**IEEE 802.24**

**Vertical Applications TAG**

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| Project | IEEE 802.24 Vertical Applications Technical Advisory GroupIEEE 802.1 Time Sensitive Networking Task GroupIEEE 802.3br past TG on Interspersing express traffic (IET) |
|  | Utility Applications of Time Sensitive Networking White Paper |
| Date Submitted | 10-July-2017 |
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| Re: | White Paper Development |
| Abstract | TSN White Paper |
| Purpose | TSN White Paper |
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# Describe why TSN is needed in a utility

In the context of this white paper, the utility is considered the entity (or entities) that manage the distribution of electricity from the transmission grid, to the distribution grid, to the customers. The power distribution network involves substations, and various protective and control devices that communicate over communications networks.

Typical utility terminology is a “low latency network”

Define what “realtime” means in the context of specific grid use cases and applications.

Real-time behavior of Ethernet based communication networks is defined in IEC 61784-2. There are 6 (plus one technology specific) consistent sets of parameters described to define the requested and achieved Real-time Ethernet behavior of end-to-end stations.

For the network components using TSN is an effort ongoing in IEC SC 65C.PT61784-6, dealing with a TSN profile for industrial automation applications.

Teleprotection – differential protection schemes require very low (<10ms) end to end latency, which must be highly consistent and predictable.

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Intra-substation LAN. Support for IEC 61850 Generic Object Oriented Substation Event (GOOSE) messages for controlling relays and switches within the substation. TR61850-90-13 addresses this

 Type of connection – typically Ethernet (copper or fiber)

 GOOSE and MMS traffic.

 TSN could be a help on the process bus -

Shared IT/OT networks over a common medium. The OT networks require a controlled, predictable latency, and freedom from dropped or lost packets. This behavior is required regardless of the loading or overloading of the IT network.

How does TSN affect this? The important benefit is providing a converged multi-service architecture. Critical services can have guaranteed performance and bounded latency. This saves cost by converging several networks into one.

But not all TSN behaviors can be built in one network component without a difficult engineering. A profile for Utilities is needed to reduce the effort of engineering. IEC TC57 is looking for such a profile and is collaborating with the IEC SC65C/MT9.PT61784-6 project team.

IEEE 802.3br provides the best basis for this instead of using only shapers.

Critical voice services from field or substation. Ensuring voice traffic is unaffected by other data flow on common network.

Field Area Network Applications – Fault Location Identification and Service Restoration (FLISR) requires predictable low latency to re-route distribution power grids to isolate faulted areas and restore power to customers so quickly that they don’t notice an interruption. TSN capabilities in the FAN could enable FLISR to operate on shared medium networks. The same low latency communication with a Distributed Energy Resources Management System (DERMS) will allow local DER devices to participate in the restoration. The DERMS may be located at a central location (away from the DER equipment). End to end connectivity between the DERMS and the DER equipment may require multiple networks, each able to support low latency applications.

Similar requirements exist with MicroGrids. Dynamic protection, reverse power flows, etc.

Potential use cases around wind farms – there may be situations where TSN is needed – protection algorithms are the main driver.

# Describe how TSN works

Don’t focus on the standards themselves, but focus on basic capabilities.

Goal of low latency vs maximum worst case latency, and leading to zero congestion loss.

A new optimization, compared to best-effort packet world.

It is not just low latency, but bounded, deterministic worst case latency. That enables the application.

Shifting paradigm from acting on the packet to acting when the packet says to act.

Secondarily, ability to guard against equipment failure.

Informational material: 802.1Qbu, 802.3br, 802.1Qbv, 802.1Qat, 802.1Qca, CB, Qcc, Qch, Qci, Qcn, Qcr, AEcg

Discuss 802.1CM and BA, as an example of industry profiles for the use of TSN

# Understand IEC 61850 activities and relationships

IEC TC57 WG 10 has started to work on the Technical Report IEC 61850-90-13  - Deterministic Networking Technologies (in IEC 61850 networks). The scope comprises use cases, potential improvements, key challenges, technology considerations (TSN, IETF DetNet), profile definitions and compatibility aspects. The set of IEEE 802.1 TSN standards (profile) is in discussion and not decided yet. The use cases and applications are structured and mapped to the following two core domains: substation automation (station and process bus) and WAN-based applications such as tele-protection and DER (Distributed Energy Resources). For substation automation network, TSN will be considered as one solution to meet functional and non-functional requirement. The following features of TSN are especially interesting for applications and networks based in IEC 61850:

* Bounded latency
* Low bounded jitter
* Zero congestion loss
* A converged network architecture

According to the network architecture recommendation in IEC 61850, a substation network is partitioned into a station and process bus. The process bus connects the IED’s (Intelligent Electronic Devices) on the level of the primary equipment, typically to Merging Units (MU). The deterministic behavior of TSN can help to foster the adoption and deployment of the process bus. Furthermore, non-functional requirements such as manageability, usability, and flexibility are addressed in the Technical Report as well as network security consideration. While the first three bullet points provide excellent support to meet functional requirements for critical protection and control applications, the converged network architecture enables a multi-service architecture. A multi-service architecture allows critical traffic on the same physical network with best-effort services such as configuration, engineering, and monitoring. This approach is a requirement specified by utilities in order to make networking more efficient. Another important aspect is guidance how to achieve co-existence and interoperability with existing technologies such as PTP (IEC 61850-9-3 Profile), PRP and HSR. This encompasses potential impact on applications, the requirement to define migration paths and to outline support for brownfield installations. The latter point addresses the fact that today’s Digital Protections Devices/IED’s do not implement a TSN-enabled network stack in order to function as a listener or talker, using the notion of TSN. On the other hand, IED’s typically have a long life-cycle (15 years and longer) and there will be a need to integrate them into a TSN-enabled network. A gateway approach addressing the specifics of IEC 61850 messages such as GOOSE and Sampled Values (SV) is in consideration. Finally, to address new use cases and opportunities derived from the capabilities of deterministic networking is another objective.

Based on the requirements, the task force responsible for IEC 61850-90-13 is asked to coordinate the work with other working groups in IEC TC 57 (Power systems management and associated information exchange) as well as with IEC SC65C, WG 15 (High Availability Networks).

How standardized APIs are integrated into 61850

What is the set used for grid applications? Relate to IEC TC57 Profiles

Harmonization of TC65 (automation) with TC57 profiles

# Explain relationships to time synchronization in 802.1AS

Power Profiles of IEEE 1588

# Relationship to IETF DETNET and RTCWEB

DETNET works over a routed network.

RTCWEB is focused on video and audio mostly, but supports it over the Internet.

What is the opportunity for wireless standards to leverage?

 The work of the IETF DETNET working group targets the same network “quality of service” (QoS) properties as TSN, namely bounded, deterministic worst-case latency that enables certain classes of applications. However, the IETF work will apply these properties to network operation at layer 3, which is the traditional purview of the IETF. The key goal of the IETF DETNET work is to utilize the common themes of congestion control and traffic scheduling to offer bounded latency to applications with these requirements.

**Wired vs. Wireless**

In addition to the common obstacles to bounded latency faced by wired networks (congestion control, resource reservation), wireless networks have additional problems not faced by wired topologies, including:

* **RF interference**: even if the issues of congestion control and resource reservation are solved, local RF interference can cause packets to be lost and/or require packets to be re-transmitted, causing increased latency.
* **Bandwidth**: many wireless mesh networks (802.15.4, LPWANs, etc.) have limited bandwidth, and operate at speeds in kilobits-per-second, as opposed to megabits-per-second or higher.
* **Resource constraints**: on wireless mesh networks, network devices will be constrained in their resources and have limited buffer space to manage congestion control.
* **Mobility**: for wireless networks supporting mobility, the potential for variances in RF interference are higher than wireless topologies that are configured statically, with no mobility support.
* **Low**-**Power**: In some wireless mesh topologies, there are battery-powered devices that need to limit their packet transmission rates, which add additional latency.

**Example Use-Cases**

The use-case examples enumerated below apply to existing wireless 802.15.4 mesh network scenarios

**Network-wide Firmware Download**

When functional or security issues are found in deployed devices, it is critical to remediate the situation as quickly as possible. Many of these situations require an entire network to be updated with new firmware. Since these networks often are associated with critical infrastructure, some measure of bounded latency will be required so that operations can be reestablished in a predictable fashion.

**Ad-Hoc communications**

Many wireless mesh applications have “automated” network traffic patterns that periodically occur, without human intervention. However, there are applications that allow operators to manually generate ad-hoc queries to network equipment. For these “interactive” applications, there is a desire for network response times to be “user friendly”, since there is a human operator awaiting response information.

**Mesh Network “Boot”**

After systemic power loss, or firmware upgrade of large portions of a wireless mesh, there is a need to “reboot” the mesh. In large wireless mesh networks, there is a “joining process” whereby each node in the network must perform a set of roundtrip packet transactions across the mesh with a network “controller”. These network transactions effectively comprise the joining process. Once joined, the devices enter their normal functional state. Operators need to be able to predict when the network is fully up and operational (all nodes joined).