



5G innovation - It's about time

by Scott Nelson, Chief Product Officer, Digi International

We have been hearing about 5G and Internet of Things for more than five years now, and we have been promised much and experienced relatively little. That is about to change as innovators engage the new possibilities.

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After beginning his career with Honeywell R&D, Scott spent 15 years at Logic PD as CTO and EVP where he grew the Product Development business to one of the country's largest such service organizations. He then served as CEO/CTO of Reuleaux Technology, an IoT consulting firm with

deep Silicon Valley and Minnesota ties.

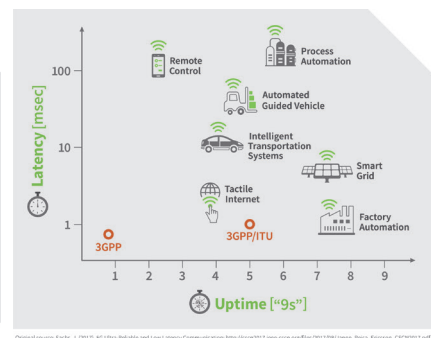
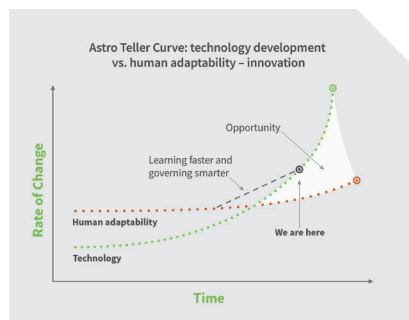
Scott holds a Ph.D. in applied physics with a doctoral minor in business from Cornell and a B.A. in physics and mathematics from St. Olaf College.

“Memory is free. Bandwidth is free. Compute is free.” That was the advice I received from one of the Fellows at the Honeywell Technology Center in the early 1990's. Moore's Law was 25 years old and he wanted me to remove these constraints from my thinking. Our job was innovation and he was helping us think differently, think out-of-the-box, about the problems we engaged.

Moore's Law has marched on for another 25 years and combined with Metcalf's Law of network impact, today almost anything is not only possible but also affordable with the Internet of Things. Almost anything, but we are still constrained by time.

Later in my career I learned that constraint can also be a source of innovation, and when it comes to 5G new freedoms will be the catalyst. Innovation with cellular communications until now has really focused on space, making distance and location irrelevant. Cellular removed the limitations of wires, connecting everything and putting eyes on things we can't see. While network virtualization now enables companies to go global without deploying people and equipment.

Today we design with ubiquitous connectivity in any given spatial context from a personal, local and wide area. Moore's Law has given us the cheap sensing, radios, and compute that cellular networks leverage to create a virtual experience that feels as if we were omnipresent. LTE is the latest stage of this technology, we are still in the midst of innovation and adaptation,



catching up to the change LTE enables.

One of the biggest constraints we are still facing is time. For instance, LTE networks have too much latency to drive a car autonomously, LTE control loop is also too slow to run a production line autonomously. Even humans, with time constants measured in tens of milliseconds, can perceive LTE latency in high resolution augmented or virtual reality systems – both visual and audio. Technologists are already working to break through the time limitation, as Teller pointed out, technology builds exponentially. Each phase of technology development doesn't just add to the previous, it multiplies it, and even if pessimists, Luddites if you will, believe that humans will fall farther behind; the optimists - the innovators - will see a whole new space for innovation.

5G attacks time, it will change the impact of time on use cases. The big changes are latency for control loops, streaming speeds for download and upload times, and the combination of latency and node density

and redundancy for increased uptime, i.e. reliability. 5G will expand the space to be able to innovate one to three orders of magnitude on each axis.

5G expands the time-based function of the network 10 to 1000 times for latency, streaming and reliability

	LTE	5G
LATENCY	0.010 sec ¹	<0.001 sec
STREAMING TIME (per 100 MB)	0.1 sec	<0.005 sec
UPTIME	99%-99.99%	99.999% ³

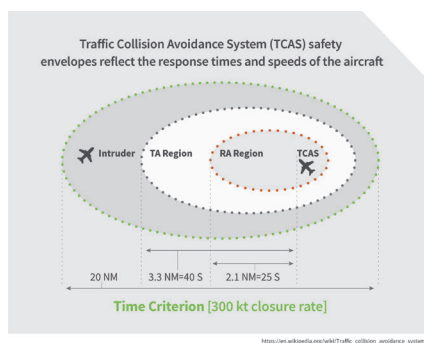
1 <https://www.gorvo.com/design-hub/blog/getting-to-5g-comparing-4g-and-5g-system-requirements>
 2 <https://www.rmmediagroup.com/repository/files/PublicSafetyGradeLTE.pdf>
 3 <https://www.a10networks.com/blog/5g-network-reliability-explained/>

So, how will innovators take advantage of this new freedom? Consider how Maxwell transformed our understanding and use of electromagnetics from static, space constrained thinking to dynamic, time-based applications. 5G will free innovators to make the internet of things (IoT) fully real time. IoT applications will transform from passive, observational applications to fully engaged, and fully cloud-integrated applications.

We consider five key ways 5G time performance will enable innovation:

1. Real-time finally becomes ‘real’ for both the industrial and the human experience

As sub millisecond latency creates real time for all but the most critical systems, 5G will address this problem. It will dramatically extend the safe operating conditions of self-driving vehicles and Intelligent Transportation Systems (ITS). Consider a 10x reduction in vehicle reaction time in the context of a Traffic Collision Avoidance System safety envelope. 5G latency will reduce the required safety envelope and transmit speeds to expand the vehicles’ awareness capability (i.e. number of tracked obstacle). Self-driving vehicles will have to interact with infrastructure, people and with other vehicles in a fully autonomous fashion used in commercial aircraft.



The ITS’s are one of the more aspirational use cases for real-time 5G systems due to the mission-critical safety requirements and speed of the vehicles. The human visual system has a response time in natural scenery of roughly 1/60th second, which means that anything we can see move in our natural experience, we are able to measure, monitor, and control. With 5G control loops we will be able to do so on traffic, water, steam, wind, rain, etc. New applications will include augmented reality solutions for human productivity improvement, smart city infrastructure and industrial automation with collaborative robotics leveraging the 5G sub-millisecond latency envelope.

2. Time for security

Security and time are opposed in the same way security and usability are opposed. The more time it takes to access a system the less usable it becomes, as security procedures become less usable the more likely it is that the user bypasses that security or refuses to use the system.

5G will again remove constraints of time,

both in data access and closed loop response for security purposes. Consider multifactor authorization via cloud integration or massive processing biometric controls like facial recognition, high speed cloud access with reduced latency will make these user acceptable. Distributed trust architectures like multi-device blockchains will also become more viable with the more dense, high capacity nodes of the 5G network. And timely access and transactional security leveraging cryptocurrency technology will enable developers to increase security without adding usability friction.

3. Application execution times create a fully intelligent edge

Another outcome of the massively, more dense 5G node deployment is a new layer of edge compute at the network level – the Multi-Access Computing edge. This cloud-like scale of compute combined with higher transmission speeds will create a virtualization at the edge that will support applications previously only supported in the cloud – principally artificial intelligence.

Look for edge application developers to accelerate their use of machine learning and AI tools previously constrained to enterprise and cloud environments. The virtualization of the edge will unleash cloud-like innovation on our physical world in the same way the internet and virtual machines transformed office and enterprise operations.

4. No down time – mission critical moves into the fog

Another key aspect is reliability, basically uptime. 5G’s reliability comes from the densification and redundant infrastructure of small and macro cells combined with Coordinated MultiPoint (CoMP) that provide “dual connectivity” to multiple cell towers. This creates a reliability that will support mission critical applications previously out of bounds for cellular networks, such in the case of self-driving vehicles both personal and mass transit, automated guided machines, water and waste water management, and a wide range of industrial automation and controls.

Secure, decentralized control with a hardware enabled, software defined edge with five-9’s uptime will enable

closing the loop through the network on a wide range of mission critical applications.

5. The IoT Time Machine - Retrofitting existing critical infrastructure

The last innovation area to note is truly an innovation of time, the IoT Time Machine. The ubiquitous cloud-level compute and pervasive network access of 5G combined with the IoT ecosystem of hardware and software modules will create a fertile field for the upgrading of existing, installed infrastructure. We will not have to wait for products and systems that have 15, 20, and 25-year life spans to wear out before we bring them forward in time on the technology curve.

For example, 5G will accelerate the retrofitting of water treatment systems to fully modernized IoT solutions. Smart sensing can be easily added to existing equipment and integrated with prediction machines in the 5G MEC edge. The cost of upgrading equipment and infrastructure with connected retrofit solutions will drop precipitously to points where the return from the optimization and prediction functions enabled by IoT will return on these investments in months rather than years. Innovators who have already upgraded their products and services with IoT technology will be able to look to the past and imagine bringing it to the present in operational terms.

Technology is a cumulative force, one the human race struggles to follow. But technology removes constraints for problem solvers and as such is also a force for innovation, perhaps THE force in today’s world. We have been hearing about 5G and Internet of Things for more than five years now, and we have been promised much and experienced relatively little. That is about to change as innovators engage the new possibilities. It’s about time.

