WHITE PAPER

Data Analytics Will Drive 5G

Develop an end-to-end data analytics strategy for 5G networks

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Introduction

This paper discusses the critical importance of having a scalable, open, flexible and end-to-end Network Data Analytics strategy to deliver on the 5G promise for all industries and societies.

Whilst telecommunications companies already make extensive use of network analytics to deliver value to their business, 5G represents an opportunity for a significant step-change in when, how and why analytics are used. Unlike previous generations, today's analytics form an integral part of the core definition of 5G and will play a crucial role in the design and operation of networks. In addition, they should also inform fundamental decisions as to what markets telcos choose to enter, and how they can win in those they select.

5G remains in its infancy, with experimentation ongoing to find the markets, business models and network deployments that work. Using analytics in a different way will create new answers that accelerate successful experimentation and deliver commercial advantage.

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Network Analytics before 5G

Many of the world's top telecommunications companies and mobile network operators already deploy network analytics to achieve significant business benefits across a variety of use cases:

- **Customer Services and Customer Care:** proactive customer retention activities, increased understanding of customer complaints, dynamic fault finding and resolution.
- **Sales and Marketing:** understanding customer usage behavior and individual experiences, churn model enhancement, real-time event-based triggers and alarms, next best offers and promotional activities, handset and device profiling, retention/ compensation offers.
- **Finance:** revenue assurance and revenue intelligence, fraud detection and prevention, multi-dimensional profitability.
- **Networks and Technology:** prioritizing rollout/ investment planning and maintenance, performance and optimization, service performance assurance and roaming/interconnect assurance.

However, after years of anticipation, 5G networks are now going live around the world with the promise to unlock a tremendous amount of new business opportunities for telcos. Network analytics promise to play a significant role not only in the design, build and operation of complex 5G networks, but in opening doors to the crucial new revenue streams that operators are seeking.

What Makes 5G Different?

Significantly faster, and with higher capacity and lower latency than previous 4G LTE networks, 5G is expected to be more than just a better pipe. It represents a purpose-built technology, designed and engineered to facilitate connected devices as well as automated systems. 5G will facilitate and accelerate the next industrial revolution, often referred to as Industry 4.0. Applications ranging from industrial automation, tactile internet, robotics, AR/VR, telemedicine and immersive learning could all ride on enhanced 5G networks as illustrated in figures 1 and 2.

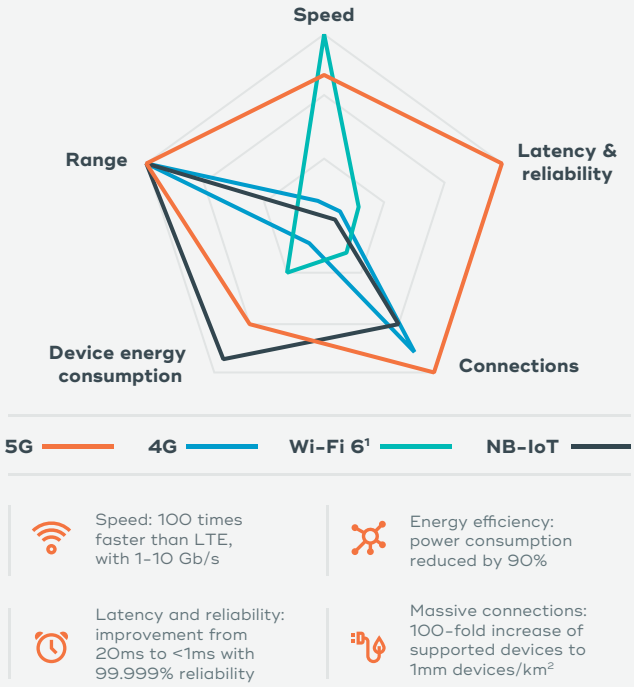

Figure 1: McKinsey analysis

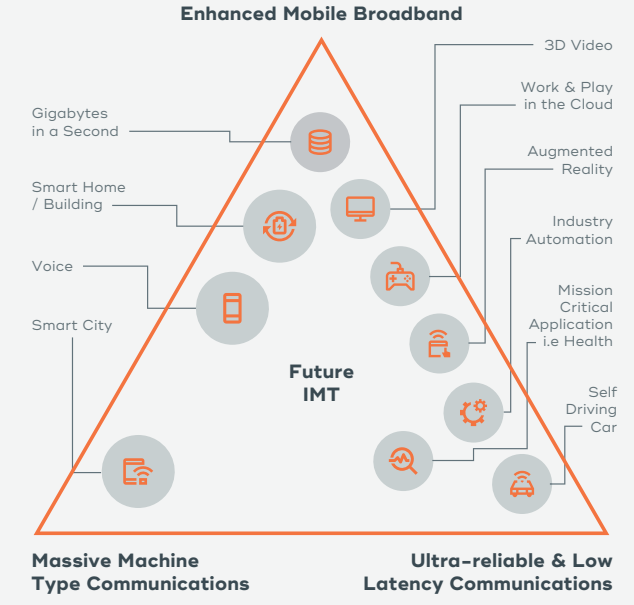

Figure 2: 5G application use cases / drivers

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These transitions to 5G require changes to the network architecture and infrastructure of telecommunication companies and service providers. A more distributed architecture is required with an increasing role for telco Multi-access Edge Computing (MEC). This will provide compute, storage and analytical services closer to the source of data to reduce backhaul traffic volumes and costs to enable very low latency.

Granular and robust network analytics will be required to help design the next generation of network topologies. These must support both the technical and the business architectures enabled and demanded by 5G. They will also help operators define the markets and services in which they can create value – see figure 3.

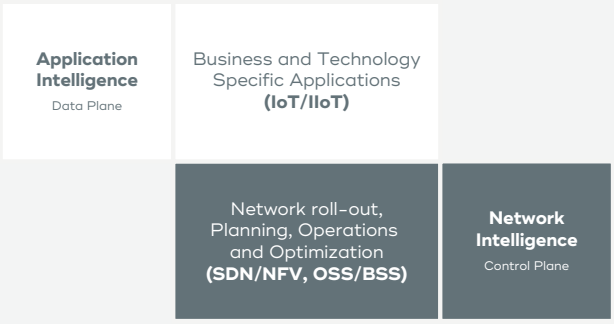

Figure 4: Source IEEE 5G

The role of Network Data Analytics in 5G

It is widely accepted that network data analytics is a key enabler for 5G cellular networks.

Telecommunication standard bodies in charge of defining 5G (i.e. 3GPP, ETSI) have created standards for network analytics. These will improve the performance of mechanisms ranging from network management and traffic engineering to radio access network selection and traffic steering.

As illustrated in figure 4, data analytics will play a dual role in this context. On one hand, it should continue to support business and technology specific applications and use cases over 5G – so called application intelligence. On the other, with "network intelligence," data analytics will play a critical role in the roll-out of 5G and network operations – where key components of an E2E Network Analytics Framework for core and RAN networks are required.

5G and its attributes enable a more open approach to network design, build and operations. Openness to build a more cost effective and agile RAN through open interfaces, open hardware and open source; and Intelligence to meet the requirements for increasingly complex, denser and richer networks through deep learning techniques and embedded intelligence (AI, ML) in every layer of the RAN architecture.

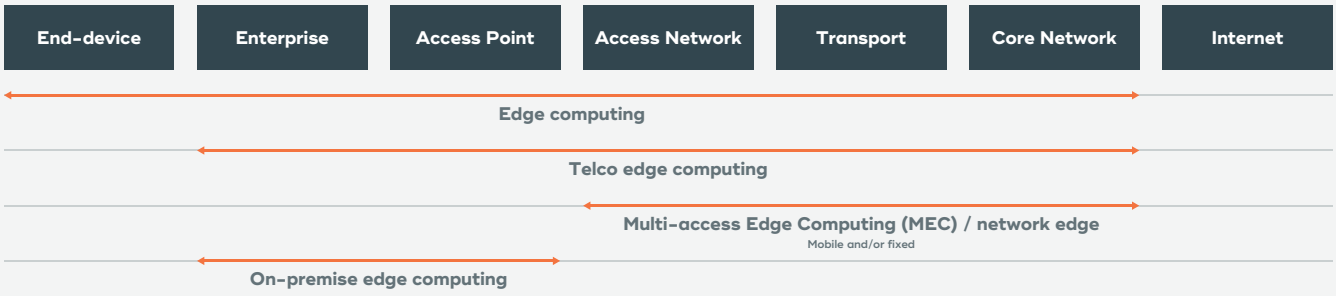

Figure 3: STL Partners-Edge computing simplified

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Defined in 3GPP TS 29.520 and further releases, Network Data Analytics Function (NWDAF) incorporates standard interfaces from the service-based architecture to collect data by subscription or a request model from other network functions and similar procedures to deliver analytics functions in the network for automation and reporting.

NWDAF is defined as a distributed architecture providing analytics at the edge and at the center. The central function for analytics (including AI and ML) needs central storage, aggregation and analysis to support a large variety of use cases. See figures 5 and 6.

The network should rely on network data analytics capabilities to continually collect data from the various network functions involved to provide 5G connectivity services and beyond. These capabilities should provide insights back to the network functions and the operator's Business Service Systems and Operational Support Systems (BSS/OSS).

Network slicing is a key opportunity enabled by 5G. By providing the ability to run multipule logical end-to-end networks on a common shared infrastructure, operators can offer multiple networks each tailored to individual customer needs. However, network data analtyics is needed to help monitor service quality and react to any network degradations. By providing failure detection, prediction and monitoring, the network can be automatically sliced for performance and resources can be adjusted to make sure the agreed SLA is delivered.

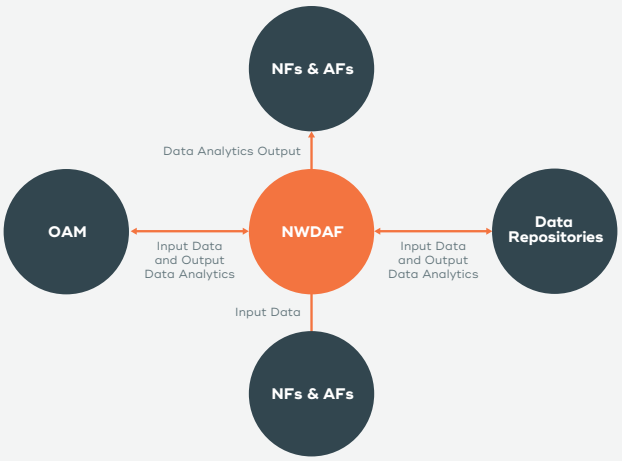

Figure 5: Network Data Analytics Function (3GPP TS 29,520)

Examples of network data analytics use cases for 5G supported by the NWDAF and defined by 3GPP (TR 23.791):

- Load-level computation and prediction for a network slice instance

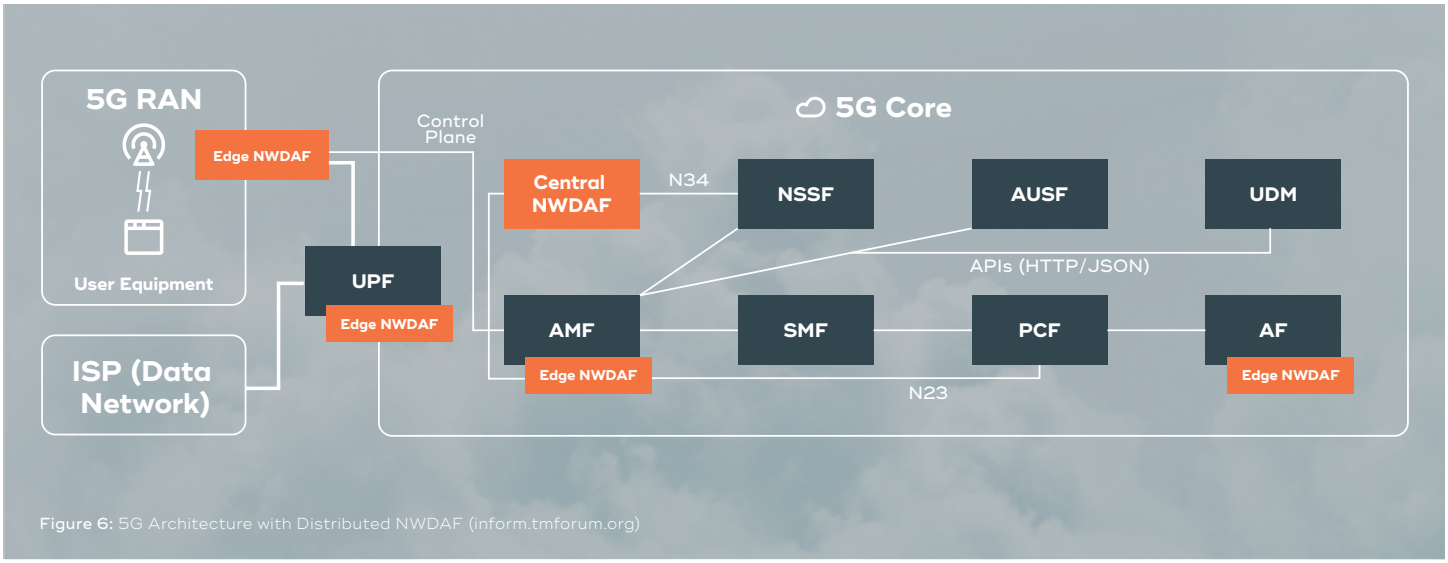

Figure 6: 5G Architecture with Distributed NWDAF (inform.tmforum.org)

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- Service experience computation and prediction for an application/User Equipment (UE) group
- Load analytics information and prediction for a specific Network Function (NF)
- Network load performance computation and future load prediction
- UE Expected behavior prediction
- UE Abnormal behavior/anomaly detection
- UE Mobility-related information and prediction
- UE Communication pattern prediction
- Congestion information – current and predicted for a specific location
- Quality of Service (QoS) sustainability that involves reporting and predicting QoS change.

Telco and cross-industry data analytics use cases are evolving from centralized towards real-time, distributed and interconnected analytics. The 5G architecture and ecosystem need to include a scalable data analytics platform able to unify and orchestrate analytics across all vertical applications, BSS and OAM layers in order to manage E2E services and their respective SLAs.

5G is also a cloudification accelerator of telco networks. To facilitate network traffic from billions of connected nodes, and the coming wave of new compute-intensive 5G applications, networks must transform to be able to deliver faster speeds, lower latency, and more capacity.

Cloudification will enable network operators to innovate with new and enhanced services. Using cloud platforms, technologies, and virtualization capabilities throughout a communications network, they will be able to make it more agile, flexible and scalable.

Data analytics platforms for 5G must offer a modern cloud data architecture. It must support real-time operations and orchestration, including native integration with data lakes and third-party services, plus agile analytics development and operation processes. Easy adaptation to telco IT and cloud/hybrid cloud architecture, with support for hybrid multi-cloud and multi MEC, will be also mandatory.

Data Analytics for Experimentation

5G can enable a large variety of use cases in many different domains, functions, and industries. Telcos must capitalize on this opportunity to expand not only their footprint, but the range of services and lines of revenue they can offer. The market opportunity for 5G has been valued at $4.7trillion, however it is expected that only around 30% of this relates to pure connectivity (see figure 7). The bigger slice is around new industry use cases.

However, many of the use cases likely to be supported by 5G remain untested, or even un-envisaged – we remain at the very early stages of exploring the potential

2025 Market Size Projections, $B

Of 4.7trillion of revenue related to 5G by 2025, about 30% will be related to connectivity

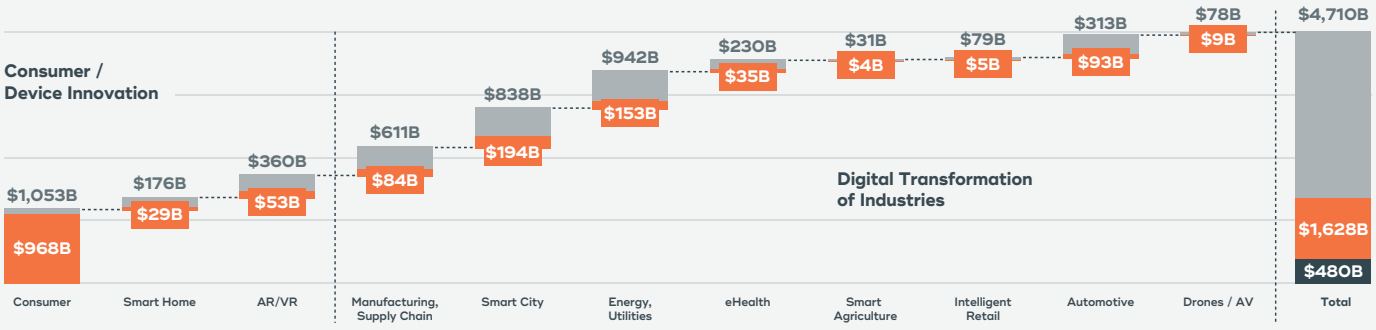

Figure 7: Harvard Business school & Keystone research and analysis

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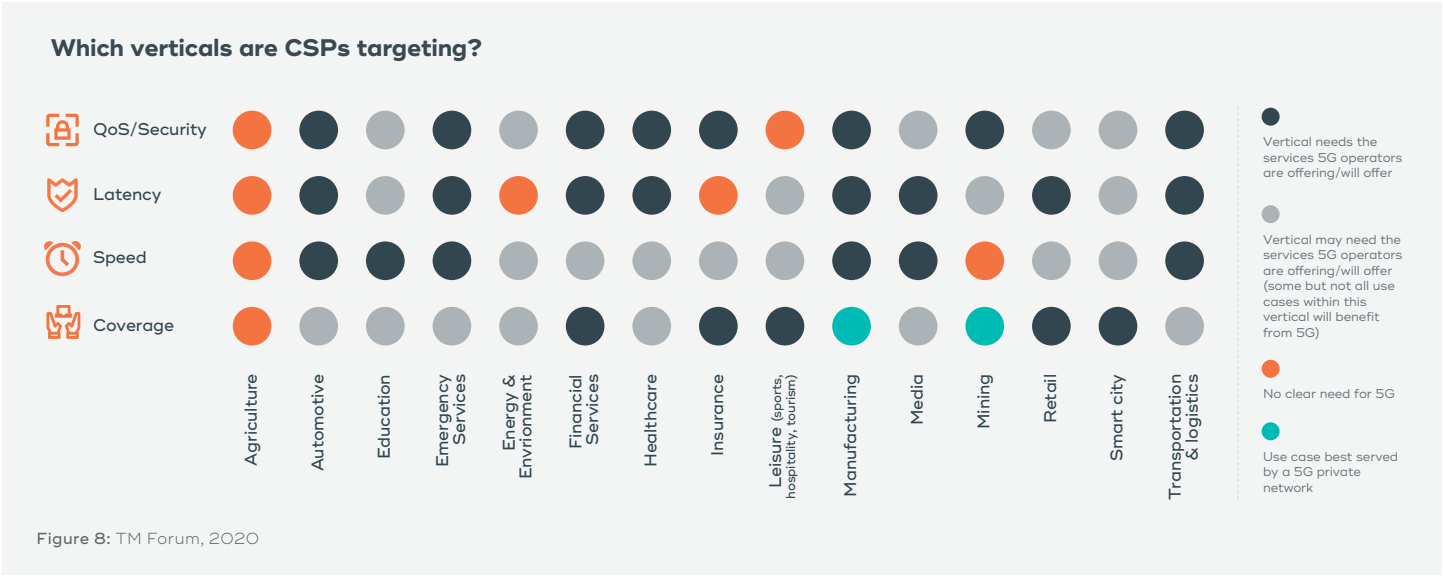

Figure 8: TM Forum, 2020

The challenge for operators is to decide where and when to invest to maximize their return on the enormous capital expenditure of the 5G network rollout. Analytics has a crucial, but to-date underutilized, role in shaping this future. As Figure 8 illustrates, communications service providers are targeting a wide range of adjacent markets for 5G services. rollout. Analytics has a crucial, but to-date underutilized, role in shaping this future. As Figure 8 illustrates, communications service providers are targeting a wide range of adjacent markets for 5G services.

Traditional B2B use cases commonly linked to Industry 4.0 applications driven by 5G include:

- Autonomous systems in factories, such as robotics, Automated Guided Vehicles (AGVs), computer vision, automated or virtual reality tools for manufacturing
- Smart cities, with applications such as HD cameras to monitor safety or advanced sensors for environmental monitoring
- Smart energy, such as smart grid control (monitoring of microgeneration sites)
- Connected offices, including sensor-based building management
- Smart security, including provision of emergency services
- Connected health, such as mobile medical monitoring
- Smart retail such as personalized experiences, payments, autonomous stores

Private networks

One new use case is already beginning to stand out as both an opportunity and a threat to telecommunications service providers. With the advent of 5G, industrial companies are becoming more interested in managing their own private networks. These networks satisfy stringent data security requirements while simultaneously providing great reliability, performance, and coverage.

Using network data to help identify potential customers, and define and deploy tailored network services, will help telcos deliver private networks that meet specialized demands. Before 5G, these types of networks were mainly used by public safety organizations. Now they can be offered to ports, airports, factories or any kind of campus requiring high security, reliability and massive machine connectivity.

Regulators in countries like Germany have already assigned over 70 licences to applicants, including BMW, for deploying private/campus 5G networks. Many other companies in different geographies will follow the same strategy. However, it is important to underline that there

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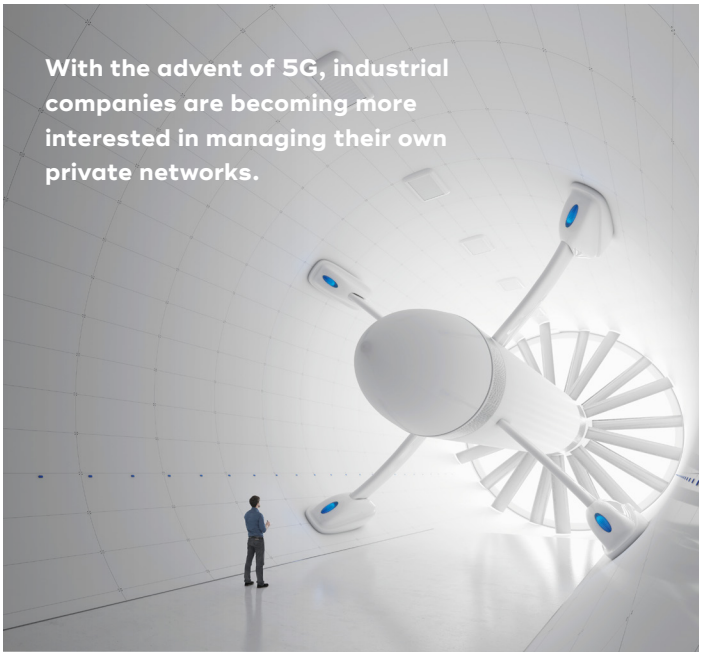
are four different types of 5G private networks which can be considered by companies depending on their business requirements and priorities:

1. Independent networks for special needs (security, reliability) and large-scale operations
2. Shared networks for different companies at the same geographic location. Radio Access Networks are shared but they use their own dedicated core network and applications
3. Mobile virtual networks operator (MVNO) for companies that don't want to own the physical infrastructure. Instead it can be virtually provided by a mobile operator
4. Network slicing for small-scale operations covered already by a commercial mobile operator. This can create a virtual and private network leveraging its physical infrastructure



Example of 5G Private Mobile Radio (PMR) Smart Port Ecosystem

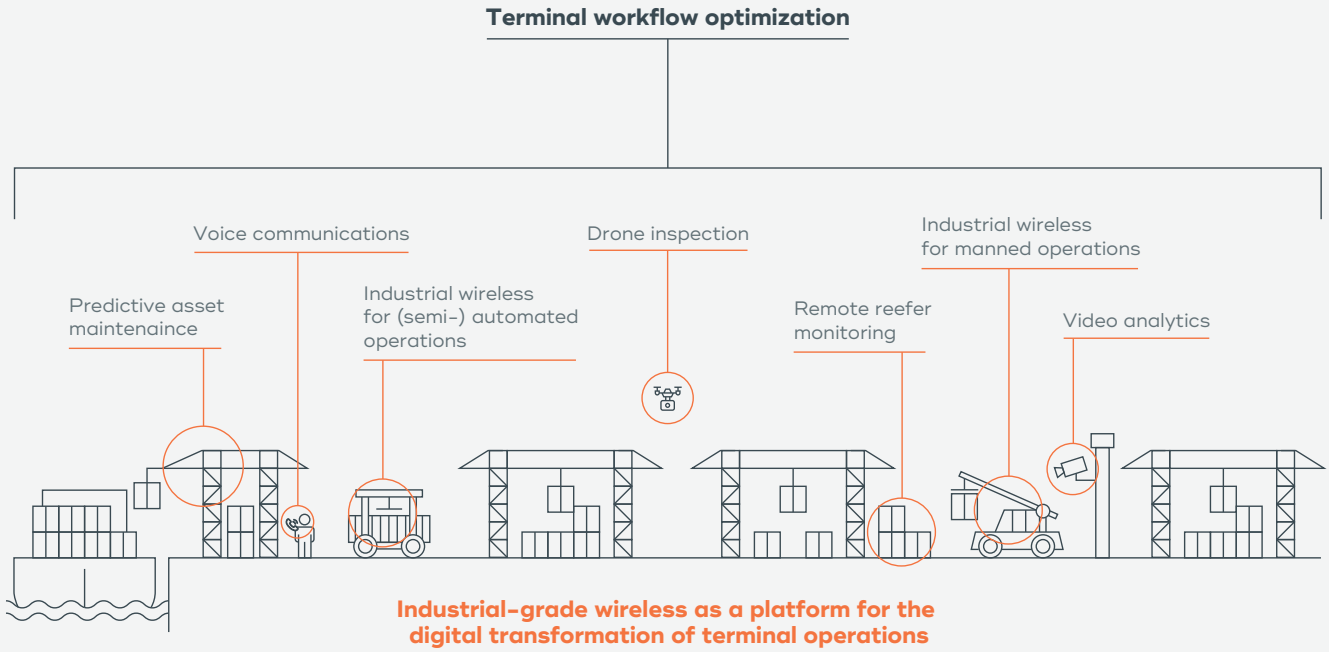


Figure 9: Nokia smart port

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Operators are experimenting with these applications, and most will be using data to justify or test candidate markets and services.

A flavor of the range of potential use cases, and the role that analytics should play in delivering them, is outlined below in figure 10.

Vertical Industries	Use Cases		Requirements	
	Solutions	Business Outcomes	Telco Offerings	Analytics
Energy & Utility	• Autonomous EV charging robot (G2V, V2G)	• Improve the quality of service and cost-effectiveness of energy service providers without hassles of switching	• 5G enabled micro-positioning • Self-driving artificial intelligence • 5G small cell tower (IoT)	• EV charging behavior analysis • 4D analytics • Autonomous infrastructure and parts analytics
Manufacturing	• Real-time process and QC with video analytics	• Increase productivity, adaptability & security by giving real-time alerts & guidance incl. labor COVID monitoring	• 5G connected cloud visual sensors • 5G video analysis platform	• AI/ML video/image analytics • Best production practice analytics • 4D analytics
Public Safety	• Digital twin infrastructure health management	• Automatically assess the quality of bridges, public buildings, roads, refineries, railroads, powerplants, etc.	• 5G connected drone/visual sensors • Ability to map cityscapes in 3D • Digital twin monitoring platform	• AI/ML video/image defection analytics • 4D analytics • Spatial analytics
Healthcare	• Remote patient health monitoring/personalized care • 5G-enabled ambulance service	• Wearables (IoMT, Internet of Medical Things) are predicted to decrease hospital costs by 16%	• 5G enabled micro-positioning • 5G connected IoMT devices • Multi-Access Edge Computing	• Predictive/prescriptive treatment plan analytics • 4D analytics
Public Transport	• Real-time streamlined traffic management	• Manage urban transportation infrastructure providing dynamic tolling and signal control	• Network protocol unification capability • 5G enabled micro-positioning • Traffic and road maintenance data	• Real-time traffic, image analytics • Pattern analytics • Time series spatial analytics
Agriculture	• 5G collars to enable real-time animal condition analytics	• Transmit biometric data to help workers proactively monitor and manage the herd remotely based on data	• 5G connected collar • Autonomous farming management • 5G enabled micro-positioning	• Biomedical, yield data analytics • Animal communication with remote diagnosis analytics
Retail	• Smart shopping assistant • Smart shelf-stock management	• Provide hyper-personalized in-store shopping experience based on shopping behavior and mange stock real-time • Better inventory management	• Visual sensors • AI/ML stock management • 5G enabled micro-positioning	• Real-time shopping history, behavior, image/pattern analytics • Autonomous supply-demand analytics
Financial Services	• Automated financial assistant • Real-time insurance damage appraising • 5G connected pop-up bank	• Provide autonomous hyper-personalized advice on spending • Autonomous video/image appraisal	• Location data • Web/app usage data • Spend monitoring finance app	• Real-time spending and banking data analytics • Autonomous wealth management
Automotive	• Real-time driving assistant	• Provide real-time information and warnings to improve safety	• LiDAR scanners • 5G small cell communication (V2X) • 3D real-time mapping • 5G enabled micro-positioning	• 360 degree view of driving patterns • Context analytics
Media & Entertainment	• Hyper-personalized immersive AR, VR, MR advertising	• Provide more impactful and relevant ads	• 5G enabled micro-positioning • AR, VR, MR ad platform for ad ecosystem players	• Real-time dynamic measurement analytics of ad effectiveness through eye tracking, biometrics

Figure 10: Industry 4.0 use case examples (Teradata)

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However, using predictive analytics to explore entirely new potential use cases based on network, usage, customer and behavioral data could offer additional value. 5G will support a panoply of innovative services and applications, and telcos need to move fast to develop, invest and partner in order to capture new markets and revenue opportunities. Unlike relatively homogenous 4G service portfolios, 5G will support thousands of niche solutions. Faster identification of the most lucrative niches, plus reduced competition and securing first-mover advantage, could all be delivered by putting predictive analytics at the heart of strategic decision making.

By creating dedicated 5G Data Labs that leverage the granular, real-time data created by 5G networks, telcos can create value and differentiation for themselves. This unique asset can not only drive collaboration across the rapidly expanding ecosystem of potential partners offering 5G-enabled digital services (see below), but facilitate the building of open, agile and scalable data pipelines and analytics stacks across partner ecosystems.

5G Data Labs allow agile assessment and development of modern 5G data analytics. Rather than an approach aiming at demonstrating and testing the technical feasibility of various analytical functions using 5G technology, they should evaluate commercial or pre-commercial use cases in realistic operational conditions. As such, 5G Data Labs will accelerate innovation and time-to-value from entirely new services and markets.

Teradata has many years' experience in building and testing data science environments and integrates seamlessly in to such facilities. Using Data as a true innovation tool is key to understanding how further services can be executed.

Automating Network Deployment

Although 5G networks are initially deployed partially on existing 4G infrastructure, the network infrastructure will gradually evolve to become more densified with different antennas, more and smaller cells, as well as higher computational power. Analytics and automation will become essential if the planning, placement and ongoing management of these much denser networks are not to become cost prohibitive. The figure below shows how advanced analytics and machine learning are used to provide recommendations that help a major North American operator reconfigure network cells to maintain service. The predictive analytics allow the operator to not only maintain network quality, but to

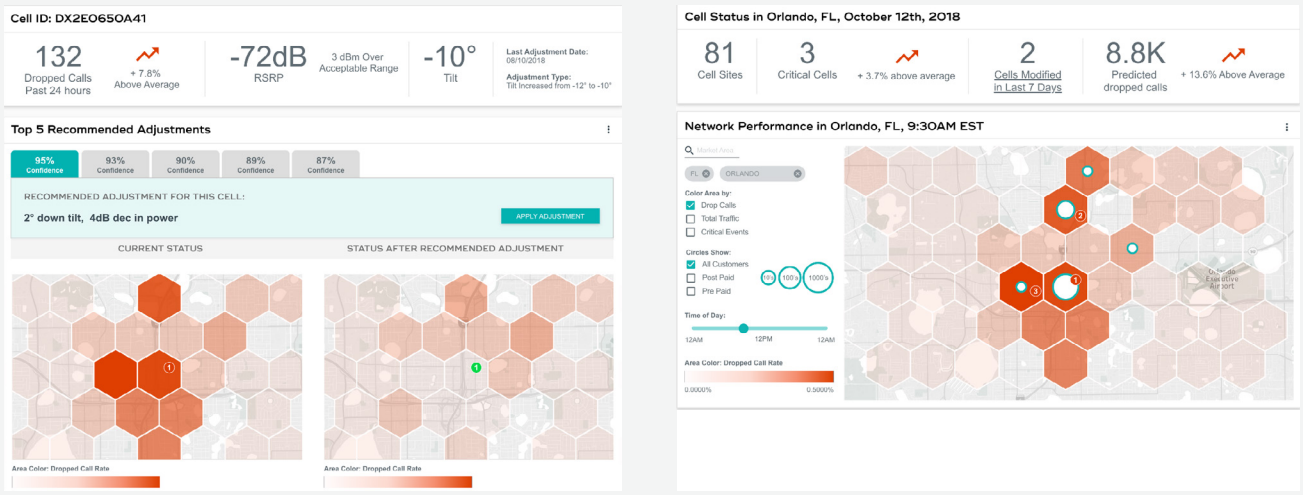

Figure 11: Mobile Network Optimization example (Teradata)

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significantly improve productivity of network engineers. The opportunity for leveraging orchestrated data becomes even broader as 5G becomes established, and networks more complex and agile. In fields such as connected cars, manufacturing/smart factories, agriculture, and smart cities, predictive analytics will be essential to maintain networks. The opportunity for leveraging orchestrated data becomes even broader as 5G becomes established, and networks more complex and agile. In fields such as connected cars, manufacturing/smart factories, agriculture, and smart cities, predictive analytics will be essential to maintain networks.

Conclusion. The Key Analytical Requirements and Enablers of 5G

5G networks need hyper scalable data analytics platforms. These platforms must be able to unify, orchestrate and analyze network data (and many other business and customer data sources) across vertical applications, BSS and OAM layers. Only then will they really support full automation of concept to cash process, closed loop assurance and management of E2E SLA.

TM Forum's Open Digital Architecture (ODA) introduces the concept of data-centric operations. These are operations that enable dynamic end-to-end processes that are intent-based, policy-driven and use common data repository for all layers. ODA also highlights the requirements of open API definitions in microservices architecture to enable containerization and support of capabilities across telcos', partners' and industries' ecosystems. Service-based interfaces implemented in a service oriented open API should facilitate the integration of data analytics across ecosystems and partners.

This implies the ability to rely on a modern cloud data architecture. Such an architecture can support real-time operations and orchestration by leveraging a native integration with data lakes (on-premises or in the cloud), and cloud first-party services, plus continuous integration and deployment with agile Development/Operations processes.

Analytical platforms need to provide the flexibility to adapt easily to telcos specific IT environments, OSS/BSS and cloud architectures – including Multi-Access Edge Computing requirements. Figure 12 illustrates what this could look like.

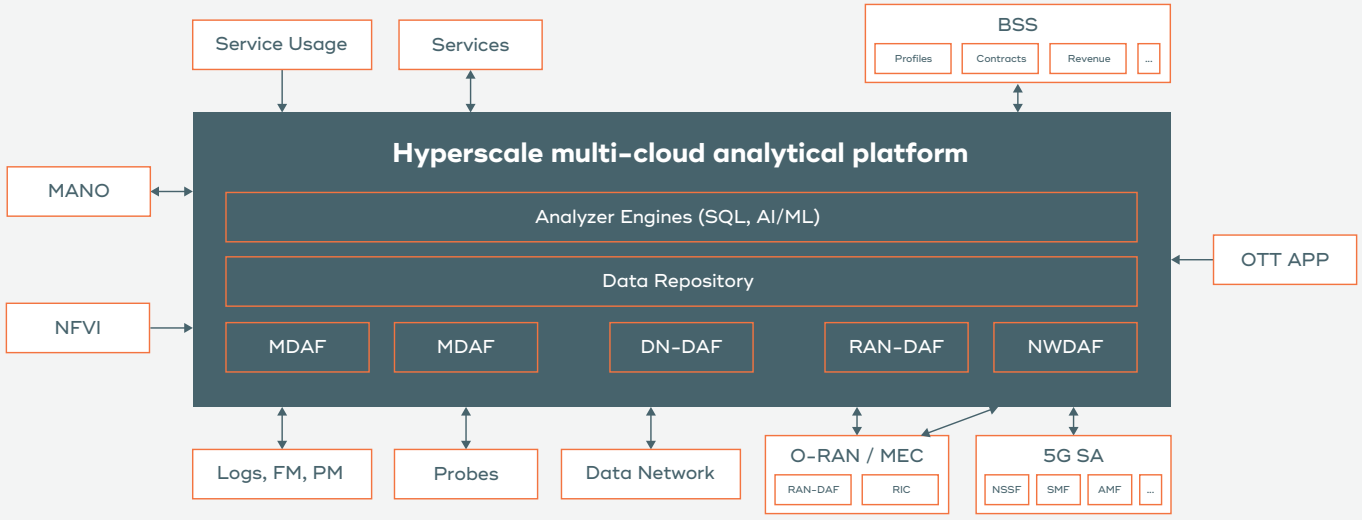

Figure 12: Hyperscale Analytical platform roles with 5G network key components and functions (Teradata)

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The focus of this paper has been to highlight the fundamental role of integrated data analytics at the scale required for 5G to deliver on its promise for all industries, not just telco. It is clear that a data orchestration engine is essential to make full use of all data generated by 5G. To deliver the insights needed to design and operate dense networks, to explore and experiment with new services, and to deliver high levels of service quality and customer satisfaction, all the data dots must be connected. This needs to happen at scale and in real-time.

Data orchestration is the automation of data -driven processes from end to end. This includes the preparation and management of the data, making decisions based on real-time advanced analytics and taking actions based on those decisions. The process spans many systems and functions present in a 5G network including varying types of enterprise-wide data.

Teradata Vantage(TM), the connected multi-cloud data platform, provides data management and analytics capabilities at hyperscale. Vantage has a unique ability to manage scale, speed, complexity, concurrency, integration and scope. This provides telecommunication companies with the advanced capabilities required to run millions of production models, on trillions of interactions, every second of every day across all parts of a 5G network. These interlinked analytics, running on tightly integrated data, ensure that network and business teams have visibility across the entire operation, ensuring consistent improvements in business outcomes and the best customer experience.

We are just at the beginning of the 5G revolution. For the first time data analytics are at the heart of communications technology and the opportunity is there to leverage its enormous power. Decisions made now - to build the right data foundations and the right architectures that can exploit them in agile and flexile ways – will define the successful impact of 5G.

As 5G continues to evolve, it is still too early to confirm what will be included in this new generation of networks. There are good reasons to believe that it will embrace new technologies such as satellite systems integrated with terrestrial wireless, ultra-dense cell networks and Internet-of-Everything (IoE) applications.

List of Acronyms and Abbreviations

3GPP	3rd Generation Partnership Project
4G	4th Generation mobile wireless communication system (LTE, LTE-A)
5G	5th Generation mobile wireless communication system
AGV	Automated Guided Vehicles
AMF	Core Access and Mobility Management Function
API	Application Programming Interface
BSS	Business Support System
FM	Fault Management Systems
DN-DAF	Data Network Analytics Function
IEEE	Institute of Electrical and Electronics Engineers
IOT	Internet of Things
IT	Information Technology
KPI	Key Performance Indicator
MANO	Management and Orchestration
MDAF	Management and Orchestration Data Analytics Function
MEC	Multi-Access Edge Computing
MVNO	Mobile Virtual Networks Operator
NFV	Network Function Virtualisation
NFVI	NFV Infrastructure
NSA	Non Standalone Architecture
NSSF	Network Slice Selection Function
NWDAF	Network Data Analytics Function
RAN	Radio Access Network
RAN-DAF	Radio Access Network Data Analytics Function
OSS	Operation Support Systems
OTT APP	Over The Top Applications
OAM	Operations Administration and Maintenance
ODA	Open Data Architecture
PM	Performance Management System
QoS	Quality of Service
SA	Standalone Architecture
SBA	Service-Based Architecture
SMF	Session Management Function
TMF	TeleManagement Forum
UE	User Equipment

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These enhancements will not only provide ubiquitous broadband and global network coverage, but always-on connectivity for new and future services and applications.

One thing we can state with confidence is that the role of data analytics in identifying, creating and delivering these next generation services will be fundamental. Now is the time to build the data infrastructure to support them.

About Teradata

Teradata is the connected multi-cloud data platform company. Our enterprise analytics solve business challenges from start to scale. Only Teradata gives you the flexibility to handle the massive and mixed data workloads of the future, today. The Teradata Vantage architecture is cloud native, delivered as-a-service, and built on an open ecosystem. These design features make Vantage the ideal platform to optimize price performance in a multi-cloud environment. Learn more at **Teradata.com.**

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