Gap analysis in 1Qcc for enhanced mechanism for Flexible Factories

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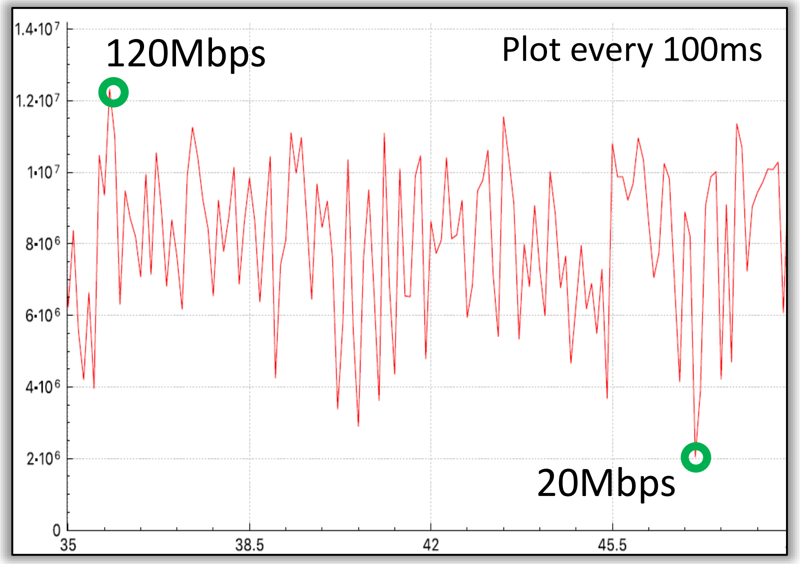
Background

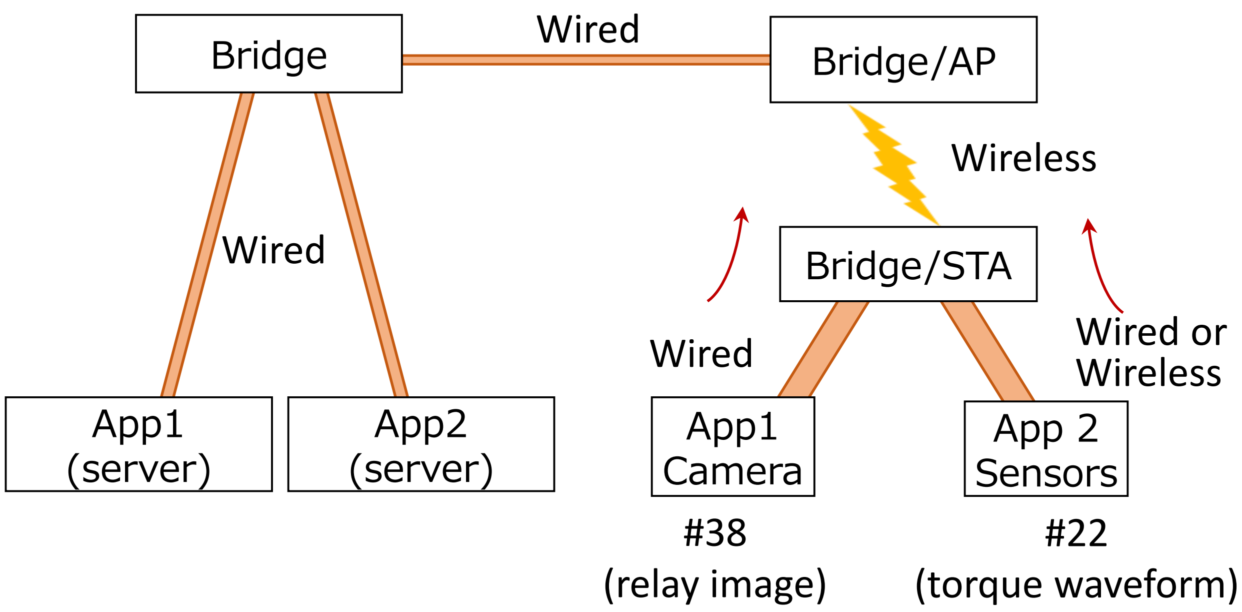
- Available wireless bandwidth dynamically changes due to various reasons
  - Path loss, fading, interference, MAC layer adaptation, …
- In addition, required bandwidth dynamically changes since traffic pattern is not uniform
  - Burst data flow, cyclic data flow, …
- Shortage of wireless bandwidth is difficult to avoid even if it occurs infrequently
  - In order to avoid the shortage, required bandwidth must be limited to very low. It is not an efficient way.



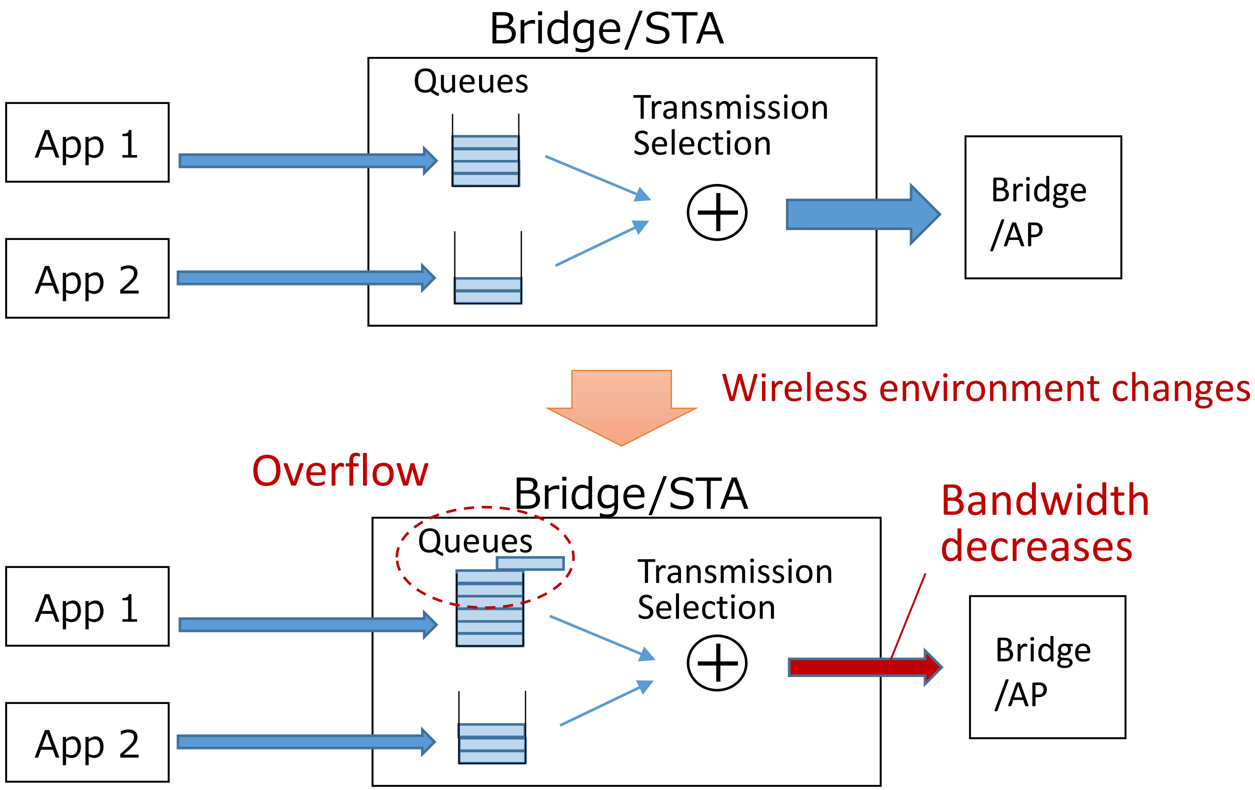
Example of measured UDP throughput
2.4GHz Ch.11 (20MHz bandwidth)

What Happens?

- Traditional issue of queues overflow when shortage of bandwidth happens



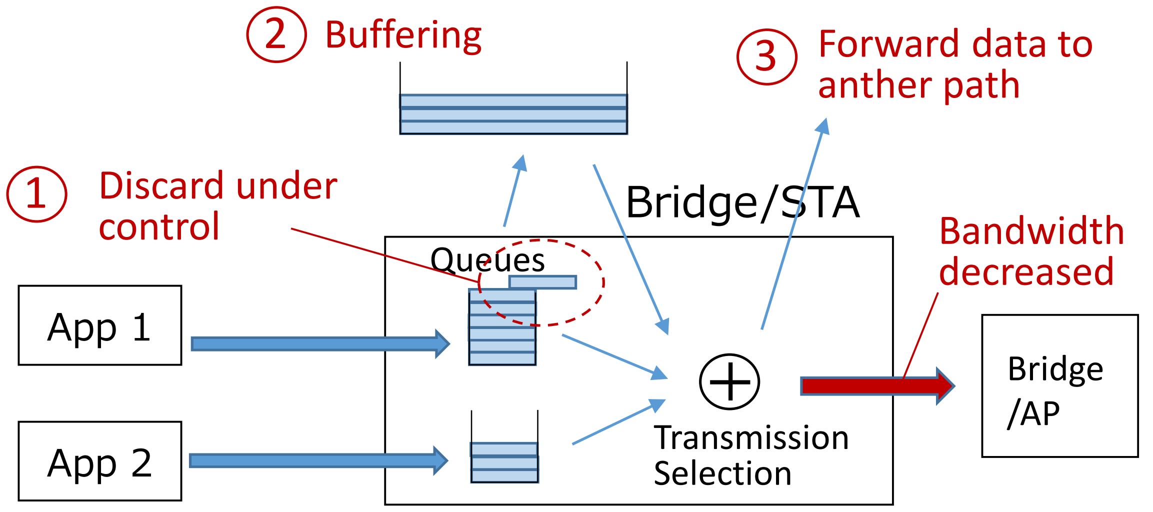
Data flow model



Flow Diagram

Advanced Forwarding

- Sophisticated and enhanced methods:
  - ① Discard under control -> reduce data not to stop high priority application
  - ② Buffering -> use additional buffer to peak-rate shaving
  - ③ Forward data to another path -> use another path or link aggregation



Flow Diagram

Bridge needs to know attributes of each flow for decision

Flow Attributes for Advance Forwarding

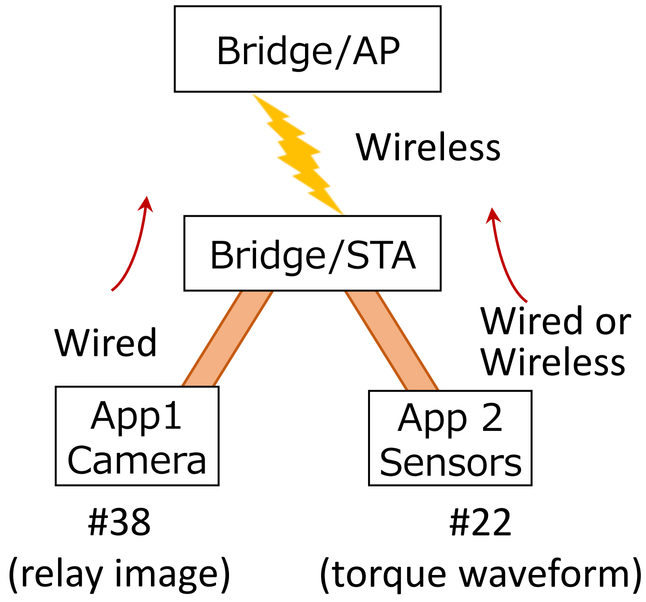
- **Application properties**
  - **Tolerance for packet losses**
    - Avoid application stopping due to dropped packets
  - **Importance of application**
- **Traffic properties**
  - **Traffic pattern**
    - Burst
      - Burst size
      - Frequency
    - Cyclic
      - Peak and average data rate
  - **Maximum latency**

} Decide if flow is to be buffered or aborted

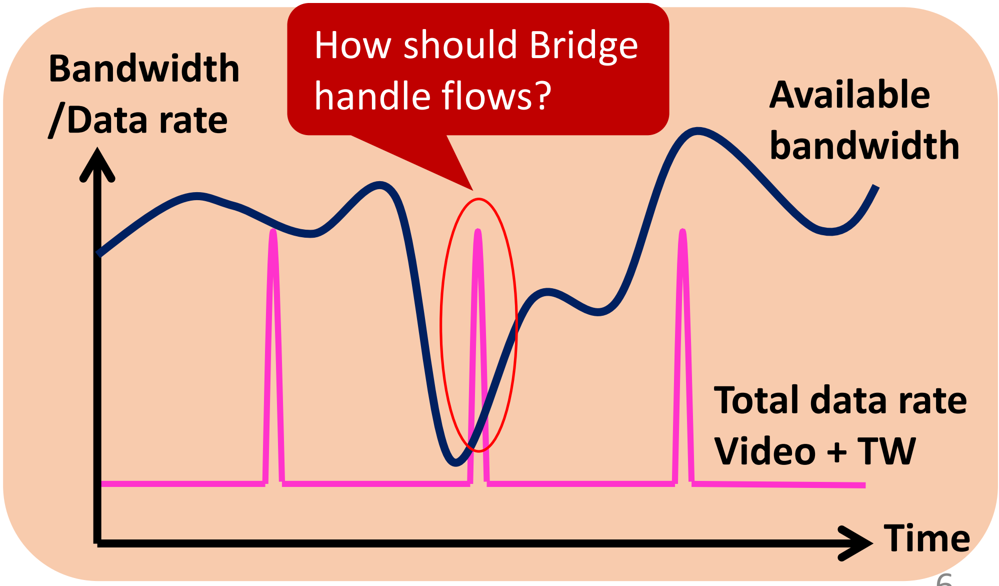
=> How to use attributes is to be explained in following slides

Example of Real Scenario

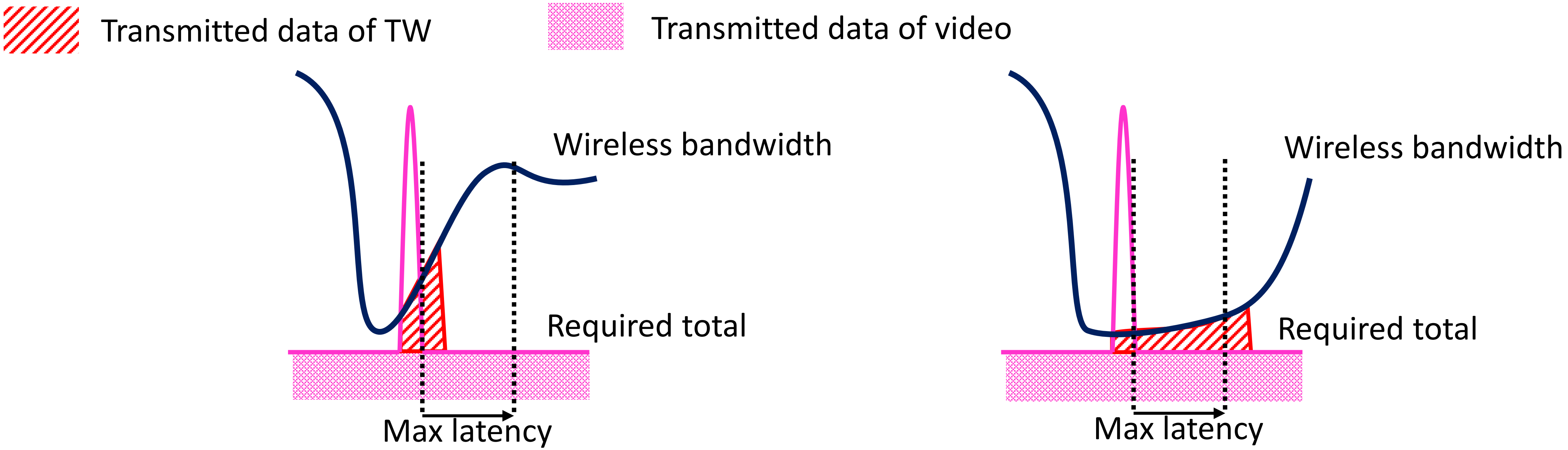
	Video	Torque wrench (TW)
Traffic pattern	Stream	Burst
Data rate	5Mbps	8Mbps (Peak rate)
Max latency	20ms	200ms
Permitted packet loss rate	0%	20%
Importance of application	Middle	High



- From QoS point of view, Video must be put high priority
  - Average rate is high, and low latency is required
  - Packet loss causes poor video quality
- However, TW application is more important
  - <u>**Low quality is acceptable, but corruption of application is not acceptable**</u>

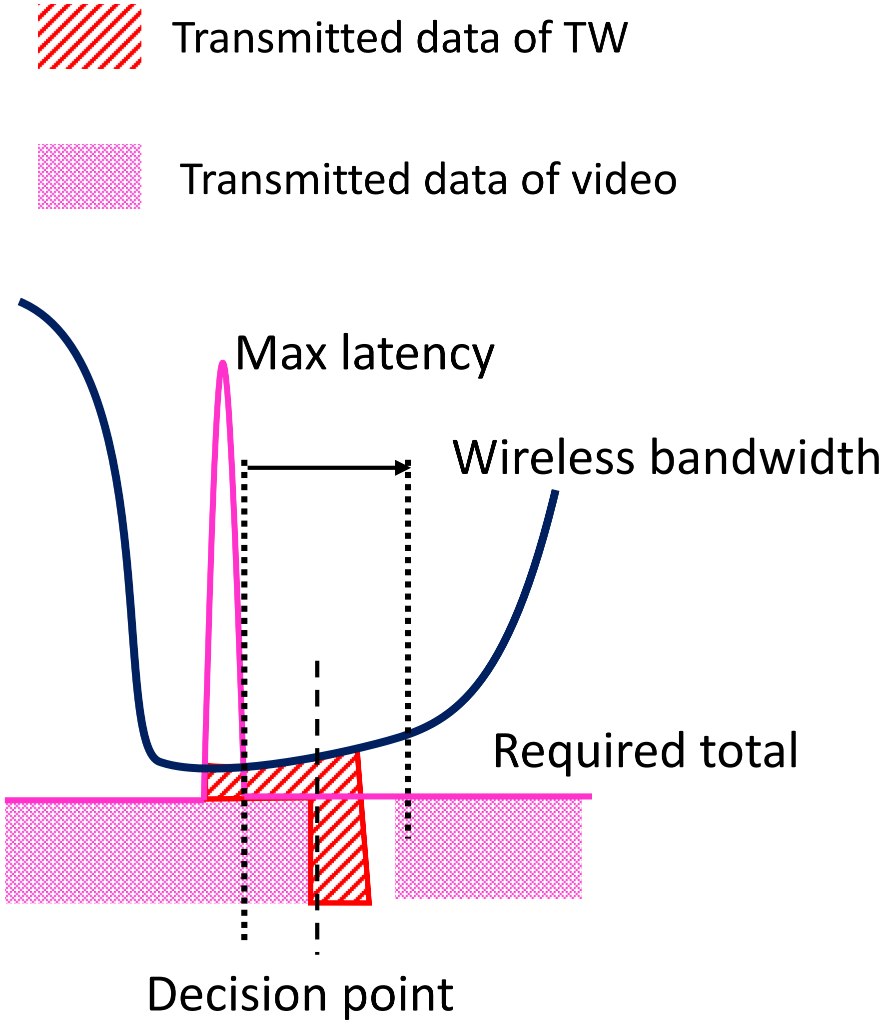


Priority Based Scheme



1. Video is transmitted with higher priority
2. TW data is buffered and transmitted using remaining bandwidth
3. If wireless bandwidth is recovered quickly (left case), TW data can be transmitted within required max latency
    - Priority based scheme works fine in this case
4. **If wireless bandwidth is not recovered (right case), TW application is corrupted**
    - **This must be avoided, but it cannot be avoided with priority based scheme**

Advanced Scheme for ①Discard under control



1. If TW data is buffered, discard up to 20% of TW data
2. If TW data is not transmitted enough at predefined decision point, Bridge makes decision:
   - Application importance of TW is higher than that of Video, Bridge tries to sustain TW
   - Traffic pattern of TW is Burst, and arrival of new packets is not expected since arrived data size is almost equal to Burst size
     - => Bridge can estimate that TW can survive by buffering or aborting Video
   - Max latency expected to be expired if Video is buffered
     - => Bridge decides to abort Video

Required Features

- **<u>Configuration of attributes to Bridge</u>**
  - Application properties
    - Tolerance for packet losses
    - Importance of application
  - Traffic properties
    - Traffic pattern
    - Max latency
- **<u>Identification of flow (stream) on Bridge</u>**
- Detection of wireless bandwidth reduction on Bridge
- Forwarding decision on Bridge
  - Discard under control
  - Buffering
  - Forward data to another path
  - …

1Qcc can be applied, but few things need to be added

Vendor specific implementation can be allowed

MSRPv1
Type-Length-Value for Talker/Listener Enhanced

Table 35-66—TLV Types

TLV	TLV Type	TLV Length
Talker	1	variable
StreamID	2	8
StreamRank	3	1
EndStationInterfaces	4	variable
InterfaceID	5	variable
DataFrameSpecification	6	18
IEEE802-MacAddresses	7	12
IEEE802-VlanTag	8	2
IPv4-tuple	9	15
IPv6-tuple	10	39
TrafficSpecification	11	9
TSpecTimeAware	12	12
UserToNetworkRequirements	13	5
InterfaceCapabilities	14	variable
Listener	15	variable
Status	16	variable
StatusInfo	17	3
AccumulatedLatency	18	4
InterfaceConfiguration	19	variable
TimeAwareOffset	20	4
FailedInterfaces	21	variable

Required bandwidth

Requirement for CNC

For stream identification

StreamRank

	Octet	Length
reserved	1	7 bits
Rank	1	1 bit

Figure 35-5 — Value of StreamRank TLV

- Basic concept of Rank is the same as that of advanced forwarding
- Application importance can be configured by Rank
- However, 1 bit is not enough to handle multiple streams
  - Expansion to reserved field is needed

Related Elements

Table 46-8—TrafficSpecification elements

Name	Data type	Reference
Interval	rational	46.2.3.5.1
MaxFramesPerInterval	uint16	46.2.3.5.2
MaxFrameSize	uint16	46.2.3.5.3
TransmissionSelection	uint8	46.2.3.5.4

Difficult to configure traffic pattern of burst traffic

There's no element corresponding to 'Tolerance for packet losses'

Table 46-10—UserToNetworkRequirements elements

Name	Data type	Reference
NumSeamlessTrees	uint8	46.2.3.6.1
MaxLatency	uint32	46.2.3.6.2

Max latency can be configured

Gap

- 1Qcc can be applied to advanced forwarding
- Few attributes are missing
  - Tolerance for packet losses
  - Traffic pattern
- Rank can be used to configure importance of application, but 1 bit is not enough

- **Potential amendment**
  - **TLV for ‘Tolerance for packet losses’ and ‘Traffic pattern’**
  - **Expansion of StreamRank**

Moving forward

- Continuing investigation of more functions by March, 2019 plenary meeting.
  - Details of following features:
    - Detection of wireless bandwidth reduction on Bridge
    - Forwarding decision on Bridge
- Identifying need to amend existing and to be integrated IEEE 802. 1Q or to create a profile for flexible factory scenarios. More volunteers are welcome.
- We intend to make proposal at March meeting:
  - To authorize TSN task group during interim meeting in May to generate PAR for amendment for 1Qcc for flexible factory IoT