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// simplify complexity

THE POWER OF NETWORK INVENTORY SOLUTIONS:

A GUIDE FOR SERVICE PROVIDERS AND NETWORK OPERATORS

IN THIS WHITE PAPER

Communications services power the world. The more complex the transmission of voice, data and video becomes, the more difficult it is for service providers to deliver on their primary objective of delivering reliable and efficient communications services. Dynamic inventory management solutions make it possible to efficiently operate the network from asset management to service delivery, assurance, and planning. This white paper discusses the important role network inventory plays in managing today's complex network infrastructure, the biggest challenges service providers face in keeping track of network components, and how a modern network inventory solution addresses these needs.

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Introduction

In the modern world, where communications technologies are at the forefront of almost everything we do, communications service providers and network operators play a critical role. Our modern lifestyles and experiences rely upon seamless connectivity and reliable, efficient communications services. Service providers and network operators of all forms (communications service providers, data center providers, network service operators, utilities, enterprise network managers and more) are responsible for managing highly complex solutions. Solutions that comprise networks, infrastructure and a variety of systems that enable the robust and cohesive supply of communications services to support the transfer of data, voice, and video traffic.

Managing the complexity of this entanglement of networks, infrastructure, systems and services is an unenviable task. The difficulty of this task is only getting tougher as communications technologies get more sophisticated, virtualized and abstracted. Service providers and network operators know that an essential element of facing these challenges on a daily basis comes down to how confidently they can rely on their network inventory solutions. Almost all business as usual (BAU) workflows they perform have some sort of dependency upon their network inventory solutions.

The development of network inventory solutions in recent years draws parallels with the way that GPS (Global Positioning Systems) have revolutionized modern navigation. While GPS navigation systems have completely revolutionized the age-old challenge of map-based navigation, dynamic network inventory has revolutionized how network operators are provided with an up-to-date awareness of their network, assets, surroundings and available routing / connectivity in near-real-time. Both GPS navigation systems and network inventory are sophisticated solutions that help users perform many different types of workflows or solve different types of problems.

Like Network Inventory is for network management, the GPS navigation is the heart of modern navigation, coordinating information to facilitate all other navigation actions.

The following table provides a comparison of how each tool supports or facilitates the most essential use-case categories:

Use-Case Category	GPS Navigation System Example	Network Inventory Example
Asset Information / Management	Helps to accurately identify, store, and communicate current location to enable insights and actions (i.e., to take an accurate inventory of current location and all nearby roads, intersections, etc.)	Helps to capture, then store, up-to-date information about the network and all its components to enable insights and actions to be performed (i.e., to take an accurate inventory of all nodes, links, etc. and their current operational status)
Fulfillment	Helps to navigate a user through all of the steps between point A to point B	Helps to navigate through all the steps to enable customers to be connected to the network, including network resource allocation for customer use
Assurance	Helps to identify problems (e.g., traffic jams or accidents) and route a user around them as optimally as possible	Helps to identify network bottlenecks, customer impacts and their root-causes, to route data traffic around the problem and manage associated repair activities
Planning	Helps to find specific locations / information (e.g., restaurants, gas stations) and consider alternative options	Helps to understand current capacity and posture of the network, then consider whether alternative configurations / augmentation would improve that posture
Digital Twin	Provides a representation of all current routes and up-to-date performance of each route-segment within a city (and even across the world)	Provides a representation of all current assets and connectivity as well as up-to-date performance / health status of each asset in the network (when linked with network assurance data feeds)

Rather than considering what each solution offers, perhaps the better comparison would be to consider what the world would be like without GPS or modern network inventory solutions. Without a properly functioning GPS capability, we might revert to paper-based maps or trial-and-error navigation. This is far more labor-intensive, error-prone and inefficient.

The same is true for network operators and service providers. Lacking an adequate and optimized network inventory affects a network operator's ability to efficiently provide high-quality and resilient services to customers. Inaccurate or incomplete network inventories can lead to delays in service delivery, increased downtime, and higher operational costs. Network inventory solutions help service providers to efficiently manage their most valuable assets – their networks, workers and customers.

It is almost impossible to adequately manage the advanced, dynamic, virtualized networks of today without a comprehensive and near-real-time view of network assets and resources. Clearly this necessitates proper tools and solutions to provide a complete and accurate view of network resources.

Inventory Challenges

Since network assets like routers and cables are a fundamental component of the communications services offered to customers, network inventory / asset management is a critical aspect of service provider operations. It is responsible for keeping track of all the physical, logical and virtual components of a network, including devices, connections, and network overlays. However, service providers face numerous challenges in this area.

One of the most significant challenges is **data quality**. High-quality data is essential for building an accurate representation (digital twin) of the network, particularly the network's physical, logical and virtual components. The ramifications of poor data quality are a lack of situational awareness leading to incorrect decision-making. The contagious effect of this is network downtime, re-work, poor customer experience and lost revenue. No matter how good a network inventory solution is, if the data quality is poor, then the overall effectiveness of the solution will also be poor.

A related challenge is **reconciling data** between the many different sources that contribute to a network inventory data set. These can include direct feeds from the devices themselves, network management systems, other OSS/BSS solutions and even other databases or data lakes. Without considered integration, this process can be time-consuming and require manual intervention, which can in turn lead to delays and errors.

Since network inventory solutions are a virtual representation, or digital twin, of the real network, service providers must also **identify network changes and insights** quickly to respond to network issues proactively. However, identifying these changes can be a daunting task, particularly when managing a large and complex network that is changing constantly.

It's in this **real-time awareness of current situations** where network inventory solutions most resemble GPS solutions – and where the contrast between old and new approaches are most apparent. They both help users to navigate their way around problems as soon as they arise and in ways that simply weren't possible before. They both provide an accurate digital twin of the network (road maps in the case of GPS, network topology maps in the case of network inventory), allowing service providers to view the network's current status, identify potential or actual issues, then make immediate and informed decisions.

Moreover, with virtualized networks causing a rapid uplift in node and link counts, network inventory solutions need to **scale to any size of network** and still perform optimally. They also need to flexibly scale to handle any type of network, including devices, connection types, and overlay network types.

With network inventory solutions performing such a pivotal role and holding large amounts of network, topology and operational data, they become a prime target for nefarious actors and **security is paramount**. This means access to network inventory solutions must be carefully managed (via privileged access controls). Similarly, inventory solutions must ensure data is protected at rest (e.g., in stored locations like databases) and in motion (e.g., when data transits between other systems, usually via APIs or Application Programming Interfaces).

Since network inventory solutions and data are central to most important network operator workflows (i.e., fulfilment, assurance, planning and asset management), it clearly plays an important role in **operational efficiency**. By using algorithmic approaches, network inventory solutions can help to automate tasks, thus reducing the need for human involvement.

While every network around the world is different, they often share common building blocks. This could include network device makes / models, connectivity patterns and communications protocols. These commonalities mean that lessons learned, and effort expended on past projects can help on future projects, but only if shared. The use of off-the-shelf, **repeatable solutions and standardization** across the industry can further optimize network inventory management, reducing duplication of efforts and resources.

Inventory Fundamentals

Network inventory solutions work by collecting and managing data about a service provider's network and infrastructure. Just like a GPS relies on map data (such as roads, buildings / addresses and network congestion), a network inventory solution also compiles a map of various assets that make up the network.

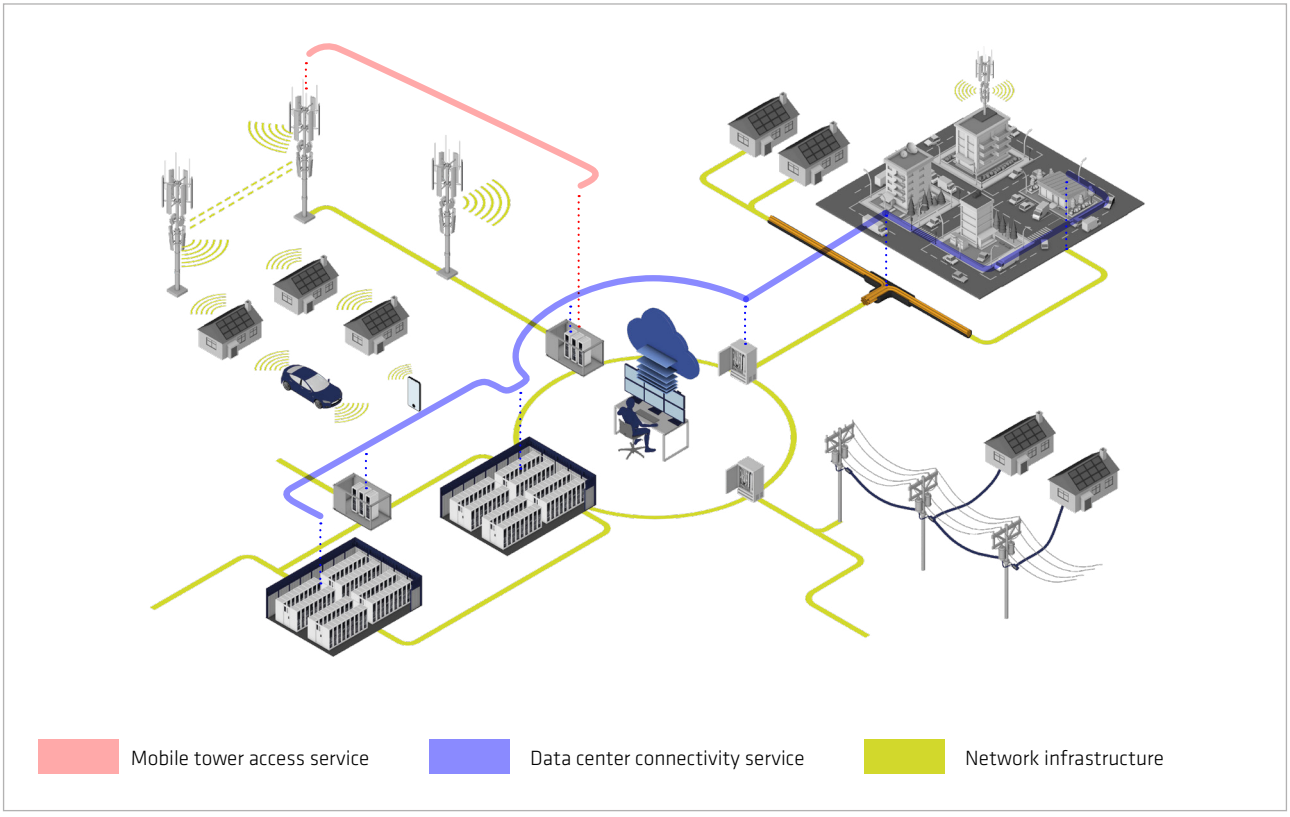
As shown in the diagram below, a network inventory data map consists of:

Active assets – examples of these include routers, switches and multiplexers. They're called active devices because they are powered and usually have interfaces (APIs) that allow up-to-date information to be collected from them.

Passive assets – examples of these include cables and junction boxes as well as racks. They're called passive devices because they don't have active electronics and there is generally no way of harvesting stored information from them (e.g., a cable doesn't maintain a record of its own name or attributes).

Logical / virtual overlays – examples of these include logical circuits, virtual private networks (VPNs), virtual network functions (VNFs), etc. These logical entities may exist within one domain (e.g., a path or trail in a transmission network) or could traverse many different network domains (e.g., an SD-WAN that includes access networks from different service providers around the world).

Each of these entities will generally have many associated attributes such as object name, object type, installed date, current status, etc.



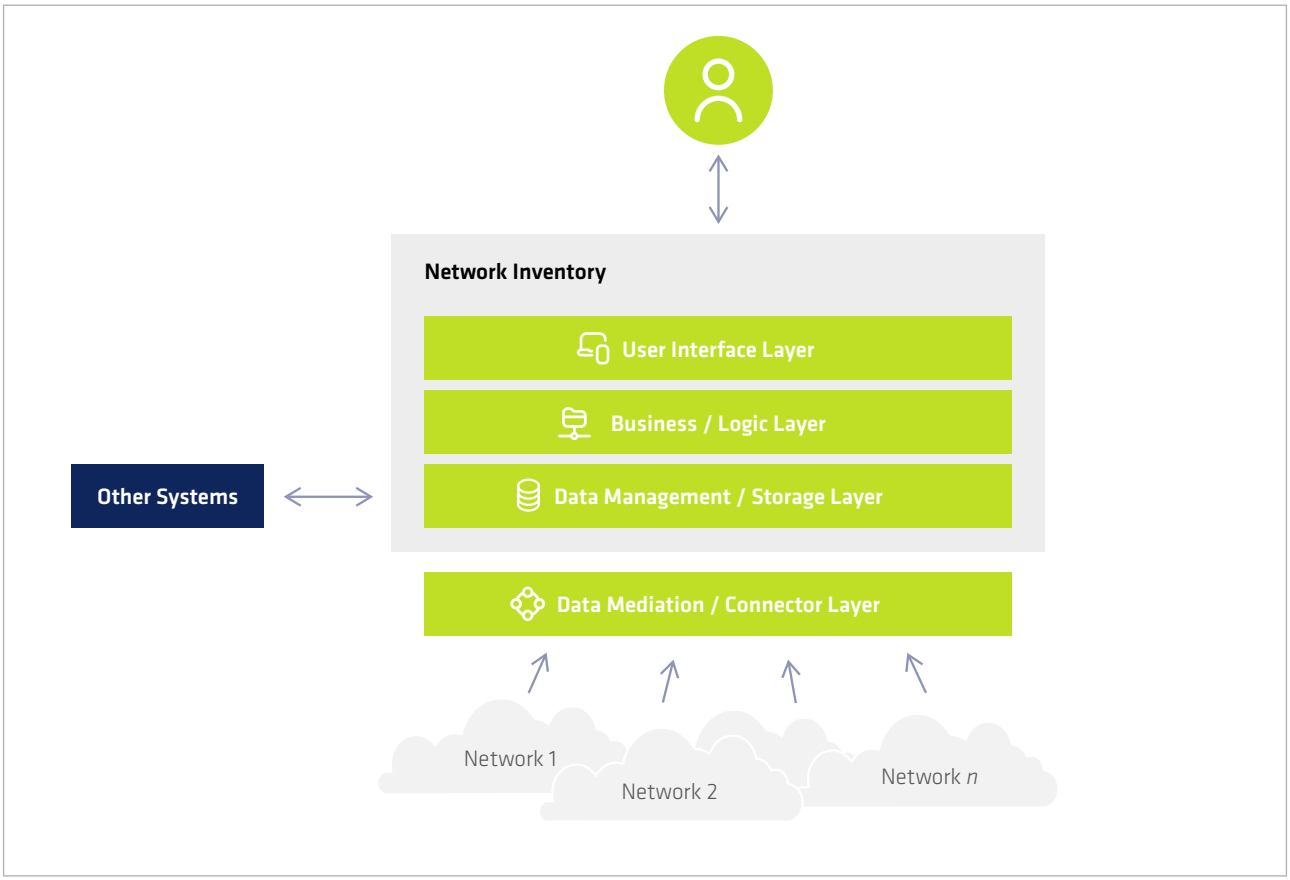
Resources and dependencies across different technologies are represented in a digital twin of the hybrid infrastructure.

Just like the many parts that make up a GPS solution (e.g., satellite, GPS receiver, mapping software, user-interface, etc.), there are many components of a network inventory solution that work together to provide users with accurate and reliable information about their network infrastructure.

The tools and components that make up network inventory solutions include data collection / transformation / integration / reconciliation, data management / repositories, data processing engines (where business rules and logic are applied), as well as the data visualization tools that are essential for workers to interact with the network inventory tools. Each of these components plays a critical role in ensuring the accuracy and reliability of network inventory data.

A High-Level Inventory Architecture

The simplified diagram below shows an example of the components that make up a working network inventory solution:



It makes sense to start from the bottom and work up in the diagram above, because ultimately the network inventory solution must reflect **the real network** (represented by the grey clouds). Often a network inventory solution must represent a collection of multiple networks, as per the example above, because a service provider's network generally consists of multiple different network domains and/or vendor products. A single customer service often traverses multiple different networks / domains and often relies on active, passive and overlay network infrastructure.

It's important to note that these networks aren't even necessarily constrained to just being communications networks. These could be power networks, which energize active assets (and are a common source of communications network outages due to planned or unplanned power outages).

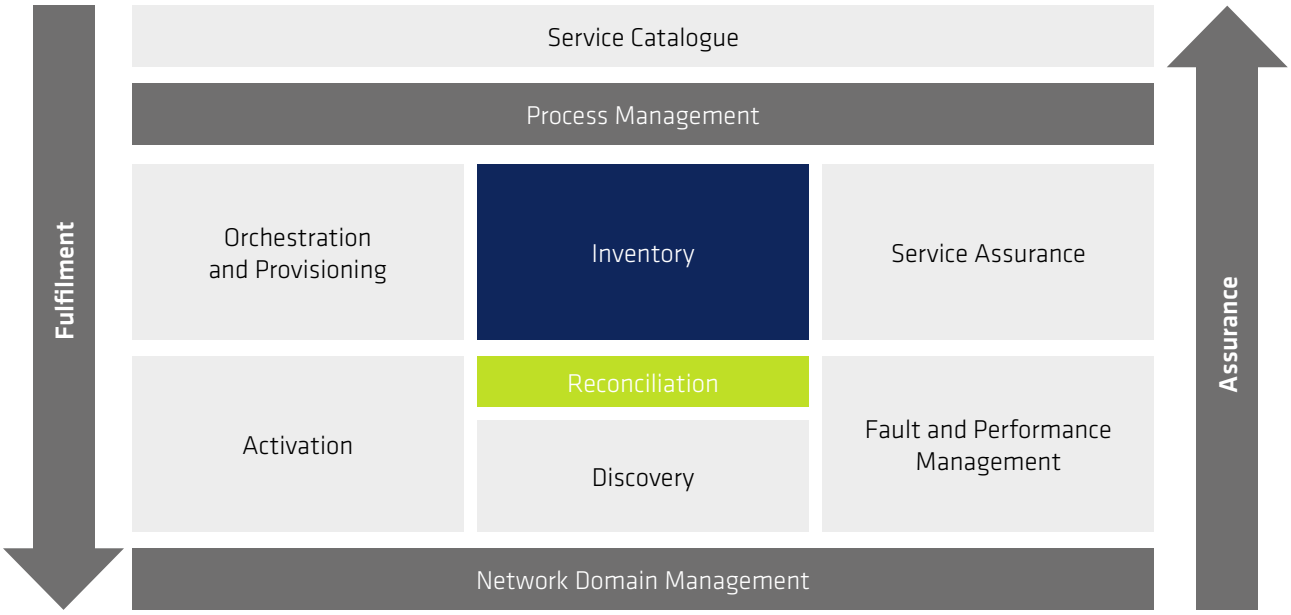
Data collection / mediation / connectors are the next crucial component of network inventory solutions. The solution must collect, reconcile and usually transform data from various sources. Data could come directly from the network, from Network Management Systems (NMS) / Element Management Systems (EMS), or even from other sources or systems. For multi-domain networks and multi-source systems, the inventory is also responsible for skillfully stitching disparate data sets together. This layer is also used to represent the APIs (Application Programming Interfaces) that allows consolidated inventory information to be shared with other systems. In some cases, the data mediation layer is considered to be part of the network inventory solution. In other solution architectures, it is considered to be separate. In the past, network inventory only needed to reconcile with the live network sporadically (e.g., once a day). In modern times, where services providers have software-centric networks that evolve dynamically, the mediation layer needs to be able to identify event-driven changes in the network immediately, as well as scale to any size of network and still perform at an optimal level.

The data management and storage layer is where the actual inventory data is stored. Network inventory solutions often utilize an off-the-shelf database management system to store, collate and cross-link data. One of the most important aspects of an inventory solution is the data model that's defined in the data management layer as this helps to determine how flexible and extendable the solution is. This is essential for modelling the many different types of networks and their various topologies, not just in today's networks, but to also deftly handle any future changes without requiring customization.

The **business or logic layer** determines how the data is interpreted, accessed and traversed. This often involves the use of algorithms and analytics tools to identify patterns, anomalies, and trends in the network data. The logic layer helps to query the data in the database and present it in a way that's more accessible for interpretation by a human or machine. For example, a specific query will perform impact analysis that alerts service providers to which customers will be impacted if a certain device or link becomes unavailable. This logic can be enacted either via a machine-based request (via the mediation layer / APIs) or via a human request (via the user interface).

The **user interface** (UI) is the most visible component of a network inventory solution. This is where a **user** (a service provider worker) interacts with a network inventory solution. The user interface must be deftly designed and user-friendly because it is responsible for visualization of complex information and presentation of insights. The method of information presentation may include dashboards, reports, maps, graphical asset visualization, tables and charts that provide service providers with valuable insights about their network infrastructure. It should allow the user to easily understand topologies and hierarchies within each network being managed, quickly identify issues and then make informed decisions. The user interface could be delivered via various different platforms, including desktop, tablet, phone or even video walls in network operations centers (NOC).

Finally, the user interactions and **workflows** (yellow arrows) allow service providers to interact with the network inventory solution. This includes some of a network operator's most critical workflows including network planning, troubleshooting, and service activation. It is the responsibility of the network inventory solution to ensure they operate efficiently and effectively, with minimal errors or fallouts. Note that the yellow arrows don't accurately represent just how sophisticated these workflows and data flows can be. The real workflows actually traverse many of the layers above.



Perhaps one of the most important workflows is **Network Discovery and Reconciliation (D&R)**. Discovery and Reconciliation is the engine that gathers and harmonizes the data that underpins network inventory solutions. It collects all of the data from all of the sources to provide a digital twin that reflects the real-world status of a service provider's network and infrastructure. Network discovery involves the use of various tools to scan and collect information about the network, including physical, logical and virtual devices, connections and topologies. Discovery depends on various layers of the network inventory solution described above including network, collection, data management and logic layers. It may also require input from external sources to enrich the data sets collected during the discovery process. Reconciliation is the process of confirming whether the gathered data matches with the inventory database. It identifies any changes or discrepancies. In many cases, the discovery and reconciliation of

passive network assets must be tackled differently (usually more manually) because passive infrastructure cannot programmatically communicate their information or status. Sophisticated passive network D&R tends to be managed as a closed-loop lifecycle from planning, to roll-out, to handover to documentation (and even through the warehouse for repairs and replacement).

End-to-end data processing is a key component of network inventory solutions, as it involves converting raw data into actionable insights. Each inventory solution uses algorithmic approaches to automate tasks as much as possible, allowing humans to focus on tasks that aren't suited to being automated.

Although not shown specifically in the diagram above, because it traverses all components, the accuracy and security of data is of utmost importance. In the same way that fast and accurate GPS data guides a person to their desired destination as optimally as possible, network inventory solutions provide service providers with the information they need to manage their network infrastructure quickly and effectively.

Limitations of Legacy Inventory Solutions

Legacy network inventory management solutions often present challenges and limitations for service providers. Network management, like map-based navigation, is much more labor-intensive, error-prone, and inefficient without modern systems. Some providers may even be familiar with managing their network assets using spreadsheets or home-grown database. This approach invariably requires more manual intervention, which can remain viable when networks are small and simple. However, as networks get larger and more sophisticated, the need for off the shelf inventory solutions becomes more apparent.

As described in the "Inventory Challenges" section earlier, common limitations experienced with legacy inventory management solutions include:

- **Flexibility and functionality gaps** – as networks become more sophisticated, many traditional inventory solutions are unable to adapt to networks that have fundamentally changed in nature (e.g., programmable, or software-defined networking [SDN]). Traditional inventory solutions were often developed before virtualization was even imagined and aren't flexible enough to adapt today. Sophisticated, flexible solutions only require configuration rather than customization, even for vastly different models like network virtualization.

- **Speed and adaptability** – networks of the past were relatively static in their configurations. Modern networks are far more adaptive, often changing automatically in response to evolving conditions in the network. Since other solutions, such as network assurance and customer activations rely on accurate inventory / resource information, it means that inventory must now collect and manage network inventory far more dynamically than in the past.

- **Security and privacy** – following many high-profile breaches of infrastructure and systems in recent times, service providers have become far more aware of the importance of security and privacy of their network and customer data. Far greater protection measures are now expected of network inventory solutions because they contain such valuable operational and customer data.

- **Assisted workflows and automation** – legacy inventory solutions were designed to be manually operated across most workflows. Service providers now expect systems that are far more autonomous (fully or semi-automated) to improve operational efficiency, accuracy and performance. The performance of legacy network inventory systems can be likened to the days prior to GPS, where drivers fumbled around with multi-page street maps as they tried to navigate across the city, causing accidents from looking down at the maps and taking sub-optimal routes. Modern network inventory solutions are far better at providing heads-up awareness across all the different domains that comprise the complete network infrastructure and its current status.

In addition, one of the biggest challenges faced by service providers with legacy inventory solutions is transformation. Operators know that they can't just make incremental improvements to their solutions. Iterative improvements are unlikely to be enough to address the fundamentally changed environments that service providers now face. Like the transition from analog street maps to digital GPS navigation, a new way of thinking and approach is required to modernize network inventory management in the virtualized age.

What's Needed

As our society becomes increasingly connected and reliant on flawless communications technologies, the role of service providers and network operators is paramount. Much like GPS systems have transformed navigation, dynamic network inventory solutions are in the process of revolutionizing the management of communications network resources. Not only do they provide a comprehensive and real-time view of the networks, but they also facilitate efficient operations from asset management to service delivery, assurance, and planning. Without these sophisticated solutions and the automations they support, we risk inefficiency, increased operational costs and potential service disruption. Within this context, the importance of robust, reliable network inventory solutions can't be underestimated.

Thank you for reading our white paper on the importance of modern network inventory solutions for service providers and network operators. To continue the conversation about modern network inventory management, we encourage you to read our white paper **Network Inventory Management Software**. It picks up where this paper leaves off with a discussion of the features of a modern inventory solution, concrete examples of how they are being used and the benefits they deliver.

At FNT Software, we understand the challenges that service providers face in managing their network inventory, and we have the expertise and solutions to help. **Contact us** directly to learn more about our services and how we can help.

About FNT

FNT is a leading provider of software solutions for the integrated management of telecommunications, IT and data center infrastructure. FNT's solutions are cloud ready and can be used worldwide as an OSS/IT management application for communications service providers, enterprises, and government organizations. Over 500 companies and public authorities rely on FNT to plan, document and manage their passive and active physical, logical and virtual IT, telecommunications, and data center infrastructures, from the physical level to business services. FNT's unified resource management capabilities store this information in a vendor-agnostic uniform data model that builds a central system of record of a hybrid infrastructure. Whatever mixture of traditional on-premise IT and private, managed and public clouds an organization uses, the single source of information about all network assets that FNT provides is the key to gaining a clear understanding of overall utilization, capacities and asset status for more efficient planning, service assurance and fulfillment processes.

FNT is headquartered in Germany and has offices in several locations in Germany as well as in New York, London, Singapore, and Timisoara. FNT offers its software in numerous countries through partnerships with market-leading IT service providers and system integrators.

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