IEEE 802.11 Working Group Reply to the WBA Liaison Statement on 5G & Wi-Fi RAN Convergence

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SUBJECT: IEEE 802.11 Working Group Reply to the WBA Liaison Statement on 5G & Wi-Fi RAN Convergence, QoS

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Dear Florin,

The IEEE 802.11 Working Group (WG) thanks the Wireless Broadband Alliance (WBA) for sharing their work on 5G and Wi-Fi RAN convergence and providing the "5G and Wi-Fi RAN Convergence – Aligning the Industry on Opportunities and Challenges" [1] white paper. The IEEE 802.11 WG also thanks the WBA for providing and presenting an overview of the white paper at the January 2021 IEEE 802.11 Virtual meeting [2].

In addition, IEEE 802.11 WG thanks the WBA 5G working group for highlighting potential challenges and gaps in the following key areas:

1. 5G and Wi-Fi convergence architecture (for Trusted and Untrusted WLAN access);
2. ATSSS multi-access functionality;
3. End-to-end Quality of Service (QoS);
4. Policy Interworking and enhancements across 5G and Wi-Fi;
5. Support for Wi-Fi only devices.

The IEEE 802.11 WG notes that the scope of IEEE Std 802.11 is the definition of one Medium Access Control (MAC) and several physical layer (PHY) specifications for wireless connectivity for fixed, portable, and moving stations (STAs) within a local area [3, 4], whereas some of the potential challenges and gaps highlighted by WBA pertain to functionality above the MAC (e.g., higher layer policies, Internet Protocol (IP) based protocols, and core network architectures). Hence, the IEEE 802.11 WG in this reply will focus on features and capabilities that IEEE Std 802.11 does define, and which are relevant to addressing these challenges and gaps – primarily in the domain of End-to-end QoS (please see the Appendix for a list of relevant features).

Use of packet classification and DSCP marking for 802.11 QoS

As noted by WBA, in deployment scenarios where (IP) data packets exchanged between a STA and a 3GPP 5G core network traverse an IEEE 802.11 air interface but do not have appropriate Differentiated Services Code Point (DSCP) marking from which the required QoS treatment can be mapped at the transmitter, rule-based packet classification and QoS assignment can be performed instead. This approach may be necessary in scenarios where any DSCP marking applied to packets at source is removed or modified by intermediate nodes on the public Internet or by Internet Service Providers (ISPs).

A procedure for access to 3GPP 5G core networks via non-3GPP access networks (i.e. IEEE 802.11 based networks) is defined in [7] whereby QoS flows are mapped, according to their QoS requirements, to IPsec (Internet Protocol security) tunnel mode Child SAs (Security Associations) between the UE and N3IWF (for untrusted access) or TNGF (for trusted access). Since each Child SA is identified by a Security Parameter Index (SPI) value, the SPI field in packet headers can be used as the packet classifier for a QoS rule. The TCLAS element defined in IEEE Std 802.11™-2020 [3] supports classification based on IPsec SPI. Please refer to subclause 9.4.2.30, Frame classifier type 10 (IP extensions and higher layer parameters). With respect to Figure 9-327, the Protocol Number or Next Header field and Filter Value/Mask fields need to be set appropriately to specify the SPI field, depending on the use of Encapsulating Security Payload (ESP) or Authentication Header (AH) protocol, (IPv4) UDP/TCP encapsulation and/or IPv6 extension headers. Multiple TCLAS elements (together with a TCLAS Processing element, see subclause 9.4.2.32) can be used to specify a classifier comprising both an SPI value and other parameters such as (outer) IP addresses and ports.

IEEE Std 802.11™-2020 defines several capabilities that make use of TCLAS elements for packet classification, notably the Stream Classification Service (SCS) (refer to subclause 11.25.2) and TS operations (refer to subclause 11.4). In both cases, the STA can request the AP to apply rules to downlink traffic that, on transmission, assign a specified User Priority (UP) to frames containing IP packets that match the TCLAS element(s) classifier. The STA might make such a request at the time the Child SAs are initiated and the corresponding SPI values, and the 5G QoS Identifiers (5QIs) of QoS flows associated with each Child SA (which can be mapped to a UP value for each Child SA), are known.

Alternatively, in some deployments (such as trusted access) the AP might be configured directly with equivalent classification rules, without explicit signaling between the STA and AP.

For Child SAs carrying uplink traffic, the STA can assign the UP of the corresponding packets autonomously, so in general (e.g., except when Admission Control is required), it is assumed no specific exchanges with the AP are required.

In cases where the UP is assigned based on DSCP marking (instead of TCLAS classifier based rules), the mapping table might be configured on both APs and STAs by the network operator using the QoS Map capability (see subclause 11.22.9).

If there are use cases in which the above mechanisms are insufficient or unsuitable (at least to the extent of achieving relative prioritization of QoS flows over the air), we request that WBA provide additional information.

Mapping 5G QoS to 802.11 QoS

The 3GPP 5QI values are used to indicate QoS requirements in terms of relative priority, GBR/non-GBR, packet delay budget, packet error rate targets, and (in certain cases) a maximum data burst size.

The relative priority associated with 5QI values is directly comparable with the IEEE 802.11 UPs (which are mapped to EDCA access categories).

However, while the relative priority (e.g., UP) of an IP flow is likely to indirectly influence whether or not other parameters associated with a 5QI are met (e.g., packet delay budget), in practice an IEEE 802.11 based network might use various monitoring, queue management and air-interface scheduling techniques to help ensure the target Key Performance Indicators (KPIs) for QoS flows in the network are met (see also below).

The TSPEC element (see subclause 9.4.2.29) can be used to explicitly exchange target KPIs between a STA and an AP for a QoS flow. The current design is primarily intended for use with Admission Control for GBR voice flows, however work is currently ongoing in the TGbe Task Group to enhance this signaling and its optimization for non-GBR flows and GBR flows for emerging applications.

Meeting 5G QoS requirements over the 802.11 PHY/MAC

A wide range of WLAN implementations based on IEEE Std 802.11 provide support for Voice, Video, and Data traffic applications, including Voice over Internet Protocol (VoIP) and Video over IP applications. There is also widespread support for “Wi-Fi Offload” – a service that provides cellular subscribers data via WLAN, as well as “Wi-Fi Calling” - a service that provides 3GPP voice and NAS services via a WLAN radio link.

As highlighted by WBA, there is an increasing range of applications (such as gaming, AR/VR and teleconferencing) that have stringent QoS requirements that must be met by the 802.11 PHY/MAC.

The UP assignment capabilities described above result in flows with different QoS requirements being separated into different queues (to help avoid head-of-line blocking), and provide differentiated channel access prioritization via EDCA access categories. This channel access prioritization is effective both within and between different IEEE Std 802.11 based WLAN networks, and is also effective with respect to other technologies that share (unlicensed) spectrum using similar channel access rules.

In addition, as noted by WBA, IEEE Std 802.11ax™-2021 defines several new powerful features such as OFDMA, UL MU-MIMO, Spatial Reuse and TWT, which provide additional degrees of freedom for spectral resource allocation that can be leveraged by the scheduler in an IEEE Std 802.11 based network to meet the KPIs of QoS traffic flows. For example, downlink OFDMA and MU-MIMO increase MAC efficiency and can reduce packet delay by transmitting packets to multiple users within the same TXOP, while Spatial Reuse can reduce packet delay by enabling additional transmit opportunities while managing interference. In addition, MU EDCA and trigger-based MU features allow uplink transmissions to be fully centrally controlled by the network. Certain KPIs such as packet error rate targets are also influenced by rate selection and retransmit behavior.

IEEE 802.11 WG notes that, as is typically the case in networking standards, a normative definition of a scheduler is out of scope of IEEE Std 802.11. However, it is also noted that many IEEE Std 802.11 based network implementations use a centralized WLAN controller that implements rich management interfaces between APs in the network and the controller for exchange of monitoring and centralized control signaling. Therefore, a centralized scheduler can leverage these PHY/MAC features to coordinate the optimal allocation of spectral resources and avoidance/mitigation of interference across the network, therefore ensuring the KPIs of QoS flows are met. In addition, policies defined at the scheduler can determine how QoS flows are treated when spectral resources are constrained (e.g., trade-off between overall network capacity and preserving the KPIs of GBR flows when link conditions degrade).

IEEE 802.11 WG agrees with WBA that analysis of these features – particularly in the form of real-world trials – is valuable to demonstrate the performance of IEEE Std 802.11 based networks for fine grained QoS control.

In addition, as regulators around the world open up access to new unlicensed spectrum in the 6 GHz band, the emergence of IEEE Std 802.11ax based implementations that support 6 GHz provides new opportunities to meet demanding QoS requirements for very high throughput and very low latency.

Finally, the IEEE 802.11 WG notes that IEEE Std 802.11ax meets or exceeds requirements specified by the International Telecommunications Union for the 5G Indoor Hotspot and Dense Urban test environments of the enhanced Mobile Broadband (eMBB) usage scenario of IMT-2020, and therefore establishes a foundation for an advanced Wi-Fi technology capable of supporting 5G network performance [5, 6].

Conclusion

The IEEE 802.11 WG reiterates its appreciation for WBA sharing its work in this area, and its willingness to continue to work with WBA to ensure that the IEEE 802.11 standard addresses the requirements of 5G use cases.

Please contact me with any questions.

Thank you and Best Regards,

/s/

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Dates of future IEEE 802.11 WG Meetings: 8-16 November 2021, 17-25 January 2022 (both electronic), see https://grouper.ieee.org/groups/802/11/Meetings/Meeting_Plan.html .

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