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PROFESSUR FÜR WERKZEUGMASCHINENENTWICKLUNG UND ADAPTIVE STEUERUNGEN

Increasing Manufacturing Resiliency: a Use Case Approach

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- **International Conference of Modern Systems Engineering Solutions**
- **MODERN SYSTEMS 2024**
- **November 03, 2024 to November 07, 2024 - Nice, France**

1. Introduction
   Description, concepts, motivation, goals, challenges

2. Solution concept
   Big Picture and workflow

3. Implementation details

4. Summary and outlook

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1. Introduction:
Description, concepts, motivation, goals, challenges

Aim

Our aim is to enable a flexible production that includes both large and small series as well as customer-specific production. To achieve this, a **corresponding assistance system has been developed.** Assistance systems are technical systems that support people in carrying out activities and make task processing more efficient and can be partially based on artificial intelligence.

https://www.istockphoto.com/de

Further points:

1. The proposed assistance system provides workers with instructions on changes to the production process almost in real time. These **changes are then visualised on tablets**, smart TVs and virtual reality glasses. With this system, the **vocational training of workers can take place inline** (i.e. during the production process itself). As far as we know, inline qualification is not yet widespread in the industry.
2. However, it is unclear whether this approach has been implemented in the manufacturing industry. The assistance system that guides in-line qualification assumes an 'a priori' classical basic training that enables the worker to fulfil their tasks safely and accurately as long as no changes are made to the production process.

Thinking Warehouse Woman On Tablet Inspection Stock Photo 2471690359 | Shutterstock

Concepts

Resiliency

Resilience (latin: to **bounce back**) is a key feature of production systems. It provides the ability to:

- **Withstanding** difficult, **unforeseen circumstances**.
- **Adapt to disruptions** without incurring significant additional costs.

Advantages:

1. Resilience is considered an essential component of the strategic field of action of Industry 4.0, as it plays a key role in enabling companies to withstand external shocks or disruptions in the social, economic or political context and adapt to new conditions.
2. In this way, companies can maintain or even increase their competitiveness and withstand external influences.
3. Resilience and adaptability are essential for an organisation to **survive in dynamic, complex environments and crisis situations**. The resilience of an organisation is crucial for the long-term success of a company.

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Resilient Images - Free Download on Freepik

Motivation

End of labour excess

Currently, the industry is preparing for the **end of the labour surplus**. Industry leaders are ‘unable to find workers with the manual, operational and highly technical skills, knowledge and experience to fill the vacancies’.

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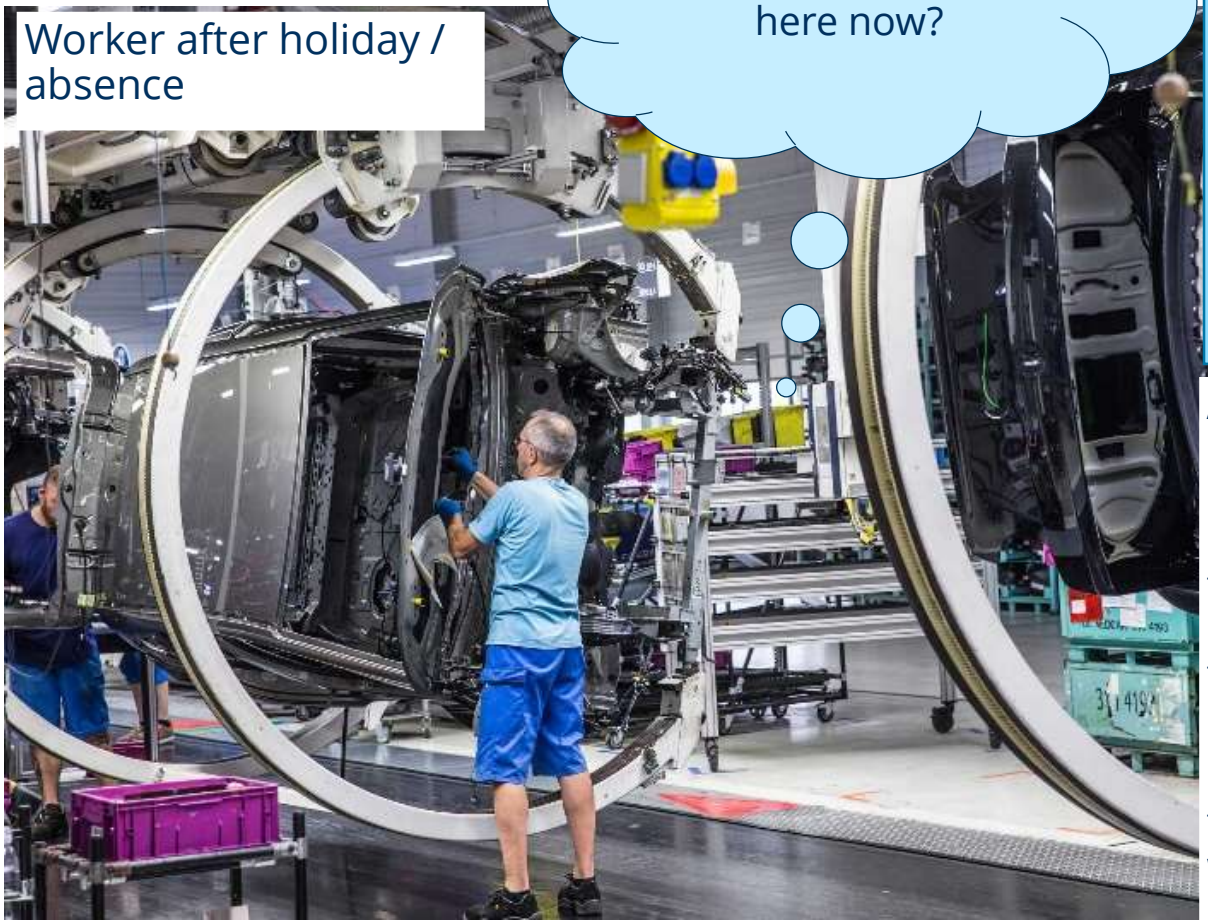
Further points :

1. Every major crisis leads to innovation, and the current situation is undoubtedly a crisis. Therefore, **knowledge acquisition in the manufacturing sector is crucial**. Therefore, shortening the learning curve is crucial. The complexity of this area makes it difficult to determine the most effective methods for knowledge transfer.
2. Although companies are aware of the importance of resilience, they often find it **difficult to determine the extent of their resilience needs**. They may lack an understanding of the true importance of resilience, so they do not know how much investment is required for resilience.

500+ Labour Pictures [HD] | Download Free Images on Unsplash

Typical work situation



'Digital' sticky notes

- Info: Turn the screw clockwise
- Learning video: How to screw in a screw?

Approach: Designing a resilient production environment -> resilience (actually the ability to react quickly to changes) includes the ability to react flexibly or adaptably, i.e. in the short term and temporarily or in the long term and permanently.

Summary / Idea: Provision of up-to-date work instructions for workers at the machine: digital sticky notes

Bildquelle: https://www.press.bmwgroup.com/deutschland/photo/detail/P90204790/bmw-group-werk-leipzig-montage-produktion-bmw-2er-active-tourer-schwenkmontage-10-2015

Challenges

Anticipating the difficulties

The way in which an organisation anticipates and responds to difficult circumstances determines its ability to recover and whether it emerges stronger. Since **crises tend to follow a similar pattern,** regardless of the triggering event, it is possible to prepare for them effectively, even in the face of unforeseen events.

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Further points:

1. To remain competitive in today's markets, it is crucial to embrace **digital transformation**. This includes automating manufacturing processes, integrating machine learning and robotics into modern production lines and feeding this information back into enterprise software to improve the agility and resilience of the entire manufacturing process.
2. A robust production **metrics monitoring system** is essential for product companies to track production efficiency and identify potential bottlenecks or risks in real time.

Digitalization Challenge Images - Free Download on Freepik

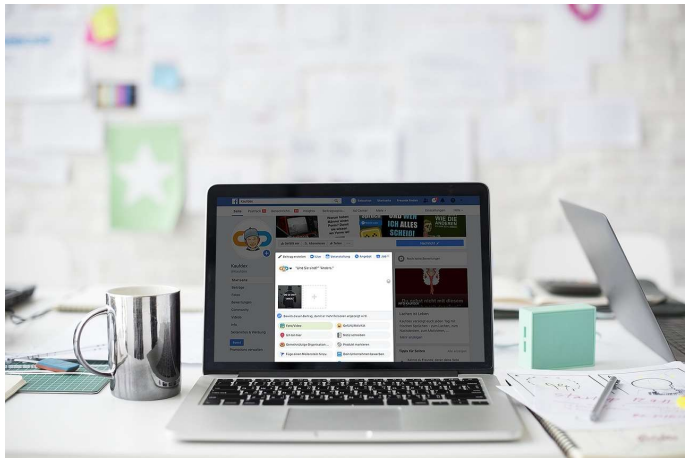
Contribution

We present a solution concept with some implementation details with the aim that the **inline qualification of employees in the manufacturing industry can take place almost in real time**, i.e., as soon as the change in the specification of the production process reaches the information system..

Contribution Images - Free Download on Freepik

Further points:

1. The feasibility of the concept was illustrated as part of the Werk 4.0 research project using an example from the **assembly line in the manufacturing industry**. The concept is largely independent of the research projects mentioned above and can therefore be easily transferred to other research/industry projects. To summarise, our approach promotes change in the manufacturing industry by advocating an inline qualification process for employees. This enables **a paradigm shift towards agile manufacturing and thus an increase in resilience**.



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Strategy

The subject of the study (feasibility analysis) and its underlying purpose was: '**To what extent can an assistance system be developed for the in-line qualification of workers**?', with the primary aim of supporting a resilient and adaptable production environment.

Chess Strategy Images - Free Download on Freepik

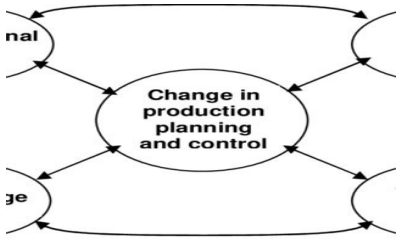
Further points:

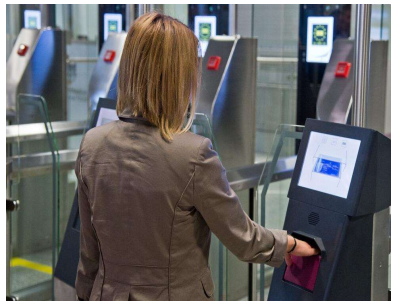
1. **The strategy is to recognise proposed changes in the production processes (which still need to be specified in detail for each use case).** Subsequently, employees are automatically informed about changed technical specifications (e.g. by updating work instructions and guidelines, relevant drawings, manuals, quality specifications, etc.), displaying the latest changes/learning content as push messages for machine operators (e.g. on a tablet, on AR glasses, on a monitor at the machine, etc.) or rather as pull messages when historical values are needed.

Free Change Management Strategy Templates | Smartsheet

Aim & Research questions (summary)

- Recognising **relevant changes** in production processes
- **Automatically inform workers** about changed engineering specifications (e.g. by updating relevant drawings, manuals, quality specifications)
- **Display changes** / learning content as push messages to machine operators while they are working on the machine (e.g. on tablet, on AR glasses, on monitor on machine)
- **Personalised overview** of relevant changes after logging on to the machine
- **Research question & challenge**: To what extent is it possible to achieve our above-mentioned goals in **real time**?





Bildquellen: Google images

Paradigm change

To summarise, our methodology advocates a **paradigm shift** in the manufacturing sector towards the **inline qualification of employees in production**. This shift is in line with the principles of agile manufacturing and ultimately **increases resilience**.

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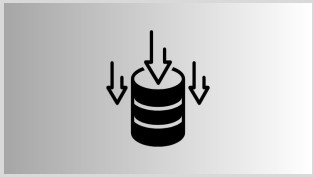
2. Solution concept: Big Picture und Workflow

Big Picture und Workflow

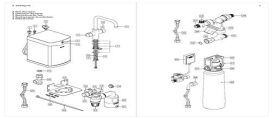
Intranet

DB server with data sources



Datenrepositorien

- Operating instructions



- Manuals

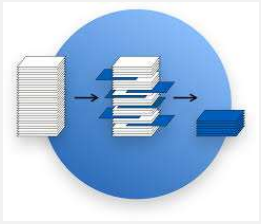
- Drawings (2-D, 3-D))

Server (e.g., VM)

Data pre-processing

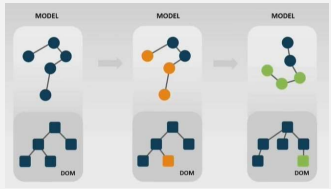
Keywording

- Extraction of metadata



Screening, selection by experts

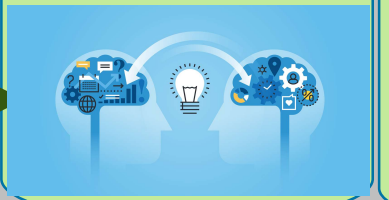
Change-Detector



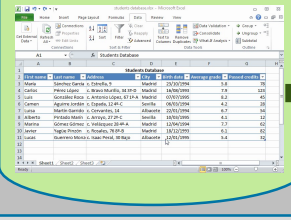
Backend

Role-specific preparation

Knowledge Base



Instruction DB

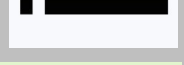


Client (Tablet, PC)

Frontend

Role-specific learning content

Instructions (‘Pull’)



Instructions (‘Push’)

images: Google images

Outline of the results

The primary objective of this study was to increase the **adaptability of manufacturing companies** by introducing agile manufacturing methods and thus **improve resilience**. To this end, an **assistance system** was developed and used for the scenario presented, which **visualises the proposed changes** to the assembly line of a production process in a manufacturing plant.

Building Resilience Symbol Concept Word Building Stock Photo 2260135689 | Shutterstock

The main advantage of this system is that it helps workers to **upskill** for their tasks during the production process by **displaying the changes on devices** such as tablets, smart screens and VR glasses, thus promoting flexibility in the production process. However, it is important to point out that this system is **not intended to replace traditional vocational training**, which remains a necessary prerequisite.

Agile Manufacturing Images - Free Download on Freepik

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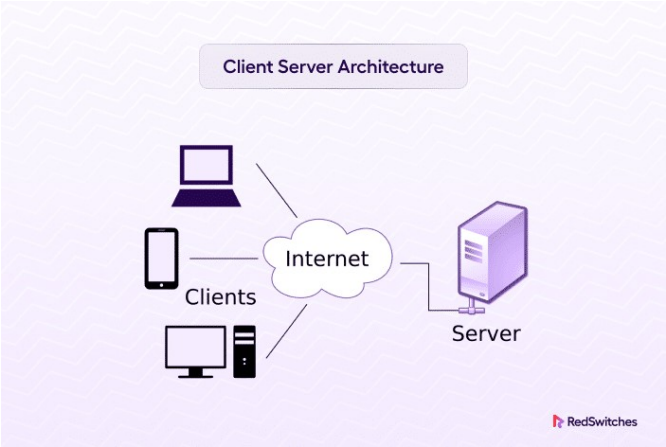
3. Implementation details

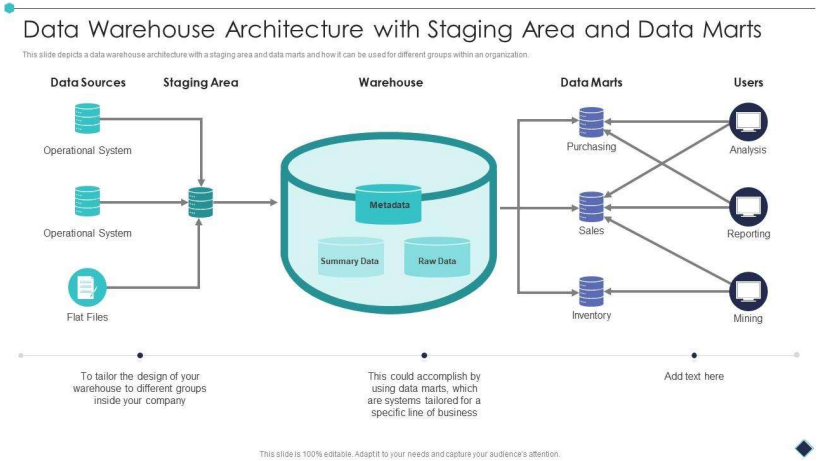
Use case: an excerpt

This use case description presents the solution concept for the inline qualification of workers. The solution concept includes **a classic server-client application with backend and frontend components**. **Portability is achieved through virtualisation** both at the operating system level through the use of virtual machines (VM) and at the application level (Docker container, Docker Swarm).

1. The implementation began with the **parsing of assembly instruction documents in PDF format**, with data extraction from these documents using rule-based processes. The extracted data is initially stored in a relational database, which enables simple pre-selection of relevant change messages through the use of filters.
2. It is necessary to develop a **near-real-time database** that prepares the data for visualisation as soon as it is loaded, eliminating the need for post-processing and time-consuming retrieval. In addition, a visualisation data mart was set up that arranges changes in such a way that immediate access to the near-real-time database is no longer necessary or has been significantly restricted.



Client Server Architecture: Types, Examples, & Benefits (redswitches.com)



Data Warehouse Architecture With Staging Area And Data Marts Analytic Application Ppt Grid | Presentation Graphics | Presentation PowerPoint Example | Slide Templates (slideteam.net)

Use case: an excerpt - cont

This data should enable both a **'push' strategy, in which changes are automatically displayed to the employee on a medium, and a 'pull' strategy, in which changes can be retrieved selectively.** It is also important to intercept possible structural changes to the input data.

Push Pull Images - Free Download on Freepik

1. The creation of a practical solution concept for use as a software prototype, the integration of the software prototype into the **Mercedes-Benz (MB) IT system**, the use of MB's data resources and the provision of a personalised summary of all relevant changes when logging into the machine are among our key objectives.

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Conclusion

We have demonstrated by using a use case that **an inline assistance system is possible**. The effort to set up such a system keeps within limits, the **benefits surpass the cost**.

In the age of Industry 5.0, which is characterised by the fusion of digital technologies with human-centric methods, **assistance systems are becoming increasingly important in the transformation of the production environment**.

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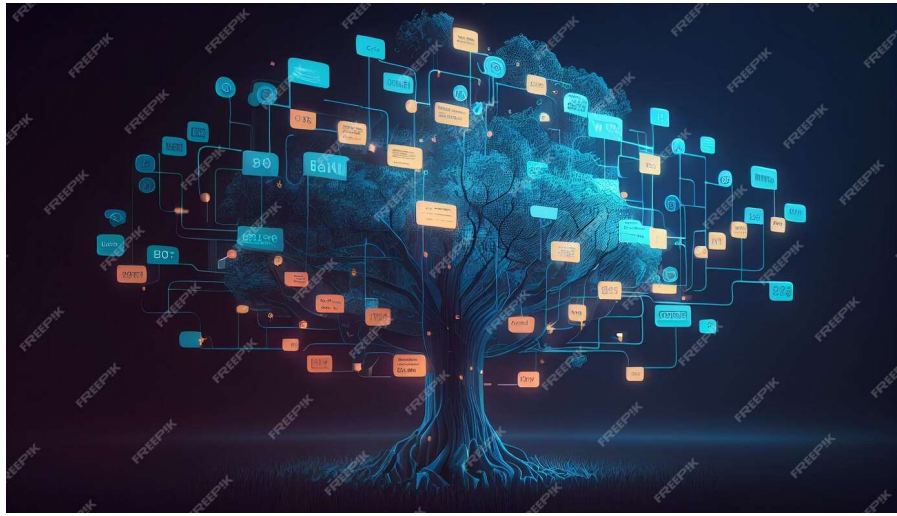
4. Summary and outlook

Summary and outlook

Summary:

- Presentation of solution concept for inline qualification of workers via worker assistance system
  - **Classic server-client application** with backend and frontend
  - **Portability via virtualisation** at operating system level (VM) and application level (Docker container, etc.)
- Storage of the extracted data in a relational database; preselection of relevant change messages via filters
- Visualisation of the changes via AR glasses



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Outlook / further work :

- **Ontology-based approach** as a data management system
- **AI-based evaluation** of internal documentation