The dawn of the 5G world

How 5G technology will ultimately alter the DNA of the digital experience

Introduction

We stand on the doorstep of the 5G world.

When the Wright brothers invented the airplane, it fundamentally altered how we experience traveling.

It wasn't just about speed. Yes, it was great getting from Chicago to Miami in less time. But flight also gave us thrill of defying gravity and soaring to new heights.

Flight became a new "user experience" for every traveler: the space-age feel of the airport; the visceral rumble in the chest as the turbine engines fire up; the press of G-force as the plane accelerates down the runway; the flutter in the stomach as the plane leaves the ground; the exhilaration of bursting through the clouds cruising at 30,000 feet.

Just as the airplane fundamentally changed the traveling experience and set off a chain reaction of innovation, so too does 5G promise to alter the nature of our digital experience.

Some hear "5G" and just think it means faster connection speeds. However, it goes beyond that. As it matures, 5G is expected to alter the very DNA of our user experience in dramatic, exciting ways—from leisure to healthcare to retail to manufacturing to finance and beyond.

To imagine what's coming, it helps to look back where we've been. How would your business be faring if you never adopted any mobile technology beyond the 2G world? It's like opting to keep the abacus instead of upgrading your team to computers and spreadsheets.

In this whitepaper, we will examine some of the key drivers of 5G innovation. We'll look at 5G as a new experience—and as a possible enabler of radically new ways to do business. Finally, we'll also look at a timeline of our path to 5G, and what you can do to prepare for what promises to be the next great, world-and-mind altering experience.

Key drivers

Several catalysts are accelerating the genesis of a 5G world. This section provides a quick overview of these key drivers.

The need for network technologies to work in harmony

Businesses and organizations find themselves in an increasingly complex network world.

In the realm of network services, a retailer or restaurant may need VPN (virtual private network) while also being able to provide access to public Wi-Fi®.

An enterprise now must move efficiently across multiple clouds and cloud platforms for processing, networking, colocation, and content delivery. As businesses navigate wireline and wireless networks, they are turning to software-defined networking (SDN) and network function virtualization (NFV).

SDN and NFV unbind network services that were once bound. The ability to divide these services into smaller, software-driven functions lets businesses, operators, and cloud providers deploy and configure these services where and how they need them. They also enable businesses to expand and contract network bandwidth based on need.

With the tides of data continuing to rise, businesses must transform through virtualization and automation to optimize the cost and scale of the experiences they want to create. Businesses must also manage mobile devices, apps, and a variety of voice and collaboration tools so their teams can connect across geography, platforms, and devices.

All these separate networks, solutions, and connections create potential chaos and gaps. They lack interoperability — or at most have spotty, hard-to-set-up interoperability. It's a bit like the frayed end of a rope, with individual fibers unbound and sprouting in different directions. That end of the rope is weaker. Developing the technology that has the capability to allow the convergence of wireline and wireless networking is like taking the frayed end of the rope and weaving it back into a unified whole.

From the core of their network all the way to the far reaches of their digital technologies, organizations want an entire tech ecosystem that integrates all these services, solutions, and products seamlessly so they work in concert. And they want more control, visibility, and personalization. It's the nature of the on-demand society in which we live, exemplified by trends like the consumerization of IT.

The cybersecurity arms race between businesses and digital criminals

5G means new opportunities for businesses to innovate. It also means more opportunities for bad actors and hackers to innovate. For example, edge clouds and IoT devices have multiplied at an exponential rate. While they represent new capabilities and services that enhance businesses, they also represent a mind-boggling amount of new endpoints and threat planes. These can be doors into the network — ways hackers can get to your data and assets.

As 5G technologies coalesce and codify, businesses want the 5G world and network — and the capabilities it can enable, all wrapped in security. Though the standards for the 5G core are still in flux, we do have indications that it will have some cool and effective features like common authentication between different access networks, new security key concepts, edge proxies, and more.

Unleashing the full potential of emerging experiences

Today, 4G is enabling many use cases. We are familiar with the Internet of Things (IoT), augmented reality and virtual reality (AR/VR), artificial intelligence and machine learning (AI/ML), autonomous vehicles, and drones. However, being able to use these tools in a distributed, highly dynamic, and mobile way has come with its challenges. There are some things not yet possible with our current network bandwidth, latency, and compute power.

For example, for users to get the best experience from their VR headsets and apps they need an extremely low motion-to-photon ratio—that's the time it takes for the data to respond to your movements and reconfigure the VR image.

When you move your head, the VR display should instantaneously reflect it in your virtual world. The greater the delay between your movement and what you see, the more "off" your virtual world appears. If it gets too jittery, it can make you feel seasick since your brain sees one type of motion, but your inner ear feels another reality. The dissonance between the two is annoying at best and sickness-inducing at worst.

If all content is local to the device then processing is faster. However the more dynamic the content is (e.g. non-localized; the device app relies on data transport and interactions from the network), there's a greater chance this data will cause nausea due to data latency.

The goal of the medium is true immersion — creating an illusion so real that it tricks the human brain completely.

To give you sense of scale, the typical refresh speeds for a computer screen are approximately 80ms. However, for AR/VR, the industry is driving the conversation toward the Vestibulo-Ocular Reflex (VOR) — the neurological process by which the brain coordinates eye and head movements to stabilize images on the retina. This is critical to synchronizing virtual and real objects to create a coherent view. The entire VOR process takes the brain 7ms, a more than 10x reduction over screen-to-brain propagation.[1]

Today's VR systems recommend a latency of <20ms for standard performance, and very low latency (<7ms) is even better. For this reason, developers and inventors want even lower latency to realize what they envision for the next iterations of VR.

While some level of AR/VR is here today, in most cases it's localized content, and to do a distributed and dynamic push of content based on analytics, it's imperative that latency is as low as possible.

Remember, we said that 5G is more than speed — it's an entire experience. 5G will do more than lower our latency — it will be able to create interactive personalized experiences, potentially even based on what you like and where you are. These dynamic AR/VR experiences will need to rely on extreme amounts of compute power, data flow, and low latency.

[1] Weldon, Marcus K. "The Future X Network: A Bell Labs Perspective." 2016.

The stakes are high: safety, performance, and reliability will need a network that delivers high speeds and data quality with ultra-low latency. Further, piecing together service, connectivity, and security as many companies do today may not cut it.

And if every millisecond counts for virtual reality, think how much low latency means to the autonomous car user experience? For passengers and pedestrians alike, it's a matter of life and death as to how fast the data travels and the quality of that data once it reaches its location.

The innovation around these vehicles alone is expected to spur the global market for autonomous driving sensor components: $4B by 2020, $15B by 2025, and $25B by 2030 (https://www.statista.com/statistics/423106/projected-global-market-for-autonomous-driving-sensor-components/).

The stakes are high: safety, performance, and reliability will need a network that delivers high speeds and data quality with ultra-low latency. Further, piecing together service, connectivity, and security as many companies do today may not cut it. Autonomous cars, and other new solutions, will need tighter integration between the application and the transport network.

Google's self-driving car currently generates 3.6 TB of data per hour (http://about.att.com/story/reinventing_the_cloud_through_edge_computing.html) and for optimal performance, needs the ultra-low latency 5G

promises. We're not there yet. A lot of processing will be done in the car, but some amount of macro data will be needed for the car to see things like cyclists that aren't as easy to predict as cars in a platoon, or for sharing data from other cars or smart cities. This is the intra/inter-connectedness that 5G promises.

5G as a technology

We say 5G, but what does it mean? Remember, it's not only speed — it's user experience. This section provides an overview of what we believe 5G will ultimately be able to deliver.

Not just another G — how future 5G and complementary technologies will change the DNA of the user experience

Let's say you live in the suburbs and you drive to work. It's about 20 miles to the downtown office once you hit the interstate. Ten years ago, the commute wasn't too bad, but now it's congested and slow. How do you improve your commuter experience?

1. Capacity is one consideration. You can make the Interstate wider, adding more lanes from one end of the commute to the other so you can accommodate more traffic.

2. Speed is another consideration. You can raise the speed limit and get faster cars on the routes.

3. Proximity is a third consideration. You can move closer to the office — so essentially you live on the edge of your office's property. Because while speed is important, if you only live 3 blocks away and ride a scooter, you'll get there in less time than if you bought a Ferrari and zoomed down an uncongested Interstate at 190 mph for 20 miles. But one downside is the cost of real estate — you may not be able to afford as many square feet of living space near the office as opposed to the suburbs, but your commute experience is better.

4. Traffic management is your final consideration for making your end-to-end commuting experience amazing. You could create HOV (high occupancy vehicle) lanes on the interstate and put programmable lanes on the surface streets around the Interstate. HOV lanes create priority lanes with less traffic for certain types of vehicles. And programmable lanes, often seen around sports stadiums, route traffic based on current congestion information. You improve how the road treats you — not how you treat the road.

Now let's translate the analogy.

1. Capacity is bandwidth. 5G will ultimately not only support a better experience per device, but also for more attached devices, such as AR goggles, machines, sensors, and drones. 5G will and its architecture will theoretically be like adding many more lanes to a 4-lane interstate.

2. Speed is how fast the data can travel. As 5G evolves, a 5G network will be like giving each car an engine with incredible top speeds and then raising the speed limit to allow for ultra-rapid transit time.

3. Proximity is the power of the edge. The 5G network (core and RAN) is designed from the get-go to be flexible and better suited for edge deployment. It brings compute resources and services closer to your work and home. Services that currently reside in a central cloud outside the mobile network can be pushed to the edge so they're on the doorstep of the devices. It will improve overall experience, end-to-end latency — not just network latency.

4. Traffic management is, as the name implies, how you manage data traffic across hyper-busy networks so it travels with reliability. Network slicing lets network operators open dedicated virtual networks over a common network infrastructure to provide functionality specific to the service or customer. It's like opening HOV lanes on the wireless network. Today we have a better Class of Service (CoS) app that can re-route traffic around jams or accidents on your route — but tomorrow virtual networks can be created on the mobile network that could essentially help the mobile network be MPLS-like.

5G is more than just speed. It is a conglomeration of technologies that will elevate and enrich the user experience from end to end.

User Experience = Speed + Latency + Reliability

The foundation of 5G

Many components of 5G are still being developed and perfected. Still, some communications companies have been conducting field tests in several cities (more on that later). These are the basic concepts underlying a 5G world.

The Peanut Butter Principle: How 4G and 5G will complement each other

If you're like many in the business world, you've been wondering if 5G will be compatible with existing 4G architecture and capabilities.

The answer is, "yes."

We call this The Peanut Butter Principle. Let's say you have a slice of bread. First, you put on a layer of smooth peanut butter. Then, you decide you want to improve the overall experience of eating your sandwich by adding some crunch. So, you spread on a layer of crunchy peanut butter over the smooth. One does not replace the other; rather, one enhances the other.

Think of the smooth peanut butter as the current LTE spectrum and the crunchy peanut butter 5G and other technologies — newly introduced elements to the peanut butter already on the bread.

It's all still peanut butter and the two blend and complement each other.

Furthermore, we're laying the foundation for 5G with LTE-LAA. We've also upgraded cell towers with LTE Advanced features like 256 QAM, 4x4 MIMO, and 3-way carrier aggregation. LTE-LAA is technology where we are able to utilize unlicensed spectrum along with licensed spectrum. These technologies serve as the runway to 5G by boosting the existing LTE network and priming it for the future of connectivity. We can enable faster speeds now, and upgrade to the 5G experience when it's ready.

What will your business look like: Use cases from the new industrial revolution

In this section, we look at how you can bridge the gap between today and the future. We'll also look at different industries and the ways 5G is projected to enhance user experience in each sector.

Laying the foundation now for 5G later

Before we look at future-looking 5G use cases, it's instructional to list some key preparations you should consider having in place so that you're ready for 5G.

- SDN and NFV — The more you can virtualize your network through SDN and NFV the readier you will be to add the features and upgrades made possible by 5G. When the network has more variables, you will be able to adjust quickly and efficiently on the fly thanks to software.

- Cloud competence — Where is your organization when it comes to colocation, cloud networking, a content delivery network, cloud disaster recovery, and virtual data centers?

- Cybersecurity — Do your security plan and capabilities cover your network from one edge to the other? Can you manage threats through strong threat intelligence? Do you have in place security for data and apps, the network and the cloud, mobile endpoints and devices, and IoT?

Healthcare

Leaders in the healthcare industry agree that patient experience is paramount. Improving the healthcare experience is a key trend that will determine whether healthcare providers succeed or fail.

Current tech trends: Wearable health devices, health monitoring and diagnostic apps, telemedicine, AI for process automation in hospitals, cybersecurity to protect electronic patient records

Predicted trends: Value-based care (rising costs of care, electronic medical records, personalized care and precision medicine, payment reforms and patient engagements); pressure to maintain profitability (staff productivity, facility efficiency, process streamlining, cost reduction— all while being innovative); growing patient demands (patients consume healthcare differently, virtualization of care, rise of informed and cost-clarity consumers, emerging social applications and new competitors); infrastructure readiness (expanding ecosystem to meet the customer where they are, infrastructure readiness and interoperability, cybersecurity and information access)

Future potential 5G use cases:

5G will begin to help solve business problems that drive revenue realization, helping healthcare providers be more profitable, efficient, smarter, secure, and most importantly more effective in caring for the patient.

Getting an annual exam or calling the doctor's office when you are sick will become less necessary. Wearables and home sensors will provide near-constant monitoring of your health and can alert you and your healthcare provider about potential ailments or abnormalities.

5G will be the intersection of network, cloud, and services. We're moving these things and distributing parts of the core so that capabilities will be at the edge and thus closer to you and your device.

Remember our traffic analogy? Now your devices will have much greater capacity, speed, proximity, and traffic management.

Telehealth will no longer be just about enabling connectivity in traditional brick-and-mortar healthcare facilities. Now we will have connected care almost everywhere. Remote patient monitoring and mobile health applications that Americans can access on their smartphones or tablets while at home or work will be part of a new and seamless way of delivering cost-effective, direct-to-consumer healthcare.

In terms of preventative care, your health wearables will calculate daily recommendations and prompt you based your medical records, real-time vitals, and projected needs.

Healthcare providers will be building an entire eco-system that creates highly responsive, effective, patient-centric experiences.

Retail

We're already trending toward selling consumers experiences — not just selling things. Retail will continue evolving toward rich, experience-based shopping.

Current tech trends: Retailers are using data and solutions from different types of endpoints to trigger customer-requested targeted marketing; retailers are also able to collect tremendous amounts of data from customers and their behaviours, enabling AI-personalization (recommending products, sending coupons for what you've purchased, redesigning home pages instantaneously based on social media profiles); smart digital price tags

Predicted trends: (1) creating the optimal fusion of the virtual and physical worlds to create intensely personalized shopper experiences; (2) in-store 3-D printers to create custom products; (3) VR and AR to virtually try on clothing, virtually remodel and redecorate your home, or holographically teleport to potential destinations to help you decide where to book your next vacation

Future 5G use cases:

With customer consent, when customers walk past your storefront, your store will be able to sense them, and based on the compute power happening right at the edge of each device and location, you can virtually clothe the customer in your latest fashions that match the customer's current and predicted preferences — and render the customer in their new wardrobe on high definition screens in the store window instantaneously.

Sensors will also be able to detect how well customers like what they see based on advanced facial recognition algorithms that can interpret subtle expressions and eye movements and show different wardrobe items that trigger more positive responses. All virtually instantaneously.

Retailers can save these personalized digital ads and create follow up marketing campaigns just for that customer.

A home improvement store may have a remodel kiosk that pulls up your floorplan and lets you walk through each room in your house in VR, changing the color of each room, switching out furniture or appliances, or even adding a new wing on the house to see how it looks.

Finance

Just as those in the healthcare industry recognize that they need to create better patient experiences through technology, so too does the finance industry realize that they must create better customer experiences. As consumers and businesses turn more and more to mobile and online banking, those financial services that can make that digital interaction exceptional will find themselves leading the pack of the new fintech landscape.

Current tech trends: Online and mobile banking and investment firms are causing the rapid shrinking of physical banks and locations; evolving cyberattacks from multiple entry points and vectors are plaguing the industry; AI bots help quickly resolve customer service issues for online interactions in finance; insurers are using IoT and AI to gather and process volumes of data that help them create better pricing models that save them and their customers money

Predicted trends: (1) Digital-only banking will continue to reduce the size and need of the physical locations; (2) real-time risk assessments and alerts will inform investing and budgeting decisions; (3) an Uber-like sharing economy will upend banking services by matching providers and users of capital

Future 5G use cases:

You will be able to create financial and insurance services experiences that are highly customized, recommending products and services based on predictive models. High-resolution video will let your customers summon your in-person or AI representatives for "anywhere" consultations.

An AI cyber-immune system will send threat intelligent defender cells (like white blood cells)

from one edge of an institution's network to the other, actively patrolling for hacker probes, patching security weak points, and evolving to match new threats. This will be augmented by new identification methods using AI and facial recognition.

Insurance companies will be able to dispatch drones for insurance investigations or even use holographic teleportation for adjusters to tour damaged property and inspect vehicles and provide benefits more rapidly.

Manufacturing

Manufacturers are using current IoT and cloud advancements to streamline processes, reduce overhead, and boost revenue.

Current tech trends: IoT devices to provide real-time feedback, optimize shipping and storage conditions, and send alerts for repairs and preventive maintenance; create smart factories with integrated IT to collect and process data for both sides of the supply chain; moving data for storing, managing, and processing needs to the cloud

Predicted trends: (1) IoT "neural" network where IoT smart sensors, fueled by edge computing power and AI, create a connected manufacturing "brain" that optimizes, reacts, and calibrates from one end of the manufacturing process to the other—informed by the intelligence at each node and endpoint; (2) robots that mimic human capabilities are used for dangerous, high-risk jobs currently filled by humans ; (3) AR/VR schematics

Future 5G use cases:

5G's high capacity, wireless flexibility, and low-latency performance make it a natural choice to support the gathering of operational intelligence. As networks grow and become smarter, they will produce far more information than their predecessors. Manufacturers that can capture and crunch these numbers can produce actionable intelligence that increases productivity.

When the network gives advanced warning that a piece of specialized equipment needs a repair, augmented reality using low-latency 5G-enabled headsets will make technicians more efficient. Level-one technicians can travel to a site and have engineers at headquarters guide them through the repair process remotely via 5G networks, using context-sensitive 3D animations to walk them through the necessary steps.

Finally, 5G will enable manufacturers to drive more functionality closer to the edge of the network. Because this network technology's reliability is so high and its latency so low, equipment can communicate wirelessly with back-end systems for time-critical operations in ways that were not possible before.

Summary

Some of these scenarios have elements that project into a future that seems wholly in the realm of science-fiction. But that's the point of the types of experiences and advancements that 5G will accelerate.

Meanwhile, some of the applications in the use cases are near-cousins of things you may be relying on today.

Critical to how fast you can hit the ground running with 5G will be the strength, breadth, and depth of your current network, cloud services, IoT, mobility, and cybersecurity. But it's not an understatement to say that most of our computing paradigms need to change to lay the groundwork for the next first-mover advantage.

A timeline

How close are we to bringing 5G and these evolutionary capabilities to the world? In this section, we briefly look at some of the milestones and stages marking the path to a variety of 5G experiences.

Spectrum investment

In terms of capacity, AT&T has invested $27 billion in spectrum over the past five years. And as a result, we have 60 megahertz of deployable spectrum, which includes First Net's (the network we're building for first responders) 20 megahertz of prime nationwide spectrum for public safety and secondary use.

Today's mobile devices and personal electronics typically use sub-6GHz frequencies on the radio frequency spectrum. But, as in our metaphor of traffic and commuting, these frequencies, or data traffic lanes, are getting increasingly congested as the number of devices proliferates.

5G will be able use new spectrum bands with significantly more depth making those lanes wider where needed (like urban areas with dense data traffic).

Part of the 5G experience will be fueled by mmWave (millimeter wave) technology. 5G will be transmitting, in part, on shorter mmWaves in the 24-300 GHz range — a section of the spectrum that hasn't been used before for wireless and mobile devices.

Also remember that 5G will not be operating only on the mmWave spectrum — it can also operate on our other bands.

5G standards

As various telecommunications standards organizations (like 3GPP and IEEE) work on codifying 5G standards, AT&T has made a commitment to build a standards-based 5G network. To accelerate availability of 5G so that some benefits could be experienced sooner, the release of 5G-based and other technologies was broken into two phases by AT&T. The first of these phases was released at the end of 2017. The second release of the 5G standard will unlock more use cases and capabilities over time. The AT&T operational approach and spectrum strategy will help bring an improved experience for businesses and consumers.

Additionally, the decision to launch 5G in two phases will bring global interoperability and scale. Even though AT&T will launch 5G early relative to most operators, as additional networks come online we expect our customers will benefit from roaming arrangements just as they have with prior generations of networks.

Test markets

AT&T worked with a variety of customers in different parts of the country to conduct trials of 5G technology. From a small car wash in north Austin, Texas, to the popular Magnolia Silos in Waco, Texas, to a family in South Bend, Indiana. We wanted to see how 5G, mmWave, and bridge technologies like localized cellular work in a variety of environments for a variety of different customers.

By conducting these trials, as well as inventing specialized measurement equipment to study certain aspects of 5G, we are continuing to collect data that is guiding our commercial 5G launches in 2018 and will help ensure we're building a 5G network that can fulfill its immense promise.

The 5G Petri dish

We wanted to see how 5G, mmWave, and bridge technologies like localized cellular work in different test markets. These are the results.
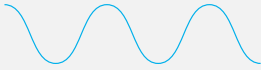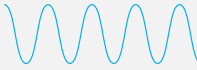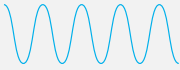
Waco, Texas
Participants: Small and mid-sized businesses

- Provided 5G mmWave service to a retail location more than 150 meters away from the cell site and observed wireless speeds of approximately 1.2 Gbps in a 400 MHz channel

What is Spectrum?

Physical Characteristics and Implications — all else being equal

CHARACTERISTICS

IMPLICATIONS

Low Frequency Ex: 600-1,000 MHz	Medium / High Frequency Ex: 1,000-3,000 MHz	mmWave Frequency Ex: 24,000 MHz +
• Travels longer distances to provide better coverage • Better in-building penetration	• Travels less distance due to greater transmission losses and thus provides less coverage • Lower coverage limits interference with other sites, making more ideal for urban areas	• Reduced range – but very small antennas • Antenna arrays used to overcome loss • Significantly larger spectrum allocations possible. High data rates enabled.
Requires fewer towers to cover a given area	Requires a denser network "grid" increasing # of sites	Range and blocking necessitates dense network of small cells
Enables better in-building coverage	More directional, and provides less penetration through walls More adjacent spectrum typically available for data usage	Provides limited penetration through any objects Spectrum to be sold in large blocks; FCC recently announced intent to sell

Sources: CNet, Dailywireless, Extremetech, CTIA

- Observed RAN latency rates at 9-12 milliseconds
- Supported hundreds of simultaneous connected users using the 5G network

Kalamazoo, Michigan
Participants: Small businesses

- Observed fewer impacts than expected on 5G mmWave signal performance due to rain, snow, or other weather events
- Learned mmWave signals can penetrate materials such as significant foliage, glass, and even walls better than initially anticipated
- Observed more than 1 Gbps speeds under line of sight conditions up to 900 feet (that's equal to the length of 3 football fields)

South Bend, Indiana
Participants: Small business and residential customers

- Observed a full end-to-end 5G network architecture, including the 5G radio system and core, demonstrating extremely low latency

- Successfully provided gigabit wireless speeds on mmWave spectrum in both line of sight and some non-line of sight conditions

The 5G litmus test

With the volume of data skyrocketing, businesses should strategically implement technologies that will not only support you today, but also provide a key bridge to future technologies. As you consider your infrastructure, ask yourself and your teams — these key questions.

Virtualization-readiness

How far along am I in transitioning to a software-defined network with network function virtualization? Have we begun to incorporate Network Function Virtualization? When it comes to network and mobility, am I on the path to virtualization so that when network services break out of the old monolithic models and workloads move closer to the user, I'm ready to distribute functions when and where they're needed?

Cloud-readiness

How much have I integrated cloud services into my business? Do I have cloud-enabled colocation services, networking, disaster recovery, and content management? Do I use a virtual data center and a content delivery network? And how ready is my cloud environment to be a part of the edge environment so that those services can be portable to the edge when you need lower latency?

IoT-readiness

Do I use IoT-enabled devices? Do I have edge-to-edge computing capacity to take advantage of IoT-enabled intelligence and analytics? How am I managing all the data I'm getting from IoT? What is my data policy around these IoT end points? What events do I want to drive to the fully optimized use of IoT?

Cybersecurity-readiness

Do my cybersecurity solutions include network, mobile, data, app, and IoT security relying on worldwide network threat intelligence based on petabytes of data? Am I looking at not only security inherent to the business but also how that relates to what my network and app developers are doing? Is my cybersecurity team engaged in the discussions at the forefront?

Summary

A critical part of being ready for 5G is making sure your end-to-end digital road map in these key areas is on track. Also, software developers and network developers need to work symbiotically as opposed to working in silos.

As you prepare, you'll be ready to take advantage of the convergence of services and developers across multiple disciplines. This is a new network affording you a great opportunity to proactively build your infrastructure in a way that optimizes 5G and other technologies for your business and your bottom line.

Why AT&T

At the beginning of this white paper, we talked about the Wright brothers and how the airplane fundamentally altered how we experience traveling. Flight became a new "user experience" for every traveler, giving us the thrill of defying gravity and soaring to new heights.

Just as the airplane fundamentally changed the traveling experience and set off chain reaction of innovation, 5G promises to alter the nature of the digital experience for business.

We like to think of 5G as the first network built with the business user in mind. We have been investing in the assets, have the reach, partnerships, and edge-to-edge capabilities to help your business be ready for 5G so you can build the experiences that delight customers.

Our services and solutions are 5G-primed. In other words, they will help businesses be ready to take advantage of 5G use cases. We have already in place an integrated tech ecosystem that gives you virtually seamless solutions. That is a strong position to be in.

It's who we are

For more than a century, AT&T has been innovating the ways we communicate and connect. This is the next leap in that technology. We deliver the seamless integration of wired and wireless, have an ecosystem of world class technology partners, and are constantly investing in business.

Let's talk about how we've been preparing for this evolution to take software-defined tech into wireless:

- We're on track to virtualize 75% of our network by 2020

- The network automation platform for which we wrote most of the code and co-founded within the Linux Foundation, ONAP, now has members that represent nearly 70% of the world's mobile subscribers

- 5G is a step in our wireless network evolution — it's the first wireless network born in the cloud

- We've launched a Palo Alto edge test zone and collaboration with GridRaster to create a software platform for enhanced AR/VR experiences on mobile devices giving us the tools to start building 5G AR/VR macro edge applications

- We're creating an open source project, hosted by The Linux Foundation, and inviting the community to join us in expanding the development of next generation zero-touch edge cloud infrastructure for carrier and enterprise networks, hopefully harmonizing the industry in creating an integrated developer platform that accelerates growth and expansion of 5G and IoT applications

It's who we'll be

We already outlined our prototype tests in various markets. We will be launching customer-ready 5G devices and services this year that will serve as critical stepping stones to the evolved 5G technology and capabilities that can enable some of the use cases described in this paper — and fundamentally alter the DNA of the digital experience forever.

For more information contact an AT&T Representative or visit https://www.att.com/5gforbiz.