Applicability of TSN to 5G services

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Background

- Conclusion from ITU-T/IEEE joint workshop, gives the following suggestion that TSN applicability for 5G services shall be investigated.

Session 3: Mobile fronthaul, 5G mobile transport

Takeaways and Conclusions

1. IEEE 802.1 TSN is applicable to 5G transport, e.g., 802.1CM TSN for Fronthaul

2. ITU-T Q13/15 is enhancing Synchronous Ethernet and the Telecom Profiles of the Precision Time Protocol to address 5G requirements

Suggestions

- ☐ ITU-T SG 15 should continue to collect 5G/IMT2020 requirements
- ☐ ITU-T Q13/15 in cooperation with 3GPP and CPRI should continue to collect synchronization requirements for 5G
- ☐ Applicability of SG15 technologies to 5G transport should be considered
- ☐ Applicability of TSN to 5G applications beyond fronthaul should be studied

*https://www.itu.int/en/ITU-T/Workshops-and-Seminars/20180127/Documents/Outcomes%20-%20Building%20Tomorrow%20Networks-Final.pdf

5G Connects Everything
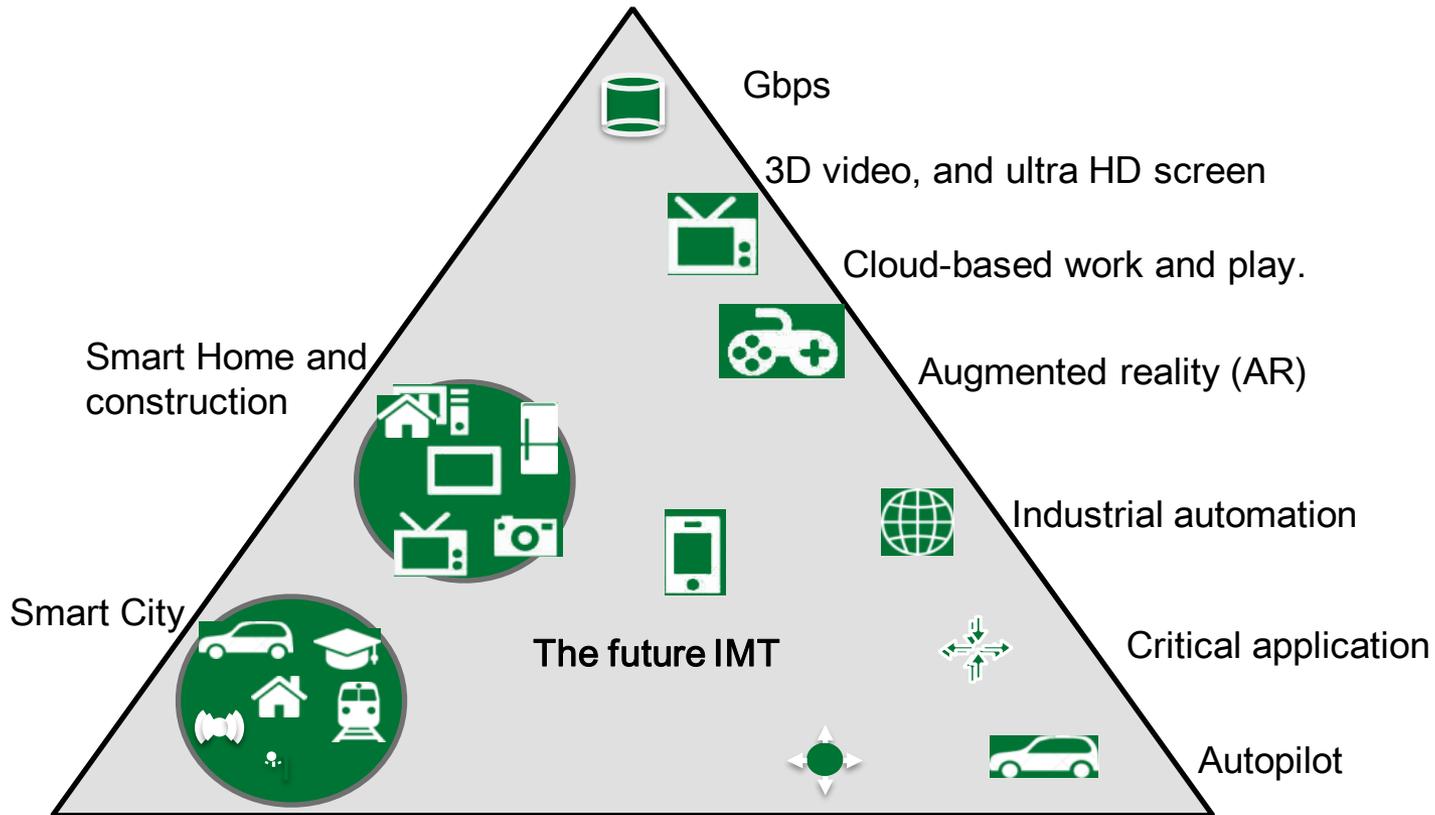
New Challenges to 5G Bearer Network

Latency	Throughput	Connections	Mobility	Network Architecture
1ms E2E Latency	Up to **10G**bps Per Connection	**1,000K** Connections Per km²	**500k**m/h High-speed Railway	**Slicing** Ability Required

❑ TSN techniques can help

> Most of uRLLC services have E2E bounded latency requirement.

> Network slicing implies no interference between applications or users.

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3GPP TS 22.261: low-latency and high-reliability scenarios

Scenario	End-to-end latency (note 3)	Jitter	Survival time	Communication service availability (note 4)	Reliability (note 4)	User experienced data rate	Payload size (note 5)	Traffic density (note 6)	Connection density (note 7)	Service area dimension (note 8)
Discrete automation – motion control (note 1)	1 ms	1 µs	0 ms	99,9999%	99,9999%	1 Mbps up to 10 Mbps	Small	1 Tbps/km^2	100 000/km^2	100 x 100 x 30 m
Discrete automation	10 ms	100 µs	0 ms	99,99%	99,99%	10 Mbps	Small to big	1 Tbps/km^2	100 000/km^2	1000 x 1000 x 30 m
Process automation – remote control	50 ms	20 ms	100 ms	99,9999%	99,9999%	1 Mbps up to 100 Mbps	Small to big	100 Gbps/km^2	1 000/km^2	300 x 300 x 50 m
Process automation – monitoring	50 ms	20 ms	100 ms	99,9%	99,9%	1 Mbps	Small	10 Gbps/km^2	10 000/km^2	300 x 300 x 50
Electricity distribution – medium voltage	25 ms	25 ms	25 ms	99,9%	99,9%	10 Mbps	Small to big	10 Gbps/km^2	1 000/km^2	100 km along power line
Electricity distribution – high voltage (note 2)	5 ms	1 ms	10 ms	99,9999%	99,9999%	10 Mbps	Small	100 Gbps/km^2	1 000/km^2 (note 9)	200 km along power line
Intelligent transport systems – infrastructure backhaul	10 ms	20 ms	100 ms	99,9999%	99,9999%	10 Mbps	Small to big	10 Gbps/km^2	1 000/km^2	2 km along a road
Tactile interaction (note 1)	0,5 ms	TBC	TBC	[99,999%]	[99,999%]	[Low]	[Small]	[Low]	[Low]	TBC
Remote control	[5 ms]	TBC	TBC	[99,999%]	[99,999%]	[From low to 10 Mbps]	[Small to big]	[Low]	[Low]	TBC

NOTE 1:   Traffic prioritization and hosting services close to the end-user may be helpful in reaching the lowest latency values.
NOTE 2:   Currently realised via wired communication lines.
NOTE 3:   This is the end-to-end latency the service requires. The end-to-end latency is not completely allocated to the 5G system in case other networks are in the communication path.
NOTE 4:   Communication service availability relates to the service interfaces, reliability relates to a given node. Reliability should be equal or higher than communication service availability.
NOTE 5:   Small: payload typically ≤ 256 bytes
NOTE 6:   Based on the assumption that all connected applications within the service volume require the user experienced data rate.
NOTE 7:   Under the assumption of 100% 5G penetration.
NOTE 8   Estimates of maximum dimensions; the last figure is the vertical dimension.
NOTE 9:   In dense urban areas.
NOTE 10: All the values in this table are targeted values and not strict requirements.

According to scenarios from 3GPP, bounded latency and jitter shall be ensured in uRLLC services

Networking Slicing Defined in 3GPP

◻ In TR 23.799: The network slice is a complete logical network (providing Telecommunication Services and Network Capabilities) including AN (RAN Access Network) and CN (Core Network).Whether RAN is sliced is up to RAN WGs to determine:

> ➢ AN can be common to multiple network slices.

> ➢ Network slices may differ for features supported and Network Functions optimisations use cases.

> ➢ Networks may deploy multiple Network slice instances delivering exactly the same optimisations and features as per but dedicated to different groups of UEs, e.g. as they deliver a different committed service and/or because they may be dedicated to a customer.
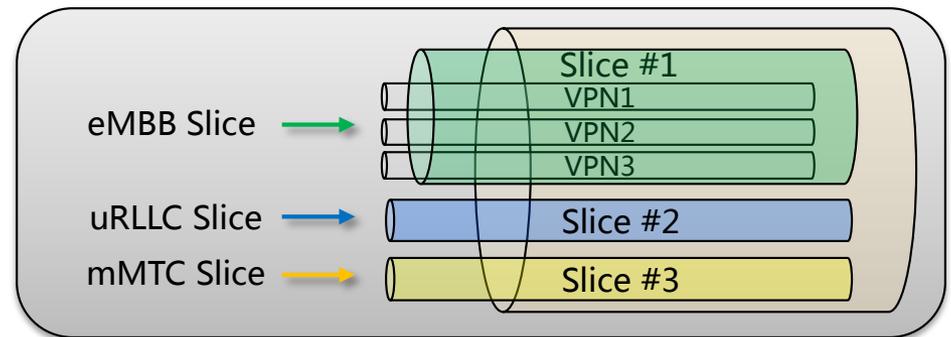
Forwarding Plane For Bounded Latency Traffic

- Choice A: Ensure average bandwidth for long term traffic in **soft partitioning network**, bounded E2E latency is achievable.
  - E2E planning with simple Qos scheduling.
  - Asynchronous TSN scheduling algorithms.
  - Others.

Choice A
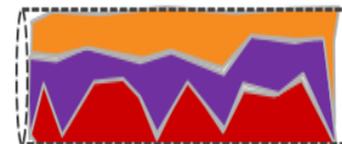
- Choice B: Guarantee strict bandwidth in **hard partitioning network**
  - Dedicate devices and links.
 - Std 802.1Qbv support up to 8 time slices at port level.
  - Others.

Choice B

Both options are valid to provide bounded latency forwarding, just with different performance on latency/jitter and buffering cost; realistic carrier network may use either one or mixture of these two options

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TSN flow Aggregation in 5G Bearer Network

- TSN techniques are necessary for bounded latency services in 5G bearer network, we like to consider it more carefully from perspective of larger scale and converged IP network.
  - Large scale and converged network means multi-hop , flexible topology and big number of traffic flows.
- Current IP network uses DiffServ model for the sake of efficiency, while TSN resource reservation and scheduling is more like IntServ model. *Flow aggregation* helps reduce number of IntServ flows, need more discussion in standard.
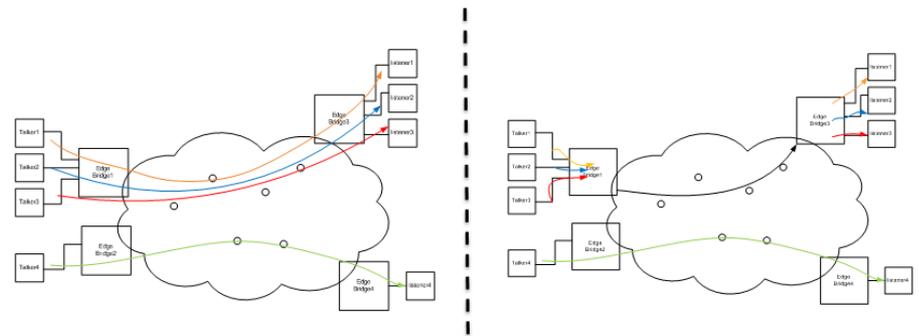

Flow aggregation illustration

Scheduling Algorithms in 5G Bearer Network

- 802.1CM as an example:

  - strict priority scheduling with E2E traffic planning provides bounded latency.

  - This achieve lowest latency with network planning, preemption can further help reduce port delay .

  - Easy deployment.

- Limitation:

  - Increasing number of CPRI flows in bridge enlarge worst forwarding delay per hop.
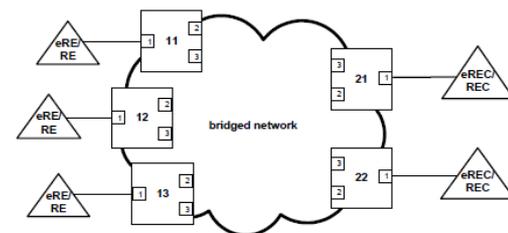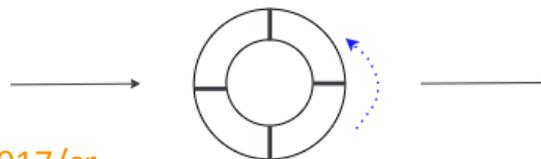
Scheduling Algorithms in 5G Bearer Network

- Current algorithm described in P802.1Qcr is not easy for bridges in bearer network
  - Direct comparison of n bit eligibility time is costly for high speed port.
- Other async scheduling approaches
  - Unsync-ed scheduled traffic with internal buffering.

Local time gate scheduling

T → L
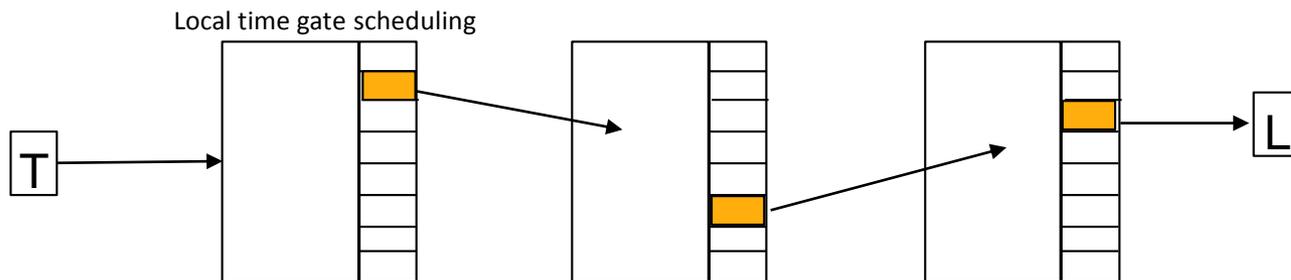
Worst case queueing latency = 8*time_slot_width;

  - *Paternoster Similar

Worst case latency = 3*epoch

*http://www.ieee802.org/1/files/public/docs2017/cr-seaman-paternoster-policing-scheduling-0317-v03.pdf

Summary

- TSN techniques are necessary for 5G uRLLC applications and network slicing in 5G bearer network.

- Topics to further investigate

  - Flow aggregation

  - Scheduling methods for large number of TSN flows , queues and physical ports.

- Would any one like to join discussing profiles for 5G bearer network solution, please come together.

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Thank you

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