DIGI

Technologies that Enable the Digital Twin

What Is a Digital Twin?

There are many definitions of a digital twin, but one that we like is from IBM.

> "A digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning, and reasoning to help decision-making."

That's easy to say and it sounds simple enough. But it takes a lot of advanced technologies working together to create sophisticated models that can mirror almost every aspect of a product or process.
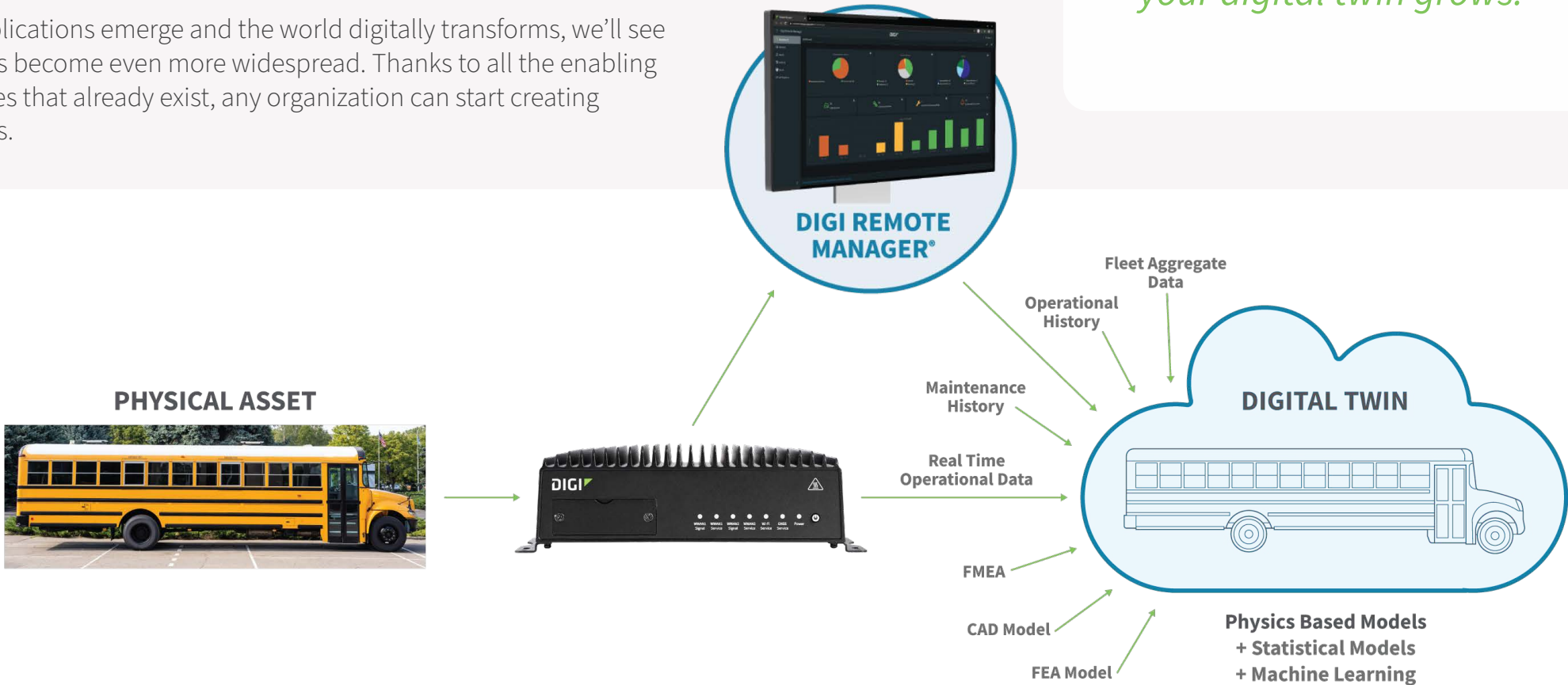
Digital Twins: Digital Modeling of Systems and Processes

Digital twins rely on the unique integration of virtual and physical devices that communicate back and forth securely in real time. They can create excellent value in simulating and visualizing complex ideas and processes, and improve decision making across business disciplines. Once digital representations of facilities, environments and people have been created, operators and maintenance teams can use them for training. It is even possible to digitize "know how" to reduce knowledge gaps across an enterprise.

As new applications emerge and the world digitally transforms, we'll see digital twins become even more widespread. Thanks to all the enabling technologies that already exist, any organization can start creating digital twins.

This ebook explores some of the enabling technologies and how they support and scale as your digital twin grows.

DIGI REMOTE MANAGER®

PHYSICAL ASSET

Fleet Aggregate Data

Operational History

Maintenance History

Real Time Operational Data

FMEA

CAD Model

FEA Model

DIGITAL TWIN

**Physics Based Models
+ Statistical Models
+ Machine Learning**

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What Technologies Enable a Digital Twin and How Do They Help?

Multiple technologies come into play in building digital twins, from physical devices to wireless communications systems, as well as AI and machine learning. These technologies come together to form a sophisticated system that can evolve and scale as your operations become more complex, and as technology advances. For example, 4G LTE and 5G networks support digital twin modeling today, but a decade from now 6G may enable capabilities we have not yet envisioned.
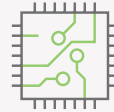
IoT Sensors

Next Generation Mobile Communications (4G LTE/5G)

Network Routers
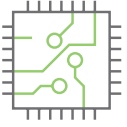
Edge Servers

IoT Gateways

Cloud Computing

AI and Machine Learning

IoT Sensors

These essential digital twin components collect and share information between the physical assets and their software twin. In fact, digital twins require many different kinds of sensors to operate. Here's how IoT sensors enable a digital twin:

- ⊘ **Remote accessibility** — Sensors allow teams to monitor and interact with the digital twin no matter the location

- ⊘ **Integration with other systems** — Sensors integrated into other systems such as enterprise resource planning and supply chains enable access to inventory levels, work orders and maintenance records

- ⊘ **Feedback** — Sensor data helps refine predictions of the real-world behavior of the system

- ⊘ **Sensor fusion** — Combining multiple different types of sensors provides the digital twin with a view of the entire system and an understanding of interdependencies

Next Generation Mobile Communications

4G LTE and 5G networks seem purpose-built for digital twins. With their speed, low latency and ability to connect numerous devices, they enhance the overall performance, functionality and value of digital twins regardless of the industries or applications. Here's how these networks enable a digital twin:

- ⊘ **Increased data transfer speeds** — LTE and 5G (and eventually 6G) have significantly higher data transfer speeds compared to previous generations, enabling faster and more efficient data exchange between digital twins and their physical counterparts

- ⊘ **Low latency** — These low-latency networks ensure accurate and timely data transmission

- ⊘ **Supports connecting massive numbers of devices** — Today's fast networks can connect a massive number of devices within a digital twin system simultaneously

- ⊘ **Brings computing closer to the network edge** — This reduces latency and enhances real-time processing

- ⊘ **Network slicing and quality of service** — Next-generation mobile networks introduce network slicing capabilities allowing dedicated virtual network segments tailored to the requirements of different applications

- ⊘ **Mobile and ubiquitous access** — 5G and future mobile network accessibility allow stakeholders to access and manage digital twins from anywhere using mobile devices

Network Routers

A [network router](#) establishes and manages network connectivity between different components of the digital twin ecosystem. Here are some of the key functions of network routers in a digital twin:

- ⊘ **Data communication** — Network routers facilitate the transmission of data packets between different devices, sensors and systems involved in the digital twin ecosystem

- ⊘ **Network segmentation** — Segmentation helps organize and isolate network traffic flow, improving performance, security and management

- ⊘ **Traffic prioritization** — Network routers allow the implementation of Quality of Service (QoS) mechanisms to enable the prioritization and management of real-time sensor readings for better responsiveness and accuracy of the digital twin

- ⊘ **Security** — Routers can enforce security measures such as packet filtering, intrusion detection and encryption to protect data transmitted within the digital twin

- ⊘ **Network resilience** — Routers ensure a digital twin remains operational even when network failures or disruptions occur

- ⊘ **Scalability** — Network routers allow expansion of the network infrastructure without significant disruptions

Digi's high-performance cellular routers support mission-critical edge compute communications.

Digi EX50 5G Cellular Router

- Future-proof and ready for new use cases such as 5G network slicing
- High-speed 5G NR and 4G LTE-Advanced Pro Cat 20 dual connectivity CBRS, C-band, FirstNet Capable™ cellular radio
- Enterprise-grade Wi-Fi 6 and dual 2.5 Gigabit Ethernet
- Extended operating temperature range for wider use cases
- Standards-based Power over Ethernet simplifies installation
- Multiple mounting options and accessories
- Serial port for remote, out-of-band management
- Securely deploy, monitor and control devices with [Digi Remote Manager®](#)
- Full-featured enterprise and industrial cellular routing platform

Edge Servers

In a digital twin, an edge server is located at the edge of the network, close to the physical system or devices being monitored by the digital twin. The edge server plays a critical role in the implementation and operation of the digital twin by providing local computing power, storage capacity and network connectivity. Here are some of the key functions of edge servers in a digital twin:

⊘ **Reduced latency** — Digital twins require real-time synchronization with their physical twins and edge servers enable faster response times by processing data locally

⊘ **Real-time analytics** — By running advanced algorithms and machine learning close to the data source, edge servers enable rapid insights

⊘ **Bandwidth optimization** — Edge servers help optimize bandwidth utilization by filtering, aggregating and preprocessing data at the edge, thus reducing network traffic and associated costs

⊘ **Data privacy and security** — Processing sensitive data locally minimizes the need for transmitting raw or identifiable data to a remote cloud, reducing privacy and security vulnerabilities

⊘ **Offline operations** — When cloud connectivity is limited or intermittent, edge servers enable digital twins to operate autonomously even without a continuous Internet connection

⊘ **Scalability** — As the digital twin ecosystem evolves or expands, additional edge servers can distribute the computational load

⊘ **Resilience** — By distributing the processing and storage capabilities across multiple edge servers, the system becomes less vulnerable to single points of failure, ensuring the availability of the digital twin

Digi Solutions for Edge Computing

Digi provides a broad selection of solutions for building edge intelligence into applications and connecting edge devices with high-performance connectivity:

Digi Embedded Systems for IoT

Embedded solutions like Digi ConnectCore® 8X system-on-modules provide fast, scalable processing for AI and computer vision tasks at the network edge

Digi XBee 3 Wireless Modules

Digi XBee® 3 smart modems enable developers to control their deployed devices' edge compute functionality

IoT Gateways

IoT gateways play a crucial role in the integration of digital twins with the IoT ecosystem and provide several important functions. Here's why IoT gateways are important to digital twins:

⊘ **Data collection** — IoT gateways serve as the entry point for data from connected devices, enabling the digital twin to access, analyze and visualize real-time information about the physical system

⊘ **Protocol translation** — IoT gateways bridge the gap between various protocols, enabling seamless communication and data exchange between devices with different standards or interfaces and the digital twin

⊘ **Data filtering and preprocessing** — IoT gateways can filter out irrelevant or redundant data, reducing the amount of data transferred and optimizing network bandwidth usage

⊘ **Edge computing** — Many IoT gateways have edge computing capabilities for real-time data analysis, immediate response and reduced latency in the digital twin ecosystem

⊘ **Connectivity and network management** — IoT gateways manage the connectivity between IoT devices and the digital twin infrastructure by handling network protocols, authentication and secure communication

⊘ **Offline and edge-cloud synchronization** — IoT gateways can store data locally during disconnected periods and sync it with the digital twin when connectivity is restored

⊘ **Security and access control** — IoT gateways act as a first line of defense against unauthorized access, protecting the data transmitted between IoT devices and the digital twin

Digi Routers and Gateways

Digi routers and gateways aggregate data, convert it from analog into digital and encrypt it before transmitting it over the network. In the case of digital twins where many different sensors collect data simultaneously, Digi routers filter and compress the data to minimize bandwidth.

Digi routers can also operate offline. They can collect and store data and then re-establish a connection to transmit information, as needed.

Cloud Computing

Cloud computing provides a scalable and flexible infrastructure to support digital twins. Here are some key aspects of cloud computing in digital twin systems:

- ⊘ **Almost unlimited scalability** — Cloud computing provides almost unlimited scalability as digital twins generate massive volumes of data

- ⊘ **Efficient computation of intensive tasks** — Offers extensive storage capabilities and high-performance computing resources, enabling digital twins to perform computationally intensive tasks efficiently

- ⊘ **Better collaboration** — Multiple teams can interact with the digital twin at the same time, improving collaboration and decision-making

- ⊘ **Ensures real-time updates** — Enables updates in real time between the physical device and the twin

- ⊘ **Cost-efficient** — Instead of building and maintaining dedicated infrastructure, cloud infrastructure provides options to pay only for what you use instead of relying on dedicated hosting
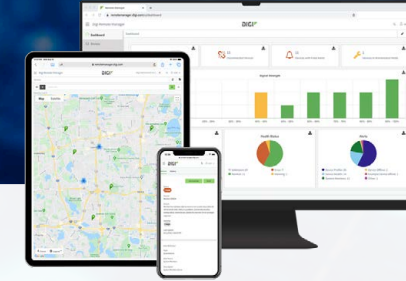
Digi Remote Manager

The Digi Remote Manager® platform is a full-featured cloud-based platform for users of Digi's modules, gateways and routers and allows you to configure, deploy and manage remote assets securely.

Digi Remote Manager offers:

- Best-in-class cloud and edge tools designed for rapid device deployment
- Monitoring of all IoT devices, including asset performance and security, with bi-directional communications
- Ability to automate mass firmware and software updates
- Management of edge devices
- Open APIs for deeper insights and control through third-party applications
- Real-time alerts and detailed reports for network health and device conditions

AI and Machine Learning

AI and machine learning enhance digital twin capabilities and effectiveness. Here are several ways in which AI and machine learning are important for digital twins:

⊘ **Data analysis and predictive modeling** — By applying techniques such as data clustering, regression, classification and anomaly detection, AI can identify patterns in the data and build predictive models to optimize the performance of the physical system

⊘ **Real-time monitoring and optimization** — By leveraging machine learning techniques, the digital twin can identify deviations from expected behavior, diagnose problems and trigger immediate actions or alerts

⊘ **Virtual sensing** — When data points or sensor readings are missing or inaccessible in the physical system, AI techniques such as virtual sensing can help fill in the gaps by estimating missing values based on available data and historical patterns

⊘ **Scenario simulation and what-if analysis** — The digital twin can use machine learning to simulate outcomes in a virtual environment, test different strategies, then implement the ideal outcome in the physical system

⊘ **Autonomous decision-making** — Autonomous decision-making allows the digital twin to respond to changing conditions and make informed decisions to improve system performance

⊘ **Continuous learning and optimization** — By analyzing data from the physical system and user feedback, the digital twin can refine its models, algorithms and predictive capabilities based on real-world feedback

⊘ **Human-machine collaboration** — AI facilitates human-machine collaboration by providing insights, recommendations and decision support to human operators and users

The Digi Implementation Team

Our professional design, implementation and certification teams help you get started on your digital twin journey so you can stay ahead of the competition.

Digi's Professional Services and Wireless Design Services teams can augment your own engineering team to ensure successful IoT project development and deployment. Our teams can help with anything from custom software development to backend server implementation, PCB layout and design, cellular, Bluetooth and Wi-Fi integration, antenna and RF design, as well as global certifications.

Let's Connect

Digi is a complete IoT solutions provider, supporting every aspect of your digital IoT planning, development and deployment. Digi has 35+ years of experience connecting the "things" in the "Internet of Things" and has been issued more than 160 patents. Connect with Digi to share your vision, get hands-on help to identify the resources and solutions needed, and bring your vision to life.

To learn more, contact your Digi representative or visit **www.digi.com**