



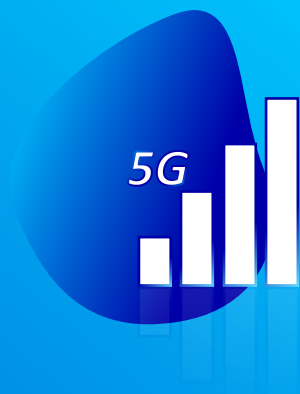
Software for 5G

Three Areas of Opportunity

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“The 5G technology is ultimately one of the most important infrastructures for the 21st century. We are going to see an extraordinary impact in the next couple of years.”

Hans Vestberg, CEO Verizon



In Brief

The next generation of mobile broadband, 5G, is nearing its time. The technology promises to allow mobile consumers to browse the web at 10x current speed, stream 4K videos with little to no delay, and experience entirely new versions of entertainment and media. The forthcoming arrival of the next generation of wireless technology, however, is much more than just about a better mobile experience. 5G represents a new, digital underpinning that will allow virtually everything around us to be connected, and in doing so create opportunities for new businesses.

Certainly, there will be companies that leverage 5G to fundamentally change the way things operate across sectors, from healthcare to manufacturing and beyond. However, there's also an interesting opportunity for businesses to develop software in support of the paradigm shifts and in turn generate broad-reaching economic value.

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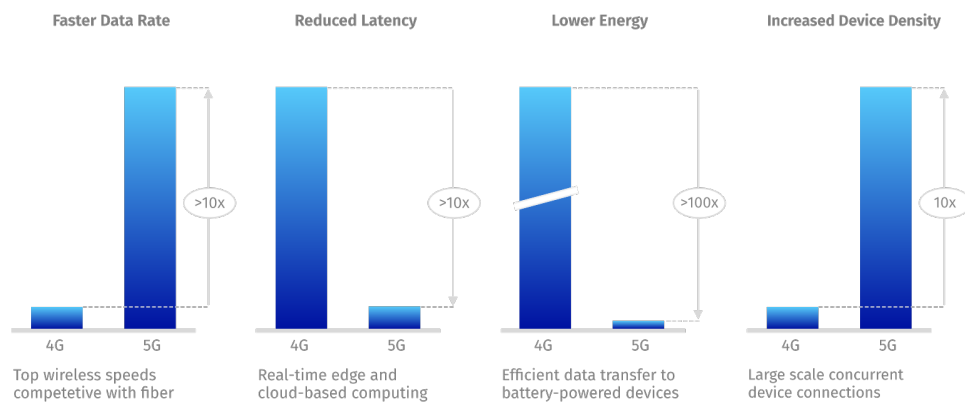
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1. Introduction

5G (Fifth generation) is the next step in wireless mobile technology. It is a set of standards agreed upon by international bodies in 2020, most notably the ITU. According to an outline specified by the ITU, 5G is expected to address the following (International Telecommunication Union, 2017):

- Enhanced mobile broadband
- Ultra-reliable and low latency communications
- Massive machine-type communications
- Fixed wireless access

Exhibit 1



Source: Generation Partnership Project; IEEE; Bain & Company

Taken together, these expectations imply that 5G will offer an enormous range of capabilities and as such will have a transformative effect on consumers and businesses. 5G is expected to buttress dramatic advancements in IoT, cloud and edge computing, cognitive computing, and the future of on-demand media. From improved video streaming to connected manufacturing facilities capturing millions of data points and autonomous vehicles, connectivity and 5G will enable smarter and more efficient businesses and provide new and unique consumer experiences.

While the ultimate promise of 5G is incredible, it's also important to consider how much is likely to be realized in the near-term. According to a McKinsey Global Institute report, a 5G future is not solely about what is happening on the frontier; there are real and immediate reasons why 5G should matter to firms and consumers in the present. As illustrated in **Exhibit 1**, the new standards boost network performance with less capital cost. Based on these factors, the report identifies near-term use cases¹ in healthcare, mobility, manufacturing, and retail that alone could increase global GDP by \$1.2 trillion to \$2 trillion. Furthermore, the increased capacity and affordability of 5G-backed fixed wireless access (FWA) will have implications for individuals across the globe,

¹ The full [report](#) lists hundreds of use cases across these sectors. Qualcomm has published [video](#) that outlines some more technical demonstrations of 5G.

enabling more people to get online. This could contribute an additional \$1.5 trillion to \$2 trillion in global economic value (Grüpink, et al., 2020).

1.1. Sample Applications

Realistic applications, such as those outlined by the McKinsey report, as well as bleeding-edge use cases like remote surgery all tie into the future of 5G. For brevity, below is a broad-strokes sample² of some practical applications that 5G will enable:

1.1.1. Surveillance Cameras

Traditional CCTV networks rely on cable and fiber connections. They're complex and expensive to implement at scale. The high bandwidth offered by 5G will allow for wireless CCTV cameras performing real-time surveillance and inspections at high-resolution 4K and 8K. According to Gartner, surveillance cameras will represent 70% of the initial 5G IoT install base (Gartner, 2019).

1.1.2. Gaming

Gaming has long been expected to transition to a streaming model, but current the network isn't capable of delivering the required low-latency responsiveness. A 0-ping wireless network that can deliver high bandwidth, like 5G, will enable gamers to stream and play with no lag. With more than 2.5 billion gamers worldwide and a growth rate of 13.4% (Newzoo, 2019), the economic implications will be dramatic.

1.1.3. Connected Vehicles

As cars become ever more connected, an unprecedented demand for lower latency, higher connection volume, and faster data transmission will grow. 5G has been designed to meet all of those demands and will enable cellular vehicle to everything (C-V2X) applications. Cars will communicate with each other, with traffic signals, and other roadside units. The ultimate goal is autonomous vehicles. The interim, however, promises safer, more reliable vehicles, optimized traffic patterns, and a better in-car experience. Nokia describes it: "imagine [a] scenario [where] you hop into a pre-warmed car with a nice cup of coffee and start following the optimum pre-calculated route. The kids in the back are strangely quiet, captivated by their favorite cartoon, even when you pass that annoying zone where your connection drops. As there is still some time left before your meeting, you schedule an appointment for that annual service, suggested by the car itself." (Krisztyián, 2020)

² Nokia has documented a more in-depth view of [5G use cases](#) that is worth further exploring.



Global 5G connections are expected to achieve 62% penetration by 2024.

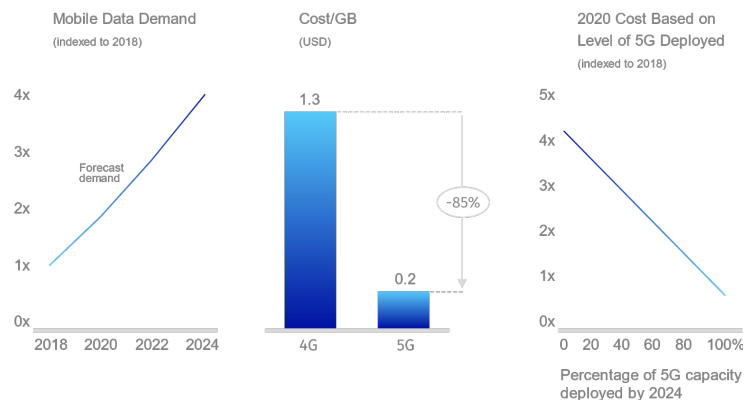
2. Market Forecast

By 2024, global 5G connections are expected to be close to 2 billion, representing 62% penetration (Ericsson). In just the next year, global spending on 5G infrastructure is forecast to be \$2.3 billion (IHS, 2020) with global revenues eclipsing \$26 billion (IDC, 2020). The overall 5G Technologies market is currently at \$32 billion and will grow at a CAGR of 26.6% over the next few years (BCC Research, 2018).

The increasing demand for fast, ultra-low latency connections, as well as the growing number of consumer and enterprise-grade, connected IoT devices will drive the growth of 5G across sectors. Data demand, as a whole, will increase 4x by 2024 and 5G promises to deliver improved access to that data at 15% of current cost (Blum, Lowe, Dahlke, & Verhoeven, 2019).

Exhibit 2

Rapid growth in data demand will drive 5G deployment



Source: Ericsson Mobility Report; Bain & Company

Consensus on a 5G rollout plan has not occurred, but most network providers are expected to go through a gradual rollout. Given the number of factors involved and the economic risks, providers will likely choose to begin with low-cost approaches that better align with existing LTE technology. According to BCG and Forrester, the great benefits of 5G won't likely be felt by customers until 2022 at the earliest, when 5G will be deployed stand-alone and independent of 4G LTE (Breitenstein, Bernold, Schicht, Wandeler, & Boek, 2019).

Though the rollout may be gradual, the use cases for more 5G will continue to build and tele-companies will have to further the deployment of the technology in the coming years. While there may be little reason for consumers and businesses to implement a 5G strategy right now, there is no doubt that 5G will fundamentally change the global network infrastructure.

“Rolling out the fifth generation of cellular mobile technology – 5G – is a multi-trillion-dollar communications revolution that will profoundly change every aspect of our lives.” (Greensill, 2019)

3. *Current State of Investment in 5G*

US mobile carriers have both made significant strides in their 5G plans. AT&T has spent over \$700 million since 2015 in Kentucky alone. These investments include 1,000+ network upgrades and 15 new cell sites. The company expects its 5G network to cover more than 200 million consumers in the US at launch (AT&T, 2018).

Verizon was the first major US telecom to begin rolling out ultra-wideband 5G service. It has launched in 30+ US cities (Verizon, 2020), and its CEO expects 50% of the country's population to have 5G access by 2024 (Vestberg, 2019).

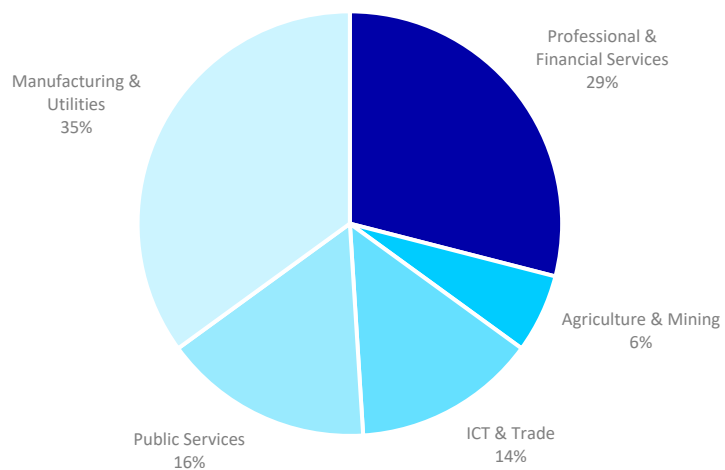
Tech companies are also investing in the technology. Samsung announced plans to invest \$22 billion in 5G and other technologies (Martin, 2018). Qualcomm, which owns approximately 15% of 5G technology patents (McBride, 2018), is betting big on the technology. Its venture arm, Qualcomm Ventures, has announced it will invest \$200 million on 5G startups (Qualcomm, 2019).

4. Areas of Opportunity

In the past, venture capitalists have avoided investing in mobile infrastructure. The high CAPEX and OPEX, as well as the dominance of large mobile carriers, has made it a sector that didn't fit with the venture model.

Exhibit 3

Share of 5G's contribution to the global economy forecast 2034, by segment



Source: GSMA Intelligence

With 5G, however, that is set to change. Just as the personal computer revolution created a cadre of successful adjacent companies (Microsoft, Oracle, Netscape, etc.), and the mobile revolution paved the way for myriad successful startups (Instagram, Waze, WhatsApp, etc.), the 5G revolution will also open up neighboring opportunities.

Providers are expecting a wide range of verticals to benefit from 5G. And because of the wide-reaching implications of 5G, a host of support systems will materialize.

While most analysis has focused on the hardware and infrastructure that will support the 5G transformation, software cannot be overlooked. Three areas, in particular, show exciting promise.

4.1. **Orchestration of Hyper-local Compute**

With 5G, connectivity will reach an entirely new level. Millions of simultaneously connected devices (Cisco, 2019) will spread throughout our world, and with it the need for near real-time data transfer and services. Whether powering IoT, self-driving vehicles, drones, or smart cities, edge computing will play a massive role in supporting the proliferation of connected devices that accomplish incredible tasks.

Today, cloud computing is pervasive and dominates the computing topology. Cloud has had a massive impact, but edge promises to be much more widespread and influential. Edge will, nevertheless, not replace cloud computing. Instead, the design of edge computing complements the cloud and as such, an entirely new infrastructure is starting to develop.

Traffic patterns will emerge to propagate enormous amounts of data between private cloud, public cloud, and edge. On-device computing and micro data centers that are as close as possible to the consumption point will be commonplace. This new foundation will require the development of software that can intelligently orchestrate the real-time delivery of compute to all of the devices, securely and without delay. Startups will emerge that use software to provide improved local interactivity, can securely and efficiently handle the transfer of large volumes of unstructured data, and provide device autonomy and privacy in a cost-effective manner.

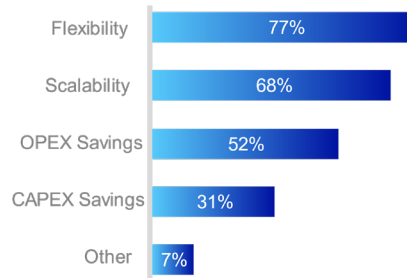
4.2. **Network Virtualization**

Software-driven approaches to networking, like NFV and SDN, have broken through in the cloud and data center spaces and the same will occur in a 5G world. With 5G, there will be a need for tools and frameworks that make it simple to deploy, manage, and provision applications and their hardware counterparts with speed, flexibility, and security. Network virtualization cost-effectively enables all of this.

In many ways, the full promise of 5G cannot be realized without software-based networking, which dramatically brings down CAPEX and OPEX, all the while lowering the time-to-market and increasing network flexibility. As 5G begins to roll-out, there will soon be startups that begin to meet the demand for this technology. Expect to see best-in-class suppliers for every aspect of the mobile-centric virtualized networking.

Exhibit 4

Perceived Benefits of Network Virtualization in Data Centers



Source: VMware

4.3. Network Insights

With the spread of millions of connected devices, virtualized networks, near-point data centers, and edge computing will come a great deal of complexity. Network providers will have to rely on tools to help them understand how their network is operating and what can be done to further optimize network delivery.

Network analytics will play a critical role in addressing the complexity of 5G to build a more robust and flexible network. Providers will rely on ML/AI algorithms to analyze network utilization and traffic in network planning and optimization. Providers will move past basic business intelligence reporting dashboard towards advanced insights to minimize network failures and aid in troubleshooting, mitigation, and remediation. Analytics-generated insights will facilitate decision making. A real opportunity exists for businesses to build around the features of 5G – more information collected faster and reliably – to develop intelligent network-focused insights that network providers will heavily rely on.

5. *Conclusion*

These three are not the only viable areas of opportunity in 5G; medicine, AR/VR, consumer entertainment, smart cities, and many more are exciting sectors. Nevertheless, software, and in particular infrastructure-supporting software, will play a major role in the realization of 5G and as such represents a real, high-growth-potential market in an area that is unwarrantedly being overlooked.

5G will fundamentally change how our world operates. It will open up a new set of network interactions and connectivity. Opportunities exist for software companies to help build the underlying services and applications that will support 5G so that it can live up to its game-changing potential.

Author



Jorge Colindres is a software engineer who's worked across product development and organizational lifecycles and has been a part of Rails, Node.js, PHP, and Clojure/JVM stacks. His current software interests lie in cloud computing and deep learning.

Previously, Jorge worked as an MBA intern at LDV Capital in New York City, an early-stage venture capital firm that invests in people building high-growth visual technology businesses. At LDV he assisted in due diligence, research, and portfolio company support.

Jorge is currently earning his MBA at the Tuuck School of Business at Dartmouth, where he is a Consortium Fellow and expects to graduate in June 2020.

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