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**A Non-Queue-Building Per-Hop Behavior (NQB PHB) for Differentiated
Services
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Abstract

This document specifies properties and characteristics of a Non-Queue-Building Per-Hop Behavior (NQB PHB). The purpose of this NQB PHB is to provide a separate queue that enables low latency and, when possible, low loss for application-limited traffic flows that would ordinarily share a queue with capacity-seeking traffic. This PHB is implemented without prioritization and without rate policing, making it suitable for environments where the use of either these features may be restricted. The NQB PHB has been developed primarily for use by access network segments, where queuing delays and queuing loss caused by Queue-Building protocols are manifested, but its use is not limited to such segments. In particular, applications to cable broadband links and mobile network radio and core segments are discussed. This document defines a standard Differentiated Services Code Point (DSCP) to identify Non-Queue-Building flows.

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[1.](#) Introduction

This document defines a Differentiated Services (DS) per-hop behavior (PHB) called "Non-Queue-Building Per-Hop Behavior" (NQB PHB), which is intended to enable networks to provide low latency and low loss for traffic flows that are relatively low data rate and that do not themselves materially contribute to queueing delay and loss. Such Non-Queue-Building flows (for example: interactive voice and video, gaming, machine to machine applications) are application limited flows that are distinguished from traffic flows managed by an end-to-end congestion control algorithm.

The vast majority of packets that are carried by broadband access networks are, in fact, managed by an end-to-end congestion control algorithm, such as Reno, Cubic or BBR. These congestion control

algorithms attempt to seek the available capacity of the end-to-end path (which can frequently be the access network link capacity), and in doing so generally overshoot the available capacity, causing a queue to build-up at the bottleneck link. This queue build up results in queuing delay (variable latency) and possibly packet loss that affects all of the applications that are sharing the bottleneck link.

In contrast to traditional congestion-controlled applications, there are a variety of relatively low data rate applications that do not materially contribute to queueing delay and loss, but are nonetheless subjected to it by sharing the same bottleneck link in the access network. Many of these applications may be sensitive to latency or latency variation, as well as packet loss, and thus produce a poor quality of experience in such conditions.

Active Queue Management (AQM) mechanisms (such as PIE [[RFC8033](#)], DOCSIS-PIE [[RFC8034](#)], or CoDel [[RFC8289](#)]) can improve the quality of experience for latency sensitive applications, but there are practical limits to the amount of improvement that can be achieved without impacting the throughput of capacity-seeking applications, particularly when only a few of such flows are present.

The NQB PHB supports differentiating between these two classes of traffic in bottleneck links and queuing them separately in order that both classes can deliver satisfactory quality of experience for their applications.

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14](#) [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

3. Overview: Non-Queue-Building Flows

There are many applications that send traffic at relatively low data rates and/or in a fairly smooth and consistent manner such that they are highly unlikely to exceed the available capacity of the network path between source and sink. These applications do not cause queues to form in network buffers, but nonetheless can be subjected to packet delay and delay variation as a result of sharing a network buffer with applications that do cause queues. Many of these applications are negatively affected by excessive packet delay and delay variation. Such applications are ideal candidates to be queued

separately from the capacity-seeking applications that are the cause of queue buildup, latency and loss.

These Non-queue-building (NQB) flows are typically UDP flows that don't seek the capacity of the link (examples: online games, voice chat, DNS lookups, real-time IoT analytics data). Here the data rate is limited by the Application itself rather than by network capacity - in many cases these applications only send a few packets per RTT. In contrast, Queue-building (QB) flows include traffic which uses the Traditional TCP or QUIC, with BBR or other TCP congestion controllers.

4. DSCP Marking of NQB Traffic

Applications that align with the above description of NQB behavior SHOULD identify themselves to the network using a DiffServ Code Point (DSCP) so that their packets can be queued separately from QB flows.

There are many application flows that fall very neatly into one or the other of these categories, but there are also application flows that may be in a gray area in between (e.g. they are NQB on higher-speed links, but QB on lower-speed links).

If there is uncertainty as to whether an application's traffic aligns with the description of NQB behavior in the preceding section, the application SHOULD NOT mark its traffic with the NQB DSCP. In such a case, the application SHOULD instead implement a congestion control mechanism, for example as described in [[RFC8085](#)].

This document recommends a DSCP of 0x2A to identify packets of NQB flows. (editor's note: this value is subject to change)

It is worthwhile to note that the NQB designation and marking is intended to convey verifiable traffic behavior, not needs or wants. Also, it is important that incentives are aligned correctly, i.e. that there is a benefit to the application in marking its packets correctly, and no benefit to an application in intentionally mismarking its traffic. Thus, a useful property of nodes that support separate queues for NQB and QB flows would be that for NQB flows, the NQB queue provides better performance than the QB queue; and for QB flows, the QB queue provides better performance than the NQB queue. By adhering to these principles, there is no incentive for senders to mismark their traffic as NQB, and further, any mismarking can be identified by the network.

In contrast to the existing standard DSCPs, which are typically only meaningful within a DiffServ Domain (e.g. an AS or an enterprise network), this DSCP is expected to be used end-to-end across the

Internet. Some network operators typically bleach (zero out) the DiffServ field on ingress into their network [[Custura](#)], and in some cases apply their own DSCP for internal usage. Networks that support the NQB PHB SHOULD preserve the NQB DSCP when forwarding via an interconnect from or to another network.

5. Non-Queue-Building PHB Requirements

A node supporting the NQB PHB makes no guarantees on latency or data rate for NQB marked flows, but instead aims to provide a bound on queuing delay for as many such marked flows as it can, and shed load when needed.

A node supporting the NQB PHB MUST provide a queue for non-queue-building traffic separate from the queue used for queue-building traffic.

NQB traffic SHOULD NOT be rate limited or rate policed separately from queue-building traffic of equivalent importance.

The NQB queue SHOULD be given equal priority compared to queue-building traffic of equivalent importance. The node SHOULD provide a scheduler that allows QB and NQB traffic of equivalent importance to share the link in a fair manner, e.g. a deficit round-robin scheduler with equal weights.

A node supporting the NQB PHB SHOULD treat traffic marked as Default (DSCP=0x00) as QB traffic having equivalent importance to the NQB marked traffic.

The NQB queue SHOULD have a buffer size that is significantly smaller than the buffer provided for QB traffic.

It is possible that due to an implementation error or misconfiguration, a QB flow would end up getting mismarked as NQB, or vice versa. In the case of an NQB flow that isn't marked as NQB and ends up in the QB queue, it would only impact its own quality of service, and so it seems to be of lesser concern. However, a QB flow that is mismarked as NQB would cause queuing delays and/or loss for all of the other flows that are sharing the NQB queue.

To prevent this situation from harming the performance of the real NQB flows, network elements that support differentiating NQB traffic SHOULD (editor's note: SHOULD vs MUST is TBD) support a "traffic protection" function that can identify QB flows that are mismarked as NQB, and reclassify those flows/packets to the QB queue. Such a function SHOULD be implemented in an objective and verifiable manner, basing its decisions upon the behavior of the flow rather than on

application-layer constructs. One example algorithm can be found in [[I-D.briscoe-docsis-q-protection](#)].

6. Relationship to L4S

Traffic flows marked with the NQB DSCP as described in this draft are intended to be compatible with [[I-D.ietf-tsvwg-l4s-arch](#)], with the result being that NQB traffic and L4S traffic can share the low-latency queue in an L4S dual-queue node [[I-D.ietf-tsvwg-aqm-dualq-coupled](#)].

7. Use Cases

7.1. DOCSIS Access Networks

Residential cable broadband Internet services are commonly configured with a single bottleneck link (the access network link) upon which the service definition is applied. The service definition, typically an upstream/downstream data rate tuple, is implemented as a configured pair of rate shapers that are applied to the user's traffic. In such networks, the quality of service that each application receives, and as a result, the quality of experience that it generates for the user is influenced by the characteristics of the access network link.

To support the NQB PHB, cable broadband services **MUST** be configured to provide a separate queue for NQB marked traffic. The NQB queue **MUST** be configured to share the service's rate shaping bandwidth with the queue for QB traffic.

7.2. Mobile Networks

Historically, mobile networks have been configured to bundle all flows to and from the Internet into a single "default" EPS bearer whose buffering characteristics are not compatible with low-latency traffic. The established behaviour is rooted partly in the desire to prioritise operators' voice services over competing over-the-top services and partly in the fact that the addition of bearers was prohibitive due to expense. Of late, said consideration seems to have lost momentum (e.g., with the rise in Multi-RAB (Radio Access Bearer) devices) and the incentives might now be aligned towards allowing a more suitable treatment of Internet real-time flows.

To support the NQB PHB, the mobile network **SHOULD** be configured to give UEs a dedicated, low-latency, non-GBR, EPS bearer, e.g. one with QCI 7, in addition to the default EPS bearer; or a Data Radio Bearer with 5QI 7 in a 5G system (see Table 5.7.4-1: Standardized 5QI to QoS characteristics mapping in [[SA-5G](#)]).

A packet carrying the NQB DSCP SHOULD be routed through the dedicated low-latency EPS bearer. A packet that has no associated NQB marking SHOULD be routed through the default EPS bearer.

7.3. WiFi Networks

WiFi networking equipment compliant with 802.11e generally supports either four or eight transmit queues and four sets of associated Enhanced Multimedia Distributed Control Access (EDCA) parameters (corresponding to the four WiFi Multimedia (WMM) Access Categories) that are used to enable differentiated media access characteristics. Implementations typically utilize the IP DSCP field to select a transmit queue, but should be considered as Non-Differentiated Services-Compliant Nodes as described in [Section 4 of \[RFC2475\]](#) because this transmit queue selection is a local implementation characteristic that is not part of a consistently operated DiffServ domain or region. As a result this document discusses interoperability with WiFi networks, as opposed to PHB compliance.

As discussed in [\[RFC8325\]](#), most existing WiFi implementations use a default DSCP to User Priority mapping that utilizes the most significant three bits of the DiffServ Field to select "User Priority" which is then mapped to the four WMM Access Categories. In order to increase the likelihood that NQB traffic is provided a separate queue from QB traffic in existing WiFi equipment, the 0x2A codepoint is preferred for NQB. This would map NQB to UP_5 which is in the "Video" Access Category. Similarly, systems that utilize [\[RFC8325\]](#), SHOULD map the NQB codepoint to UP_5 in the "Video" Access Category.

While the DSCP to User Priority mapping can enable WiFi systems to support the NQB PHB requirement for segregated queuing, many currently deployed WiFi systems may not be capable of supporting the remaining NQB PHB requirements in [Section 5](#). This is discussed further below.

Existing WiFi devices are unlikely to support a traffic protection algorithm, so traffic mismarked as NQB is not likely to be detected and remedied by such devices.

Furthermore, in their default configuration, existing WiFi devices utilize EDCA parameters that result in statistical prioritization of the "Video" Access Category above the "Best Effort" Access Category. If left unchanged, this would violate the NQB PHB requirement for equal prioritization, and could erode the principle of alignment of incentives. In order to preserve the incentives principle, WiFi systems SHOULD configure the EDCA parameters for the Video Access Category to match those of the Best Effort Access Category.

In cases where a network operator is delivering traffic into an unmanaged WiFi network outside of their control (e.g. a residential ISP delivering traffic to a customer's home network), the network operator should presume that the existing WiFi equipment does not support the safeguards that are provided by the NQB PHB requirements, and thus should take precautions to prevent issues. In these situations, the operator SHOULD deploy a policing function on NQB marked traffic that minimizes the potential for starvation of traffic marked Default, for example by limiting the rate of such traffic to a set fraction of the customer's service rate.

As an additional safeguard, and to prevent the inadvertent introduction of problematic traffic into unmanaged WiFi networks, network equipment that is intended to deliver traffic into unmanaged WiFi networks (e.g. an access network gateway for a residential ISP) MUST by default remap the NQB DSCP to Default. Such equipment MUST support the ability to configure the remapping, so that (when appropriate safeguards are in place) traffic can be delivered as NQB-marked.

8. Acknowledgements

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9. IANA Considerations

This draft proposes the registration of a standardized DSCP = 0x2A to denote Non-Queue-Building behavior.

10. Security Considerations

There is no incentive for an application to mismark its packets as NQB (or vice versa). If a queue-building flow were to mark its packets as NQB, it could experience excessive packet loss (in the case that traffic protection is not supported by a node) or it could receive no benefit (in the case that traffic protection is supported). If a non-queue-building flow were to fail to mark its packets as NQB, it could suffer the latency and loss typical of sharing a queue with capacity seeking traffic.

The NQB signal is not integrity protected and could be flipped by an on-path attacker. This might negatively affect the QoS of the tampered flow.

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