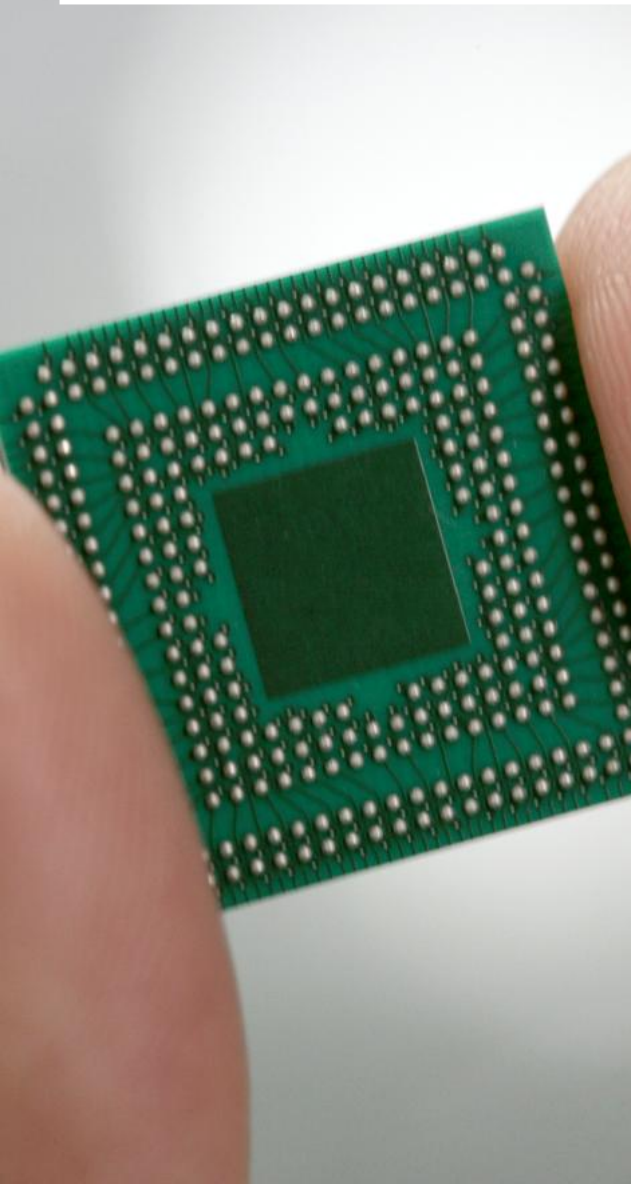
SIEMENS



Robustness for Control-Data-Traffic in Time Sensitive Networks

2013-07-15 -v01-

IEEE 802.1 TSN TG Meeting
Geneva - Switzerland

Presenter:
Franz-Josef Goetz, Siemens AG

franz-josef.goetz@siemens.com

Structure of this Presentation

SIEMENS

1. Terminology for Control Data Traffic (CD-Traffic)
2. Multiple Traffic Classes for Control Data Traffic
3. Impact of CD-Class B on Class A
4. Bandwidth Metering Methods for Control Data Traffic

Structure of this Presentation

SIEMENS

1. **Terminology for Control Data Traffic (CD-Traffic)**
2. **Multiple Traffic Classes for Control Data Traffic**
3. **Impact of CD-Class B on Class A**
4. **Bandwidth Metering Methods for Control Data Traffic**

SIEMENS

Terminology for Control Data Traffic (CDT)

- **Control Data Traffic (alias Scheduled Traffic)**
  - Bandwidth limit for CDT (use case dependent, max. up to FE 50%?, max. up to GE 15%?)
  - Separate queues and guaranteed resources for CD-Streams
    - Queue for CD-Traffic has highest priority for transmission
  - Standardized shaper (under discussion TAS, …) to guarantee latency
    - computable and therefore predictable
  - Talker – three transmission options
    - Not synchronized – rate constraint traffic
    - Synchronized + burst (multiple CD-Streams)
    - Synchronized + scheduled (transmission time)
  - One transmission period (2^N x 31,25µs for industrial applications) per traffic class within one domain
  - CD-Traffic-Classes (TSN shall support at least one CD-Traffic-Class)
    - **CD-Streams Class A (e.g. motion control application)**
      (transmission period e.g. 125µs, guaranteed lowest latency)
    - **CD-Streams Class B (e.g. industrial control application)**
      (transmission period 1ms, guaranteed low latency)

Structure of this Presentation

SIEMENS

1. Terminology for Control Data Traffic (CD-Traffic)
2. **Multiple Traffic Classes for Control Data Traffic**
3. Impact of CD-Class B on Class A
4. Bandwidth Metering Methods for Control Data Traffic

SIEMENS

Why multiple Traffic Classes for Control-Data-Traffic

Reasons for more than one Classes for Control Data Traffic:

- Minimizing amount of traffic per class helps to guarantee low latency

- Support different transmission periods (TP) within one network
  - critical Control Data Traffic (e.g. for motion control, TP =125µs)
  - non-critical Control Data Traffic (e.g. for industrial control, TP = 1ms)

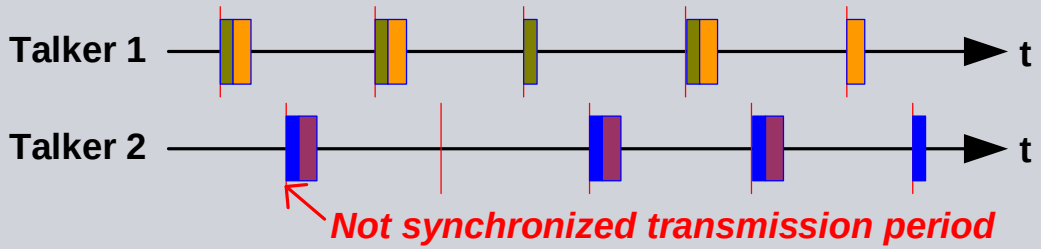
  => One transmission period within one traffic class

Talker for Control Data Traffic
Three Options for Transmission of CDT

SIEMENS

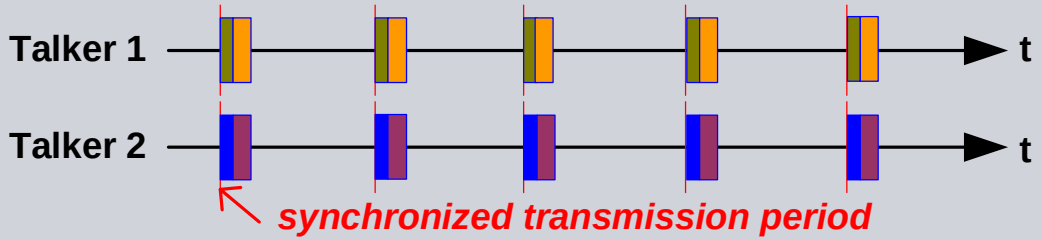
Event based control data traffic for industrial control

Use Case 1: Rate constrained Control Data Traffic
Talker are not synchronized



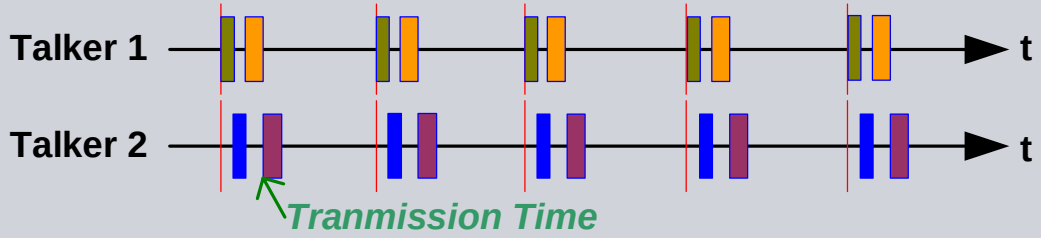
Synchronized control data traffic for motion control

Use Case 2: Talker are synchronized
Transmitting bursty periodical Control Data Traffic



Synchronized and scheduled control data traffic for motion control

Use Case 3: Talker are synchronized
Tranmitting scheduled Control Data Traffic



Advantages of synchronized Talkers with scheduled Control Data Traffic

SIEMENS

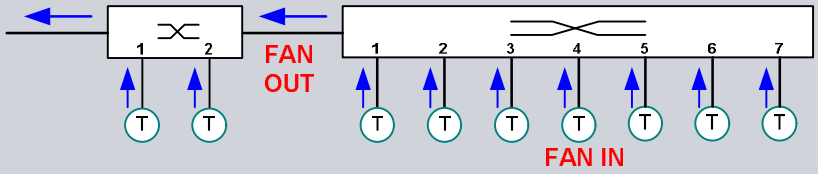
Assumptions:

- Engineered time sensitive network domain
- All Talkers are synchronized by working clock
- Transmission time for Control Data Frames is configured

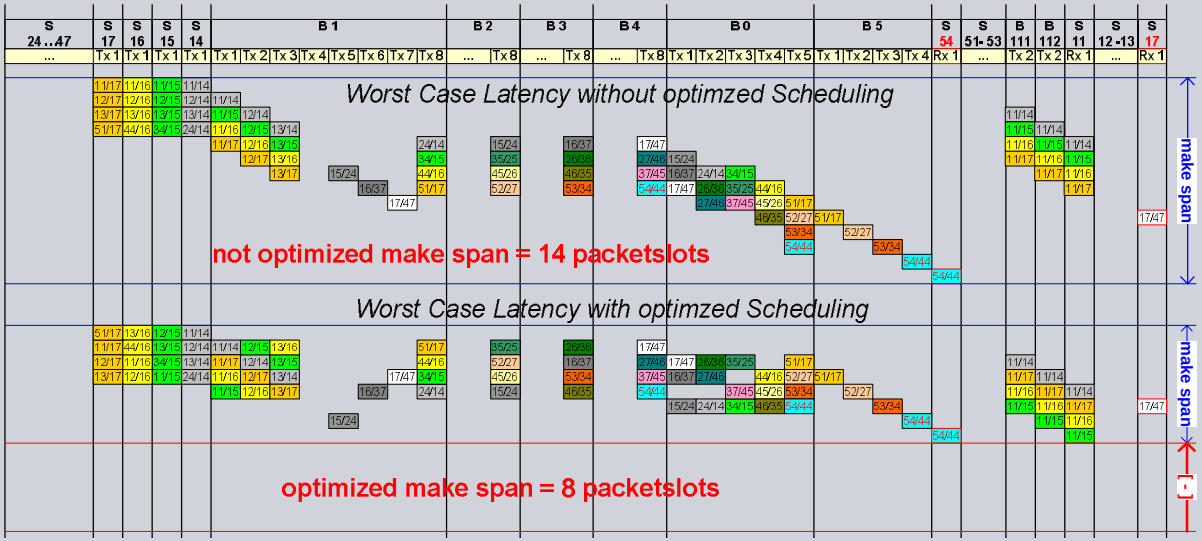
Reasons:

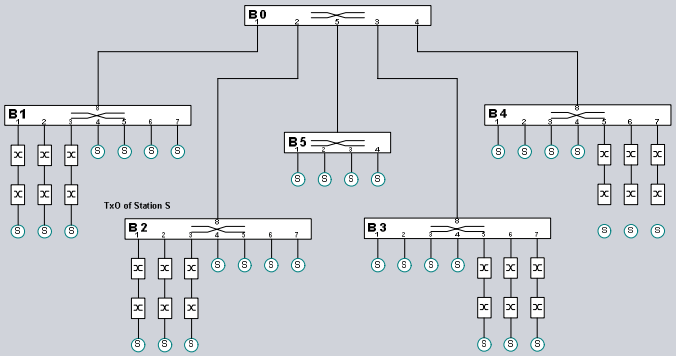
- Optimize usage of resources in bridges
- Minimize make span by optimizing transmission order
- Minimize receive jitter (avoid miss ordering)

Scheduling to optimize resources in bridges



Talker for Control Data Traffic





See: (http://www.ieee802.org/1/files/public/docs2011/new-fjg-ULLStreams-Routing-Scheduling-1111-v01.pdf)

Scenarios for Control Data Traffic in converged Time Sensitive Networks (TSN)

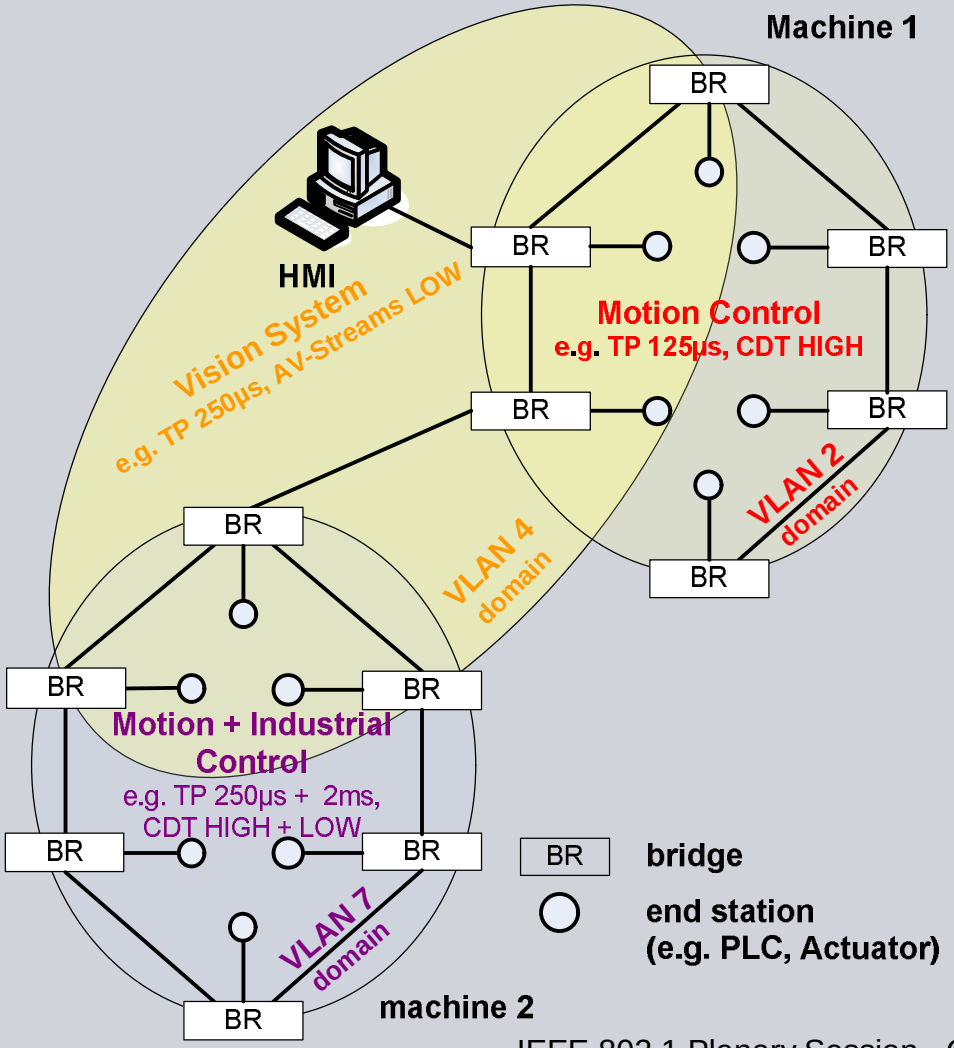
SIEMENS

Multiple machines within one time sensitive network

Machine 1
- VLAN 2 domain
- CD-Streams High
- Transmission period 125µs

Machine 2
- VLAN 7 domain
- CD-Streams High & Low
- Transmission period 250µs & 2ms

HMI
- VLAN 4 domain
- Overlapping VLAN domain 2 & 7
- AV-Streams Low
- Transmission period 250µs



Structure of this Presentation

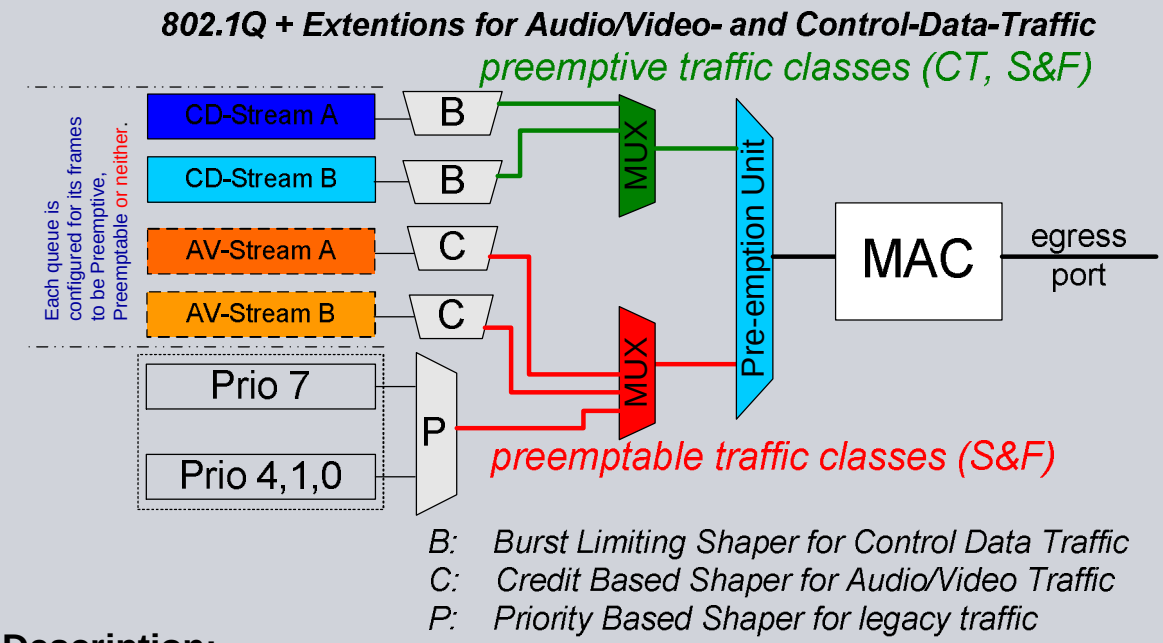
SIEMENS

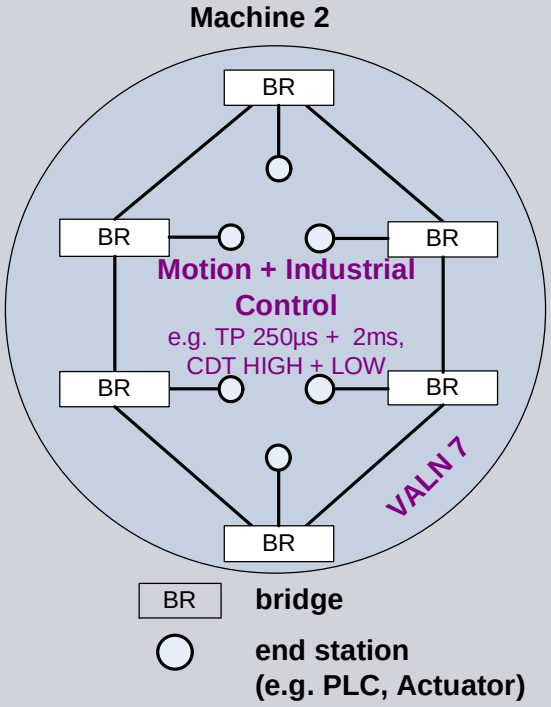
1. Terminology for Control Data Traffic (CD-Traffic)
2. Multiple Traffic Classes for Control Data Traffic
3. Impact of CD-Class B on Class A
4. Bandwidth Metering Methods for Control Data Traffic

Impact of a CD Traffic Class B on Latency for CD Traffic Class A

SIEMENS

Example which supports two CDT Classes with one pre-emption unit





Description:

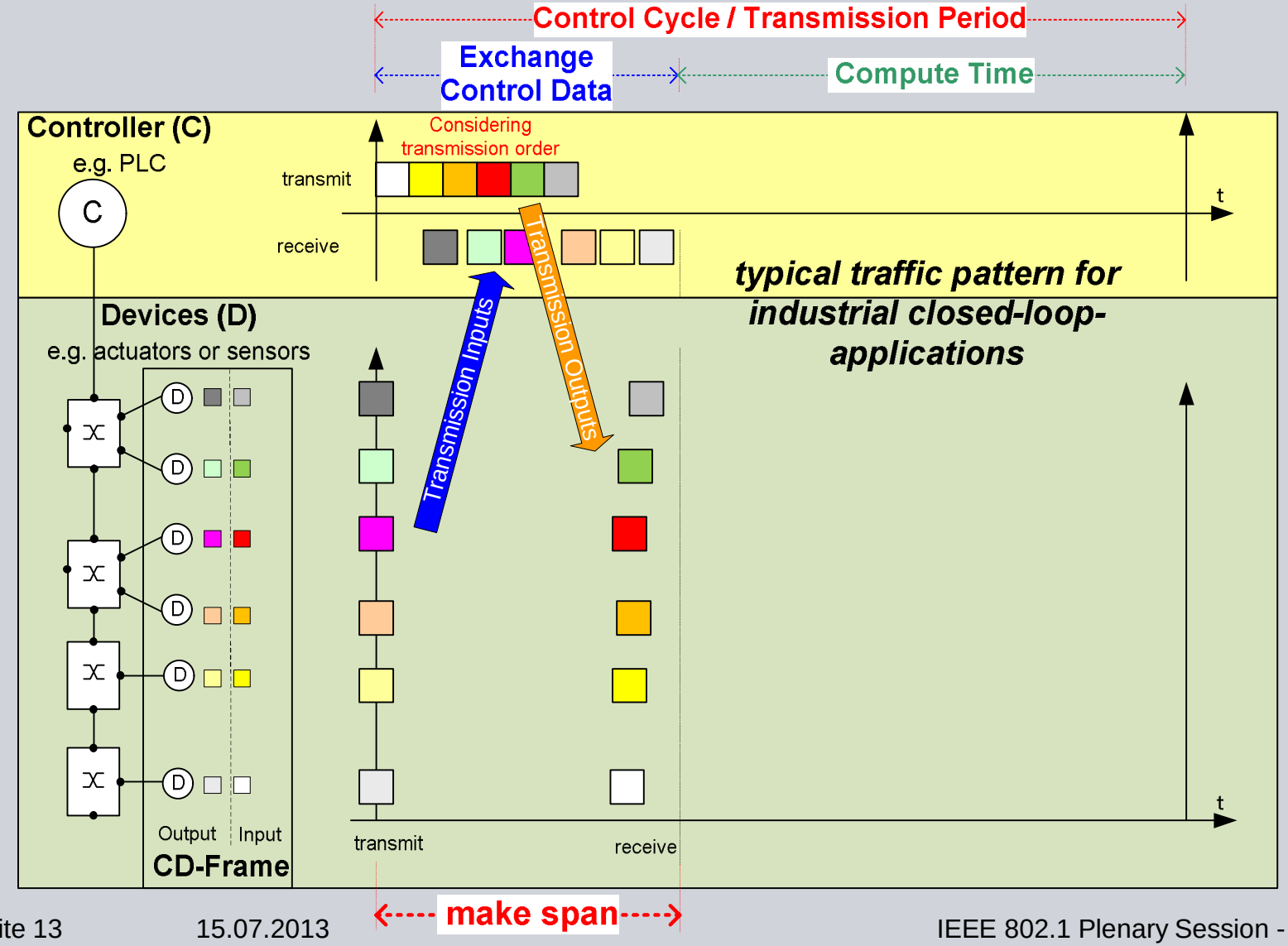
- **CD-Stream Class A has highest priority**
- **CD-Stream Class B can not preempted by CD-Stream Class A**
- **CD-Stream Class A and B have restricted frame size (e.g. 105 Bytes)**
- **When CD-Stream Class A & B exists CD-Stream Class A can be delayed per hope by max. frame size of CD-Stream Class B or by max. fragment size of legacy traffic**
- **CD-Stream Class A & B can preempt AV-Stream Class A&B and legacy traffic**

Structure of this Presentation

SIEMENS

1. Terminology for Control Data Traffic (CD-Traffic)
2. Multiple Traffic Classes for Control Data Traffic
3. Impact of CD-Class B on Class A
4. **Bandwidth Metering Methods for Control Data Traffic**

Recap: Typical Pattern for Control Data Traffic



SIEMENS

Requirements for Control Data Traffic (CDT)

Assumptions for Control Data Traffic:

- Talker are transmitting periodically
- Typically latency << transmission period
  - Listener receive Control Data Traffic within the transmission period -

Requirements for CDT:

- Guarantee bandwidth and resources (shortest path & bandwidth reservation is required) in bridges
- Guarantee low latency
  - Protect network against end stations (talker) which are transmitting more CD-Traffic as reserved
  - Shaper shall not add additional latency
  - Recognize bandwidth overload within a transmission period – comparable TAS
    - Bandwidth overload within one TP should not have impact in next TP
    - Precise and fast recognition of overload situations
  - Guarantee bandwidth, resources and latency for other traffic classes
  - Diagnostic information

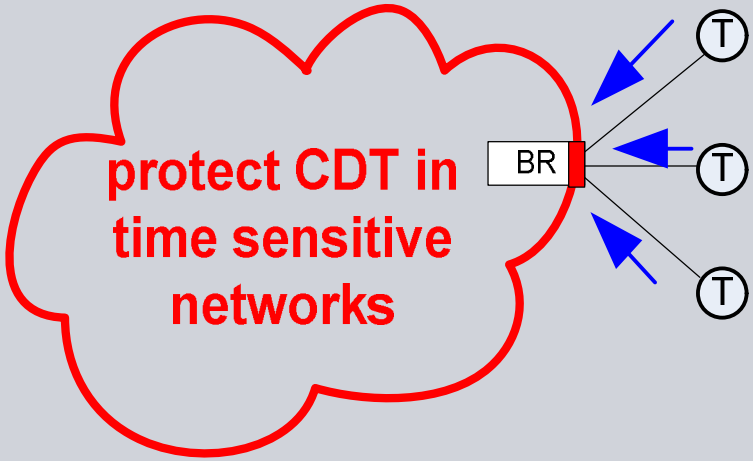
=> For Control Data Traffic guarantee for low latency is required

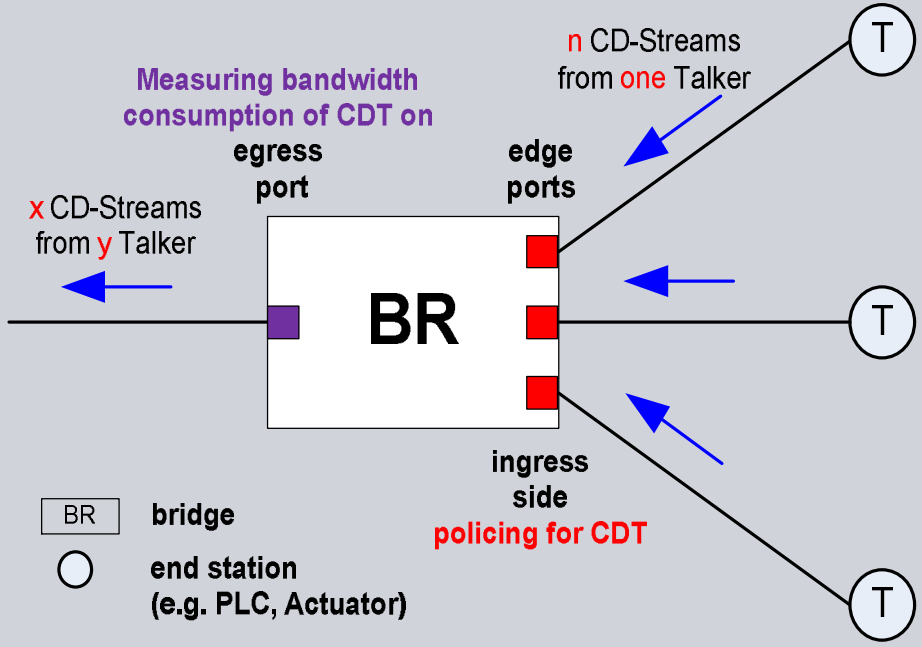
Where to do Bandwidth Metering to get a Robust Control Data Traffic Class?

SIEMENS

How to guarantee low latency for Control Data Traffic?

- **Policing (bandwidth metering) on the edge port – Talker**
  - To protect the Control Data Class within an time sensitive network against overload
  - Protect switching resources in network components
  - To locate misbehave talker -> Get better diagnostic information by locating misbehave Talker on edge port
- **Bandwidth metering on egress port – Traffic Class**
  - Detection of overload situations
  - Flush Queue / discard Frames
  - Diagnostic





Policing for Control Data Traffic on the edge port

Assumption:

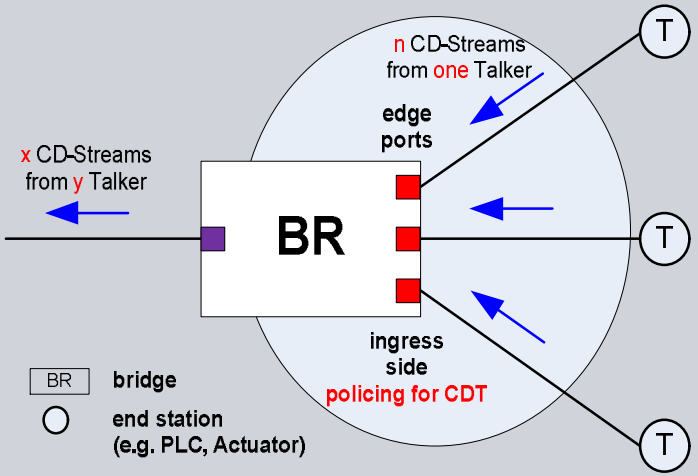
- **Fix transmission period**

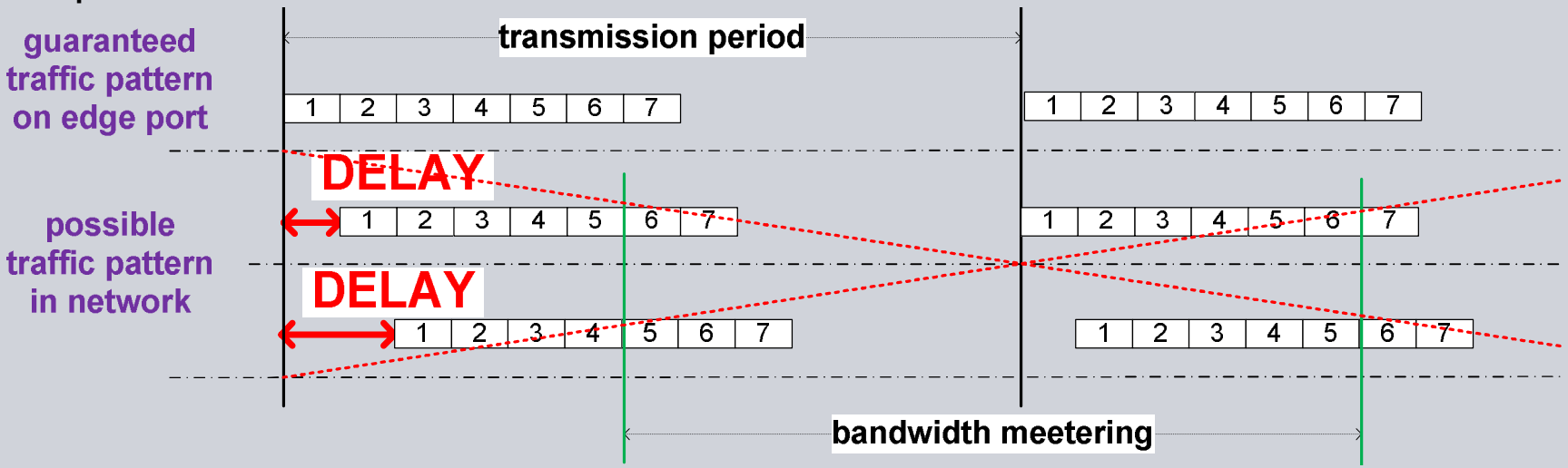
Advantage:

- **Bandwidth metering is much more accurate (deterministic, no jitter)**

Solution:

- **Policing bandwidth on edge port**
  (An important building block to guarantee low latency)
  - **per Class?**
  - **per Stream?**





Overload Detection for Control Data Traffic on the egress port

SIEMENS

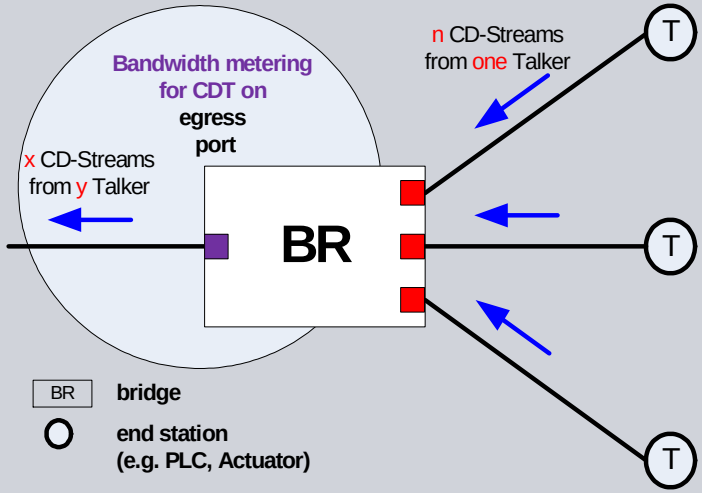
To guarantee low latency for Control Data Traffic different mechanism on the egress port of a bridge are required:

- **Detect overload situations for Control Data Traffic**
- **Flush Control Data transmission queue / discard CD-Frames**
- **Diagnostic information**

  Counter for overload situations

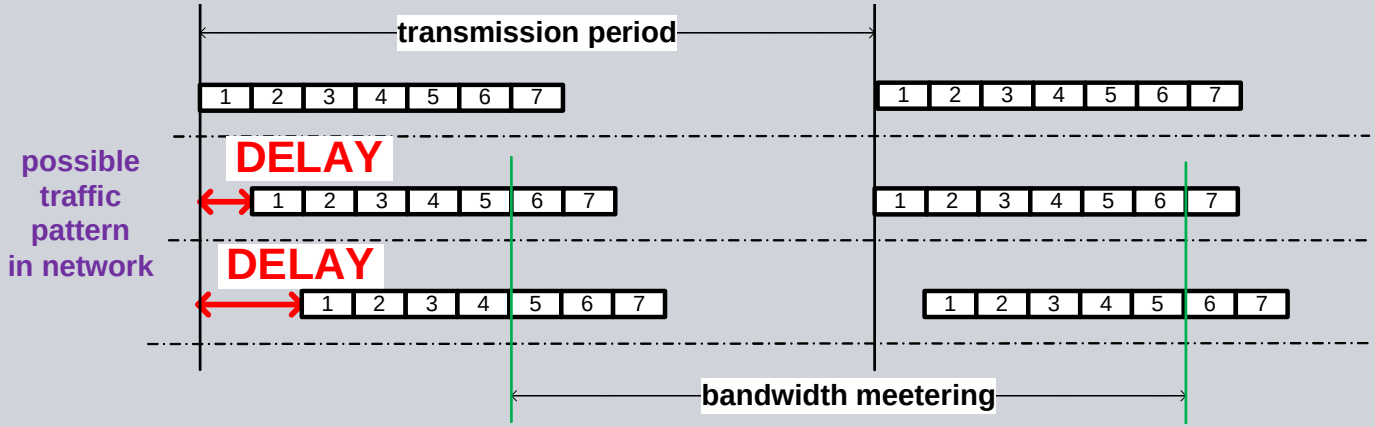
  Counter for dropped CD-Frames in overload situations

  Counter for dropped CD-Frames



Without mechanism like "always wait for t MaxPreemption" combined with scheduling, which avoid reordering and queuing in bridges for Control Data Traffic transmission delay can jitter!!

(see http://www.ieee802.org/1/files/public/docs2013/new-tsn-specht-talker-scheduled-traffic-support-20130318.pdf)



Methods to measure bandwidth consumption of Control Data Traffic

SIEMENS

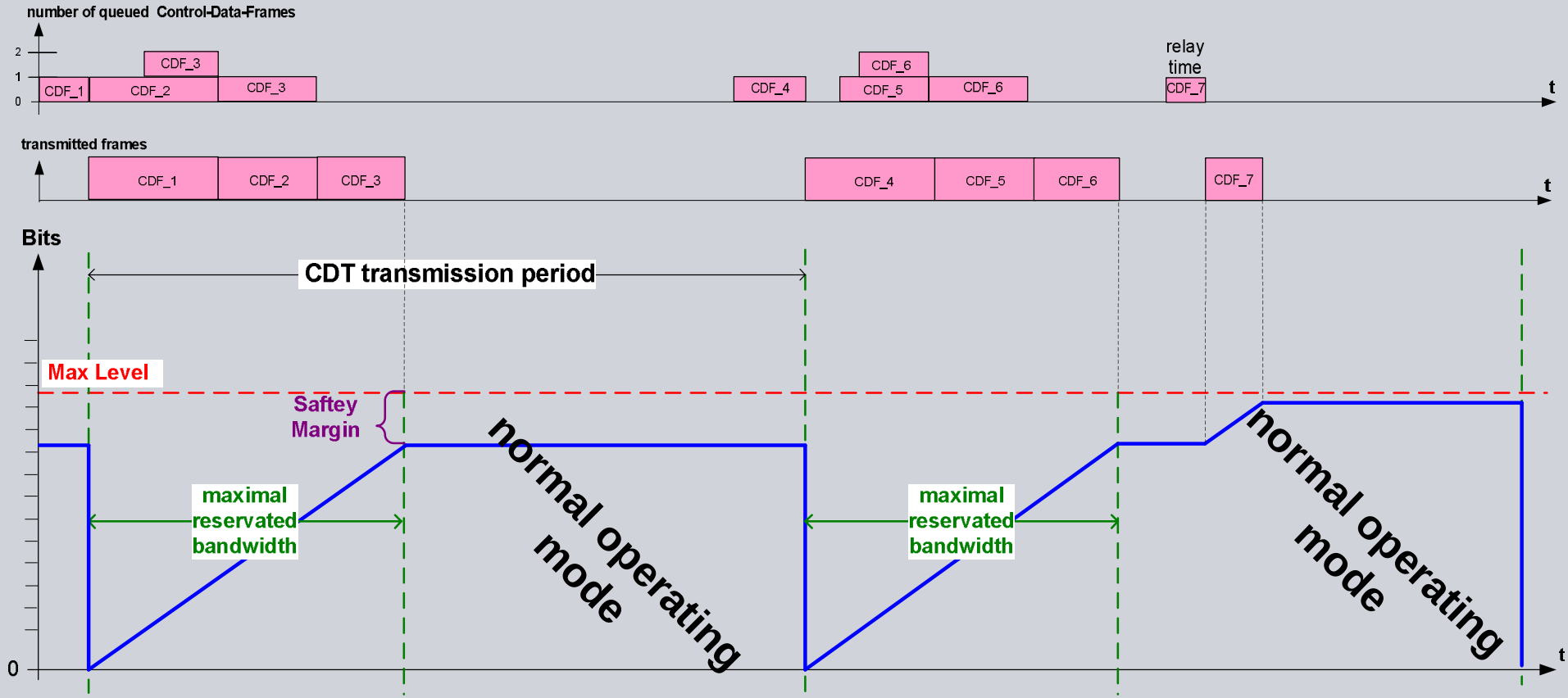
Which is the right method to measure bandwidth consumption of Control Data Traffic?

- Bandwidth metering?
- Flush Control Data Queue or drop Control Data Frames?

Proposal (1): Bandwidth Metering for CDT with one Synchronized Sampling Window

SIEMENS

Normal operating mode

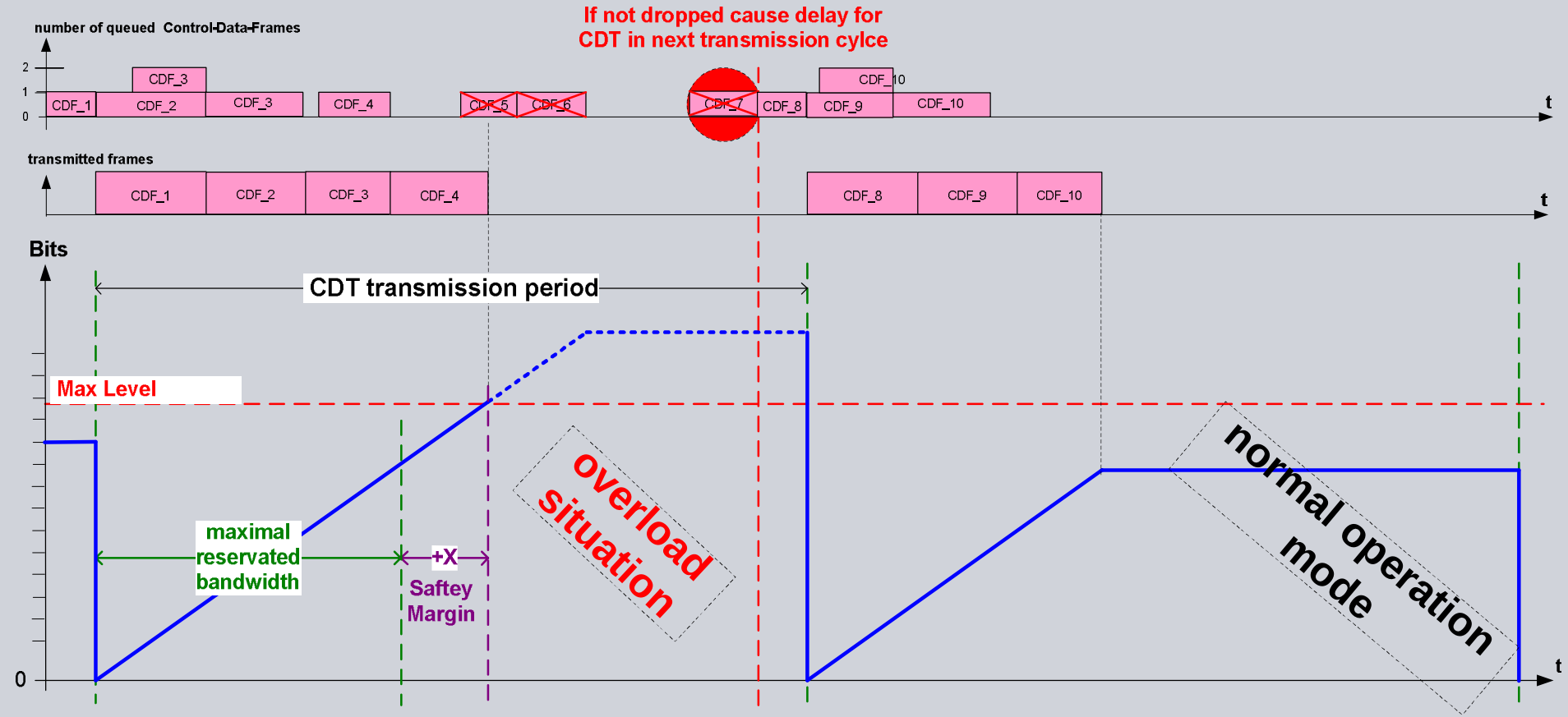


Proposal (1): Bandwidth Metering for CDT with one Synchronized Sampling Window

SIEMENS

Detection of overload situation

-> drop CD-Frames to avoid impact on next transmission period

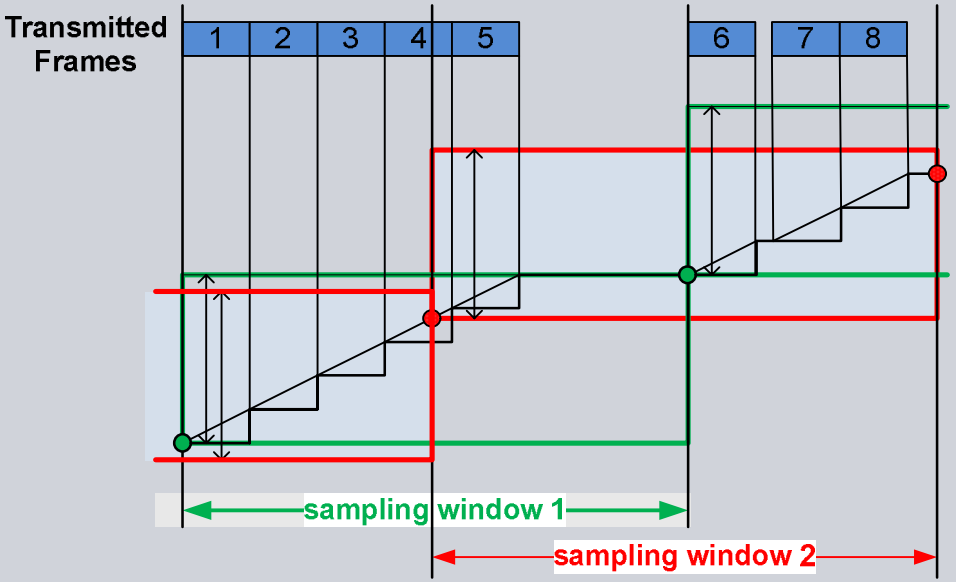


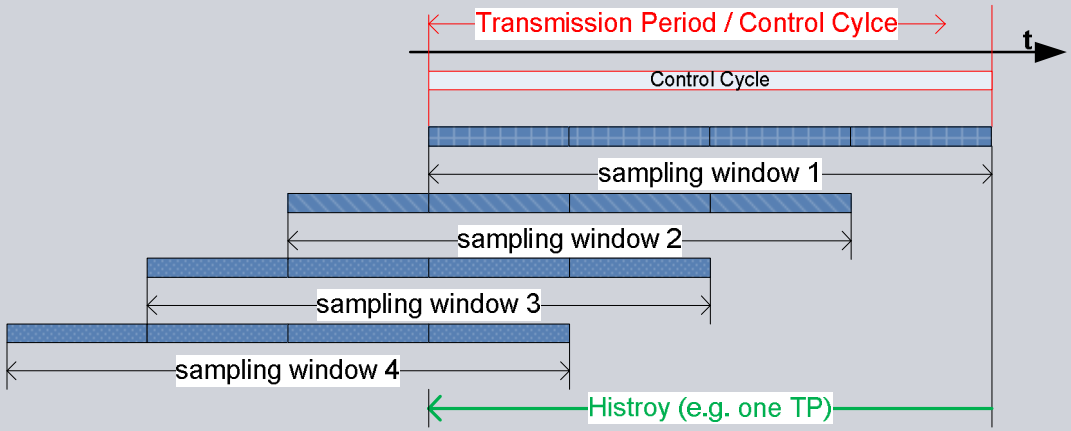
Proposal (2): Bandwidth Metering for CDT with multiple not synchronized Sampling Window

SIEMENS

Idea:

- Multiple overlapping sampling window (2 – n) to measure bandwidth consumption for Contorl Data Traffic
- Sampling window has buffered history of Control Data traffic load over 1 or multiple transmission periods

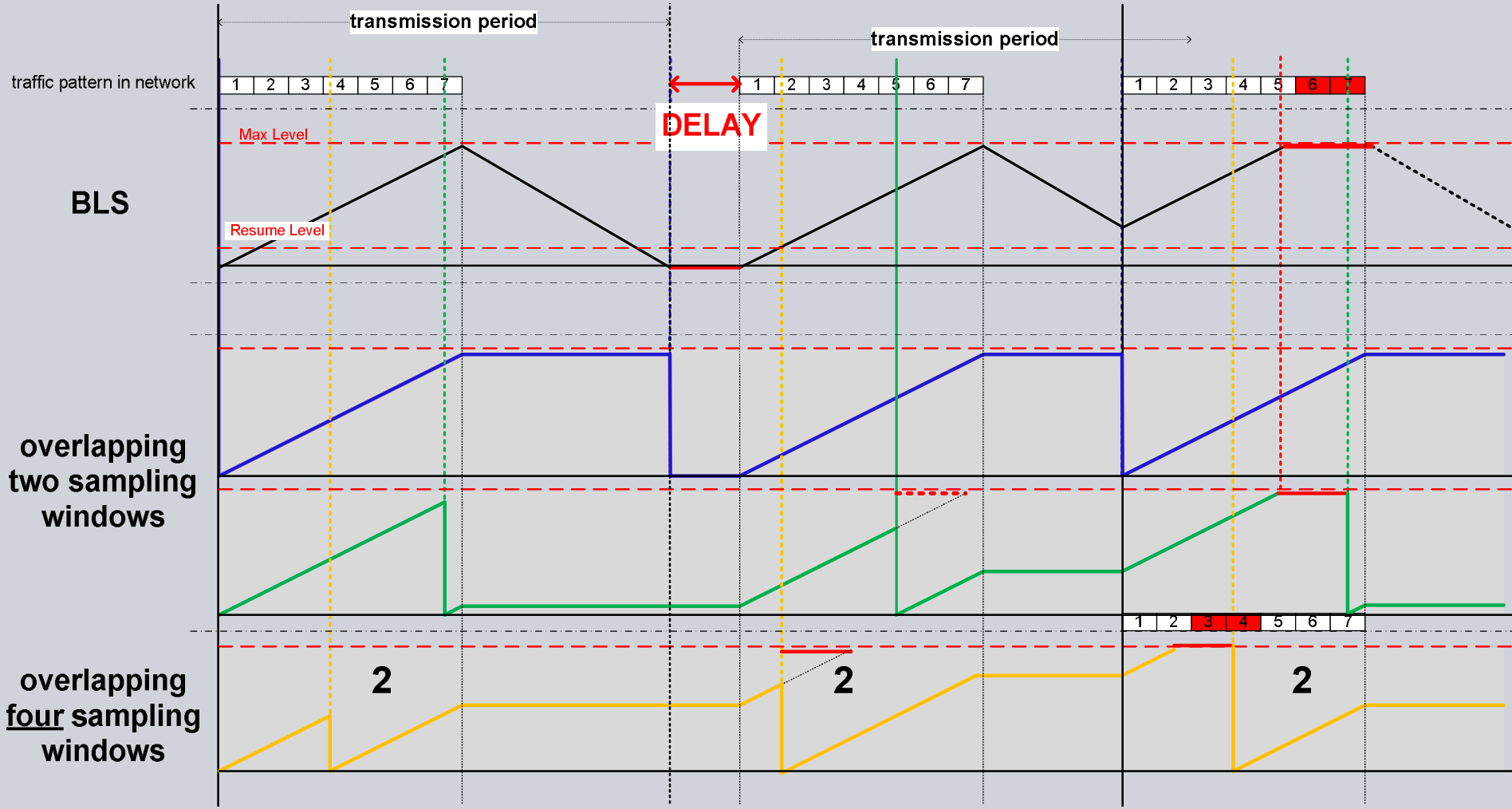




Proposal (2): Bandwidth Metering for CDT with multiple not synchronized Sampling Window

SIEMENS

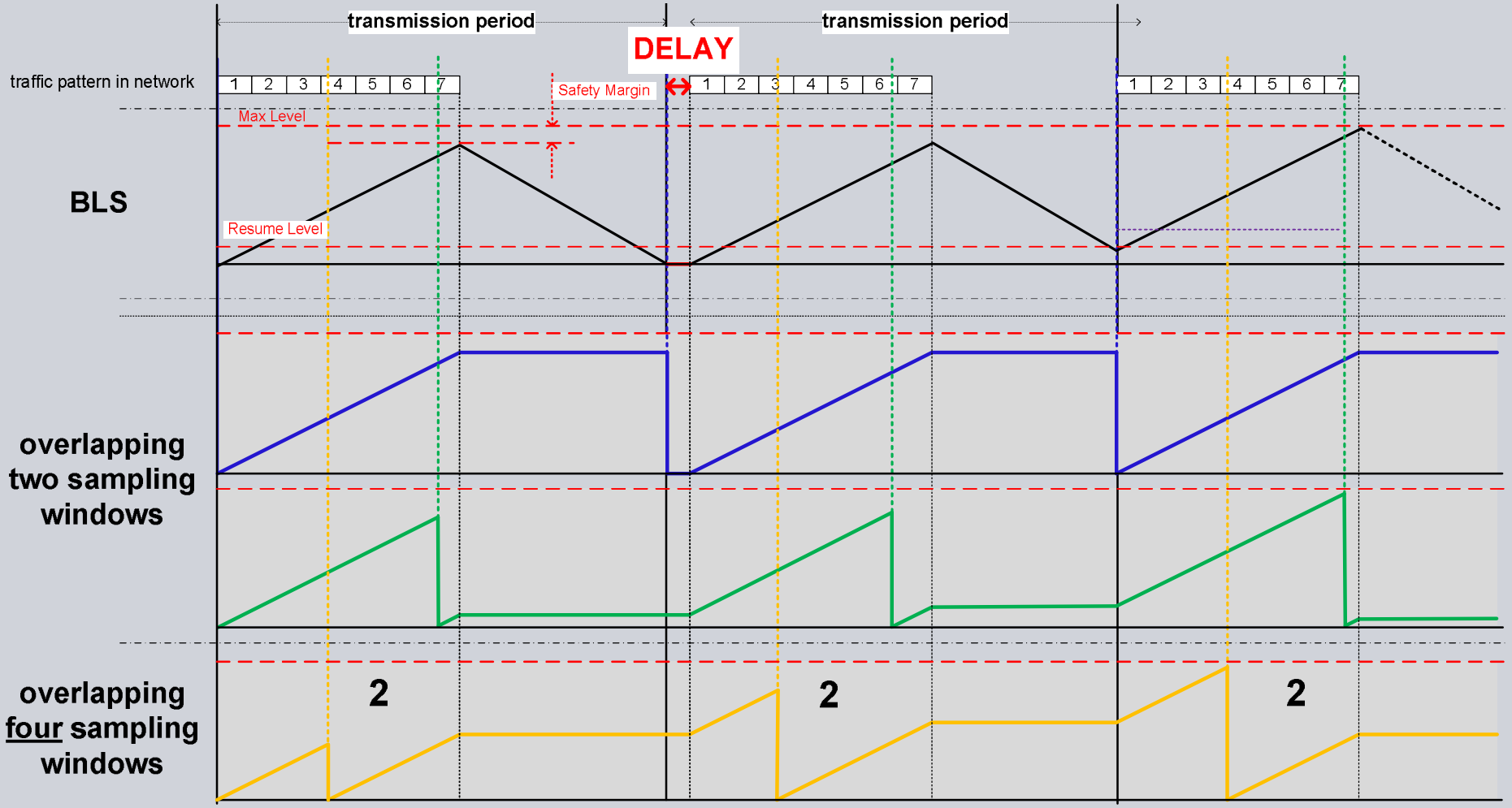
Without Safety Margin



Proposal (2): Bandwidth Metering for CDT with multiple not synchronized Sampling Window

SIEMENS

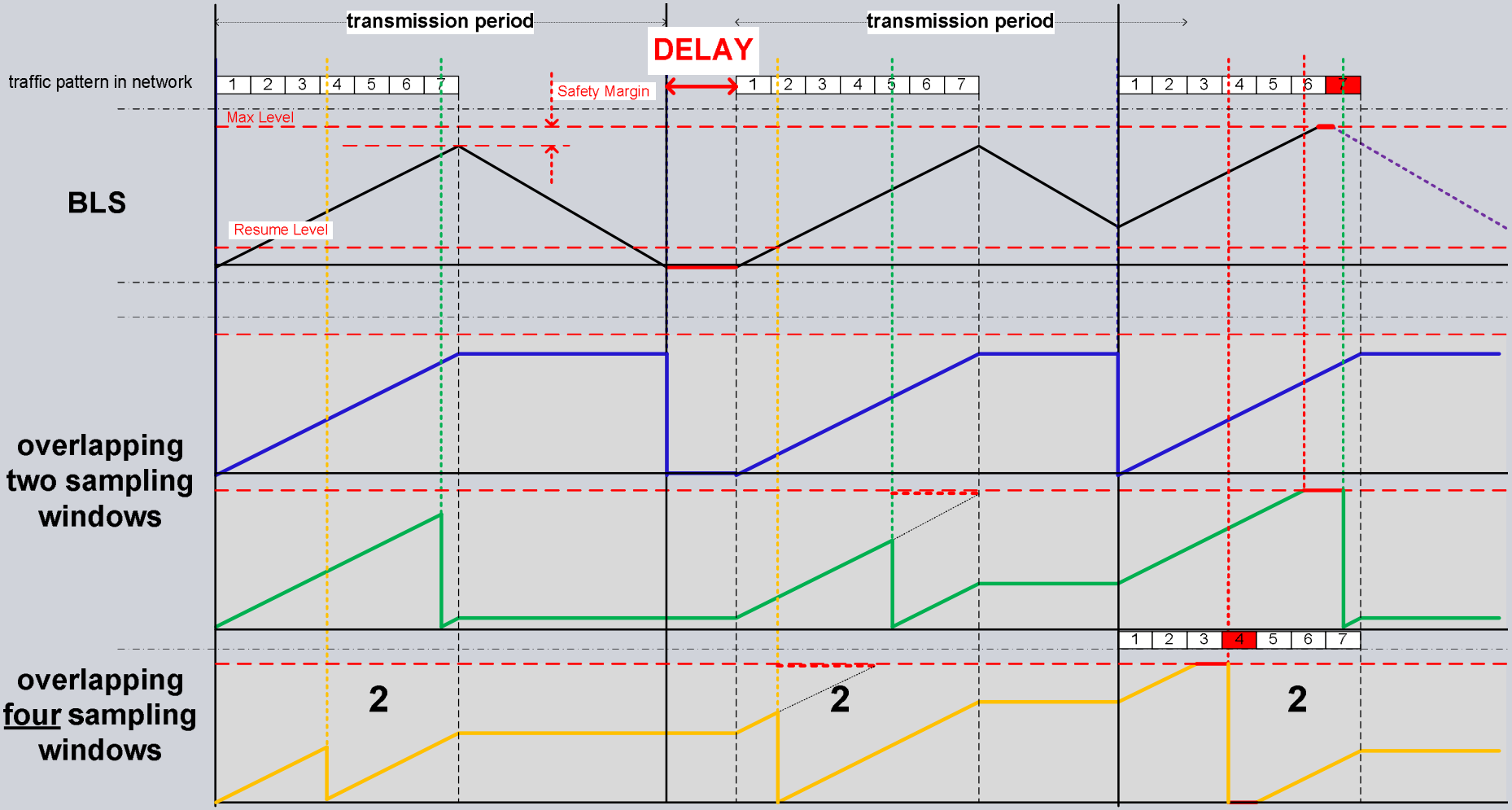
With Safety Margin & delay for CD-Frames is in range



Proposal (2): Bandwidth Metering for CDT with multiple not synchronized Sampling Window

SIEMENS

With Safety Margin & delay for CD-Frames is out of range

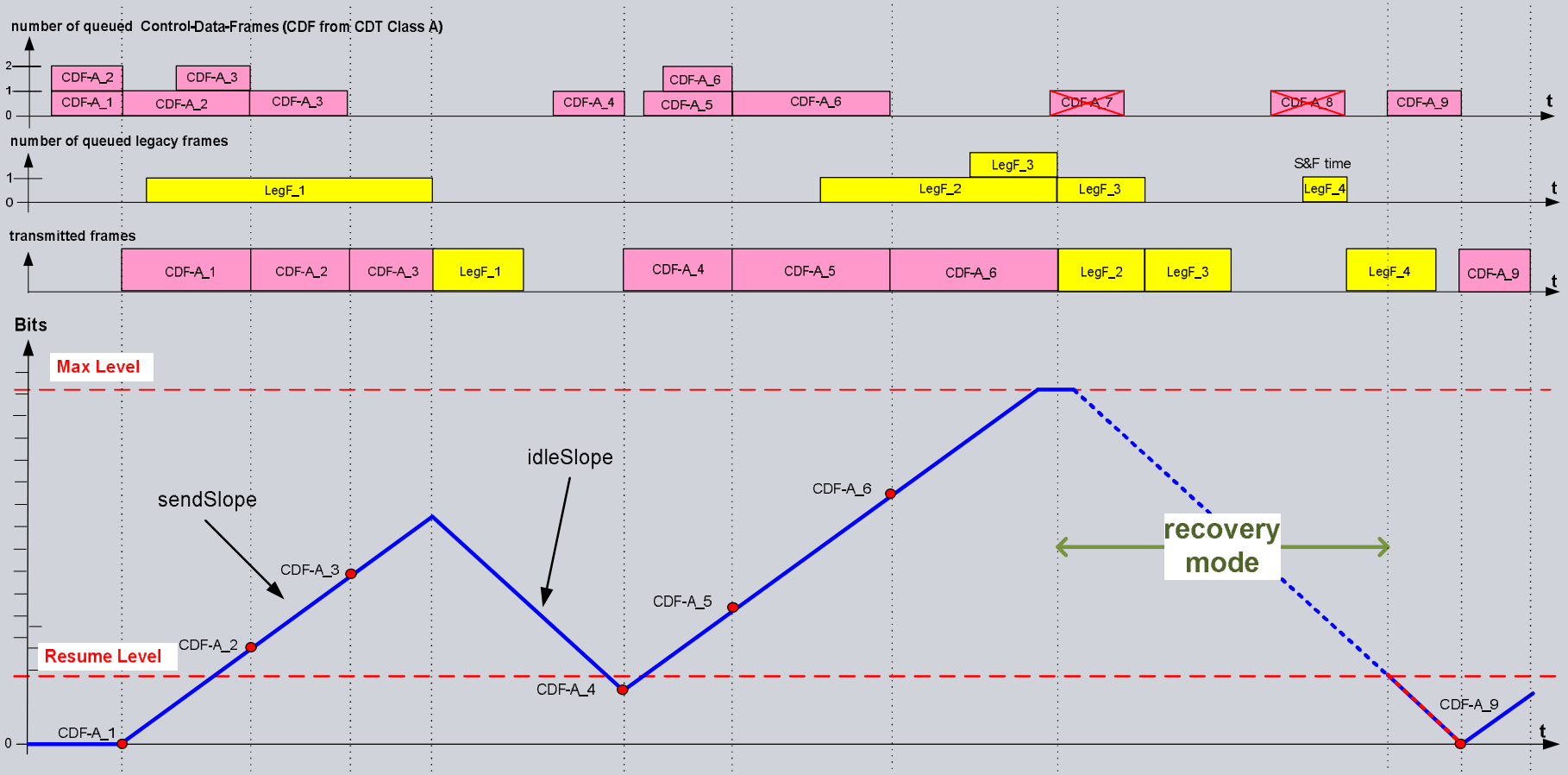


Proposal (3): Bandwidth Metering for CDT with Burst Limiting Shaper (BLS)

SIEMENS

- When received CD-Frames & CD transmission queue is not in recovery mode
  –> CD transmission queue has highest priority to guarantee low latency for CDT

- Guarantee and limit bandwidth and resources
- Allow bursts but also limit to max burst size
- During recovery discard CDT-Frames & flush queue

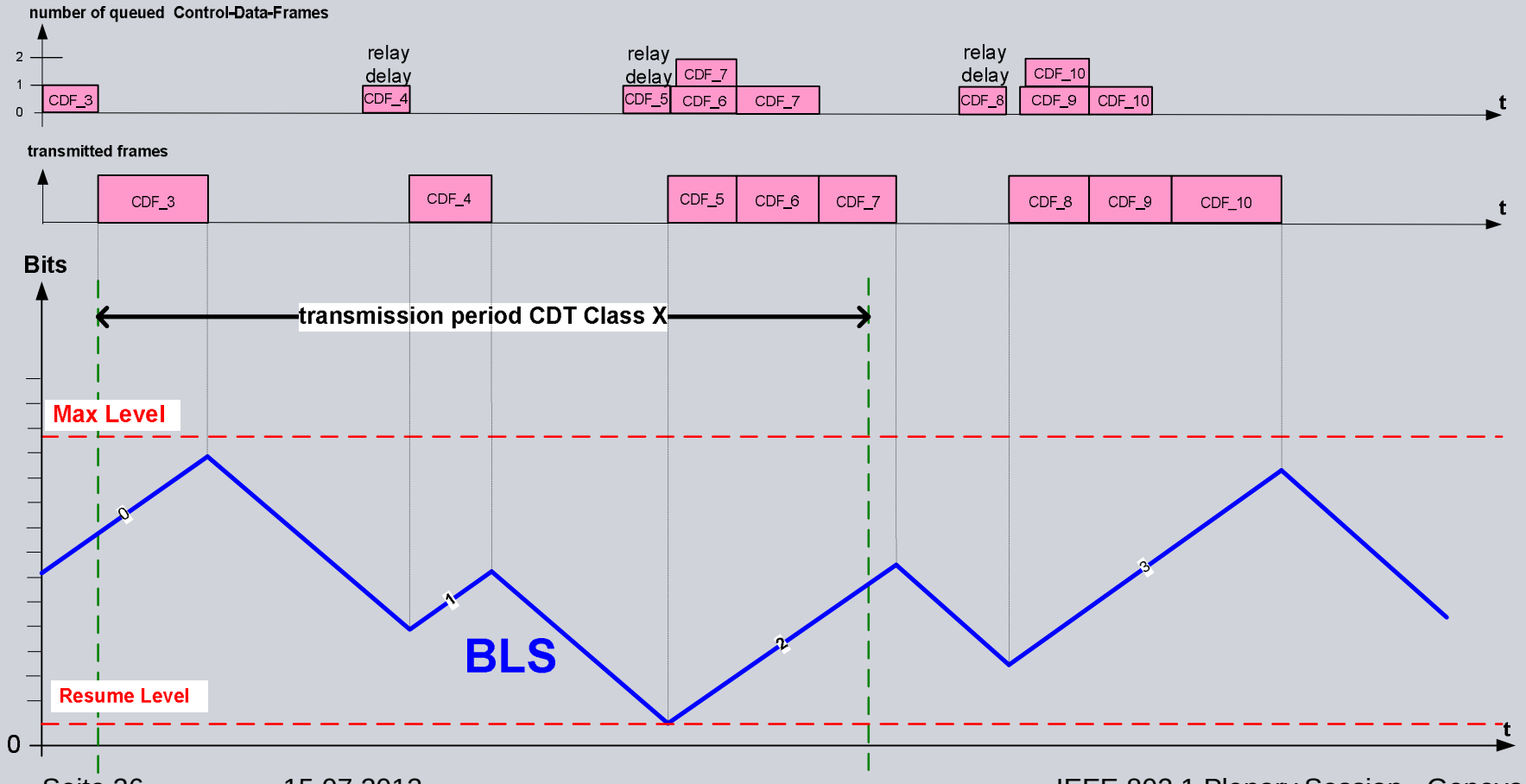


Proposal (3): Bandwidth Metering for CDT with Burst Limiting Shaper (BLS)

SIEMENS

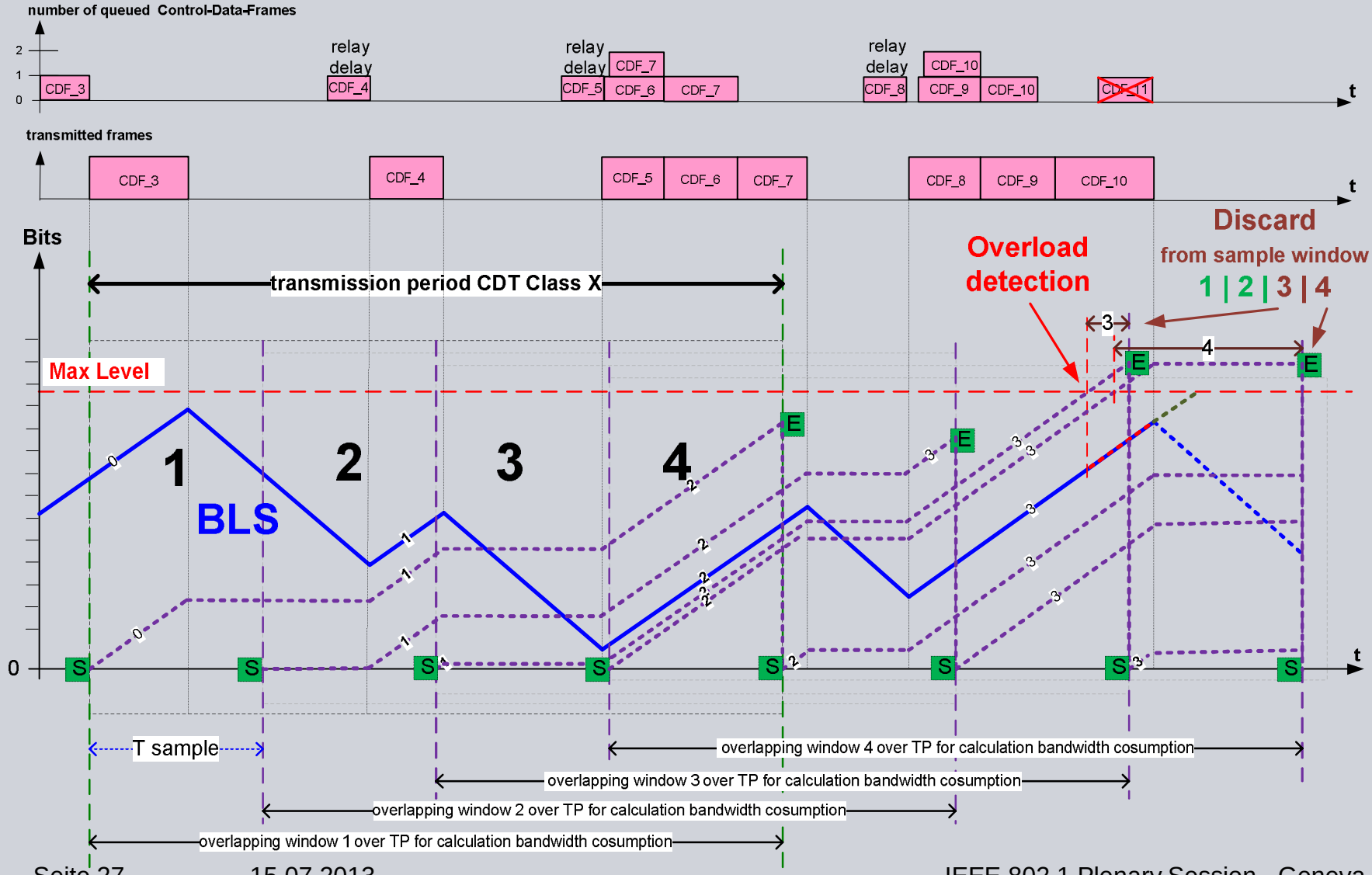
Open questions:

- Is the detection of overload situations from BLS good enough for Control Data Traffic?
- How to set the Resume Level of the Burst Limiting Shaper?



Proposal (3): Bandwidth Metering for CDT with Burst Limiting Shaper (BLS)

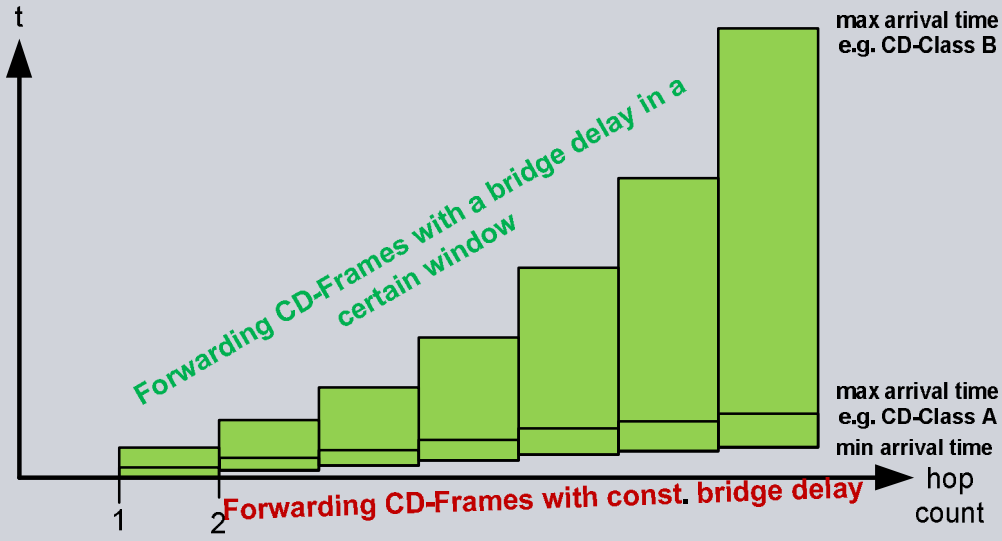
SIEMENS



How to calculate the Safety Margin?

SIEMENS

To calculate the Safety Margin to detect very precise overload situations for CDT the following attributes shall be considered:



Min and max arrival time for CD-Streams

- **Control Data Class (A or B)**
- **Shaper** (TAS, …)
- **Pre-emption enabled (t MaxPreemption)**
- **Always wait for t MaxPreemption**
- **Transmission mode for CDT**
  - *Event based & rate constrained*
  - *Synchronized (bust)*
  - *Synchronized and scheduled*
- **Max bandwidth for Control Data Class**
- **Guaranteed or changing transmission order**
  - ***Topology*** *(daisy chain, star, …)*
  - ***Scheduling***
  - *other mechanism*
- **Link Speed**
  (different link speed on the path)
- …

SIEMENS

THANK YOU for your attention!

Questions?