Security and Congestion Modeling and Resilience Testing for 5G and Virtual Networks

Addressing federal agency challenges with 5G/SDN/NFV to provide solutions for resilience in next generation use cases

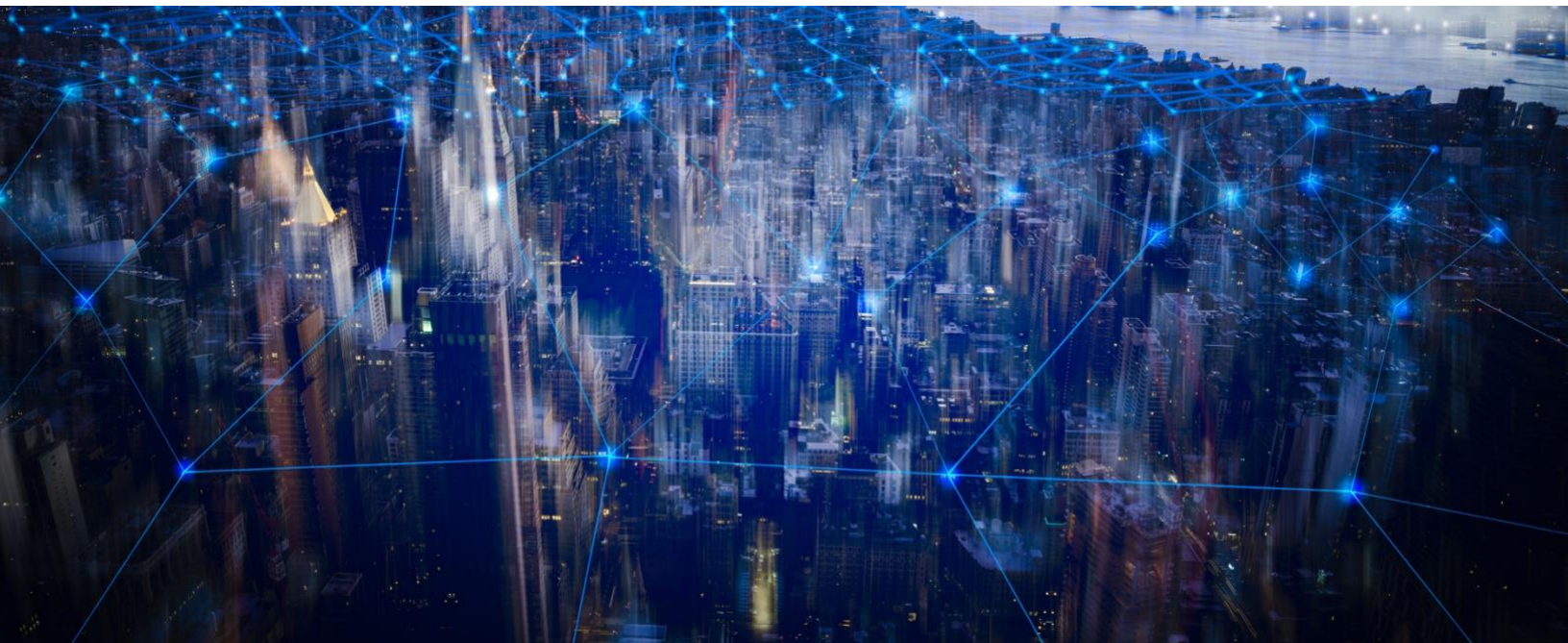*Denise Masi, Ph.D.; Olga Aparicio; Muhammad Hussain, Ph.D.*

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List of Acronyms

4G	Fourth generation	**5G**	Fifth generation
5QI	5G QoS Identifier	**API**	Application programming interfaces
gNB	Next Generation NodeB	**IP**	Internet Protocol
IoT	Internet of things	**LAN**	Local area network
MEC	Multi-access edge computing	**MPLS**	Multiprotocol Label Switching
NFV	Network functions virtualization	**NICC**	Noblis Innovation and Collaboration Center
NNI	Network-to-network interface	**QoS**	Quality of service
RAN	Radio access network	**RF**	Radio frequency
SASE	Secure Access Service Edge	**SDN**	Software-defined networking
SD-WAN	Software-defined networking in a wide area network	**SME**	Subject-matter expert
SPOF	Single point of failure	**TIC**	Trusted Internet Connection
UE	User equipment	**USG**	U.S. government
VNF	Virtual Network Function	**vWAN**	Virtual wide area network
WAN	Wide area network		

Overview

New transformative technologies and novel architectures being developed by standards bodies (including the fifth generation (5G) wireless networks) are extremely complex. The benefits of 5G are made possible by virtualization, cloudification, and automation technologies such as network functions virtualization (NFV) and Software Defined Networks (SDN) to implement the 5G architecture. This technology transformation includes the shift from static, deterministic traffic management to a more agile network which is application aware.

U.S. government (USG) agencies need hands-on, impartial assistance to navigate the complexities of 5G and virtualization technologies and enable the new vertical use cases (e.g., augmented reality/virtual reality, mission critical applications, vehicular communications) during normal and disaster conditions. Research and experimentation are needed to develop intelligent design and deployment strategies for key 5G architectural features such as network slicing and multi-access edge computing (MEC) that will provide these use cases with the required performance and security in demand by USG clients. Noblis' telecom experts have developed capabilities to further the state-of-the-art in these areas.

Noblis Applied Network, Cloud, and 5G Noblis Virtualized Testbed Capabilities

The Noblis Innovation and Collaboration Center (NICC), located at our Reston, Virginia headquarters, is where complex problems are explored to create practical, forward-thinking, sustainable solutions. It consists of laboratory spaces and collaborative work areas where our employees and clients can prototype, analyze, model, simulate and showcase results and new ideas.

Our telecom experts have established an Applied Network, Cloud, and 5G Noblis Virtualized Testbed that leverages advances in SDN and NFV as well as 5G wireless technologies (in collaboration with the Internet of Things (IoT) Lab) to test new architectures and concepts. This testbed allows us to study potential challenges and assess innovative solutions, ensuring the agency adoption of these technologies will be successful.

Through this testbed, we utilize modeling and SDN/NFV/5G solutioning, assessment, optimization, and proof of concept testing in a vendor-neutral network. Specific capabilities in architecture, design, network component evaluation, and security testing and evaluation include:

- High fidelity, end-to-end SDN/NFV/5G testing and emulation/simulation to explore areas of concern for agencies and associated implementation solutions

- SDN/NFV/5G network performance, architectural alternatives, and resilience across multiple network interfaces

- Emulation of impacts of network impairments (e.g., latency, jitter, errors, malformed packets, etc.) and solutions

- Fourth generation (4G)/5G modeling and simulation of priority mechanisms and quality of service (QoS) to ensure performance for special traffic streams

- Integration of network slicing, IoT, and MEC for end-to-end testing

- Expertise in Trusted Internet Connections (TIC) solutions and alignment with evolving cybersecurity methods

- Incorporation of network security into an integrated enterprise security strategy (e.g., zero trust architecture)

- Single point of failure (SPOF) identification and mitigation analyses for locations requiring highly survivable connectivity

- Proven strategies for true resilience (physical, carrier and technology diversity in access layer; dual carrier/network diversity in transport layer)

Specific questions of interest in 5G technology that we are exploring include:

- Can 5G dynamic network slicing, with automatic resource scaling, be used during network congestion to ensure that emergency personnel communications are treated with priorities based on the severity of the emergency? How do we design algorithms for dynamic network slicing with automatic scaling of slice resources during congestion and incorporate these algorithms into the orchestrator to evaluate the responsiveness of these algorithms? Can a single slice for mission critical traffic using differentiated 5G QoS Identifier (5QI) values provide the required performance for these users' applications, versus the use of multiple slices for these applications?
- Can the telecommunications network provide end-to-end performance, which is consistent regardless of the transmission media, wireline versus wireless? How can wireline and wireless slices be integrated to demonstrate that performance, priority and security of federated network slices can be carried over multiple administrative domains, especially at the network-to-network interface (NNI) between service providers?
- Can 5G in conjunction with network virtualization SDN/NFV as well as Secure Access Service Edge (SASE) architecture to directly connect mobile users to the cloud provide a full path to modernization capable of meeting the 'on-the-fly' demands for network reconfiguration to allocate network resources where needed?

Figure 1 is a conceptual model depicting the expanded SDN/NFV/5G testbed. We are actively establishing end-to-end connectivity and traffic flows, integrating 5G user equipment/Next Generation NodeB (UE/gNB) and core emulators with the Noblis SDN/NFV testbed and associated components including traffic generation (utilizing application programming interfaces (APIs)) and SDN in wide area network (SD-WAN) capabilities.
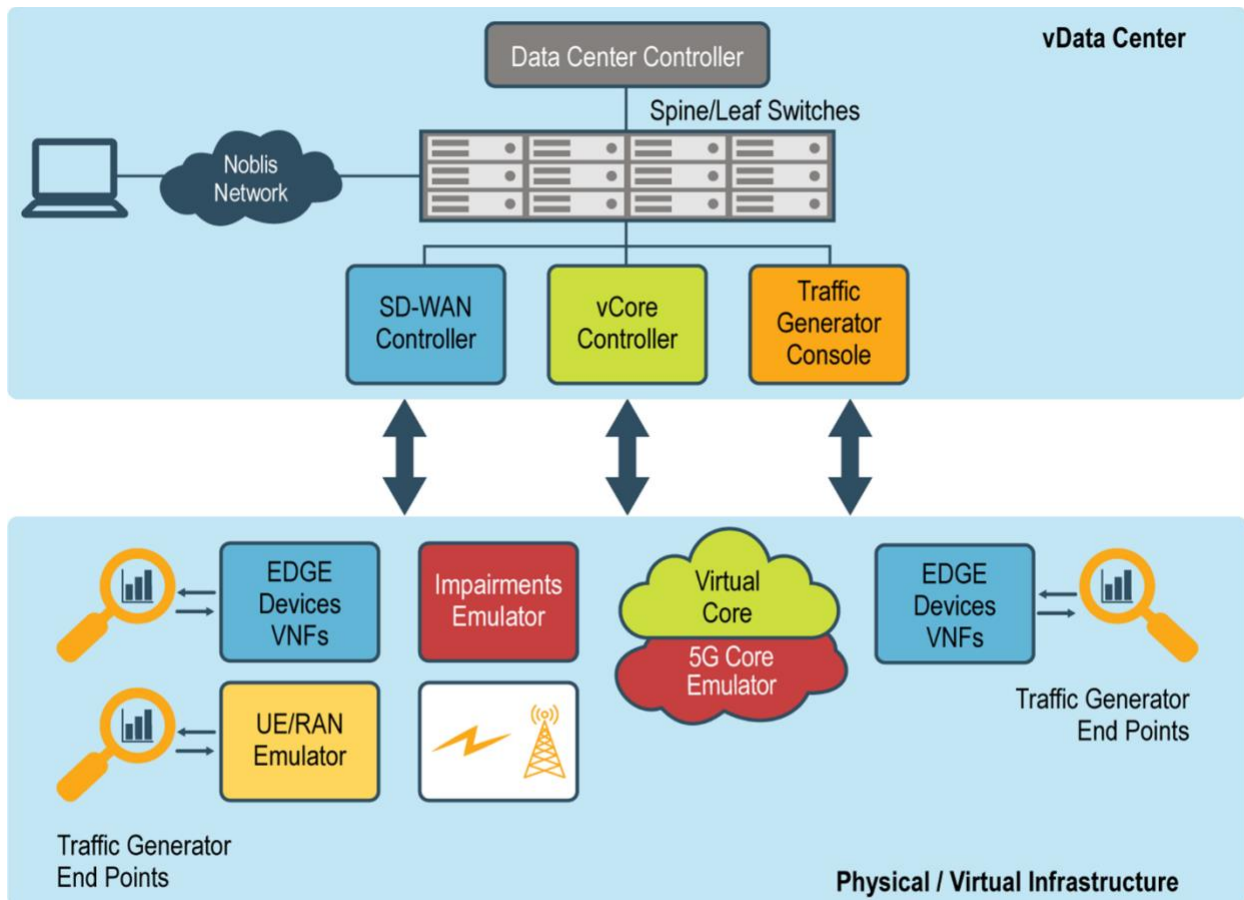
Figure 1. Noblis integrated SDN/NFV/5G testbed provides end-to-end connectivity with 5G access.

Key building blocks of the testbed include:

- Virtual data center: Enables connectivity to all devices in the network through a controller.

- vWANs – NFV routing functions, full high-capacity Multiprotocol Label Switching (MPLS) routers: Provides transport to the traffic coming from the edge devices connected to customers' local area networks (LANs).

- SD-WAN overlay: Sets tunnels from the edge device over the vWAN.

- 5G user equipment (UE), radio access network (RAN) and Core Emulators (standalone architecture).

- Traffic generators: Can have up to 200 endpoints generating traffic.

- Emulator of network impairments: Access links can be modified by injecting impairments, e.g., latency, jitter, errors, malformed packets, etc.

Team

Noblis subject-matter experts (SMEs) on the 5G and virtualization team include experts in the areas of 4G/5G standards, radio frequency (RF) engineering, radio network optimization, wireless communications modeling and simulation, algorithm development, cloud and virtualization technologies (e.g., SDN/NFV, SD-WAN), next generation networks, Internet Protocol (IP) networks, optical networking, solution architecture, test engineering, cybersecurity, reverse engineering, machine learning, control systems, sensors, IoT, blockchain, autonomous robotics, and connected vehicles.

Noblis' proven performance supporting the federal government, coupled with our subject matter expertise in 5G and related evolving communications and networking technologies, will help agencies create new, innovative solutions essential to the future.

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