Digital Twin Dashboards

Digital twin

- A digital twin is a virtual representation of a physical object or system that uses real-time data to ***accurately reflect its real-world counterpart's behavior, performance and conditions***.
- Digital twins enable continuous monitoring, simulation and analysis of an object, product or system over the course of its lifecycle, from design and production to maintenance and decommissioning.

Digital Twin Dashboards

- Digital twin dashboard design requires a fundamentally different approach than conventional business intelligence or operational dashboards.
- **Traditional dashboards** primarily focus on displaying what happened—historical performance metrics, completed transactions, and retrospective analysis.
- **Digital twin dashboards** must simultaneously show what's happening now, what's likely to happen next, and what could happen under different scenarios.

Key Features of Digital Twin Dashboard

- **Real-Time Asset Monitoring**
- Track equipment, machines, and systems with live data updates from IoT sensors and connected devices.
- **IoT Visualization Dashboard**
- Interactive dashboards that present complex data in easy-to-understand visual formats.
- **3D Digital Twin Models**
- Create dynamic 3D representations of physical assets for better visualization and control.
- **Predictive Analytics & Insights**

- Use AI-driven analytics to predict failures, optimize maintenance, and improve operational efficiency.
- **Alerts & Anomaly Detection**
- Receive instant alerts for abnormal behavior, system failures, or performance deviations.
- **Integration with Enterprise Systems**
- Seamlessly connect with ERP, MES, SCADA, and other enterprise applications.
- **Customizable Dashboard Views**
- Tailor dashboards based on roles, departments, and business requirements.

Use Cases of Digital Twin Dashboard

- **Smart Factory Dashboard –** Monitor machines, production lines, and overall plant performance in real time
- **Logistics & Supply Chain –** Track shipments, assets, and warehouse operations with enhanced visibility
- **Energy & Utilities –** Monitor grids, equipment health, and energy consumption patterns efficiently
- **Healthcare Systems –** Track medical equipment, assets, and facility operations seamlessly
- **Smart Buildings & Cities –** Manage infrastructure, utilities, and environmental systems intelligently

Core Mechanism of Digital Twins

- **Virtual Model**: A digital twin is a software-based representation of a physical asset (e.g., a machine, building, or even a city).

- **Real-Time Data Exchange**: **Sensors on the physical system** send continuous data (temperature, vibration, usage metrics, etc.) to **the twin.**

- **Bidirectional Feedback**: **The twin** not only mirrors the physical system but can also send optimized instructions back, enabling predictive maintenance and performance tuning.

- **Simulation & Prediction**: Engineers can run "what-if" scenarios on the twin without risking the real system, helping forecast failures or test improvements.

- **Lifecycle Coverage**: Digital twins span the entire lifecycle — design, production, operation, and decommissioning.

Digital Twin Architecture



- **Digital twin architecture** is the layered technical structure that connects a physical asset to its live virtual model:
- the sensors and connectivity that **capture data from the real world**, the systems that **process and model it**, and the interface that makes it **usable**.

The layers of a digital twin architecture

- A digital twin architecture is typically described as a stack, running from the physical world

to the interface a person interacts with.

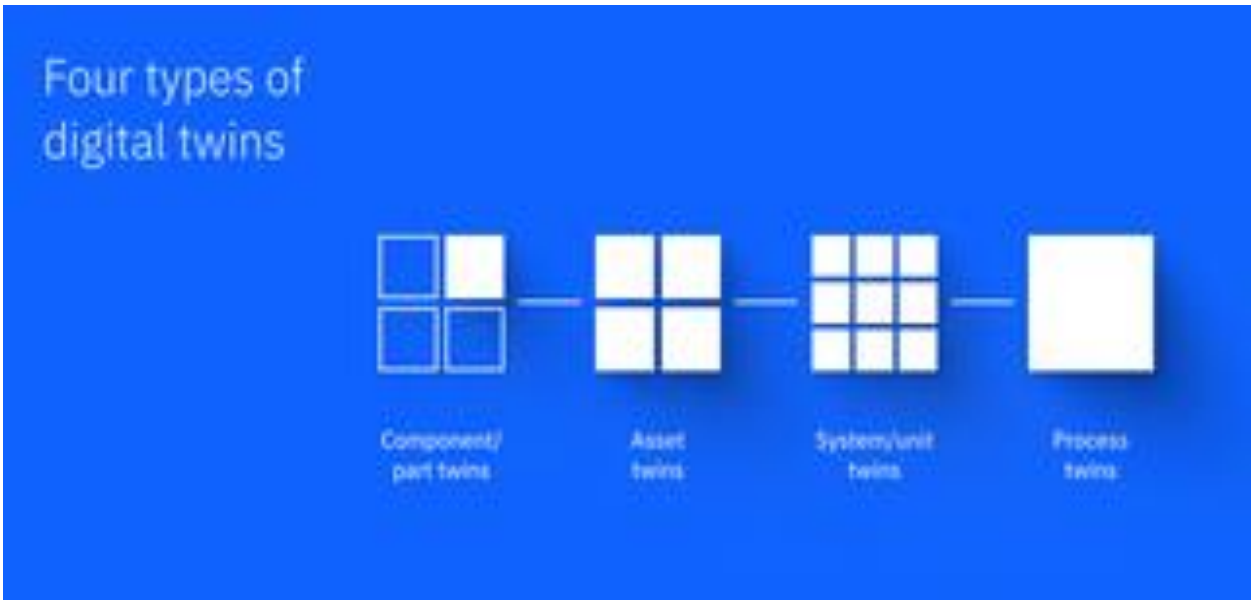
- While implementations vary, most digital twin systems include six recurring layers:
- **1. Physical layer.** The real-world asset, machine, product, or environment being twinned, along with the sensors and instrumentation attached to it.
- **2. Data acquisition and connectivity layer.** IoT devices, sensors, and edge hardware that capture data at the source and transmit it, often filtering or pre-processing at the edge before it moves further up the stack.
- **3. Integration layer.** The middleware and APIs that pull data in from multiple sources - sensors, but also existing systems like MES or ERP - and normalize it into a consistent format the rest of the architecture can use.
- **4. Digital model layer.** The virtual representation itself: **the geometry, structure, and logic that mirror the physical asset**.
    - This is often built from CAD or BIM source data and is the core of the "twin."
- **5. Analytics and AI layer.** Simulation, machine learning, and analytics run against the digital model and incoming data to generate insight; detecting anomalies, **predicting failures, or testing** what-if scenarios.
- **6. Visualization and application layer.** The interface where people actually see and interact with the twin: dashboards, 3D visualizations, or applications built on top of the model and its analytics. This is where real-time 3D and converted CAD/BIM data live in the stack, turning the digital model and its data into something a person can see, navigate, and act on.

Key components of a digital twin

- **Data sources.** Sensors, IoT devices, and existing enterprise systems that generate the raw data feeding the twin.
- **Connectivity.** The networking and protocols (often edge-to-cloud) that move data from where it's generated to where it's processed.
- **The virtual model.** The digital representation of the physical asset's structure, geometry, and behavior, frequently originating from CAD or BIM data.

- **The analytics and simulation engine.** The software that processes incoming data against the model to produce insight, run simulations, or apply machine learning.
- **The user interface.** The dashboard, visualization, or application through which a person interacts with the twin's output.
- **The bidirectional data link.** The mechanism connecting insight generated by the twin back to the physical asset or to the people who work with it, closing the loop between digital insight and physical action.

The four types of digital twins



- **Component twins**
- Component twins, or parts twins, are the digital representation of a single piece of an entire system. These are essential parts of the operation of an asset, such as a motor within a wind turbine.
- **Asset twins**
- In digital twin terminology, **assets** are two or more components that work together as part of a more comprehensive system. Asset twins virtually represent how the components interact and produce performance data that you can analyze to make informed decisions.
- **System twins**

- A higher level of abstraction from asset twins are system twins, or unit twins. A system twin shows **how different assets work together as part of a broader system**. The visibility offered by system twin technology allows you to make decisions about performance enhancements or efficiencies.

- **Process twins**

- Process twins show you the digital environment of a whole object and provide insight into how its various components, assets, and units work together. For example, a digital process twin can digitally reproduce how your entire manufacturing facility is operating, bringing together all of the components within it.

Benefits of digital twins

- **Improved performance**

- Real-time information and insights provided by digital twins let you optimize the performance of your equipment, plant, or facilities. Issues can be dealt with as they occur, ensuring systems work at their peak and reduce downtime.

- **Predictive capabilities**

- Digital twins can offer you a complete visual and digital view of your manufacturing plant, commercial building, or facility even if it is made up of thousands of pieces of equipment. Smart sensors monitor the output of every component, flagging issues or faults as they happen. You can take action at the first sign of problems rather than waiting until equipment completely breaks down.

- **Remote monitoring**

- The virtual nature of digital twins means you can remotely monitor and control facilities. Remote monitoring also means fewer people have to check on potentially dangerous industrial equipment.

- **Accelerated production time**

- You can accelerate production time on products and facilities before they exist by building digital replicas. By running scenarios, you can see how your product or facility reacts to failures and make the necessary changes before actual production.