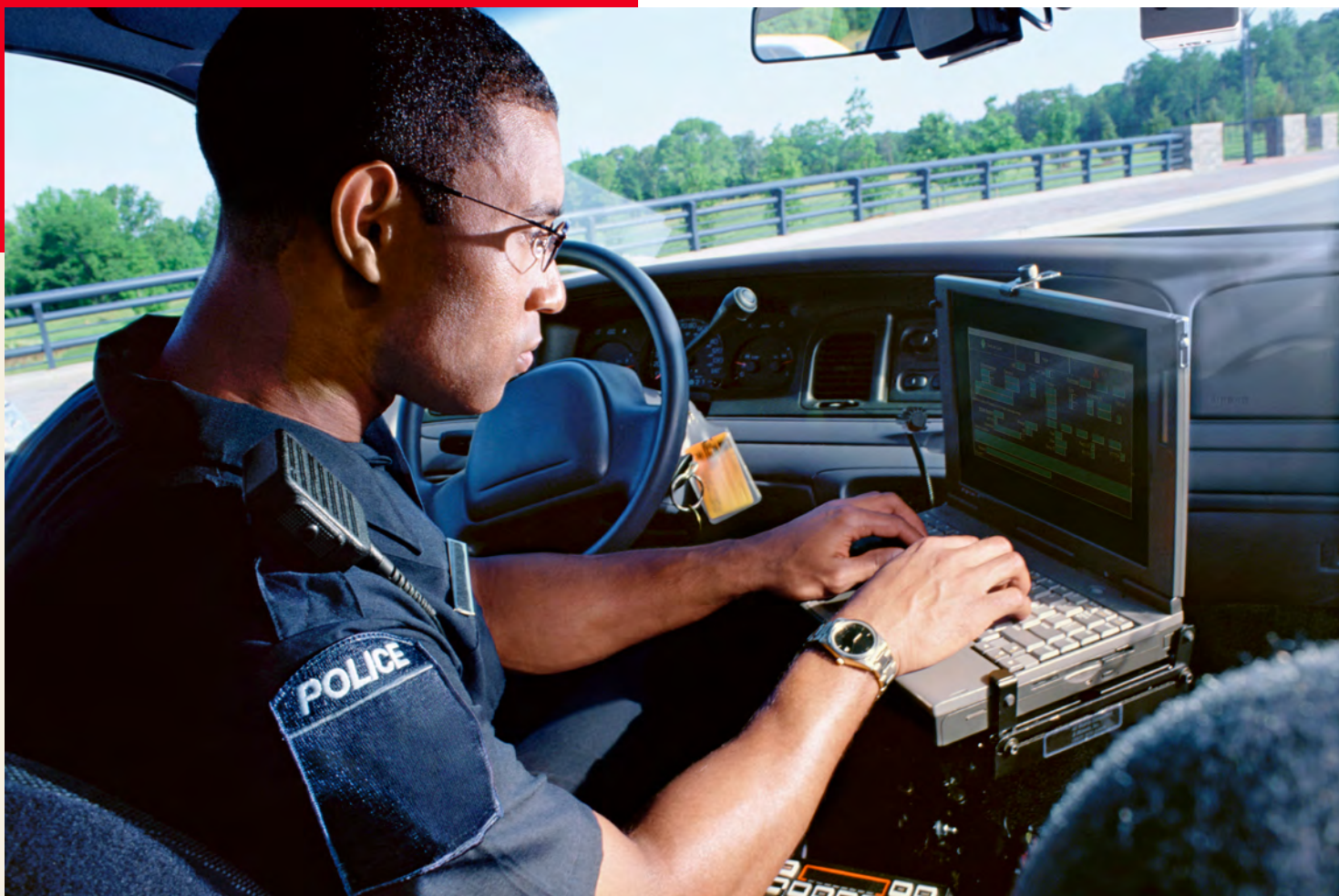


Revolutionizing mission-critical communications

Verizon Frontline Network Slice





5G technology has unlocked a plethora of new capabilities, with network slice standing out as a transformative innovation.

Network slice allows for the creation of multiple virtualized and independent logical networks on a common physical infrastructure. Each slice can be tailored to meet specific quality of service (QoS) demands for different applications, services or customer segments. This white paper presents a high-level overview of network slice technology and takes a deeper dive into Verizon Frontline Network Slice solutions for laptops, tablets, smartphones and connected vehicles. These solutions are designed to deliver enhanced and prioritized connectivity that supports first responders during mission-critical operations. We will explore the architecture, benefits, performance characteristics and relevant use cases.

Introduction to network slice

What is network slice?

Network slice is a feature of 5G standalone (SA) network architecture that enables mobile network operators to provide dedicated virtual networks with specific functionalities tailored to meet diverse service requirements. Essentially, it allows a single physical network infrastructure to be partitioned into multiple independent logical networks. Each “slice” can be optimized for different characteristics, such as bandwidth, latency and reliability, catering to a wide array of use cases, including mission-critical services.

The role of 5G SA

True network slice capabilities are realized with 5G SA network architecture. Unlike 5G nonstandalone (NSA) networks that rely on an existing 4G LTE core, 5G SA networks use a new 5G core (5GC). This cloud-native, service-based architecture is essential for the end-to-end management and orchestration of network slices, providing the flexibility and control needed to deliver customized network services.

How network slice works

Network slice spans different domains of the network:

- **Radio access network (RAN):** Resources in the RAN (e.g., spectrum, processing power) can be partitioned and prioritized for different slices.
- **Transport network:** The transport network helps ensure that data from different slices is routed appropriately and meets the defined performance criteria.
- **Core network:** The 5GC allows for the creation of dedicated control and user plane functions for each slice, providing isolation and customized functionality.

User Equipment Route Selection Policy (URSP) is a key mechanism that enables devices to select and connect to the appropriate network slice based on the application being used or predefined policies.



Key benefits of network slice

- **Service differentiation:** tailored connectivity solutions for diverse market segments (e.g., enterprise, public safety, automotive)
- **Resource optimization:** efficient allocation and utilization of network resources based on the specific needs of each slice
- **Enhanced user experience:** improved performance for critical applications by providing necessary QoS parameters
- **Increased flexibility and agility:** faster service deployment and modification of network characteristics

It's important to note that network slice itself does not create new capacity but provides additional tools for efficient resource distribution among various services.



Verizon Frontline is committed to keeping first responders connected with an award-winning network including priority and preemption services, a dedicated crisis response team, and 24/7 customer support.



Verizon Frontline: a commitment to public safety

For nearly three decades, Verizon has demonstrated a commitment to supporting first responders by delivering reliable and resilient mission-critical communication solutions. Verizon Frontline is the embodiment of this commitment, offering a suite of services and solutions specifically designed for the public safety community. This includes an award-winning network with priority and preemption services, a dedicated crisis response team, and 24/7 customer support. Verizon Frontline is the advanced network and technology for first responders, providing them with the tools they need to carry out their missions effectively and safely.

Keeping pace with our longstanding support for first responders, Verizon Frontline continues to expand the connectivity portfolio with additional offerings designed to help keep them connected in the field. These offerings include:

- Verizon Frontline Network Slice - Laptops
- Verizon Frontline Network Slice - Tablets
- Verizon Frontline Network Slice - Smartphones
- Verizon Frontline Network Slice - Connected Vehicle

Verizon Frontline Network Slice

Overview and purpose

Verizon Frontline Network Slice solutions are built on Verizon's 5G SA network and are designed to provide public safety agencies with an enhanced, prioritized connectivity experience. These innovative solutions provide dedicated 5G network resources for first responder laptops, tablets, smartphones and connected vehicles to help sustain mission-critical communications and maintain high performance, especially in congested environments. While they use shared network infrastructure, Verizon Frontline Network Slice can provide an improved user experience through dedicated network resources and prioritization mechanisms.

Target users and qualification

Verizon Frontline Network Slice solutions are currently available for first responders within specific defined North American Industry Classification System (NAICS) codes, including:

- Police Protection – 922120
- Fire Protection – 922160
- Ambulance Services – 621910
- National Security – 928110



Key features and capabilities

Verizon Frontline Network Slice solutions incorporate several key features to deliver enhanced performance:

Dedicated virtual network resources

Verizon Frontline Network Slice solutions carve out virtual resources to provide a degree of isolation and upgraded performance for first responders – even while sharing the physical infrastructure.

Priority and preemption

Verizon Frontline Network Slice solutions help ensure that public safety communications receive higher priority over other traffic on the network. In extreme congestion, preemption mechanisms can further help ensure that resources are available for critical users. This includes features such as unified access control (UAC) for high-priority access.

Advanced connectivity

Built for field use, these advanced mobility solutions are designed to deliver Verizon Frontline Network Slice features to the devices first responder use during their missions, helping enable reliable access to critical communications, data and applications when it matters most.

Enhanced QoS

These advanced solutions use a specific 5G QoS identifier (5QI) designed for services that require low latency and guaranteed flow bit rate, making it suitable for applications such as real-time video and critical data transmission. They leverage this designated 5QI with a significant scheduler weight on uplink (UL) and downlink to further prioritize traffic.

Dynamic radio resource partitioning

For added connectivity, these solutions employ dynamic radio resource partitioning, dedicating a percentage of radio resources to help ensure a better user experience for public safety users during network congestion.

Use cases for connected public safety laptops, tablets and smartphones:

- **Mobile command and incident management with laptops:** supports computer-aided dispatch (CAD) and mapping tools that depend on a consistent, high-bandwidth connection to track units in real time
- **Interactive mapping and digital floor plans with tablets:** gives first responders a live view of personnel locations overlaid on digital blueprints for better situational awareness
- **High-performance field applications with smartphones:** helps officers use facial recognition in some states, biometric scanning and other advanced mobile tools to verify access at secure perimeters

Connected vehicle solution

One application of Verizon Frontline Network Slice is the connected vehicle solution, which helps enable public safety vehicles to function as mobile command and communication hubs for real-time communications and field operations.

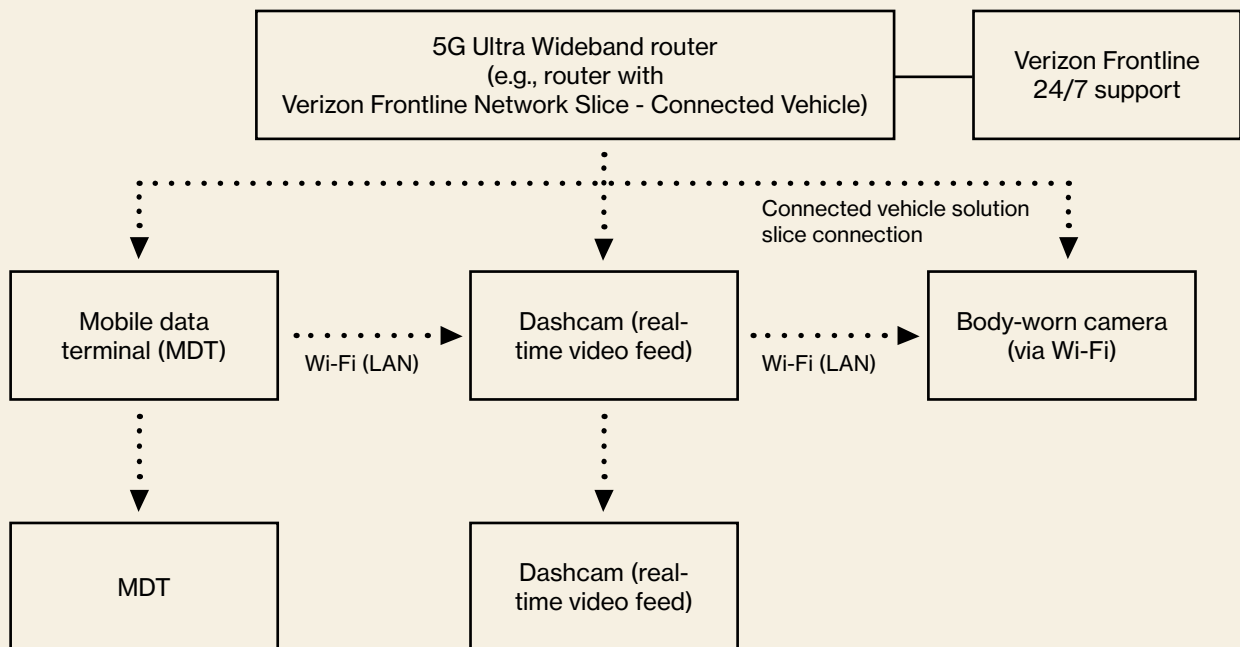
In-vehicle solution and architecture

The Verizon Frontline Network Slice - Connected Vehicle solution typically involves a ruggedized 5G in-vehicle router. This router acts as a gateway, providing connectivity for various devices and applications within the vehicle.

Use cases for connected public safety vehicles:

- **Enhanced emergency response:** improved coordination from mobile units during disasters and large-scale events through reliable real-time data and video sharing
- **Mobile command centers:** dependable and seamless connectivity for mobile units acting as field command posts
- **Remote monitoring and situational awareness:** supports public safety operations through real-time video feeds from dashcams and body-worn cameras as well as data from various sensors and applications
- **Reliable access to critical information:** helping ensure that officers can access databases, mapping applications and other critical information systems, even in congested areas

Figure 1: conceptual diagram of Verizon Frontline Network Slice - Connected Vehicle setup



The router connects to the Verizon 5G network using Verizon Frontline Network Slice - Connected Vehicle, which further provides connectivity for data traffic from connected peripherals (such as MDTs, dashcams, body-worn cameras via Wi-Fi and vehicle telematics) and benefits from the slice's prioritization and QoS enhancements.

Performance and impact of the connected vehicle solution

For Verizon Frontline Network Slice - Connected Vehicle, performance testing and impact assessments are crucial to understanding the value of the solution.

Performance benchmarks: throughput, latency, jitter

Testing conducted by Verizon's product and RAN planning teams has demonstrated that the connected vehicle solution provides a superior experience compared to standard 5G SA mobility connections, especially under congested conditions and in challenging signal areas (e.g., far cell).

Key performance indicator improvements with the connected vehicle solution (examples from provided data):

- **Latency:** significant reductions in latency (e.g., p90 latency improvements of up to 35x in some test cases such as body camera live video stream under 100% UL congestion)
- **Jitter:** substantial improvements in jitter (e.g., up to 6x improvement in the same test case)
- **Packet loss:** drastic reduction in packet loss (e.g., from 29.07% on standard 5G SA to 0.14% on the connected vehicle solution in the body camera test case)
- **Throughput:** higher average throughput for connectivity via the connected vehicle solution compared to default throughput, especially under load (e.g., notably higher throughput with the connected vehicle solution's user equipment than default user equipment throughput in midcell average UL throughput tests)



Verizon Frontline Network Slice prioritizes first responders while balancing the needs of general consumers.

Impact on shared network resources

While Verizon Frontline Network Slice - Connected Vehicle prioritizes public safety users, it operates on a shared network. The design aims to balance the needs of public safety users with those of general consumers.

- **Resource allocation:** With features such as dynamic radio resource partitioning (e.g., a defined percentage reserved), a portion of resources is set aside. Beyond this, the higher scheduling weight associated with its designated 5QI means the connected vehicle solution users will get a larger share of the available common resources during contention.
- **Impact during incidents:** During large incidents with high demand from public safety users, there might be a temporary impact on users in the immediate vicinity. However, this is generally comparable to the impact seen during any major incident today where network resources become heavily utilized. The goal of the connected vehicle solution is to help ensure that public safety communications are maintained even in these scenarios.

Comparison with standard 5G and previous solutions

Technical tests have shown notable improvements for the connected vehicle solution compared to existing public safety offerings (likely including those on 5G NSA or 4G LTE with priority). The enhancements in latency, jitter, packet loss and throughput have been shown during testing to be particularly significant in mid- and far-cell environments, where much public safety activity occurs.



Technical architecture of Verizon Frontline Network Slice

Several technical elements underpin the functionality of Verizon Frontline Network Slice:

Slice identification

Each network slice is identified by a single-network slice selection assistance information (S-NSSAI). The specified S-NSSAI for Verizon Frontline Network Slice is SST=1 (Slice/Service Type for Enhanced Mobile Broadband, often used as a base for prioritized services) and SD=5 (Slice Differentiator, a Verizon-specific value for this slice). This unique identifier allows Verizon Frontline Network Slice capable devices and the network to recognize and manage traffic for the Frontline slice.

RAN optimizations

Verizon Frontline Network Slice goes beyond dynamic radio resource partitioning and prioritized scheduling for its designated 5QI and uses other RAN features to further enhance performance for public safety users. These include:

- **UAC:** This feature employs a high-priority access class to help ensure that Verizon Frontline Network Slice users can access the network effectively, especially during congestion.
- **Bearer-based priority and preemption:** Using a high Allocation and Retention Priority value, Verizon Frontline Network Slice signals to the network the critical nature of these bearers for resource allocation and retention.
- **Unique Radio Frequency Service Profile/Subscriber Profile ID:** A specific profile identifier is used, enabling the network to apply tailored radio resource management policies for Verizon Frontline Network Slice traffic.



Core network and transport integration

- **Core network options:** Verizon Frontline Network Slice use cases can utilize the 5G SA public internet core or a mobile private network (MPN) core with Direct Internet Access (DIA) 2.0, depending on the specific service requirements.
- **Transport QoS:** The designated 5QI used in the RAN is mapped to a specific Differentiated Services Code Point value in the transport network. This helps ensure that the priority assigned in the radio network is maintained as traffic traverses the backhaul and core transport infrastructure, preserving end-to-end QoS.



Integration with MPN core and our connected vehicle solution

Verizon Frontline Network Slice - Connected Vehicle can use an MPN core, often in conjunction with DIA 2.0. This integration offers significant advantages for public safety agencies requiring enhanced security, control and dedicated connectivity to their private resources.

Concept of MPN integration: An MPN provides an isolated, secure, and often on-premises or cloud-hosted network environment tailored to an organization's specific needs. When the connected vehicle solution is integrated with an MPN core, the prioritized and resilient connectivity of these solutions is extended directly to the agency's private network. This means that data traffic from first responders can be securely routed to and from the agency's internal applications, databases and other sensitive resources, bypassing the public internet for such communications.

Benefits for public safety:

- **Enhanced security:** Keeping critical operational data within the private network boundary significantly improves data security and compliance with agency policies.
- **Direct access to private resources:** This kind of access helps ensure that first responders using the connected vehicle solution have reliable and prioritized access to their agency's specific applications (e.g., CAD, records management systems) even when operating in the field.
- **Customized control:** Agencies can have more granular control over their network policies, IP addressing and security configurations within their MPN environment.
- **Data sovereignty:** Helping meet requirements for data to remain within a defined private network or geographic location facilitates data security and privacy.

Role of DIA 2.0: In an MPN context with DIA 2.0, traffic destined for the public internet can be routed directly from the MPN core, while traffic intended for the agency's private resources remains within the MPN. This provides an efficient way to access public cloud services or general internet resources without compromising the security or performance of private network traffic. For connected vehicle solution users, this means their internet-bound traffic still benefits from the slice's prioritization up to the public internet breakout point, while internal traffic receives end-to-end prioritized and secure handling via the MPN.

This combination allows public safety agencies to leverage the advanced capabilities of Verizon Frontline Network Slice solutions for prioritized field communications while helping ensure secure and controlled access to their own private network infrastructure and applications.

Conclusion

Network slice represents a paradigm shift in how mobile networks can deliver customized services. To provide a significantly enhanced and reliable communication experience, Verizon Frontline Network Slice leverages this 5G SA capability to empower public safety operations. By offering dedicated virtual network resources, robust priority and preemption mechanisms, and optimized QoS parameters, Verizon Frontline Network Slice solutions help ensure that first responders have access to the critical connectivity they need, especially during high-traffic events and in challenging network conditions.

The performance improvements demonstrated in terms of throughput, latency, jitter and packet loss underscore the tangible benefits of Verizon Frontline Network Slice solutions for mission-critical applications, particularly for connected vehicles and mobile devices equipped with data-intensive tools. As 5G SA networks continue to evolve, these solutions will play an increasingly vital role in empowering first responders, improving situational awareness and ultimately contributing to safer communities.

Learn more

For more information, visit [verizon.com/frontlinenetworkslice](https://www.verizon.com/frontlinenetworkslice).



