

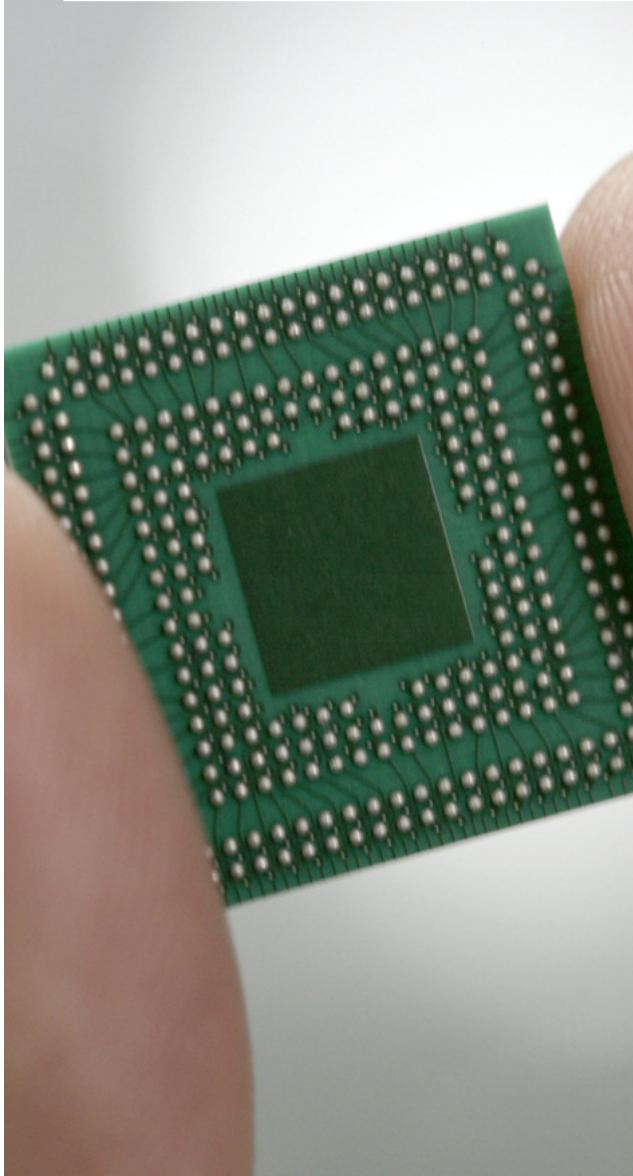
Alternative Shaper for Scheduled Traffic in Time Sensitive Networks

2013-01-15

IEEE 802.1 TSN TG Meeting - Vancouver

Franz-Josef Götz, Siemens AG

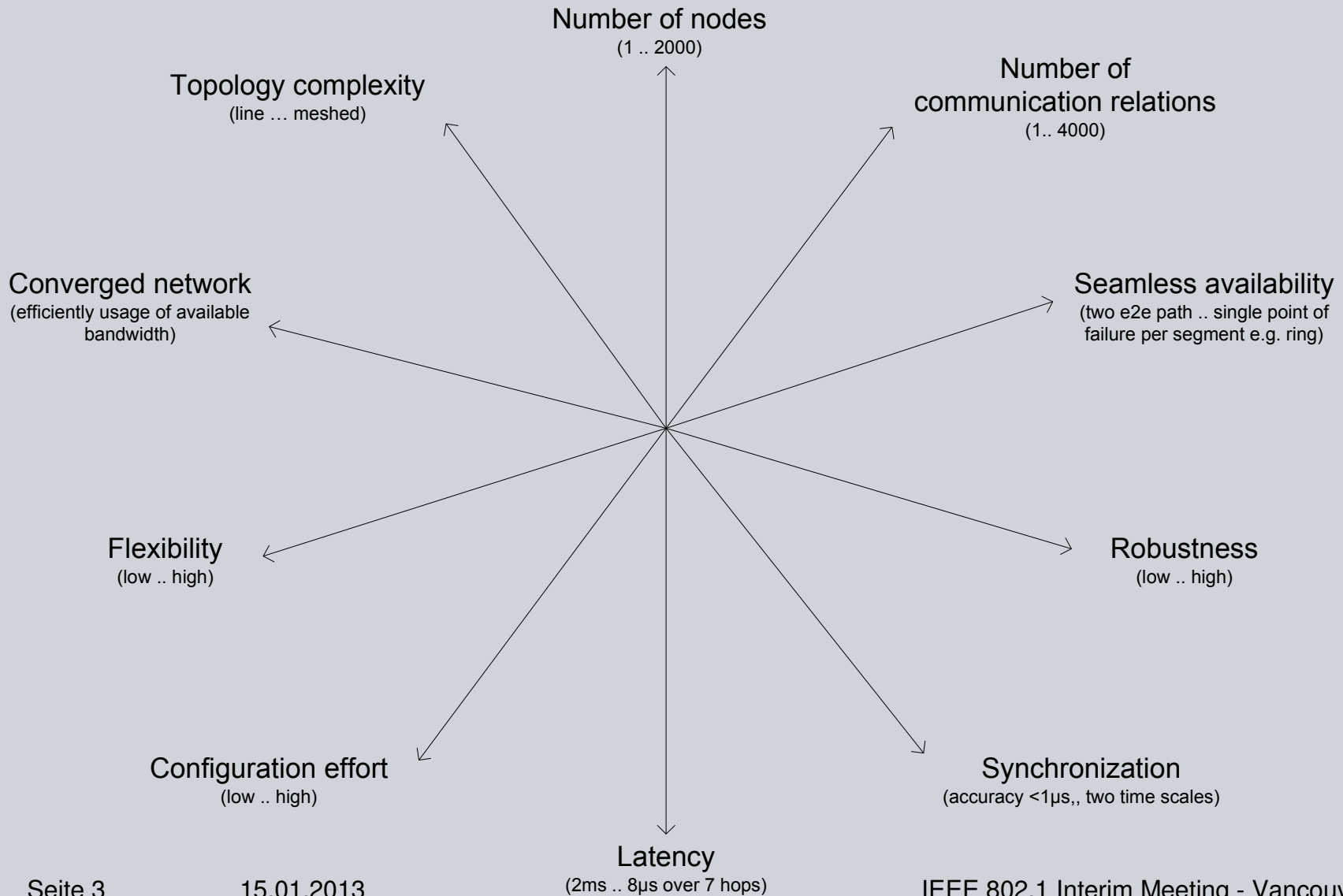
franz-josef.goetz@siemens.com



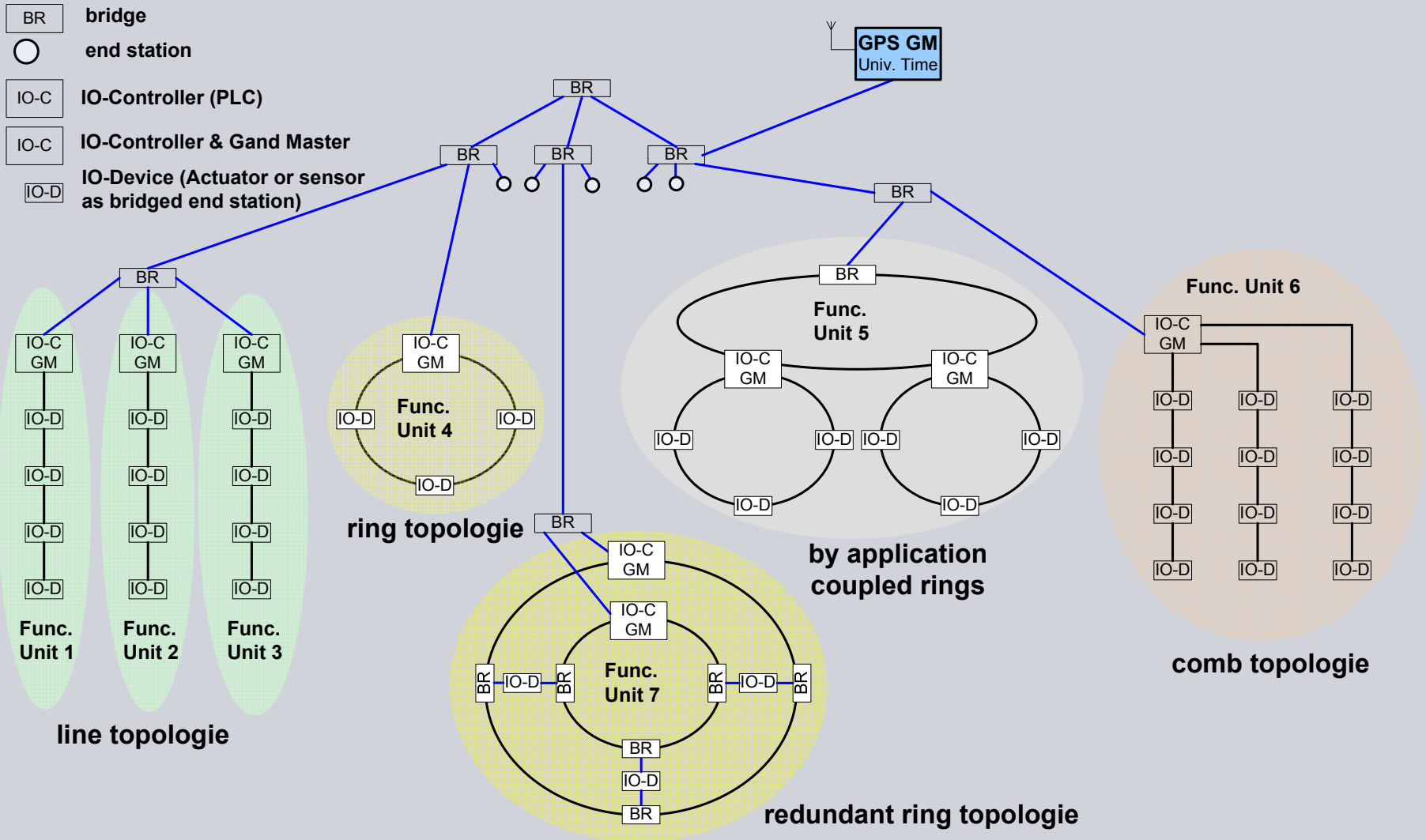
Structure of this Presentation

1. Feature Diagram for Time Sensitive Networks (TSN) @ Industrial
2. Traffic Shapers to support Low Latency for Scheduled Traffic (ST)
3. Simulation Results (one Use Case)
Time aware Shaper (TAS) <-> Burst limiting Shaper (BLS)
 - a) Low Latency for Scheduled Traffic with **constant** Frame Size
 - b) Low Latency for Scheduled Traffic with **random** Frame Size
 - c) Low Latency for Scheduled Traffic with **random** Frame Size **and optimized Window Size for TAS**

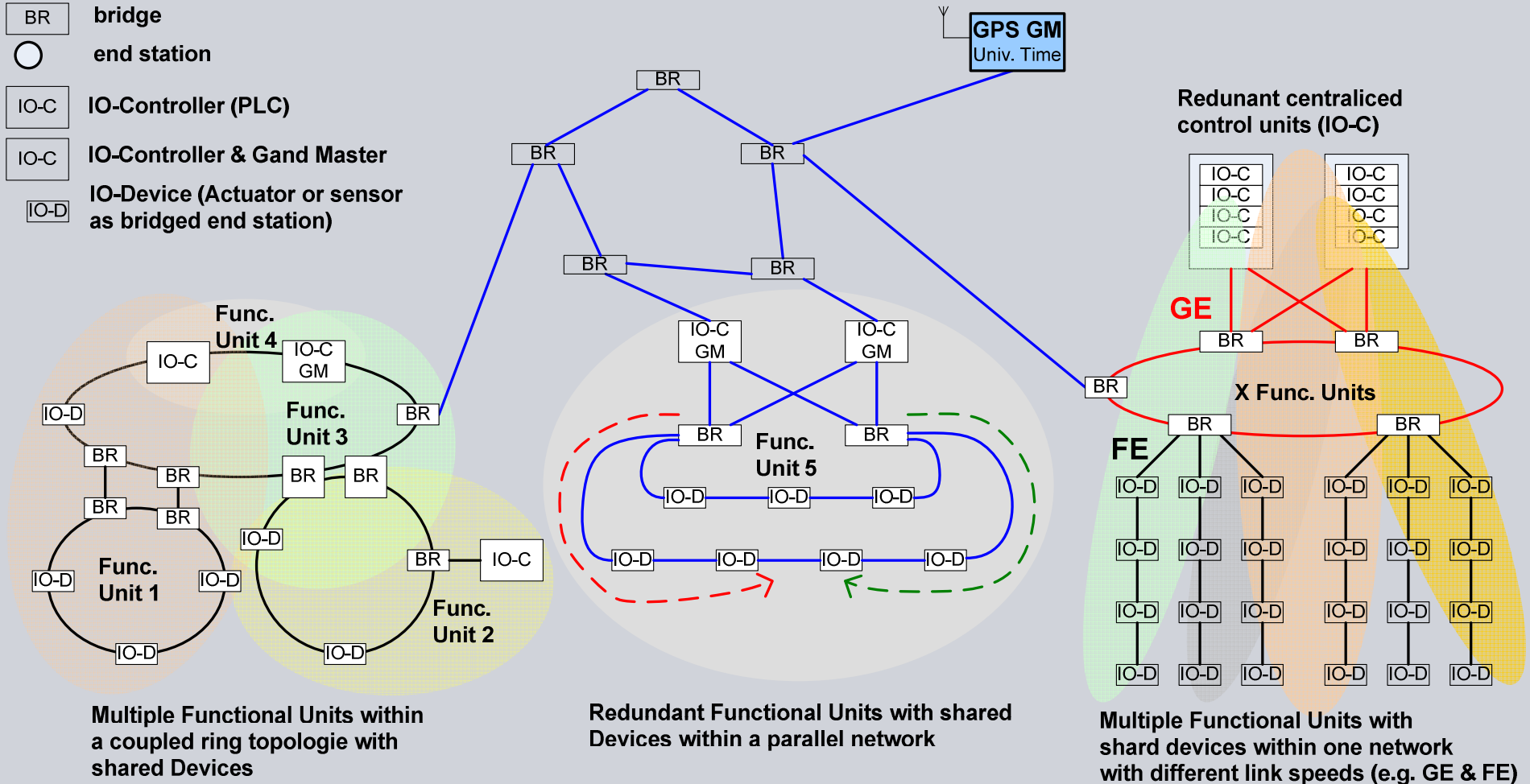
Feature Diagram for Time Sensitive Networks (TSN) @ Industrial - Consideration



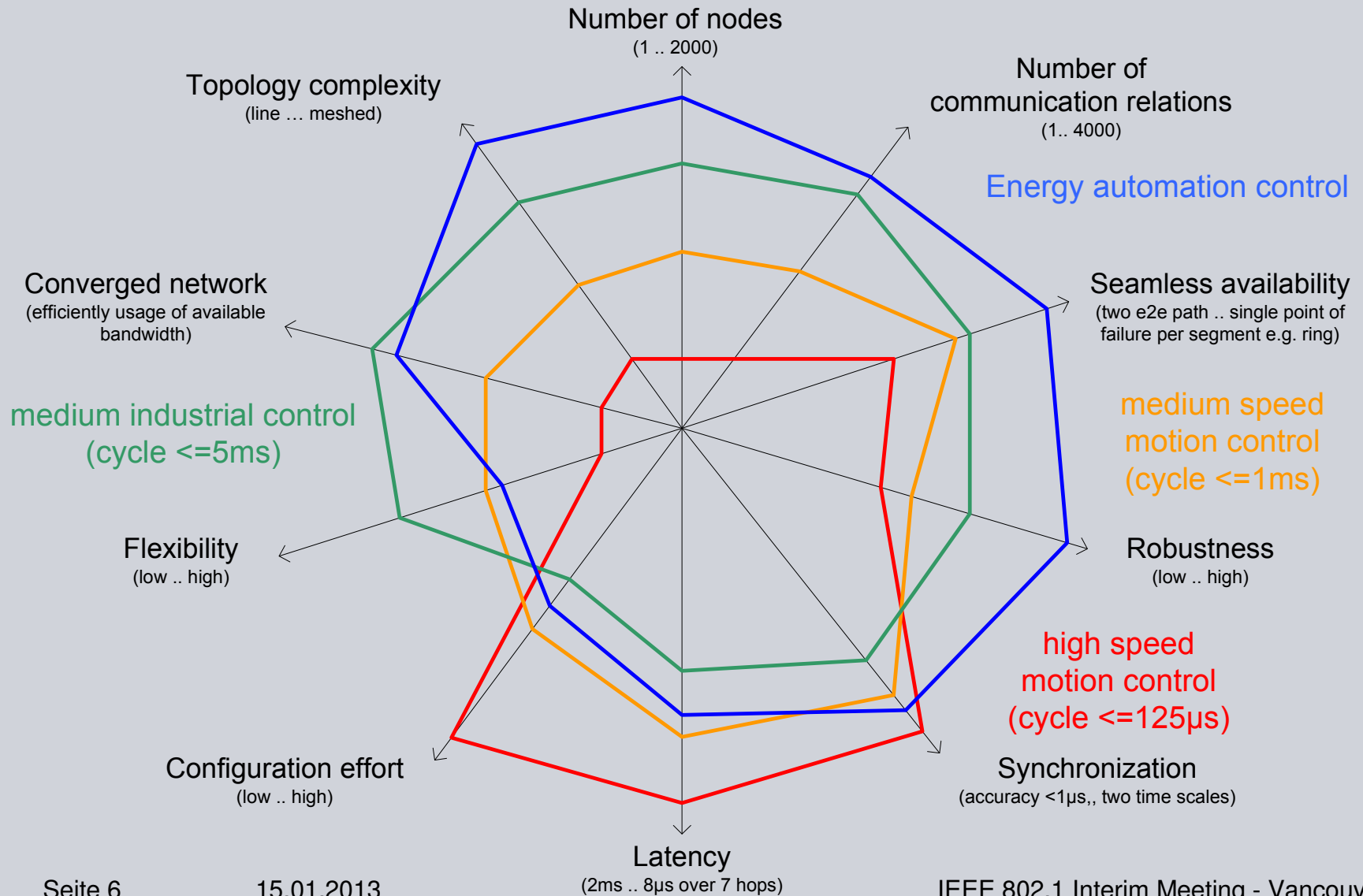
Topologies, Redundancy, Synchronization & Communication Relations in Industrial Networks (1)



Future Topologies, Redundancy, Synchronization & Communication Relations in Industrial Networks (1)



Feature Diagram for Time Sensitive Networks (TSN) @ Industrial



Feature List for Time Sensitive Networks (TSN) @ Industrial



Feature		Applications Technology	High speed motion control	Medium speed motion control	Medium Industrial control	Energy Automation	Automotive ???	...
Sync	Working Clock	Hot- or cold- standby GM	X	X		X		
		Multi path for sync messages to support high availability	X	X		X		
		Sync tree for universal time			X			
Seamless Availability		Network segment protection				X		
		Duplicate generation & elimination (end station & bridges)	X	X	X	X		
Scheduling		Time based transmission in nodes (offline engineered)	X	X				
Reservation		Bandwidth & resources	X	X	X	(X)		
L2 Routing		Multi path - without reconfiguration, at startup	X	X	X	X		
		Single path – with reconfiguration	(X)	X	X			
Low Latency	Shaper	Time Aware Shaper (TAS)	X			(X)		
		Burst Limiting Shaper (BLS)		X	X	X		
		Pre-emption	X	X	X	X		
		Scheduled Traffic Class A & B	X	X	X	X		

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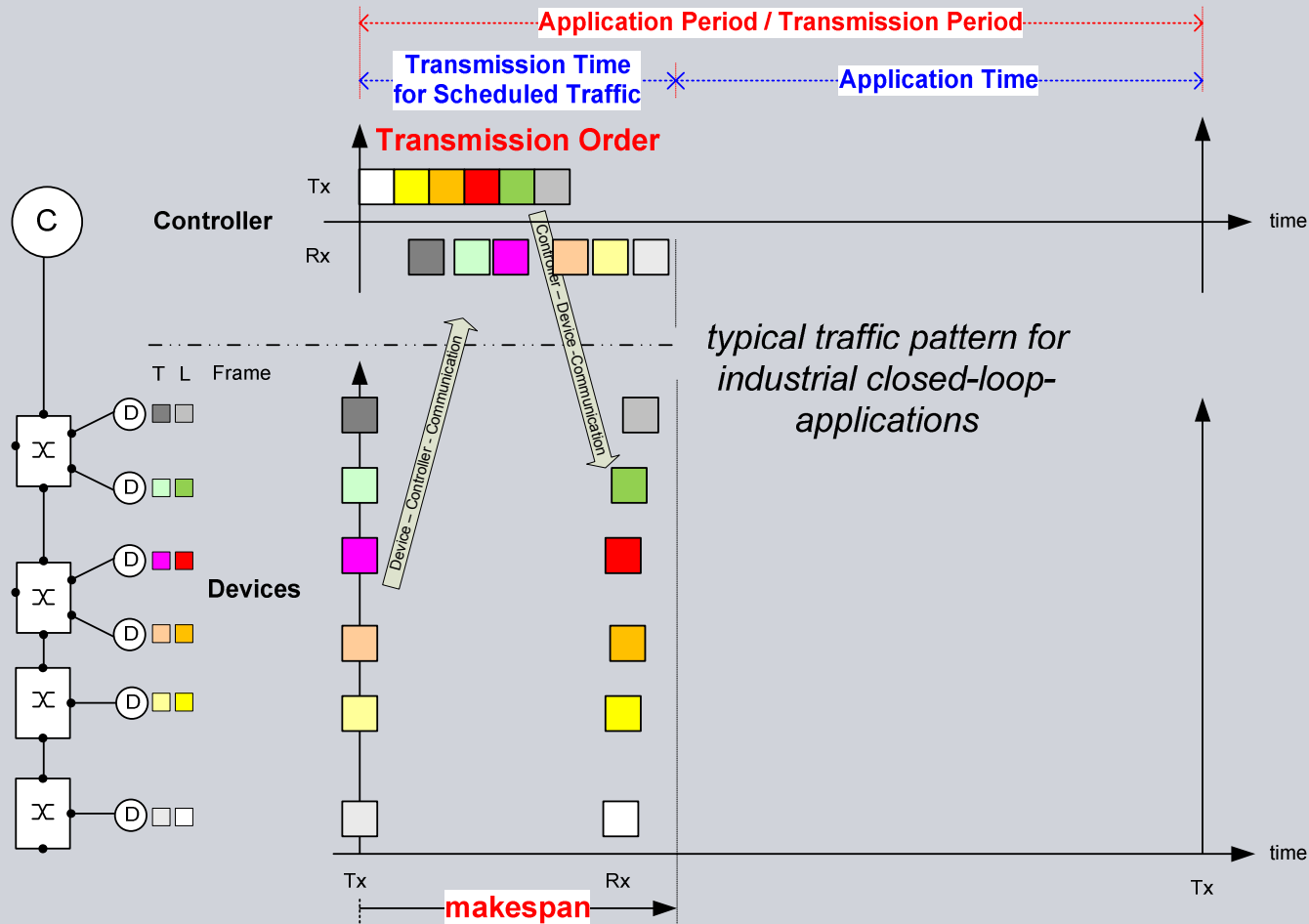
Goals for successful Time Sensitive Networks

- **Adapt complexity to requirements (KISS)**
- **Minimize overall complexity at application side to improve acceptance**
- **Minimization of hardware complexity should not lead to unnecessary higher complexity for network configuration management and end users**

Recap: Low Latency is required to minimize Transmission Time for Scheduled Traffic



Scheduled Traffic for automation applications



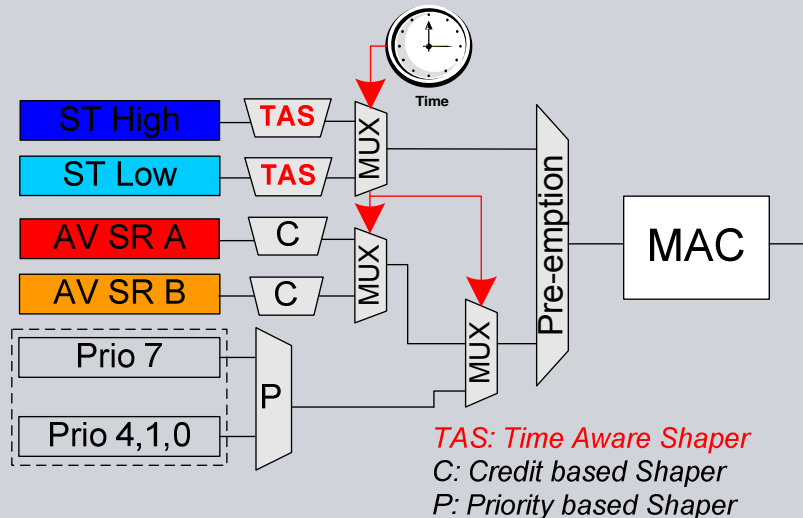
Transmission of Scheduled Traffic within transmission time for Scheduled Traffic

Recap: Proposed Traffic Shapers to support Low Latency for Scheduled Traffic (ST)

Details: <http://www.ieee802.org/1/files/public/docs2012/new-goetz-CtrDataScheduler-0712-v1.pdf>

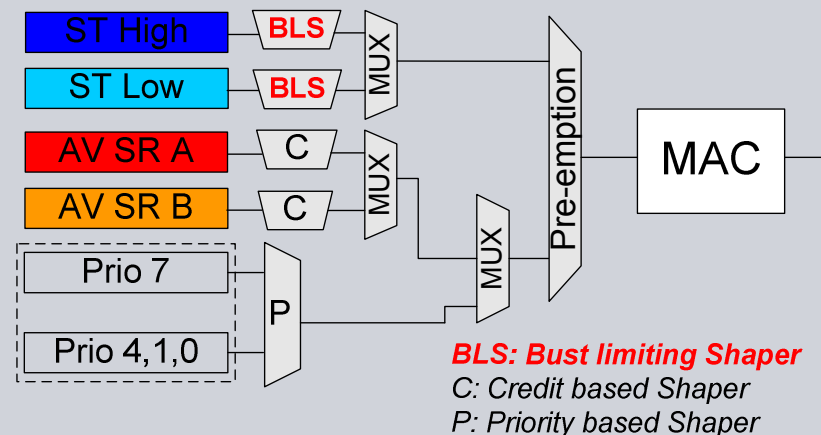
Time aware Shaper (TAS)

802.1Q + Extensions for Reserved and Scheduled Traffic



NEW: Burst Limiting Shaper (BLS)

802.1Q + Extensions for Reserved and Scheduled Traffic



Recap: Why an **ADDITIONAL** Shaper for Scheduled Traffic

Reasons:

- **Shaper with less configuration effort in bridges** (only bandwidth – not window size)
 - Adapt to different link speeds within a network
 - Automatically adaption to traffic flow
 - For mashed networks with multiple talker
 - Plugging of new components may change bandwidth but the time schedule must not adapted

- **The shaper shall support periodic and event-based Scheduled Traffic** (bandwidth limitation)

- **Robust for safety critical applications**
 - Emergency operation features – (fail operational behavior)

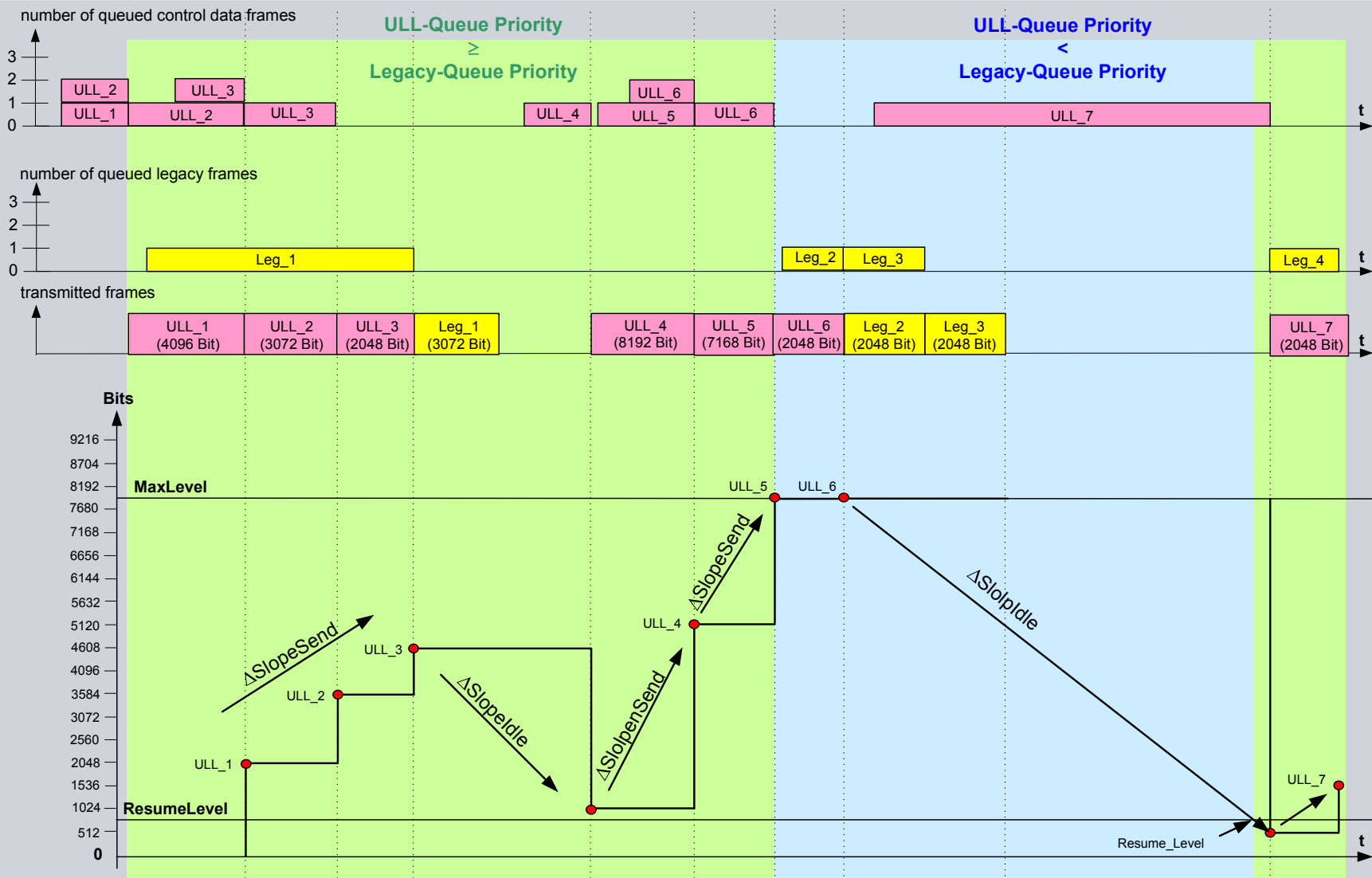
Requirements on a Traffic Shaper for Scheduled Traffic

SIEMENS

- **Guaranteed Low Latency for Scheduled Traffic**
- **Guarantee for maximum burst size for Scheduled Traffic**
- **Guaranteed bandwidth for other traffic classes**
- **Avoid to add additional latencies**

<http://www.ieee802.org/1/files/public/docs2011/new-goetz-avb-ext-industrcom-0113-v01.pdf>

Proposed: Burst Limiting Shaper (BLS) for Scheduled Traffic

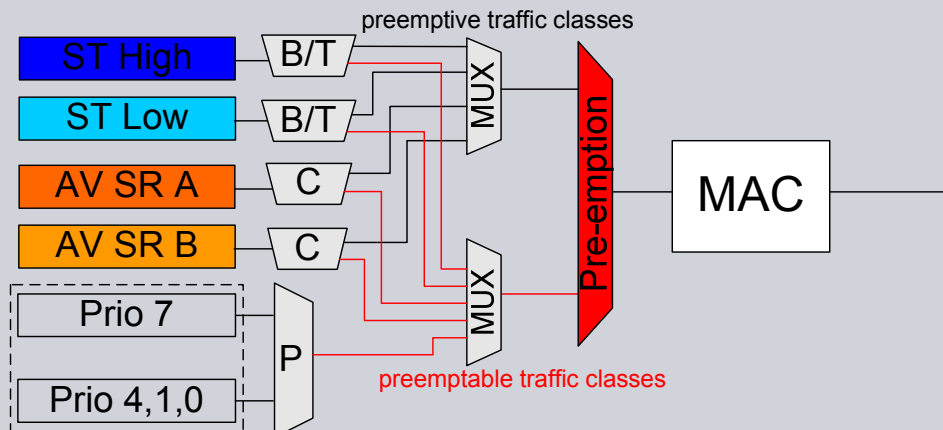


Recap: Pre-emption to support Low Latency for Scheduled Traffic

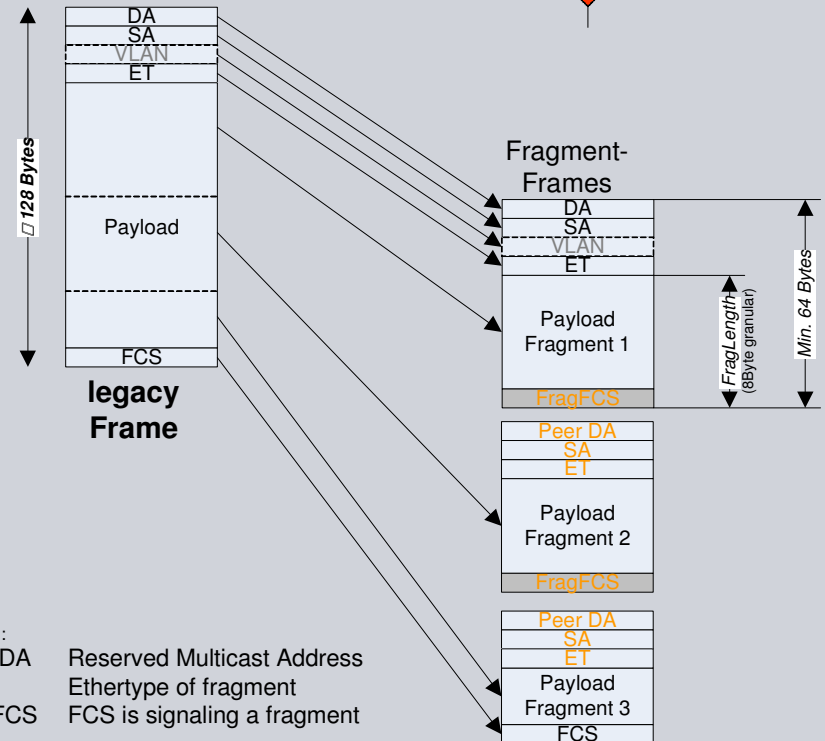
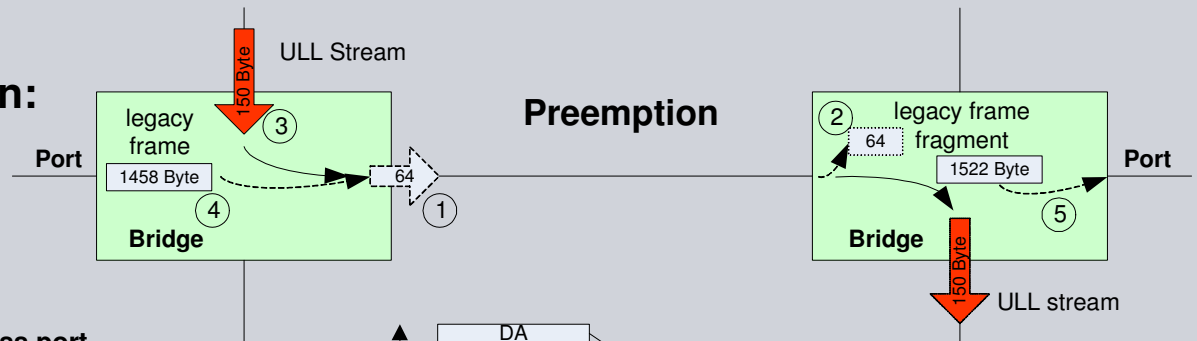
Mechanism to support pre-emption:

- LLDP shall be use for auto negotiation
 - Pre-emption supported
 - Min fragment size
- **Configurable** pre-emptive traffic classes
- Peer-to-Peer fragmentation of legacy traffic on egress port
- Peer-to-Peer reassemble of legacy traffic on ingress port

802.1Q + Extentions for Reserved and Scheduled Traffic



B/T: BLS or TAS shaper for Scheduled Traffic
 C: Credit based Shaper for Reserved Traffic
 P: Priority based Shaper for legacy traffic



Legend:
 Peer DA Reserved Multicast Address
 ET Ethertype of fragment
 FragFCS FCS is signaling a fragment

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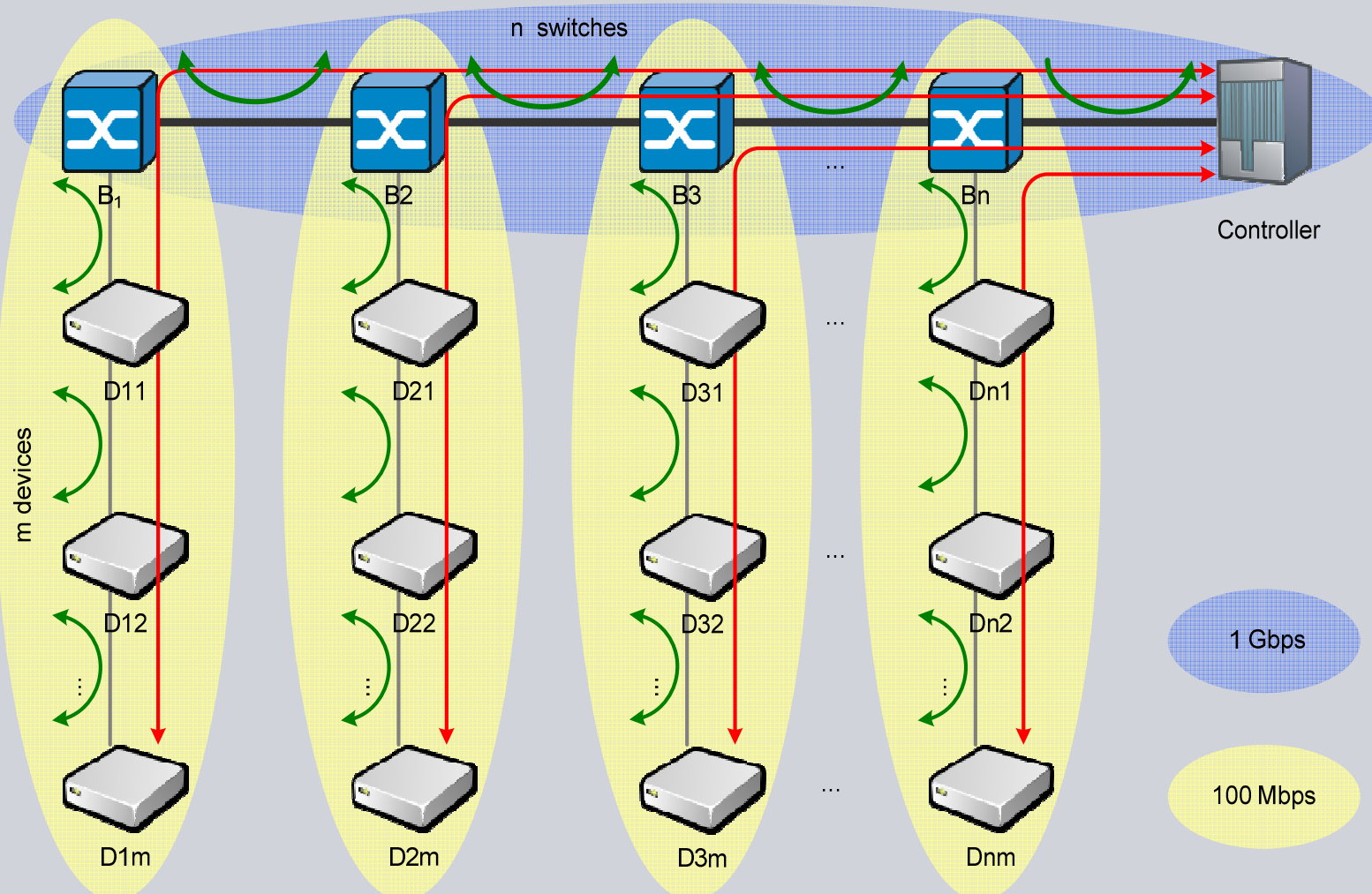
3. Simulation Results (one Use Case)

Time aware Shaper (TAS) <-> Burst limiting Shaper (BLS)

- a) Low Latency for Scheduled Traffic with **constant** Frame Size
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- c) Low Latency for Scheduled Traffic with **random** Frame Size **and optimized Window Size for TAS**

Simulation - Latency for Scheduled Traffic
 Time aware Shaper (TAS) <-> Burst limiting Shaper (BLS)

Topology & CR: **Controller (PLC, GE) <-> Devices (Actuators, Sensors, FE)**

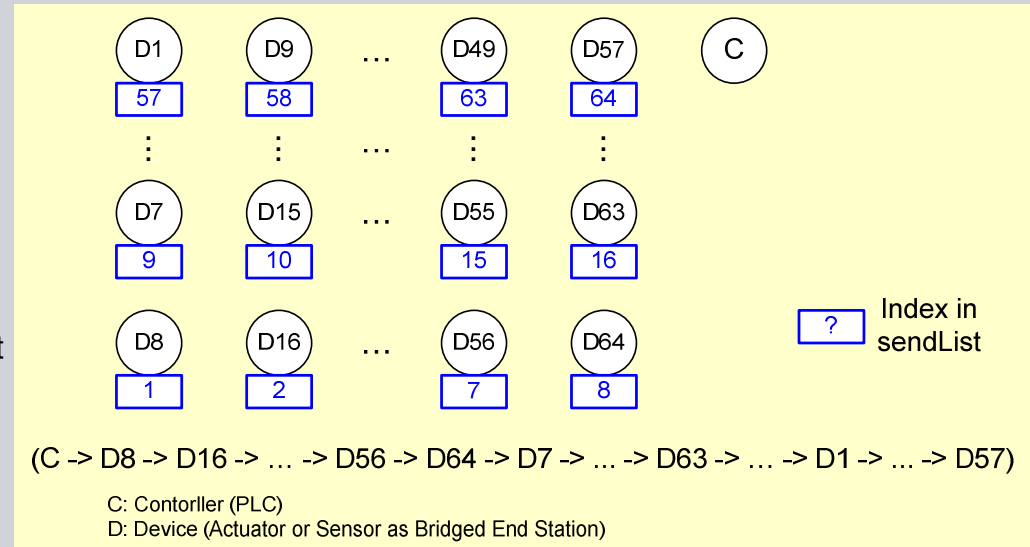


Simulations of 3 UC - Latency for Scheduled Traffic

Time aware Shaper (TAS) <-> Burst limiting Shaper (BLS)

General Settings (1):

- **Network:** 8 bridges, 8x8 devices (bridged end stations)
- **Real time application (synchronized)**
 - Transmission order (C->D): farthest first, nearest last
 - Traffic load for Scheduled Traffic < 50%
 - Frame Size for Scheduled Traffic:
 - **UC 1** constant size: 64 Bytes
 - **UC 2** random size: 10% 64 Bytes, 10% 512 Bytes, 80% between 128~384 Bytes
- **Best effort traffic:**
 - Traffic load < 30%
 - Frame size:
 - 25% max_size, 25% min_size, 50% between 250~1250 Bytes
 - 25% burst (frames in chain), 75% non-burst



Simulations of 3 UC - Latency for Scheduled Traffic

Time aware Shaper (TAS) <-> Burst Limiting Shaper (BLS)

General Settings (2)

▪ BLS & TAS

- Transmission period: 250 us for Scheduled Traffic with constant frame size,
- Transmission period: 875 us for Scheduled Traffic with random frame size
- **Window size (only for TAS):**
 - **UC 1** – Window size = 85 us for Scheduled Traffic with constant frame size
 - **UC 2** – Window size is 400 us for Scheduled Traffic with random frame size
 - **UC 3 based on UC 2** – Window size optimized
 - **Window start time always at the beginning of cycle**
 - **Window close time varies for different location of station**
 - **Window close time right after the station has transmitted the last Scheduled frame**

▪ Cut-through mod only for Scheduled Traffic

- Delay: 48 bytes

▪ Bridging delay: 500 ns; cable + PHY delay: 750 ns

▪ Pre-emption in combination with TAS or BLS

UC 1a Simulation - Low Latency for Scheduled Traffic with **constant** Frame Size of **64Bytes, S&F@GE & FE**



S&F (Store & Forward) @ GE & FE, Scheduled Traffic with constant frame size = 64 Byte							
Shaper	Best Effort Load	Scheduled Traffic communication time * (us)		Best Effort GE E2E delay** (us)		Best Effort FE E2E delay** (us)	
BLS	0	79.64 (79.64)	79.64 (79.64)	n/a	n/a	n/a	n/a
	5%	83.36 (95.36)	86.87 (123.4)	5.084 (57.55)	5.014 (64.86)	41.17 (581.2)	38.68 (652.9)
	10%	84.90 (97.62)	89.45 (123.5)	5.729 (60.68)	6.145 (69.66)	42.48 (584.4)	38.73 (624.3)
	15%	86.37 (100.4)	91.74 (123.6)	6.460 (73.75)	7.316 (79.56)	43.13 (785.7)	41.87 (723.2)
	20%	87.66 (100.8)	93.71 (123.9)	8.164 (91.10)	9.280 (94.27)	47.21 (687.7)	47.05 (875.4)
	25%	88.77 (101.4)	95.97 (124.1)	10.24 (97.19)	11.41 (148.3)	53.55 (745.5)	53.28 (994.0)
	30%	89.69 (103.7)	97.73 (124.4)	12.64 (155.7)	14.96 (161.7)	59.91 (879.3)	60.99 (929.7)
TAS (cycle = 250 us, window size = 85 us)	0			n/a	n/a	n/a	n/a
	5%			20.56 (112.2)	19.29 (109.2)	61.22 (802.5)	67.18 (714.1)
	10%			25.49 (122.0)	20.68 (120.2)	63.93 (744.9)	68.78 (749.2)
	15%	79.64 (79.64)	79.64 (79.64)	29.24 (196.4)	23.51 (172.2)	71.22 (929.4)	75.32 (834.6)
	20%			33.69 (240.7)	27.07 (221.3)	81.82 (939.2)	85.81 (943.0)
	25%			38.44 (265.4)	32.19 (307.4)	94.29 (968.0)	99.79 (1162)
	30%			45.15 (373.5)	38.73 (379.1)	110.4 (999.9)	115.6 (1303)
Value Format: mean (max)		C->D	D->C	C->D	D->C	C->D	D->C

* transmission delay for Scheduled Traffic: time from start of transmission of the first frame to receiving of the last frame

** E2E delay for Best Effort Traffic: time from transmitting the frame to receiving

UC 1b Simulation - Low Latency for Scheduled Traffic with **constant** Frame Size of **64Bytes**, **S&F@GE** + **CT@FE**



S&F@GE, CT@FE, Scheduled Traffic with constant frame size = 64 Byte							
Shaper	Best Effort Load	Scheduled Traffic communication time * (us)		Best Effort GE E2E delay** (us)		Best Effort FE E2E delay** (us)	
BLS	0	70.89 (70.89)	70.89 (70.89)	n/a	n/a	n/a	n/a
	5%	76.32 (88.39)	75.12 (92.72)	5.084 (57.55)	5.643 (66.11)	40.53 (581.2)	39.94 (602.1)
	10%	78.14 (91.50)	77.38 (93.58)	5.729 (60.58)	6.643 (67.89)	41.43 (584.4)	40.85 (630.9)
	15%	79.54 (91.73)	79.29 (94.22)	6.460 (73.75)	7.699 (77.92)	43.18 (687.7)	42.49 (710.6)
	20%	81.09 (95.95)	80.82 (97.61)	8.164 (91.10)	9.619 (95.35)	47.22 (745.5)	47.08 (856.4)
	25%	82.00 (97.06)	82.39 (99.05)	10.24 (97.19)	11.74 (155.5)	53.58 (785.7)	52.80 (898.0)
	30%	82.87 (99.01)	83.91 (103.1)	12.64 (155.7)	15.17 (159.4)	59.92 (879.3)	59.99 (962.5)
TAS (cycle = 250 us, window size = 85 us)	0	70.89 (70.89)	70.89 (70.89)	n/a	n/a	n/a	n/a
	5%			20.56 (112.2)	19.29 (109.2)	61.22 (802.5)	67.18 (714.1)
	10%			25.49 (122.0)	20.68 (120.2)	63.93 (744.9)	68.78 (749.2)
	15%			29.24 (196.4)	23.51 (172.2)	71.22 (929.4)	75.32 (834.6)
	20%			33.69 (240.7)	27.07 (221.3)	81.82 (939.2)	85.81 (943.0)
	25%			38.44 (265.4)	32.19 (307.4)	94.29 (968.0)	99.79 (1162)
	30%			45.15 (373.5)	38.73 (379.1)	110.4 (999.9)	115.6 (1303)
Value Format: mean (max)		C->D	D->C	C->D	D->C	C->D	D->C

UC 1c Simulation - Low Latency for Scheduled Traffic with **constant** Frame Size of **64Bytes, CT@GE & FE**

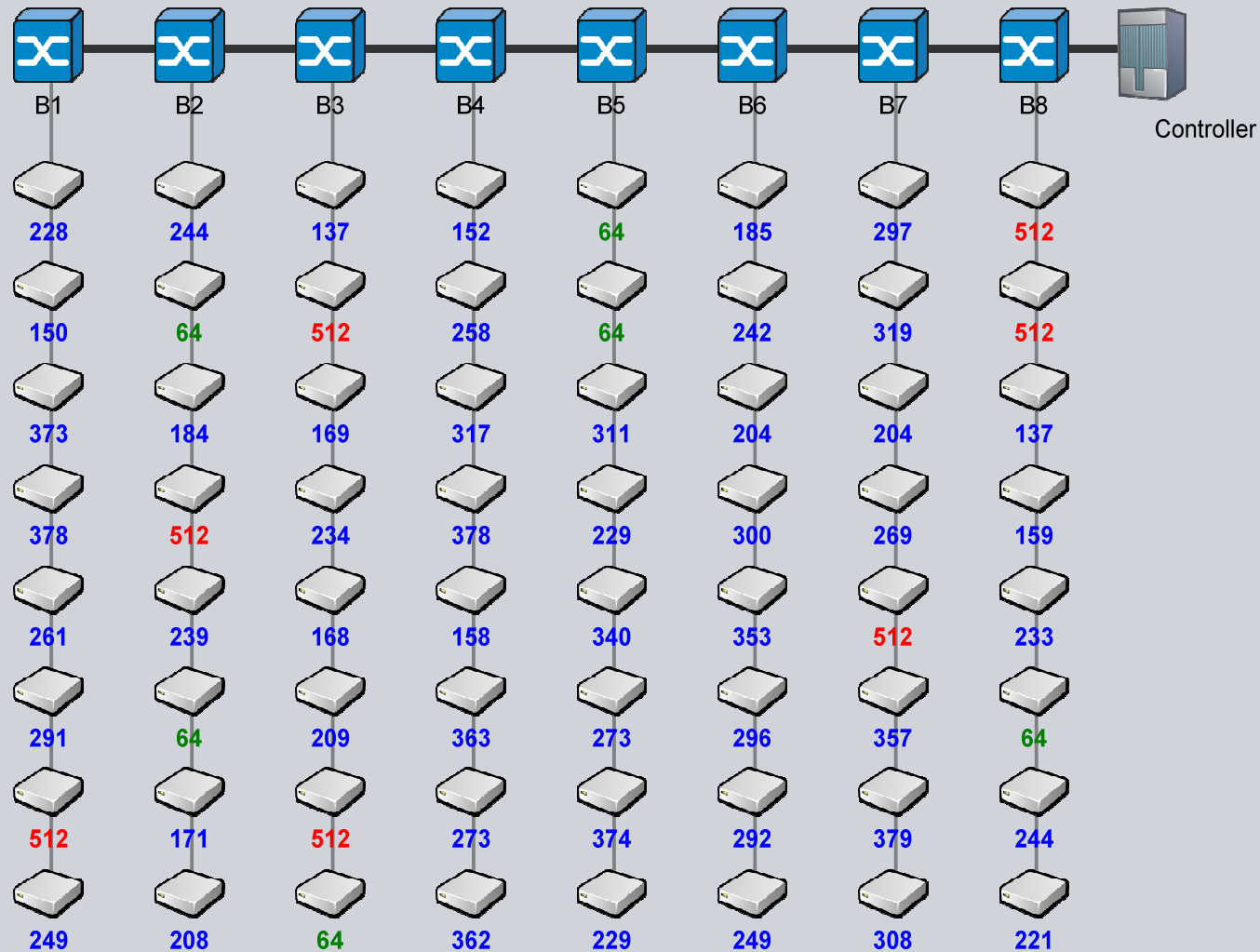


CT @GE&FE, Scheduled Traffic with constant frame size = 64 Byte							
Shaper	Best Effort Load	Scheduled Traffic communication time * (us)		Best Effort GE E2E delay** (us)		Best Effort FE E2E delay** (us)	
BLS	0	69.99 (69.99)	69.99 (69.99)	n/a	n/a	n/a	n/a
	5%	75.43 (88.13)	74.37 (91.68)	5.080 (57.25)	5.637 (66.01)	40.53 (581.2)	39.94 (602.1)
	10%	77.38 (91.30)	76.65 (91.89)	5.724 (60.19)	6.626 (67.74)	41.43 (584.4)	40.85 (630.9)
	15%	78.85 (91.55)	78.56 (93.54)	6.455 (73.77)	7.605 (78.23)	43.18 (687.7)	42.49 (710.6)
	20%	80.37 (95.95)	80.10 (97.03)	8.163 (90.10)	9.542 (95.04)	47.22 (745.5)	47.08 (856.4)
	25%	81.35 (97.01)	81.66 (97.74)	10.24 (96.54)	11.73 (154.2)	53.58 (785.7)	52.80 (898.0)
	30%	82.20 (97.48)	83.17 (102.2)	12.64 (154.4)	15.16 (158.6)	59.92 (879.2)	59.99 (962.5)
TAS (cycle = 250 us, window size = 85 us)	0			n/a	n/a	n/a	n/a
	5%			20.56 (112.2)	19.29 (109.2)	61.22 (802.5)	67.18 (714.1)
	10%			25.49 (122.0)	20.68 (120.2)	63.93 (744.9)	68.78 (749.2)
	15%	69.99 (69.99)	69.99 (69.99)	29.24 (196.4)	23.51 (172.2)	71.22 (929.4)	75.32 (834.6)
	20%			33.69 (240.7)	27.07 (221.3)	81.82 (939.2)	85.81 (943.0)
	25%			38.44 (265.4)	32.19 (307.4)	94.29 (968.0)	99.79 (1162)
	30%			45.15 (373.5)	38.73 (379.1)	110.4 (999.9)	115.6 (1303)
Value Format: mean (max)		C->D	D->C	C->D	D->C	C->D	D->C

Simulation - Low Latency for Scheduled Traffic with **random** Frame Size



Distribution of frame size for Scheduled Traffic:



UC 2a Simulation - Low Latency for Scheduled Traffic with **random** Frame Size **S&F@GE & FE**



S&F@GE & FE, Scheduled Traffic with random frame size							
Shaper	Best Effort Load	Scheduled Traffic communication time * (us)		Best Effort GE E2E delay** (us)		Best Effort FE E2E delay** (us)	
BLS	0	367.6 (367.2)	355.9 (355.9)	n/a	n/a	n/a	n/a
	5%	368.5 (380.2)	357.0 (365.4)	5.465 (156.2)	4.507 (84.78)	53.50 (650.9)	49.56 (638.4)
	10%	369.0 (380.6)	357.7 (369.8)	6.546 (158.5)	5.300 (119.3)	50.89 (687.5)	51.97 (676.7)
	15%	369.6 (380.9)	358.3 (372.4)	7.662 (161.0)	6.438 (153.93)	52.92 (774.8)	53.62 (749.5)
	20%	370.2 (382.2)	359.1 (373.4)	9.546 (185.4)	8.500 (171.8)	56.82 (778.0)	55.97 (792.2)
	25%	371.1 (384.3)	360.0 (374.4)	11.60 (188.8)	10.82 (186.6)	63.02 (782.7)	61.60 (904.7)
	30%	371.6 (384.5)	360.5 (381.5)	14.39 (196.3)	13.90 (203.1)	69.42 (801.5)	68.68 (995.6)
TAS (cycle = 875 us, window size = 380 us)	0	367.6 (367.2)	355.9 (355.9)	n/a	n/a	n/a	n/a
	5%			92.40 (403.2)	92.16 (406.5)	152.8 (922.7)	158.7 (1127)
	10%			99.99 (407.8)	98.84 (406.6)	154.8 (1093)	160.7 (1162)
	15%			107.8 (418.7)	106.2 (418.8)	164.1 (1201)	170.5 (1165)
	20%			117.3 (450.1)	116.1 (424.2)	179.3 (1333)	186.4 (1215)
	25%			127.6 (485.2)	126.2 (466.4)	198.3 (1436)	207.5 (1408)
	30%			139.0 (501.3)	139.3 (624.2)	222.2 (1467)	233.9 (1477)
Value Format: mean (max)		C->D	D->C	C->D	D->C	C->D	D->C

* transmission delay for Scheduled Traffic: time from start of transmission of the first frame to receiving of the last frame

** E2E delay for Best Effort Traffic: time from transmitting the frame to receiving

UC 2b Simulation - Low Latency for Scheduled Traffic with **random** Frame Size **S&F@GE + CT@FE**



S&F@GE + CT@FE, Scheduled Traffic with random frame size							
Shaper	NRT Load	Scheduled Traffic communication time * (us)		Best Effort GE E2E delay** (us)		Best Effort FE E2E delay** (us)	
BLS	0	248.8 (248.8)	237.2 (237.2)	n/a	n/a	n/a	n/a
	5%	249.1 (255.4)	237.4 (243.8)	5.465 (156.2)	4.979 (137.9)	50.52 (650.9)	53.98 (670.1)
	10%	249.2 (255.5)	237.7 (243.9)	6.546 (158.5)	5.964 (174.9)	52.64 (687.5)	55.70 (672.9)
	15%	249.3 (255.6)	237.9 (244.3)	7.662 (161.0)	7.386 (177.4)	53.05 (778.0)	56.89 (680.7)
	20%	249.4 (255.8)	238.1 (244.5)	9.600 (185.4)	9.614 (180.5)	56.74 (782.7)	59.76 (785.7)
	25%	249.6 (255.9)	238.4 (244.8)	11.63 (188.8)	11.93 (196.9)	62.77 (793.4)	65.13 (898.4)
	30%	249.7 (256.0)	238.5 (245.0)	14.37 (196.3)	14.99 (214.7)	69.28 (837.7)	71.65 (964.1)
TAS (cycle = 875 us, window size = 380 us)	0	248.8 (248.8)	237.2 (237.2)	n/a	n/a	n/a	n/a
	5%			92.40 (403.2)	92.16 (406.5)	152.8 (922.7)	158.7 (1127)
	10%			99.99 (407.8)	98.84 (406.6)	154.8 (1093)	160.7 (1162)
	15%			107.8 (418.7)	106.2 (418.8)	164.1 (1201)	170.5 (1165)
	20%			117.3 (450.1)	116.1 (424.2)	179.3 (1333)	186.4 (1215)
	25%			127.6 (485.2)	126.2 (466.4)	198.3 (1436)	207.5 (1408)
	30%			139.0 (501.3)	139.3 (624.2)	222.2 (1467)	233.9 (1477)
Value Format: mean (max)		C->D	D->C	C->D	D->C	C->D	D->C

UC 2c Simulation - Low Latency for Scheduled Traffic with **random** Frame Size **CT@GE & FE**



CT@GE & FE, Scheduled Traffic with random frame size							
Shaper	Best Effort Load	Scheduled Traffic communication time * (us)		Best Effort GE E2E delay** (us)		Best Effort FE E2E delay** (us)	
BLS	0	243.7 (243.7)	231.8 (231.8)	n/a	n/a	n/a	n/a
	5%	244.0 (250.6)	232.0 (238.1)	5.261 (154.9)	4.920 (144.5)	50.74 (650.9)	53.98 (670.1)
	10%	244.1 (250.8)	232.0 (238.3)	6.349 (156.9)	5.978 (173.8)	52.76 (687.5)	55.70 (672.9)
	15%	244.3 (250.8)	232.2 (238.4)	7.528 8159.7)	7.425 (175.4)	53.32 (778.0)	56.89 (680.7)
	20%	244.4 (250.9)	232.3 (238.5)	9.461 (184.5)	9.725 (180.6)	56.83 (782.7)	59.76 (785.7)
	25%	244.5 (250.9)	232.5 (238.5)	11.52 (186.9)	12.04 (198.1)	62.85 (793.4)	65.13 (898.4)
	30%	244.6 (251.0)	232.6 (238.6)	14.23 (194.4)	15.11 (216.2)	69.35 (937.7)	71.65 (964.1)
TAS (cycle = 875 us, window size = 380 us)	0	243.7 (243.7)	231.8 (231.8)	n/a	n/a	n/a	n/a
	5%			92.40 (403.2)	92.16 (406.5)	152.8 (922.7)	158.7 (1127)
	10%			99.99 (407.8)	98.84 (406.6)	154.8 (1093)	160.7 (1162)
	15%			107.8 (418.7)	106.2 (418.8)	164.1 (1201)	170.5 (1165)
	20%			117.3 (450.1)	116.1 (424.2)	179.3 (1333)	186.4 (1215)
	25%			127.6 (485.2)	126.2 (466.4)	198.3 (1436)	207.5 (1408)
	30%			139.0 (501.3)	139.3 (624.2)	222.2 (1467)	233.9 (1477)
Value Format: mean (max)		C->D	D->C	C->D	D->C	C->D	D->C

UC 3 Simulation - Low Latency for Scheduled Traffic with **random** Frame Size **CT@GE & FE** and **optimized Window Size (close)**



CT@GE & FE, Scheduled Traffic with random frame Size + optimized window size							
Shaper	Best Effort Load	Scheduled Traffic communication time * (us)		Best Effort GE E2E delay** (us)		Best Effort FE E2E delay** (us)	
TAS Not optimized window size (cycle = 875 us, window size = 380 us)	0	243.7 (243.7)	231.8 (231.8)	n/a	n/a	n/a	n/a
	5%			92.40 (403.2)	92.16 (406.5)	152.8 (922.7)	158.7 (1127)
	10%			99.99 (407.8)	98.84 (406.6)	154.8 (1093)	160.7 (1162)
	15%			107.8 (418.7)	106.2 (418.8)	164.1 (1201)	170.5 (1165)
	20%			117.3 (450.1)	116.1 (424.2)	179.3 (1333)	186.4 (1215)
	25%			127.6 (485.2)	126.2 (466.4)	198.3 (1436)	207.5 (1408)
	30%			139.0 (501.3)	139.3 (624.2)	222.2 (1467)	233.9 (1477)
TAS Optimized window size (cycle = 875 us, window size < 380 us)	0			n/a	n/a	n/a	n/a
	5%			31.01 (267.1)	34.33 (254.8)	63.92 (650.5)	57.13 (591.6)
	10%			34.06 (269.2)	36.76 (255.4)	66.68 (776.3)	59.03 (600.2)
	15%			37.13 (277.1)	40.37 (267.5)	68.49 (793.7)	60.20 (682.02)
	20%			41.27 (292.6)	44.79 (275.2)	71.53 (900.6)	62.77 (790.3)
	25%			45.60 (296.8)	49.70 (301.7)	78.24 (817.0)	68.83 (817.6)
	30%			50.94 (322.7)	55.13 (352.1)	85.52 (902.1)	74.56 (971.9)
Value Format: mean (max)		C->D	D->C	C->D	D->C	C->D	D->C

Comparison BLS <-> TAS for Scheduled Traffic with **random** Frame Size **CT@GE & FE** and **optimized Window Size**

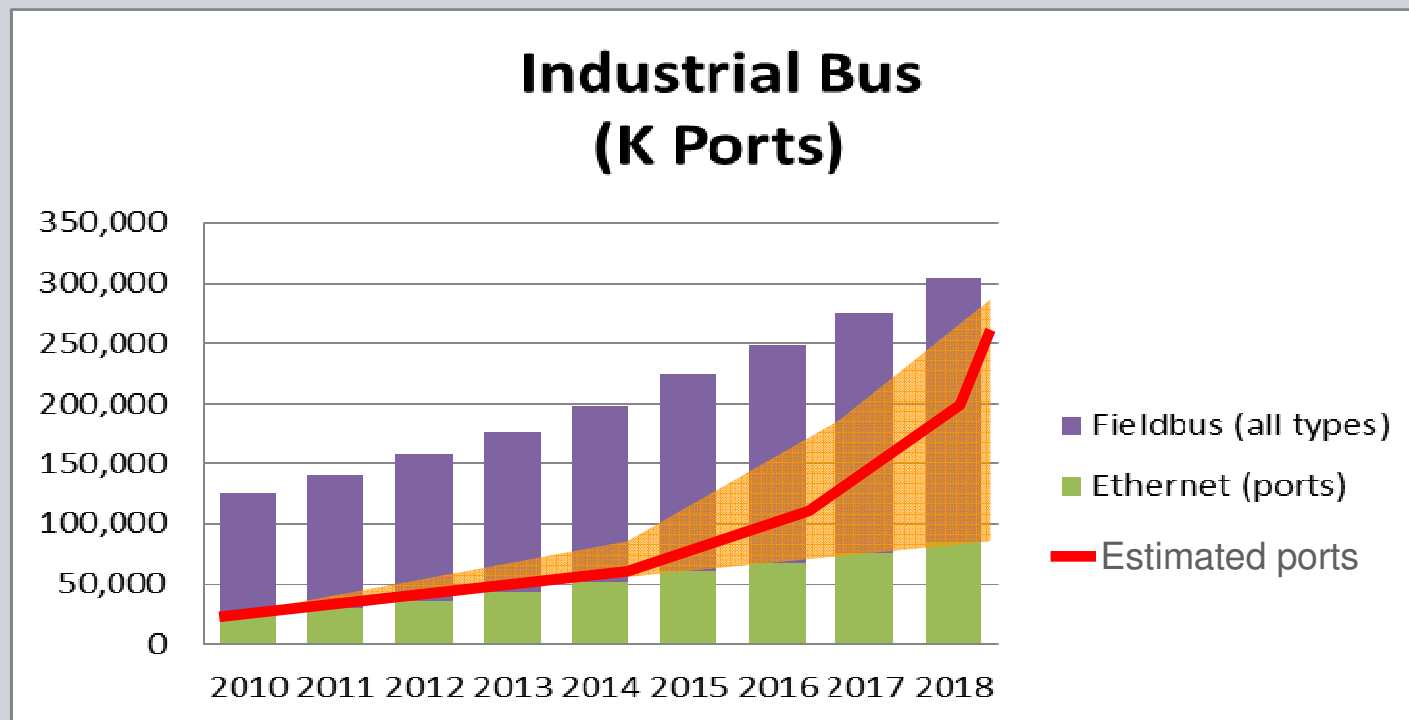


BLS <-> TAS with optimized window size and Schedule Traffic with random frame size							
Shaper	Best Effort Load	Scheduled Traffic communication time * (us)		Best Effort GE E2E delay** (us)		Best Effort FE E2E delay** (us)	
BLS	0	243.7 (243.7)	231.8 (231.8)	n/a	n/a	n/a	n/a
	5%	244.0 (250.6)	232.0 (238.1)	5.261 (154.9)	4.920 (144.5)	50.74 (650.9)	53.98 (670.1)
	10%	244.1 (250.8)	232.0 (238.3)	6.349 (156.9)	5.978 (173.8)	52.76 (687.5)	55.70 (672.9)
	15%	244.3 (250.8)	232.2 (238.4)	7.528 (159.7)	7.425 (175.4)	53.32 (778.0)	56.89 (680.7)
	20%	244.4 (250.9)	232.3 (238.5)	9.461 (184.5)	9.725 (180.6)	56.83 (782.7)	59.76 (785.7)
	25%	244.5 (250.9)	232.5 (238.5)	11.52 (186.9)	12.04 (198.1)	62.85 (793.4)	65.13 (898.4)
	30%	244.6 (251.0)	232.6 (238.6)	14.23 (194.4)	15.11 (216.2)	69.35 (937.7)	71.65 (964.1)
TAS Optimized window size (cycle = 875 us, window size < 380 us)	0	243.7 (243.7)	231.8 (231.8)	n/a	n/a	n/a	n/a
	5%			31.01 (267.1)	34.33 (254.8)	63.92 (650.5)	57.13 (591.6)
	10%			34.06 (269.2)	36.76 (255.4)	66.68 (776.3)	59.03 (600.2)
	15%			37.13 (277.1)	40.37 (267.5)	68.49 (793.7)	60.20 (682.02)
	20%			41.27 (292.6)	44.79 (275.2)	71.53 (900.6)	62.77 (790.3)
	25%			45.60 (296.8)	49.70 (301.7)	78.24 (817.0)	68.83 (817.6)
	30%			50.94 (322.7)	55.13 (352.1)	85.52 (902.1)	74.56 (971.9)
<i>Value Format: mean (max)</i>		<i>C->D</i>	<i>D->C</i>	<i>C->D</i>	<i>D->C</i>	<i>C->D</i>	<i>D->C</i>

Conclusion

We have to find out which mechanism must be supported by TSN to cover the requirements for a wide range of industrial applications so that time sensitive Ethernet based networks (TSN) become successful!!

Estimated change of Industrial Market



Source: Contributions from Hirschmann, Siemens and Broadcom