The dissolution of the automation pyramid revolutionizes the way products are manufactured and developed tomorrow

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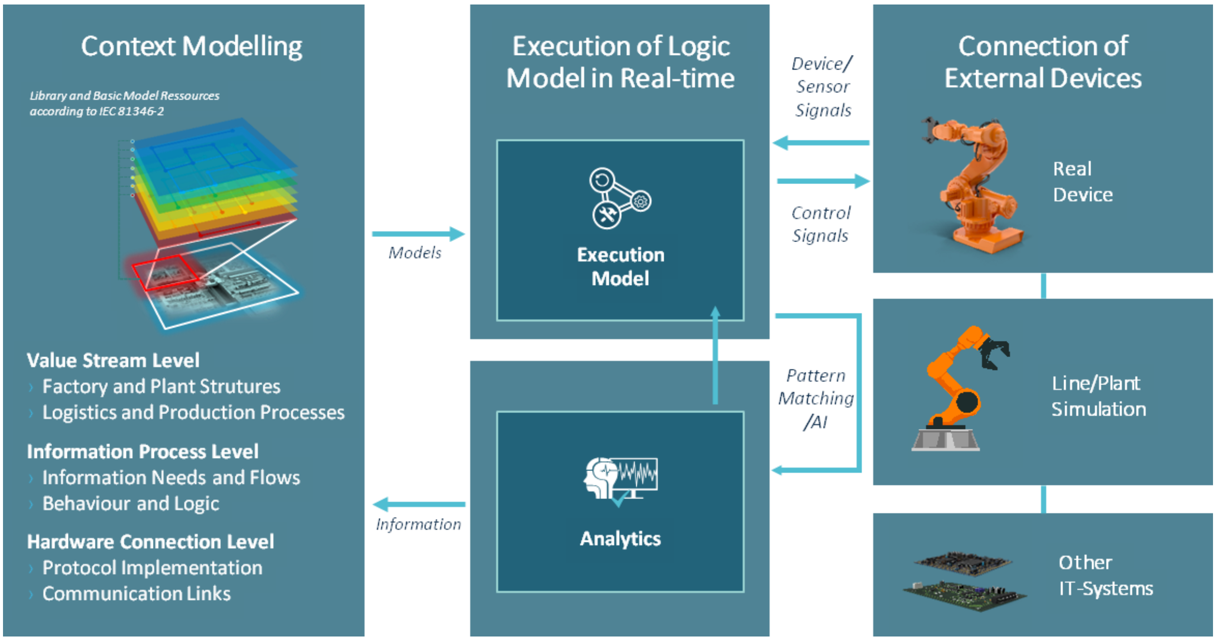
Planning, control and analysis of a convertible and flexible production in real time - isn't that the dream of every production manager? The ASCon Digital Twin enables this through a comprehensive information model and a high-performance execution architecture. It links all information from PLM, ERP/MES and shop floor involved in production to a consistent information management without having to define the individual semantic and ontological relationships in advance. The production process is thus mapped and controlled comprehensively, completely and adaptable at any time, the modelled value-added chains are executed directly, operating resources can be exchanged without changes in the control logic. https://vimeo.com/335170810

The digital twin is omnipresent today, mostly understood as a virtual image of a delimited real system, without any possibility of intervention or feedback from the virtual into reality. Our understanding of the digital twin, on the contrary, is that not only the characteristics, but above all the behaviour of the virtual and the real part of the twin must be identical at all times, and for this to happen, they must be coupled bidirectionally.



Picture 1: *The behaviour of the virtual and the real part of the twin must be identical and bidirectionally coupled. This is the only way to draw the right conclusions in the overall context of a manufacturing system at all times and to make decisions via the digital twin that are immediately implemented in the real system.*

The transfer of the properties from the real part of the twin to the virtual part is done by recording and storing the nominal/actual values. The reverse transfer from the virtual to the real twin part is done by impressing the desired state changes on the real system, i.e. by direct control of the real system by the virtual twin part. Especially the imposition of new behavior from the virtual to the real part is a big challenge, because the control systems of the real systems are mostly hard-coded today and therefore flexible changes and short-term adjustments in the parameterization or a change of the control logic are not possible.

With today's solutions, virtual commissioning works for small and delimited plant sections. However, this is not possible for more complex production systems, consisting of intercommunicating controllers, often from different manufacturers, because PLC programs usually only map the local behavior of individual systems. The construction of a digital twin, which maps both the overall system properties and the individual behavior of the subsystems, is not feasible for an overall system extending over the levels of today's hierarchical automation pyramid.

This is exactly where the ASCon Digital Twin differs fundamentally: Using a modular, changeable behavior model, the entire behavior of complex production systems is mapped, which includes both the virtual (simulating) and the real (executing) part of the twin, from sensor level to order control. As a result, the real or executing part is no longer programmed elaborately and error-prone, but is modeled flexibly, without programming (no-coding) and executed by the high-performance real-time engine of the ASCon Digital Twin, whose innovative technology has been applied for a worldwide patent.

Managing the overarching value creation process

Regardless of which acquisition systems and which combination of information and signal sources are available in production: these signals, data and information can be integrated into the context of a continuous value creation model, combined with other data from product and process management and used in a coordinated manner to control production.
Functional expansions and parameter changes are thus possible at short notice even after commissioning, without having to resort to external service providers again and again.
Likewise, a retrofit with high quality and more flexibility can be controlled even without the purchase of completely new systems, the planning/implementation period is shortened, and the risk of undesired side effects is reduced.

Directly execute the modelled value chains

With the process description of the data-driven value-added chains, the models that can be executed in real time on any distributed hardware of the control level (PLC, edge devices, cloud, ...) are automatically created. This allows the planner to test his processes and incorporate changes safely during the first definition. The individual production plans for the single piece to be manufactured are created "on the fly". Exactly what was planned is executed without the need for a PLC programmer.

Best Practice: Reduce complexity and unnecessary variance

The process description is based on modular function and process blocks, which the user can take from a library or define himself, making planning and control of production easier and of a higher quality. This also supports computer-aided comparison with already modelled processes and continuous learning from and towards best practices.

Replacement of hardware devices without changing the higher-level control logic

Due to the independence of the data-driven process logic from the logic of the executing hardware, only the part of the plant and process control that is technically necessary or specified by the manufacturer remains there. All process elements for the orchestration and linking of the added value are described and processed in the execution model - an explicit implementation on the PLC level is therefore no longer necessary.

Modelling and value stream analysis.

A common method for the optimization of value-added processes is value stream analysis, in which the relevant material, energy and information flows are recorded. In practical application, the focus is primarily on the material flows, while the information flows are usually treated only very subordinately. The method of ASCon Systems for modeling the Digital Twins takes up the value stream analysis, but focuses on the flow and continuity of the information streams. For this purpose, the information offers and needs of all business objects are combined into a holistic information model, which thus forms the heart of the digital twin, the "context".

Regardless of which acquisition systems and which combination of information and signal sources are present in production: these signals, data and information are integrated into the context of the digital twin for process and product. The ASCon information model describes the logical relationships and interactions between the information objects that are based on signals and data. The continuous flow of the information streams is created by the detailed description of which objects receive, use and pass on which information and how, and by the direct execution of this information model in the ASCon Digital Twin. The network of connections remains dynamically changeable, so that model changes are possible at any time: When executing the model in the Digital Twin, functional extensions and parameter changes remain possible at any time and at short notice, even after commissioning and during runtime.

No-coding: Configuration instead of programming

Our uniform information model for manufacturing brings together all available information and signal sources and links them to control the value-added processes. All components of the information model are configured, not programmed, in the digital twin model. The dynamic side of the twin, the execution model in manufacturing, is created directly by "injecting" the information model into its runtime services.

The processes described in the information model are turned into a runnable control program for manufacturing via the highly parallel micro-service architecture of the ASCon Digital Twin without writing a single line of code. This "no-coding" enables planning experts to specify and model the logical behavior of production resources and processes themselves. Predefined logic blocks and/or customer-specific behavior libraries thus enable highly standardized and modular planning. Ongoing changes to process sequences can thus be implemented in minutes instead of days or weeks.

ASCon's digital twin realizes the direct, immediate and bidirectional connection of Product Lifecycle Management (PLM) and the control of serial production: As soon as a behavior model is created, the virtual commissioning can begin with the connection of any mixture of virtual and real hardware and the direct execution of the modeled behavior model in the runtime services of the digital twin.

The traditional, hierarchically structured control architecture with local resources and only local access to sensors and information is replaced by a modular architecture with scalable, redundant global resources that have access to all available information. Due to the persistence of all information and events captured by the digital twin, not only local, process-related information and process results are available as before, but also permanently all available global, non-process-related information as well as all conditions that led to this information and the associated plant and process behavior.

Wanting to realize this with the current state of the art would mean that not only selected actual values would have to be communicated by the respective controllers, e.g. PLC, but also all states of the internally used variables that are important for the sequence and the result of the control program: With today's PLC technology this is hardly possible.

Disconnect process logic from the hardware.

Today, business logic and device-specific logic are closely related. A real separation rarely happens. This becomes particularly apparent when hardware is to be replaced, or when a concrete implementation of a business logic is to be reused and should interact with other hardware.

The information model underlying the ASCon Digital Twin clearly separates business- and device-specific logic. Thus the dynamic execution model of the Digital Twin becomes completely independent of the hardware used. This applies both to the control or server hardware used and to the sensors and actuators to be connected. What remains is the bidirectional coupling of physical signal and logical representation, e.g. via bus coupler. To protect existing investments, existing systems with their respective capabilities can also be connected to the digital twin at any time.

The strict separation of business and device-specific logic requires a control and data flow adapted to the respective device. The adaptation to the individual communication behavior, as well as the preparation of the data contents to be exchanged bidirectionally, is carried out via device drivers: processing chains that are likewise flexibly assembled without programming ("no coding") and without measurable losses in latency and runtime behavior.

The ASCon Digital Twin can thus be connected to any device on the shop floor. Each individual micro service can flexibly bundle the communication with the devices. The micro-services, which are interconnected via high-performance streaming, link edge devices and cloud resources to form a virtual control hardware for the overarching information model of manufacturing.

Simulate planning in real time.

This can be simulated in real time at an early stage of production planning: The expected behaviour of the production equipment can be checked, the planning quality is raised to a new level and the costs and time required for error correction are drastically reduced.

Since the sequence control of the production plants is directly derived from the planning model when modeling the digital twin, the planning model is correspondingly detailed and maps the complete control logic. Because all information objects in the context of planning are available at any time, simulations can be carried out at any time without major effort. In this way, if the simulation model behaves unexpectedly or incorrectly, the causes and therefore planning or modeling errors can be quickly identified. This reliably prevents planning gaps and planning errors from leading to unexpected plant behavior during commissioning or later during operation.

The simulations during the planning phase are of particular quality, since the control logic at the time of the simulation, without deviations or inaccuracies, is exactly the control logic that controls the production processes of the real plants from commissioning onwards. The plant behaviour can be tested extensively and at an early stage under varying conditions, so that possible errors can be detected even before productive operation. In addition, alternative plans as well as already foreseeable later process changes in production can be easily compared and evaluated.

The persistent storage of all information and signals makes it possible to go back to a point in time in the past, e.g. to analyse under which conditions a certain condition occurred or an error occurred, which is a considerable time advantage, especially when commissioning new plants.

Execute target process in real time.

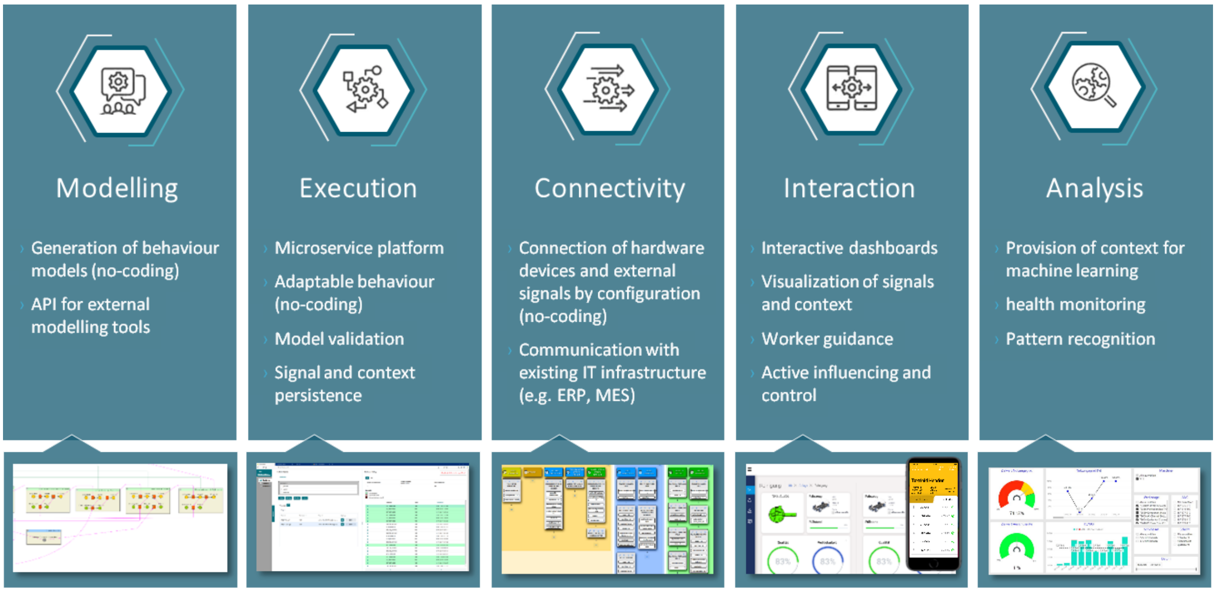
In the context of all information objects, the control logic depicted in the information model, which corresponds completely to the planned target process tested by the simulation, controls the real production plants.

Device drivers not only connect hardware and software components and external services with the digital twin, but also permanently synchronize the internal information model with the physical device behavior. Thus the ASCon Digital Twin directly accesses the hardware level of production from the planning level and is thus able to replace the logic level of today's PLC solutions.

All signals, data, information and states of production are captured by the Digital Twin in real time and persistently stored in Digital Lifecycle Files. This means that the complete history of the production processes in the complete value-added context is available at any time, e.g. for analysis, observation and evaluation with artificial intelligence, which can then immediately process the acquired and stored signals and states in the context of their origin without the need for time-consuming preparation and enrichment of the data.

With the high-performance, status-oriented and discrete-event execution architecture on which the ASCon Digital Twin is based, we open up flexibility and short-term adaptability of the sequence control of production plants without programming.

The ASCon Digital Twin runs on edge devices "on premise" as well as - where the requirements for signal and process runtimes allow it - in the cloud. It works with all devices and devices commonly used in the shop floor, e.g. directly with bus couplers or by integrating existing PLCs, thus lowering the entry and investment hurdles on the way to digitized production: This is real investment protection for the existing infrastructure.

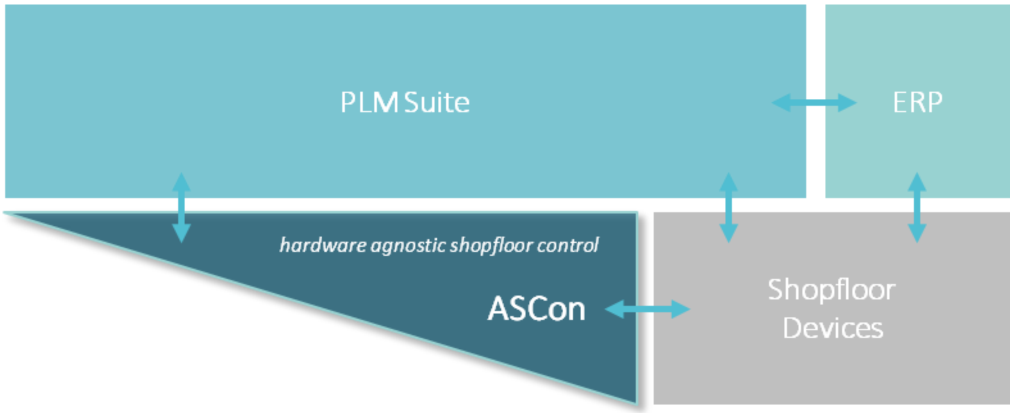


Picture 2: *The components of the ASCon Digital Twin: The real-time operating system for manufacturing, with which we are dissolving the automation pyramid and thus also the dependency on today's dominant control manufacturers.*

Coupling of product development and manufacturing - Closed Loop PLM

With the integration of the logical behavior of manufacturing systems based on an event-driven behavior model, the ASCon Digital Twin brings a decisive coupling component to the PLM-based design process: the mapping of the logical behavior of a plant as part of the design process in such a way that behavior modeling immediately enables plant control.

With the connection of the different development areas at the earliest possible point in time at a still high level of abstraction and the possibility to switch seamlessly between the development view with all variant information and the production view down to the individual parts, the validation of the control logic already begins in the design phase: development time and change loops are reduced and production gains flexibility and adaptability.



Picture 3: *The integration of product development, manufacturing planning and production is the key to future competitiveness: The ASCon Digital Twin couples the design process with the shop floor via event-driven behavioral models*

By recording real production data during operation in digital life cycle records and recording all relevant KPIs, the quality processes of the various quality control loops (cycle, section, line, plant, development) can be integrated directly into the processes instead of having to process them downstream.

Conclusion:

Modular, adaptable systems require modular, adaptable information models that carry from design, through planning, to execution without media disruption. This applies not only to production and logistics, but also to other fields of application of the digital twin, e.g. in building and infrastructure management.

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