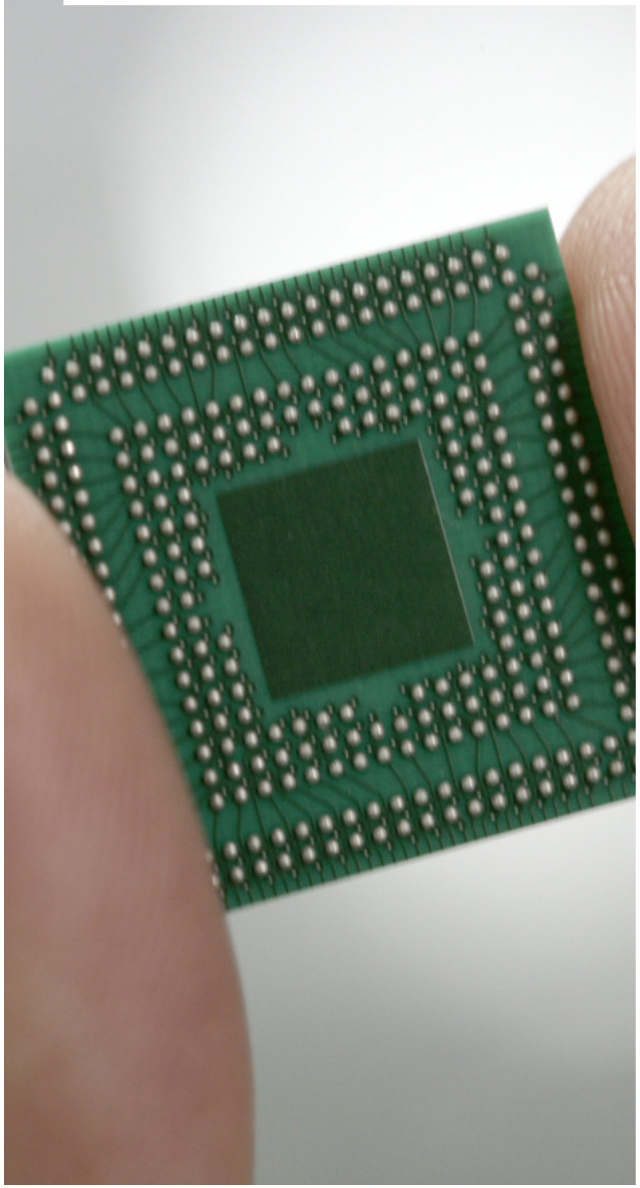

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Ultra Low Latency Traffic Class @ Industry

2012-01-17 - Munich

IEEE 802.1 AVB TG

Real Time Communication Symposium

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Agenda

- Audio / Video Bridging, AVB Gen 1
- Requirements from Industry for AVB Gen 2
- Proposed Mechanism for ULL Streams (1 - 5)
- Scenario: Routing & Scheduling for ULL Streams (1 - 5)
- Conclusion

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Audio / Video Bridging, AVB Gen 1

- **New mechanism for Ethernet specified from IEEE 802.1 AVB working group for Version 1.0**
  - Synchronization protocol and hardware time stamping for time accuracy << 1µs in bridged Ethernet network
  - To guarantee QoS for streams the AVB standard has specified:
    - Forwarding and queuing enhancements in network components to guarantee determinism and max. latency < 2ms for streams
    - Multiple Stream Reservation Protocol to guarantee resources in network components and to avoid packet lost

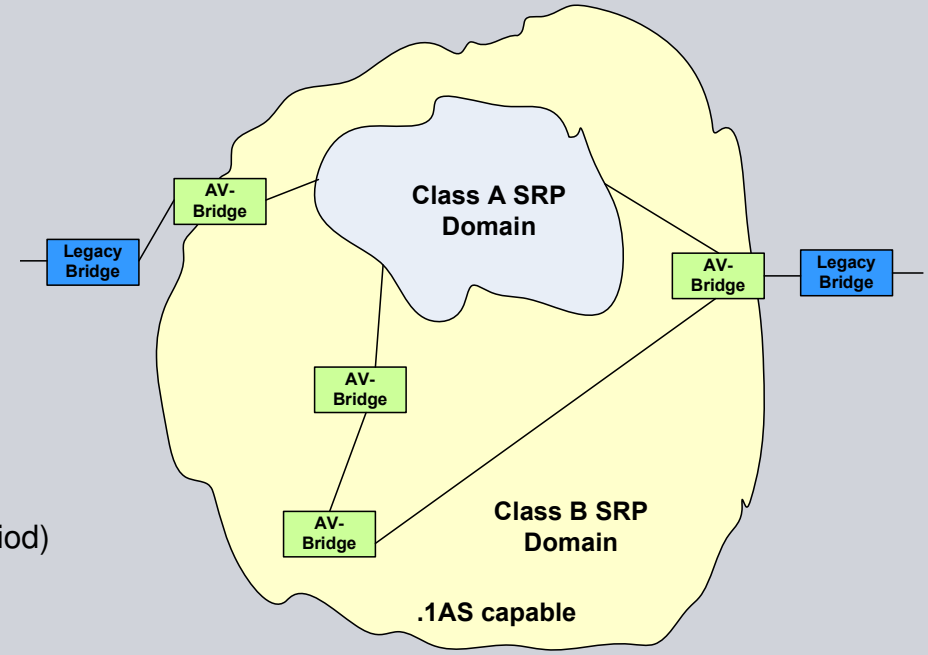
⇒**Synchronization and guaranteed QoS are basic requirements**

AVB Gen 1 Mechanismen (1)

- **Separate Traffic Class for AV Streams**
  - Stream Class A with 125 ms transmission period and max. latency of 2ms over 7 hops
  - Stream Class B with 250 ms transmission period and max. latency of 20ms over 7 hops

SR class	Default priority	Default regenerated priority for SRP domain boundary ports	Range
A	3	1	0 – 7
B	2	1	0 – 7

- **Bandwidth reservatiion (MSRP)**
  - AV End Station & AV-Bridge
  - Follows RSTP data tree
  - Restricted bandwidth (75% of available bandwidth for AV Streams)
  - Domain boundaries
  - Avoid flooding for AV streams
  - 64-Bit StreamID (Talker SA + ID)
  - 32-Bit TSpec (MaxFrameSize, MaxTransmitionPeriod)



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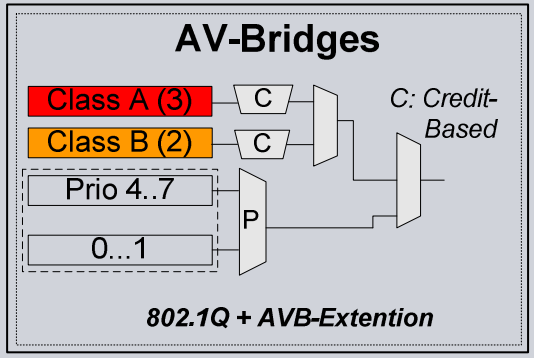
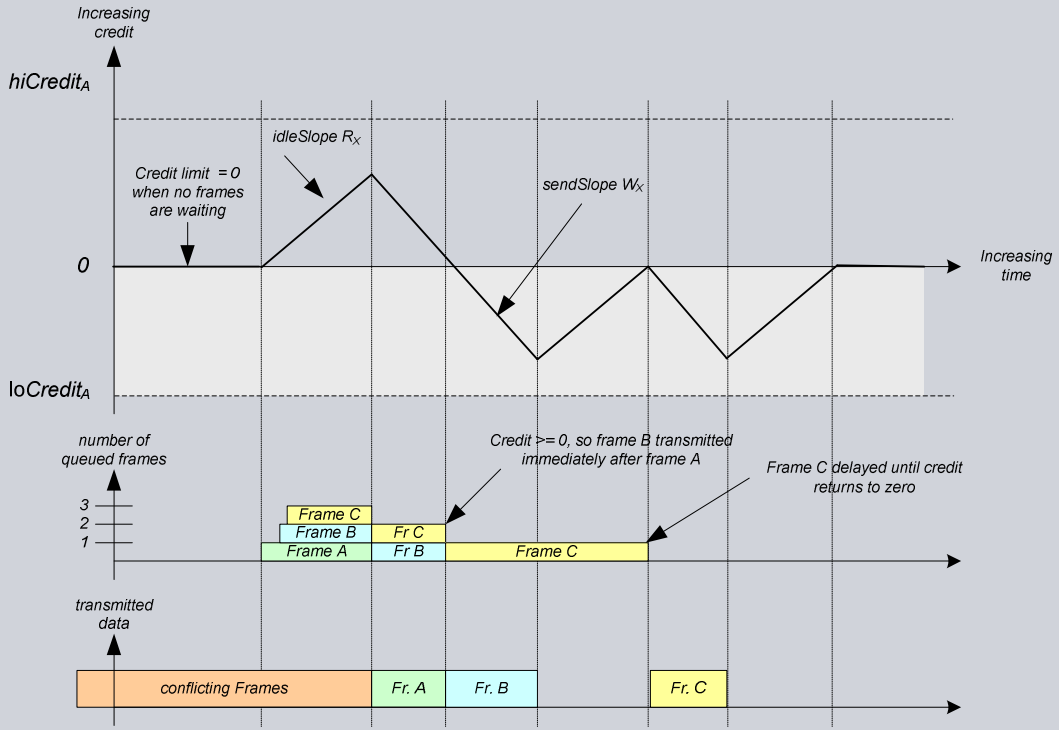
AVB Gen 1 Mechanismen (2)

- **AV-Bridge Extensions**
  - Per SR Class Queue
  - Per SR Class separate Resources
  - Credit based transmission selection algorithmus





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Requirements from Industry for AVB Gen 2

- Enhancements for gPTP
  - Universal time and working clock for synchronized applications
  - Industrial parameter set
  - High availability of synchronization (guaranteed take over time)
  - Security
- Ultra low latency for control traffic which is used for industrial applications
  - …
- Media redundancy for high availability industrial applications
  - …

New Ultra Low Latency (ULL) Traffic Class for Streams from Automation Perspective

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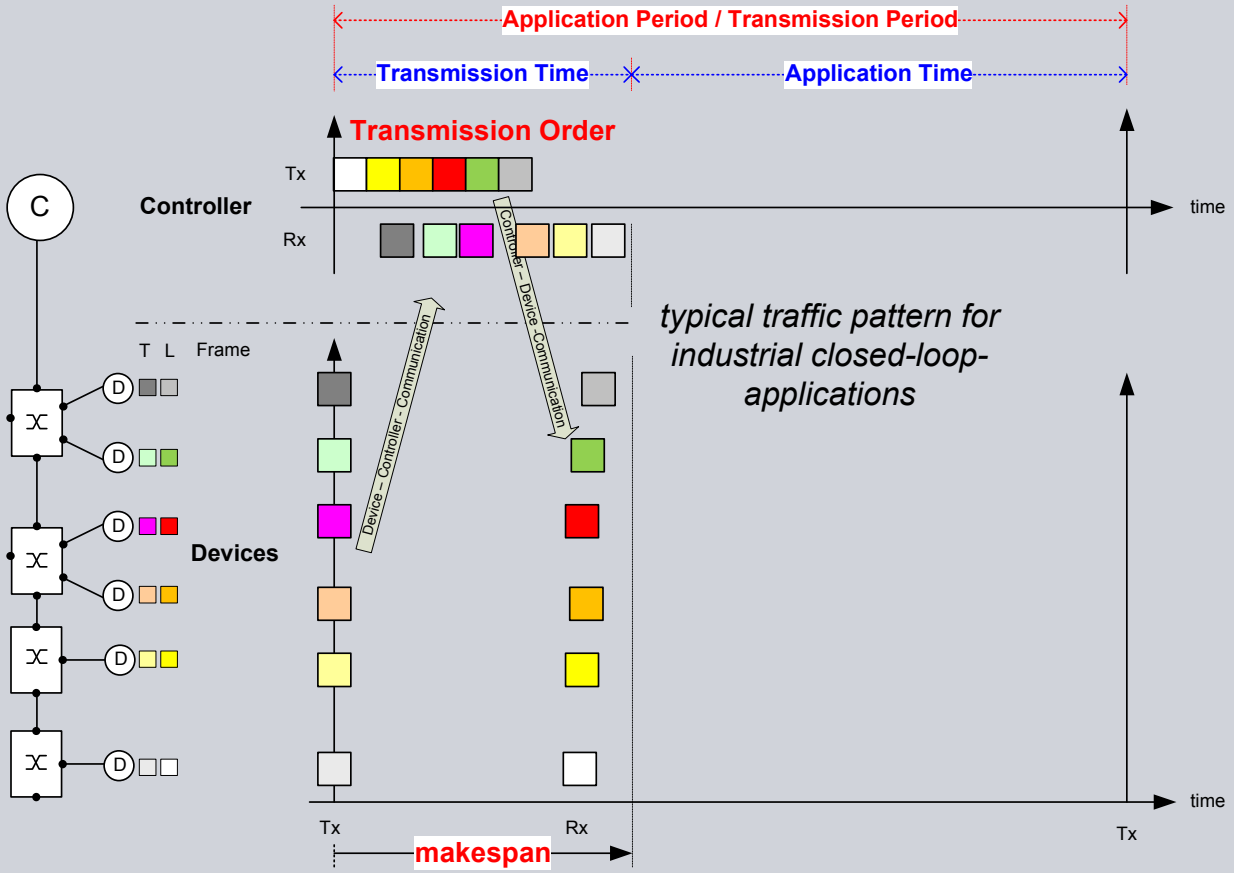
Typical traffic pattern for control traffic

ULL Stream for automation applications



Transmission of all ULL Streams within transmission time

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Objectives to guarantee ultra low latency

- Predictable bandwidth (traffic load) and resources
- Use appropriate (e.g. shortest) communication path
- Minimize delays for ULL Streams caused by
  - Traffic shaper
  - Bubbling talker
  - Traffic congestion
  - Interference from
    - legacy traffic and other traffic classes (e.g. AV Streams)
    - other ULL Streams

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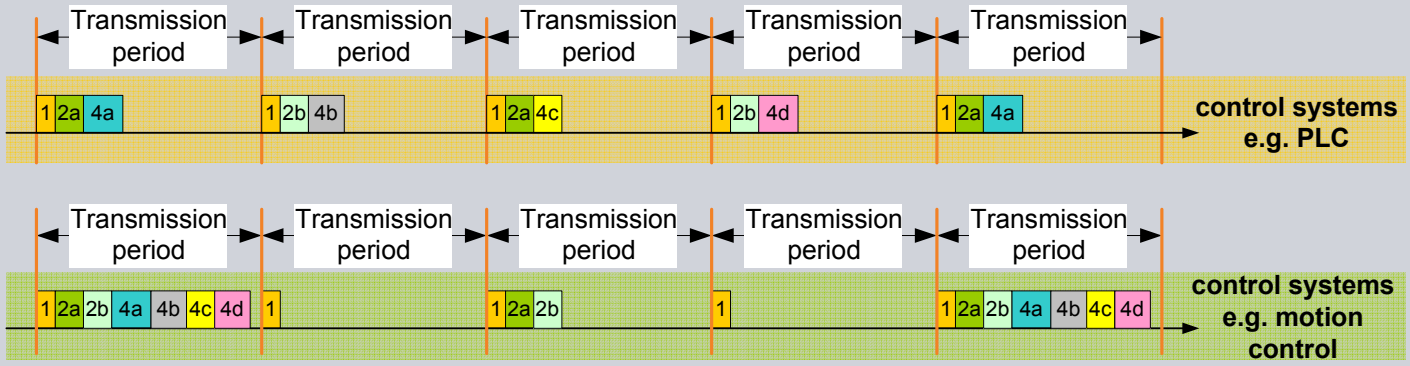
Proposed Mechanism for ULL Streams (1)

- **A new Traffic Class for Ultra low Latency (ULL) Streams**
  (e.g. combinable with AV Stream class A)

  - Range of transmission periods in steps of 2^N x 31,25µs
    (31,25µs - 1ms)
  - Worst case latency (max. E2E Latency) over all received ULL Streams within transmission period,
    required latency < 2 µs / Gb hop (length < 64 Bytes by empty tx queue)

Multiple transmission periods in parallel



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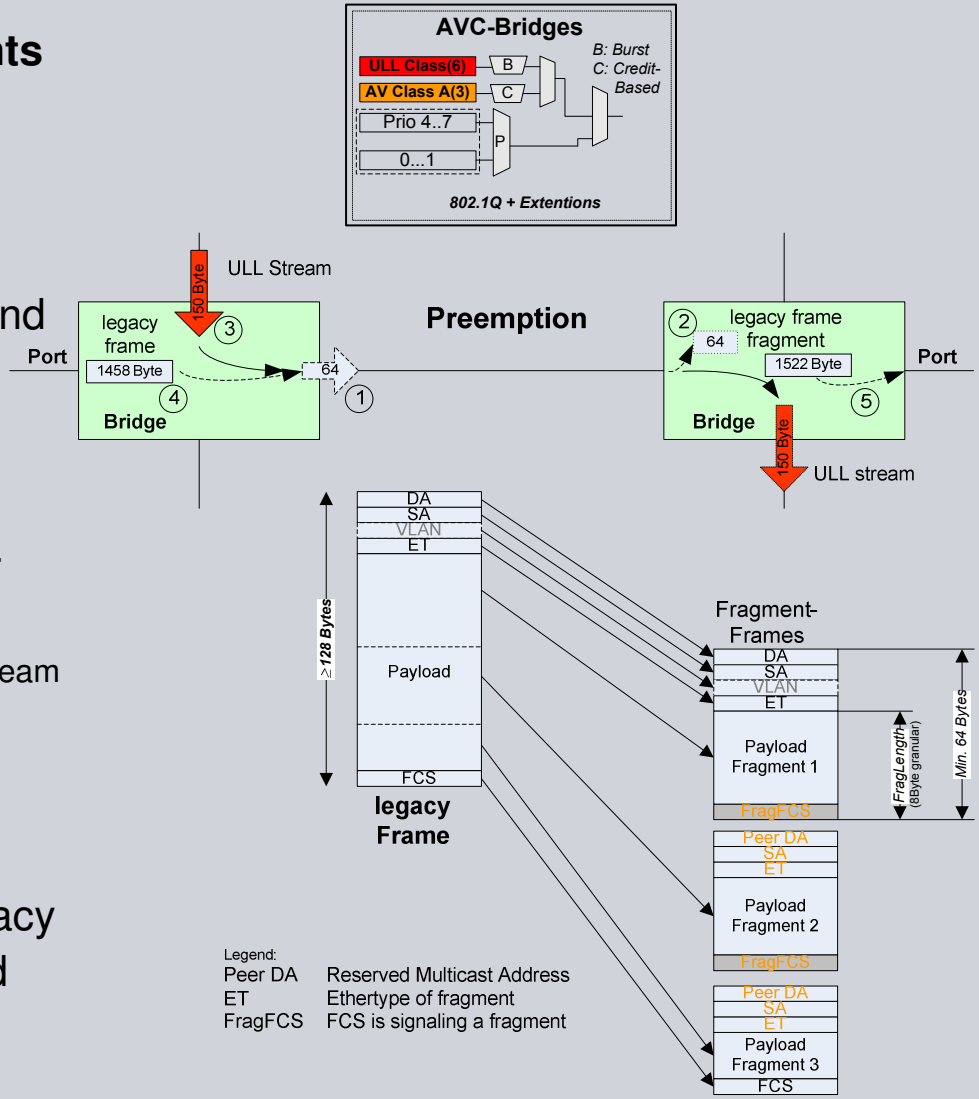
Proposed Mechanism for ULL Streams (2)

- **Forwarding and queuing enhancements for bridges and end stations**
  - ULL SR Class Queue
  - ULL SR Class separate Resources
  - Enhanced traffic shaper in bridges and end station for ULL Streams
    - isochronous transmission for ULL Streams by end station
    - bursty or time aware scheduler for ULL Streams in bridges
      (e.g. get always highest priority when ULL Stream is in transmit queue)
  - Cut Through
  - Pre-emption for ULL Streams
    - Peer-to-Peer fragmentation of legacy traffic and AV Streams on demand



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Proposed Mechanism for ULL Streams (3)

- **Specify mechanism and strategy to avoid and resolve traffic congestion of ULL Streams**
  - Identify overload situations (e.g. bubbling idiot) and aged ULL Streams
  - Discard these conflicting ULL Streams
- **Minimize interference of ULL Streams in bridges**
  - Support for optimized sequence of ULL Steams on egress port

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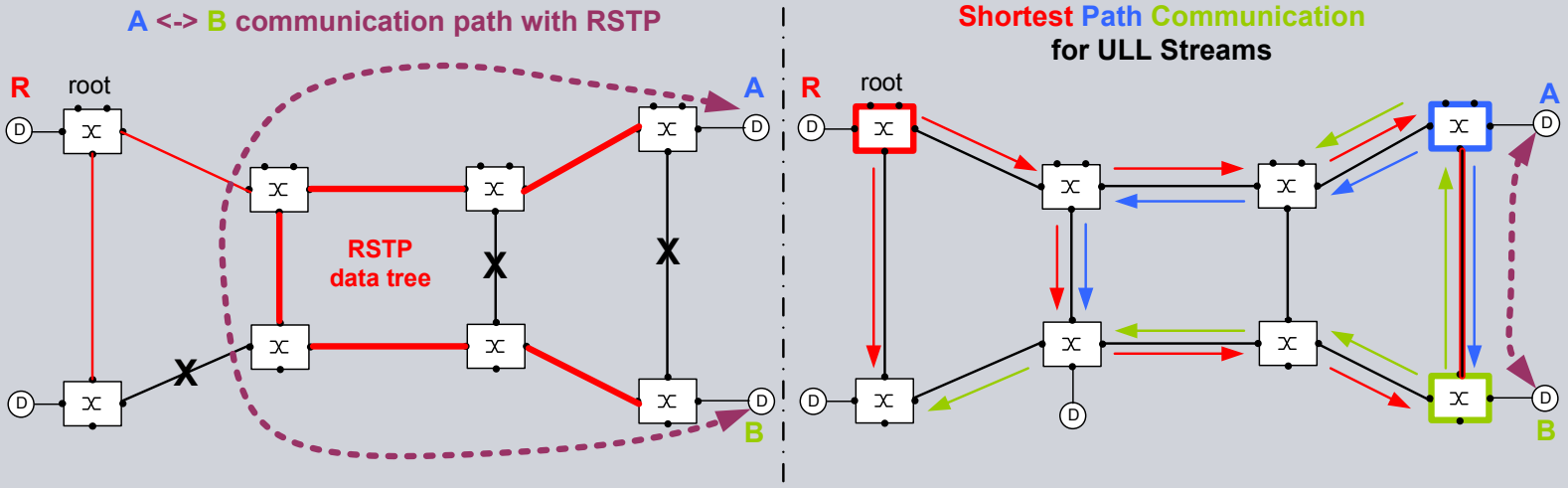
Proposed Mechanism for ULL Streams (4)

- **Calculable and guaranteed bandwidth and resources**
  - ***Routing***
    - Transmission path for ULL Streams is independent from RSTP
    - Guaranteed bandwidth
    - Shortest path
    - Multiple path for high availability
      - Duplicated ULL Stream in parallel over 2nd independent shortest communication path

Configuration of shortest communication path with topology network information
+ offline – engineered
+ at runtime – centralized or decentralized with routing protocol



Proposed Mechanism for ULL Streams (5)

- ***Scheduling***
  - transmission time to minimize make span
  - minimize and guaranteed resources in bridges for ULL Streams

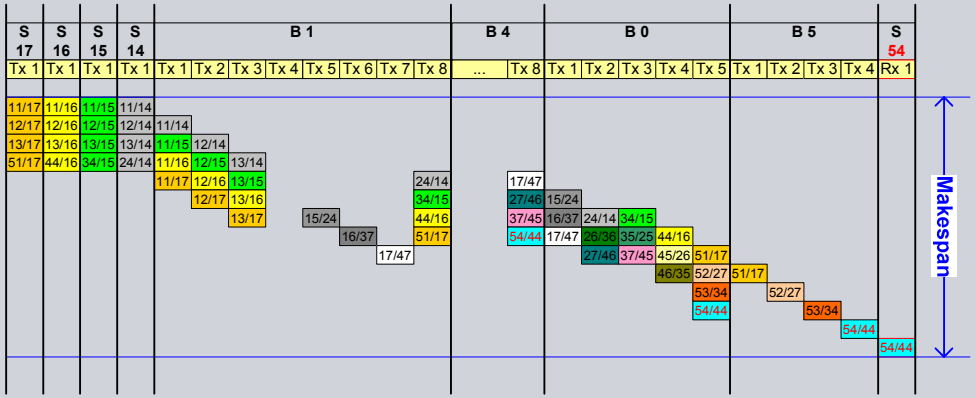
Configuration of schedule with topology network information
+ offline – engineered
+ at runtime – centralized or decentralized with routing protocol

The following slides show a scenario for scheduling:

Assumption:

- All end station are synchronized
- ULL Streams are transmitted over shortest path
- Same packet length for all ULL Streams (packet slot)
- No interference legacy traffic or additional delays
  - No pre-emption
  - No bridge delay
- E2E hop count is always 4
- Store & Forward for ULL Streams

Scheduling



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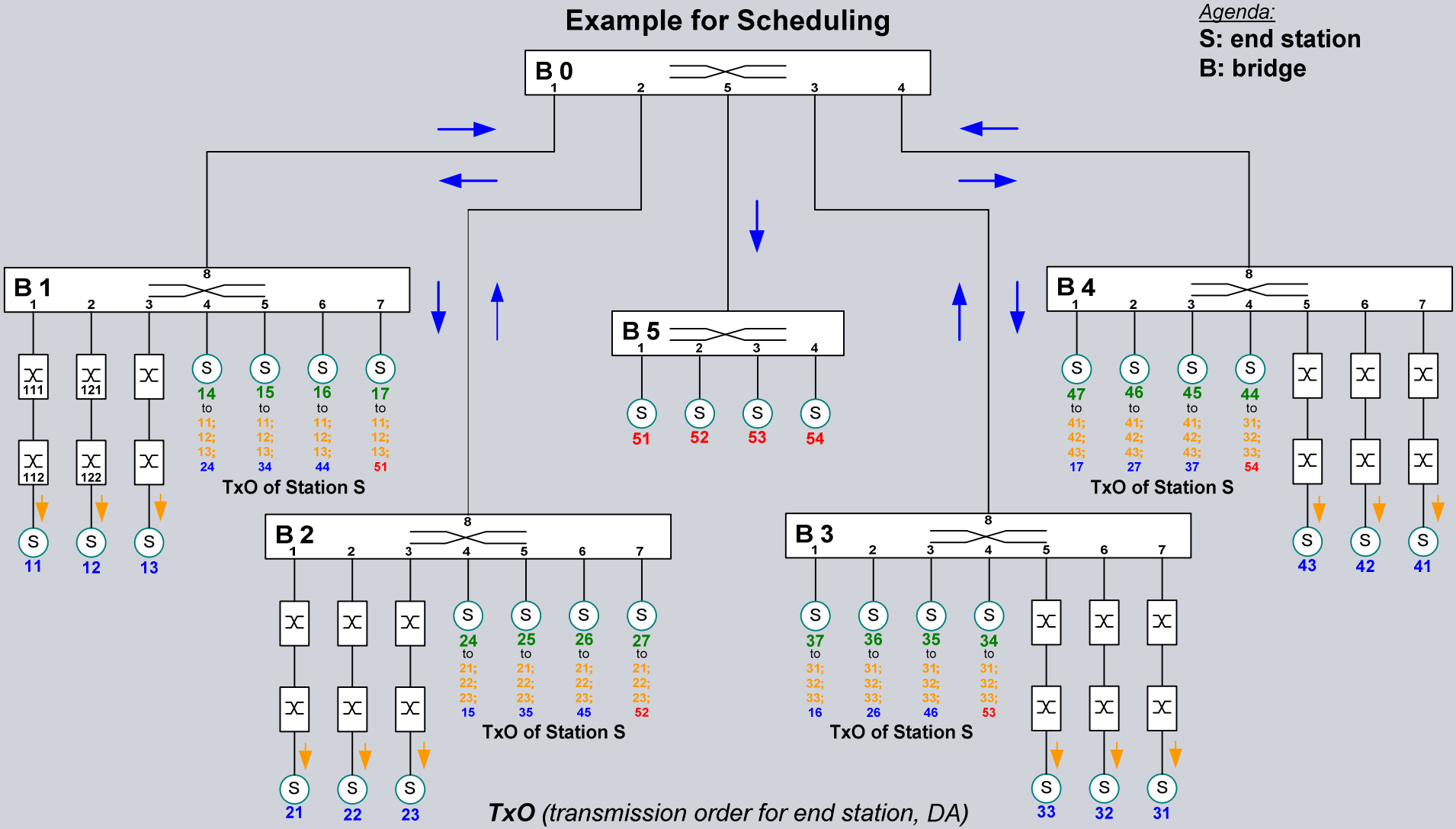
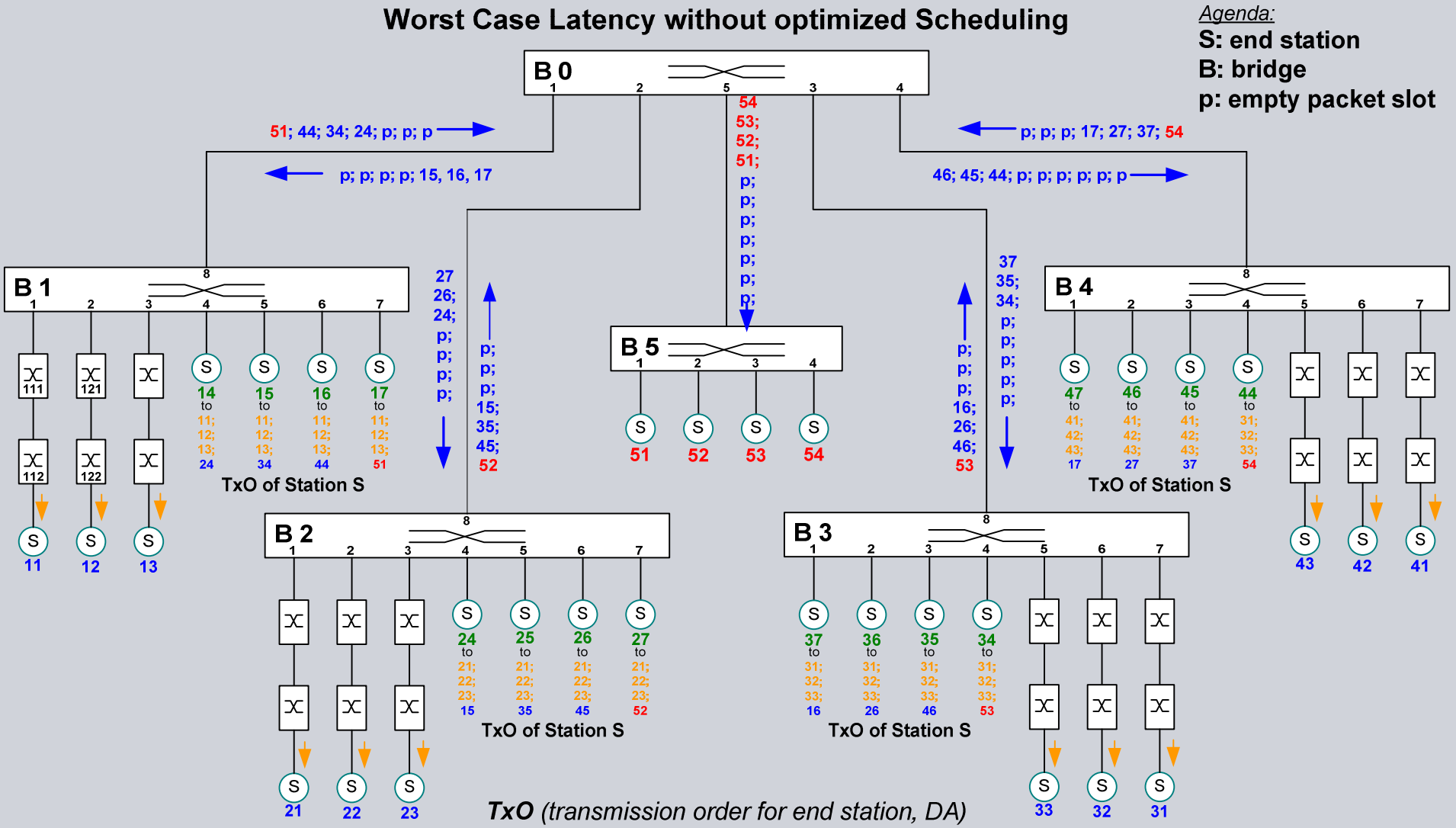
Scenario: Routing & Scheduling for ULL Streams (1)



Scenario: Routing & Scheduling for ULL Streams (2)



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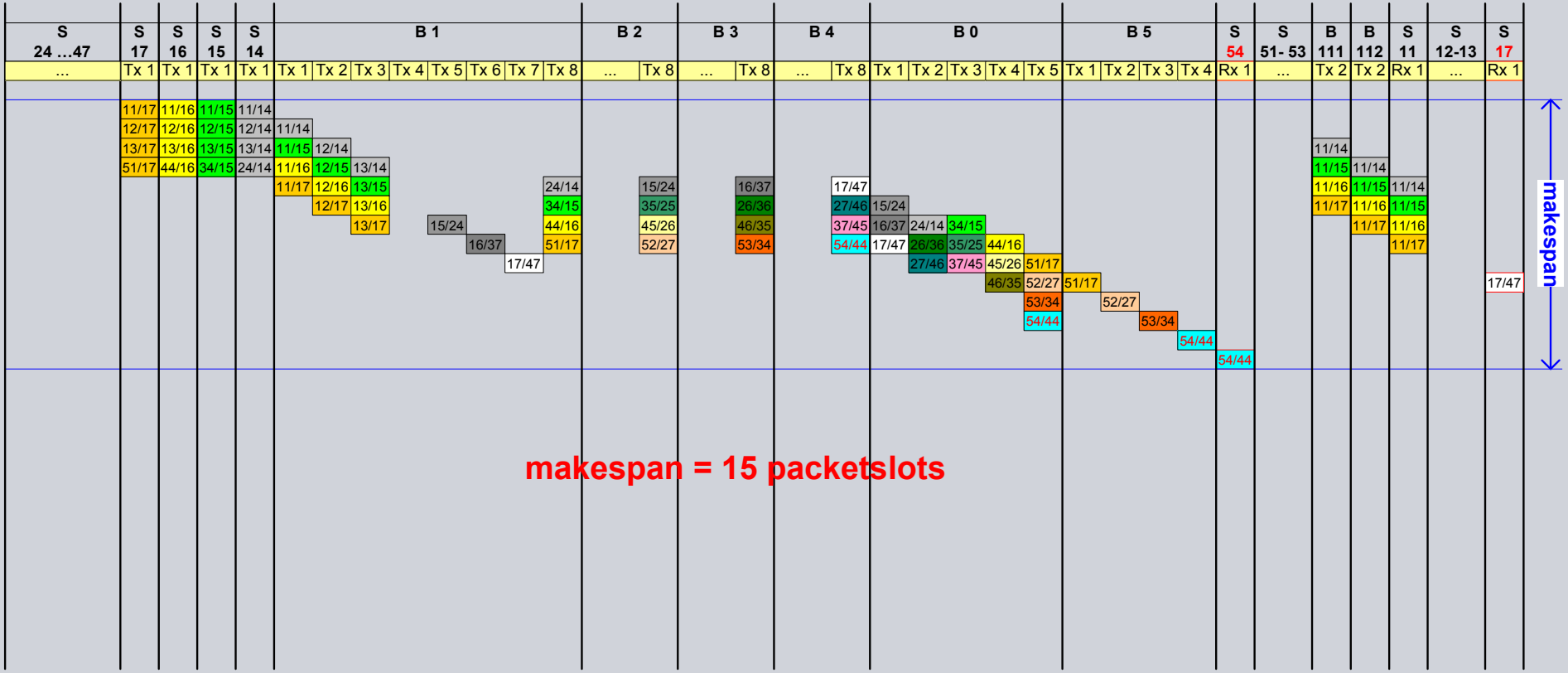
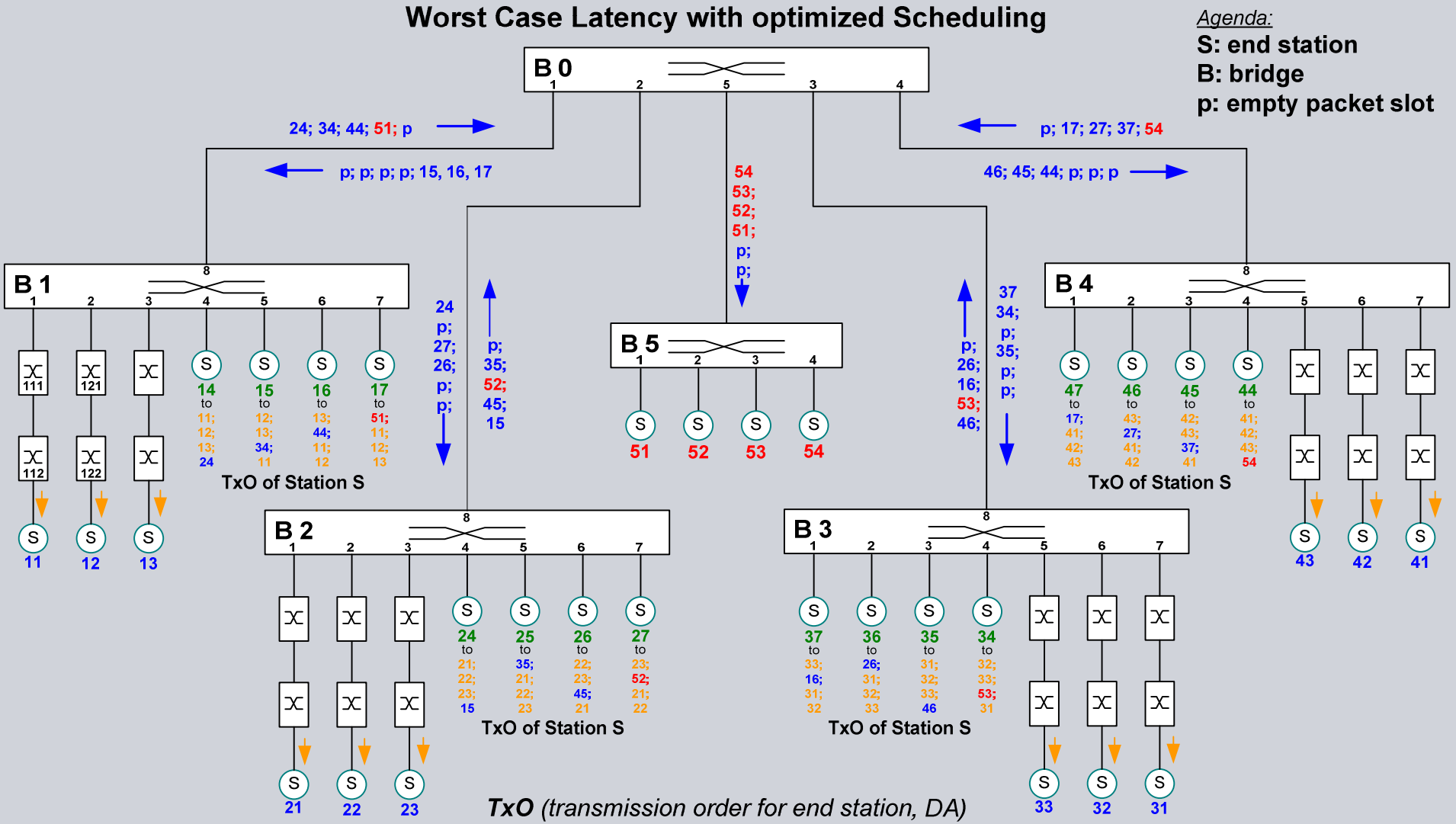
Scenario: Routing & Scheduling for ULL Streams (3)

Worst Case Latency without optimized Scheduling



makespan = 15 packetslots

Scenario: Routing & Scheduling for ULL Streams (4)



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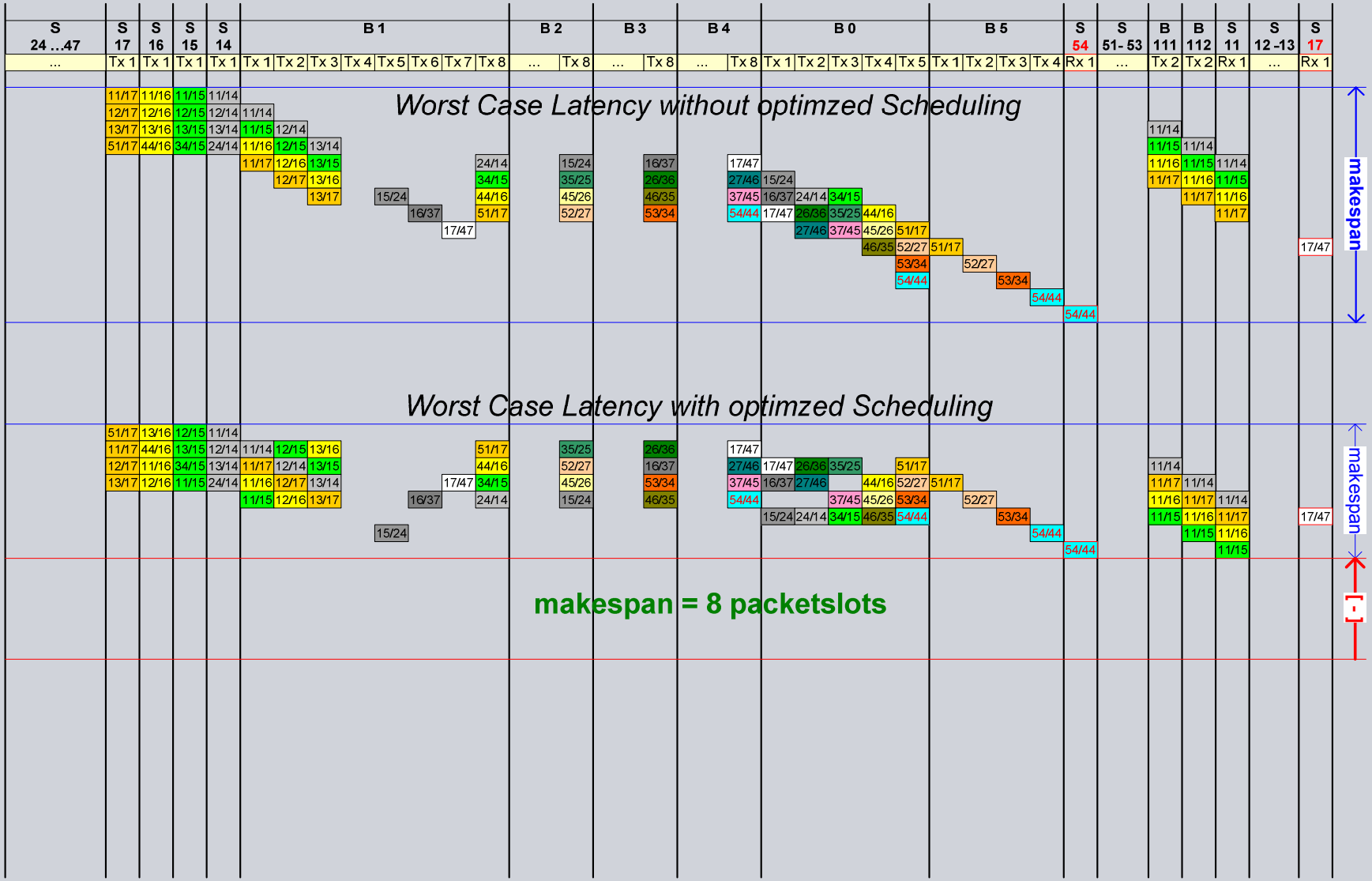
Scenario: Routing & Scheduling for ULL Streams (5)



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Overview of proposed Mechanism

Mechanism		Rating		
		Ultra Low Latency	Robustness	Availability
Separate traffic class for control (ULL Streams)		A	A	-
Forwarding and queuing enhancements (inside bridge or end station)	Separate ULL queue with guaranteed resources	-	AAA	A
	Bursty or time aware shaper	AAA	-	-
	Cut Through with Pre-emption	AA	-	-
	Guaranteed transmission order in end stations	AA	-	-
	Guaranteed transmission order in bridges	A	-	-
	Bandwidth observation	B	AAA	A
Pre-emption (Fragmentation on Demand) + LLDP		AAA	-	-
Routing protocol	Limited and guaranteed bandwidth	A	A	A
	Shortest Path	AAA	-	-
	multiple Path	-	-	AAA
Scheduling protocol		AAA	A	A
Synchronization	high accuracy < 1µs	A	B	-
	high availability	-	AA	AAA

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Conclusion

The pre-emption is an important mechanism but Routing and Scheduling has the same relevance for ultra low latency.

An additional ultra low latency stream class for high performance and robust closed loop controls which can handle temporary overload situations in bridged Ethernet networks is a not-easy-to-establish but a

feasible technology.