Capgemini engineering

ACCELERATING INDUSTRIAL DIGITAL TRANSFORMATION THROUGH 5G

How to deliver rapid business value with 5G private networks and microservices

CONTENTS

INTRODUCTION: 5G OPPORTUNITIES AND CHALLENGES

Recent Capgemini research found that 40% of industrial organizations expect to roll out 5G at a site within two years.

Beneath this simple statistic lies many new challenges. Rolling out a 5G network is an essential element of transforming manufacturing facilities into smart digital environments. So how does one go about it? What are the game-changing use cases that a 5G network will unlock, and how will they support your business? The second question is the more important and should shape the answer to the first.

A 5G private network essentially ringfences radio coverage (over the chosen radio spectrum band) over a defined area, which can be used privately by an organization, creating a discrete private network secure from outside interference. The 5G network can then be configured to enable data to be transferred wirelessly across a wide range of bandwidths, enabling ultra-fast, ultra-low latency data transfer.

Your company's operating devices and technologies can then be securely connected to that network, providing high levels control across operations and high-resolution multi-device data collection on an unprecedented scale, on which companies can run analytics and AI/ML algorithms.

The difference between 5G private networks and other networks, such as Wi-Fi or wired, is that it removes technical limitations that impede many use cases. It will allow thousands of devices to be added and will communicate flawlessly, even when transferring large amounts of data such as video streams. It will provide benefits not achievable with previous network approaches, such as complete site coverage holes (no darkspots), consistent quality of service (no handover issues for mobile applications when switching between access points), security and performance (bandwidth, reliability and ultra-low latency). Furthermore, 5G networks are software-defined and based on a flexible underlying infrastructure, making them highly reconfigurable and able to evolve as needs change.

All of this means 5G holds huge advantages for highly connected industrial settings: everything from factory floor automation, to autonomous vehicle testing centers, to safety management on oil rigs. This in turn opens new opportunities to deploy sophisticated use cases that require huge amounts of data from multiple devices, such as those listed in the 'Use cases for 5G Private Networks in Manufacturing' boxout.

> "Industry excitement is struggling to convert the potential of 5G into proven use cases."

Use cases for 5G Private Networks in Manufacturing

- Real-time Asset Track and Trace with maximum accuracy
- Massive sensor networks for predictive maintenance
- Collaborative robots and industrial automation
- Energy usage monitoring and optimization
- AR/VR site and layout planning
- AR/VR overlays for assisted maintenance
- Video-based site inspection and quality inspection
- Video and image analysis to detect risks such as gas leaks, or to monitor and analyze crowd and/or objects movements, distances and counting
- Drone flight path management and real-time video uploads
- Inventory management and supplier/partner connectivity

But, while 5G private networks clearly offer huge benefits, the problem is that building them in a way that is useful is challenging, because they present new technologies and approaches that are different from those use in WiFi and wired networks, currently used for industrial connectivity.

The physical 5G private network infrastructure offers a wide variety of options and need for fine tuning. And that is the easy bit. The biggest challenge is building a portfolio of use cases on the network (such as those listed above) that are tailored to your needs and will deliver value and generate ROI.

This digitization of industrial operations involves bringing together a wide range of high-end technology, including sensors (attached to multi-vendor operational technologies, many of which were not originally designed to be connected); connectivity technology and protocols (often across networks); and cloud platforms, and ensuring they all work together. This is not a simple task as it involves multiple technologies, end-to-end integration, and a shift to new ways of working.

It is not surprising, then, that industry excitement is struggling to convert the potential of 5G into proven use cases. 55% of industrial organizations, for example, reported difficulties with defining 5G use cases and estimating their ROI, 67% cited difficulties with accessing vertical-specific 5G solutions as barriers to implementation, and 69% cited challenges with adapting business operations with 5G use cases.[3]

In this paper, we will discuss those challenges and propose sensible ways to navigate it.

THE PATH TO VALUE FOR 5G PRIVATE NETWORKS

Implementing a 5G private network is not simply a case of designing a network architecture and building it. Such an approach would set you on a path to a long and expensive project that may end up not-fit-for-purpose.

Instead, it is far better to start small and build some pilot use cases designed to take advantage of the 5G network. Then, with these ready to go, use these to define your initial network architecture. Then test and refine on the network, and roll out, evolving the network architecture iteratively as you go. Over time build more use cases and evolve the network – in a continuous feedback loop – towards an optimal state for your business. Doing so means you will be better able to learn about both processes and infrastructure decisions.

This section will look at the different components of a fit-for-purpose 5G private network.

1. Start with business use cases, not tech

The very first step should be to define a few use cases that meet your business goals, within the context of what a 5G private network might be able to deliver.

Identify what it is you want to achieve. Perhaps it's an AR system that offers contextual maintenance advice to engineers as they arrive at a job, or a system that visually maps how people move through a factory to assist fire escape planning.

To ensure you consider the full range of possibilities, read case studies by others with similar needs, or consult the experts who have delivered them. Ensure all decisions remain closely aligned to your business goals.

5G private networks are highly reconfigurable, so you will be able to iteratively build more use cases down the line,

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and update requirements as you go. But scoping out a few early use cases that meet immediate and valuable business objectives will ensure you deliver value quickly from your 5G investment and set up the network and associated systems in a way that works best for your needs.

2. Embrace microservices to deliver business goals

Once you have your use cases defined, you need to build them. If you want to rapidly deploy and scale quality use cases, the key is to embrace microservices.

As their name suggests, microservices of reusable components and building blocks – such as object recognition, A/V Call signaling, 3D object rendering in AR, voice and video communications, and so on. Essentially, they are pieces of code built on a common software foundation, which can be combined and deployed into a wide range of technology agnostic applications.

Many useful microservices already exist as modules ready for 5G integration – with all the important bits – authentication, compatibility, analytics – built in. So do the APIs that allow them to integrate device or application software, through which they receive requests, process them, and generate a response.

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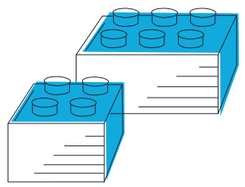


Like Lego bricks, each microservice block can be put together with others to create a use case. For example, an assisted maintenance use case may combine blocks on sensor data processing and analytics to define the problem, natural language processing to process the correct part of maintenance manual, and AR overlays to show the engineer what goes where.

Access to a broad library of microservices will take 80% of the work out of a use case by using building blocks that already exist. The remaining 20% is your own code that needs to be written to glue things together and tailor to the specific use case and environment. That is much easier than building every use case from scratch.

Each of these microservices can be hosted at the edge or in the cloud. They can be deployed, tweaked, and then redeployed independently without affecting the integrity of the application. This allows you to build a proof of concept, then cheaply and rapidly scale it to an enterprise grade application.

Microservices therefore enable a highly agile approach – often described as continuous integration/continuous delivery/continuous testing – to building use cases on a 5G private network. Rather than a centralized approach where all changes need to be top-down, microservices are decoupled from the underlying hardware and can run as decentralized modules with their own runtime environment. This makes modifications easy and allows simple redeployment of valuable services between similar use cases – both critical in an evolving network.

This decentralized approach also means microservices hold up well in the face of failure: allowing nearby services to continue to function as the failed service is retired, without ripples of consequences through the network – vital as networks perform ever more complicated functions.

Success Story: Video analytics for quality inspection

Taiwan-based IT hardware manufacturer Inventec deployed a 5G private network at one of its plants. The network is part of an active production line, and was set up with the goal of increasing efficiency and reducing manpower using AI-based Automatic Optical Inspection (AOI) in the assembly line. The network has delivered significant improvements in quality and productivity, including an increase in first pass yield from 70% to over 85%, and a reduction in re-inspection labor force of 50%. It has also enabled Inventec to adjust production lines faster.[4]

3. Deploy the tech stack

Once you have identified your business goals, initial use cases, and the microservices to enable these, you eventually need to build the technology architecture and software frameworks to deploy them into. An enterprise setup with 5G private network architecture is the sum of the convergence of Operational Technology, Information Technology, and Network Technology.

Setting this up is a technically complicated job that will define the network for the long term, especially for the early adopters, since everything is new. Although tweaks will inevitably be needed as new use cases arrive, it always makes sense that the initial setup is aligned to a set of high-value use cases, rather than building something that needs to be constantly reconfigured to accommodate your needs.

Operational Technology (OT)

This is the technology that does the work – the robot arms on the assembly line, milling machines, oil drills, and high throughput screening assays. They are made up of sensors and control systems, and the software that run and manage data from both.

These devices need to be connected into an IoT network. Newer ones may work out of the box, but many legacy devices will not have been designed to collect/send a lot of data or for 5G connectivity, so will require the addition of technology to enable them to connect to 5G and any other network the device may need. Such technology may need new sensors to monitor their activity and upgraded control systems, radio (i.e., the access point that provides the data transmission via a communications network), core (the software part – database, storage, etc), and edge capability (the processing that happens at the devices) – upgrading legacy OT to become smart & connected requires retrofitting custom work and integration with 5G network.

Success Story: Teleoperated machinery

In Japan, NEC Corporation, telecom operator KDDI, and construction company Obayashi jointly and successfully tested a 5G-enabled remote monitoring and control system to remotely operate construction machinery. 2K and 4K cameras, installed on construction machines, were used to transmit video and image data in real time using 5G.[5]

The whole IoT network will require a connectivity management platform to ensure device connect to the right place and right time, including switching between networks if appropriate (in some networks there will be a need for 5G to coexist with legacy wired and wireless ethernet based networks in an integrated way).

Each of these devices also needs to be tracked for functionality, health, and to ensure that they belong on the enterprise. Since there are interdependencies between the connected devices, with each device carrying specific context and state which contribute to a workflow, it is vitally important to ensure platforms to manage security, correlation of health and state, and data analyses across all contributing devices.

Information Technology (IT)

This is more familiar ground for many. It consists of the software applications that run of laptops and phones that provide people with useful tools and advice. It also encompasses the database management and data analytics that enable you to take the data from the many connected devices and turn it into useful insight. Many companies will have these technologies and skillsets in place, but will need to understand how these applications and IT architecture integrate with new contexts presented by 5G.

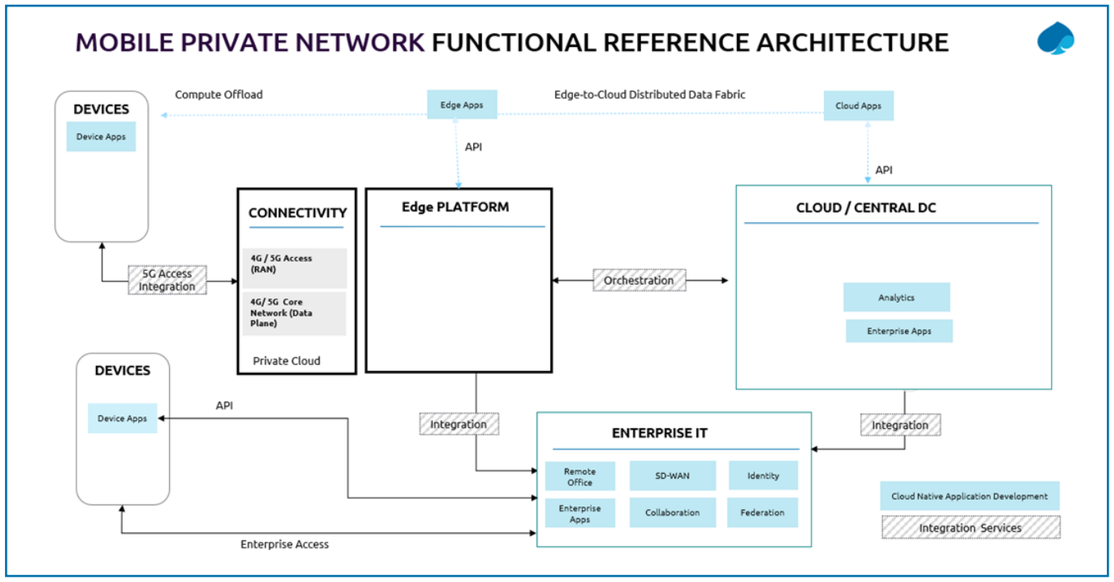
Network Technology (NT)

Network Technology is the bit that enables IT and OT to communicate, so you can get the data from your sensors into your cloud-based AI algorithms, and then deliver that insight onto the user's device or back into the OT control systems.

This means radio access technology that connects you into the wider 5G network providers. You may elect to create different slices of your network for different purposes and performance requirements. You may also opt to buy in slices of bandwidth from dedicated service providers rather than build your own.

Most private network deployments fit into one of two categories: They can be physically isolated private 5G networks, such as a 5G island network in an Enterprise, or a private 5G network can share the mobile operator's public 5G network resources.

In the first case, the enterprise can deploy a complete 5G network within its premises (this will include: the base station (gNB); User Plane Function (UPF) to connect the data coming over the Radio Area Network (RAN) to the Internet; 5G Core to establish secure connectivity to the network for users, Unified Data Management (UDM) to control network user data; and Multi-access Edge Computing (MEC) to provide computing functions required by users on edge nodes).



In the second, the architecture can be disaggregated, with 5G RAN and UPF onsite for low latency processing, and the rest hosted in a service provider's cloud.

The exact architecture that combines all these parts will define how the data is shared across the private network, but also how it flows securely in and out of the network, for example to cloud services or to approved suppliers.

Although this may seem like the defining point of a 5G network, in many ways it is the simplest bit. The network itself is a commodity, the value comes from what you build on it. Nonetheless, there are choices to made about architectures and configuration and choices of vendors with different value proposition. You should define and specify your network to enable your use cases.

The key to success: Bringing IT, OT and NT together

Unlike previous network approaches, 5G networks can be disaggregated, i.e., all these bits can come from different providers, but can be made up of different parts suited to your needs. This allows a lot of flexibility but also makes specifying a network architecture complicated, due to installing 5G and stitching the 5G use cases across IT+OT+NT. This requires detailed and robust design and iterative "design-test-learn-adapt-repeat" fine-tuning. This is particularly complicated since it has never been done before for most organisations, though many elements will get easier with experience.

This process is often complex and siloed. Those who understand operations don't always understand network communications, and those who understand IT don't often understand operations. Creating a collaborative environment where the people of various expertise areas can come together and share their knowledge is crucial to achieving the full capabilities of IT+OT+NT. Collaborative and agile development and testing processes are key to ensuring that use cases and business processes solve the real problem.

Success Story: Video -based site inspection

Lufthansa Technik, the German airline's maintenance and services division, set up to 5G private network at its campus in Hamburg in January 2020. Since then, the company has experienced significant improvements in latency and reliability compared to its Wi-Fi networks, reporting a latency of seven milliseconds.[1] [2]

BUILDING A USE CASE PORTFOLIO: A TEMPLATE

1. Start small and build microservice use cases

- Identify what you want to achieve with your 5G private network
- Identify potential use cases and the business value they would bring to
- Identify the microservice building blocks that will enable them
- Write the supporting code to adapt groups of microservices to your specific needs

2. Build the solution

- With your use cases in mind, conduct an initial 5G architecture design combining suitable technologies from multiple vendors, considering established 5G private network blueprints as a foundation
- If not already available through your organisation, deploy network technologies and IoT connectivity, and cloud services to ensure you can deliver your use cases
- Engage in limited component and microservice selection to deliver early use cases
- Integrate and validate into your network
- Rinse and repeat until you have production-grade use cases
- Perform these steps multiple times to build a portfolio of overlapping use cases

3. Deploy on site

- Integrate and verify IT and OT systems end-to-end
- Ensure that wired, wireless ethernet-based, and new 5G-based networks are managed in an integrated way
- Go live with new use cases

4. Feedback learnings as you go to ensure tech and skills evolve according to need

- Deploy agile teams to continue to develop new use cases that harness the 5G networks capabilities to deliver business value
- Setup tools to capture and share learnings
- Identify and bring in new skills to build more complex tools onto the – e.g. bespoke AIs to derive insights from image or machine data

5. Build a managed services team to maintain and upgrade network

- Establish a professional team to handle troubleshooting and maintenance of the network
- Proactively scan data and network for bugs and opportunities to improve software and hardware
- Deploy over-the-air (OTA) updates to continually improve and add new capability

Success Story: AMRs/AGVs/ AIVs/drones

Mercedes-Benz's 'Factory 56' plant is equipped with a 5G private network. Its traditional assembly lines have been replaced with driverless transport systems/ AGVs (Automated Guided Vehicles) that increase the overall flexibility of the production process.[6]

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In summary

The path to 5G private network value is to start small and build pilot use cases designed to take advantage of the 5G network. Use these to define your initial network architecture. Take an agile approach; testing, refining, and launching more use cases over time, and evolving the architecture iteratively as you go. 5G private networks should be seen as an ongoing business transformation programme, not a one-off technology project. That is the way to ensure they deliver tangible value from day one.

How Capgemini can help

Capgemini is a Global System Integrator that can design, deploy, and manage post installation of a highly customised network. Our 20,000 network specialists worldwide have the expertise and experience to ensure the proper security, state, and health of a 5G private network and its systems.

We have successfully implemented over 1,100 5G and edge projects since the start of 2020, enabling customers to take advantage of reusable microservices, orchestration, and analytics capabilities.

We have developed a full stack approach to rapidly designing and scaling 5G private network use cases, which includes:

- The latest evolution of blueprints, designed for a disaggregated network solution that includes multi-vendor radio access, edge, and core.
- A library of microservices - common foundation software and hardware components – that are reusable and can be used to iteratively develop and deploy use cases mapped to platforms and business processes. Microservices can be deployed on both third-party network elements, or on frameworks developed in-house for many core components, including Edge compute.
- Our mobile edge computing platform offers a simplified developer experience, and incorporates relevant APIs that developers can use in their SDKs and for developer-facing services.
- Powerful tools, developed in-house and with ecosystem partners, to enable the unified management of the converged network required for the integration of an organization's OT, NT, and IT systems.

Contact engineering@capgemini.com to find out more.

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