THE NEXT NORMAL

Innovation Applied

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There are tectonic shifts occurring in telecommunications infrastructure that will have a profound effect on aviation. The latest smartphones point to how quickly these transformations are happening. Anyone who purchased a new mobile phone in the last six months likely has support for 5G – the fifth generation of mobile telecommunications standards.

It's difficult to understand how transformative 5G is. Once more 5G networks are up and running, phone users will begin to recognize the power of the new capabilities, which deliver vastly more data at much faster speeds. However, phones are just the beginning, and they aren't the true customers of 5G. The Internet of Things (IoT) is where a major transformation will occur.

Harnessing the Power of a Virtualized Telecommunication Infrastructure

Under the hood, 5G relies heavily on virtualization. Over the last decade, virtually all computing environments have moved into a virtual ecosystem. Cloud computing, in particular, has paved the way for virtualization at scale. With 5G, the virtualization that was once limited to data centers is now permeating the entire internet infrastructure. Rather than using specialized switches and routers designed for only one task, 5G is turning everything electronic into a virtual machine.

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The software replaces hardware throughout. The organizations that supply these services are turning away from fixed-function devices and toward micro services that can be elastically deployed in any cloud environment.

As a result, the cloud is no longer just in data centers. It will underpin telecommunications infrastructure and every cellular base station. This advancement is transformative because this software can be used to build a telecommunications network capable of servicing any imaginable application.

Another transformative facet of 5G virtualization is the notion of "network slicing," which allows software developers to divide single network connections into multiple, distinct virtual connections that provide different amounts of resources to different types of traffic. For instance, a developer could create an end-to-end segment of the cloud that travels all the way from an industrial piece of equipment to the compute and storage functions associated with that equipment, which live in the cloud.

Network slicing is a very powerful concept for supporting real-time, industrial applications of 5G that require the guarantee of a particular level of service. For example, if 5G were being used for command-and-control functions of BVLOS drones in an urban area, the season finale of a popular TV series shouldn't suddenly overwhelm the 5G networks. That could cause congestion for ATM functions that might be happening over the same network. Network slicing prevents such occurrences by segmenting the network to provide different service quality to different types of users.

Edge Computing Accelerates Data Delivery

Another transformational element of 5G is the notion of "edge computing." While 4G's large-scale computing existed primarily in data-center environments, 5G allows for local computing.

Edge computing is the practice of capturing, storing, processing, and analyzing data near the client – where the data is generated or needed – instead of in a centralized data-processing warehouse. By bringing computation and data storage closer to this "edge," it's possible to process and transmit only relevant information, and that reduces latency issues.

This will enable many industrial applications, where the goal is to achieve one-millisecond-level latencies or better. As a frame of reference, light takes about 15 milliseconds to cross the continental United States. What is seen today in many networks are latencies on the order of 50 to 100 milliseconds. Although that may be acceptable for applications such as voice transmission, it doesn't support real-time industrial applications within the IoT.

Say an industrial manufacturing facility is using closed-loop controls to coordinate the robotic actuators operating parts of the assembly line. To avoid timing divergences, very low-latency communication is needed among the different components. Edge computing answers that need by providing sub-millisecond latencies. It accomplishes this by moving the workload out of the data center and into closer proximity to the computing and the devices interacting with it.

In the aviation domain, edge computing – with its ability to achieve very low latencies – has significant potential to support ATM applications, including collision avoidance mechanisms for unmanned aircraft. However, this will require the development of interoperable machine-to-machine interfaces that can work across different cloud vendors, across different 5G carriers, and across different unmanned aircraft operators. Additionally, prior to designing those interfaces, the aviation industry must develop standards that provide the rigorous safety parameters the designs must meet.

In the meantime, The MITRE Corporation, which operates the FAA's federally funded R&D center, has begun exploring some of the applications of 5G in the aviation industry. MITRE recently launched the Open Generation Consortium (Open Gen) – a privately funded R&D community – to bring together organizations with shared interests to envision, design, develop, and demonstrate innovative solutions uniquely enabled by emerging 5G capabilities. Open Gen will complement existing groups in the United States by testing 5G standards and

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use cases, including how 5G capabilities can be used to accelerate the integration of drones in commercial airspace. An early focus is how to use 5G to enable command-and-control functions for drones operating beyond the remote pilot's line of sight, an issue that presents a myriad of technology challenges.

One of these challenges is the radio frequency (RF) environment in which these drones will operate. Today's cellular networks, which rely on physical antennas, are designed to provide service to users that are primarily on the ground. In contrast, with 5G, smart beamforming antenna technologies can be designed to provide coverage to support aerospace applications.

Whereas conventional antenna arrays broadcast signals in all directions, beamforming antenna arrays focus their signals on a specific receiving device. By concentrating the energy more narrowly, these arrays increase the strength of the signal. That results in higher signal quality, faster information transfer, and reduced interference from other signals.

Nevertheless, a drone that's flying over a city may be within the range of hundreds of cellular base stations during its journey, which complicates the challenge of managing RF resources and controlling interference. To meet that challenge, Open Gen industry and academic research test beds will explore how AI can manage interference to and from drones operating within 5G networks.

AI is a Game-Changer

AI now pervades society and is producing more advanced capabilities every day. Recent years have seen significant increases in the sophistication of perception algorithms that can perform object recognition functions. These capabilities – made possible by deep learning, advances in computing technology, and the scale of available data – go far beyond rudimentary image processing, instead offering machine perception at scale. This creates huge opportunities in terms of collision avoidance functions and traffic management for autonomous vehicles.

Although the data-hungry and compute-hungry nature of these algorithms presents challenges, 5G and edge computing have the potential to provide an essential underpinning layer to unlock the potential of AI, particularly in safety-critical, real-time applications such as ATC. This is possible because, with AI, high-performance computing can be leveraged to train and refine models that are then executed at the edge.

Alongside Potential, There's Danger

While these technological advancements offer huge promise, the dangers they present cannot be ignored. In the aviation context, these dangers take the form of possible disruption to the safety, reliability, and security of the airspace system. As these advanced technologies are introduced in the aviation environment, where safety is paramount, cybersecurity threats must be addressed. The concept of "nonlinear failure mode" can be valuable here.

For traditional electromechanical devices, researchers can do thousands of tests and come up with metrics representing the probability of failure as a function of time. However, with sophisticated AI 5G-related technologies, researchers don't have the same ability to project failure linearly. AI itself has become so complex that it's become impossible to test every possible scenario that could occur.

Considerable research is still necessary to determine how those failure modes will work in algorithmically-enabled systems. There is also work needed to understand how new 5G technologies will operate as they rely more and more on a virtual infrastructure. If those questions are answered in a way that meet aviation's stringent quality-of-service requirements, there is a tremendous opportunity for efficiencies across the board in the aerospace system.

Given its need to assure the safety, security, and reliability of all its systems, the aviation industry represents one of the toughest use cases in the 5G vision. However, as more robust, tested evaluation infrastructures are built, more and more of the envisioned benefits can be achieved.

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