FACTORY2FIT

Human-centred Adaptation and Task Distribution utilizing Levels of Automation

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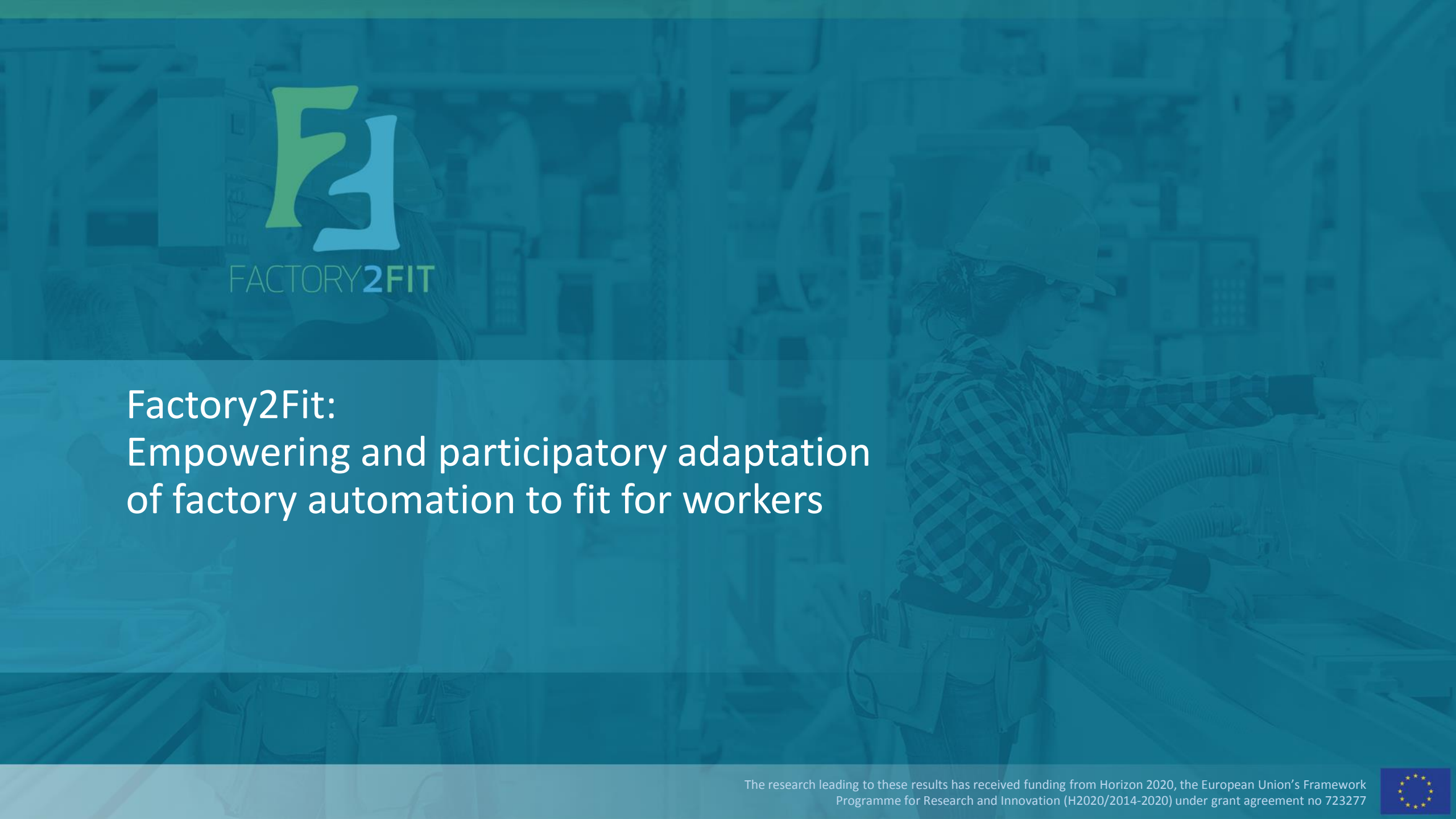

Factory2Fit:
Empowering and participatory adaptation of factory automation to fit for workers

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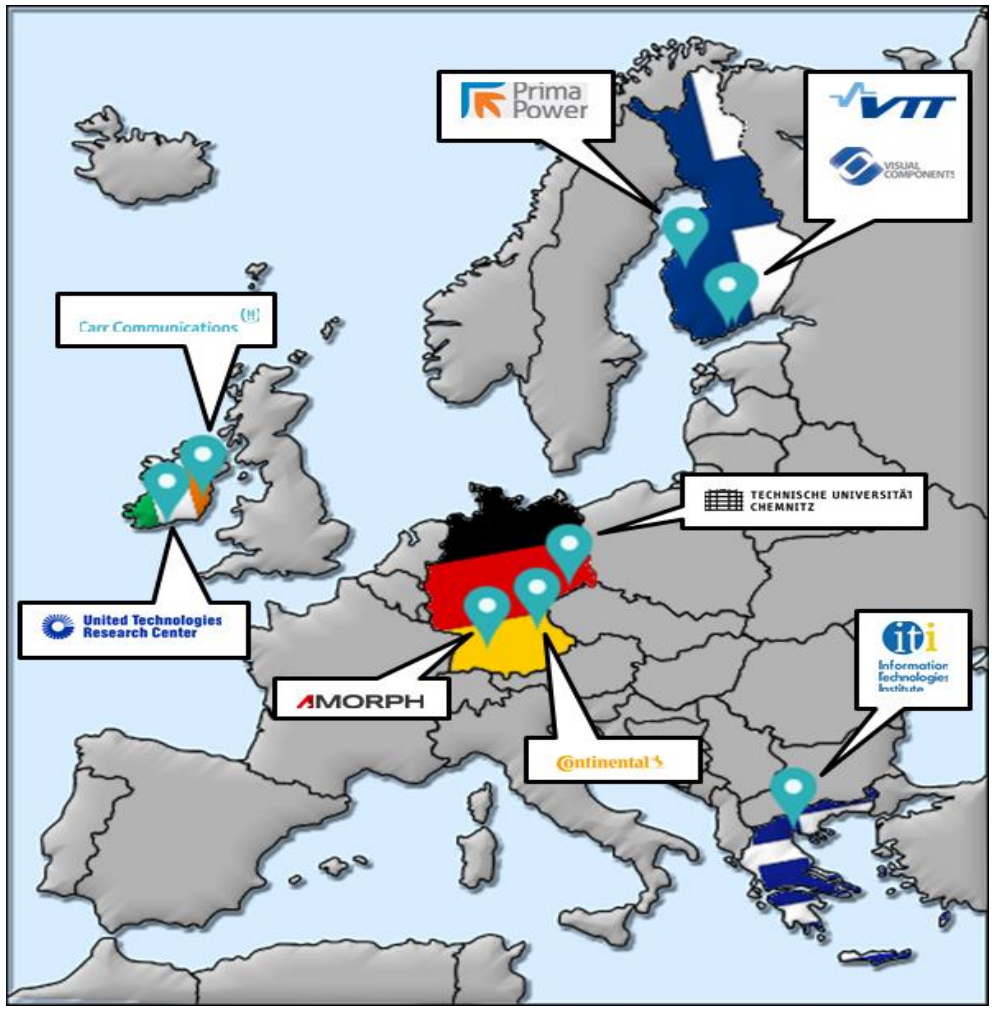
Factory2Fit – Some facts…

- Factory2Fit - Empowering and participatory adaptation of factory automation to fit for workers
- H2020 Factories of the Future, FoF-4 project
- 1.10.2016 – 30.9.2019
- 9 partners
- EU funding 4,3 M€
- Coordinator: Dr Eija Kaasinen,
  VTT Technical Research Centre of Finland



Factory2Fit – Objective and expected impacts

Main objective:

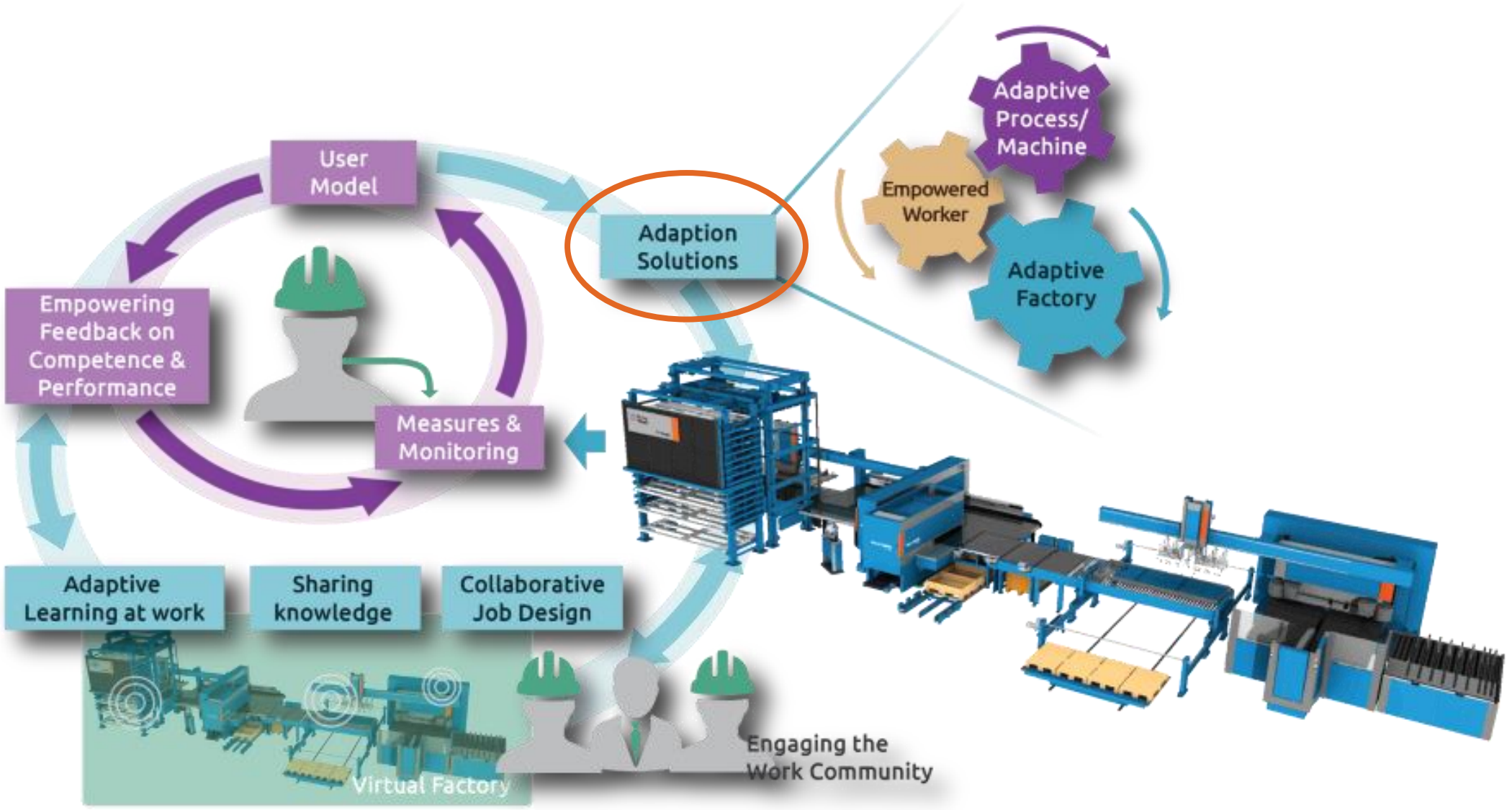
Develop and pilot adaptive human-automation interaction solutions that …

- improve the flow of working
- support the worker in understanding and developing his/her competences and
- engage workers to share knowledge and to participate in designing their own work and training.

Expected impacts:

1. Increased the adaptability of manufacturing systems by 50% to fit for worker skills and preferences
2. Further increase work satisfaction at least 15%
3. Work satisfaction further leads to 5-15% increase in productivity and 10-30% increase in manufacturing quality;
4. Increased interest towards manufacturing jobs in the society with wide dissemination activities
5. Wide adoption of the new developments in advanced manufacturing systems, based on active exploitation activities

Factory2Fit – Approach



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Automation Adaptation System(s): Theoretical basics and types of adaptation

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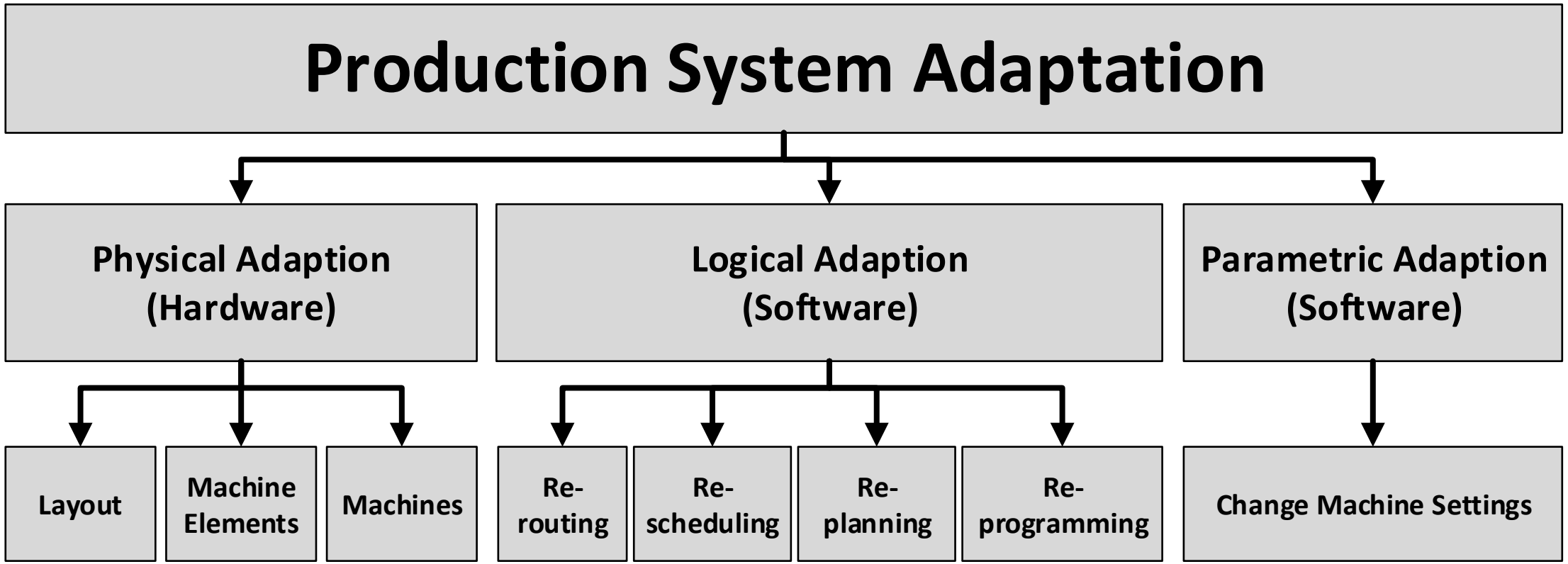
Motivation

- Industry 4.0 leads to new approaches and provides new solutions and technologies to companies in various fields
- A „Smart Factory“ is seen as a key enabler to deal with current trends and new customer demands
- Smart Factories allow to design production environments with higher degree of automation, efficiency and flexibility
- Smart Factories also allow to utilize the new solutions and enablers to adapt work environments to the skills, capabilities and preferences of individual workers

Type(s) of adaptation



Adaptation fields within the production system (Based on Järvenpää et al., 2016)

Degree of automation

Automation is the 'full or partial replacement of a function previously carried out by the human operator' (Parasuraman et al., 2000, p. 287).

Relevant individual factors for human-machine collaboration are …

- Trust in automation solutions
- Mental workload
- Situational awareness (or loss of it)
- Skill delegation
- Automation-induced complacency
- Stress, anxiety, …
- Work safety

Relevant organizational factors for human-machine collaboration are …

- Communication
- Formation of multi-disciplinary teams
- Worker involvement and engagement
- Identification of process owners and champions
- Organizational flexibility
- Top management commitment

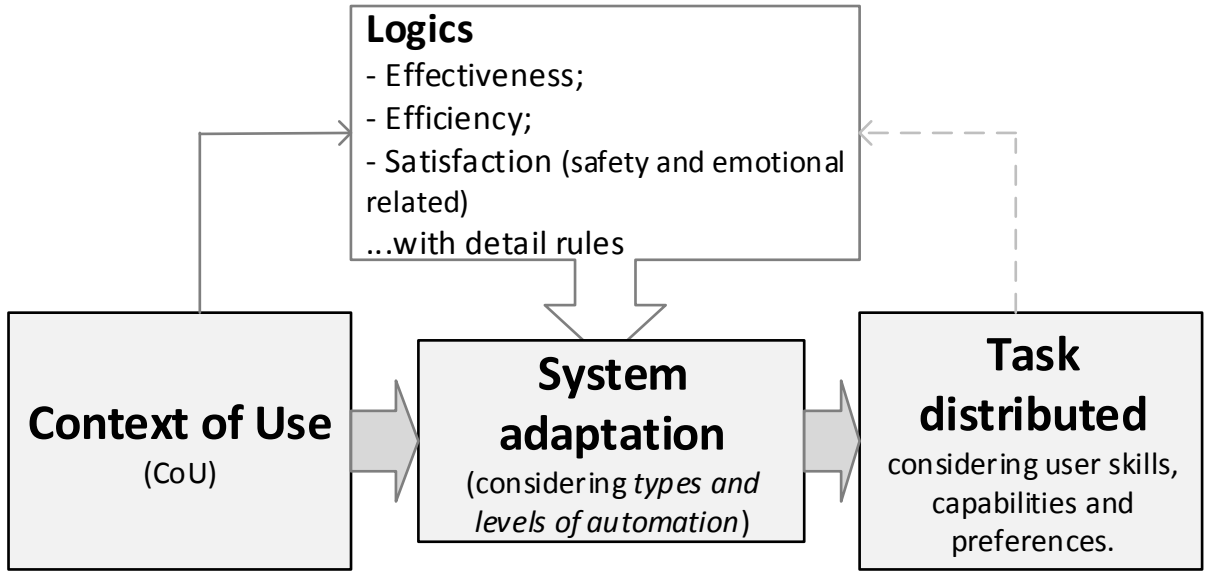
Level	Description
Level 1	The computer offers no assistance, human must take all decisions and actions.
Level 2	The computer offers a complete set of decision/action alternatives.
Level 3	Narrows the selection down to a few choices.
Level 4	Suggests one alternative.
Level 5	Executes the suggestion if the human approves.
Level 6	Allows the human a restricted time to veto before automatic execution.
Level 7	Executes automatically, then necessarily informs the human. When error occurs, can reject further actions and inform human for correction.
Level 8	Informs the human only if asked. When error occurs, can reject further actions and inform human for correction.
Level 9	Informs the human only if the computer decides to. When error occurs, gives the information to human and the performance could be corrected while operating.
Level 10	The computer decides everything, acts autonomously. Errors could be anticipated and the actions could be adjusted to avoid an error. When the problem cannot be avoided, gives inform to human beforehand.

Descriptions of automation levels

Framework for adaptation

Relevant aspects for the framework:

- Manner how to perform a task
- Ongoing decision support to define suitable Level of Automation (LoA)
- Routine tasks vs. adaptation tasks
- Physical-related vs. control-related tasks
- Control-related cognitive processes:
  - Data collection
  - Data processing
  - Decision making
  - Task implementation



General Framework for the adaptation system

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Automation Adaptation System(s): Levels of Automation and Setup of a human-centred Adaptation System

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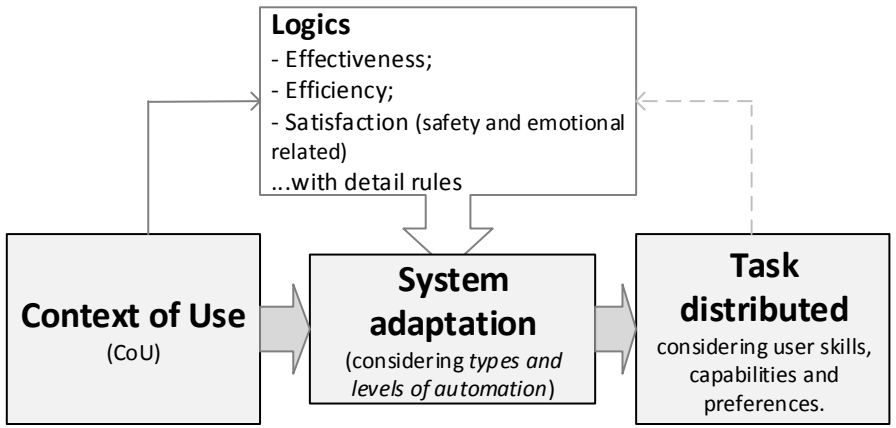
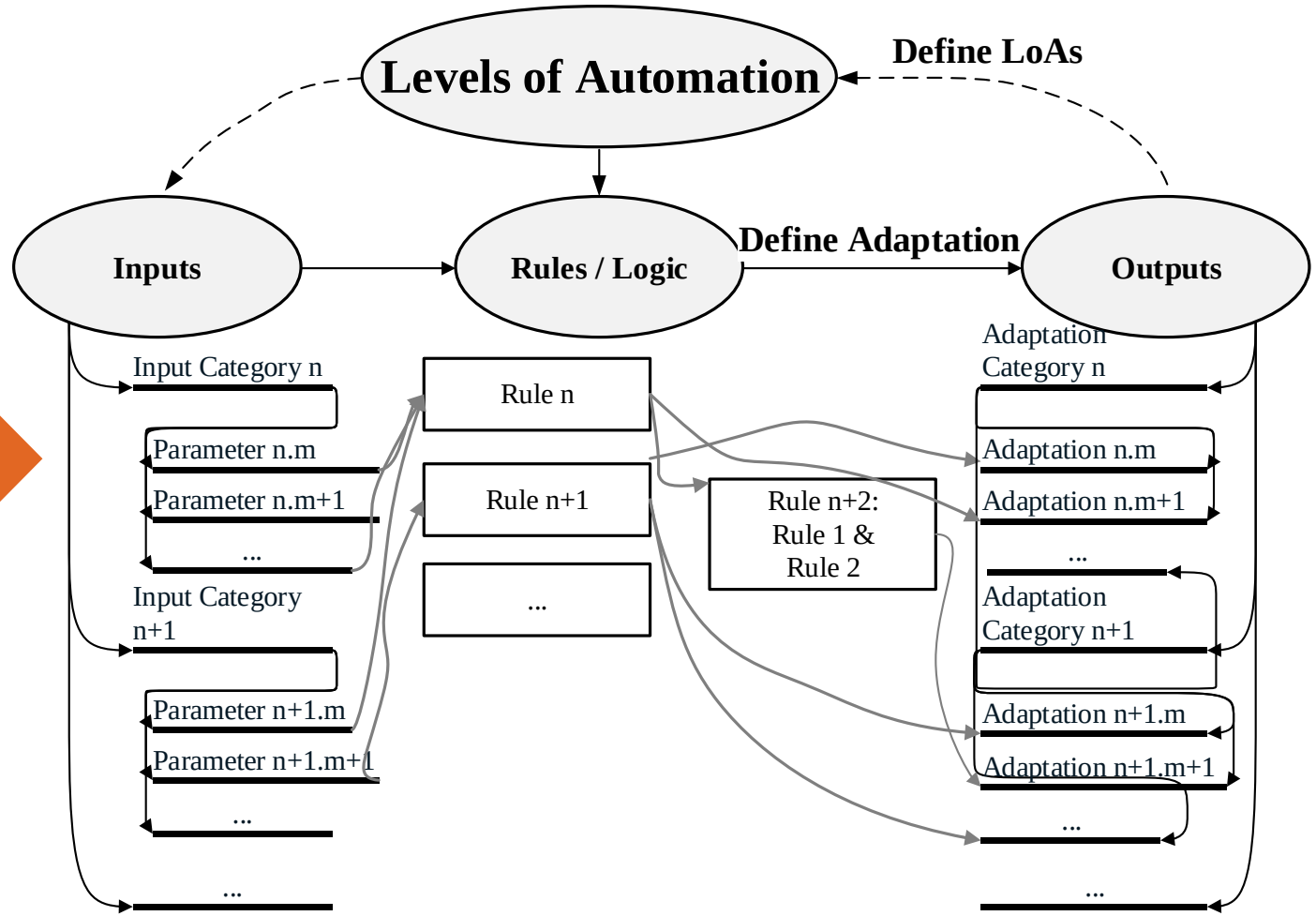
Transferring the framework into an automation adaptation system



General Framework for the adaptation system



Concept of the automation adaptation system

Transferring the framework into an automation adaptation system

Inputs:

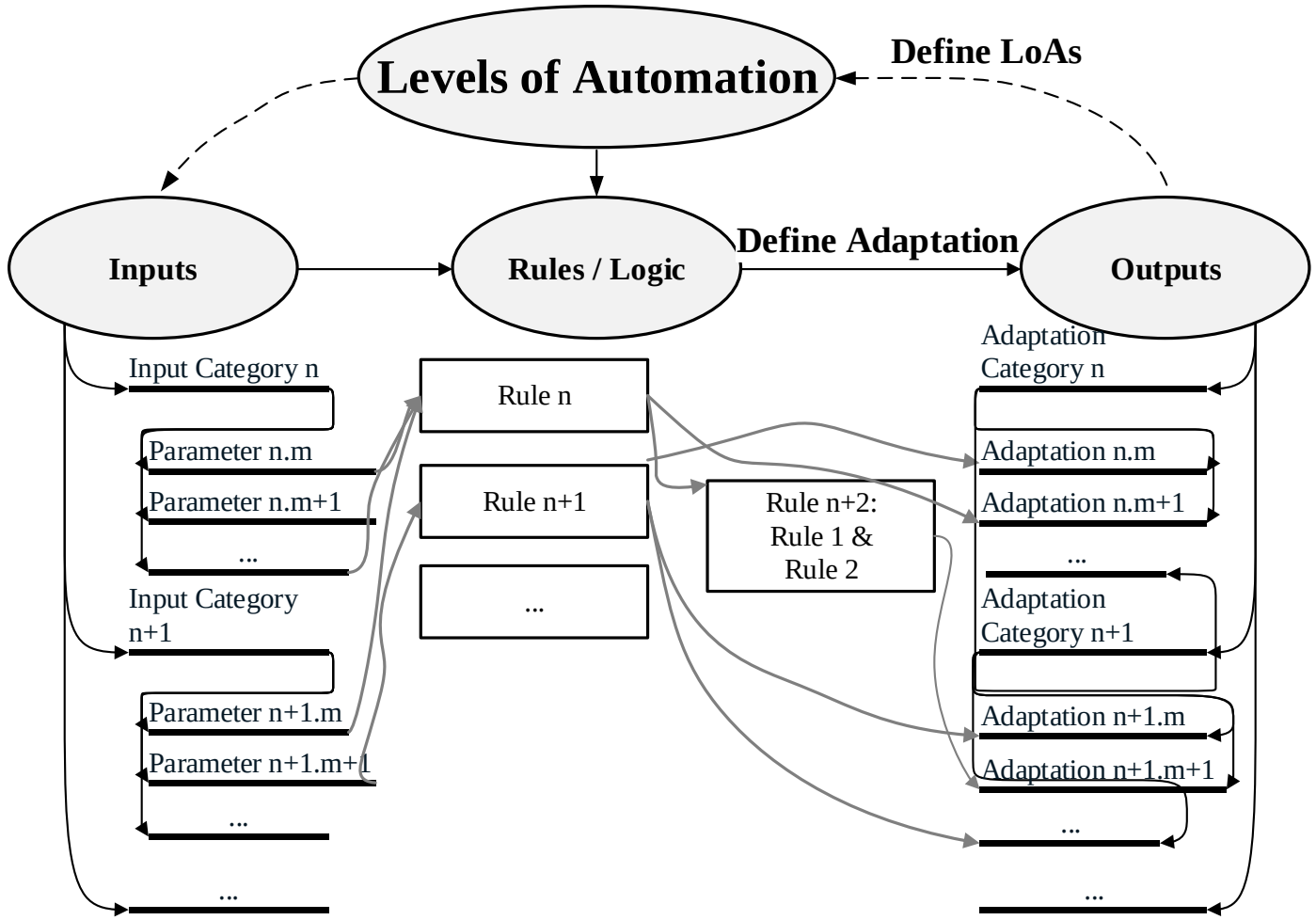
- Available information to capture the current Context of Use (CoU)
- Any digital available and relevant information can be used (e.g. skills, preferences, sensors)

Outputs:

- Available elements for adaptation and their Levels of Automation (LoA)
- Trigger modification of workplaces or tasks according inputs (e.g. preferences)

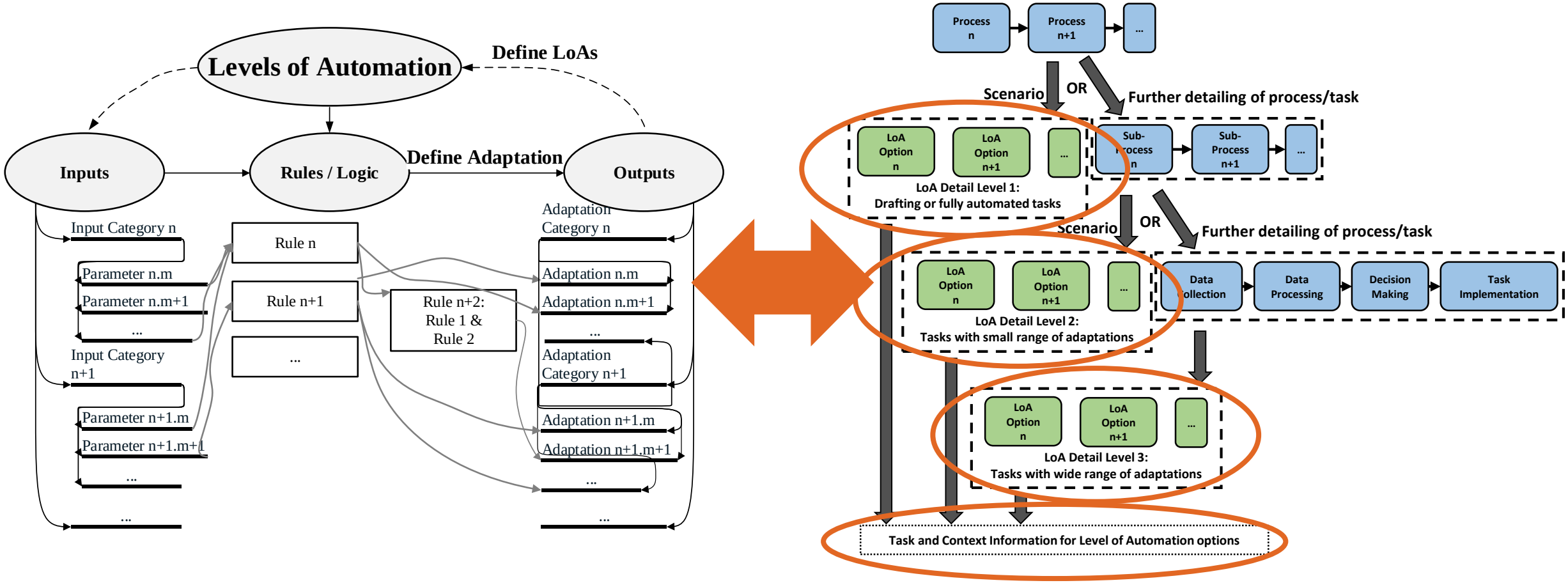
Rules:

- Adaptation based on current CoU and related values
- Ongoing decision support to define suitable Level of Automation (LoA)



Concept of the automation adaptation system

Matching the adaptation system with production processes …

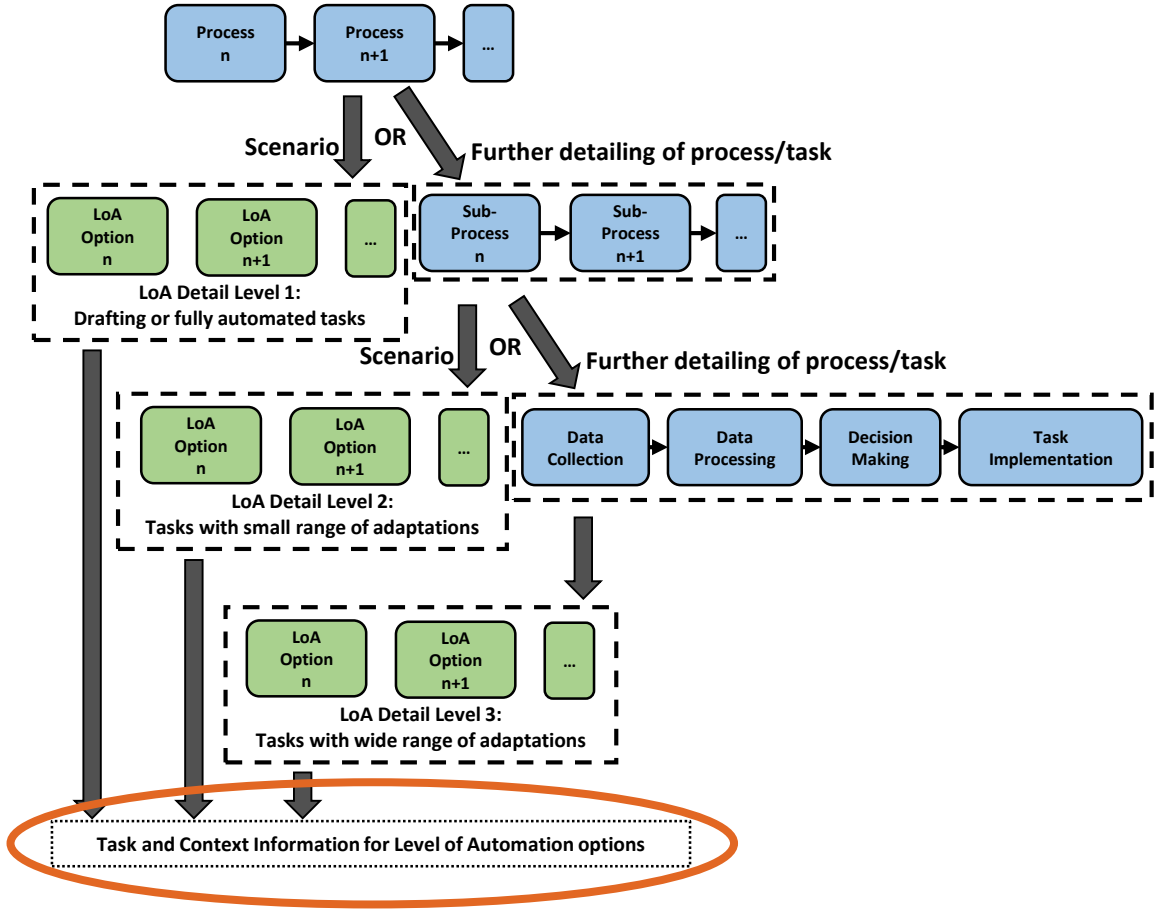


- LoA definition methodology combined with process description approach, which allows to describe LoAs as different manners of task execution.
- LoAs treated as separate layer of process description, called ***LoA Profiles***.

… and describing adaptable elements and features

Task and Context Information for Level of Automation Options:

- **Task Characteristics**
  - **Online Measurements**
    - **General Task Characteristics** (e.g. Tact rate, Tolerance for accuracy, Time share of sub-tasks, Duration of (sub)tasks, Interruptions, Number of (sub)tasks)
    - **Decisions** (e.g. Availability of necessary information for decisions, Level of cognitive regulation)
    - **Ergonomics** (e.g. Duration of recreation intervals, Number of recreational intervals)
    - **Materials / Product** (e.g. Number of materials handled)
  - **Offline Data**
    - **General Task Characteristics** (e.g. Weights to be handled, Forces to be applied, Buffer times, Type of the task, Number of tasks require different competencies)
    - **Process Results** (e.g. Number of task intervention possibilities, Predictability)
    - **Decisions** (e.g. Autonomy for decision, number of task execution alternatives, Criticality of decision, implication of decisions, Number of decisions)
    - **Task Performance Dynamics** (e.g. Likelihood of process or task changes, number of changes per period, Predictability of changes, Controllability of changes)
    - **Ergonomics** (e.g. EAWS evaluation points, Required body postures, Travel distances)
    - **Materials / Product** (e.g. Material supply)
    - **Collaboration** (e.g. Coordination requirements, Communication requirements, Dependability on others, number of relations)
- **Contextual Characteristics**
  - **Online Measurements**
    - **Environment** (e.g. Room temperature, Outside temperature, Relative humidity, Air velocity, Sound pressure level, Vibration intensity: acceleration)
  - **Offline Data**
    - **Social** (e.g. Coordination requirements, Communication requirements, Dependability on others)
    - **Organizational** (e.g. Shift schedule, Current work hours, Work break schedule)
- **Adaptation Information and Rules**
  - **Physical Adaptation Rules**
  - **Control-Related Adaptation Rules**



- LoA Profiles matched against inputs (e.g. worker preferences)
  - Inputs treated as requirements for generating matching rules.
  - Matching rules are utilized to determine if LoA Profile actually satisfies the input requirements.

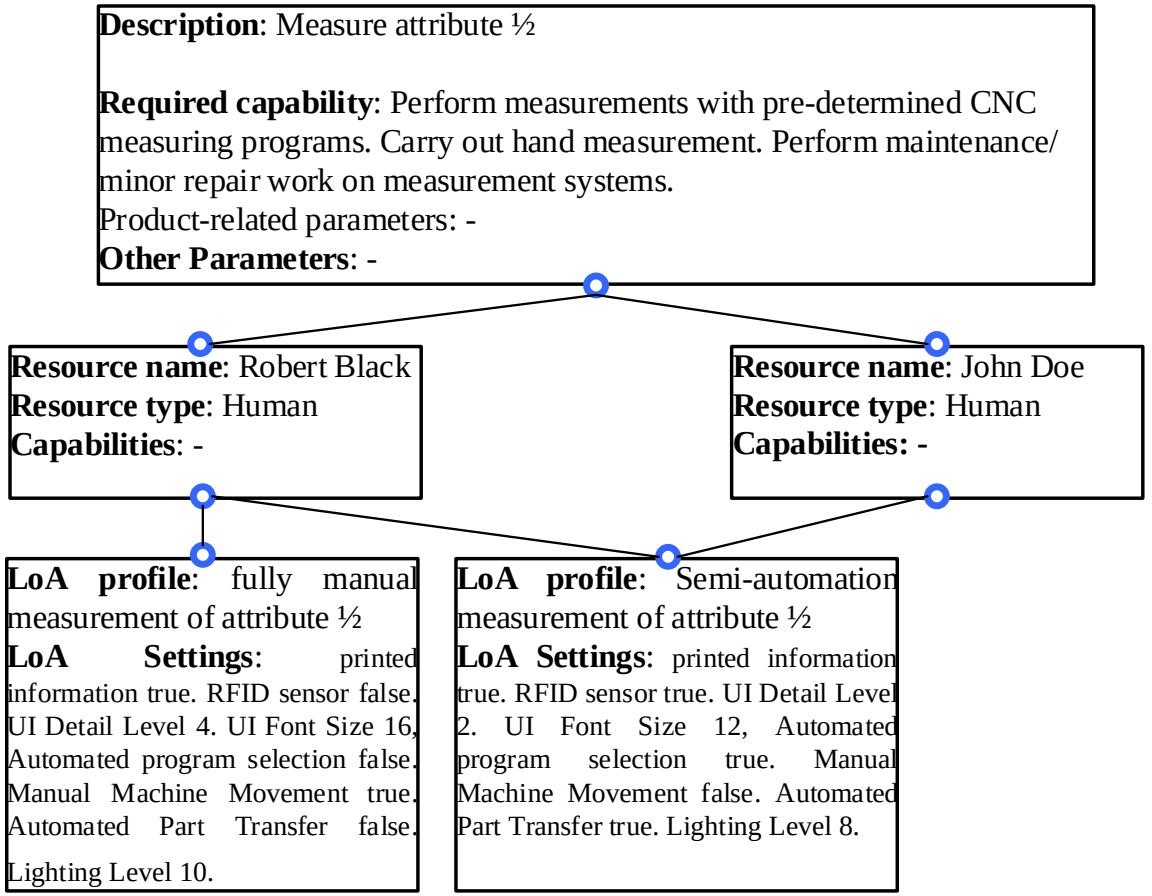
Implementing the adaptation system in production environment

Setup of the adaptation system:

1) Define systems and processes to be adapted
2) Identify adaptable elements
3) Define available LoAs for each element
4) Relate LoAs with corresponding input parameters and values (CoU)

Operating the automation adaptation engine:

1) Match workers to processes / tasks based on capabilities, skills, preferences and availablity
2) Match LoA of process / task to matched workers based on available LoAs and preferences
3) Determine candidate to perform task and adapt process / task / workplace when task is started



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Conclusions

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Conclusions and outlook

- Human-machine adaptation and improved task distribution are key enablers for future improvement and Smart Factories
- A human-centered methodology to describe Levels of Automation (LoA) as well as an engine to match LoA with current Context of Use (CoU) has been developed
- First scenarios for application have been described in the project Factory2Fit and pilot planning is currently in finalization
- Piloting results as well as workers feedback need to be evaluated and used as input for further development and refinement

Thank you for your attention!

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www.tu-chemnitz.de/mb/FabrPlan/
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