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Independent market research and competitive analysis of next-generation business and technology solutions for service providers and vendors

The Key Role Resource Management Plays in 5G

A Heavy Reading white paper produced for FNT

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INTRODUCTION

Operators globally are investing tens of billions of dollars in 5G networks and spectrum and have great expectations for future revenue opportunities enabled by the technology. Omdia research forecasts that global 5G services revenue will grow to $540.1bn by 2026. The potential of the technology extends well beyond the mobile industry itself, as 5G is set to become a critical component of the digital economy and the next generation of industrial technology, Industry 4.0. 5G itself needs a set of enabling technologies, including network slicing, automation, and virtualization. Much less covered, however, is the role of resource management in 5G.

This white paper focuses specifically on the role of unified resource management in successful 5G strategies. It describes a set of key characteristics for 5G networks and details how unified resource management is important for each. The paper concludes with the key details to seek in resource management in a 5G environment.

THE 5G ERA AND BEYOND

5G mobile service revenue is set for rapid growth over the coming few years, driven by the rapid adoption of 5G devices and higher spending by 5G customers as they increase their usage of data and digital services. 5G accounted for just 0.7% of global mobile services revenue in 2019, the year in which the technology was launched globally. Omdia forecasts that annual 5G mobile services revenue will reach $540.1bn worldwide and account for 59.2% of global mobile services revenue in 2026.

Clearly, 5G is essential for mobile network operators. However, the benefits that 5G is expected to deliver reach far beyond the mobile network operators (MNOs) themselves as 5G becomes one of the key foundational technologies underpinning the global digital economy and Industry 4.0.

The potential impacts and opportunities globally are massive. Worldwide, the digital economy improves economic and societal outcomes and serves as a source for innovation and productivity growth. The United Nations cites a range from 4.5% to 15.5% of global GDP for the digital economy, or $4tn to $13.6tn in 2019 (based on 2019 global GDP of $87.8tn). Industry 4.0 (commonly called the Fourth Industrial Revolution) is set to merge new information and communications technology (ICT) with traditional manufacturing and industrial practices to usher in a new era of unprecedented and global industrial advancement. The World Economic Forum estimates that Industry 4.0 will collectively drive $100tn in economic value globally through 2025.

The new digital economy and Industry 4.0 share common ICT enablers and will be built largely—but not exclusively—around mobility, including Internet of Things (IoT)/machine-to-machine, cloud, artificial intelligence (AI), and 5G. **Figure 1** shows Omdia forecasts across several IoT and 5G growth areas.

Figure 1: IoT and 5G growth expectations (in $m)

	2019	2024	CAGR 2019–24
Global IoT devices	10,809	25,441	18.7%
Global Industrial IoT devices	1,116	2,181	14.3%
Global smart home devices	2,349	8,564	29.5%
Global 5G mobile subscriptions	20	2,027	151.9%

Source: Omdia, 2020

CHARACTERISTICS OF 5G NETWORKS

New sites – small cells

While the number of macro cell sites held steady through the mid-2000s, 5G is accelerating a trend in cell site additions. An accurate global picture is difficult to obtain currently, but US industry group CTIA states that 68,000 new outdoor cells sites were added in the US from 2018 to 2020, a number that is greater than the total of all new cell sites in the US between 2011 and 2018 combined.

The additions are coming from cell site densification initiatives, which are primarily based on small cells. As opposed to traditional macro tower sites, small cells are designed to be small and lightweight for deployment on streetlights, utility poles, and sides of buildings.

Small cell densification is required because 5G high band spectrum (also called millimeter spectrum, or mmWave) that delivers gigabit fixed and mobile broadband data rates comes with limitations on transmission distances. Whereas sub-6 GHz mid-band spectrum can cover distances measured in kilometers, mmWave spectrum is limited to hundreds of meters only. Thus, communications service providers (CSPs) investing in mmWave spectrum must also invest in small cells.

The result is that many more cell sites are required to reach customers. And the new mmWave sites that are being built are of the small cell variety—they are not macros. Verizon is one very good example of an operator that has aligned its mmWave strategy with small cells. It targeted 14,000 new cell sites in 2021 and announced in December that it had exceeded that target.

Site acquisition and the rollout of equipment, cables, and site connectivity are major tasks for MNOs that need to be handled properly from a resource management perspective, as discussed later.

Open and multi-vendor

In mobile networks today, interoperability is common in the air interface, where standards-compliant mobile devices can operate over many operator networks, but the RAN has historically remained closed and proprietary. With 5G, however, there is significant interest among operators globally to open the RAN to enable interoperability among components, subsystems, and software sourced from multiple suppliers.

There are several key drivers for the open RAN trend, and Heavy Reading has researched this topic in detail over the past several years. At a high level, the key open RAN and interoperability drivers are the following:

- Break vendor-proprietary RAN lock-in
- Reduce network costs
- Offer new services and monetization opportunities
- Enable faster innovation with diverse ecosystem
- Enable RAN virtualization

Several industry groups have emerged to address the new requirements for open RANs, including the O-RAN Alliance, Telecom Infra Project (TIP), and 3GPP.

With the move to open RAN, CSPs face increasing challenges to manage resources in a multi-vendor environment.

Service automation and process-driven rollout management

Service automation and process-driven rollout management are mandates for network operators, which must adapt to communications in the 21st century or face extinction. As such, automation affects all aspects of network operators' businesses across technologies, business lines, and business functions. This includes migration to 5G, which will provide much of the technology and services underpinning for promising growth opportunities in IoT, healthcare, smart cities, Industry 4.0, automotive, and other use cases. Notably, the promise of automation extends to both internal benefits (such as reducing opex through automating tasks) and external benefits (such as faster time to market and new and differentiated revenue streams).

Heavy Reading survey data consistently shows that external (or revenue-generating) benefits take precedence over cost-savings measures. In 5G, this revenue-facing aspect of automation is best encapsulated in the concept of network slicing, which allows multiple virtual networks to be created on top of a common shared physical infrastructure. CSPs view network slicing as crucial for addressing the promising use cases referenced above while still maintaining a single physical infrastructure.

For any kind of automation, an up-to-date resource management database with accurate as-is and planning data is the foundation.

Hybrid: Virtual and physical

Both software-defined networking (SDN) and virtualization are strong trends in 5G. SDN is required to achieve control plane (CP) and user plane (UP) separation as defined in 5G architectures, and virtualization is needed to pool and share commercial off-the-shelf (COTS) hardware resources across multiple RAN functions, such as virtual DUs and virtual CUs. However, as virtual networks multiply, physical networks do not simply disappear. Rather, virtualization results in the creation of hybrid 5G networks consisting of both virtual and physical resources.

First, while virtualization is mainstream in the mobile core, it is not yet dominant in other segments of the mobile network (such as the RAN). Second, even with widespread virtualization, there will always be physical assets in the network, such as Layer 1 elements (e.g., remote units, or RUs) and physical ducts, fibers, facilities, etc.

The resulting complex hybrid networks include the following resources:

- **Physical resources:** Antennas, radio units (RUs), and other 5G physical equipment on mobile sites
- **DC infrastructure:** Edge data center floor plans, racks, and power and cooling devices
- **Logical telco resources:** Fronthaul, midhaul, and backhaul transmission links
- **Logical IT resources:** Servers, server clusters, platforms, and storage
- **Virtual resources:** Clouds, virtual machines, containers, virtualized baseband equipment, and multi-access edge computing (MEC) applications
- **Resource-facing services:** Network slices for IoT and augmented reality

The cross-domain and multi-technology management of physical, logical, and virtual resources is a precondition for efficient 5G network rollout and operations.

Mergers and acquisitions

Mergers and acquisitions have always been an integral part of the communications industry, and the pace is accelerating as service providers jockey for leadership positions within the complex global ecosystem that 5G is creating. In addition to CSPs, the 5G ecosystem includes tower companies, fiber infrastructure providers, cloud providers, and data center real estate companies (with an increasing focus on edge locations).

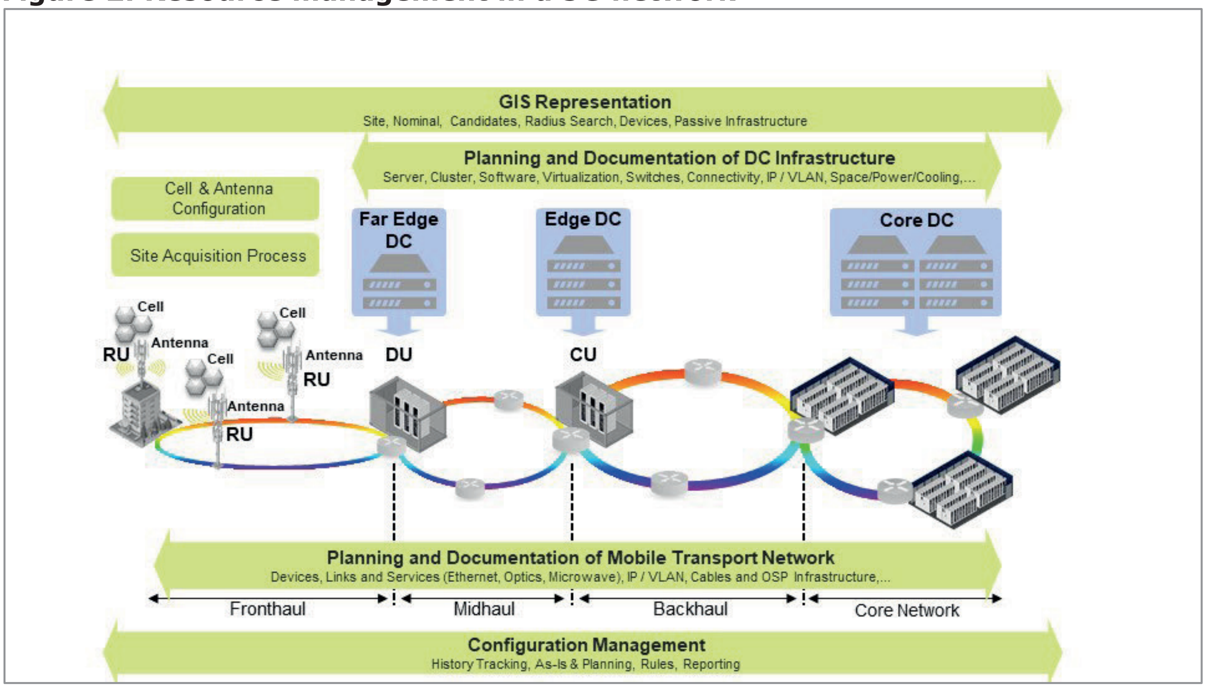
After the deals are signed, the hard work of merging disparate networks and assets begins—and this includes different networks, physical buildings, vendors, technologies, and business/ operations support systems (B/OSS). In many cases, the merging entities are themselves merged entities that have not fully completed previous network integrations, which can take many years.

For the merger of resource data bases, downtimes during the migration of the systems are a critical aspect. Zero downtime migration processes must be the target to simplify and speed up companies' integration.

THE ROLE OF RESOURCE MANAGEMENT IN 5G NETWORKS

Inventory resource management is a broad term, and different types of networks—data center provider, broadband service provider, mobile operator, and enterprise—have different types of inventories and different characteristics. **Figure 2** shows the various domains in an end-to-end 5G network and identifies the relevant areas of resource management associated with each domain.

Figure 2: Resource management in a 5G network



Source: FNT, 2022

Creating the foundation

Resource management is a fundamental network task that, despite its importance, does not get sufficient industry attention. However, one critical element that all the 5G requirements identified in the previous section have in common is that resource management can make or break them. Resource management truly is the foundation on which the 5G network is built.

Below, Heavy Reading discusses several of the 5G network requirements and the key role of inventory resource management in each.

New sites

Operators need to accurately document the thousands of new sites that are being added to the network. This includes all documentation for the active infrastructure (RRUs, BBUs, switches, etc.), as well as the passive infrastructure associated with the cell sites (cabling, ducts, batteries, etc.). Resource management can also play a critical role in the site acquisition process. It begins when a new site is needed in an area but the physical position is not known. The first step is selecting possible candidate sites, and then purchase and rental information is collected for each. Candidate sites can be documented, geographically mapped, and analyzed in combination with existing inventory as well as other parameters, such as location conditions for power, climate, radiation, or even contractual topics. When a site is finally chosen, the data can be moved from a planned status into the as-is status in the inventory database.

Orchestration and automation

A successful automation strategy requires accurate and consistent inventory data that is linked to the higher layer management and orchestration systems that are configuring, turning up, provisioning, restoring, and implementing any other automated functions in the network. The inventory data must also be unified across domains and dynamically updated by the active network wherever possible. Inventory inaccuracies and gaps are a long-standing (though seldom publicly discussed) problem within CSPs. A common theme among leading CSPs that have adopted automation strategies is that accurate and unified inventory management is a prerequisite. Often, the first use case for automation is on the inventory data collection process itself (e.g., using telemetry).

Besides the active network resources, the passive network infrastructure and site data must also be kept up to date. Process-driven rollout automation and change handling ensure the high quality of all planned and documented passive infrastructure and site data.

Multi-vendor and hybrid networks

Breaking vendor lock-in and increasing the diversity of suppliers are two of the main drivers for moving to open networks—including open 5G RAN and open 5G transport. While increasing the number of suppliers provides pricing power in contract negotiations and helps accelerate innovation, it also complicates things on the operations side. Each vendor comes with its own element management system (EMS) and network management system (NMS) specific to its own product lines. In these complex, multi-vendor networks, a "single source of truth" database is needed for all of the network assets and supporting the basic processes in network operations. Other network systems, such as OSS and orchestration, then draw from this unified and accurate database when performing their own functions.

Likewise, the same principles hold true for hybrid networks consisting of both physical and virtualized network domains. CSPs need to see all the dependencies between active physical, logical, and virtual resources, as well as the passive infrastructure, such as cabling. A single source of truth database is essential.

Mergers and acquisitions

Historically, merging operator inventory systems has been a manual process. In essence, a merger serves as a catalyst for a network migration that must take place. Automated, real-time network discovery across domains provides major benefits in these scenarios, including the following:

- **Greater accuracy:** Accurate inventory systems reduce outages caused by merging networks as well as during future failovers. They also increase confidence on both sides of the merger to move forward.
- **Greater speed:** The faster migrations can be completed, the quicker cost savings can be achieved and new services can be introduced. Whether public or private, investors will closely monitor the speed with which merger goals are achieved.

- **Lower costs:** Eliminating redundant networks and processes as quickly as possible is a top priority among C-level executives, as the opex and capex drain reduces top-line and bottom-line revenue and delays financial goals. Additionally, service disruptions caused by inventory inaccuracies and manual errors in migrations can result in lost customers and bad publicity at a vulnerable time when competitors are hypervigilant.

The merger of companies typically results in resource management systems being consolidated and migrated to one single system. Reducing downtimes during migration is critical for network planning and operations. Therefore, zero downtime migration approaches must be applied during the transition phase.

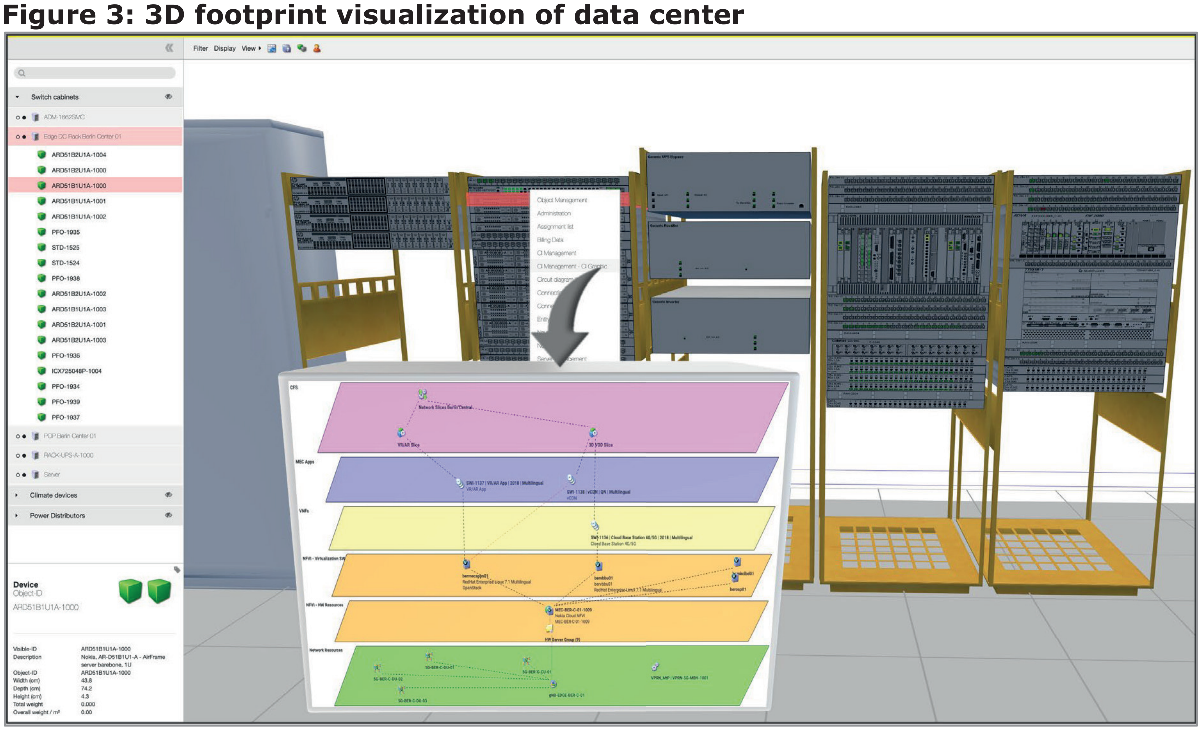
HOW TO MANAGE RESOURCES IN A 5G ENVIRONMENT

The digital twin concept is growing in popularity among IT and communications, with AT&T, BT, Orange, Telefónica, and Verizon among the many CSPs promoting the benefits of digital twin—both for internal operations and externally for their enterprise customers.

A digital twin is a virtual representation that serves as the real-time digital counterpart of a physical object or process. For CSPs, central offices and data centers, cell towers, network elements, physical and logical connections and services, configuration parameters, and more are all components of a digital twin model for the physical, logical, and virtual network.

Figure 3 is an example of what a digital twin looks like for network resources.

Figure 3: 3D footprint visualization of data center



Source: FNT, 2022

Below, Heavy Reading provides detail on what to look for when building a digital twin of the network.

Automated data reconciliation

Key to the digital twin concept is that it is a *real-time* digital replica of the network. A true digital twin for the physical, logical, and virtual network must be synchronized with the original so that changes in the network are quickly reflected in the digital representation (or model). Automated tools are required to interact regularly with active resources to obtain the current state and parameters and update the database regularly. The vendor must have broad and deep integration across suppliers, including both physical and virtual elements. This means extensive component libraries that have likely been built out over many years.

A precise definition of "near-real time" for the network digital twin is still to be determined. Registering minutes-level changes may be important for higher layer control and orchestration functions but are likely disruptive at the inventory database level that is the focus of this paper. This database serves as the history record of the network.

In the past, CSPs typically applied one full reconciliation per day. With a higher dynamic in 5G networks, there is a need to increase the reconciliation frequency. According to resource management supplier FNT, one full reconciliation per day is still recommended to prevent discrepancies. But event-driven reconciliation is the way to synchronize deltas in near-real time and to comply with the higher dynamic needs.

Even with automated data reconciliation, there will always be limitations to the dynamic database because passive network infrastructure simply cannot be updated through automation. Passive network infrastructure includes fibers, cabling ducts, buildings, street furniture, and anything else that exists "offline." Fortunately, passive elements are not dynamic in nature, but they do need to be tracked and updated with accuracy.

Unified end-to-end view

A complete, end-to-end network resource repository is required for the database to fulfill its function as the single source of truth in the network. As illustrated in **Figure 2**, the 5G network consists of many domains, technologies, sites, and suppliers. The network includes active and passive and physical, virtual, and logical resources. Unified resource management provides a holistic view to manage the different operational processes.

Although historically static, vendor EMS and NMS are increasingly adding levels of automation (sometimes being rebranded as "controllers" in the process). However, even with automation, these element and network management systems remain vendor-specific; therefore, they cannot provide the required end-to-end view. Third-party vendors are moving to fill this end-to-end management void, but here too, CSPs must be careful in their selection. Emerging suppliers specializing in resource management for virtual resources may ignore the hybrid physical and virtual reality that will exist for the vast majority of CSPs for many years to come.

Integration with higher layer control and orchestration

As noted earlier, a unified resource database is a prerequisite for the rollout of automation and orchestration use cases in the network, whether it is on the physical equipment rollout level, a logical connectivity layer, or a virtualized 5G network (including network slicing). SDN control and orchestration systems (and other IT systems) draw on data stored in the unified database to perform provisioning, activation, and other automated functions. Thus, tight integration between the database and multiple control/orchestration systems, using open REST APIs, for example, is crucial.

Northbound data sharing can be implemented on an event-driven basis. This means the digital twin shares its data with other orchestrators and OSS/BSS in near-real time.

Complex visualization

Lastly, a full network database is extremely complex, with a single cell site having thousands of configuration parameters, for example. Automated orchestration systems may be able to quickly glean network data on-demand, but the database must also be usable by human operators. A graphical user interface (GUI) interface is ideal, with complex visualization of the entire network—from the physical building layout down to the individual equipment port level, along with logical and virtual network resources. GUI representation at the vendor EMS/NMS level has been standard for many years, but the new requirement is for a single, unified user interface for everything in the network. The digital twin shown in **Figure 3** is an example of this type of visualization in a complex network.

CONCLUSION

Unified resource management is the common foundation on which an end-to-end 5G network is built. It plays a make-or-break role in activities and functions, including cell site acquisition, merger and acquisition integration, orchestration and automation, network slicing, and multi-vendor and multi-technology hybrid networks, among others. Unified resource management is also essential for creating a digital twin replica of the hybrid network.

In building out a successful unified resource management strategy for 5G, Heavy Reading recommends the following:

- Near-real-time synchronization between the database and all active network resources to maintain the highest level of accuracy at all times.
- A common end-to-end repository covering active and all passive infrastructure and physical, virtual, and logical resources.
- A variety of open interfaces for integration with higher layer management, control, and orchestration systems that interact with—and make decisions based on—the unified database foundation.
- A high level of configuration options to support customer-specific data and processes and to prevent vendor-lock-in.