**IEEE P802.24**

**Vertical Applications Technical Advisory Group**

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| Project | IEEE P802.24 Vertical Applications Technical Advisory Group |
| Title | **Low Latency Communication White Paper** |
| Date Submitted | 15 January, 2019 |
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| Re: | N/A |
| Abstract | This contribution provides a first version of the Table of Contents of the Low Latency Communication White Paper. It will be updated (along with this Abstract) as the content materializes and is included. |
| Purpose | Assist in the development of the Low Latency Communication White Paper |
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# Background and Introduction

General information on low latency communication, background and the drive for it (e.g., linked to “5G” and IMT-2020 requirements), possibilities that are created (in a general sense), challenges that are encountered, etc.

# Low Latency Communications Applications

Some detail about the possible applications for low latency communications. E.g., Haptic Communication expanding the human senses and interactions that can be conveyed over communication links, expanding machine “senses” and interactions that can be conveyed over communication links, the “Tactile Internet” and Industry 4.0, investment/trading(?), etc. It will be noted that many of the applications also link to high reliability, profoundly affecting the low latency solutions that might be used.

Different application categories / markets

Unique low latency requirements specific to applications and markets

Consider dividing applications and use cases into human interaction and machine-only.

 Haptic applications include a human – tactile and kinesthetic. (Oliver Holland)

Haptic and VR environments are the most challenging for low latency since the user is engaged with more senses, and more sensitive? Latency has a bigger effect.

Many critical infrastructure applications are machine only, but still latency-critical.

 E.G. electric utility grid protection

Implications of low latency networks on cyber-security. How is the threat surface changed in a low latency network?

Crisis management – ensuring that applications that require low response times are not affected by crisis events. More related to ultra-reliable than low-latency communications.

Use Case Applications from RTA TIG (11-18-2009 last revision)

 Need to review and determine if we need to include any of them. (

Use Case Applications from 802.21 AR/VR enablers. (Subir, Dillon Seo)

 Consider 802.11be and 802.15.3c

# Performance Requirements for Low Latency Communication

Derived from the discussion on applications in Section 2 and also using other sources such as the ITU definition of URLLC, will list the performance requirements of low latency communication such as:

* End-to-end data transfer latency (Edge to Edge)
* Session establishment latency(?)
* Perhaps radio access latency (noting that in some fora, this distinction is made) E.G. use cases with edge intelligence where the device to edge computing service is the critical path.
* Reliability, noting that many applications also have this requirement
* Data capacity (identify trade-offs between achieving low latency and most efficient use of bandwidth)
* Synchronization among flows (e.g., with audio/video for haptic+AV applications…?)
* Etc.
* What is the opportunity for networks to retry lost packets? How does this vary for different applications and use cases?
* Describe the relationship between reliability requirements and data rate. Not all low latency applications require high bandwidth, but the application demands very high reliability (in terms of meeting the latency requirement)
* Some applications have a requirement for precision in the haptic feedback (precision is related to low latency – delay results in error)

# Key Technologies/Solutions Supporting Low Latency Communication

Summarizing those technologies that have to be considered/utilized in order to achieve low latency, often in conjunction with high reliability. E.g.,

* Changes to framing to minimize wait time to receive a frame before processing the frame
* Softwarization to optimize communication path through invoking elements in software at better locations?
* Network sharing to optimize communication path; neutral hosting, etc., etc.
* Multi-connectivity (as a means to still achieve reliability while reducing latency—noting that many low latency applications also require a vast *increase* in reliability compared with what is currently achieved (at least wirelessly))
* New coding approaches to achieve latency and high reliability
* New protocols
* Others (e.g., security implications and solutions)?
* Using adaptive links, multi path, and multi-band links. Multi-connectivity.
* Etc., etc. (to be added to a refined)

# IEEE 802 Standards Supporting Low Latency Communications

List of IEEE 802 standards/amendments, etc., that can already assist or realize in low latency (some in tandem with high reliability) communication, and reasoning as to how. Also listing target standards for enhancements towards low latency communication, and reasoning as to why.

## Current Standards (published)

802.1 TSN (family of standard – pull from 802.24 TSN white paper)

802.3br Interspersing Express Traffic

802.11ad (60 GHz) defines a scheduled MAC layer

802.11ai Fast Initial Link Setup, 802.11r Fast Handover (“Fast” is a relative term)

802.15.4 TSCH (more predictable, but not extremely low latency – 100 mS range)

802.15.3 support low latency, isochronous streaming. Two way streaming. 802.15.3e specifies fast link setup and teardown.

802.16 and 802.22 provide scheduled MAC with predictable latency (10s of mS)

## Target Standards for Enhancements (amendments being considered or underway)

802.11ax features present in the amendment can be used to improve latency, but low latency is not a design requirement.

* 1. **potential future activities (not yet with a PAR)**

802.11 EHT Task Group (11be) will include RTA as part of the scope of the PAR for EHT.

802.11bd V2X, low latency is a requirement for V2V use cases

# Adaptions and Recommendations for IEEE 802 Standards to Enhance Low Latency Communications Support

Suggestions on which technologies (mentioned in Section 4 above) must be introduced, and very high-level suggestions on how it might be done. Both to enhance current standards supporting low latency, as well as the target ones.

Are there common themes that can be applied across 802 technologies to enhance low latency?

We expect the 802.1 TSN TG to continue to provide the overall framework and architecture for low latency across multiple standards.

# Conclusion and Future Work/Timeplan

Per usual content in this section. But could also try to project an overall vision/timeplan for implementation of such work—or such content might be extracted to its own Section? Of course, would require careful coordination with the relevant WGs.

Develop a roadmap for all 802 standards relevant to Low Latency

Identify any gaps at the architecture level for consideration by 802.1 TSN

# References