Development of a Valuation Method for IoT-Platforms

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Abstract. A production facility enables the collecting of many different data with existing machinery. One reason for this are modern machines, which are usually equipped with cyber-physical-systems (CPS). CPS are the basis of Industry 4.0 and enable machines to collect and transfer data by using sensors and a communication interface. The IoT-platform can visualize and analyse the data collected. This enables production to be optimized by detecting and minimizing weak points. Due to the topicality of this topic, there is a large variety of platform providers on the market. However, the IoT-platforms of the different providers have different strengths and weaknesses. In order to be able to keep track of existing IoT-platform solutions and to be able to better point out advantages and disadvantages, this paper presents a method that supports the suitability and choice of an IoT-platform solution.

For this reason, a method will be developed which is based on a matrix in which selected IoT-platform solutions are listed. In addition, criteria for evaluation are detected and an evaluation scheme is integrated. Based on the evaluation the method determines a suitable IoT-platform by taking the customer needs into account. After a brief introduction and portraying the state of the art, the concept of the evaluation matrix is followed by an outlook and a short summary.

Keywords: Platform · Industry 4.0 · Digitalization · Project ArePron

1 Introduction

Data are often referred to as the oil of the 21st century because of their current importance. A large number of different data can be generated in a production facility with existing machinery. On the one hand, these are machine-unspecific data such as temperature or humidity inside and outside the machine hall. On the other hand, machine-specific data such as machine temperature, lubricant level, set-up time or energy consumption can also be recorded. Sensors can also be used to determine production duration or quality. One reason for the ever simpler generation of data is the implementation of cyber-physical systems (CPS) directly in the machines used in production. CPS consist of an integrated system, an actuator and a communication module. If several of these CPSs are in use for one production, this is referred to as cyber-physical production systems (CPPS).

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CPS are the basis of industry 4.0 and enable the acquisition of physical data and the influence on physical processes by the existing actuators. Furthermore, data evaluation and storage as well as the resulting active or reactive interaction between the real and the digital world are of relevance. The prerequisite for this is a communication module that can be used for local or global communication [1].

This technology contributes to the fact that the worldwide amount of data will grow from 33 Zettabyte[1] today to 175 Zettabyte in 2025 [2]. Businesses need to prepare for this data growth and existing infrastructure should be rethought and adapted. The development of an in-house strategy should also be considered. Existing IoT-platform solutions can become very important and provide added value for companies. With the help of IoT-platforms, the data generated can be visualized and analysed. Thus, production can be optimized by uncovering and minimizing weak points. In addition, the system can independently point out errors, such as an excessively large deviation between actual data and target data. Due to the topicality of this subject, there are a large number of platform providers on the market. However, these differ with regard to various criteria, such as existing functionalities, the suitable range of applications or the provider, which is why companies must be supported in the search for and selection of a solution [3].

In order to be able to keep track of existing IoT-platform solutions and to be able to better point out advantages and disadvantages, this paper presents a method that supports the suitability and choice of an IoT-platform solution. The method is based on a matrix in which selected IoT-platform solutions are listed. In addition, criteria for evaluation are recorded and an evaluation scheme is integrated. On the basis of the evaluation and taking into account the requirements, the method determines a suitable IoT platform. This paper focuses on the core of the method, the evaluation matrix.

As part of the ArePron project (agile resource-efficient production network), two existing learning factories at TU Darmstadt will be networked to form a production network and expanded to include an IoT-platform. With the help of the IoT-platform, a component-based recording of resource use and consumption will take place. In addition, a "common currency" will be introduced to compare the whole resource consumption and therefore possibilities will be developed for converting value-added processes into a resource-optimized production process. This project is supported by the Hessian Ministry of Economics, Energy, Transport and Regional Development and the European Union [4].

2 Automation Pyramid and IoT-Platforms

The hierarchical structure of a factory and communication inside companies can be simplified using an automation pyramid [5]. Different processes are subdivided into different levels, making production boundaries visible. Automation pyramids are usually displayed with three to seven levels (see Fig. 1) [6]. In most cases, the individual levels are supported by different systems, such as PLC, SCADA, ERP or MES. Of major relevance is the data transfer within the individual levels, but also between the levels.

[1] 1 Zettabyte = 10^{21} Bytes = 1.000.000.000 Terabytes

From bottom to top, the amount of data in the individual levels increases, while the need for decreases due to low latency.

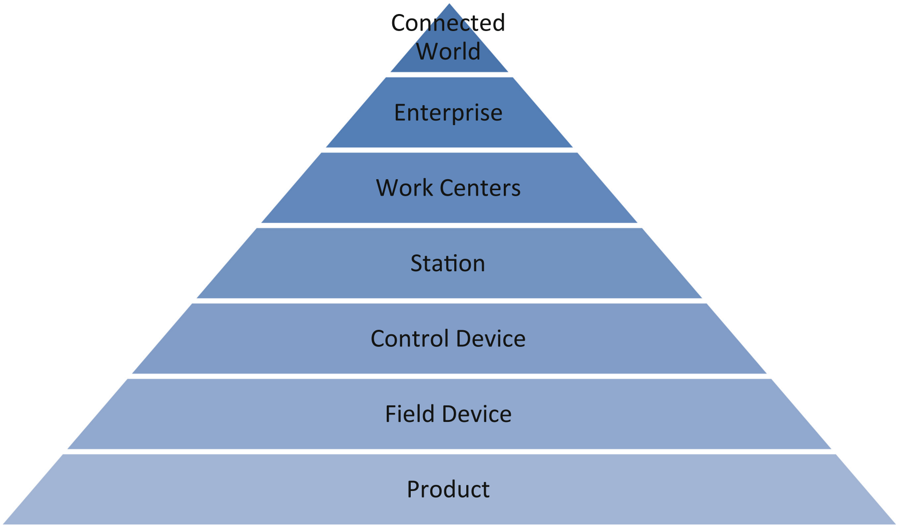

Fig. 1. Classification of IoT-platforms in an automation pyramid according to RAMI4.0 [7]

As a result of digitalization and new emerging technological possibilities, such as the use of cloud computing or the connection of a production to IoT-platforms, the pyramid is flattening more and more and the number of levels is tending to decline resulting in less hierarchical structures. The reason for this is the integration of networked, decentralized systems that make data, services and functionalities available where the need arises in production. By using CPS in production, generated data can be transferred directly to integrated systems such as IoT-platforms. Previously, data was transferred from the field level via the Control Device, Station and Work Center levels to the Enterprise level. RAMI 4.0 is followed by Connected World at the top of the pyramid, which includes the entire company group, external service providers, suppliers and customers [8]. This detour is no longer up to date due to modern and more flexible communication channels, which explains the flattening of the automation pyramid.

These developments are beneficial for the use of platforms. In case of platforms, a primary distinction must be made between transaction platforms, innovation platforms, investment platforms and integration platforms [9].

Transaction platforms such as eBay, Uber or Airbnb take on the role of intermediaries for the sale of products or services connecting buyers and sellers. Innovation platforms are platforms that provide an innovation in the form of a product or service. Building on this innovation, others can become a part of the platform through their own ideas and developments to expand it further. One example is Axoom's IoT-platform. Other companies can use the product as a basis to offer new products and services. On the one hand, these can be innovative apps with new business models for the companies. Another possibility is the sale of manufacturer-dependent machine tool data, so-called technology data, with which customers can manufacture in high quality immediately after purchase, without having to carry out samples [10]. This saves time and money and customers can immediately gain added value through the platform.

Integration platforms relate to the characteristics of transaction platforms and innovation platforms. A well-known example of this is Google's operating system Android, on which over 3.3 million apps from various providers are now available [11]. In addition, Android brings the agent and buyer together via a single platform.

Finally, there are investment platforms to be mentioned which have to be distinguished from those mentioned so far. Users of the platforms are companies that act as holding companies, investors or both, and pursue a platform portfolio strategy [9]. An example of this is the company Booking Holding, which is not a platform in the actual sense but is a shareholder of various products such as Booking.com, Kayak.com or momondo and can therefore be described as an investment platform.

IoT-platforms can deliver significant business value by capturing production data and transferring it into an IoT-platform. The IoT-platform allows data to be stored, processed and analysed. From the generated data, relevant results for production and the company can be derived. This could be information on the power consumption of a machine tool or the current state of the machine, for example. The acquisition of the current position of an object can also be displayed in IoT-platforms.

3 Concept for a Method of Valuation for IoT-Platforms

After a brief explanation of IoT-platforms in Sect. 1, now the concept of a method supporting the selection of IoT-platform will be described. This is necessary due to the large number of platform providers and the differences between different IoT-platforms. The method allows interested parties of an IoT-platform to directly access relevant requirements, add requirements as needed and evaluate the IoT-platform if necessary. The method is based on a matrix (see Table 1) in which various criteria, subcriteria and selected IoT-platforms can be found. The evaluations have to be entered into the matrix shown in Table 2.

Table 1. Structure of the evaluation matrix

Main criterion	Secondary criterion	Platform A	Platform B	Platform …
Main criterion A	Secondary criterion A1	++	−−	…
	Secondary criterion A2	+	−	…
Main criterion B	Secondary criterion B1	o	o	…
Main criterion …	Secondary criterion …	++	−−	…

Table 2. Valuation possibilities

++	Fully applicable
+	Applies largely
o	No statement possible
−	Applies in part
−−	Not applicable

The valuation options are shown in Table 2.

The statement "Fully applicable" (++) means that the relevant subcriterion is fully applicable and met by the IoT-platform. In contrast, a subcriterion is not met in any way in the "not applicable" (−−) rating. In case of the ratings "largely applies" (+) and "applies in part" (−), a subcriterion is met or not met with restrictions. Finally, the evaluation "no statement possible" (o) is required in order to be able to neutrally evaluate a subcriterion if information is missing. The evaluation options are decisive for the selection of an IoT-platform and are taken into account in the developed logic as part of the method.

The main criteria and their respective subcriteria are presented below. They are the core of the method and represent a collection of relevant properties for the selection of an IoT-platform. It is possible to change the criteria or add new criteria as needed. Each criteria of an IoT-platform must be evaluated as objectively as possible so that the result of the selection is not distorted.

In the following, the main criteria with associated subcriteria are presented and briefly explained:

Criterion Usability

The usability criterion refers to the user-friendliness of a platform. It describes the extent to which users can achieve a goal effective[2], efficient[3] and satisfactorily [4] in a defined application context.

- Platform Setup: Describes the usability of the platform setup.
- Integration of new devices: Describes the usability regarding the integration of new devices into the platform.
- Import of measurement data: Describes the usability regarding the import of measurement data into the platform.
- Intuitively usable: Describes the positive usability of the platform without prior knowledge from associated documentation or similar.
- Stability of data transmission: Describes the probability of the occurrence of unexpected effects of changes on data transmission.

[2] "Accuracy and completeness with which users achieve certain goals" [12].

[3] "Resources used in relation to the results achieved" [12].

[4] "Extent to which the user's physical, cognitive and emotional reactions resulting from the use of a system, product or service correspond to the user's requirements and expectations" [12].

- Stability of the platform: Describes the probability of unexpected effects of changes on the platform.
- User Experience: Includes all effects, such as perception and reactions, that the use of a user interface has on a user before, during and after use [13].
- Reliability of data transmission: Describes the maintenance of a certain line level of data transmission under certain conditions over a defined period.
- Reliability of the platform: Describes the maintenance of a certain line level of the platform under certain conditions over a defined period.

Criterion Data Processing:
The criterion data processing describes the automated processing of data in electronic form within the platform. In addition, the possibilities of data processing within the platform are considered in this main criterion.

- Recording amount: Describes the upper bound for the recording amount of platform data.
- Display of a data series: Describes the possibilities, such as using different diagram types or lists, of visualization data series.
- Display of different sensor data: Describes the possibility of displaying different sensor data.
- Amount of data during transmission: Describes the size of data sent to a platform and its compression options.
- Data point display: Describes the possibilities of displaying data points.
- Exportability of the data: Describes whether data can be exported.
- Speed at which measurement data is transferred to the platform: Describes the latency between the collection of a measurement value and its appearance on the platform.
- Grouping of sensors: Possibility to classify groups of different sensors.
- Transmission frequency: Describes the support of different transmission frequencies of a platform.

Criterion Documentation
The criterion documentation describes the possibility of using manual or similar sources of information, which can explain and simplify the use of the platform. The documentation is usually integrated into the platform or made available by the provider as a document.

- Status: Describes the status of documentation with regard to the version of the platform and its available functionalities.
- Handling: Describes the transferability of documentation to real events.
- Correctness: Describes the extent to which the documentation corresponds to the real use.
- Clarity: Describes the clarity of the documentation. The structure, table of contents and intuitive finding of relevant information are taken into account.

Criterion Surface

The Surface criterion describes the structure and surface of the platform. The evaluation of design and clarity (which is not completely objective) must be taken into account. Therefore, a high weighting of these two subcriteria is not recommended.

- Design: Describes formal aesthetic functions as well as sign and symbol functions.
- Individually customizable: Describes whether a platform has the ability to customize its interface.
- Clarity: Describes the clearness of the platform.

Criterion Basic Functions

The basic functions criterion describes the existence and use of various platform functionalities. This includes, for example, the possibility of creating rules, automatic notifications when defined events occur or monitoring connected systems.

- Automatic connection: Describes the possibility of automatically connecting systems, sensors or machines to the platform on restart or reconnection.
- Own programming: Describes the possibility whether own programs or algorithms can be integrated directly into the platform.
- Creation of rules: Describes the possibility whether rules can be integrated into the platform.
- Restarting the systems: Describes whether it is possible to restart connected systems such as machines, sensors or systems from the platform.
- Monitoring active devices: Describes the possibility of recording whether the device is on or off.
- Monitoring of running production: Describes the possibility of supervisioning a running production.
- Support of different languages: Describes the support of the platform of different programming languages.
- Warning systems: Describes whether a warning system is existing within the platform.
- Condition monitoring of machine data: Describes the possibility of capturing machine data via the platform.

Criterion Administration

The criterion Administration describes the administrative possibilities within the platform.

- Platform maintenance effort: Describes the administrative effort required to maintain a platform.
- Role distribution for platform access: Describes the possibility of distributing roles so that users have different rights within the platform.
- Assignment of access rights: Describes the possibility of assigning access rights so that access to the platform can be restricted individually.

Criterion Interoperability
The interoperability criterion describes the ability of the platform to interact with different systems.

- Integration of different systems: Describes the possibility of connecting different IT systems, such as Manufacturing Execution System (MES) or Enterprise Resource Planning (ERP), to the platform.
- Communication from system to platform: Describes the possibility of sending data from different systems to the platform.
- Platform to System Sending Capability: Describes the ability to send data from the platform to different systems.
- Connection of devices: Describes the possibility of connecting different machines, which use different communication options to the platform.

After carrying out the evaluation of an IoT-platform, or using existing evaluations, a suitable IoT-platform is selected. For this purpose, the sub criteria indicate whether it is a must request, a target request or a wish request for the interested party. The more information is indicated thereby, the more suitable is the selection of the suitable solution. Specifying too many mandatory requirements can mean that no suitable IoT-platform can be found, since no IoT-platform can meet all mandatory requirements. A weighting option has therefore been added to the method, which can be used after an unsuccessful search. The most relevant mandatory requirements can be re-weighted to find an IoT-platform that comes closest to your requirements. Finally, all IoT-platforms included in the selection are listed in a table. The IoT-platforms are sorted in descending order by overlapping their own requirements and the appropriate range of functionalities of the IoT-platform. The logic used to make the selection is not described in more detail in this paper.

4 Conclusion and Outlook

Following the introduction of the IoT-platform and the associated changes to existing productions, this paper presented a method for evaluating and selecting suitable IoT-platforms. The method makes sense due to the large number of different platform providers, as there are large differences with regard to the existing IoT-platforms. The method draws on a matrix in which the functionalities and properties of an IoT-platform can be specified. The evaluation of the IoT-platforms can be carried out by the user or previous evaluations published within the ArePron project can be used. It is also possible to adapt previous evaluations. Once the relevant IoT-platforms have been integrated into the matrix and evaluated, the IoT-platform is selected. To do this, the interested party must first define mandatory, target and optional requirements. Subsequently, all IoT-platforms are presented in a table with regard to their conformity.

The ArePron project is currently conducting a market analysis of existing IoT-platforms. Selected platforms are evaluated within the framework of the project and integrated into the matrix. For this purpose, a benchmark will be carried out to ensure objectivity and comparability of the results. The results will be stored in a database that will be accessed by a program in the form of a web application. This program guides the user through the method and displays the results after using the method.

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