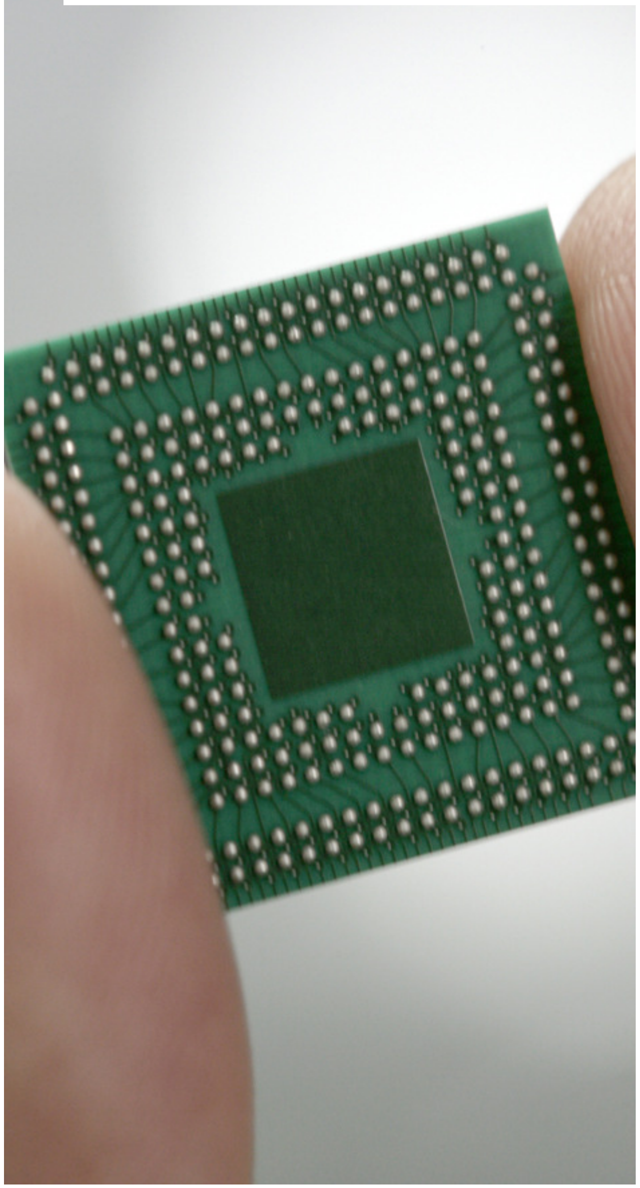

Ultra Low Latency Traffic Class @ Industry

2011-11-07

IEEE 802.1 AVB TG Meeting – Atlanta

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

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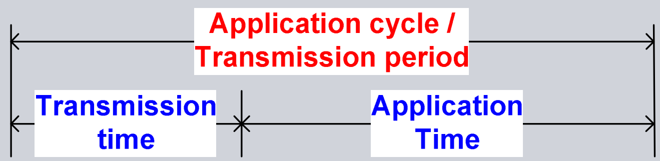
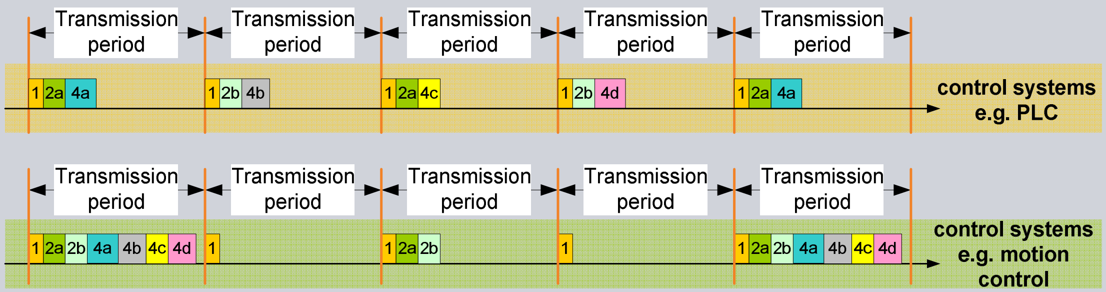
Characteristic:

- Range of transmission periods in steps of 2^N x 31,25µs (31,25µs - 1ms)
  - Transmission period equals application cycle
  - Transmission time for ULL streams << transmission period



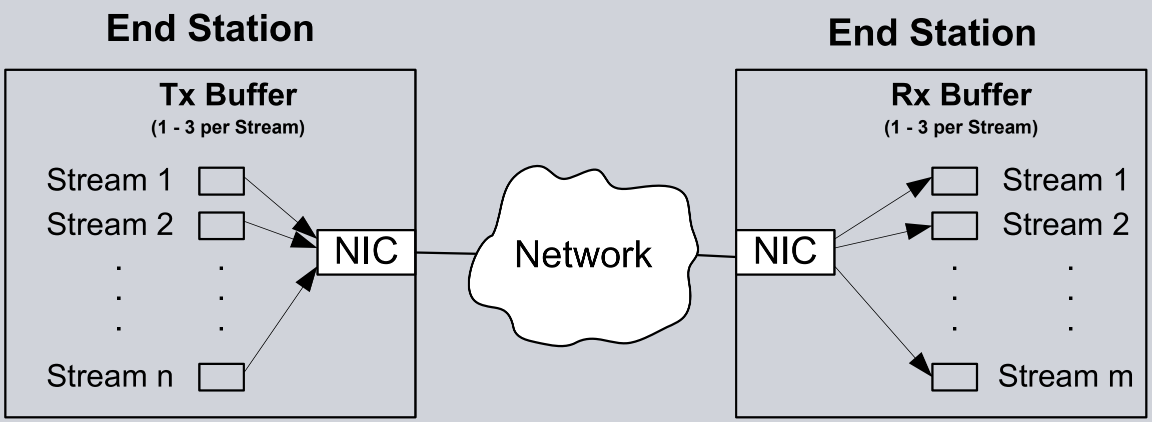
  - Multiple transmission periods in parallel



- Frame length for ULL Streams typ. in the range of 64 – 400Bytes

Characteristic

- Buffered transmit and receive ULL Stream interface
  - Limited transmit and receive buffer per ULL Stream
  - Control loop application do calculation based on latest input data
    (old input data are obsolete)



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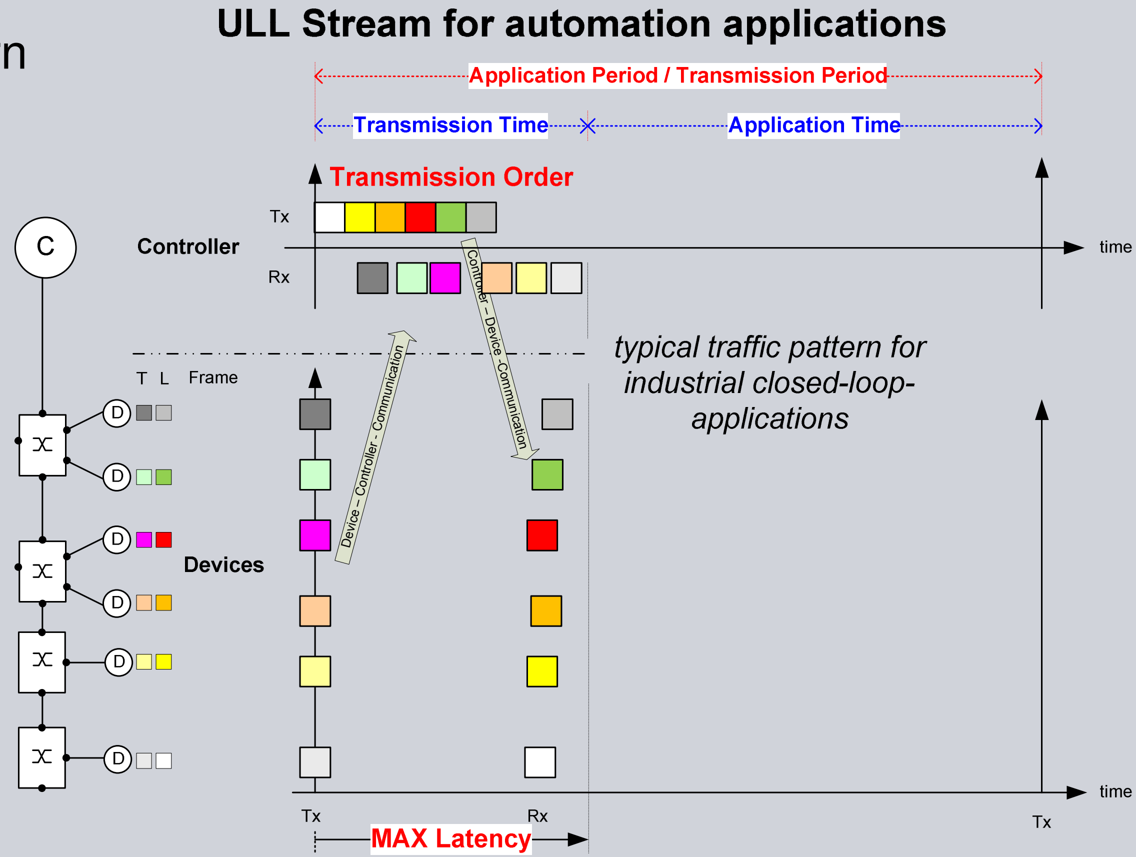
Characteristic

- Traffic pattern



- Transmission of all ULL Streams within transmission time
  - Worst case latency (max. E2E Latency) over all received ULL Streams within transmission period, required latency < 2 µs / GBit hop (length < 64 Bytes by empty tx queue)

Objectives to guarantee ultra low latency

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

Proposed Mechanism to support ULL Streams

Separate ULL Streams from AV Streams and legacy traffic

- Introduce Ultra Low Latency Traffic Class
  (e.g. combinable with AV Stream class A)
    - Default priority value: 5
    - VLAN ID is user specific or reserved
- Enhanced traffic shaper in bridges and end station for ULL Streams
    - isochronous transmission for ULL Streams by end station
    - burst scheduler for ULL Streams in bridges
- Preemption for ULL Streams
    - Peer-to-Peer fragmentation of legacy traffic and AV Streams on demand

Calculable and guaranteed bandwidth and resources

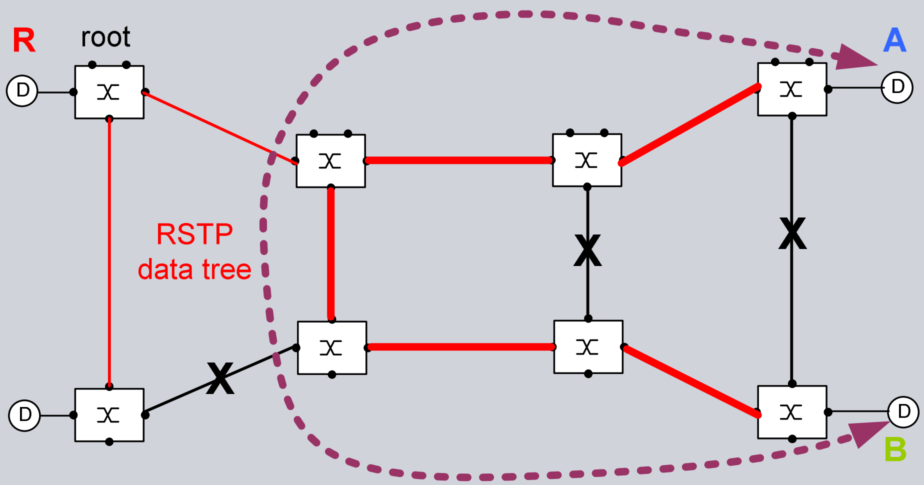
- Bandwidth reservation for ULL Streams to guarantee resources in bridges and end stations

Proposed Mechanism to support ULL Streams

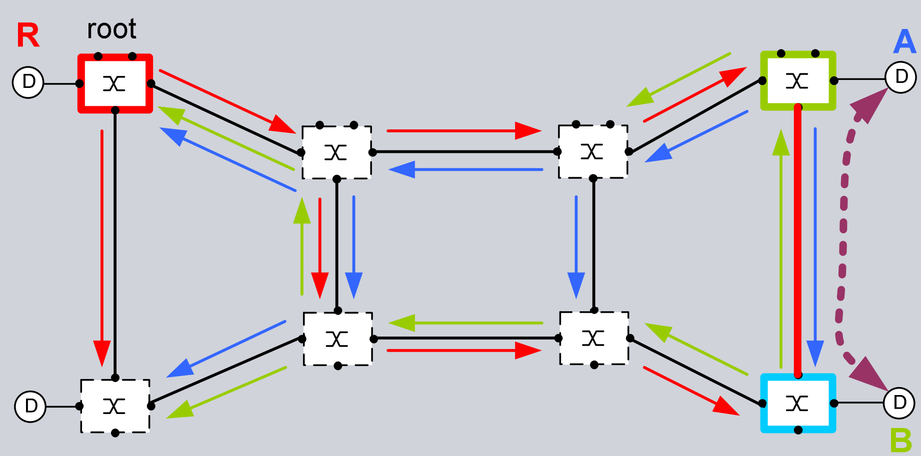
Use shortest communication path for ULL Streams

- Transmission path for ULL Streams is independent from RSTP
- Configuration of shortest communication path with network topology information
  - offline – engineered
  - at runtime – centralized or decentralized with routing protocol

A <-> B communication path with RSTP



Shortest Path Communication



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Proposed Mechanism to support ULL Streams

<u>Minimize delays for ULL Streams</u>

- ULL Stream traffic shaper in bridges
  - Get always highest priority when ULL Stream is in transmit queue
    (restricted to reserved bandwidth and resources to protect other traffic classes)

- 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
  - Support more than one ULL Stream classes

- Minimize interference of ULL Streams by end stations
  - Scheduled transmission of ULL Streams
  - Optimized transmission order by using network topology knowledge

Minimize interference of ULL Streams

Scheduled transmission to minimize time for ULL Streams

(The following slides will 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 Preemption
  - No Bridge delay
- E2E hop count is always 4

Minimize interference of ULL Streams by Routing & Scheduling

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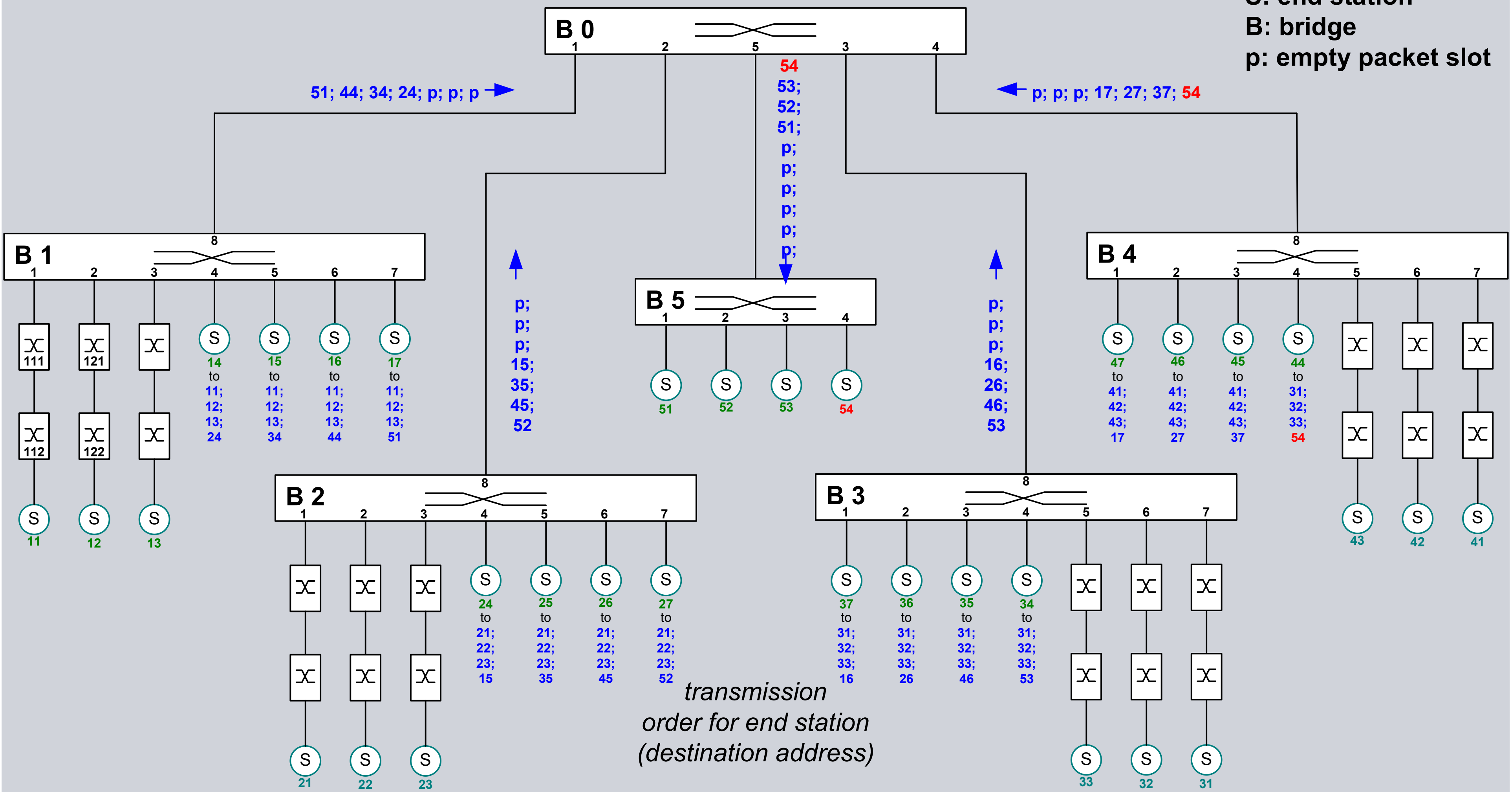
Worst Case Latency without Scheduling

Agenda:

S: end station
B: bridge
p: empty packet slot



Minimize interference of ULL Streams by Routing & Scheduling

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Worst Case Latency without Scheduling

Minimize interference of ULL Streams by Routing & Scheduling

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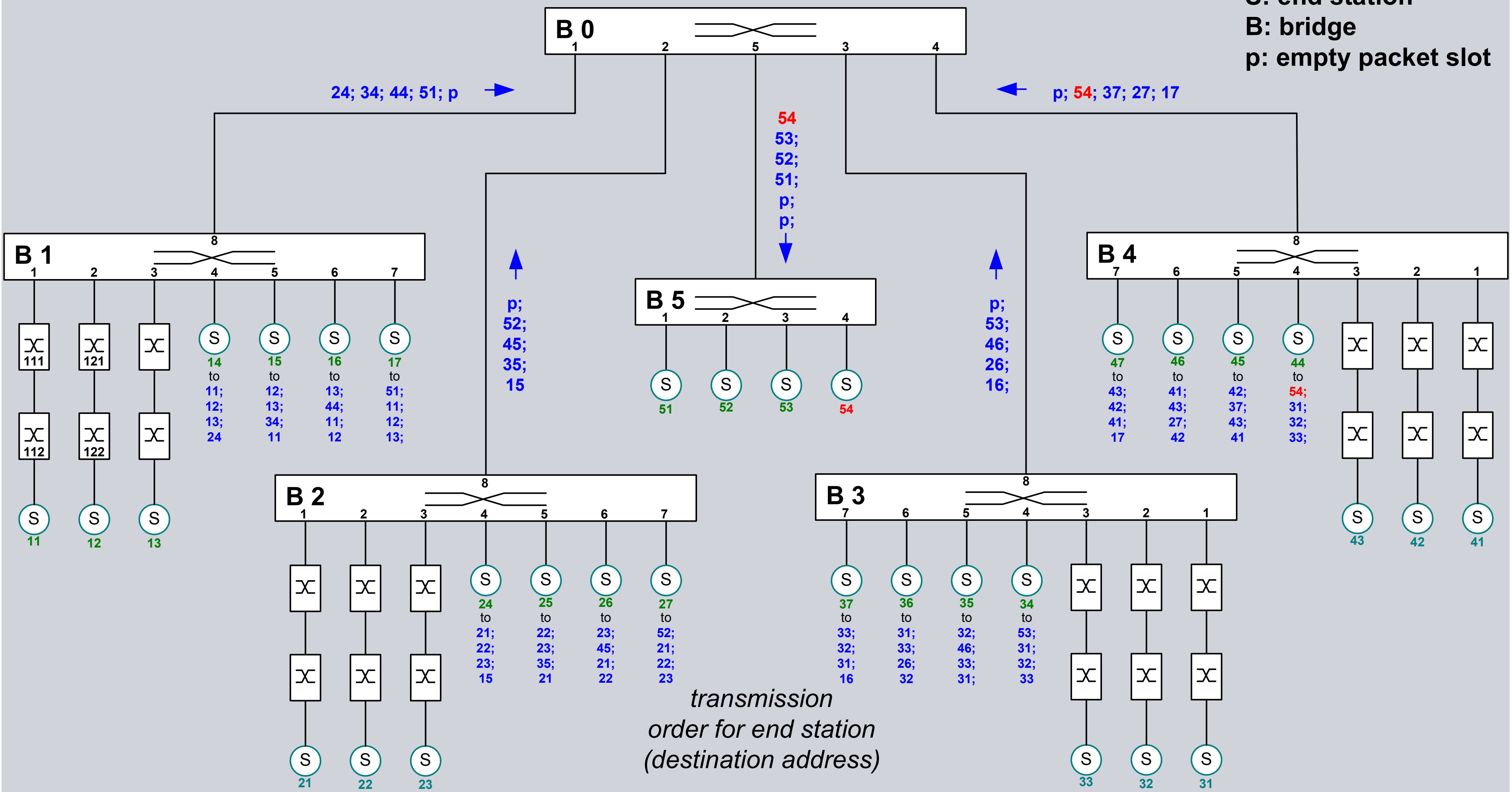
Worst Case Latency with Scheduling (1)

Agenda:
S: end station
B: bridge
p: empty packet slot



Minimize interference of ULL Streams by Routing & Scheduling

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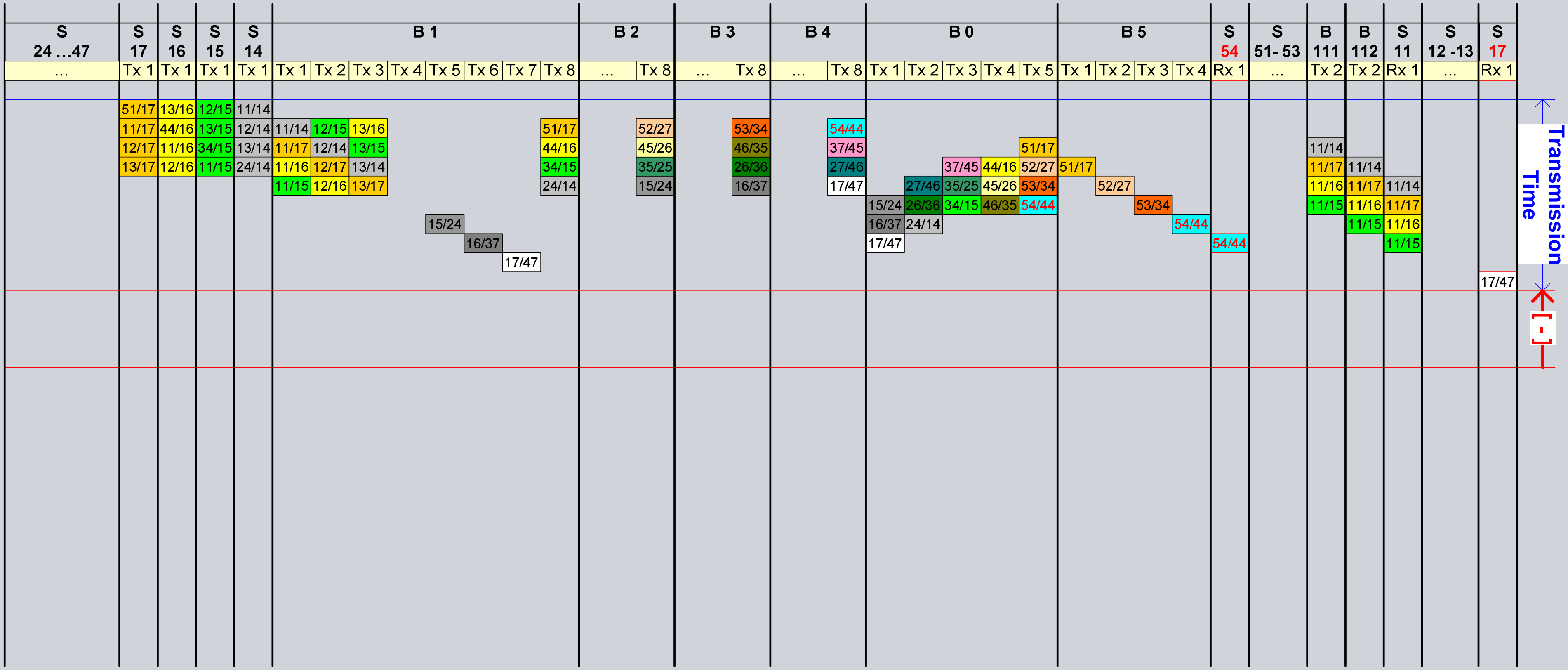
Worst Case Latency with Scheduling (1)



Minimize interference of ULL Streams by Routing & Scheduling

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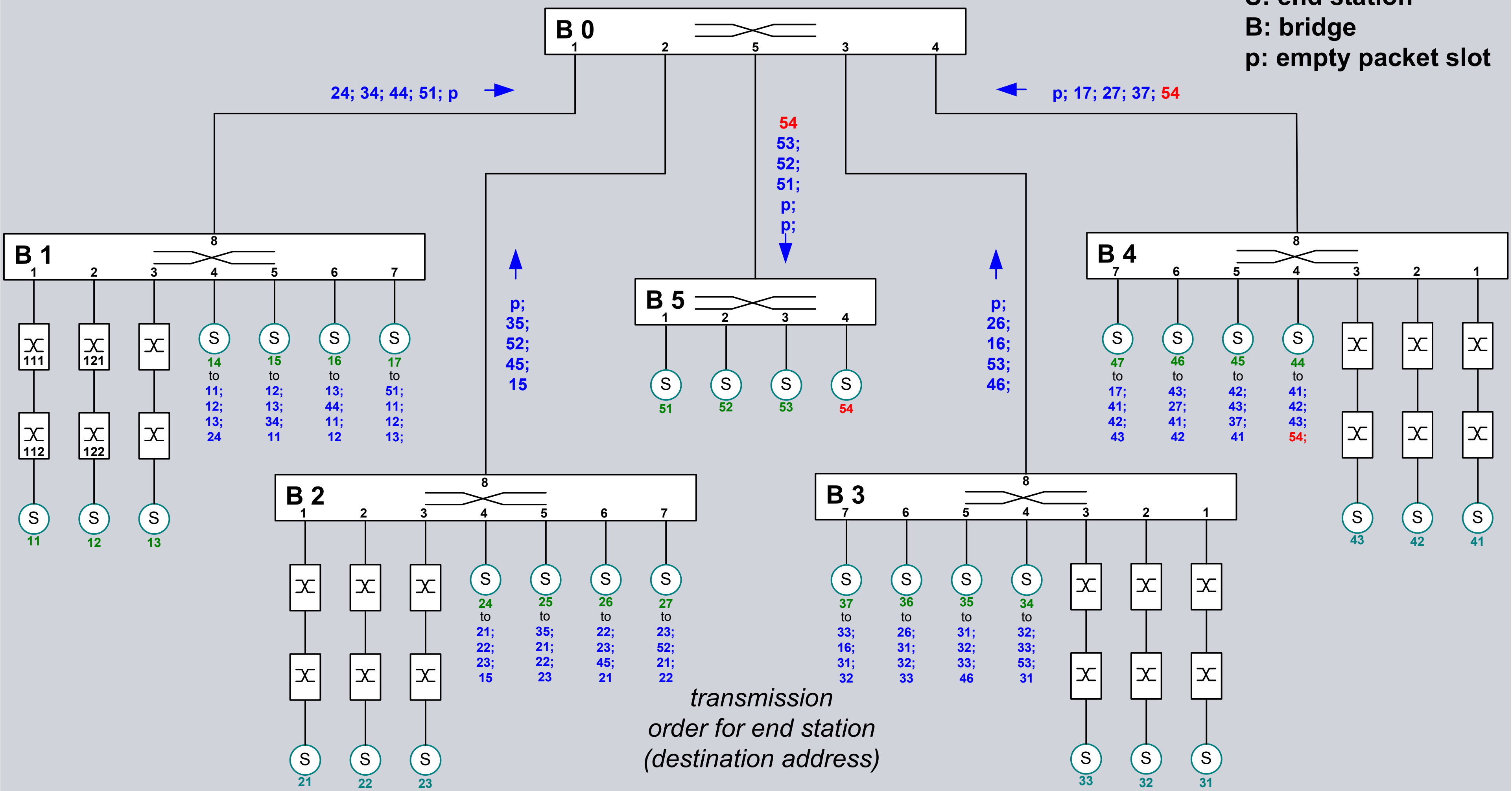
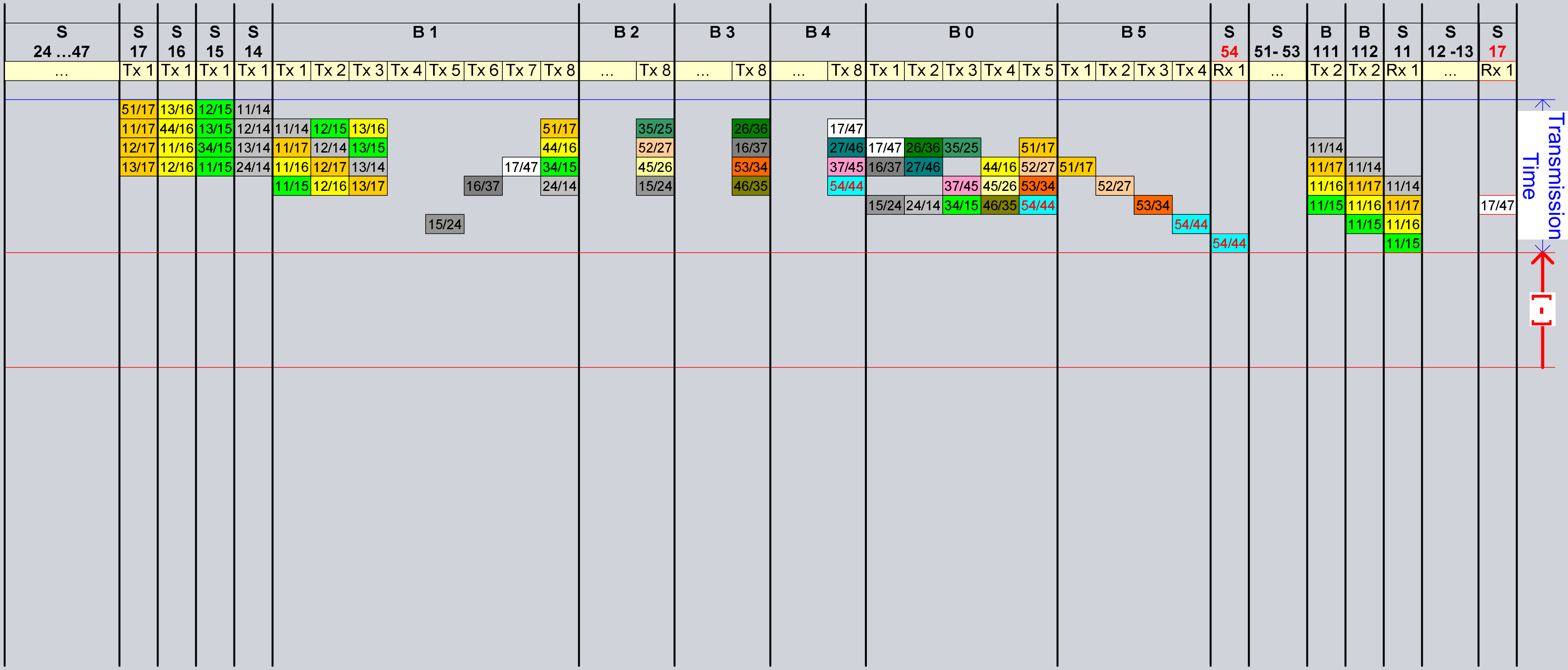
Worst Case Latency with Scheduling (2)

Agenda:
S: end station
B: bridge
p: empty packet slot



Minimize interference of ULL Streams by Routing & Scheduling

Worst Case Latency with Scheduling (2)



Minimize interference of ULL Streams by Routing & Scheduling

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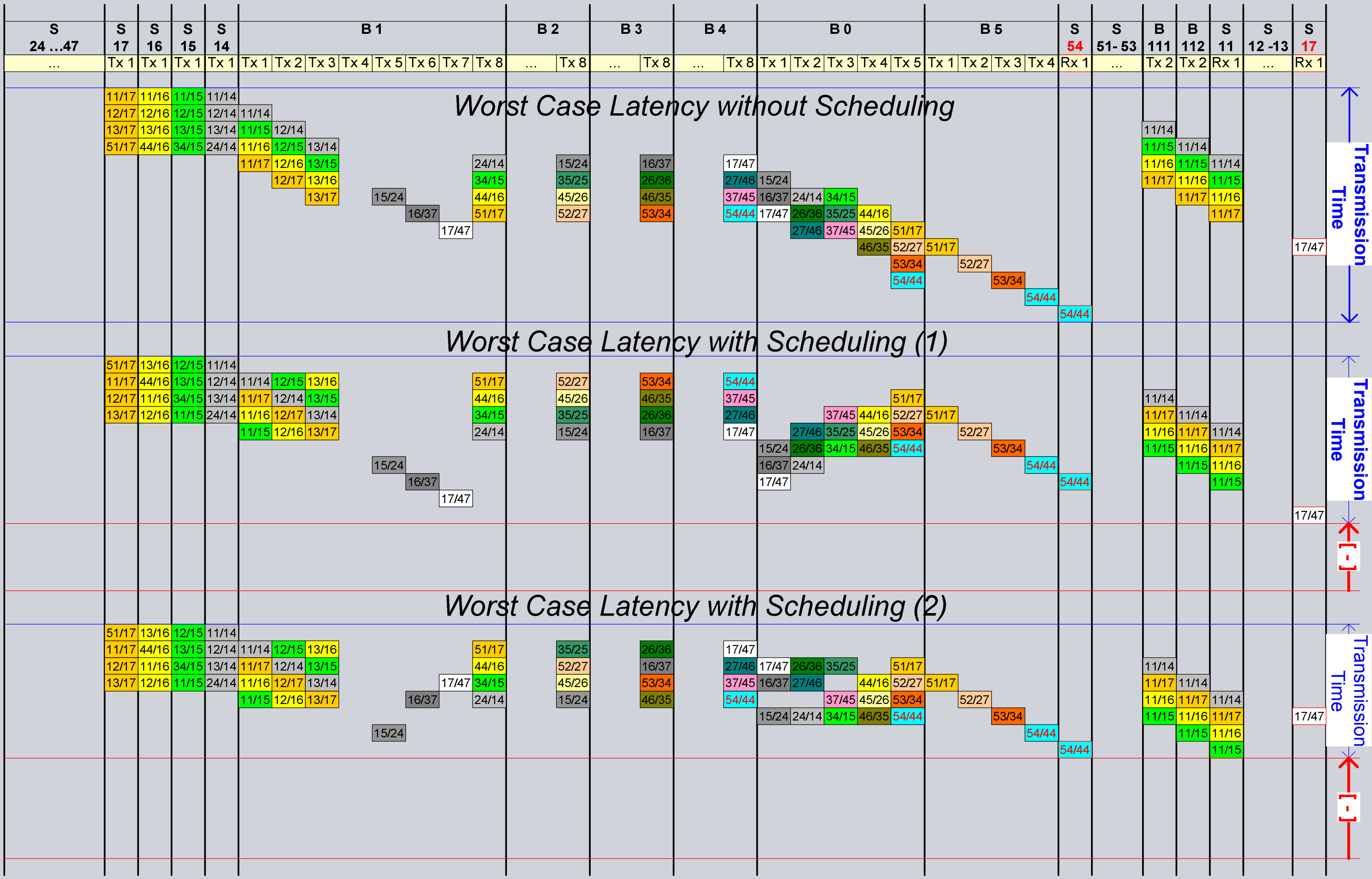

ULL and AV Streams within one network

Impact of ULL Streams on AV Streams

- Max burst size of ULL Stream
  - Limit for max. burst size
  - Restricted frame length for ULL Streams
  - Must be considered by latency calculation for AV Streams

- Preemption Mechanism
  - Must be considered by bandwidth calculation for AV Streams

Seamless Redundancy for ULL Streams

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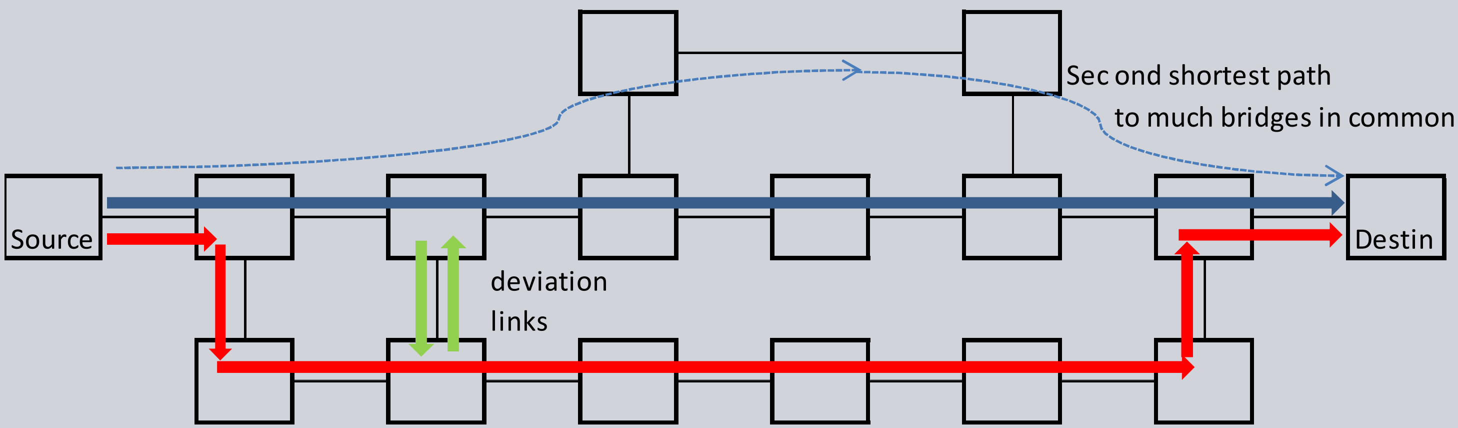
<u>Transmission of seamless ULL Streams</u>

- Duplicated 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
- Rules for selecting best alternate path
  - All paths fulfilling the latency and bandwidth requirements can be candidates
  - Alternate path with the lowest number of bridges in common is the primary choice
  - Selection of “deviation links” to enhance availability
    (new paths must fulfill latency and bandwith requirements)



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Closing

The preemption 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.