lifecycle of a customer-provider-relationship
  - One-time execution

- Conventional business processes
  - Equal sequence for different customers
  - Modelling in sections
  - Repeatable execution

Concept
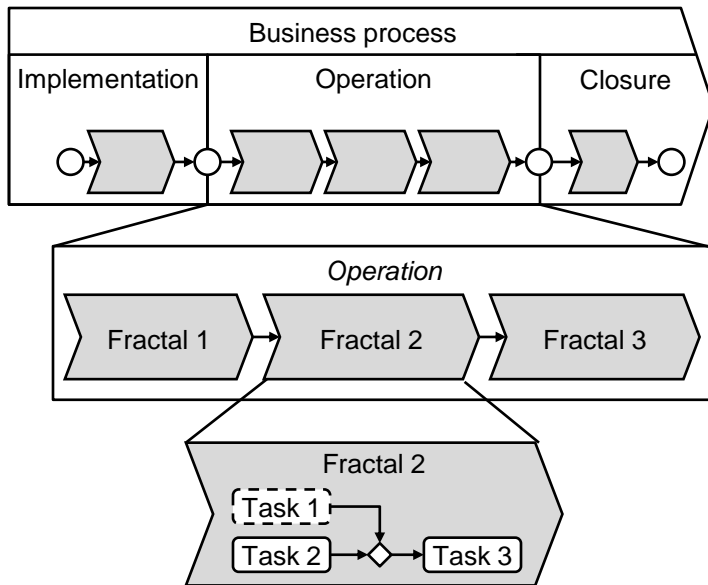
- Customer individual business process is divided into lifecycle phases
- Process fractals will be assigned to lifecycle phases to fulfill customer requirements
- Sequence of tasks is controlled by configuration parameters
- Configuration parameters are customer individually attributed

Concept

1. Submit customer master data and initial information

2. Set IPS² lifecycle phases

3. Select process fractals

4. Individualize process fractals

    4a. Determine configuration parameters

    4b. Determine responsibilities

5. Simulate IPS² business process

6. Execute IPS² business process

7. Evaluate execution

- Seven stage procedure for modeling, simulation and execution
- Selection of activities in dependence of multi project management according to the Project Management Institute (PMI)

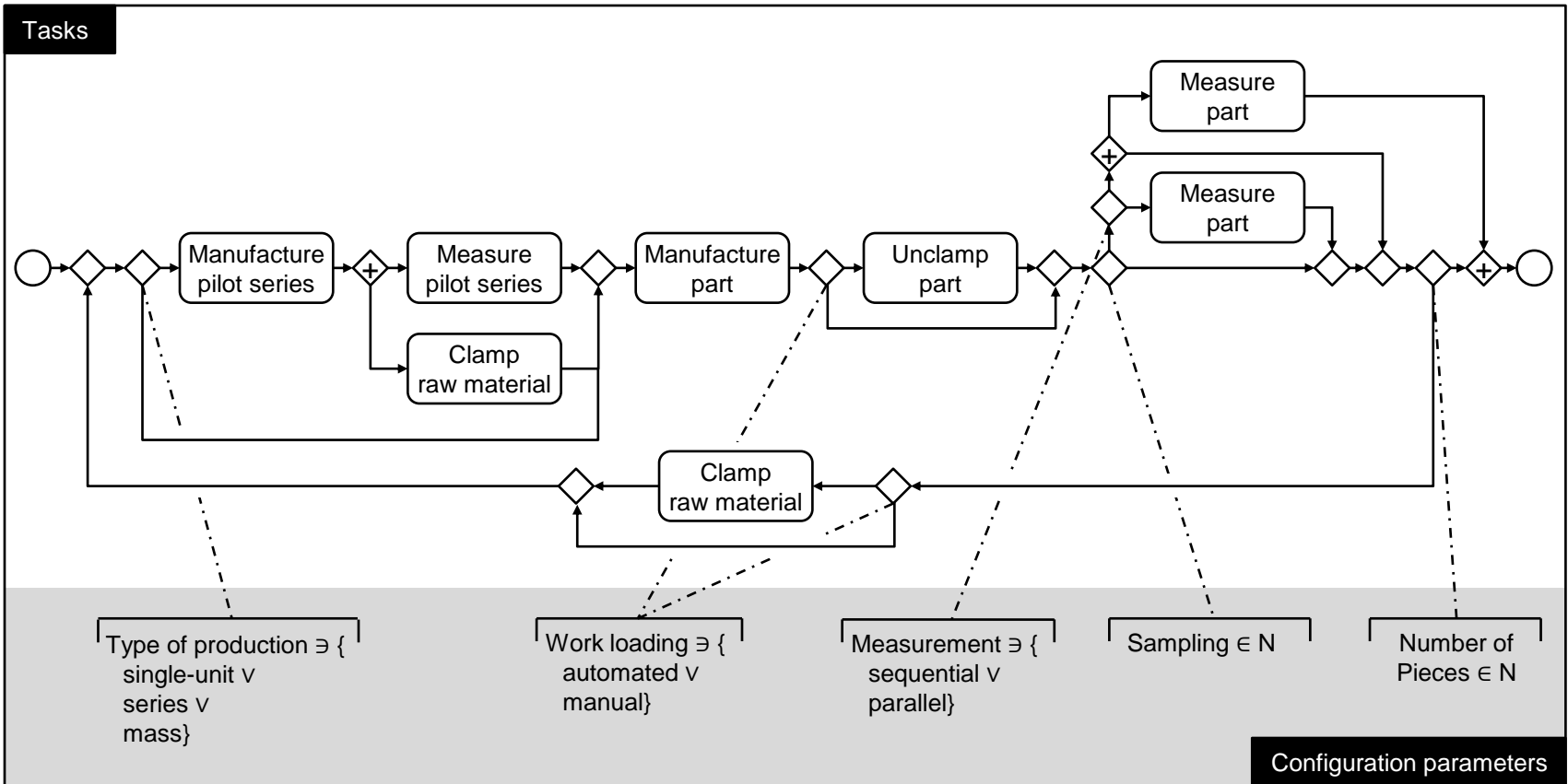# Modeling

- Process fractals are selected in a database

- Example of necessary lifecycle phases and process fractals to fulfill customer's needs (operation in the result oriented business model)

- Configuration parameters are attributed

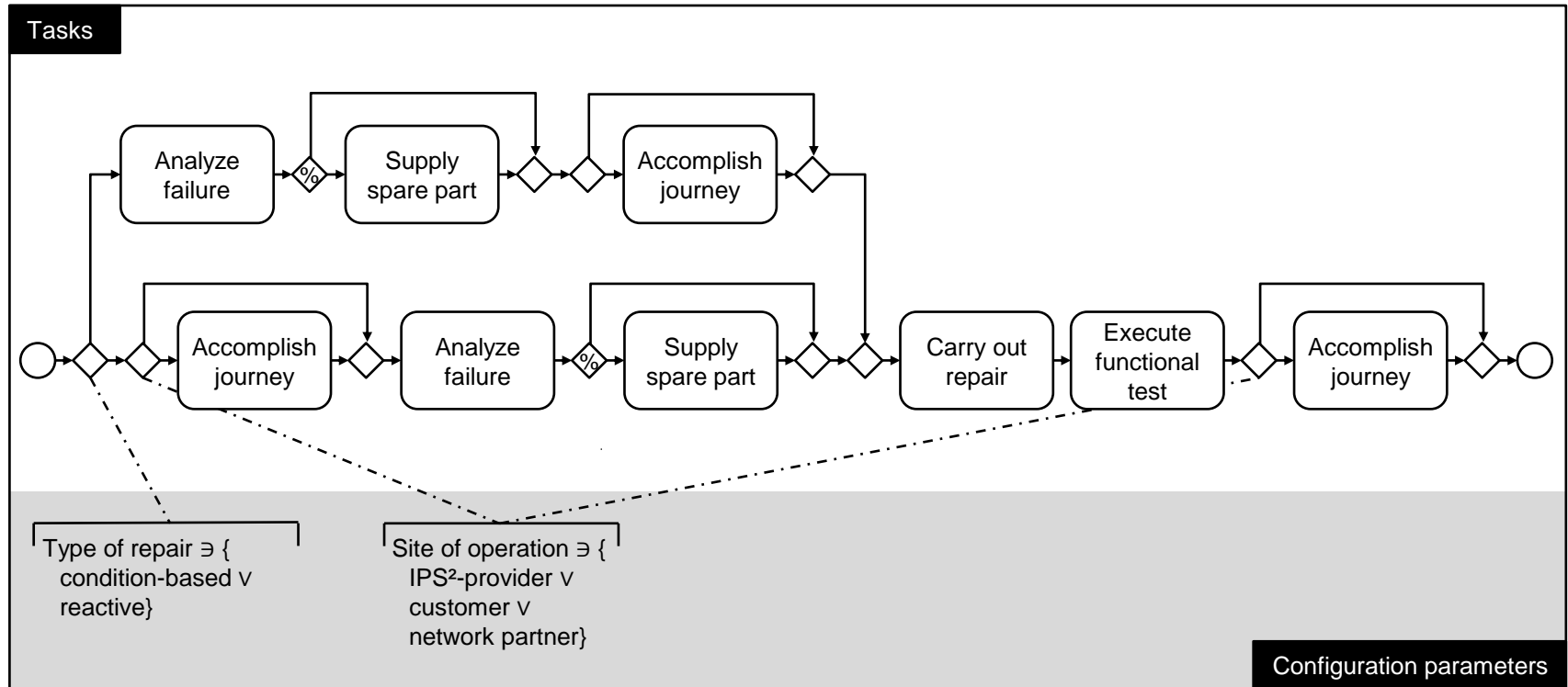- Example of attributed configuration parameters of the process fractal "manufacturing" in the use phase

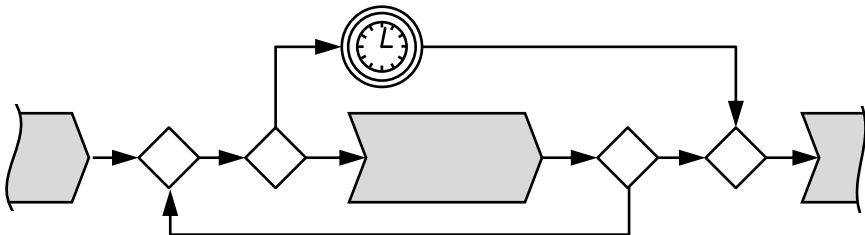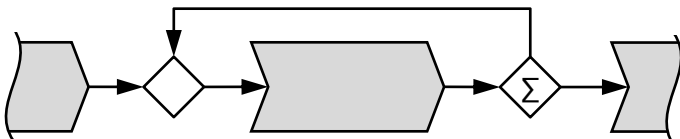# Modeling

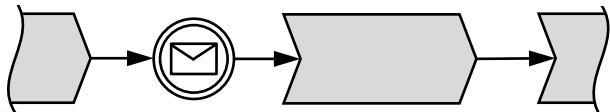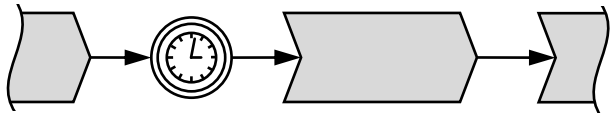Process fractal "manufacturing"

Modeling

Process fractal "repair"

Modeling

- One-time execution of Fractals
  - Direct → fractal starts after the ending of the previous fractal
  - Time based → fractal starts after a defined time period or at a particular time
  - Event based → fractal starts after an event occurs, e. g. signal of a machine tool, or notice of the customer
- Repeated execution of Fractals
  - Determined → fractal will be performed a specific number of time
  - Scheduled → fractal will be performed until a particular time

Simulation
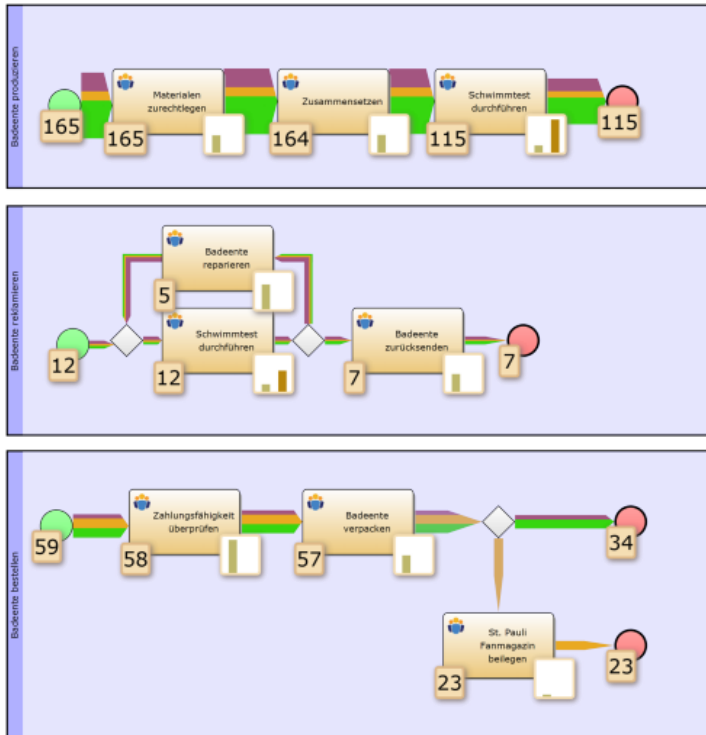
- Characteristics of IYOPRO's simulation environment:
  - Interface to the open source simulation library DESMO-J
  - Discrete event simulation (DES) of process models
  - Consideration of all process models for the determination of resource utilization

- Procedure:
  - Determination of simulation parameters, e. g. task duration, branch probability, and resource costs
  - Determination of simulation period
  - Simulation execution
  - If necessary, process model optimization

Simulation
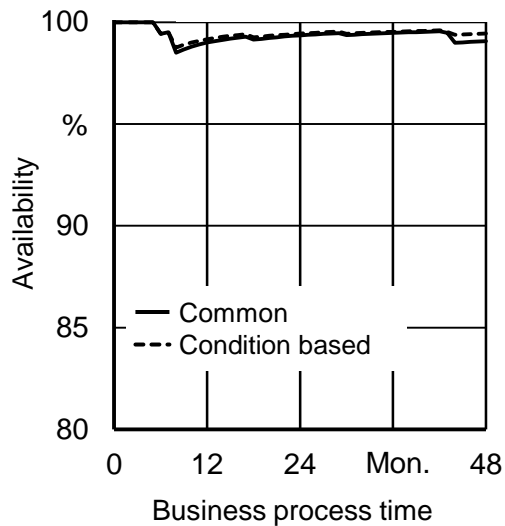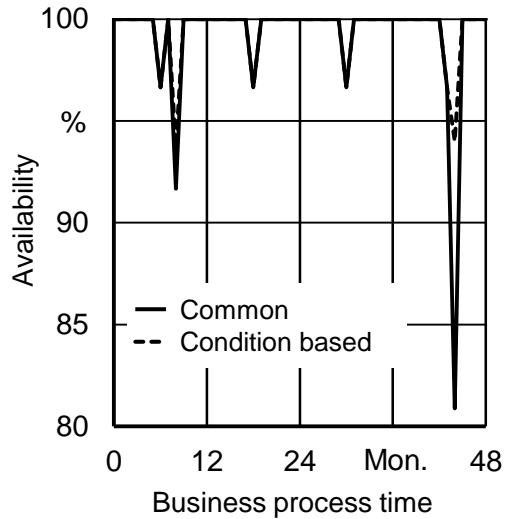
- Selection of simulation goals:
  - Lead time of delivery
  - Costs
  - Resource utilization
  - Availability of production resources
  - Producible number of pieces
- Simulation of a machine tool's availability to verify the necessity of condition based maintenance
- Advantages of condition based maintenance:
  - Travel time does not effect the availability negatively
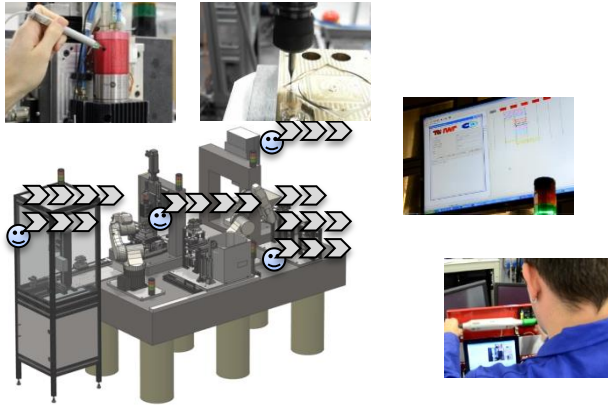 - Elimination of on-site analysis leads to shortened repair time

Execution

IPS²-LMS: IPS²-Lifecycle Management System
IPS²-ES: IPS²-Execution System
VLCU: Virtual Lifecycle Unit
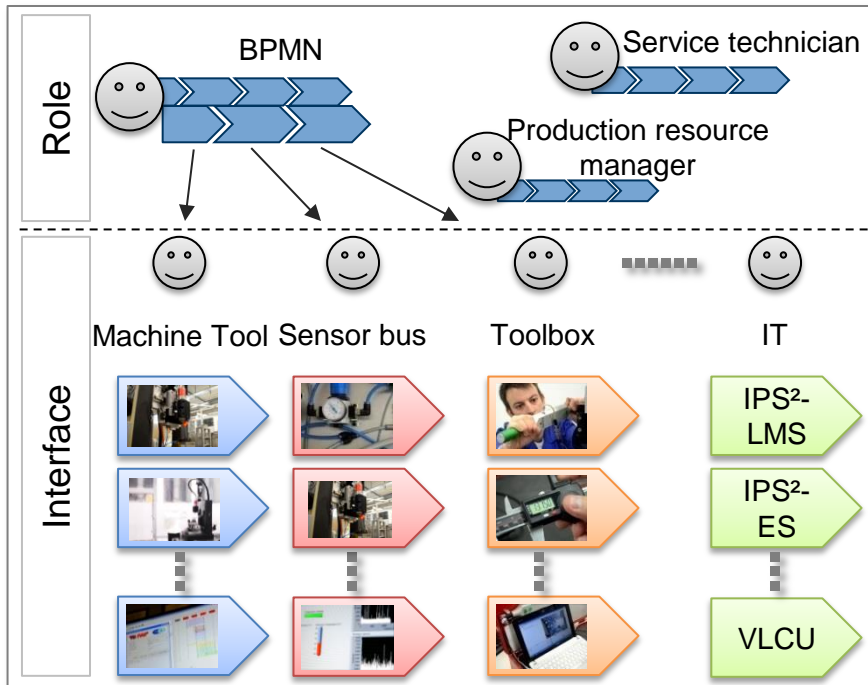
- Business processes consist of manual and automated tasks
  - Manual tasks are transmitted to roles
  - Automated tasks are executed by a software agent system
- Agent system consists of role agents and interface agents
  - Role agents represent key roles in the IPS² delivery, e. g. service technician
  - Interface agents serve the purpose of integrating heterogeneous systems, e. g. sensors, machine tools and IT systems
- BPMN agent encapsulates all functions of the machine tool

Execution

Advantages of the agent system:

- Integration of human as well as technical resources in the IPS² delivery

- Modular automation architecture allowing for high flexibility of the IPS² provider during varying customer requirements or business model changes

- IPS² provider can reuse developed functions/services for different customers
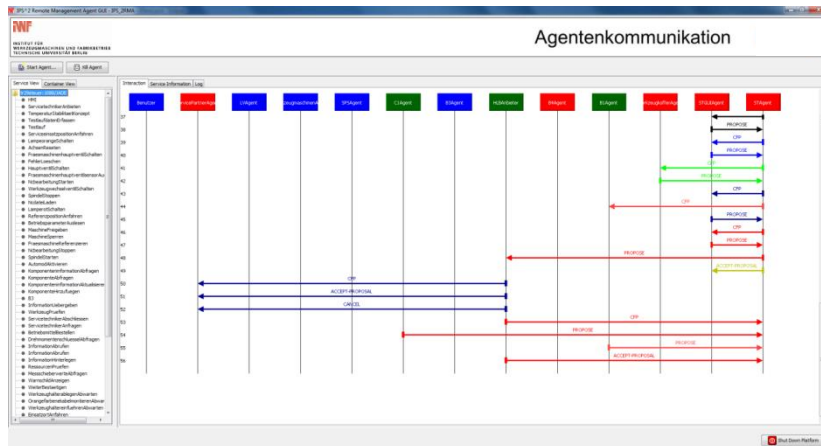
Execution

UML diagram of the agent system communication
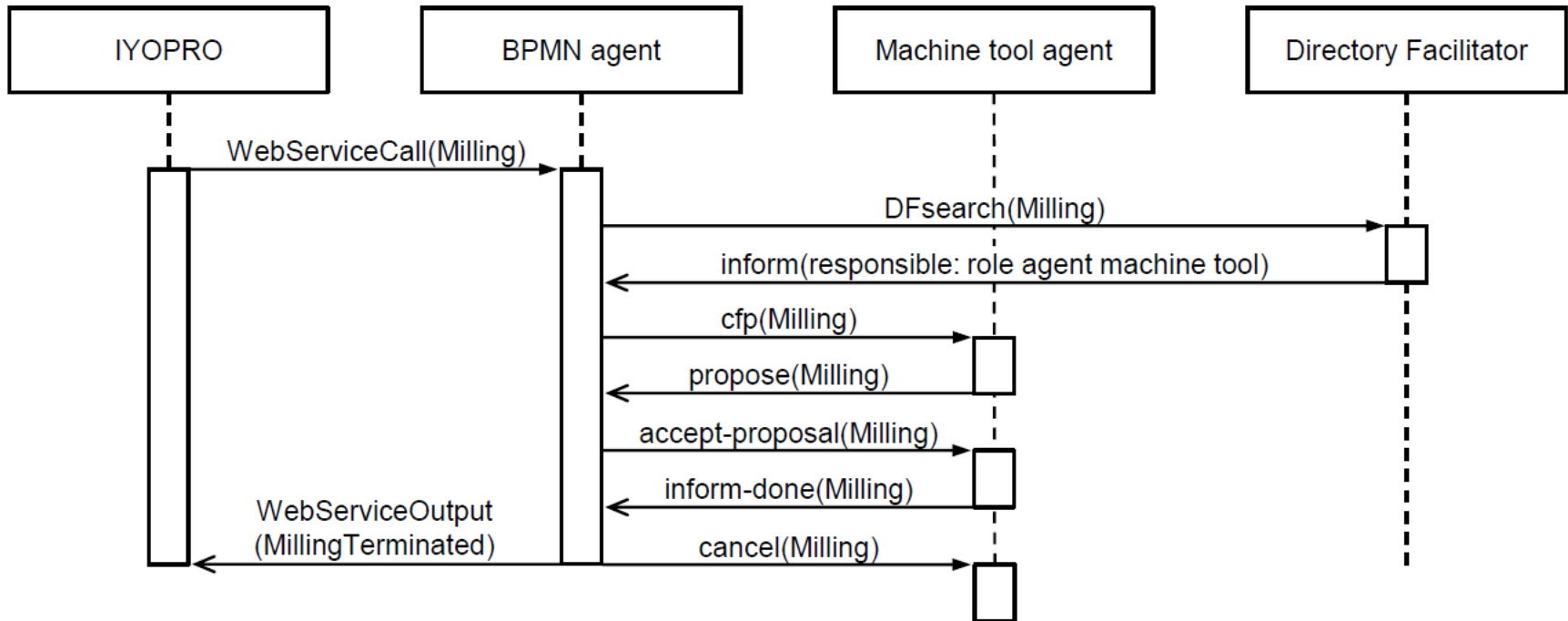
Evaluation

- Type of evaluation according to HEVNER ET AL.
  - Descriptive
  - Constructed scenario to demonstrate the method's utility
- Type of evaluation according to KROMREY
  - Impact evaluation
  - Summative
  - Internal
  - Evaluation criteria = requirements of the method

Summary

- Efficient modeling of customer individual business processes through process fractals and configuration parameters

- Simulation of the IPS² delivery by using the software IYOPRO of the company intellivate GmbH

- Execution of business processes by a process engine and an agent system which are linked through web services

- Future Work:
  – Execution of a project for the application and evaluation of the modeling method in a company which develops machine tools and delivers services for dental products
  – Development of fractals and configurations parameters for different industrial sectors (currently the focus is on the micro production)

Thank you for your attention!

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