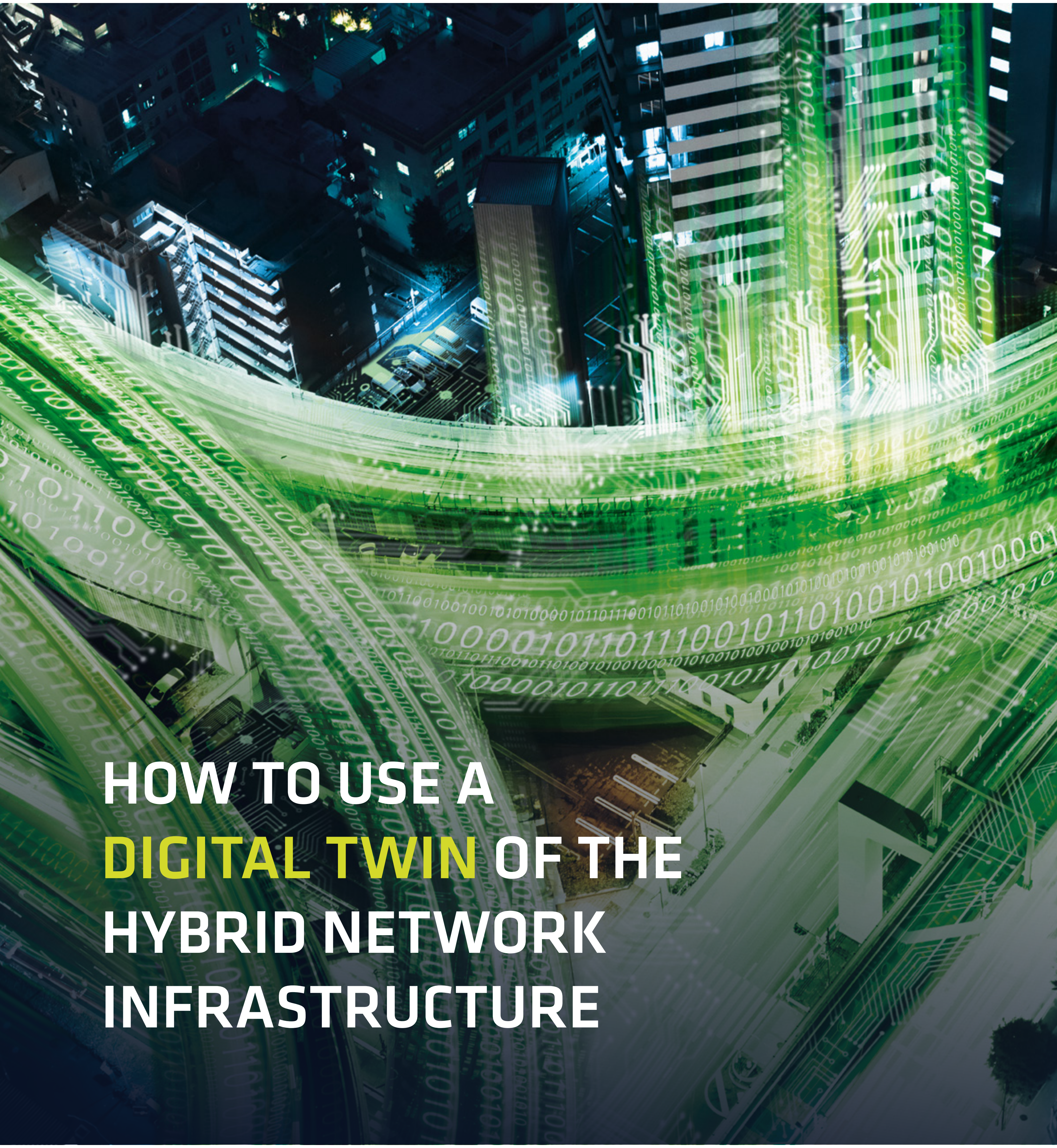
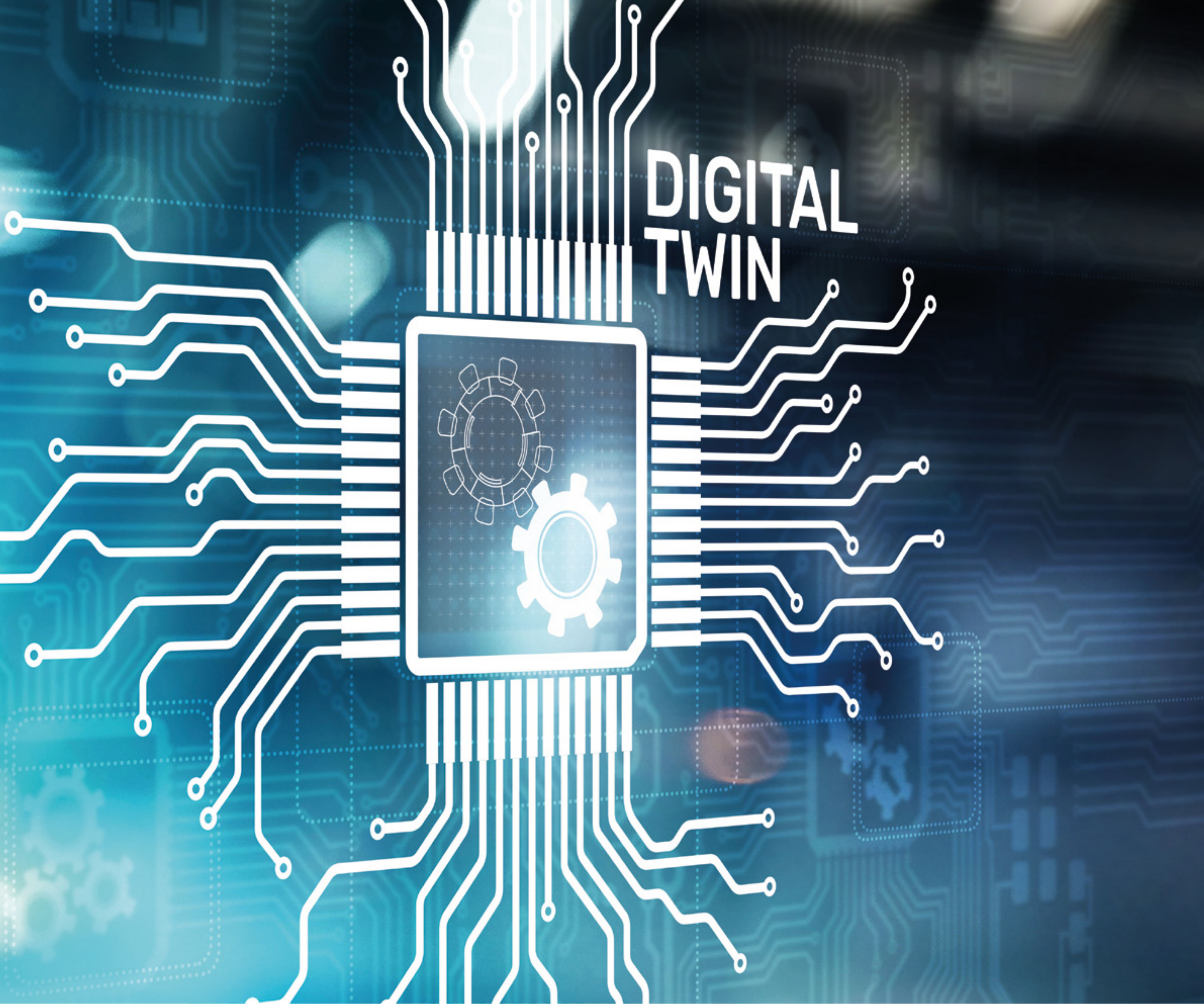


HOW TO USE A DIGITAL TWIN OF THE HYBRID NETWORK INFRASTRUCTURE



IN THIS WHITE PAPER

Digital transformation has moved from a buzz word to a way of life. Businesses accept the fact that old business models are not economically viable in the digital world, and understand they need to make significant changes to adapt to this new reality. One change garnering growing acceptance is the use of the digital twin. This white paper discusses the important role a digital twin plays in managing today's complex hybrid network infrastructure, highlights how digital twins are being applied, and reveals the benefits that result from this new approach.

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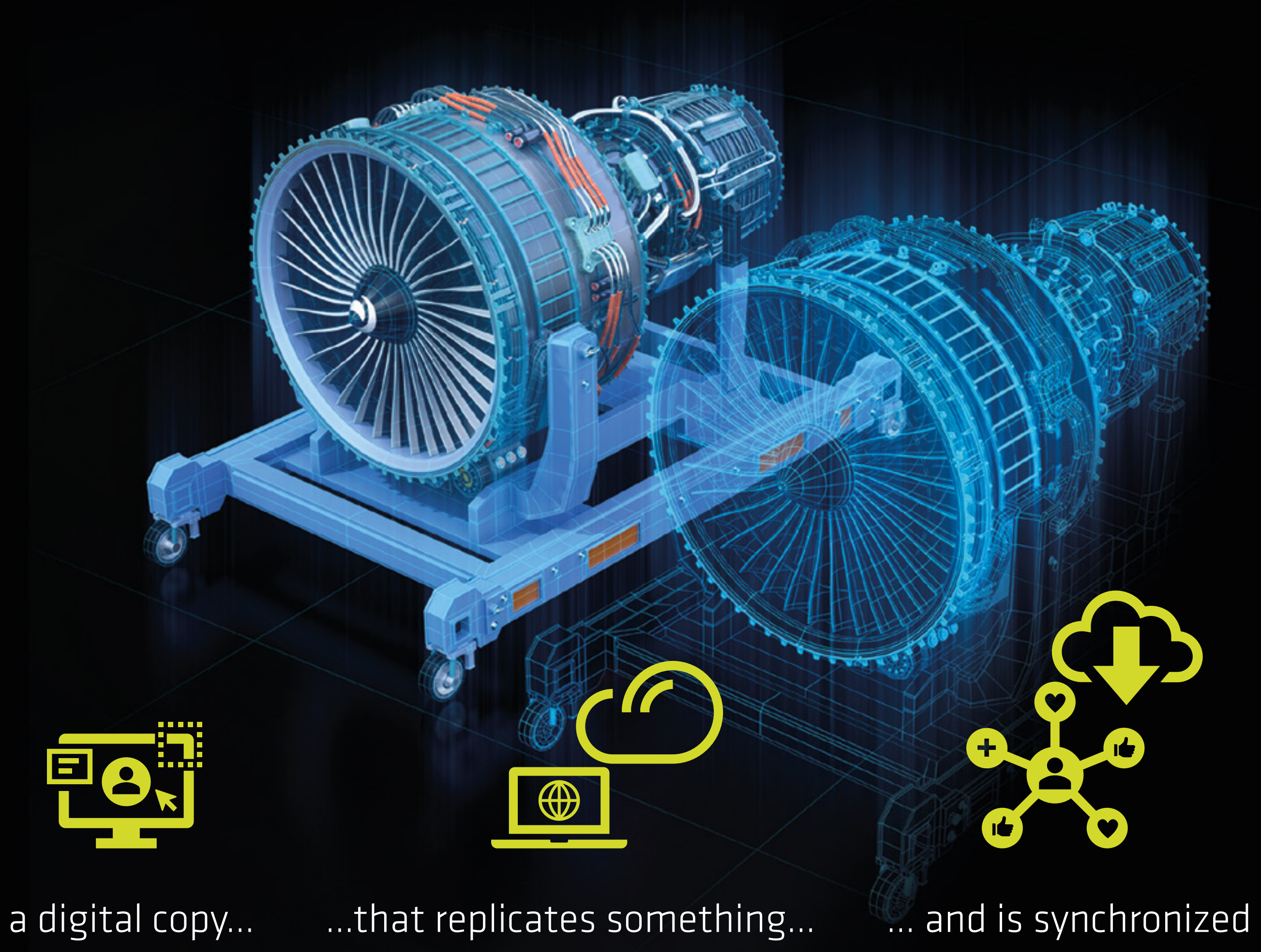
What is a Digital Twin?



Digital twins are changing the way businesses operate

We are firmly entrenched in the 4th Industrial Revolution, a new era that builds on and extends the impact of digitization by further embedding technology into everyday life. Pervasive digitization is the new normal, and businesses need to adapt to survive. Most realize this, as evidenced by a McKinsey survey in which 92% of company leaders surveyed believed that their current business model would not remain economically viable through digitization. Almost universally, organizations understood the necessity of deploying new technologies to survive.

In the communications industry, that means being prepared to meet the next wave of network and service demands. CSPs need to ensure they can constantly evolve based on customer requirements, new trends and opportunities, and technological change. Some of the requirements of these demands present sizable hurdles: continued investments in greater broadband capacity to keep up with growth in global data traffic, bring broadband to rural areas to reduce the digital divide, faster connections with minimal latency, ability to accommodate exponentially more connected devices, and the continued drive to push networks further to the edge.

The quest to nimbly respond to these challenges is behind the growing adoption of digital twins. Digital twins are increasingly recognized to be a powerful tool in a CSP's toolbox. They are effective at helping service providers meet the myriad of demands that arise in these dynamic times. This paper examines how CSPs are applying digital twins of their Hybrid Network Infrastructure and the resulting outcomes.

Why service providers are using digital twins

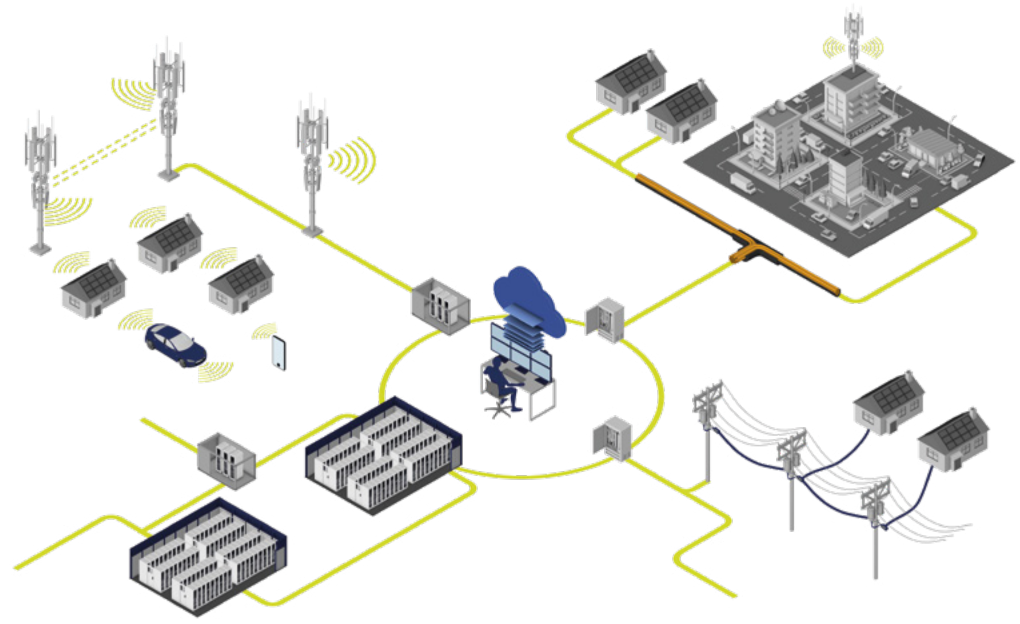
A digital twin is a digital replication of something. Digital twins can take many forms, but they all capture and utilize data that represents something in the real world. Examples of what can be replicated as a digital twin include an organization, building, city, product, and even a process. A telecom providers' entire network, or parts of it such as sites, towers, network elements, physical and logical connections and services, virtualized resources as well as all kind of configuration parameters are potential candidates for a digital twin.

A digital twin is synchronized with the original. Dynamic updates to reflect real world changes are a critical and distinguishing feature of a digital twin, as a copy only has value if it is an exact duplication. When a digital twin is utilized, changes to the network can be planned first with the digital twin and the results of the changes can be analyzed before any action is taken. When the planned changes are executed in the network, they are verified against the digital twin through data reconciliation. This closed loop principle is integral for high data consistency and optimized operational processes.

The objective of a digital twin is to understand the state of the object that it replicates, respond to changes, improve business operations, and ultimately add value. Its purpose is to act as a mirror to simulate, predict and forecast the behavior of its real-world counterpart. For service providers and telecom operators, it is an approach that enables them to manage their network and services in an intelligent, proactive, dynamic, and automated way.

A CSP that represents its network as a digital twin can realize significant business value. For example, it can run simulations to predict impact of failures, plan changes and rollouts or analyze the impact of planned maintenance tasks. Modelling and simulating scenarios enables them to automate processes and increase their agility to speed up product development lifecycles, save time, and reduce costs.

A CSP's hybrid network infrastructure is an ideal candidate to be twinned. A hybrid network is comprised of many unique objects: fiber, transport network, wireless or wireline access network, core data centers, and multiple edge sites with a large variety of different virtualized resources from various suppliers. The configuration data of the active nodes, passive devices, mobile cells or from many other logical and virtual components must be represented as well. A digital twin brings together the data of these many diverse components, across many different Telco, IT and Data Center technologies, from multiple vendors, to create value for the CSP.



All kinds of resources and hierarchical dependencies across different technologies - from wireline and wireless access to the transport down to core network and data center sites, that are provided by various suppliers – are represented in a digital twin of the hybrid infrastructure.

A look under the hood of a digital twin

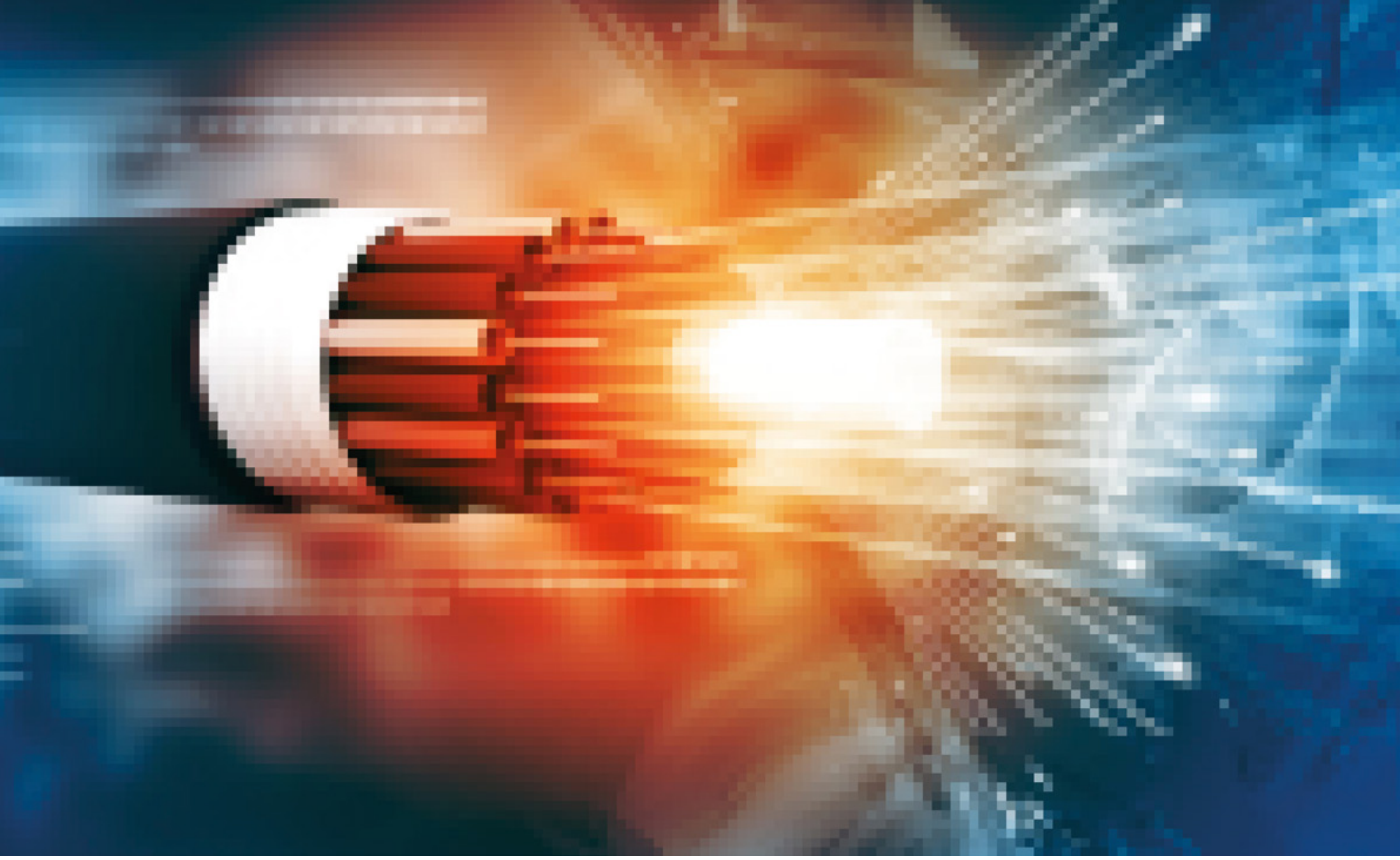
To grasp the value of a digital twin of the hybrid network infrastructure, one needs to appreciate its complexities. A CSP's hybrid network infrastructure has vast reach. It encompasses the data center, the network, and the customer edge. All technologies used throughout each domain - all active physical, logical and virtual resources, and all passive infrastructure and inventory in the inside and outside plant – are part of the infrastructure. So are the dependencies between them.

The nature of today's communication infrastructure presents significant challenges. It crosses domains and is distributed across many sites. It consists of multiple and heterogeneous technologies, which are separate but must coexist and work together to form the final services. And its technologies and assets are from many different suppliers, which means multiple data models must be applied and different operational behaviors must be accommodated.

Given all these disparate pieces, operations, service assurance, service fulfillment and design and planning can be challenging. Complex coordination and tracking are needed. These are all areas where a digital twin can assist. It replicates and visualizes the hybrid network infrastructure as a geo-referenced or schematic representation that shows all relevant infrastructure and resource details about used and available capacities, as well as dependencies and relationships between the resources across the technologies and vendors.

A digital twin of a hybrid network infrastructure, therefore, must represent:

- **Physical** components of POPs, data center sites, RAN sites, street cabinets, customer or any other network sites – with individual rooms, racks, and equipment
- **Active** nodes spread across the network - shelves, cards, modules down to individual objects
- **Passive** infrastructure of a network – trays, ducts, micro-duct bundles, cables and fibers, including detailed data about splice closures, cassettes, splices, patch panels, patch cables
- **Logical** connections – links and connections between the many active nodes and resources
- **Dependencies** between connection hierarchies – across various technologies
- **Virtual** resources based on NFV-Infrastructure – servers, clusters, virtual machines, VNFs
- **Configuration data** – assigned to active nodes, logical resources such as cells or links, virtual objects, passive equipment



Uses cases for a Digital Twin

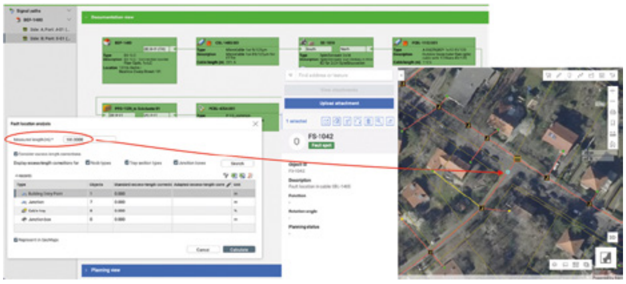
Service providers will benefit from the use of a digital twin when it comes to operations and service assurance, design, planning and capacity management, as well as fulfillment and orchestration of their hybrid network infrastructure resources and services.

OPERATIONS AND SERVICE ASSURANCE USE CASES

A digital twin can be used to run various simulations. It delivers a visual representation of the network infrastructure to support much more informed decisions. It gives critical information before any action that could affect customers is taken. For example, it can be used to identify customers who may be affected by planned maintenance so you can notify them in advance or reroute connections. Without a digital twin, performing a card exchange requires network engineers to query various data sources and management systems to analyze the situation and understand the impact on customers. This is a very time consuming and error-prone task. However, the data contained in a digital twin enables and optimizes running a what / if simulation of this task. The digital twin reveals all the connections and services that will be affected, and a report can detail the connections and services running over the card. Algorithms calculate whether a service is up or down based on the underlying redundancies and protections applied in the network. This simulation provides the inputs needed for the operator to either reroute connections or inform people about downtimes.

This kind of simulation can also be used for a routing diversity analysis to check whether the design of diverse routed connections is made properly. If there has been a mistake, such as the primary and secondary route both use a common resource, it can be fixed before an outage occurs.

In addition to simulating what / if scenarios, a digital twin can be used to perform an impact analysis of an outage by analyzing and simulating the impact to services and to customers when there is an outage. If there is a cable break on a physical connection between two active nodes, the digital twin can calculate the connections and services affected and provide results, including identifying redundant routing and which services are down. A signal trace of the network connection supports using OTDR measurement data to calculate precisely where the fault is located. The digital twin will provide the geo-coordinates and show the location on a map.

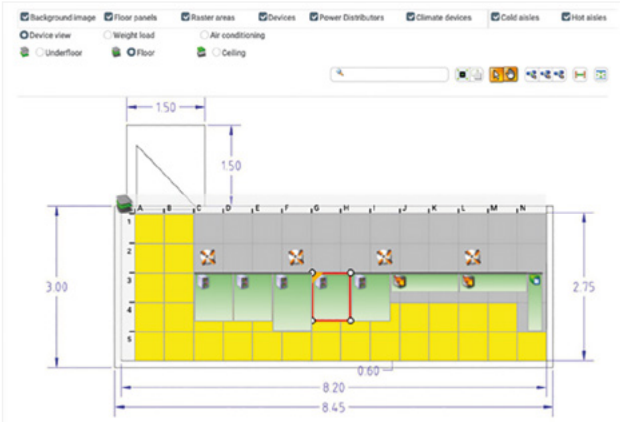


OTDR fault localization connects measurement data with digital twin data and shows the location on a map.

DESIGN, PLANNING AND CAPACITY MANAGEMENT USE CASES

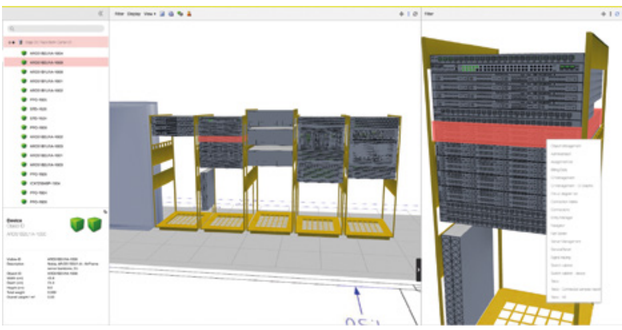
From small changes to large network transformations and complete rollouts, the accurate replication of the network and its data is one of the most valuable benefits a digital twin delivers. A 5G rollout, for example, requires a very efficient planning, design and rollout procedure due to the higher density and thus increased number of 5G mobile sites. A digital twin-based approach cuts rollout times dramatically by managing the site selection process and optimizing every phase of the rollout.

A mobile network scenario provides a good example of how a digital twin can be used to assist planning additional resources based on current capacities and resources. To start, you will need a digital twin that represents the as-is status of your network and your current mobile sites. A digital twin can provide a digital replication of your network to be used in scenarios such as one in which mobile sites and the assigned nodes are connected in the fronthaul to an edge data center, which is then connected to the core data center via the midhaul / backhaul. The edge data center uses server infrastructure and switch-based network connectivity. All of this can be displayed in a 2D footprint visualization of the container-based edge data center site.



2D footprint visualization highlights where in a room or a container the resources in question are located.

Depending on the functionality supported by the digital twin, the edge date center can also be visualized in a 3D footprint in which you can zoom in and walk through, select a device, and access additional information. For example, you may need specific details about a server or server-cluster, which is hosting several virtualized applications. The digital twin will not only show that information, it will also show the virtual resources running on the servers, with all the dependencies between the relevant 5G slices on the top layer and the underlying virtualized resources, down to hardware and network resources.



3D footprint visualization provides virtual data center walk-through with direct access to any assigned data.

All details about the server cluster and the installed virtual machines and applications are represented by the digital twin, as well as the virtualized 5G RAN Central Units with the assigned RAN Distributed Units running in the edge data center. The RAN Distributed Units are related to the individual mobile sites, with the assigned mobile cells, and the corresponding RAN configuration data.

The fronthaul connection to a site is also represented in the digital twin. The logical connection to the site, the

underlying physical interconnection with the site, and its georeferenced representation on a map are all included. Once again, depending on the features of the digital twin, you have the ability to drill down from the birds-eye view to get additional location intelligence, based on a variety of different background maps. If part of the digital twin, a map application provides additional search capabilities for addresses or objects. It allows you to navigate directly to these sites and get further information or display site photos.

A digital twin also shows how the midhaul / backhaul connects the edge data center to a core data center by applying the same functionality and information used for fronthaul connections. It can reveal where the terminating node of a connection is located within the core data center and inform the user if additional changes are planned in the same shelf. The core data center can also be graphically visualized in a 3D footprint that users can virtually walk through and easily see the current situation as well any planned extensions.

Precise load and capacity information is key to accurately assess capacity needs and proactively strengthen infrastructure. A digital twin uses data to assess expected needs for extensions and changes. A digital twin can be used to analyze optimal usage of available resources, then plan the appropriate adjustments to maintain uninterrupted delivery of services. A digital twin can also help identify and reclaim stranded capacity, which positively impacts the bottom line.

Consider, for example, how deployed network configurations change when new equipment is introduced, or network changes are executed. This happens incrementally over time. In some cases, these changes can cause stranded capacity. This is a known issue that is not easily rectified. Maintaining an accurate inventory of network resources and keeping track of all changes is thus vital for efficient operations and planning.

There are a number of tools available to help service providers deal with capacity management, such as network planning systems per domain, element and network management systems per vendor and technology, inventory management per domain, asset management and ERP tools. The problem with them is that they are mostly used in isolation so a holistic, up to date, end-to-end view of the network with its physical, logical and virtual resources, the services running on it, and the history of changes are often lacking. A digital twin can bring together all this information for an accurate network inventory and resource management, which is the basis for optimizing capacity.

The point is that whatever change, transformation or rollout planning is required, whether it's about building up and connecting new sites, providing additional capacities in fronthaul, midhaul and backhaul, or adding resources in edge or core data centers, the corresponding design and planning is carried out with the digital twin based on the as-is replication of the network. Based on this planning data, the execution of the assigned tasks in the network are managed, the planned changes are verified via reconciliation, and the digital twin is updated with the new as-is status of the network.

This closed loop principle is integral for high data consistency. The "loop is closed" when the resources in operation are compared with the original planned resources, and any data discrepancies due to planning changes, installation errors or changes made because of outages have been resolved. Without data consistency, a planned network extension may be not implemented, or it may be implemented incorrectly. For example, slots may already be occupied by undocumented cards, or there may be network misconfigurations because of wrong assumptions that were based on incorrect network documentation. These scenarios are painful and expensive – and highly avoidable. The closed loop principle ensures that the next planning cycle is built on verified and accurate data, and that no surprises await the technician.

FULFILLMENT AND SERVICE ORCHESTRATION USE CASES

The fulfillment and end-to-end orchestration of services across a hybrid network infrastructure is very complex and challenging for service providers, as these use cases use traditional physical and logical resources in combination with the virtualized part of the network. These use cases are traditionally handled by domain-specific and siloed operational support systems and tools.

The digital twin forms the basis by providing all relevant physical, logical and virtual resources across the entire hybrid network infrastructure. Protecting against vendor lock-in, the digital twin is a multi-vendor, multi-technology and multi-domain platform delivering this resource data to any fulfillment and orchestration platform based on an integrated data model.

Fulfillment and orchestration use cases typically operate with both resources available in the network as well as resources still in the rollout phase. Since the digital twin covers both available and planned resources, it is the ideal central system of record to simulate, plan and run fulfillment and service orchestration scenarios. It supports customer requests for both standardized products requiring service orchestration including CPE rollout and configuration and for non-standardized B2B solutions. In both cases, the digital twin can provide the available resource data and required parameters for rollout, provisioning, and configuration management in addition to enabling feasibility analysis, planning, and rollout orchestration.

The digital twin serves as the single source of truth to provide the relevant data, in a reliable and consistent way, to support orchestrating and activating hybrid end-to-end services across the network. It also supports more specialized tasks such as:

- managing network slicing across multiple domains in 5G networks
- planning and deploying virtualized DUs and CUs of the Cloud-RAN in Edge and Core Data Centers
- designing and assigning the VLAN and IP configuration for layer 2 and layer 3 services

The digital twin provides the resource data for these different use cases and allows for structuring and managing the processes used for execution. As such, the digital twin enables faster delivery and optimized lead times. And, since this data can also be used to plan and simulate use cases, the operator is able to anticipate issues and be proactive in its response, which ultimately facilitates predicting lead times and decreasing the cost to operate.

FNT checks all the boxes for your digital twin needs

Certain features and capabilities are essential for a digital twin to deliver on its full potential. The following list is a guide that details key features to look for as you evaluate potential solutions.

✓ **Vendor-agnostic, uniform data model.** All types of resources in the hybrid network infrastructure must be represented in the digital twin, irrespective of vendor and technology. This is a mandatory prerequisite for any digital twin scenario.

FNT software is based on a comprehensive data model that serves as the foundation for the digital twin. It crosses data center, IT and telecommunications domains, effectively eliminating data silos within an organization. It comes with an extensive CI library of 70,000+ IT and telecommunications components stored as objects, along with logical relationships, to facilitate initial setup, additions, and changes, including validation rules to support mapping of configurations and infrastructures. It therefore delivers an integrated representation of the network infrastructure resources and provides much-needed transparency, from physical level to business services.

✓ **Synchronizes with your network.** A digital twin must always reflect any changes made, regardless of whether executed manually or via an orchestration, fulfillment of other type of management system.

FNT software automates reconciliation processes to ensure data integrity. When changes, planned in the software, are executed, the data in the digital twin is automatically updated with its new status. It is put through reconciliation processes to find and fix discrepancies between data from network devices and the OSS/BSS. This ensures that the digital twin is providing users throughout the organization with the same consistent view of the network, at all times.

✓ **Integrates with other relevant OSS/BSS/IT solutions.** Integration is essential, as the digital twin works as a data hub to fully support, analyze and simulate “real world” scenarios.

FNT’s software has an extensive connectivity layer that exchanges data with third-party systems, exposing the data to any application that needs it. Its open REST API, the ETL technologies, and prepackaged interfaces extend usability of infrastructure information.

✓ **Strong visualization, reporting and analytics capabilities.** The digital twin encompasses a huge amount of data, relationships, and dependencies. Knowledge-based decisions yield better outcomes, but only when data transparency is in place to inform decision making.

FNT provides this much-needed transparency with graphical visualization and presentation of infrastructure and service data. FNT’s presentation of digital twin data makes it possible to recognize patterns within the data, visualize structures, and gain a better understanding of dependencies, all of which make it easier to cull insights and drive better decision making.

✓ **Ability to properly manage user access.** Defining specific rights and permissions of individual users and groups is an important function for any software application. This is especially true of the digital twin, since it is a huge, organization-wide repository of critical infrastructure data. It is vital to have guardrails in place to protect the data within and prevent unauthorized access and changes to the data.

FNT software supports role-based user management and multi-user capability. It defines and authorizes each individual user or group and maintains detailed information on several levels across many different domains. Implementing tailored user profiles and access rights ensures that people only see what they are allowed to. Such predefined roles and privileges greatly simplify the administration effort.

About FNT

FNT GmbH, headquartered in Ellwangen (Jagst), Germany, simplifies the management of highly complex digital infrastructures in companies and public authorities with its FNT Command Platform. With the cloud-enabled "software made in Germany", IT, telecommunications and data center infrastructures can be efficiently recorded as digital twins and documented across all levels from buildings to digital services. The software also offers open interfaces and numerous functions for planning, implementing and automating transformations and changes in an integrated manner. FNT's customers include more than 500 companies and government agencies worldwide, including more than half of the DAX-40 listed corporations. FNT operates offices in several locations in Germany as well as in New York, London, Singapore and Timisoara and has an international partner system with market-leading IT service providers and system integrators.

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