You have a choice in your team's network.

1. Introduction

This white paper provides an overview of the Verizon Wireless Private Network Traffic Management (PNTM) solution. The solution leverages quality of service (QoS) technology in our 4G LTE Private Network to deliver a differentiated network experience for subscribers using business-critical applications.

1.1 Audience

We developed this white paper for business and government customers, IT administrators, technical decision makers and Verizon sales associates and solution engineers. It is assumed that readers have a solid understanding of computers, networks and wireless technologies.

2. Executive summary

Thanks to the evolution of LTE technology and Third Generation Partnership Project (3GPP) standards, we can now leverage QoS network technology for our 4G LTE Private Network subscribers. Verizon Private Network Traffic Management can greatly improve user experiences on your Private Network. It allows you to create IP traffic preferences for business-critical applications, which helps keep the right applications available and predictable at the right times, even during times of peak network demand. With Private Network Traffic Management, you get:

- **More control**. When the network becomes congested, Private Network Traffic Management allows you to prioritize applications for optimal performance

- **Higher productivity**. With more predictable application performance during high-traffic periods, you can use business-critical applications when and where you need them

- **Increased flexibility**. Private Network Traffic Management lets you map your most important applications into the business-critical class of service (CoS) based on the applications' requirements

- **New potential**. Now you can extend QoS policies traditionally provided on fixed WAN to the private network, giving you expanded network control

3. Private Network Traffic Management

Private Network Traffic Management relies on three core LTE network pillars to help make application performance more predictable during heavy network use:

- **Traffic Priority**. Provides the supporting structure for how packets are treated within the private network

- **Admission Priority**. Provides the framework to allocate and retain network resources during heavy network use

- **Access Priority**. Provides the network mechanism to allocate radio resources to a subscriber during heavy network use. Applies only to the Public Safety service option

Private Network Traffic Management provides the following subscription options:

- Enhanced is the entry level available to enterprise and government customers. It allows you to map business-critical applications into a service class with a maximum of 0.5 Mbps. The remaining applications are mapped into the Best Effort service class and will use the leftover bandwidth as available

- Premium is the highest level available to enterprise and government customers. It allows you to map business-critical applications into a service class with a maximum of 2 Mbps.

verizon✓

Private Network Traffic Management service options

|	Business Critical CoS				Best Effort CoS
Subscriber	Subscription type	Access priority-RF	0.5 Mbps	2 Mbps	Access to available 4G LTE bandwidth
Enterprise/ Government	Enhanced		✓		✓
Enterprise/ Government	Premium			✓	✓
Qualifying first-responder agencies	Public Safety	✓		✓	✓
	Recommended for video, Voice over IP, interactive services and other business-critical applications				(Suitable for best-effort applications, e.g., email, web browsing)
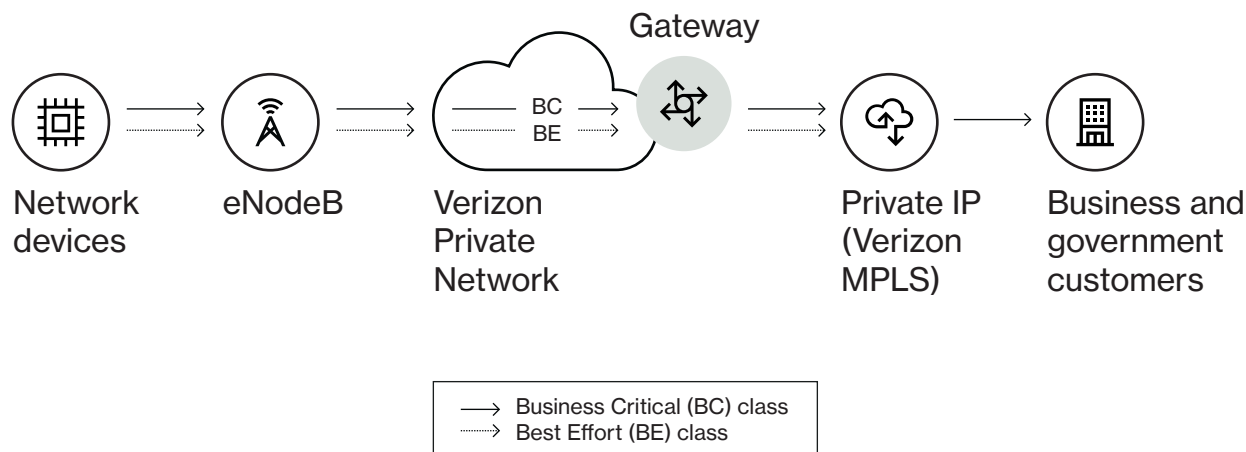
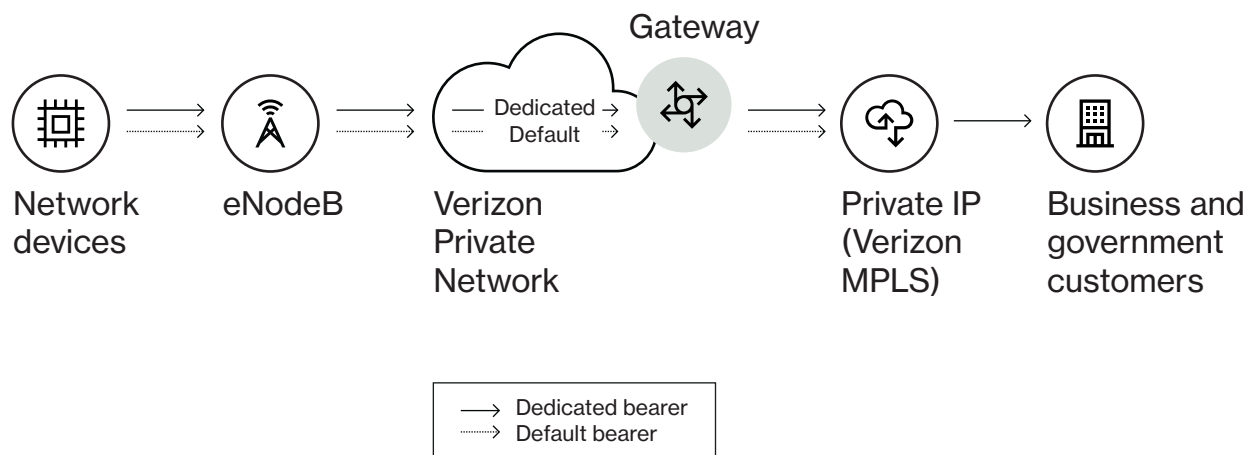Figure 1. Private Network Traffic Management

Figure 2. Private Network Traffic Management bearer

verizon✓

The remaining applications are mapped into the Best Effort service class and will use the leftover bandwidth as available

- Public Safety is the highest service option level and is reserved for qualified public safety customers. It allows you to map business-critical applications into a service class with a maximum of 2 Mbps. The remaining applications are mapped into the Best Effort service class and will use the leftover bandwidth as available. Public Safety also gets priority on the radio access network during heavy network use.

4. How does Private Network Traffic Management work?

4.1 Traffic Priority

You can prioritize IP packets in the 4G LTE Private Network using standards-based QoS markings between user equipment (UE) and the Private Network gateway (see figure 1). A set of bearers between the UE and the enterprise gateway (ExGW) carries user-data IP flows and receives specific IP traffic treatment, discussed later in this section. You can also enable end-to-end prioritization by implementing QoS capabilities on your enterprise IP network—for example, Verizon Private IP service.

4.1.1 Private Network Traffic Management bearers

When the UE attaches to the Private Network, it is assigned two bearers that remain as long as the UE is attached (see figure 2).

The default bearer transports IP traffic that does not require any specific QoS treatment, such as best-effort IP flows (email, web, etc.). These IP flows are carried on the Best Effort class over the Private Network.

The dedicated bearer transports IP flows that need specific QoS treatment, such as enterprise Voice over IP (VoIP). Business-critical applications are mapped to the dedicated bearer using applications IP marking; please see section 4.1.3 for additional details.

4.1.2 Private Network Traffic Management bearer properties

Non-guaranteed bit rate (non-GBR): Bearer does not have a fixed bandwidth allocation and there is no guarantee as to how much traffic it can carry. Default and dedicated bearers are non-GBR.

Maximum bit rate (MBR): A specified MBR is applied to the uplink and downlink dedicated bearer, and is set based on your subscription level: 2 Mbps for Public Safety and Premium, 0.5 Mbps for Enhanced. The Private Network gateway (ExGW) is responsible for enforcing the MBR. And because the dedicated bearer carries your business-critical applications, be sure to carefully consider the applications' bandwidth requirements before placing them in the Business Critical class. IP packets with bit rates exceeding the applicable MBR will be discarded.

4.1.3 Private Network Traffic Management IP flow classifications

Private Network Traffic Management relies on your application IP markings on the UE and network to prioritize the IP flows over the 4G LTE Private Network. IP markings are preserved and passed across the 4G LTE Private Network, which follows rules based on those markings to determine whether the IP packets should be placed on the dedicated or default bearer.

Each bearer is associated with a traffic flow template (TFT), which is basically the IP filter for the uplink IP flows. The TFT uses the IP header's type of service (ToS) to assign the IP flow to the dedicated or default bearer. Similar IP rules are applied on the downlink IP flows on the Private Network gateway.

Private Network Traffic Management is differentiated-services (DiffServ) aware. It uses the IP DiffServ Code Point (DSCP) value carried in the original IP-packet-header ToS to map business-critical applications to the correct bearer. Table 1 provides the DSCP values required for the Business Critical and Best Effort classes.

Business Critical class is recommended for video, VoIP, interactive services and other critical applications that need priority treatment. Best Effort class is suitable to best-effort applications, such as email and web browsing.

Each Private Network Traffic Management bearer has an associated QoS class identifier (QCI). The QCI determines how to treat IP packets on a given bearer. The default bearer is assigned to QCI 8 and the dedicated bearer is assigned to QCI 7. The eNodeB (eNB), a base transceiver station that connects UE to the 4G LTE network, uses a scheduling algorithm to forward uplink and downlink IP packets to the respective bearers. The eNB has a higher scheduling weight for QCI 7 than the QCI 8 bearer. During congestion, that means prioritizing QCI 7 IP flows on the dedicated bearer on the air interface above the default bearer's QCI 8 IP flows.

4.1.4 IP backbone

The IP backbone refers to the Verizon IP core infrastructure that transports Private Network Traffic Management IP flows to and from the Private Network gateway. The Verizon IP core is designed with the highest redundancy and resiliency available, and the IP backbone is engineered to minimize congestion due to circuit or hardware failures. Although we do not expect to see congestion in the IP backbone, we have implemented common QoS techniques, such as Class-Based Weighted Fair Queueing (CBWFQ) and Priority Queueing. Business-critical IP flows, which are on the dedicated bearer, are also prioritized on the IP core.

4.2 Admission Priority

verizon✓

Admission Priority manages the allocation and retention of Private Network Traffic Management bearers, which control how traffic flows into the network. It works through allocation and retention priority (ARP), which is a value that determines whether to accept new bearer creation or change requests, based on the current resource situation. The lower the ARP value, the more likely the request will be accepted. Public Safety class has the lowest ARP value, followed by the Premium and Enhanced classes.

4.3 Access Priority

Access class barring (ACB) is an LTE access-control mechanism that prioritizes radio bandwidth for emergency service subscribers. It helps ensure that service agencies will be able to communicate and stay connected during overload network conditions caused by public-safety concerns, such as states of emergency and national disasters. During these situations, ACB prevents UE users from accessing radio resources if not authorized by their access class. Enhanced and Premium subscribers are assigned access classes 0 to 9. Public Safety subscribers belong to high-priority access classes 11 to 15, and will never be barred from accessing radio resources. During overload network conditions, the eNB performs ACB and allocates access to the high-priority access classes, while denying access to lower-priority requesters. ACB is automated on the Verizon radio access network during peak network use.

4.4 End-to-end QoS

If you have the Verizon Wireless Private Network with Verizon Private IP, you can extend Private Network Traffic Management CoS into Private IP CoS. The Private IP service will add a Private IP wireless gateway (PWG) with Private IP Enhanced

Traffic Management (ETM) if you use Expedited Forwarding (EF) on the Private Network. This design allows Private Network Traffic Management CoS to map to Private IP CoS. Dedicated physical circuits such as point-to-point (Ethernet private lines) are supported access options as well.

5. 4G LTE Private Network Traffic Management devices

Private Network Traffic Management requires eligible 4G LTE devices provisioned on the Private Network. These devices can use Private Network Traffic Management only on the 4G LTE access technology; previous access technologies, such as 3G, do not support it.

The LTE devices should:

- Support network-initiated QoS for both default and dedicated bearers, including the creation of new dedicated bearers using the 3GPP standard
- Support changes to the QoS for the default or dedicated bearer using the 3GPP standard
- Support the removal of a dedicated bearer using the 3GPP standard
- Route IP packets to the dedicated bearer based on TFT information provided by the Verizon Wireless network

Please reach out to your Verizon contact for the latest list of eligible devices.
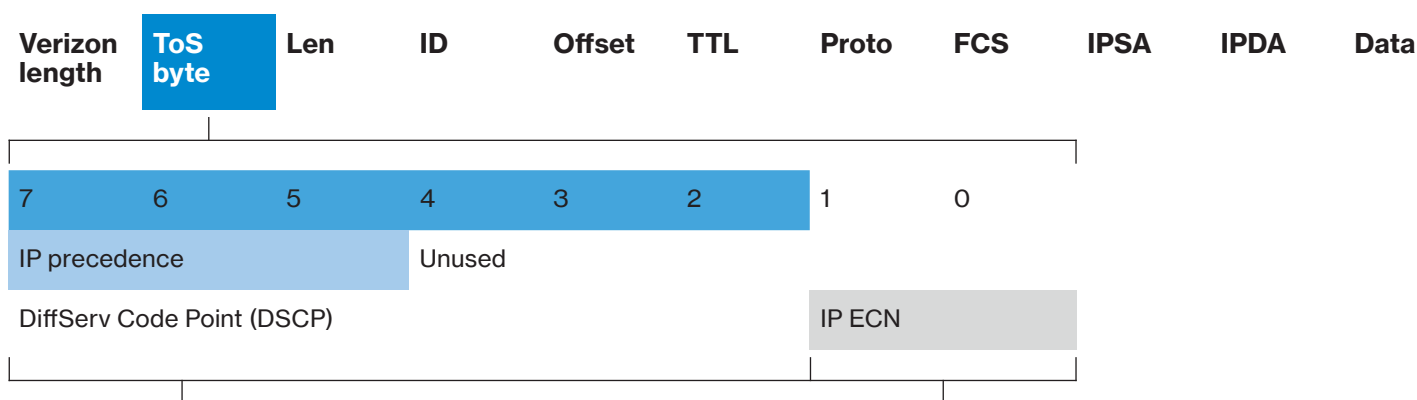
Verizon length	ToS byte	Len	ID	Offset	TTL	Proto	FCS	IPSA	IPDA	Data

7	6	5	4	3	2	1	0
IP precedence			Unused				
DiffServ Code Point (DSCP)						IP ECN	

Figure 3. IPv4 packet header

verizon✓

Figure 4. TOS/DSCP—aware bearing binding
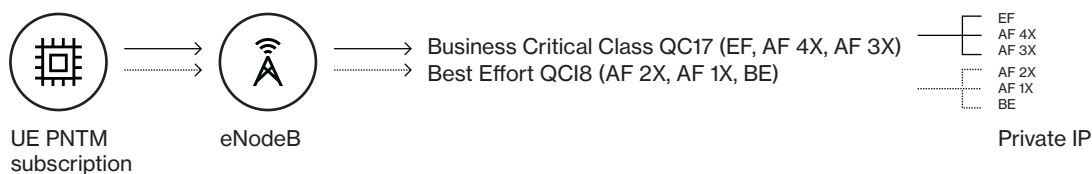
Figure 5. Private Network Traffic Management and Private IP classes mapping

User datagram IP header			
PNTM classes	**DiffServ Code Point (DSCP)**	**Class selector (CS)**	**PNTM LTE bearer**
Business Critical	EF	5	Dedicated bearer
Business Critical	AF 4X	4	Dedicated bearer
Business Critical	AF 3X	3	Dedicated bearer
Best Effort	AF 2X	2	Default bearer
Best Effort	AF 1X	1	Default bearer
Best Effort	CS6, CS7	6, 7	Default bearer

Table 1. DSCP values required for PNTM classes

6. LTE roaming

Private Network Traffic Management capability will not be in service when roaming off the Verizon Wireless network, as roaming carriers' networks can't establish the Private Network Traffic Management dedicated bearer.

7. Conclusion

Verizon allows you to extend QoS policies traditionally provided over fixed WAN (MPLS) networks to prioritize traffic over the Verizon Wireless Private Network. Private Network Traffic Management helps maintain business-critical services so you can connect, collaborate, communicate and deliver a better customer experience when it matters most.

Learn more:

verizonwireless.com/privatenetwork

When it comes to your team's communications, you are not locked into one provider. You have a choice. Your team is relying on you to choose America's most reliable network. And that's Verizon. Are you ready?

Definition of terms

3GPP (Third Generation Partnership Project):
Collaboration between groups of telecommunications associations responsible for developing specifications for advanced mobile communication

Bearer:
Virtual tunnel connecting two or more points in the LTE core network

CBWFQ (Class-Based Weighted Fair Queueing):
QoS technique that provides support for user-defined traffic classes based on match criteria, including protocols and DSCP values

DSCP (DiffServ Code Point):
The six most significant bits of the ToS byte IP header

eNB (eNodeB):
Base transceiver station that connects UE to the LTE network

PQ (priority queueing):
QoS technique in which a high-priority IP packet is transmitted before a low-priority IP packet

QCI (QoS class identifier):
Pointer that serves as a reference to provide prioritized packet-forwarding treatment

QoS (quality of service):
The ability to provide different priority to different applications, users or data flows

TFT (traffic flow template):
Defines rules so that the UE and network know which IP packet should be sent on a particular dedicated bearer

UE (user equipment):
Devices used directly by end users to communicate with the LTE network