Class A
Latency Issues

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Latency Calculations

- The latency calculations in this presentation are last bit in – last bit out

- The MAC delays are not taken into account

- The switching delays are not taken into account

- The mentioned number of bytes are incl. preamble and IFG

- The numbers in the graphics are µs

- @FE 7.2µs (90 bytes), 123.36µs (1542 bytes), 86.4µs (1080 bytes)

- @GE 7.2µs (900 bytes), 12.36µs (1542 bytes)
Fast Ethernet
Class A Latency
Primary Effects
Primary Effect 1: Store-and-Forward Delay
Store-and-Forward Delay
Primary Effect 2: Interfering Class A Streams and Shaper
Interfering Class A Streams and Shaper
Possible Solutions

• Interfering Class A Streams:
  – Time slots
  – Limit max. used Class A bandwidth (<75%)

• Shaper:
  – Time slots
  – Changes to CBS (allow burst)

see Franz Goetz “AVB + Extensions for Industrial Communication”, Kauai 2011
Primary Effect 3: Interfering Legacy Frame
Interfering Legacy Frame + Interfering Class A Streams
(= Late Interfering Frame)
Possible Solutions

- Fragmentize interfering non class A traffic
- Reduce MTU
- Time slots (separate slots for streams and legacy traffic)

see Franz Goetz “AVB + Extensions for Industrial Communication”, Kauai 2011
Secondary Effects
Secondary Effect 1: Burst
Bursting Talker

ingress: 7.20

credit

egress:

Interfering Legacy Frame 0/0 0/1 0/2

130.56
12.76
7.20
119.44
7.20

Bridge with Bursting Ingress

credit

122.58

240.38

12/0 11/0 10/0 9/0 8/0 7/0 6/0 5/0 4/0 3/0 2/0 1/0 0/0

240.38

12/1 11/1 10/1 9/1 8/1 7/1 6/1 5/1 4/1 3/1 2/1 1/1 0/1

240.38

12/2 11/2 10/2 9/2 8/2 7/2 6/2 5/2 4/2 3/2 2/2 1/2 0/2

240.38

12/3 11/3 10/3 9/3 8/3 7/3 6/3 5/3 4/3 3/3 2/3 1/3 0/3

240.38

Bursting Ingress with Interfering Frame
Secondary Effect 2: Growing Burst
Example 1: Interfering Frame + More Bandwidth Allocated than Used (1)
Example 1: Interfering Frame + More Bandwidth Allocated than Used (2)
Example 2: Interfering Frame + Changing Position
Example 3: Interfering Frame + Not Equally Spaced Frames (1)
Example 3: Interfering Frame + Not Equally Spaced Frames (2)
Example 3: Interfering Frame + Not Equally Spaced Frames (3)
Secondary Effect 3: Constant Higher Latency
Egress with Equally Spaced Ingress
Egress with Bursting Ingress

constant higher latency after burst
Egress with Bursting Ingress and Interfering Frame
Egress with Bursting Ingress and Interfering Frame

constant latency
Egress with Bursting Ingress and Interfering Frame

increase of latency due to an interfering frame

Interfering Legacy Frame 0

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Egress with Bursting Ingress and Interfering Frame

again constant higher latency

300.94
269.54
240.38
240.38

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Conclusions

- A burst causes a permanent higher latency.

- This higher latency is only reduced in the case of an “over allocation” of bandwidth (e.g. stream allocated but not used, slightly more bandwidth allocated than used, …)

- The latency is reduced in the short period before the next burst but reaches the higher value again after the burst.
Secondary Effect 4: Quasi-Burst
Bursting Talker

-ingress:

-egress:

-credit:

-Interfering Legacy Frame 0
Equally Spaced Frames after Burst
Not Equally Spaced Frames after Burst

How much latency can this effect add?

latency increase

122.58
240.38
245.94
245.94

119.44
Talker with two Streams (90, 1080 bytes)
Talker with two Streams (90, 1080 bytes) (1)
Talker with two Streams (90, 1080 bytes) (2)
Talker with two Streams (90, 1080 bytes) (3)
The two ingress streams are both from the same talker.
Bridge after this talker (1)

The two ingress streams are both from the same talker
Bridge after this talker (2)

The two ingress streams are both from the same talker
The two ingress streams are both from the same talker
The two ingress streams are both from the same talker

Bridge after this talker (4)

increase of latency due to an interfering legacy frame
Bridge after this talker (5)

The two ingress streams are both from the same talker

after this there is also a permanent increase of latency in the next bridge
Bridge with 13 Quasi-Bursting Talkers
Bridge with 13 Quasi-Bursting Talkers (1)
Bridge with 13 Quasi-Bursting Talkers (2)
Bridge with 13 Quasi-Bursting Talkers (3)
Secondary Effect 5: Combined Burst and Quasi-Burst
Combined Burst and Quasi-Burst - Talker
Combined Burst and Quasi-Burst – Talker (1)
Combined Burst and Quasi-Burst – Talker (2)
Combined Burst and Quasi-Burst - Bridge
Combined Burst and Quasi-Burst – Bridge (1)
Combined Burst and Quasi-Burst – Bridge (2)
Combined Burst and Quasi-Burst – Bridge (3)
Combined Burst and Quasi-Burst – Bridge (4)

constant higher latency
Simple Fast Ethernet Example
Example

- 90 byte class A stream from T1 to L1 (active)
  - 7 hops
- 90 byte class A stream from T2 to L1 (active)
  - 2 hops
- 400 byte class A stream from T1 to L2 (allocated, but not (yet) used)
  - 7 hops
- Legacy frame is transmitted from T1 to L1 one clk cycle before the class A frame is ready to be transmitted
Example – Talker T1

Interfering Legacy Frame

130.56
12.76
119.44

7.20

credit
egress:

Talker T1
Example – Bridge 1
Example – Bridge 2

Ingress:
7.20

Credit

Egress:
Interfering Legacy Frame

123.36

123.36

123.36

123.36

9.48

122.72
Interfering Legacy Frame

Example – Bridge 3
Example – Bridge 4

ingress:

Interfering Legacy Frame

egress:
Example – Bridge 6

Example of Bridge 6 operation: credit ingress:

- Interfering Legacy Frame
- 0/1/0/1/1/1/2/1/3/1/4/1/5/1/6

ExampleBridge 6 Operation
Example - Results

Even in a network with a “simple” topology a burst can cause a high latency

Is this scenario realistic?

- What has to occur to create the burst?
  1. More bandwidth than used has to be allocated
     1. Stream allocated but not (yet) used
     2. Allocated bandwidth not completely used
  2. There has to be a big interfering legacy frame
     In the shown case the interfering legacy frame (in talker T1) is transmitted 1 clk cycle before the class A frame is ready to be transmitted (worst case)
     → Even if this dose not happen a max legacy frame would automatically create a growing burst in the next bridges

- What has to happen in bridge 6?
  1. The stream packet from talker T1 has to arrive after the burst
  2. There has to be a “late interfering frame”

What latency should be reported by a bridge?
Gigabit Ethernet
Class A Latency
Primary Effect 1: Store-and-Forward Delay
Store-and-Forward Delay
Primary Effect 2: Interfering Class A Streams and Shaper
Interfering Class A Streams and Shaper
Primary Effect 3: Interfering Legacy Frame
Interfering Legacy Frame + Interfering Class A Streams
(= Late Interfering Frame)
Secondary Effects
Secondary Effect 1: Burst
Bursting Talker
Bridge with Bursting Ingress
Bursting Ingress with Interfering Frame
Secondary Effect 2: Growing Burst
First Bridge after Talker
Second Bridge after Talker (1)
Second Bridge after Talker (2)

Delayed by 12.36μs (max. legacy frame)!
Conclusions

- Bursts and growing bursts are possible in GE but it is more unlikely that they happen compared to FE

- The consequences are the same as in FE

- It is also possible to create a short quasi-burst and even the combination of a burst and a quasi-burst
Thank You