Enterprise Information Systems vs. Digital Twins – A Case Study on the Properties, Purpose, and Future Relationship in the Logistics Sector

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Abstract

Traditional enterprise information systems have been around for more than 40 years. They are designed to support business processes and deliver information to the people within a company who require it for their work. However, there are blind spots that these systems are unable to address. In this article, we investigate how digital twins, which are based on the technology and architecture of the Industrial Internet of Things, as well as the principles of cyber-physical systems, can be used to fill such gaps and elucidate how their application will affect the prospective relationship between internal information systems and digital twins. The insights are based on a single case study within the logistics department of an industrial company and its service provider. From the case study, properties of both system types were identified that provided a basis for comparison and stimulated discussion about their future dependencies.

Keywords: digital twin, enterprise IS, interface, IoT, relationship.

1. Introduction and relevance

Companies of all sizes and from diverse industries use various information systems (IS) to handle their everyday business (Laudon & Laudon, 2020). Since their invention, the total number and complexity of information systems has been increasing, which is reflected in the market growth of business software (Gartner Inc., 2022; Power & Hadidi, 2018). For the individual enterprise, there are often more than 100 systems in a medium-sized company and thousands in large corporations. The necessity of keeping the systems updated and properly functioning requires constant care by consultants, specialists, and developers worldwide. To cope with the ongoing changes and to keep them aligned with the business, approaches such as enterprise architecture management, DevOps and IT service management have been developed to handle the increasing complexity of the systems and their interrelationships (Axelos Limited, 2019; Jabbari et al., 2016; Lankhorst, 2013).

While big software vendors that develop and provide enterprise IS, such as enterprise resource planning (ERP), supply chain management, or business intelligence (BI) systems, exist and play indispensable roles, they tend to become commodities since they provide overlapping functions and are available on the market for purchase or rent (Bitkom e.V. & Bitkom Research, 2022; Weilgum, 2008). The use of cloud-based software as a service solution has further increased the trend of more generic systems that no longer provide unique or custom features to individual companies (Travica, 2014).

Besides the information systems, companies also use assets or devices that apply operational technology (OT) which uses vendor-specific control logic in closed systems (Industrial Internet Consortium, 2019; Lara et al., 2019). Since companies often employ assets from different vendors that each use their own technologies, orchestrating processes across multiple assets is not viable.

Disruptive innovations are happening nowadays based on the industrial internet of things (IIoT). IIoT solutions are built to replace existing operations technology (OT) by converging IT and OT in cyber-physical systems (ISO, 2020). The literature makes it clear that the digital twin forms the core of a IIoT solution and a cyber-physical system by representing assets and enabling the collection of data about the real world, processing this data, and initiating actions based on the identified current situation – all of which are based on standardized internet technology (Industrial Internet Consortium, 2019; Lee, 2010; Rajive Joshi, 2022). These digital twins enable interoperability and foster the cooperation of enterprises in ecosystems (Petrik & Herzwurm, 2020).

Yet, questions about what the future relationship between IIoT solutions and internal enterprise IS will look like remain to be addressed. This topic requires thorough investigation in order to determine the potentials and challenges that exist as a way to move the topic forward. A comparison of the system types and the consequences of their coexistence for their usage in the future are the central themes of this paper.

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2.Research goal, design, and methods

The research goal of this paper, based on a case study, is to both highlight differences between traditional, internal enterprise IS and digital twins, and to discuss their future relationships based on our findings.

The paper follows the research process and principles outlined by design science research (Hevner et al., 2004; Österle et al., 2011). Building on this paradigm, the dual scientific research approach was used for the design of artifacts which were generated in close collaboration between research institutions and companies. This approach is especially suitable for the generation of findings that augment the body of knowledge from a given field, specifically in the case of IS. The research design applied here (cf. Figure 1) is based on the method of using abstract findings from real-world cases in order to identify relevant research outcomes (Weber et al., 2021).

Initially a structured literature analysis was performed to identify the current state of the subject in the academic literature. Regarding the search process, the documentation, and the interpretation of the results, recommendations presented in a number of published works were followed (Brendel, 2020; Brocke, 2009; Levy & Ellis, 2006). Searches were performed using Web of Science and the AIS eLibrary (AISeL) with keywords. To identify related work or a possible research gap, the following keywords were used: ("enterprise information systems" OR "enterprise resource planning" OR "internal systems") AND (iiot OR "digital twin" OR "cyber-physical system") AND (compare OR comparison OR vs. OR relationship OR relation OR future OR interface). The results were limited to 2014 or later since only by then had digital twins and IIoT solutions been established. In Web of Science 317 hits were reported, while the AISeL produced a total of 50. For those 367 articles, the abstracts and titles were examined for their relevance. After screening the hits, 16 sources from Web of Science and another 11 from the AISeL were read and included for further analysis in this article.

After the initial literature review on the current state of research, case study research was chosen as the main research method (Yin, 2018). A case study is a suitable method to investigate the reasons behind a certain phenomenon in the real world. In this article, the aim was to gain insights into how the introduction of IIoT solutions reflects on existing enterprise IS and what constitutes their relationship (and why). A single longitudinal case study is the basis for the findings reported here.

The project execution was divided into a business and a technical task group: The business task group considered the business aspects, such as the information demand, requirements of the digital twin, the division of tasks between the involved parties, and the implications for the business models. The technical task group discussed sensors, architecture, services, and data processing. To address both committees' needs, several researchers from different research disciplines participated. The overlaps of both task groups were coordinated internally at each company.

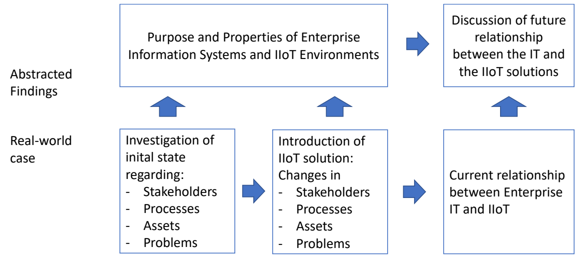

Figure 1. Research design.

Since the authors directly participated in the research, access to the required documents, data sources and the data itself was readily available. Meetings were continuously held with the various stakeholders, such as the logistics managers, the executive staff, and the workers from both companies involved. The collected information about the case was documented in a case database to ensure the intersubjectivity and traceability of our research. Based on the documentation that was double-checked by multiple researchers, it was possible to derive conclusions and to verify the arguments based on empirical evidence.

3. Results from the literature review

3.1. Current state of research and practice regarding enterprise IS and IIoT digital twins

In companies there are a number of business IS used every day. Among those traditional enterprise systems are customer relationship management systems, enterprise resource planning systems, supply chain management systems, human resource management systems, warehouse management systems, business intelligence systems, and many more (Gronwald, 2017; Laudon & Laudon, 2020). The focus is on enterprise resource planning systems since they are capable of including the functionalities of the others and are therefore a feasible representation of this system class. In this paper the authors aim to abstract from this single system type as a basis to formulate more general statements.

The systems are nowadays based on service-oriented architectures or microservices and run in cloud infrastructures (Majedi & Osman, 2008). They have vendor-specific functionalities and interfaces, i.e. they cannot be considered to be open systems (Haddara & Elragal, 2015), which is why in SMEs the current IT infrastructure is considered to be a challenge when designing new solutions (Kumar et al., 2021).

At the same time, our economy has reached a maturity level that makes it difficult for individual companies to generate new value based on product or product innovations. Instead, value is increasingly created by business ecosystems (Matthyssens, 2019). Cyber-physical systems are the basis for collaboration in ecosystems (Mezgár, 2019) since they are the main enabler of interoperability, which is required to cooperate across company borders (Schilberg et al., 2017).

In this article these systems are contrasted with digital twins as they are considered to be the main part of IIoT solutions. They are a virtual representation of a real asset (Grieves, 2016). The broader IIoT solution also deals with the assets, the sensors, the connectivity, and the trustworthiness of the solution, whereas the digital twin is at the core for processing the incoming data and call services that cause actions in the real world (Enders & Hoßbach, 2019).

Most use cases are in the industrial sector, however since the case reported here is in the logistics sector, a closer look in the current literature was taken (Garay-Rondero et al., 2020; Kosacka-Olejnik et al., 2021; Zoubek & Simon, 2021). The conclusions reported state that the introduction of IIoT and digital twins is a major change in the sector that influences everything – from strategy over processes and people to the infrastructure itself.

3.2. Related work regarding the relationship between traditional enterprise IS and IioT solutions

The literature review on related work revealed that the topic addressed in this paper is represented in the literature by three types of articles. First, there are articles that discuss the future of traditional enterprise IS in general or within the context of the IioT. Second, there are articles that describe new IoT solutions which mention the relationship with the existing internal legacy systems. Finally, there are articles that are concerned with the problem of integration.

The first type puts the topic on the research agenda by expressing the need to deal with challenges that arise from IIoT applications (Jonathan et al., 2021; Panetto et al., 2016; Sedera et al., 2018; vom Brocke et al., 2018). This is very important to document the relevance of the issues and to motivate researchers and practitioners to develop solutions.

The second type mainly states that either data must be extracted from existing IS and fed into the digital twin or other ways of co-existence need to be found, however without going into further detail (Dietz & Pernul, 2020; Freese & Ludwig, 2021; Kiel et al., 2017; Marinelli et al., 2021).

The third type proposes a service-oriented architecture to increase the interoperability of the existing IS (Amini & Abukari, 2020; Berger et al., 2016; Jung et al., 2017).

However, the identified articles have not implemented digital twins, instead they draw from ideation, discussion, and lab settings. In contrast, this paper will contribute to the discussion based on a real-world case.

4. Case Study in logistics

4.1. Initial state

Our case deals with the internal transport within a large German industrial company. The company's internal logistics department is responsible for moving larger items, mostly palettes, within the warehouse area, e.g., from the truck unloading area to the warehouse, within the warehouse, or back from the warehouse to the destination of the respective goods.

The company has outsourced this task to an external solution provider that is handling the transportation of the goods on behalf of the industrial enterprise. We will call this service partner in the following "the logistics company". Consequently, there are two companies involved in the case: First, the industrial company that needs the parts for their production, owns the warehouse, and has the requirement of having goods handled; second, the logistics company that has to ensure that the parts are transported, stored, loaded and unloaded, and delivered as requested. The logistics company provides the necessary resources, such as employees and machinery.

Both companies use traditional enterprise IS, such as enterprise resource planning and warehouse management solutions, that are available as standardized software products by large vendors.

The enterprise resource planning (ERP) system of the industrial company creates transportation requests that are to be fulfilled by the service company. The service company is responsible for handling the requests and do so by means of their available resources, such as the employees and the machinery, that are located on the grounds of the industrial company. In our case, the equipment consists of forklifts from different vendors.

Each request by the industrial company is stored in the enterprise IS of the logistics provider, since the transport information must be communicated to their employees (cf. Figure 3).

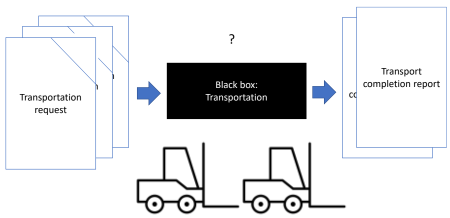

Figure 3. Transportation as a black box.

After the transportation has been completed, the logistics company issues some feedback on the status of the products, i.e., they report the current location of the goods to the industrial company, which in turn will be able to track them further.

The logistics company receives a monthly payment for their services. The system is operational and the transportation needs are handled effectively.

From the managerial perspective, however, there is a lack of insight into the process. The logistics management from both parties involved lack access to further details, such as:

- Are the transportation tasks handled efficiently?
- Do we need more or less resources to handle the amount of transportation requests?
- Are there peaks in the workload that we need to address?
- In what way could the logistic processes be improved?
- Which equipment vendor is the best fit to our requirements?

A consequence, for example, is that this situation leaves the logistics management with the impression that since they have no way of measuring the ongoing logistic activities, there is also no way of knowing whether the logistics company is providing the best possible service at the best possible price to the industrial company.

4.2 Introduction of an IIoT solution

Since the information demand of the logistics management could not be met with the existing solutions, the two companies jointly set up a project with the goal to bring transparency to the logistic flows. On the scale presented by Zoubek and Simon (Zoubek & Simon, 2021), this step suggests a shift from Level 2 to Level 3 regarding the automation of logistic processes.

The architecture of the IIoT solution, which was developed within the scope of the case study is depicted below (cf. Figure 4).

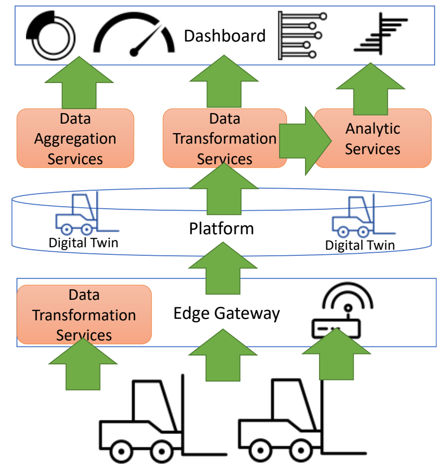

Figure 4: IIoT solution architecture.

The components are sensors, an edge gateway, a platform, and a dashboard. In between these components, partners can add services such as analytic or data transformation services. The following section describes the IIoT solution in detail, layer by layer.

Physical layer: On the physical layer, sensors were added to the forklifts in order to collect data about the current status of the vehicles. The sensors added were able to determine the position and the state of the asset, which could be inactive, loading, driving, or transporting. In addition, we used sensors to measure the workload, such as the weight that was being transported, or the height of the movement operations. An IIoT gateway was used for this purpose, which was connected to, amongst others, sensors for track and trace, as well as load handling. Lastly, a sensor was installed to capture the ID of the goods transported.

Platform layer: In the platform layer, complete IoT solutions were leveraged such as Amazon Web Services or Microsoft Azure IoT. These provided connectors to the sensors and were able to handle the incoming data. Digital twins of the assets were created that contained the last updated set of sensor outputs together with the asset ID. The main task of the platform was to store the data in a shared data space that fulfilled the requirements of IT-security.

Service layer: Services could be run either on the edge gateway or on top of the platform. For this case, services were needed that could transform the data into the required data type and analytic services were needed that could build on the collected data in order to be able to generate insights. The services could be offered by all partners in the ecosystem or the platform provider. In this case, the sensor vendor provided the services.

Dashboard layer: There was one common dashboard for the partners. They could access the current state of each forklift, or use views that showed the aggregated information for all forklifts combined. It was also possible to derive calculated values, such as the average duration of battery loading time per day or the length of time a forklift was in use compared to the time it was switched off.

New stakeholders: To build this IIoT solution, two new partners were added to the ecosystem: First, a sensor vendor that provided the required sensors and the gateway; and second, researchers with knowledge about this type of solution. The dashboard was developed by the internal IT department of the logistics company.

The implementation and introduction of the IIoT solution required approximately four weeks from the time the decision was made to pursue it to the installation of sensors, rollout, and testing. The feedback from the management of both companies involved was very positive. They continue to frequently use the dashboard and are now able to make adjustments to their processes (e.g optimization of material supply) and resources (e.g. reduction of the number of required forklifts) based on the insights they gain about the ongoing transport procedures. The solution effectively addresses the black box problem.

This IIoT solution currently provides transparency, i.e., it realizes the principle of "cyberization of the physical" (ctp). Nonetheless, at this stage it does not yet exert control autonomously back to the physical assets (also called "physicalizing the cyber", ptc), which is the next research step to be investigated. As a result, in accordance with the partners involved, the current IIoT solution will be extended over the next months in order to achieve this goal.

4.3 Relationship between the IIoT solution and the enterprise IS in this case study

In this case study, there was some degree of information which was off limits to each of the cooperating companies. Examples are that the logistics company did not need to know details about the goods they were transporting, nor did the industrial company need to be informed about the internal costs accrued by the equipment and personnel employed by the logistics company. To ensure that such information could not be shared accidentally, pseudonymization of the objects and people involved was applied (Werling et al., 2022).

The necessity for which is obvious: details about the goods are not needed to fulfill the job requirements, and are rather part of the production and supply chain built up by the industrial company over many years. Naturally, a company would not want to share detailed information about the parts used in their production, nor would they want to share details about their suppliers.

At the same time, it would be disadvantageous for the logistics company if their paying customer, the industrial company, would know the actual costs involved in realizing the work order, since this would weaken their position in negotiations and compromise profits. Furthermore, details about the equipment being used, such as the brand of the forklifts, might have an impact on the cost or the performance and should therefore also not be disclosed.

The two companies stored these details in their internal enterprise IS, such as their ERP or HR systems. Data from the IIoT solution and that from their internal data was combined to analyze the situation from their individual perspectives based on a commonly shared basis.

To achieve this, the companies used different means. Each company utilized their own approach – one company used the logical relationship between data sets to integrate the data, the other used the links between the systems' environments to navigate from one system to the other.

Scenario 1: Extract and integrate: The logistics company used a spreadsheet solution to combine internal company data with the data collected by the IIoT solution in order to calculate processing costs, and to compare the performance of various forklifts. Hereby they extracted data from the internal systems, and integrated this data to address their information demands.

Scenario 2: The industrial company was primarily interested in knowing if the logistics were being handled efficiently. They did not want to pay for superfluous resources, and were hence interested in the loading factor of the current resources in order to plan for future changes. An example of such would be an increase in production capacities, which would in turn require increased logistics demand. Such questions can be answered by the IIoT solution. In addition, if details about a specific part are needed, they can be searched for using the corresponding randomized part number in both solutions to determine where it is located or when it was last moved and by whom. This enables tracking and tracing of goods throughout the logistical processing, which has become increasingly important due to laws that require such tracking or when it is urgently needed, for example in the case of missing parts.

Regarding the concept of the relationship of the systems, this indicates that the systems were kept separate. Identifiers were applied to switch between the systems, but there was no integration at the time of the case study.

5. Comparison of the digital twin solution and enterprise IS

Based on our case study, a comparison of IIoT and enterprise IS, such as ERP-systems, was possible. The comparison was structured according to different categories and has been summarized in a table (cf. Table 1).

Table 1. Comparison of solution types.

Category	Enterprise IS	Digital Twin/ IIoT solution
Access	Single company of focus	Multiple companies as partners in the ecosystem
Components	Database + functions	Platform + services
Cost	Licensing, running	Running, sensors + gateways
Extensibility	Limited, requires programming	Services can be flexibly added to the solution
Focus	Supporting business processes	Evaluating interactions between assets
Function principle	Business transactions	Cyberize the physical + physicalize the cyber
Hosting	On premises or private cloud	Public cloud
Point of Failure (Architecture)	Central	Decentral
Responsibility	IT Department	Business unit
Risks	Well understood	Potential non-acceptance
Standard-ization of interfaces	vendor-specific solution	Standardized (internet protocol stack)
Time needed to implement	Months	Weeks

Access: Traditional IS are intended for internal usage. They are built to support the processes and people in one specific company. On the contrary, the IIoT solution in this case was beneficial to the ecosystem which included rather multiple players, since multiple parties were able in parallel to access the data created by the machines.

Function principle and Focus: Internal IS are transaction-oriented and their goal is to support business processes and decision processes by providing and storing information. Digital Twins on the other hand, focus on the interactions of real-world entities. The goal in this case was to gain insights into the processes that would allow for improvements in the future.

Responsibility and Hosting: Whereas traditional internal IS are usually managed by the internal IT departments, in this case, the IIoT solution was introduced by the logistics departments. The IT department was involved in building the dashboard according to the company standards, but had no decisive influence on the overall solution. The hosting situation operates similarly: Internal systems are hosted internally – possibly physically on premise or in a private cloud. Digital twins are based on platforms that are hosted by large scale platform providers and their public cloud infrastructures.

Components and Fault tolerance: Enterprise IS use an internal database, usually relational, together with functions or services. This also means that there is one single point of failure if the system fails. For digital twins, these components are replaced by the platform and services. While seemingly similar, the services are actually not identical. In traditional IS we find pre-defined services, whereas in IIoT systems, anyone can add new services to the environment, which is also reflected in the degree of standardization.

Standardization of interfaces and Extensibility: The digital twin environment is based on standardized internet technologies. The environment can be extended by adding new business partners in the ecosystem, new devices, and also new services. Internal systems usually provide pre-defined interfaces that are vendor-specific.

Time to implement: The process to prepare for the implementation includes time to collect requirements, involve stakeholders, compare possible solutions, customize them, and introduce them in the company. This is needed to ensure the ongoing operation of the systems, especially when replacing an existing system. In this case, sensors were simply added to the forklifts and then connected to the internet. Moreover, the services were defined and implemented. For this a much smaller group of people were involved and standardized components available on the market were used.

Cost: The cost can be divided into costs that occur once and recurring expenses that occur regularly. In this case, there was a one-time investment needed to purchase the sensors and gateways. However, the cost of installing and running an IIoT solution is significantly lower than maintaining a typical internal information system at a larger company. Here the companies involved achieved a positive cost-benefit ratio, which is substantiated by the fact that the companies involved decided to extend the current solution and, beyond that, have agreed to build further digital twins for other aspects of the business agreement.

Risks: Regarding the risks involved, the risks are well known and understood in established enterprise IS. The use of digital twins in this case resulted in a potential acceptance risk since there was a higher level of transparency in the ongoing activities and in the actions of the people involved, as they could be continuously retrieved and monitored. To reduce this risk, we involved all stakeholders and informed them about the goals of the project and why the conditions were necessary. The perceived risk of losing control of their data by storing it on a cloud platform was diminished due to the pseudonymization and permission was granted to use cloud computing by the information security officer of the industrial company. Other technical risks were mitigated by the concept of trustworthiness, which is an essential part of every IIoT solution (Buchheit et al., 2021).

6. Implications for the relationship between digital twins and enterprise IS

In this section, the implications are discussed with regard to different time frames in the future since it is expected that changes will require different amount of time until they take root and can be implemented.

Based on current developments regarding the asset administration shell and efforts of the digital twin consortium, there is a tendency towards standardized digital twins that will be easier and faster to build with a higher level of interoperability. There is also ongoing work focused on the hiding of information or the control of data so that partners in the ecosystem are not able to access all data within a digital twin (GAIA-X, 2022; Werling et al., 2022). This would reduce the need to store information in internal systems. However, this will take some time to become established on the market, since standardized digital twins are usually part of newly sold product service systems. Existing systems can be backfitted by adding sensors and establishing an internet connection, as was performed for this case study, the companies themselves are responsible for managing the required changes.

Short-term relationship: Our estimates suggest that in the next two to four years, enterprise IS will remain the dominant systems within companies as they contain the relevant master data and represent the current business logic. A data exchange with IIoT solutions can be achieved through interface programming or manually by the users. It requires time to learn about the possibilities and benefits of new solutions and to implement them within companies. In addition, current developments and the experiences from the case study show that partial digital twins will likely be established in the next two to four years. These are characterized by the fact that they contain, in particular, condition data based on existing OT values or retrofitted sensor technology. These are often proprietary and adapted to use cases. Examples for this are the rudimentary digital twins, that contain location, weight, pressure etc. as described in the case study. IT professionals have to adapt to this shift, which has even been described as a culture change (Stentoft et al., 2019; Türkeş et al., 2019). However, it is already possible to observe an increasing rate of digital twins being built and various studies predict steady market growth in this field.

Mid-term relationship: In the next 10 years, we expect that digital twins will be increasingly popular due to the offers from vendors and the increasing competition between and importance of ecosystems (Demil et al., 2018). The gained flexibility through decentralized control and newly established service orientation are advantages that should prevail.

Vendors of ERP systems have already announced plans to adjust their systems to be able to handle more sensor data and increase the analytic capabilities with the aim to be beneficial for IIoT solutions (Becker et al., 2021). However, ERP systems are based on the assumption that there is one focal company in control of the processes, which may no longer be the case in situations in which orchestration of multiple players is needed. In addition, ERP systems are still unable to handle the vast amount of sensor data to be processed (Not given, 2020).

It is more likely that they will transition into services, which will become part of the IIoT solution. These services can be very valuable since they can provide insights into the business logic based on the functions the systems currently offer, such as diagnostics (Haddara & Elragal, 2015). A model for this was proposed by Schnicke and colleagues (Schnicke et al., 2020).

In addition, from this work early indications were derived concerning the standards for digital twins with the expectation that they will be established for objects such as forklifts or electric motors in the next 10 years. Concurrently, this is also observable in the activities of the Industrial Digital Twin Association (IDTA) and the Digital Twin Consortium (DTC). The discussions and developments that are driven by these consortia suggest that digital twins of standard objects will find a broad application in the mid-term. This development is also supported by the increasing use of tools from the leading HyberScalers to manage digital twins. Examples of this are Amazon AWS IoT TwinMaker or Microsoft Azure Digital Twins.

Long-term prediction: In the long run, the relevance of internal enterprise IS is expected to diminish. Accordingly, Kosacka-Olejnik and colleagues (Kosacka-Olejnik et al., 2021) expect that there will be either digital twins or warehouse management systems in the future. Other researchers support this transition by providing a method to move from enterprise systems to cyber-physical systems (Wu et al., 2021). Especially if the principle of execution control will be further established based on digital twins, the assets will be able to exert decentralized control. We already found this to be true in another case of a cyber physical production environment, which was self-organizing and thus no longer needed a central system to exert control on the assets (Lachenmaier, 2019).

Within a single company and stable environment, traditional enterprise IS can still be used to ensure operational excellence and best practice business processes that adhere to legal requirements.

7. Limitations and outlook

One limitation of this research is that it is based on examining only a single case study. To address that weakness, our research group is already conducting similar research projects in other industries with other companies in order to establish more empirical evidence and thereby further the discussion.

Another limitation is that thus far there has only been very limited empirical evidence established to support the long-term prediction; importantly however, to account this issue in this case the researchers involved have drawn from their own insights as well as from the literature, and have used structured means of comparison to add certainty to the possible future outcomes.

In this case study, great enthusiasm on behalf of the stakeholders was experienced. Their daily use of the IIoT solution and motivation to implement more digital twins throughout their corporations relay a high level of acceptance. We expect that this case and other such cases will have an impact on the market which will contribute to the adoption of digital twins.

The consequences for IS research are already discernable. While topics such as the digital transformation are currently experiencing a frenzy, there is a real need for research with respect to how we can continue to relate to existing internal systems that contain viable information (Panetto et al., 2016).

A further concern, as has been shown by the history of enterprise IS, is that over time numerous distinct systems have been implemented that even to the present day are not able to work well together. The management of all the existing systems is challenging and occupies resources in IT departments, which are then no longer available for other tasks or innovative pursuits. Therefore, every party should try to build digital twins based on referential standards in order to both ensure their interoperability (Budiardjo & Migliori, 2021) and to be able integrate them into a strategic approach thereby leveraging existing frameworks, methods, and tools. An example is enterprise architecture management, which also requires adjustments to be able to focus on ecosystems and products instead of on single companies (Kaidalova et al., 2018).

As an additional next step in our research, the goal is to develop a modelling language for digital twins that will incorporate elements capable of linking existing internal enterprise IS, which will consequently simplify the development of interfaces.

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