



**A look at the Digital Twin concept as applied to Industrial
Automation**

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The Industrial Internet of Things (IIoT) is becoming a reality.

The Digital Twin will be a significant step forward for Automation Systems.

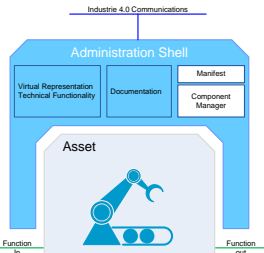
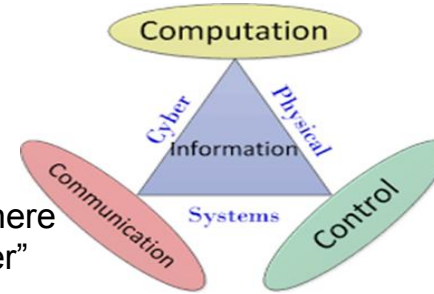
Ghosts in the machine!

The general structure and some features for every twin will need to be similar.

The applications of the Digital Twin in an Automation System are numerous.

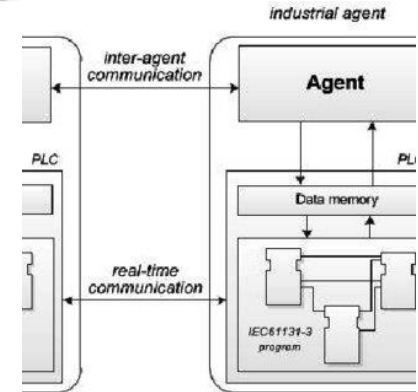


- The origin of the concept
 - Cyber-Physical Systems
 - Dr. Helen Gill, National Science Foundation
 - “an integration of computation with physical processes where the system is the intersection of the physical and the cyber”

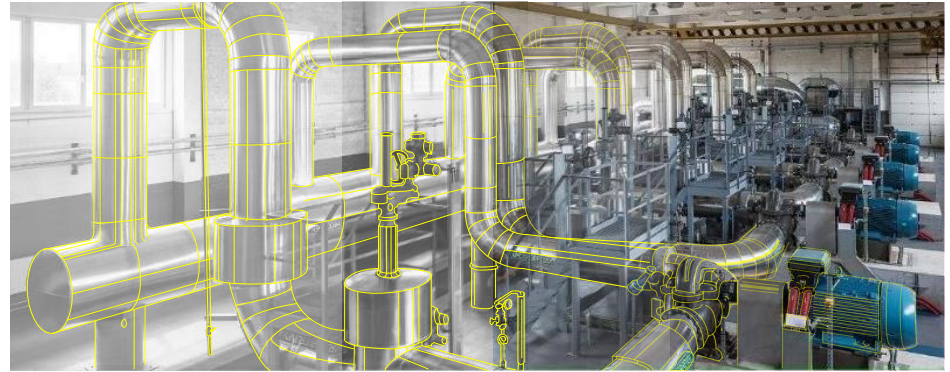


- Global/country initiatives are driving the concept of Digital Twins.

- Not entirely a new concept
- Industrial Automation Agents have been around a long time



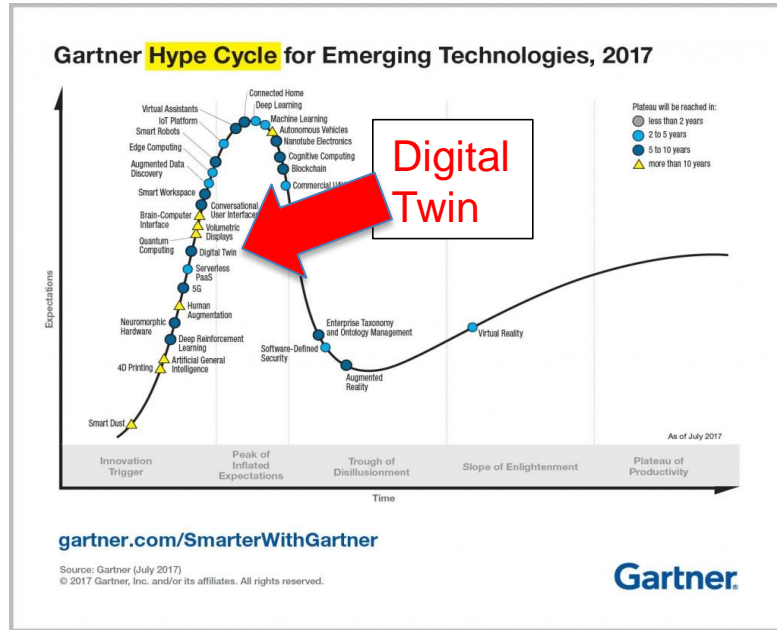
- There are many different definitions
- “a digital twin is a dynamic digital representation of an industrial asset, that enables companies to better understand and predict the performance of their machines and find new revenue streams, and change the way their business operates”
- “the expectation for twins is to be able to do functional tests on twins in an offline system and verify prerequisite on system management before propagating the twin into the real environment, and how to manage transition phase with the quality management”



- Common elements:
 - Digital (cyber) representation
 - Attached to a physical device
 - Reflects the state
 - Contains performance aspects

Why Digital Twins Matter

- This is NOT “happy engineering”
- Industry Analysts agree Digital Twins are a significant technology



- Gartner:
 - top 10 strategic technology for 2018
 - 50% adoption by 2021
- Deloitte:
 - 38% growth annually to \$16B by 2023
 - But needs careful installation
- ARC and GE:
 - Top 5 key technology trend for 2018
 - A major impact on Process and Discrete Automation in 2018

- We are not designing a Digital Twin here
- The Digital Twin is an exact operational duplicate of the device
 - Upon the discretion of the user
- Configuration can be done offline or online through the twin
- The Digital Twin could only exist offline
 - An independent element for simulation and verification
- The Digital Twin knows more about the device than device knows about itself
 - Critical information about the device can be linked or contained in the twin
 - BOM, material composition, damaging conditions, usage history including environmental conditions, etc.
 - The twin can inform the operator of improper conditions for the device of which the device is not and/or cannot be aware

- Still not designing a Digital Twin
- The Digital Twin can be available to the system even when the device is not available
 - All information about the physical device is available to the system through the twin
- There is no need to develop new configuration standards
 - Established standards such as FDT or FDI or others can be used
- The Digital Twin can be a single entry point for communicating with the device
 - The system talks to the twin and the twin updates the device depending on the level of trust
- The configuration mechanism should be the same when used for online or offline configuration

- Market analyst, Deloitte, warns us about usage of Digital Twins in simple systems, do not let Digital Twin technology make any system overly complex
- “Systemness” (Dr. P. Martin) matters. The Digital Twin must be able to made up of other Digital Twins.
 - Every device should have a Digital Twin
 - Every Digital Twin should be able to connect to other Digital Twins to form twins of Assets
 - Asset Digital Twins should connect together to form systems
 - Systems should connect together to form larger systems, i.e. Systems of Systems
 - This should all happen seamlessly

Digital Twins in Automation Systems

- How Twins work inside the Automation System
 - The Digital Twin is the primary resource for interaction
 - The systems talks to the twin
 - The system must operate even if the twin is not available (offline)
 - Regardless of the reason, the system must be robust enough to operate without the twin
 - Even in a degraded manner (fewer services)
 - The location of the Digital Twin can be anywhere it is practical to be placed
 - In an external cloud
 - An on-premise cloud
 - Cloud attached to the network (“Fog”)
 - The “real-time” speed of the network will affect the location of the Digital Twin

Digital Twins in Automation Systems

- There must be a means for mass online configuration of the Digital Twins
 - In a system where there are 100's or even 1000's of devices and twins, manual configuration not practical
 - An O&G refinery for example will have 1000's of device/twin sets over a large area. Automation of configuration/reconfiguration will be needed
- The Digital Twin can translate between the vernacular of the control system and the vernacular of the device
 - A device that has capabilities needed for the control functionality but not the communication protocols can be bridged by the twin where the twin speaks the language of the system and the different language of the device.

- Changes in CIP will be needed to support Digital Twins
- Redundant Owner for I/O will be important for:
 - Using multiple twins for the same asset
 - Redundancy or failover purposes with twins
 - In Safety applications
 - A twin and its associated device may use it for synchronization
- Multicast feature of EtherNet/IP will be needed and may need refinement
 - Again using multiple twins for the same asset
 - Also redundancy and/or failure
 - Possibly safety
 - Multiple twins for the same application
 - To enable the device to continue operation without its twin

Digital Twin Support in CIP

- New Objects and Assemblies
 - Association objects to tie twins to devices
 - Normalizing attributes such as configuring features that are in the twin but not in the device
 - Hierarchical objects that tie system of twins into a single twin
- xDS (EDS replacement concept) inclusion
 - Basis for configuration of the twin
 - Keep the twin current/up to date
 - An authentication tool for the twin

Digital Twin Support in CIP

- Definition of common Ontologies and Semantics (the language and vocabulary of the system)
 - Needed for communication of between twins and for driving analytics
 - New objects and attributes for these purposes
- Energy and Power Objects updates
 - Support the Digital Twins as the main services provider for a system
 - Energy and Power management will happen through the Digital Twins
- FWD/Open changes will be needed
 - With the close relationship between the twin and the device
 - Sent to the twin only? Or the twin and the device?

- What Digital Twins bring to Automation Systems
- Market Analysts are expecting:
 - Greater operational efficiency
 - More profitable operation
 - Increased and new services
 - leading to greater revenue
 - Simplification of commissioning/recommissioning
 - Truly reconfigurable manufacturing
- Simulation as a Service
 - Actual versus Expected
 - Actual versus Predicted
 - Accurate system change prediction
 - Accurate long term operation analysis
 - (not bounded by time)

- What Digital Twins bring to Automation Systems
- Commissioning as a Service
 - Iterative pre-commissioning service
 - Based around the control function
 - Choose the assets see how they fit before committing
 - Complete the commissioning process before commissioning
 - Reconfigurable Manufacturing
 - Significant changes to process can be tested with known impact and known execution
- Training as a Service
 - Pre-commissioning process training
 - Know the operation before it is built
 - Ongoing operational training
 - New hire training
 - One cannot hurt cyberspace (?)

- What Digital Twins bring to Automation Systems
- CapEx Reduction
 - The customer will understand what she or he is buying with confidence
 - Expansion/reconfiguration will be a known cost
 - Making planning easier, more confident
 - The profits achieved from CapEx can be easily measured
 - The customer will know when the system has paid for itself
- OpEx Reduction
 - Improved maintenance with lower cost
 - Better trained personnel
 - True predictive maintenance
 - Greater up time, longer sustained production cycles

Benefits of Digital Twins

- Digital Twins bring the FUN back to Automation Systems
- Bring the fun back to Automation
- Make automation attractive to the Millennial Generation
 - It is more digitally connected
 - New facet to automation
 - Ties the skillset of Millennials to real automation systems



- Digital Twins are the future
- When not if, those without lose
- CapEx/OpEx gains are the selling points
- We are all in this together
- Standardization is a must
- I am not a “Mad Scientist”
- Or perhaps, we are all “Mad Scientists”





THANK YOU