Digital Twins Will Drive the Future of Digital Transformation

White Paper

By Marty Sprinzen, CEO
Vantiq Inc
July 2022

VANTIQ

Table of Contents

Executive Summary

There is a major shift taking place in how the world around us operates. Increasingly our physical systems are being augmented by digital systems which can create virtual representations of the physical entities.

By representing complex physical environments digitally such as a large building, factory, airport, or an oil refinery, we can monitor and control things in new and innovative ways. Such a representation is referred to as a Digital Twin.

> The use of Digital Twins dramatically improves operational efficiency, safety, and security, while reducing cost, waste, and redundancy.

A Digital Twin can analyze and act to address complex problems such as a flood, a major traffic accident, a factory breakdown, or suspicious behavior in an airport, all in real-time. It can also simulate such events in advance to better prepare for when they happen.

VANTIQ is working with its customers and partners to develop Digital Twin applications to solve complex operating problems, reduce cost and complexity, and create new revenue streams. For example, with the help of the VANTIQ platform, Ford is developing traffic and parking management systems, SoftBank is creating Smart Buildings which offer targeted advertising, and Bimernet, a BIM platform provider, is connecting to real-time data to improve the operations of buildings. Innovative strategies will be created as Digital Twin technology becomes further understood and appreciated. Companies will need to implement the technology to remain competitive. Governments will need to create Digital Twins to address environmental concerns and save lives. The impact of Digital Twin technology will be major and occur faster than expected.

Advanced Digital Twins require IoT (Internet of Things), AI (Artificial Intelligence) and Edge computing (to bring computation and data storage closer to the location where it is actually needed, for more information see VANTIQ's white paper on Distributed Business Applications). Thanks to Moore's law, which exponentially reduces hardware costs, these advanced technologies are now at the point where they can be extensively deployed.

Executive Summary *(Continued)*

Consequently, the time to create advanced Digital Twins is now. Unlike any other platform in the market, VANTIQ contains the core technologies needed to rapidly create and operate Digital Twins. This includes an event broker to move information from anywhere to anywhere, low-code application development to create and implement business logic, and flexible deployment to ensure things run smoothly in a highly distributed environment. Digital Twins created with VANTIQ also include intelligent man-machine collaboration so that humans can be kept in the loop and take control when necessary.

The VANTIQ platform simplifies the complexity of building Digital Twins and is the most complete solution available.

> Consequently, VANTIQ has a much higher success rate for creating advanced Digital Twins than any other solution.

This can be compared to the 50-84% failure rates that occur when using other solutions for Digital Transformation (historically, this is the broader industry category that includes Digital Twins), according to numerous industry analysts.

We are at the early stages of Digital Twin technology. In the near future, networks will change how they behave for security and performance reasons. Intelligent sensors will better deal with security threats. The Edge and the Cloud will logically merge so that the location of processing logic (software) can dynamically change in real time. For example, if one camera detects a terrorist, you want all cameras to be focused on the individual's whereabouts in real time.

This document describes the technologies required for today's Digital Twins and how the VANTIQ platform is architected to meet the evolving requirements.

The Digital Twin Market Opportunity

The market for Digital Twins is rapidly growing since the required supporting technologies are now becoming widespread and available at reasonable costs. Over four years ago, VANTIQ had the foresight to recognize this trend and designed the VANTIQ platform accordingly. With this first mover advantage, VANTIQ is uniquely positioned to enable advanced Digital Twins to be created today.

"Most new IoT systems require real-time or near-real-time data about the events and state associated with physical things such as machines, vehicles, people, buildings or other assets."

Gartner

Why and How to Design Digital Twins

Much research and analysis has been published on the Digital Twin market:

- The global digital twin market reached US$ 10.3 Billion in 2021 and will reach US$ 54.6 Billion by 2027, exhibiting at a CAGR of 31.7% (Research and Markets, March 2022),
- Furtune Business Insights believes the market will grow at a 40.6% CAGR from 2022 to 2029 (ID FBI106246, 2022)
- From 2021 to 2027, the number of new physical assets and processes that are modeled as digital twins will increase from 5% to 60% resulting in operational performance optimization (IDC FutureScape Nov 22, 2021)
- The digital twin market will cross the chasm in 2026 to reach $183 billion in revenue by 2031 (Gartner G00755100, Feb 16, 2022)

The impact of Digital Twins will likely be much larger than predicted since more complex and beneficial use cases will be created than the simple ones presented in the above reports. Most of their estimates are based on first-generation Digital Twins rather than the advanced ones presented in this paper.

The VANTIQ platform is currently being used to build advanced Digital Twins by SIs (System Integrators) to address customer needs, telecom companies to enhance their strategic offerings, leading industrial companies (automotive and Oil & Gas) to innovate for competitive reasons, and governments to address environmental concerns. Like the smartphone or the internet, it is impossible to predict all of the innovative uses that will be thought of as global creativity accelerates.

Evolution of Digital Twin Technology

FIRST GENERATION OF DIGITAL TWINS

Computer aided design of an asset such as a motor has existed for decades. Over time, sensors have been installed in physical devices to monitor parameters such as temperature and frequency. Predictive analytics can then be used to analyze the generated data to predict failures. Up until now, Digital Twins have been created to model a machine such as a motor, generator, or medical device, to improve its operational performance during its product life cycle. This is the first generation of Digital Twins.

NEW DIGITAL TWINS FOR COMPLEX ENVIRONMENTS

The cost and availability of cloud infrastructure, edge computing, and IoT devices have improved considerably over the last decade, with advances primarily in the last few years. Now, more than ever, there is the data to not only model a large and complex physical environment, but bring that model to life with sensors, cameras, and monitoring systems. This will lead to a new type of advanced digital twin – one that is larger in scope and significantly more powerful for the business.

To explain how advanced Digital Twins operate, let's use a simple example using the app Waze. You can do a *what-if* simulation of your drive from A to B with Waze taking into consideration environmental conditions such as traffic, weather and road blockages. Then you can use the app to monitor and guide you during your trip, offering itinerary updates in real time and obtaining relevant information from other drivers through social networking. The difference between the Waze app and the simpler first-generation Digital Twins mentioned above, is that it is working in a complex physical environment, using a map and location services (GPS) in combination with situationally relevant information from other systems, all while collaborating with the user in real time. A far more comprehensive use would be to monitor a city's traffic with continuous updates from tens or hundreds of thousands of sensors and coordinate the relevant traffic control systems. By optimizing traffic lights, accident management, infrastructure utilization, and emergency response, a Digital Twin can intelligently control the overall flow of vehicles and improve the effectiveness of the system.

Evolution of Digital Twin Technology *(Cont.)*

NEW DIGITAL TWINS FOR COMPLEX ENVIRONMENTS

Continued

A Digital Twin can represent a complex environment such as a large building, an Oil & Gas facility, or a port. To do this, the assets and people in the physical environment (space) and their changes (time) need to be continuously updated and analyzed to accurately reflect the current status. VANTIQ is working with numerous partners – SoftBank, Total, Ford, and Glotech/Beijing Airport – to enable Digital Twin technology to model and control complex physical environments.

The construction industry serves as a prime example of how Digital Twins can be created from existing systems to produce significant value. In the majority of high-end construction projects, a 3D BIM (Building Information Model) is created in the design phase and used during construction. To create a Digital Twin, a BIM is interfaced to sensors and other data to make it live for real-time operations. These Digital Twins will be used to improve efficiency, safety, security, reduce waste, and decrease theft. Their usage can be applied to many environments such as a smart building, smart store, smart infrastructure, smart railway, smart port and so on.

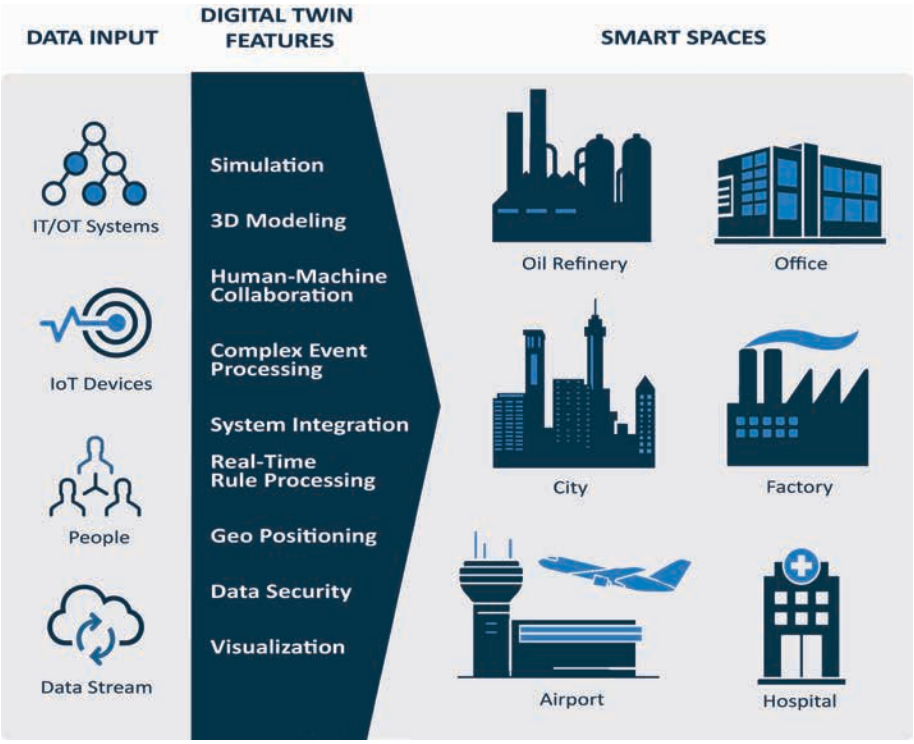


Figure 1: New Digital Twins will take information from many systems and understand what is happening in real time. This will enable effective operations of smart spaces.

Example VANTIQ Digital Twins

EXAMPLE 1: SMART BUILDING

An increasingly desirable use case for Digital Twins is in the domain of Smart Buildings. Up until now, most smart building models have been used to simulate physical systems and detect issues during the construction process. But an event-driven application with appropriate sensors makes it possible to take the building model and bring it to life for ongoing operational uses (see Figure 2).

Starting with a Building Information Model (BIM), an operator can implement a live model that can analyze streaming data characterizing the real-time status of the building. The application can then either automatically, or in collaboration with human operators, improve operational efficiency, detect security incidents, and adjust environmental settings. Additionally, machine learning algorithms will be used to predict future states of building systems and recommend actions to take place such as send out a repairman or take a machine offline.

VANTIQ is working with Bimernet to create a seamless system that combines their 3D BIM with the VANTIQ platform's real-time, event-driven processing capabilities. The result will be a fully animated 3D BIM depicting the real-time behavior of the building, including its occupants and other relevant environmental conditions. This real-time BIM enables simplified operations, coordination among vendors when problems occur, and improved safety and security for occupants. The real-time 3D visualization capability will highlight problems as they occur without information overload for operations personnel. When issues arise, recommended actions will be offered to the operators via VANTIQ's collaboration capabilities.

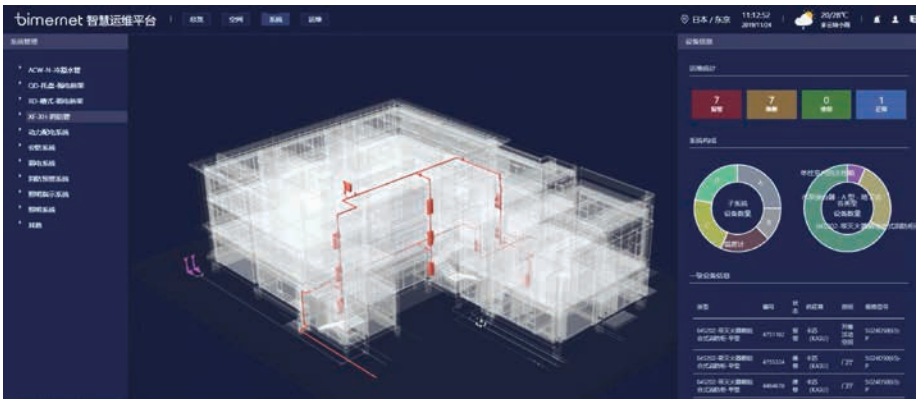


Figure 2: 3D Digital Twin of a commercial building enabled via a BIM, whose systems are now monitored and controlled in real-time by an event-driven application. Image courtesy of VANTIQ partner Bimernet.

Example VANTIQ Digital Twins *(Continued)*

EXAMPLE 2: AIRPORT

Large public facilities such as airports and train stations are logical places to implement Digital Twins that can be used for both simulating possible situations and for improving the ongoing operations of the space. VANTIQ partner Amorph, provider of a real time operations management system for airports, is using a digital twin to plan, forecast and manage passenger flows and airport resources.

When combined with image recognition technologies, a deep understanding of the locations and status of people in each facility is obtained.

During the COVID-19 pandemic, possible infections could be automatically detected and individuals tracked using thermal imaging cameras and behavioral identification. Real-time data from computer vision systems, flight information, passenger flows, and on-site security are all connected into a shared real-time floorplan and dashboard. Passengers with high temperatures can be actively detected and the appropriate response automatically taken. The application is extensible to cover all aspect of airport operations including security, resource allocation, and access management.

Figure 3: Digital Twin of an airport is used in conjunction with object detection technologies to determine the movement and status of people in the terminal. Images courtesy of VANTIQ partner Amorph.

Example VANTIQ Digital Twins *(Continued)*

EXAMPLE 3: OIL REFINERY

For complex infrastructure, such as that found in an oil refinery, being able to simulate problems before they occur is extremely useful. But even more important is the ability to use the digital representation of physical systems to direct actions in real time to save lives.

Total, a leading Oil & Gas company in Europe, has used VANTIQ to develop an advanced Digital Twin of oil refinery operations as part of its Total Anomaly Detection Initiative (TADI). The main purpose of this initiative is to save lives in the event of an incident such as a noxious gas leak or equipment failure. By creating a real-time model of the refinery, personnel in the area of an incident are alerted and then specifically directed in conjunction with other technologies, such as service robots, to coordinate an effective response (see Figure 4).

One of the biggest challenges in operating such a complex environment is getting humans to recognize when something occurs outside of normal operations. Total employs a Doctor of Psychology to address the cognitive biases of people and specify how VANTIQ can help make problems more salient to the human operators. Accordingly, situations that are out of the ordinary are better addressed when software logic works closely with humans – less is missed as human expectations of how events are expected to unfold (called confirmation bias) can result in problems not being seen. The human to machine collaboration models in VANTIQ were one of two primary reasons VANTIQ was chosen, the other being speed of development. Total, working with VANTIQ, is pushing the state of the art of Digital Twin technology for the Oil & Gas industry.

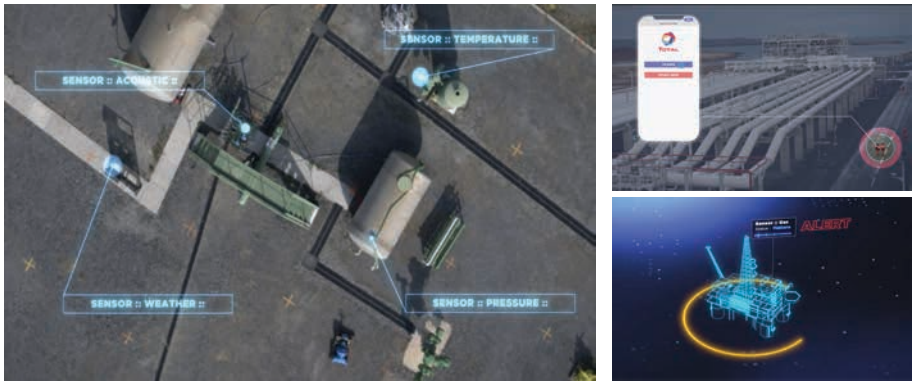


Figure 4: Digital Twin of an oil refinery is used to detect problems and manage operations in real time. Images courtesy of VANTIQ customer Total.

Opportunities with Digital Twins

BUSINESS OPPORTUNITIES

Global 5000 companies, SIs (System Integrators), and ISVs (independent software vendors) who recognize the need for Digital Twins and are first to market will create innovative business opportunities. These Digital Twins can be created as templates and resold many times.

Large commercial areas with many pedestrians such as in an airport or a train station, can use digital twins to improve the customer experience. For example, a Digital Twin of a train station can guide passengers using AR (Augmented Reality) from one platform to another. In frustrating situations, such as a 25 minute train delay, local retail and food outlets can automatically offer discounted items or food-to-go. Focused advertisements can combine demographic information with situational context to understand the current customer experience and create new sales opportunities.

This can also apply to employee experience and satisfaction. VANTIQ partner SoftBank is creating a Digital Twin of their new headquarters to make it the smartest building complex in the world (See Figure 5).

Advanced uses of Digital Twins to remotely monitor and operate physical environments will create new market opportunities. Safety, security and improved operations can be dramatically improved. Mines, oil platforms, or any large venue can be remotely operated with far fewer people on site, if any. New companies will be created that specialize in remote operations of such environments.

There are many more examples of the business opportunities that advanced Digital Twins can and will create. As with other innovations, global creativity will result in many innovative ideas and applications.

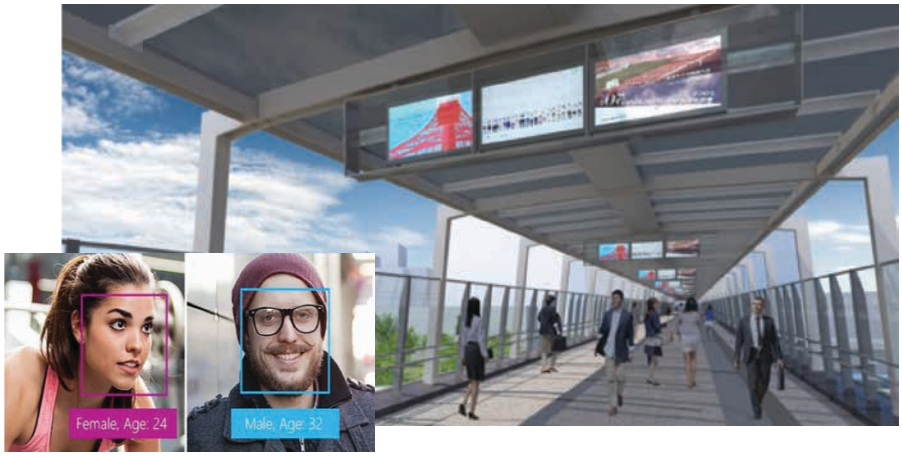


Figure 5: Intelligent Advertising based on demographic image recognition and situational intelligence. Image courtesy of VANTIQ partner SoftBank.

Opportunities with Digital Twins

SUSTAINABILITY AND ENVIRONMENTAL BENEFITS

To achieve sustainability, humankind will need to improve operational efficiency, use alternative resources and reduce waste. It is estimated that 40% of food produce is wasted. Creating Digital Twins to monitor and improve supply chain operations and produce management can make a big difference (see Figure 6).

> "Sustainable architecture is architecture that seeks to minimize the negative environmental impact of buildings by efficiency and moderation in the use of materials, energy, and development space and the ecosystem at large." - Wikipedia

Digital Twin technology can assist with this goal through the effective modeling and real-time management of smart buildings.

Digital Twins can also help to address environmental problems and accidents. For example, when a gas leak occurs, Total has developed a VANTIQ Digital Twin to immediately initiate repairs and direct humans safely away from the problem area. VANTIQ is working with a partner in France to guide and assist humans in flooding situations. In addition, Digital Twin simulations of disasters can prepare first responders and plan automated responses (open gates) to save lives.

Figure 6: Smart agriculture solution to more efficiently manage water systems and increase food production. Image courtesy of VANTIQ customer Waterbit.

Digital Twin Platform Requirements

VANTIQ platform has a unique set of capabilities for Digital Twins.

Digital Twins require a modern platform that is architected from the ground up to be:

- **Real Time and Event Driven** – to be able to receive events and analyze them anywhere, add context from relevant external sources, and pass the information on as it is happening. For example, if a fire alarm goes off, that event is instantly analyzed and contextualized to determine if it is a real threat. The alert is sent to relevant business systems such as security, door control, and emergency services. These systems are able to respond in real time and dynamically change as the situation evolves. This type of asynchronous data must be dealt with as it occurs – not put in a database for later analysis.

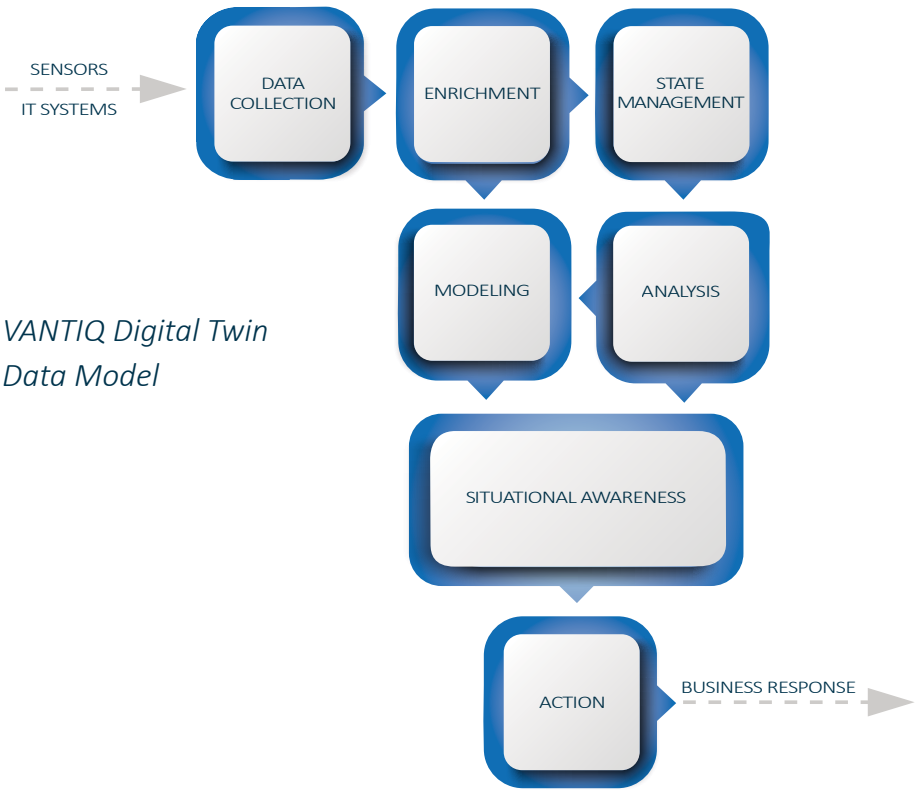
- **Edge and Cloud Enabled** – to deal with time sensitive information and not overload the network. Analytics and AI will run on the Edge. You would not want your brain to be remotely located (even over a highly reliable network). The Edge must be dynamically updated in real time to the current situation and directed as to what actions to take. Furthermore, with the scale of data involved in these systems, effective use of the Edge will mean events of interest will only go where they need to, and performance is reliable.

- **Human-machine collaboration** – to enable humans to add value to situations using their experience, intuition, and ability to generalize. Effective collaboration provides a 1+1=3 outcome with machines and humans each doing what they do best. Humans will drive decision making when needed since machines should not be left to automate the world alone – at least not in any foreseeable future. For example, if an autopilot in a plane is taking control from the pilot, it should collaborate with the pilot and not override what the pilot attempts to do. The ability to generalize makes humans better decision makers than software algorithms in many situations.

Digital Twin Platform Requirements *(Continued)*

- **Mission-Critical** – to assure very high levels of reliability, security, and performance. As the world becomes more dependent on IoT and Digital Twins, this requirement will grow. For example, if an accident occurs, the event must be reliably sent and received by the system that will address the problem. There is no room for communication error when lives are at risk.
- **Agile** – to very rapidly build and evolve Digital Twins to allow for experimentation and the rapid addition of capabilities as requirements quickly change in this new and growing market. For example, if a new set of automatic entry gates are malfunctioning and harming people, the controlling software should be immediately updated, even on hundreds of Edge nodes.

Figure 7: VANTIQ uses a low code development environment to quickly and effectively convert real-time data from the environment into intelligent business responses



VANTIQ Digital Twin Data Model

Features of Next-Generation Digital Twins

VISUALIZE REAL-TIME DATA

Visualizations are exceedingly useful with Digital Twins to assist with human interpretation of current or simulated status. 2D or 3D representations of the physical environments are extremely helpful to show what is currently happening in the real world and alert users to important situations as they occur. In Figure 8 below, a map juxtaposed with a real-time image is displayed to provide improved situational awareness for operations personnel.

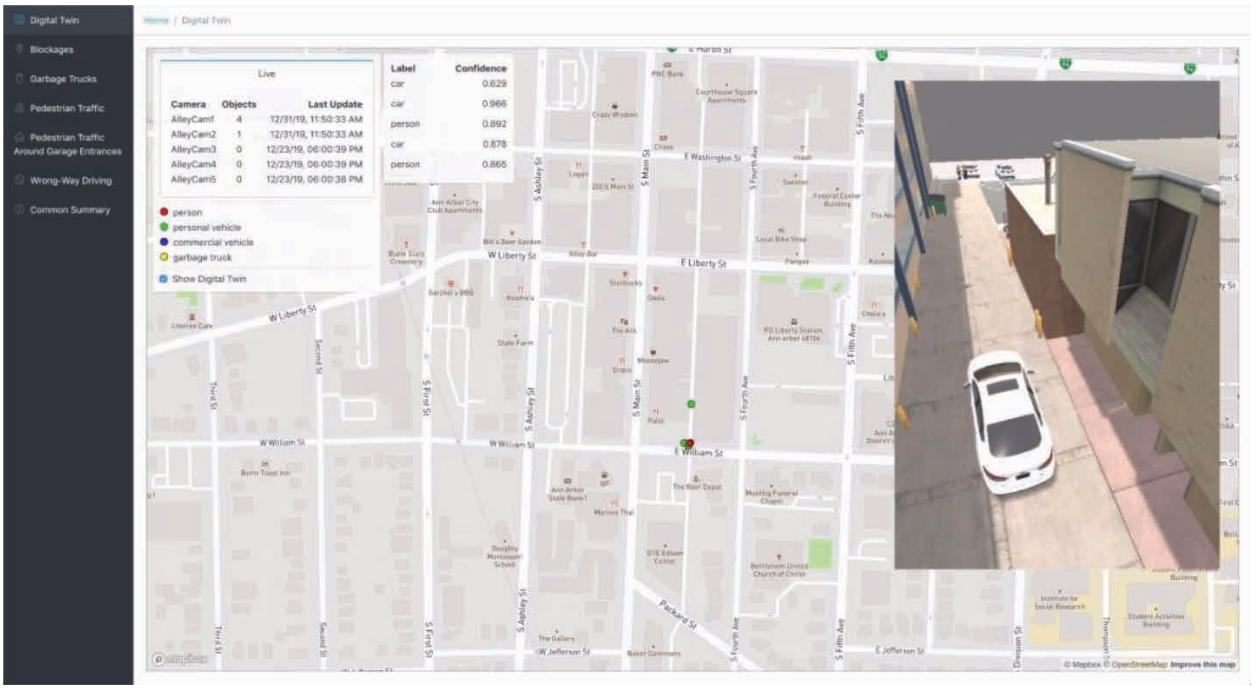


Figure 8: A Digital Twin of a smart alleyway is used to visualize the current status of the alleyway and look for situations of interest such as a car blocking traffic access or a safety concern. Image courtesy of VANTIQ customer Ford Motor Company.

Features of Next-Generation Digital Twins

(Continued)

ADAPT TO NEW REQUIREMENTS

Complex systems such as cities, have evolved incrementally over time. They are highly complex – think about traffic/transportation, waste/sewage removal, food/water distribution, electrical distribution, field services, and so on. How did this complexity evolve? The answer is piece-by-piece with many humans each playing a small part in the design. It also took a lot of time – hundreds of years – and lots of innovations such as power grids, elevators, air conditioners and so on. Now with Digital Twin technology, we are able to implement changes in the real world much easier and faster.

This speed can have unintended consequences. Even though it was fiction, the loss of control that occurred in the movie Jurassic Park should give us pause. We are dealing with CAS (Complex Adaptive Systems) that will be specified by humans. Humans add the adaptive feedback to make changes and, with a Digital Twin, it can be done quickly. Consequently, it will be critical to identify and fix problems with speed and intelligence. Old style legacy technology lifecycles are not an option with the real world depending upon Digital Twins working properly. If an application has a major safety issue, such as a false alarm or vulnerability to a cyberattack, it must be immediately addressed. Fast modifications to a Digital Twin require flexibility to quickly update the logic, architecture, or any part of an application. Anything within VANTIQ can be dynamically changed while the system is running.

Figure 9: Control room operators and Digital Twin systems must cohesively work as one, with humans able to intervene and update the system as needed.

Features of Next-Generation Digital Twins

(Continued)

USE EMBEDDED AI FOR DISTRIBUTED INTELLIGENCE

So far, AI has mostly been deployed in the Cloud. Amazon and Netflix were early users. New deployments of AI will be ubiquitous – in the Cloud, on the Edge, in the user's device. In addition, multiple AI services may be run simultaneously. For example, an image may be analyzed by various AI services searching for different objects or events – is someone running, prone, is there a leak, is there an earthquake? After initial processing on the Edge, databases can be referenced in the Cloud for more in-depth analysis.

A Digital Twin provides a shared virtual model so that data from multiple distributed AI services can be combined and used collectively.

The amount of AI being created in the world is growing exponentially in applicability and sophistication. It is being created by computer science teams at universities and tech firms of all sizes. Digital Twins benefit from this rapid growth as more innovative AI capabilities will continuously replace existing ones.

Figure 10: Distributed AI will both make businesses more intelligent and improve the effectiveness of employees

Features of Next-Generation Digital Twins

(Continued)

DYNAMICALLY RESPOND TO SITUATIONS OF INTEREST

The software and business logic running Digital Twin applications will need to be dynamic to meet immediate and changing needs. A few real-life situations when this would be required:

- Locating a lost child in a city park
- Tracking a terrorist in a large venue during a concert
- Monitoring a toxic chemical being dispersed in a populated area
- Tracking a suspicious vehicle traveling on a freeway

As we look to do more complex analysis of what is happening in real time, such as in the examples above, the logic of what to look for and the analysis of the inputs (AI) will have to be provisioned to the edge computers in real time. An example will help to explain why. Let's say a suspect is identified via an image from a camera that is then passed to a Cloud application and matched against a database of known terrorists. This takes many seconds or tens of seconds even with a fast network and fast processing. Let's also assume there are hundreds or even thousands of edge nodes co-located with cameras at many locations in the near environment. If the camera edge nodes are constantly updated with relevant information, such as the details of a subject of interest, then tracking the individual can be much more effective. The solution is to have all the Edge nodes and cameras simultaneously searching by providing each of them with a representation of the individual and the associated AI required to perform the identification.

With arrays of sensors measuring different things, it may be beneficial to repurpose some sensors so that they can work together to perform a task – an example might be to simultaneously analyze images and sounds to improve the accuracy of identification. The ability to dynamically reallocate processing and logic as conditions and configurations change enables Digital Twins to adapt to what is happening in the environment in real time. VANTIQ fully enables these capabilities.

Features of Next-Generation Digital Twins

(Continued)

SIMULATE THE FUTURE

For obvious reasons, being able to simulate possible future scenarios is a very powerful capability of Digital Twins. This enables *what-if* scenarios to be addressed prior to operational plans being finalized. Multiple simulations can be investigated by design personnel as well as operations personnel for situations that could raise concerns such as an intrusion or a flood. To enable this, Digital Twins can be copied and run simulated data to measure resource utilization, potential points of failure, and performance in extraordinary situations.

INTEROPERATE ACROSS BUSINESS SYSTEMS

Consideration needs to be given to how Digital Twins interoperate. For example, if a Smart Building is being evacuated, in order to guide people to the safest and fastest exits, collaborating with a Digital Twin of the local environment or of a transportation system can help to dynamically determine the best exit routes given the number of people and egress capabilities. VANTIQ includes a catalog of events to allow authorized subscribers to be informed of events of interest such as those from another Digital Twin.
Furthermore, there can be nested digital twins such as a motor, inside a car, inside a factory, that are structured in a hierarchy and communicate relevant information.

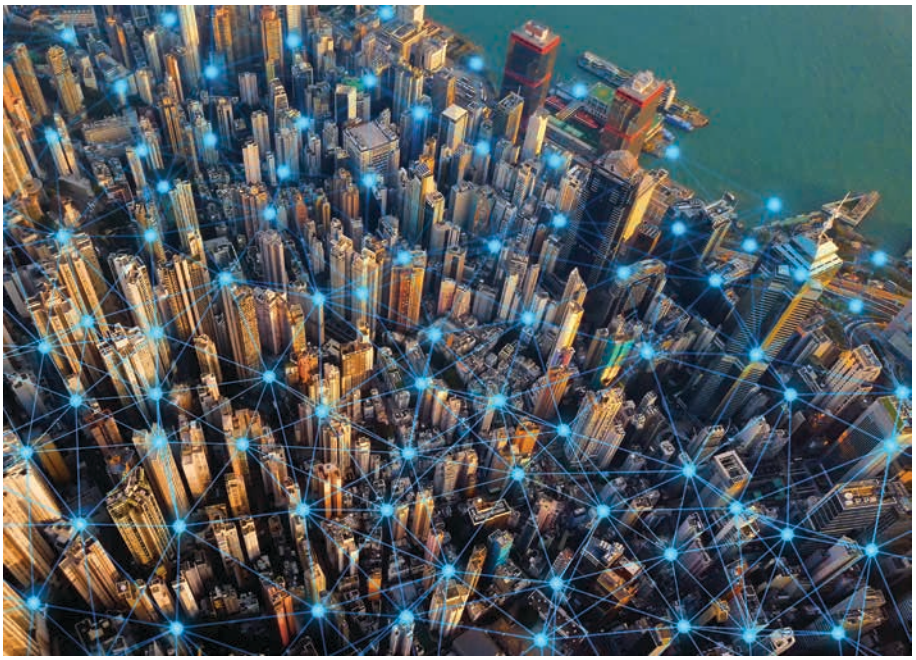


Figure 11: Effectively connecting data between systems in a complex environment is made possible with a Digital Twin framework

Summary

The exponential growth in sensors, Edge computing, and AI, combined with faster networks (5G) will enable innovation unlike anything we have ever experienced. Digital twin technology is growing to leverage these advances and take on a much larger and more powerful role in business operations. As the industry learns more about developing these systems, new use cases will be created rapidly and in innovative ways that are hard to predict. The impact on how the world operates will be dramatic. VANTIQ intends to lead in creating advanced Digital Twins that drive this change.

ABOUT VANTIQ

Customers around the globe rely on VANTIQ to quickly and easily create the next generation of transformative digital applications to serve the Internet of Things (IoT), smart cities/buildings, oil and gas, healthcare/life sciences, and telecommunications, among other industries. VANTIQ powers these mission-critical real-time business operations with our low code event-driven architecture (EDA) application development platform. Founded in 2015 by renowned business and technology leaders Marty Sprinzen and Paul Butterworth, VANTIQ dramatically reduces time-to-market, significantly lowers development and maintenance costs, and provides maximum agility in response to constantly changing operational requirements.

Learn more at www.vantiq.com.

VANTIQ