RED RIVER VIEWPOINT

5G AND ENTERPRISE IT MADE SIMPLE

Bill Halpin

Red River

TECHNOLOGY DECISIONS AREN'T BLACK AND WHITE. **THINK RED.**

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1. INTRODUCTION

5G technology will drive the next generation of mobile networking. Telcos, service providers, and equipment vendors are gearing up for a massive rollout of new technologies and products to bring 5G services to market. This whitepaper considers 5G's impact on enterprise networking and on service providers.

Key Points:

- 5G improves mobile network speed, latency, and capacity.
- Multiple layers of technology are changing to a software-defined operational model.

The market for 5G is enormous, measuring hundreds of billions of dollars over 5-10 years. This creates hype as marketing dollars are spent to influence buyers.

- There are plans to offer private WAN services, called 'network slicing', but it's unclear that buyers will pay for this MPLS-like private service in an era of SD-WAN.

5G's influence is likely to be felt in a variety of areas. For example:

- SD-WAN may consume bandwidth from 5G broadband.
- IoT deployments will be enabled by increased density and improved performance. Low-power services will enable 10-year battery life.
- Remote working will become more feasible.

This paper provides background and insights into 5G so that an enterprise IT professional can speak knowledgeably when needed. This is an overview of the technology and its potential impacts.

2. WHAT 5G OFFERS TO ENTERPRISES

5G - The Fifth Generation of mobile networking technology: 5G is intended to signal a major advancement over current 4G and 4.5G standards, with a focus on latency, speed, and power reduction.

Speed: Faster networks improve access to online services for customers, and improve the speed of business-to-business communications (video, voice, ecommerce). 5G's speed may also impact SD-WAN deployments.

Latency: Improved latency will support new services. Two-way interactive video is an obvious use case, but there's limited evidence that it's a market driver compared with 4G solutions. 5G latency within the mobile cell should be much lower, below 1 millisecond, compared with 30-70 ms for 4G.

Density: 5G supports more devices per tower, leading to more devices per area. Today, IoT devices connect to local WiFi, but could connect to 5G networks instead.

Fewer Networks: Replace WiFi networks with 5G and simplify operations.

Network Slicing: This technology segments the mobile service provider network for service guarantees and privacy.

Analytics: Some providers promote the capture and sale of user data and activity.

How organizations can take advantage of these characteristics?

3. SPEED AND SD-WAN

The promise of fast mobile broadband over wireless will suit some SD-WAN use cases. Here are some to consider:

Rapid Site Deployment: A 5G connection could serve as a stopgap while waiting for a wired circuit. 5G may not be perfect, but sometimes something is better than nothing.

Mobile Site: Robust 5G services may enable businesses to set up a branch location on demand. Consider short-term use cases such as pop-up shops, public events and performances, or branches that operate part-time.

Managed Service: A cloud-managed service that requires on-site technology may be served by 5G. Avoid connecting to the corporate network, go direct to 5G. Suitable for short-term engagements, pilots etc.

3.1 Remote Working

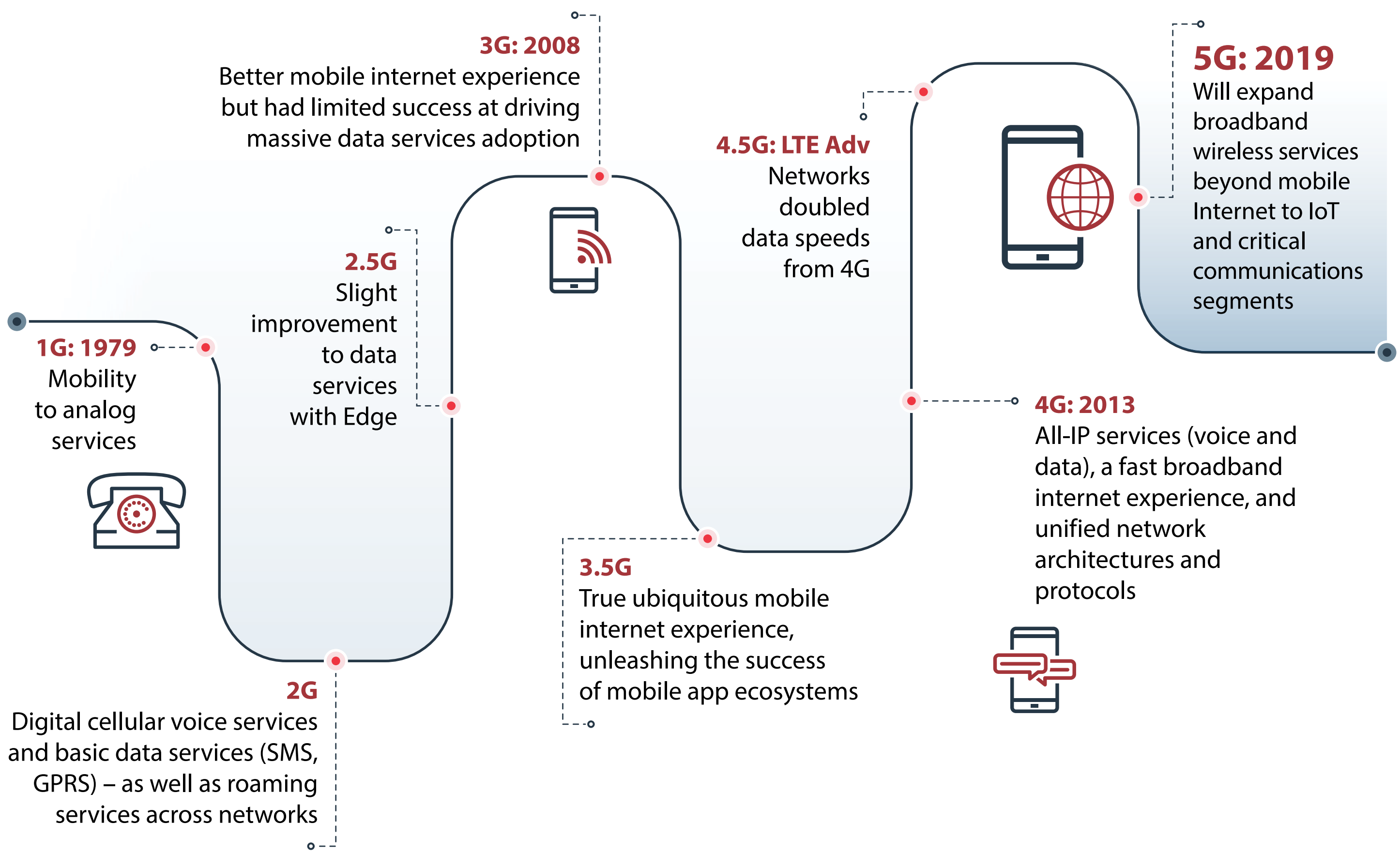
As public WAN (Internet) bandwidth increases, so does the capability for remote working. Robust mobile bandwidth should improve the remote working experience for those users that need mobility and find 3G/4G is limited.

3.2 Voice and Video

Early generations of mobile networks focused on voice calls and closed network messaging (e.g., SMS, MMS). You will notice that 5G goals do not mention voice or video as most users have moved to OTT data-based services that use IP protocols.

3.3 Mobile Standards Progression

It's worth noting the transition from voice to data as standards have progressed:



3.4 Comparing 3G/4G/5G

This table roughly compares details between 3G, 4G, and 5G. It's useful for understanding the progression in speed and the transition from voice/circuits to packets.

Feature	3G	4G	5G
Frequency Band	1.8 – 2.5 GHz	600 – 1 GHz 2 – 8 GHz	600 MHz - 6 GHz (mmWave) bands (24 – 86 GHz)
Frequency Bandwidth	5 – 20 MHz	5 – 20 MHz	5 – 20 MHz Multichannels
Data Rate	Up to 2 Mbps (384 kpbs WAN)	Up to 20 Mbps or more	Up to 20 Gbps
Access	Wideband CDMA	CDMA or OFDM (TDMA)	UF-OFDM, GFDM
Switching	Circuit/Packet	Packet	Packet

What does this mean in terms of real bandwidth? The following table shows maximum and typical bandwidths for each standard. For completeness, it also shows the variations in technologies under each major 'G' release.

Generation	Technology	Max Download Speed	Typical Download Speed
3G	3G (Basic)	0.3 Mbit/s	0.1 Mbit/s
	HSPA	7.2 Mbit/s	1.5 Mbit/s
	HSPA+	21 Mbit/s	4 Mbit/s
	DC-HSPA+	42 Mbit/s	8 Mbit/s
4G	LTE Category 4	150 Mbit/s	12 – 15 Mbit/s
4.5G (or +)	LTE-Advanced CAT6	300 Mbit/s	24 – 30 Mbit/s
	LTE-Advanced CAT9	450 Mbit/s	60 Mbit/s
	LTE-Advanced CAT12	600 Mbit/s	TBC*
	LTE-Advanced CAT16	979 Mbit/s	TBC*
5G	5G	1,000 – 10,000 Mbit/s (1-10 Gbit/s)	TBC*

*To be confirmed. No real-world figures are currently available.

3.5 False 5G

As the table shows, advancements such as Cat12 and Cat16 offer improved speeds over standard 4G, but they are not 5G. Some providers, namely AT&T in the United States, have falsely marked 4.5G or 4G+ phones with 5G logos. Other providers may follow suit, but this is deceptive marketing.

4.5G has been around for quite some time and is completely incompatible with 5G. This appears to be a political move to appease the current U.S. federal government and moves to take a new approach to mobile infrastructure.

4. WHAT 5G OFFERS TO USERS

5G technology standards have 8 specifications that drive the technology:

- Up to 10Gbps data rate - > 10 to 100x improvement over 4G and 4.5G networks
- 1 millisecond latency
- 1000x bandwidth per unit area
- Up to 100x number of connected devices per unit area (compared with 4G LTE) 99.999% availability
- 99.999% availability
- 100% coverage
- 90% reduction in network energy usage
- Up to 10-year battery life for low-power IoT devices

These statements are aspirational design goals but it would seem that most of them are being met.

Increased speed and latency in the radio network by moving to an IP-native radio encoding will result in visible responsiveness because the current 4G latency is 10-20ms.

The high data rate enables service providers to consider offering mobile broadband services to the home. Pricing could be competitive with fixed broadband by avoiding the capital cost of installing physical cabling.

Improvements to network power consumption should reduce costs and address environmental concerns. The use of virtualization, containers, and software-operated POPs will be key.

User devices may also consume less power.

4.1 Low Power and IoT

There are (too) many initiatives for low-power 5G technology, including Z-Wave, SigFox, LoRa, NB-IOT, and others.

Broad technical features include:

- Low frequency
- Low bandwidth / low speed / low data rate
- Long distance (a function of lower frequencies)

IoT is a new market and worth many billions (how many billions varies among analysts) and this causes a special type of faux-innovation brain blackout at vendors. In telco-land, when a new market emerges, the instinctive reaction is to take ownership and control of the new market by developing a proprietary technology and pretending that it has special magic powers.

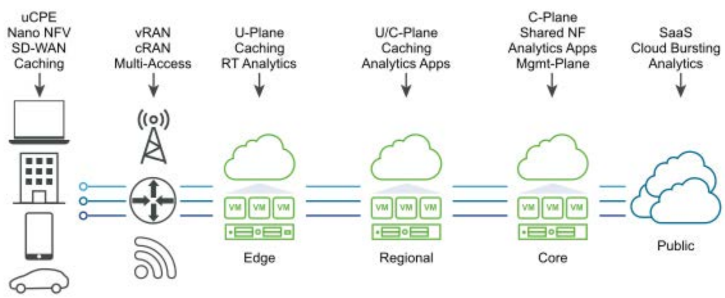
This topic is covered in more detail in the "Low Power 5G" section.

4.2 Expect 3-5 years to mainstream

The next phase of standards for 5G are expected to be complete in 2020. It's unlikely that the majority of smartphones will have 5G support until 2021 or so. Mobile carriers will deploy a few 5G towers in certain cities and towns. These will be part marketing, part demonstration, and part evaluation.

5. SERVICE PROVIDERS AND 5G

5G has three separate infrastructure networks: Radio, POP (or Edge), and Backhaul. Each of these networks has different equipment, vendors, and operations.



Source: Vmware Vcloud NFV

Note: The number of functional areas varies according to your perspective. Some analysts claim five or seven.

5.1 Radio Changes

New radio systems will be deployed to take advantage of the large amount of new spectrum allocated and purchased for 5G wireless connections. Antennas, towers, and other infrastructure require substantial changes to use the new spectrum and will need to be deployed before smartphones will be available to use them.

The use of modern software defined radio methods such as MIMO, Massive MIMO, and Beamforming offer substantial improvements to the customer experience. (More details in the next section).

5.2 Backhaul

A key 5G value is improved speed, with promises of gigabits per second per device. This will require upgrades in the network backbone to shift more data around. Specific impacts include:

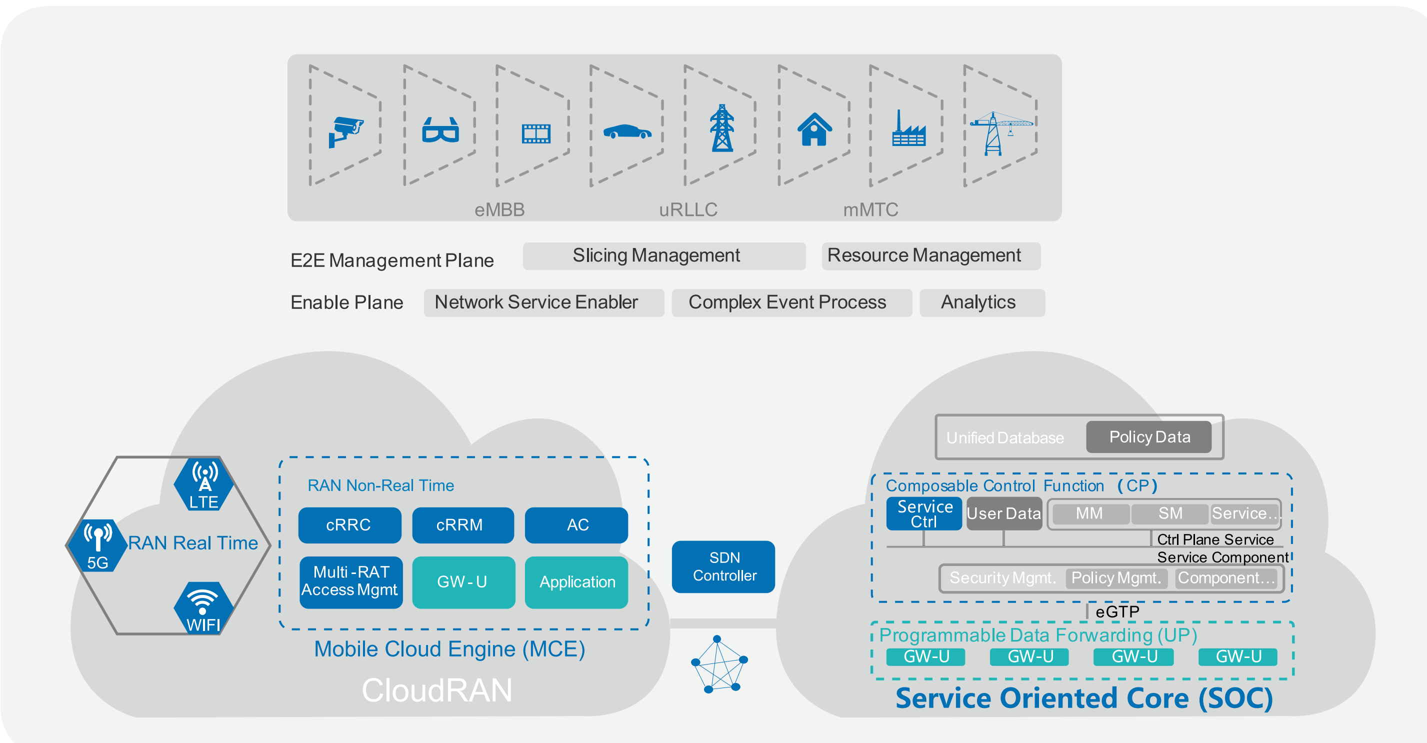
- Upgrades to optical networks with new WDM equipment to increase fibre data speeds to 100, 200, and 400G
- Upgrades to routers and switches to support higher network speeds, especially 100G
- Changes to tower equipment to increase user density, reduce processing delays for user authentication, and support accounting

5.3 POP / Edge Changes

Most service providers seem to agree that moving from monolithic physical appliances to virtual infrastructures such as OpenStack or Kubernetes (or both) is the future. This will drive a generational technology process transition from manual process to a software operations model.

5.4 What Service Providers Hope to Achieve

Most service providers have slow moving, fixed, expensive infrastructure. The emergence of cloud, virtualization, and wide-scale automation and orchestration systems may help providers transform their infrastructure and operations to be more flexible, dynamic, and software-driven. Platforms such as CORD use well known hypervisors, software storage, and SDN to operate mini-data centers at the edge of the network.



Source: Huawei - 5g Network Architecture A High-Level Perspective

5.5 Multiple Services, Standards, And Site Types

5G networks must be able to provide diverse services with different KPIs, support multiple standards at the same time (5G, LTE, and Wi-Fi), and coordinate different site types (macro, micro, and pico base stations). The challenge to create a network architecture capable of supporting such flexibility while meeting different access types is difficult at telco scale.

5.6 Multi-Connectivity Technologies

5G is expected to co-exist with 4G LTE and Wi-Fi for an extended period of time. Multi-connectivity technologies must be coordinated based on traffic and mobility requirements of user equipment to provide sufficient transmission throughput and mobile continuity.

5.7 On-Demand Deployment

5G network architecture will be designed based on access sites and three-layer DCs. According to different service requirements, fiber optic cable availability, and network resource allocations, RAN real time and non-real time resources can be deployed on site or on the access cloud side. This further requires that the service gateway location may also be deployed on the access cloud or on the core network side.

5.8 Flexible Orchestration of Network Functions

Enhanced Mobile Broadband (eMBB) requires a large throughput for scheduling. Ultra Reliable Low Latency Communications (uRLLC) requires ultra-low latency and high reliability. Networks must flexibly orchestrate network capabilities to consider service characteristics. This significantly simplifies network functions and increases network efficiency.

5.9 Shorter Period of Service Deployment

The current technology stack is fixed and hard to change. Adopting 'software defined' or 'software operated' infrastructure in the network should increase the rate of change at lower cost points. This is basically similar to the benefits that virtualization and cloud offer to enterprise data centers today.

6. MODERN RADIO METHODS

5G will adopt modern technology for managing radio signals using new radio methods such as Beamforming and Massive MIMO. Also significant is the use of software defined/programmable radios for rapid changes in spectrum allocation and management.

Beamforming or spatial filtering is a signal processing technique used in sensor arrays for directional signal transmission or reception. This is achieved by combining elements in an antenna array in such a way that signals at particular angles experience constructive interference while others experience destructive interference. Beamforming can be used at both the transmitting and receiving ends in order to achieve spatial selectivity. The improvement compared with omnidirectional reception/transmission is known as the directivity of the array.

– Wikipedia

MIMO (multiple-input and multiple-output) is a method for multiplying the capacity of a radio link using multiple transmission and receiving antennas to exploit multipath propagation.

– Wikipedia

Software-Defined Radio (SDR) is another key technology change. Software is used to drive the radio access network that connects endpoints. Previously, analog or fixed systems would decode the radio signal, but the fixed systems couldn't be changed. SDRs offer opportunities to add new radio protocols and frequencies over time.

SDR is a radio communication system where components that have been traditionally implemented in hardware (e.g., mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented by means of software on a personal computer or embedded system. While the concept of SDR is not new, the rapidly evolving capabilities of digital electronics render practical many processes which were once only theoretically possible.

– Wikipedia

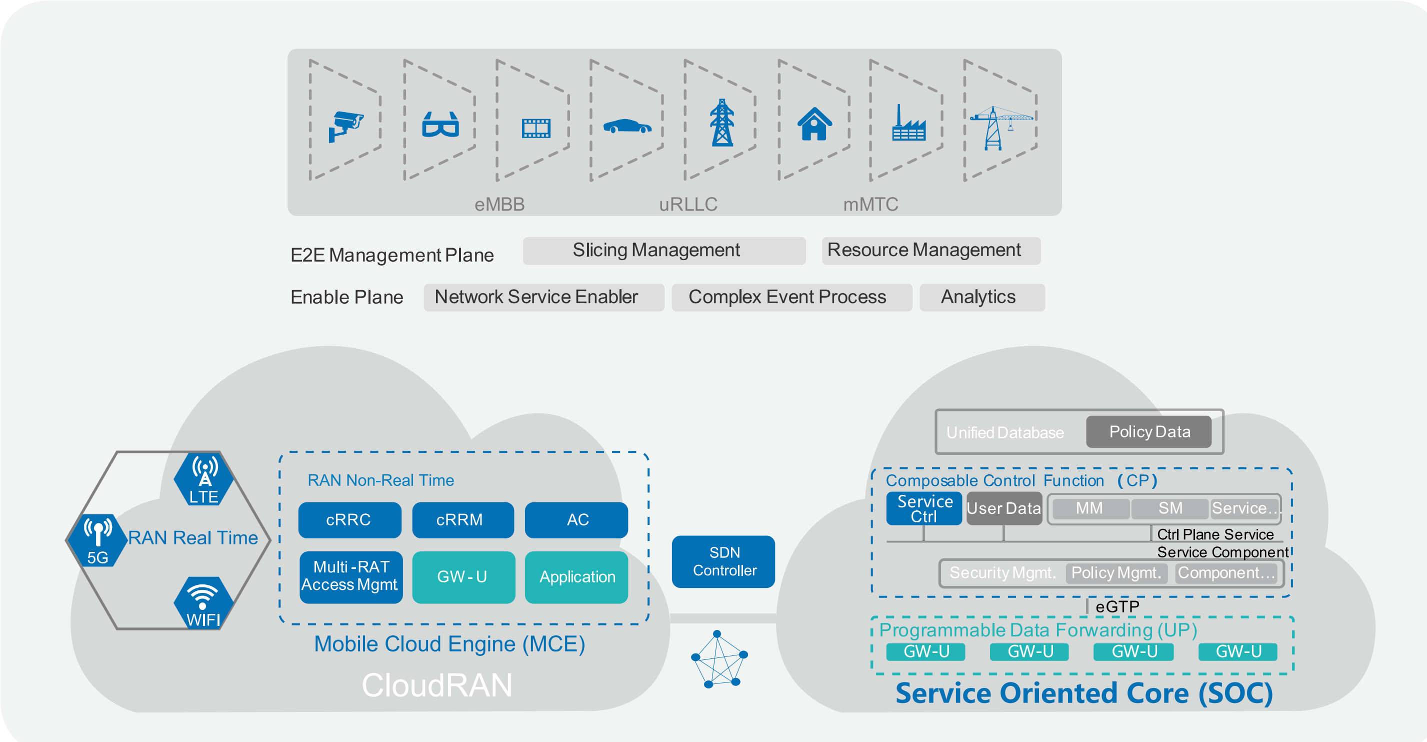
SDR is vital for scaling MIMO and beamforming because they can adaptively lock onto directional signals and thus receive weaker transmissions, increasing the range and speed. Spectrum management for mobile telcos is a critical area of profitability. The ability to reallocate spectrum from one tower to another, or to adjust the transmission power to open capacity in the next suburb, or to quickly add new frequencies to increase capacity has always been desirable but somewhat impractical do the slowmoving nature of radio infrastructure.

Using software to program antennas and radio, in combination with improvements in monitoring and analytics, changes the business model. Lower operational costs, improved density, and better throughput should improve profitability. For 5G radio vendors, this will be prime area of innovation as software signal processing is new while minimizing increased power consumption of x86 compute (a key issue for edge processing).

7. CLOUD RAN

Today, service providers operate their radio access networks from self-operated data centers. As discussed in the previous section, Software Defined Radio will use far more compute infrastructure at the edge POP and in the core platform.

Some vendors offer virtualization platforms like VMware vCloud or OpenStack to move to modern infrastructure and replace the dedicated physical appliances in use today.



Source: Huawei - Vmware Vcloud NFV

Cloud-based RAN solutions are on the market. They offer telcos a fully managed platform for the RAN where the available capacity is effectively infinite and many operational dependencies are removed.

For enterprises accustomed to slow moving, lumbering service providers, there is hope that some providers could dramatically improve their service.

7.1 Edge Computing

Under each radio tower is a small base station that houses operational equipment. Twenty years ago, these towers were furnished with proprietary and highly customized equipment. More recently, the equipment vendors have been using x86 computers dressed up as custom equipment (i.e., Nokia IPSO Linux) to deliver a monolithic, integrated, full-service solution.

Cloud computing has forced a change in the land of the telcos, and applications are moving to virtual machines. This leads to the base station transforming into a micro-data-center running orchestration tools for VMs, networking, and storage.

There are several names for this product change, but edge computing leads the buzzword bandwagon. Some marketing describes edge computing as a rise in smarter IoT devices that are more like computers than dumb devices of today.

It's likely that 'edge computing' will be used to describe any sort of compute that isn't in a public cloud.

8. LOW POWER 5G

Low power 5G is a group of technologies intended to enable low-power, battery operated devices to connect directly to 5G networks instead of using short-range wireless (e.g., Bluetooth/WiFi).

These technologies are hyped as enabling the future of IoT. Most IoT communication will be machine-to-machine, such as probes, sensors and devices communicating with a central application to collect data or take action.

5G could possibly be used in IoT, but it's too early to call. The primary drawback is the cost of 5G service in a licensed spectrum compared to a private WiFi network.

Another limiting factor may be the confusing mishmash of 5G standards in this space, including NB-IoT, LTE-M, and LoRa. NB-IOT is an open standard, LTE-M is part of the 4G standard, and LoRa is proprietary.

8.1 Key Aspects of Low Power 5G

Low frequency: Lower frequencies propagate further and use less power to transmit a signal. Expect to see allocators in the sub-1Ghz range, likely 700khz where older television spectrum has been reclaimed.

Low bandwidth: Devices are expected to be simple, single-function, and unlikely to transfer large volumes of data.

Long distance: Low power 5G should provide sufficient coverage over long distances, and penetrate buildings where sensors will be located.

Low data rate: Devices are likely to be quiescent for long periods of time to save battery. When active, they could transmit just a few hundred bytes before shutting down. There is limited capacity to handle user authentication, such as 3G/4G does for mobile phones.

Long battery life: Standards are targeting 10 years of operation on a single battery (such as a CR22 button battery). It's possible that some devices could draw power from ambient radio signals, but this is likely several years away. These features will have substantial impact on device management and load predictions because devices are effectively 'always off', unlike the 'mostly on' status of existing 3G/4G devices.

8.2 What Low Power Means for Enterprises

There is a lot of change happening in enterprise WiFi. New standards such as 802.11ax promise gigabit performance. New hardware and software platforms offer better features for identity management, automation, and so on.

When planning for future density, consider that many devices may not connect to the WiFi network but directly to 5G.

For example, a building management company may deploy sensors throughout a building to offer a service for cooling and heating. For some companies, these sensors could connect directly to the 5G network, require no power for up to 10 years, and require very little administration.

Technologies such Bluetooth Low Energy (BLE), Sigfox, and Zigbee are being promoted as solutions for location tracking and beacons that use the unlicensed spectrum. 5G has proposed standards for these services and may offer alternatives.

Don't over-invest in WiFi on the premise that a massive growth in IoT devices will use your WiFi network to connect to off-site management software

9. PERFORMANCE OF A RADIO NETWORK

This section provides some background on the capacity and throughput of wireless networking, which is defined by signal frequency and signal type. Please note that this a practical summary and not a comprehensive analysis.

The reach or distance of a radio signal is determined by several factors:

9.1 Sensitivity and strength

In 5G, the strength or power of the transmitted signal is rigidly controlled by law. This ensures that a transmitter does not impact other transmitters or overload the receiver.

Receiver sensitivity is determined by the physical equipment itself, such as build quality, antenna design, and electronic components. Expensive receivers have greater sensitivity and can decode lower power signals (as money improves quality). Minimum sensitivity is defined in the standards.

Note that all devices send and receive signals. The difference between a base station and handset is the number of different radio streams being handled.

9.2 Reach

Low frequency signals, say below 1 Gigahertz, are less impacted by noise and obstructions. For example, television and AM radio operate in the 600 – 800Mhz range, where the distance from antenna to receiver can be measured in the hundreds of miles.

High frequency signals attenuate (weaken) as they propagate through the environment (air), are more susceptible to noise, and might not pass through obstructions such as trees, glass, or walls.

9.3 Bandwidth

Low frequency signals have slower digital data rates while high frequency signals have higher rates. See Nyquists-Shannon Theorem for more.

Bandwidth can be improved through specific encoding such PAM or QAM, which improves the amount of data carried, though at the cost of complex encoding and decoding processes.

9.4 5G spectrum allocations

4G LTE supports burst download speeds above 200Mbps and sustained speeds at 40Mbps. New 5G standards have the potential to reach 20 Gbps, though only under specific conditions.

Mobile devices must be able to connect at very high frequencies to achieve full duplex and high data rate connections. While Software Defined Radio can optimize the signal and thus throughput, improvements to the radio network are only one part of the user experience. Backhaul networks, Internet connectivity, and servers will affect performance.

Link: 5G - Waveform Candidate - 5G - http://www.sharetechnote.com/html/5G/5G_FR_Bandwidth.html

9.5 Spectrum Breakdown

Current 3G and 4G spectrum uses lower frequency bands than 5G networks. It's a complex topic to outline, but lower frequencies can penetrate buildings and travel longer distances. This improves the economics of network buildout.

As frequencies increase, particularly into mmWave, penetration and reach reduce dramatically.

Souce: Qualcomm

For 5G networks, the spectrum is broadly separated into 3 layers.

- **Sub 1Ghz** spectrum will provide coverage at low data rates. The signal propagates farther and reaches indoor locations. Some countries have reallocated spectrum from analog television (by replacing it with digital television) to increase capacity.
- **1Ghz - 6Ghz** will be for capacity and coverage. The higher frequency improves the data rate. Most allocations are around the 3.5Ghz band and operate well for open air use; e.g., streets, cars, buses, and so on. Some indoor penetration is possible depending on the receiver's distance from the base station. 1Ghz - 6Ghz will be the main frequency band for 5G operations.
- **30Ghz - 300Ghz** is a super data transfer frequency band for high capacity. While the signal has limited range and poor penetration, the high data rates will reduce load on other spectrum and increase capacity. Longer term, it will be useful for high density environments such as office towers and residential buildings, where mobile broadband may replace wired Internet.

9.6 Variation by country

Radio performance is often dictated by spectrum licensing and the licenses each telco has in a given area.

In the United States, many of the licenses for 1Ghz - 6Ghz spectrum are owned by satellite companies. The wireless telcos have focussed on 4G LTE Evolution standards that let them use their mmWave spectrum licenses to improve data. Perhaps unwisely, they have renamed this 5G Evolution to make claims that they have 5G, which they do not.

9.7 Reallocation

Many existing telcos have spectrum licenses that have been used for 2G and 3G. The protocols on that spectrum are not compatible, and thus older networks are actively shut down.

As the number of paying customers shrinks on those technologies, the spectrum is reallocated to 4G and 5G networks. Modern smartphones have programmable modems and flexible antennas that allow handsets to operate over a range of frequencies that are defined in relevant standards and likely do not require hardware upgrades.

Remember that newer standards are faster, denser, and often need less device power, which offers customers incentives to migrate.

9.8 mmWave, Microcells and WiFi Offload

mmWave spectrum sits between microwave (30Ghz) and infrared (300GHz range) wavelengths. These very high frequencies carry vast amounts of data due to spectrum breadth. However, the signal cannot travel long distances or pass through physical barriers measured in tens or a few hundred meters (less than today's WiFi). This is well suited to densely populated cities or high-rise buildings. The short distance allows for spectrum reuse in adjacent areas, further improving performance.

For low-density areas, mobile broadband services over 1Gigabit seem unlikely for several years because of limited lower frequency spectrum that would have enough reach.

This may require micro-cell devices deployed inside buildings to get high density and high-speed coverage. In principle, this would be similar to today's WiFi. Note that previous attempts at microcells for 4G failed, so there is reason to be skeptical.

9.9 WiFi offload

WiFi offload may be important in 5G's early rollout. If customer devices can transparently connect to WiFi as well as 5G, 4G, or 3G networks, the network operator may be able to get flexibility. It's not yet clear how a device could decide which network is optimal and when to switch between network base stations / micro cells with WiFi.

9.10 Political Geofencing

Like most mobile wireless upgrade cycles, the transition to 5G has become politicized. We should remember that the transition to 3G and 4G were accompanied by a substantial media circus and marketing efforts. If history repeats, then 5G will have a similar path.

9.11 Why Politics?

- Governments own spectrum and sell it for state revenue
- Governments want to ensure that their countries are business competitive; and public data networks are key element in business productivity
- Communications networks are a linchpin of modern society. Disruption of networks may lead to civil unrest

Will the divided political landscape make network slicing fail? Will governments support 5G networking and actively encourage telcos to roll out new infrastructure?

10. WHY SO MUCH HYPE?

There's a lot of coverage about 5G networking. What drives it?

10.1 Huge Money

The 5G market is projected to be tens of billions per year. Total market value is some epic number like $1 trillion.

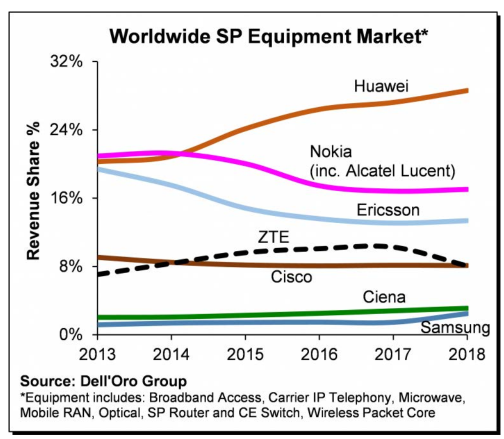
Dell'Oro: "The latest Mobile RAN 5-year forecast report claims the robust demand for 5G NR will propel the cumulative worldwide RAN market to nearly $160 B over the next five years." - That's just the radio network.

IDC: "IDC Forecasts 5G Network Infrastructure Revenue to Reach $26 Billion in 2022 as Network Build-Outs Progress and 5G-Enabled Solutions Gain Traction". A Google search will show massive numbers in just about every area.

10.2 Market Competition

5G represents a once-in-decade market transition for telcos and equipment vendors. The transition is both an opportunity and a risk for telco suppliers. Losing multi-billion dollar sales will have substantial impact on business performance, forecasts, and share prices.

The 4G market is stable and mature. Research from Dell'Oro suggests largely static market shares between major brands.



10.3 4G Reaching Capacity, Internet of Things

4G networks are projected to reach capacity some time between 2021 and 2025. Compared to 5G, 4G has less spectrum available and makes less efficient use of it. While the numbers of consumer smartphone has stabilized (there are only so many people in the world), it is reasonable to expect that IoT will increase the number of devices that want connectivity.

It's not a given that all these IoT devices will connect to public networks. For example, consumer devices connect to home WiFi networks and use wired broadband.

10.4 Global Competitiveness

Spectrum auctions from governments for 5G-ready spectrum have been underway for a number of years. As discussed in the previous section, better telecommunications is important to national economies.

10.5 WiFi 5 Vs. 5G

Note: The Wi-Fi Alliance is attempting to simplify wireless standards with a new naming convention:

- Wi-Fi 6 to identify devices that support 802.11ax technology
- Wi-Fi 5 to identify devices that support 802.11ac technology
- Wi-Fi 4 to identify devices that support 802.11n technology

There is quite a bit of confusion in the press and media on the difference between 5G and WiFi 5, so beware of that when researching.

To make matters more confusing, some 5G carriers plan to use WiFi in the unlicensed spectrum to offload traffic from their licensed spectrum. This means that WiFi-capable endpoints (smartphones most likely) would be directed to WiFi connections to reduce load on licensed 5G spectrum.

So WiFi 5 is a sub-component of 5G, but its standards are developed by the WiFi Alliance. 5G standards are developed by 3GPP.

Link: Wi-Fi Alliance® introduces Wi-Fi 6 | Wi-Fi Alliance - https://www.wi-fi.org/newsevents/newsroom/wi-fi-alliance-introduces-wi-fi-6

Link: 3GPP - Release 16 - http://www.3gpp.org/release-16

11. IMPROVED IDENTITY SYSTEMS

This point isn't directly related to 5G networking, but the market transition will require new hardware and the opportunity to improve subscriber identity and security.

SIM cards are being replaced with embedded SIM (eSIM), a secure, tamper-proof but programmable chip enclave. Available in various form factors, either plugged-in or soldered, eSIM is expected to be standard in 5G devices. It should also provided better subscription management by mobile companies

RED RIVER
Corporate Headquarters
21 Water St., Suite 500
Claremont, NH 03743
800.769.3060 toll free
603.448.8880 phone
603.448.8844 fax

redriver.com

Red River