

**Testing the WR Network  
of the FAIR  
General Machine Timing System**

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GSI, August 2016**

Table 1. Abbreviations used in this document

Table 2. Glossary of Related Terms

1.FAIR General Machine Timing system at GSI

2. Benchmarking the FAIR WR Network

2.1 Test of 4 WR switch network without VLAN

2.1.1 Test Setup

2.1.2 Frame Loss Rate and Misorder Frame Rate Test Result

2.1.2.1 Frame Loss Rate and Misorder Frame Rate for DM Broadcast frames

2.1.2.2 Frame Loss Rate and Misorder Frame Rate for DM Unicast frames

2.1.2.3 Frame Loss Rate and Misorder Frame Rate for B2B Unicast frames

2.1.2.4 Frame Loss Rate and Misorder Frame Rate for B2B Broadcast frames

2.1.2.5 Frame Loss Rate and Misorder Frame Rate for Mgmt Traffic frames

2.1.3 Latency and Jitter Test Result

2.1.3.1 Latency and Jitter for DM Broadcast frames

2.1.3.1.1 Average Latency and Jitter

2.1.3.1.2 Maximum/Minimum Latency and Jitter

2.1.3.2 Latency and Jitter for DM Unicast frames

2.1.3.2.1 Average Latency and Jitter

2.1.3.2.2 Maximum/Minimum Latency and Jitter

2.1.3.3 Latency and Jitter of B2B Unicast frames

2.1.3.3.1 Average Latency and Jitter

2.1.3.3.2 Maximum/Minimum Latency and Jitter

2.1.3.4 Latency and Jitter of B2B Broadcast frames

2.1.3.4.1 Average Latency and Jitter

2.1.3.4.2 Maximum/Minimum Latency and Jitter

2.1.3.5 Latency and Jitter of Mgmt Traffic frames

2.1.3.5.1 Average Latency and Jitter

2.1.3.5.2 Maximum/Minimum Latency and Jitter

2.1.4 Result and Conclusion

2.2 Test of 4 WR switch network with VLAN

2.2.1 Test Setup

2.2.2 Frame Loss Rate and Misorder Frame Rate Test Result

2.2.2.1 Frame Loss Rate and Misorder Frame Rate for VLAN 7 DM Broadcast

2.2.2.2 Frame Loss Rate and Misorder Frame Rate for VLAN 7 DM Unicast

2.2.2.2 Frame Loss Rate and Misorder Frame Rate for VLAN 7 B2B Unicast

2.2.2.2 Frame Loss Rate and Misorder Frame Rate for VLAN 6 B2B Broadcast

2.2.2.2 frame Loss Rate and Misorder Frame Rate for VLAN 5 Mgmt Traffic

2.2.3 Latency and Jitter Test Result

2.2.3.1 Latency and Jitter of VLAN 7 DM Broadcast

2.2.3.1.1 Average Latency and Jitter

2.2.3.1.2 Maximum/Minimum Latency and Jitter

2.2.3.2 Latency and Jitter of VLAN 7 DM Unicast

2.2.3.2.1 Average Latency and Jitter

2.2.3.2.2 Maximum/Minimum Latency and Jitter

2.2.3.3 Latency and Jitter of VLAN 6 B2B Broadcast

2.2.3.3.1 Average Latency and Jitter

2.2.3.3.2 Maximum/Minimum Latency and Jitter

2.2.3.4 Latency and Jitter of VLAN 5 Mgmt Traffic

2.2.3.2.1 Average Latency and Jitter

2.2.3.4.2 Maximum/Minimum Latency and Jitter

2.2.4 Result and Conclusion

2.3 Comparison of the 4 layers WR switch network without VLAN and with VLAN

Table 1. Abbreviations used in this document

Avg	Average
CM	Clock Master
DM	Data Master
B2B	Bunch-to-Bucket
GMT	General Machine Timing system
FAIR	Facility for Antiproton and Ion Research
Max	Maximum
MGMT	Management
SW	Switch
VLAN	Virtual Local Area Network
WR	White Rabbit
Xena	The name of a traffic generator

Table 2. Glossary of Related Terms

Term	Definition
Burst	A group of consecutive frames with shorter interframe gaps than frames arriving before or after the burst of frames.
Frame loss rate	The ratio of the number of the lost frames to the number of the theoretic received frames of a tested port.
Jitter <sup>1</sup>	The absolute value of the difference between the latency of two consecutive received frames belonging to the same stream from one Xena port to another Xena port.
Latency	The time interval between the time of Xena port receiving frame and the time of another Xena port sending frame.
Misorder frame rate	The ratio of the number of misordered frames to the number of the theoretic received frames of a tested port.
Timing frame	An ethernet frame with 110 bytes frame length.

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<sup>1</sup> Xena jitter

<[http://www.xenanetworks.com/wp-content/uploads/Measuring\\_Frame\\_latency\\_Variation.pdf](http://www.xenanetworks.com/wp-content/uploads/Measuring_Frame_latency_Variation.pdf)>

# 1. FAIR General Machine Timing system at GSI

The upcoming FAIR<sup>2</sup>, Facility for Antiproton and Ion Research, facility at GSI, is a new international accelerator for the research with antiprotons and ions, aiming at providing high-energy beams with high intensities.

The General Machine Timing<sup>3</sup> (GMT) system is used at FAIR for the time synchronization of more than 2000-3000 nodes with nanosecond accuracy, distribution of timing messages and subsequent generation of real-time actions by the nodes of the timing system.

The primary task of the GMT system is the hard real-time control of the GSI and FAIR accelerator complex with sub-ns precision. Second, the GMT system generates on-time actions at the Front-End Controller<sup>4</sup> (FEC). Such an action triggers a prepared activity at the FEC. The fundamental idea behind the GMT is the concept of time-based control. As a prerequisite, all nodes of the GMT share a common notion of time provided by the White Rabbit (WR) via the dedicated WR network, timing network. The Data Master (DM) controls the facility in hard real-time by broadcast timing messages with absolute execution time stamps, via the timing network to the Timing Receivers (TR) embedded in the FECs. The messages must be distributed with an upper bound latency.

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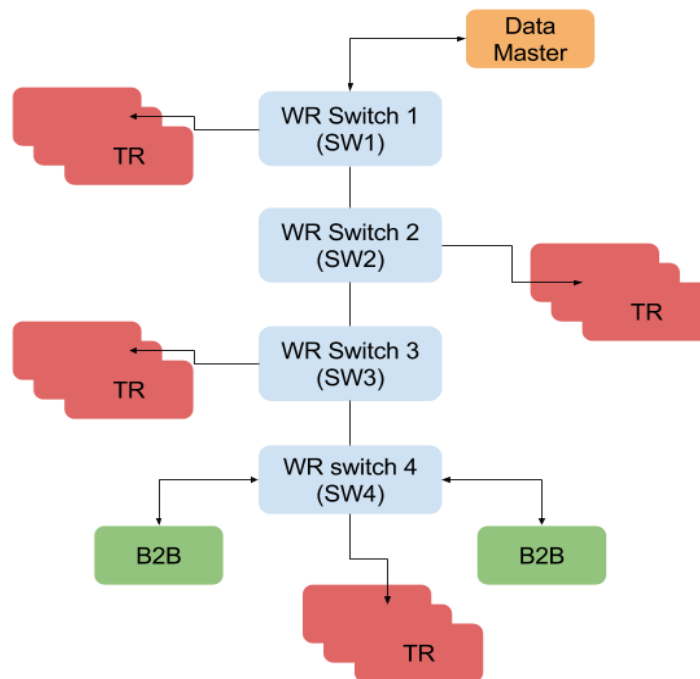
<sup>2</sup> Facility for Antiproton and Ion Research facility  
<<http://www.fair-center.eu/>>

<sup>3</sup> General Machine Timing system  
<[https://www-acc.gsi.de/wiki/pub/Timing/TimingSystemDocuments/GMT\\_Description\\_v3-1.pdf](https://www-acc.gsi.de/wiki/pub/Timing/TimingSystemDocuments/GMT_Description_v3-1.pdf) >

<sup>4</sup> Bär, R. "The New FAIR Accelerator Complex at GSI: Project, Controls ... - CERN." 2015.  
<<https://accelconf.web.cern.ch/accelconf/ica07/PAPERS/TOAB01.PDF>>

## 2. Benchmarking the FAIR WR Network

In this document, the Timing Group of GSI presents the network measurements done on the testing FAIR timing network. This network is built using a tree topology with up to 4 layers of WR Switches. On top of the tree sits the Data Master broadcasting timing frames<sup>5</sup>. In every layer of switches, there are TRs receiving timing frames. Besides, in the FAIR WR Network, it will be point to point communication among a set of nodes carrying out special use cases. In the measurements, we test the viability of the network for the Bunch to Bucket (B2B) transfer<sup>6</sup>.



The traffic generated from the Data Master or B2B belongs to the critical data for the FAIR accelerator. Therefore, the forwarding of this traffic in the WR network has to be reliable with a low frame error rate and the latency from sender (DM or B2B) to receiver (TR) below a defined upper bound. There is no special requirements for the so called Mgmt traffic present in the network, e.g. dhcp, snmp, ldpc, etc... The requirements for three different kind of traffic are summarized in the following table:

<sup>5</sup> Data Master broadcasts Timing frames

<<https://www-acc.gsi.de/wiki/Timing/TimingSystemEvent>>

<sup>6</sup> Bai12, J. "First Idea on Bunch to Bucket Transfer for FAIR " 2014.

<<http://cas.web.cern.ch/CAS/CzechRepublic2014/PosterSession/Bai.pdf>>

<b>Networking Requirements</b>	<b>DM Broadcast</b>	<b>DM Unicast</b>	<b>B2B Broadcast<sup>7</sup></b>	<b>B2B Unicast</b>	<b>Mgmt Traffic</b>
<b>Frame Error Rate</b>	$10^{-12}$	$10^{-12}$	$10^{-8}$	$10^{-7}$	Best Effort
<b>Upper bound latency of the WR network</b>	<300us	<500us	<400us	<400us	Best Effort
<b>Upper bound latency per WR Switch layer</b>	<40us	<30us	<30us	<30us	Best Effort

For the benchmark, we have used Xena Traffic Generator<sup>8</sup> for generating the different traffics. In the next chapters, we present the results of the benchmark focusing on the frame errors and latency. If you want to consult and check the original tests results from Xena, please check our repository<sup>9</sup>.

<sup>7</sup> The lost frame of the B2B Broadcast and Unicast will cause the failure of the B2B transfer, the frame error rate is defined as one B2B transfer failure every month.

<sup>8</sup> "What we do - Xena Networks." 2014. 15 Aug. 2016

<<http://www.xenanetworks.com/what-we-do/>>

<sup>9</sup> [https://github.com/GSI-CS-CO/network\\_testing.git](https://github.com/GSI-CS-CO/network_testing.git)

## 2.1 Test of 4 WR switch network without VLAN

Test Date and Time:	2016-08-09, 16:19
Test Duration:	03:10:28 (h:m:s)
Test WR switch	Seven Solutions

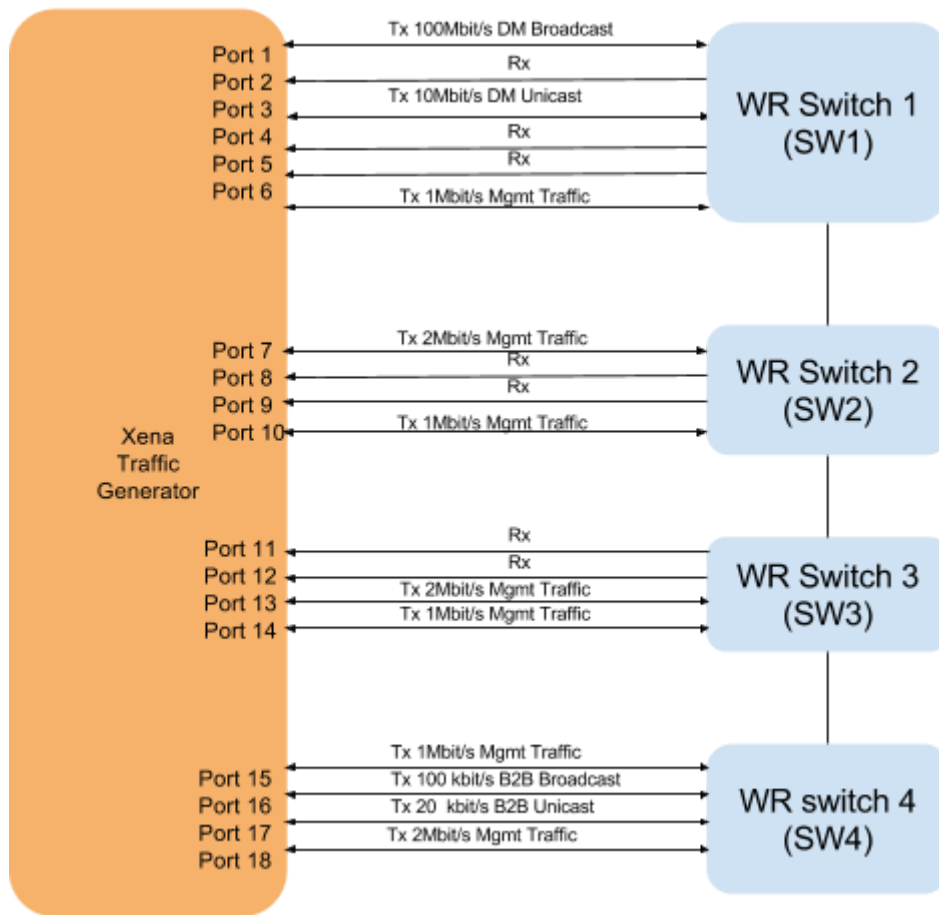
### 2.1.1 Test Setup

The Xena Traffic Generator is connected to the four layers of WR switches. It receives and produces the traffic as follows:

Switch	Traffic Gen. Xena Port	Traffic Bandwidth- Length	App
1 Layer WR Switch	Port 1	Tx 100 Mbit/s 110 bytes	<b>DM Broadcast</b>
	Port 3	Tx 10 Mbit/s 110 bytes	<b>DM Unicast</b>
	Port 2, 4 & 5	Rx Traffic	Xena Measurement
	Port 6	1 Mbit/s 64 - 1518 bytes	Mgmt Traffic
2 Layer WR Switch	Port 7	2 Mbit/s 64 - 1518 bytes	Mgmt Traffic
	Port 8 & 9	Rx Traffic	Xena Measurement
	Port 10	1 Mbit/s 64 - 1518 bytes	Mgmt Traffic
3 Layer WR Switch	Port 11 & 12	Rx Traffic	Xena Measurement
	Port 13	2 Mbit/s 64 - 1518 bytes	Mgmt Traffic
	Port 14	1 Mbit/s 64 - 1518 bytes	Mgmt Traffic
4 Layer WR Switch	Port 15	1 Mbit/s 64 - 1518 bytes	Mgmt Traffic
	Port 16	24.64 kbit/s 110 bytes	<b>B2B Broadcast</b> <sup>10</sup>
	Port 17	4.4 kbit/s 110 bytes	<b>B2B Unicast</b>
	Port 18	2 Mbit/s 64 - 1518 bytes	Mgmt Traffic

<sup>10</sup> Bai, J. "Bunch to Bucket Transfer System for FAIR - Proceedings." 2015.  
<<http://icalepcs.synchrotron.org.au/papers/wepgf119.pdf>>



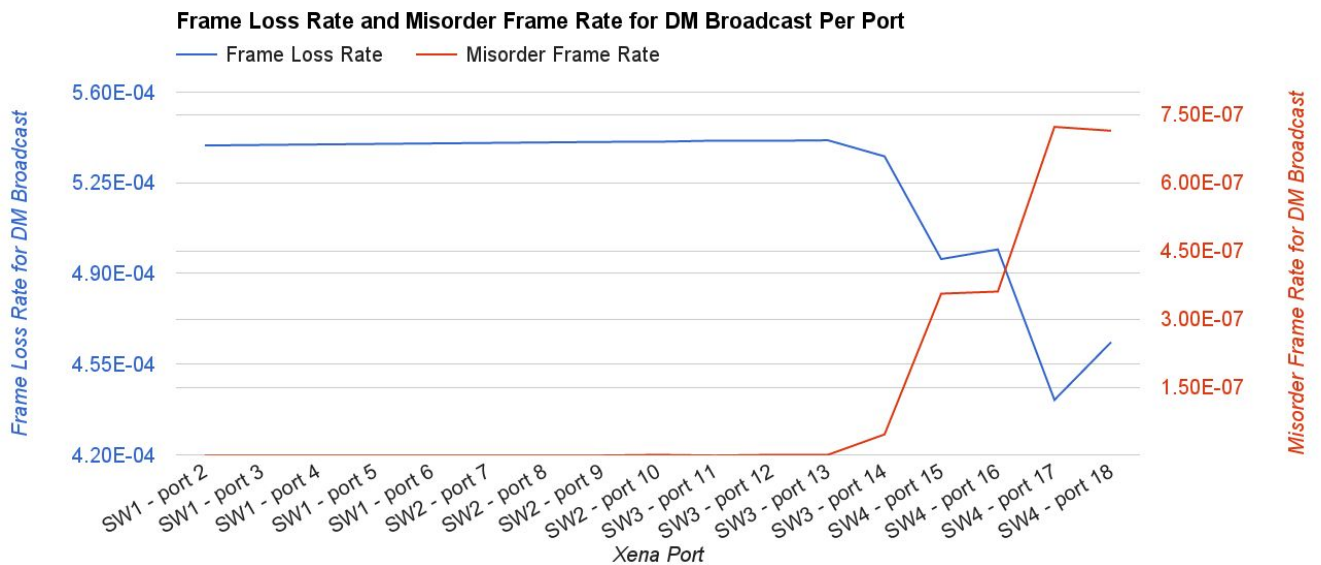


## 2.1.2 Frame Loss Rate and Misorder Frame Rate Test Result

In this section, the frame loss rate and the misorder frame rate of DM Broadcast, DM Unicast, B2B Broadcast, B2B Unicast and the Mgmt Traffic frames will be checked.

### 2.1.2.1 Frame Loss Rate and Misorder Frame Rate for DM Broadcast frames

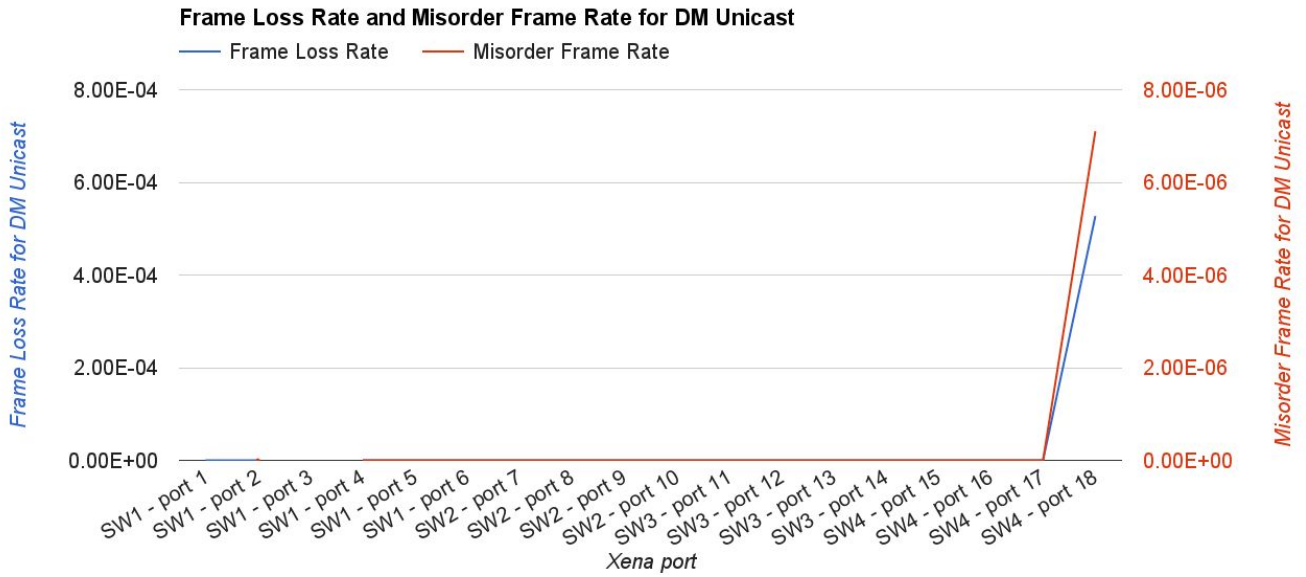
The frame loss rate and the misorder frame rate of the stream from port 1 to other ports are measured.



For the WR switch 1, 2 and 3, the frame loss rate of every port is 0.054%. For the WR switch 4, the frame loss rate of each port is between 0.044% and 0.054%. It does not meet the DM Broadcast requirements of the WR network for FAIR.

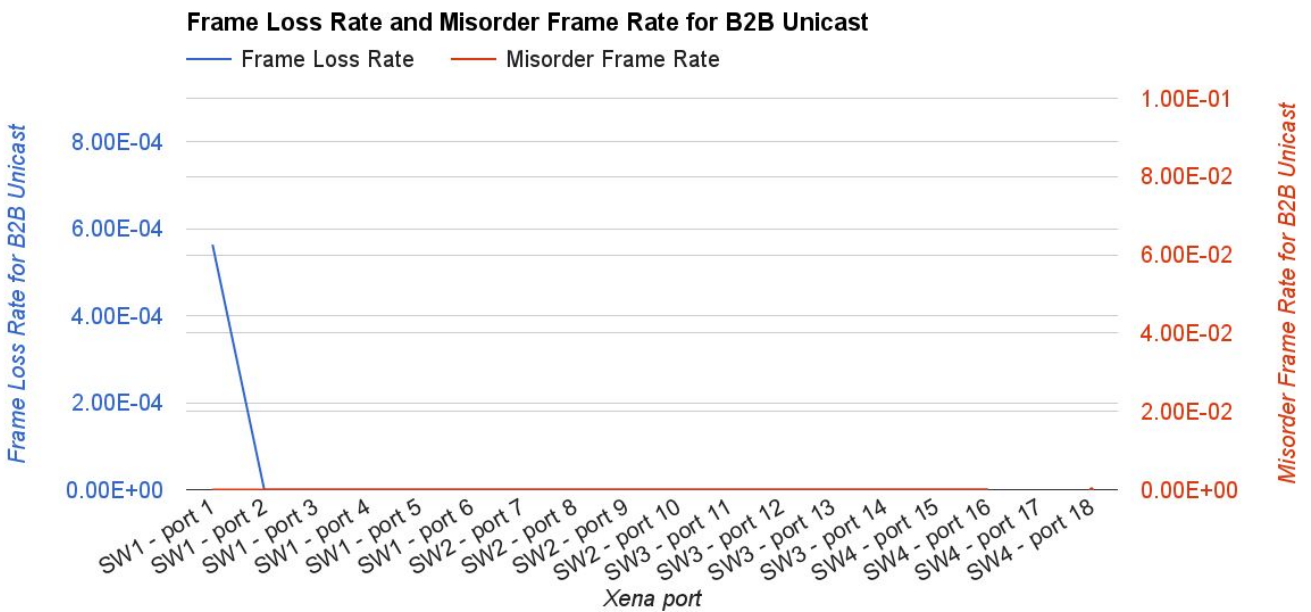
For the WR switch 1 and 2, the misorder frame rate of every port is 0. For the WR switch 3, the misorder frame rate of port 14 is  $4.7 \times 10^{-8}$ . For the WR switch 4, the misorder frame rate of each port is between  $3.6 \times 10^{-7}$  and  $7.3 \times 10^{-7}$ . It does not meet the DM Broadcast requirements of the WR network for FAIR.

### 2.1.2.2 Frame Loss Rate and Misorder Frame Rate for DM Unicast frames



The frames are unicast frames from port 3 to port 18, so only the frame loss rate and the misorder frame rate of the stream from port 3 to port 18 are measured. The frame loss rate is 0.053%. The misorder frame rate of the stream from port 3 to port 18 is  $7.1 \times 10^{-6}$ . They do not meet the DM Unicast requirements of the WR network for FAIR.

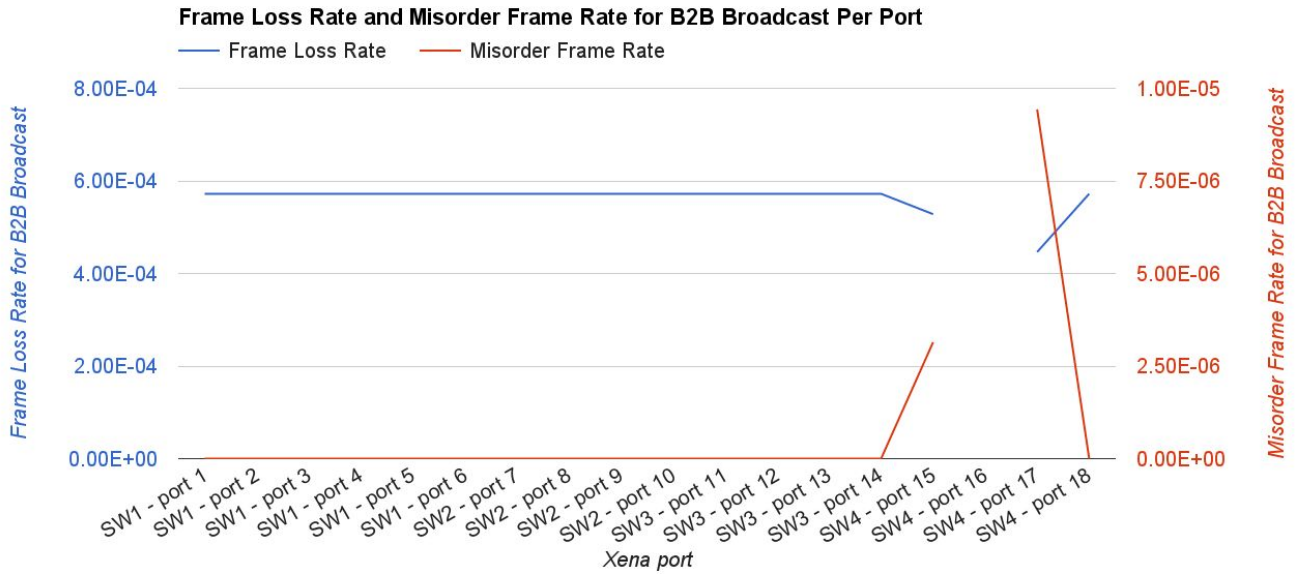
### 2.1.2.3 Frame Loss Rate and Misorder Frame Rate for B2B Unicast frames



The frames are unicast frames from port 17 to port 1, so only the frame loss rate and the misorder frame rate of the stream from port 17 to port 1 is measured. The frame loss rate is 0.056%. It does not meet the B2B Unicast requirement of the WR network for FAIR. The misorder frame rate of the stream is 0.

### 2.1.2.4 Frame Loss Rate and Misorder Frame Rate for B2B Broadcast frames

The frame loss rate and the misorder frame rate of the stream from port 16 to other ports are measured.

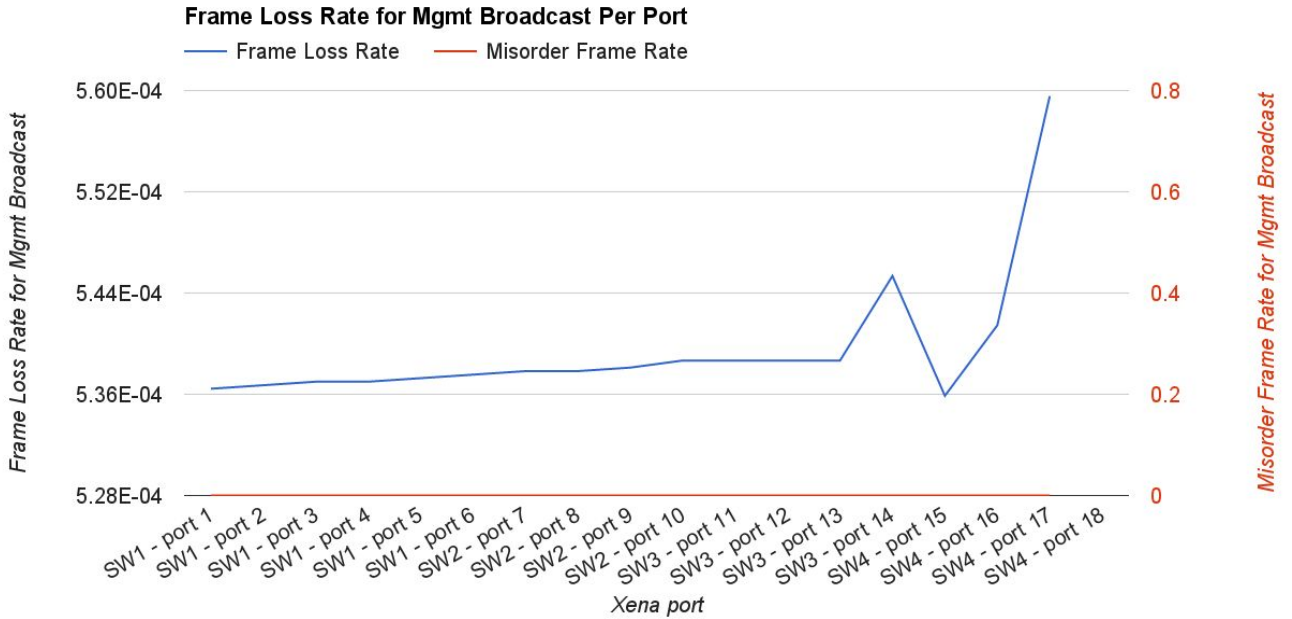


For the WR switch 1, 2 and 3, the frame loss rate of every port is 0.057% . For the WR switch 4, the frame loss rate of each port is between 0.045% and 0.057%. It does not meet the B2B Broadcast requirement of the WR network for FAIR.

For the WR switch 1, 2 and 3, the misorder frame rate of every port is 0. For the WR switch 4, the misorder frame rate of each port is between  $3.1 \times 10^{-6}$  and  $9.5 \times 10^{-6}$ . It does not meet the B2B Broadcast requirements of the WR network for FAIR.

### 2.1.2.5 Frame Loss Rate and Misorder Frame Rate for Mgmt Traffic frames

The frame loss rate and the misorder frame rate of the stream from port 18 to other ports are measured.



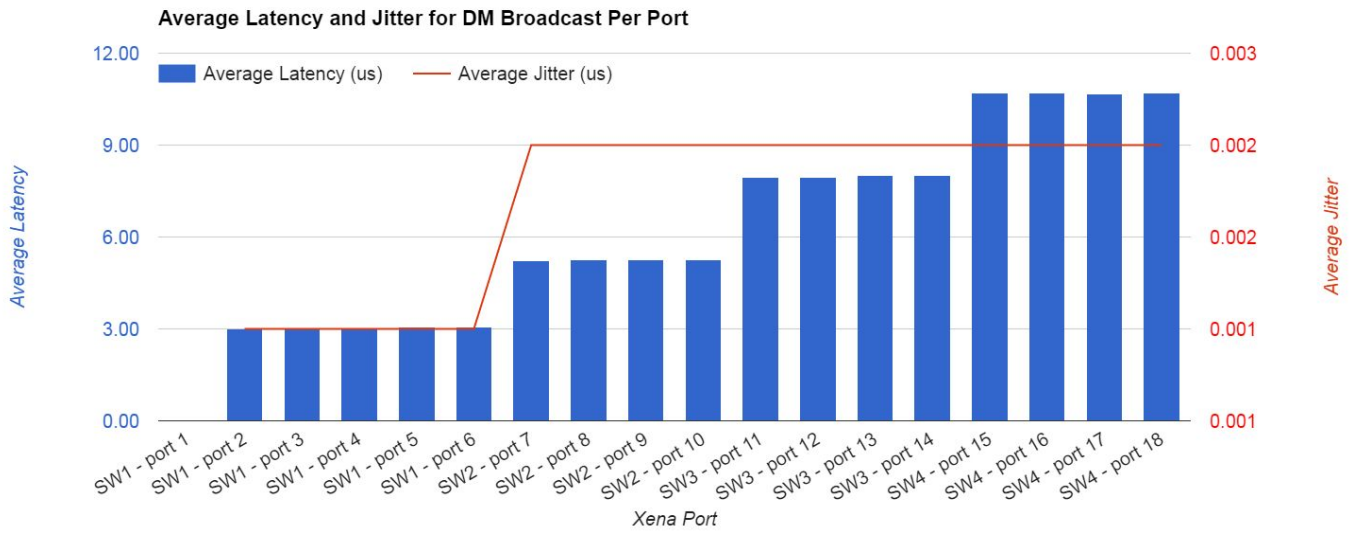
For the WR switch 1 and 2, the frame loss rate of every port is 0.054%. For the WR switch 3, the frame loss rate of port 11, 12, 13 and 14 is between 0.054% and 0.055%. For the WR switch 4, the frame loss rate of port 15, 16, 17 and 18 is between 0.054% and 0.056%. It does not meet the Mgmt Traffic requirements of the WR network for FAIR. The misorder frame rate of all ports is 0.

## 2.1.3 Latency and Jitter Test Result

### 2.1.3.1 Latency and Jitter for DM Broadcast frames

For the DM Broadcast frames, the latency and jitter of the stream from port 1 to other ports are measured.

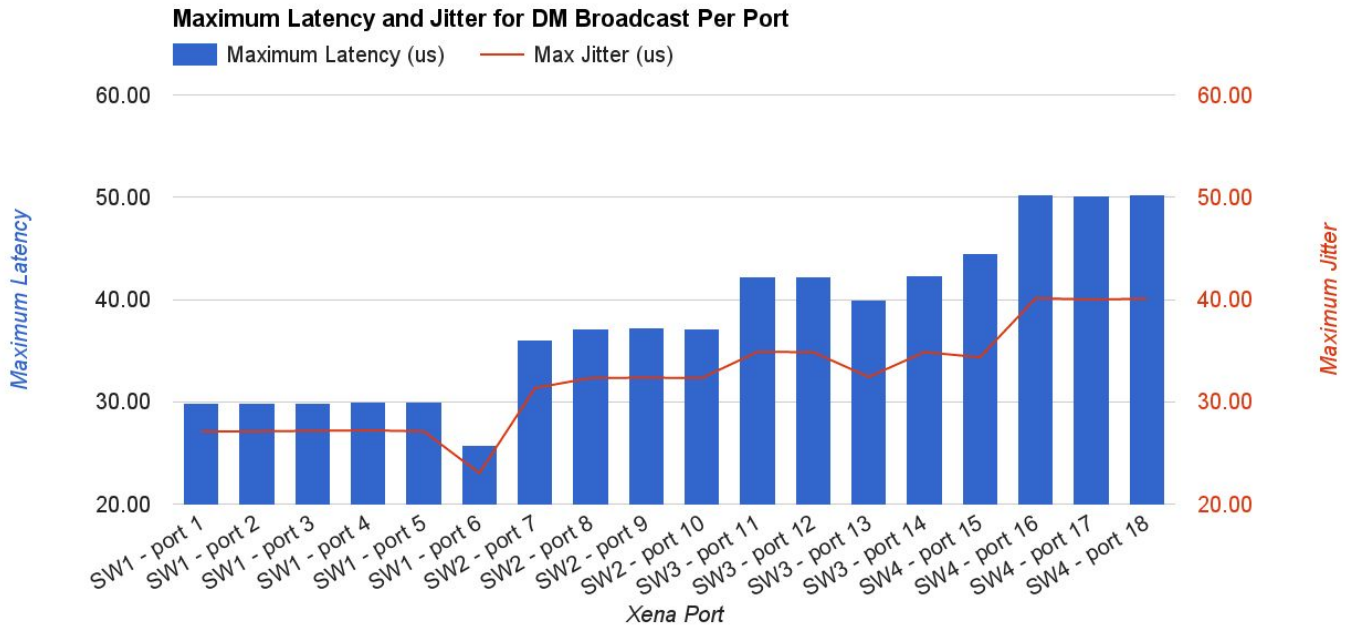
#### 2.1.3.1.1 Average Latency and Jitter



Layer of WR Switches	Avg Latency	Avg Jitter
1	3us	0.001us
2	5us	0.002us
3	8us	0.002us
4	11us	0.002us

They meet the DM Broadcast requirements of the WR network for FAIR.

2.1.3.1.2 Maximum/Minimum Latency and Jitter



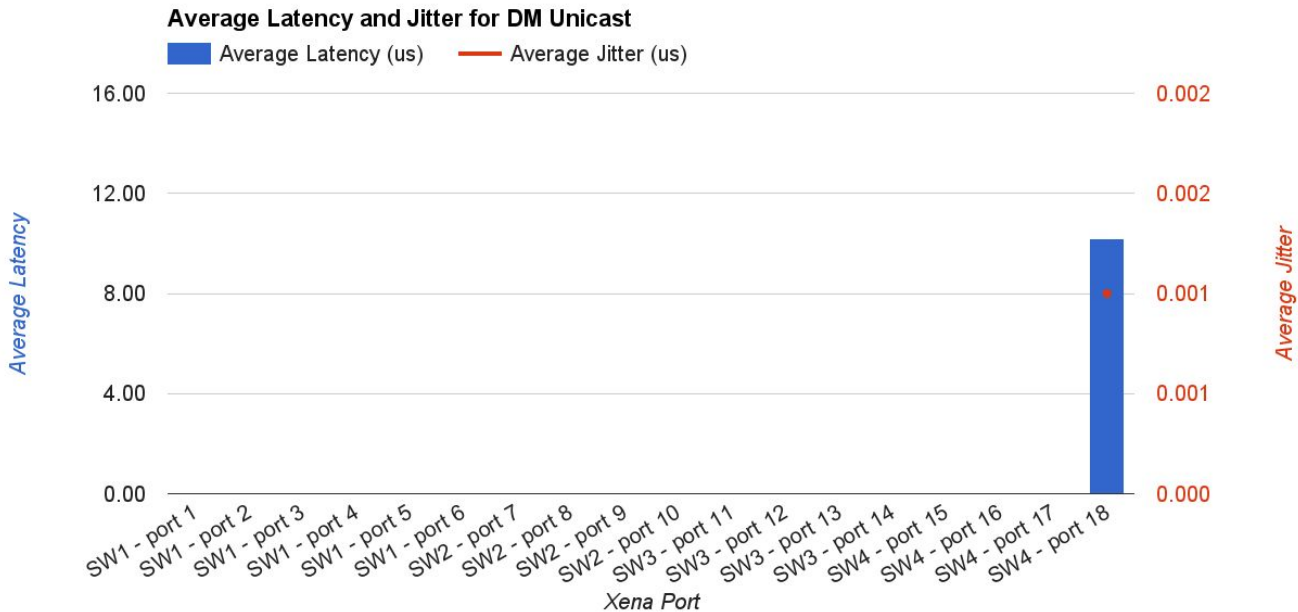
Layer of WR Switches	Max Latency	Max Jitter
1	30us	28us
2	38us	33us
3	42us	35us
4	51us	41us

They meet the DM Broadcast requirements of the WR network for FAIR.

### 2.1.3.2 Latency and Jitter for DM Unicast frames

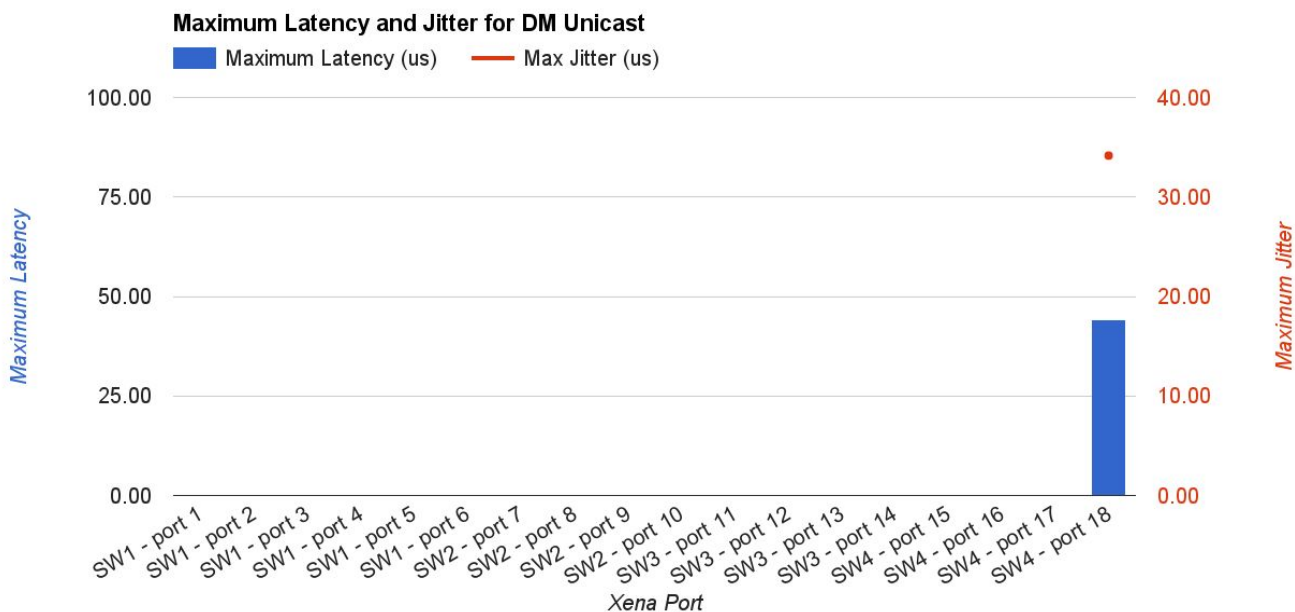
For the DM Unicast frames, the latency and jitter of the stream from port 3 to port 18 are measured.

#### 2.1.3.2.1 Average Latency and Jitter



The average latency of the unicast stream from port 3 to port 18 via 4 WR switch is approximate 11us. The jitter is 1ns. They meet the DM Unicast requirements of the WR network for FAIR.

#### 2.1.3.2.2 Maximum/Minimum Latency and Jitter



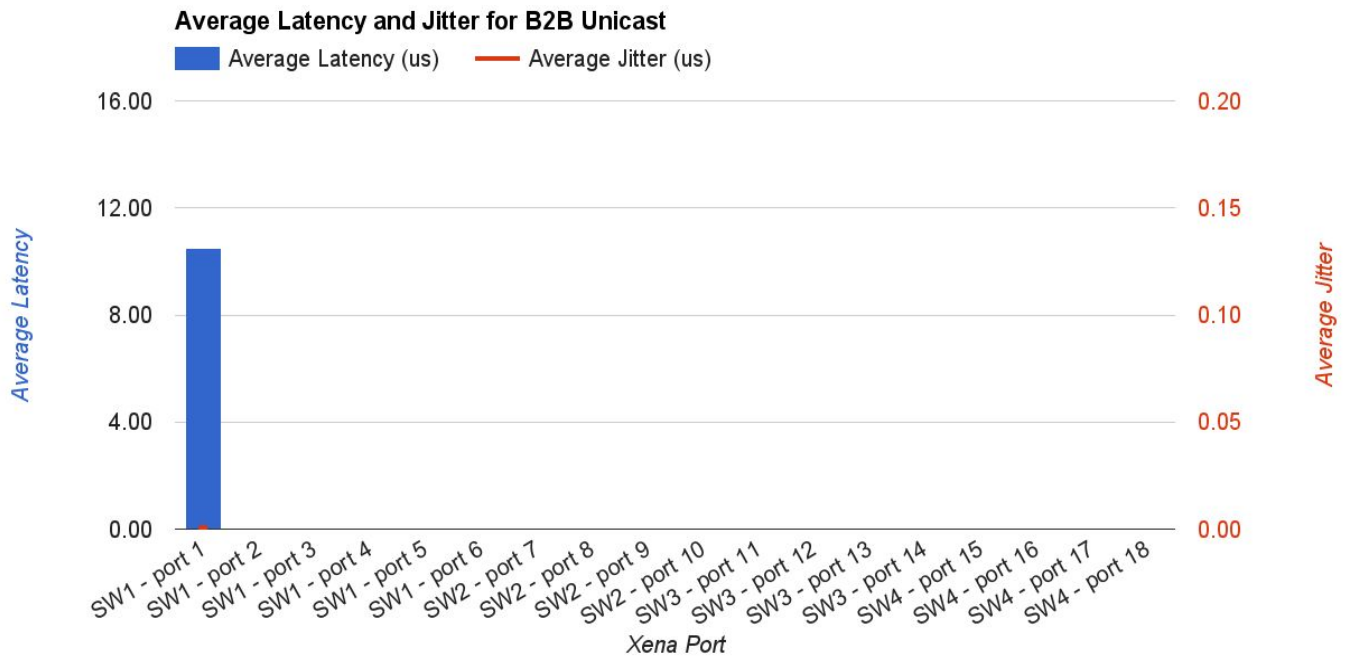


The maximum latency of the unicast stream from port 3 to port 18 via 4 WR switch is approximate 45us. The maximum jitter is 34us. They meet the DM Unicast requirements of the WR network for FAIR.

### 2.1.3.3 Latency and Jitter of B2B Unicast frames

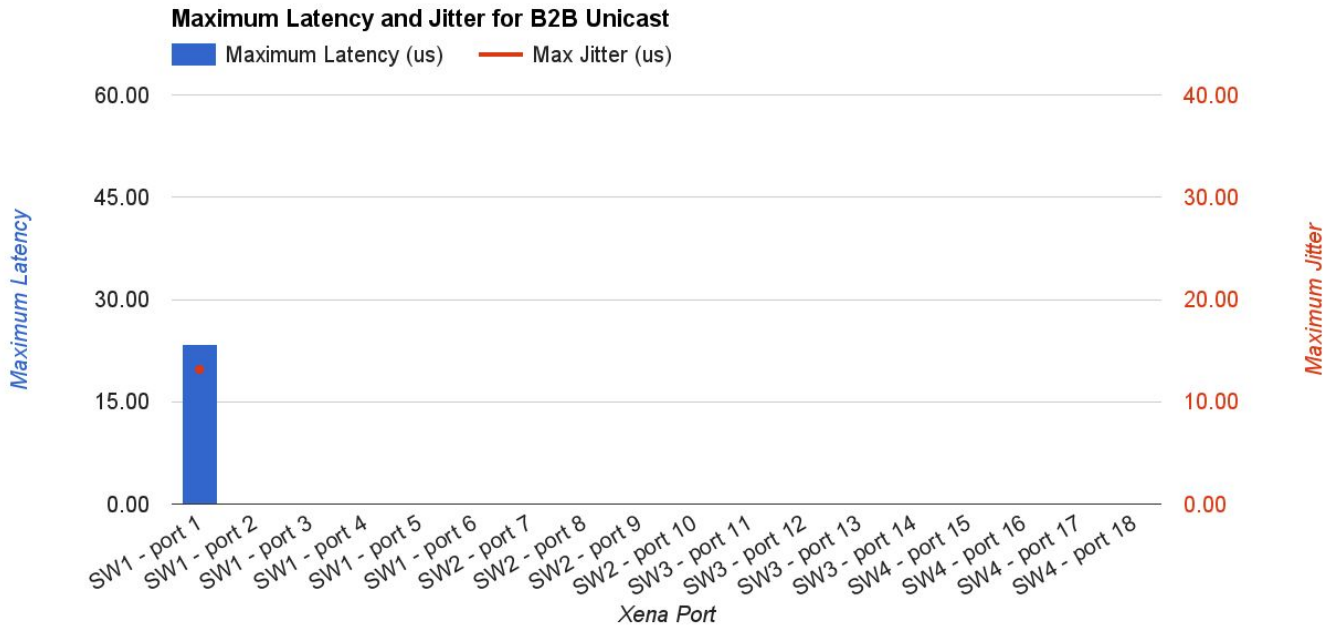
For the B2B Unicast frames, the latency and jitter of the stream from port 17 to port 1 are measured.

#### 2.1.3.3.1 Average Latency and Jitter



The average latency of the unicast stream from port 17 to port 1 via 4 WR switch is approximate 11us. The average jitter is 1ns. They meet the DM Unicast requirement of the WR network for FAIR.

### 2.1.3.3.2 Maximum/Minimum Latency and Jitter

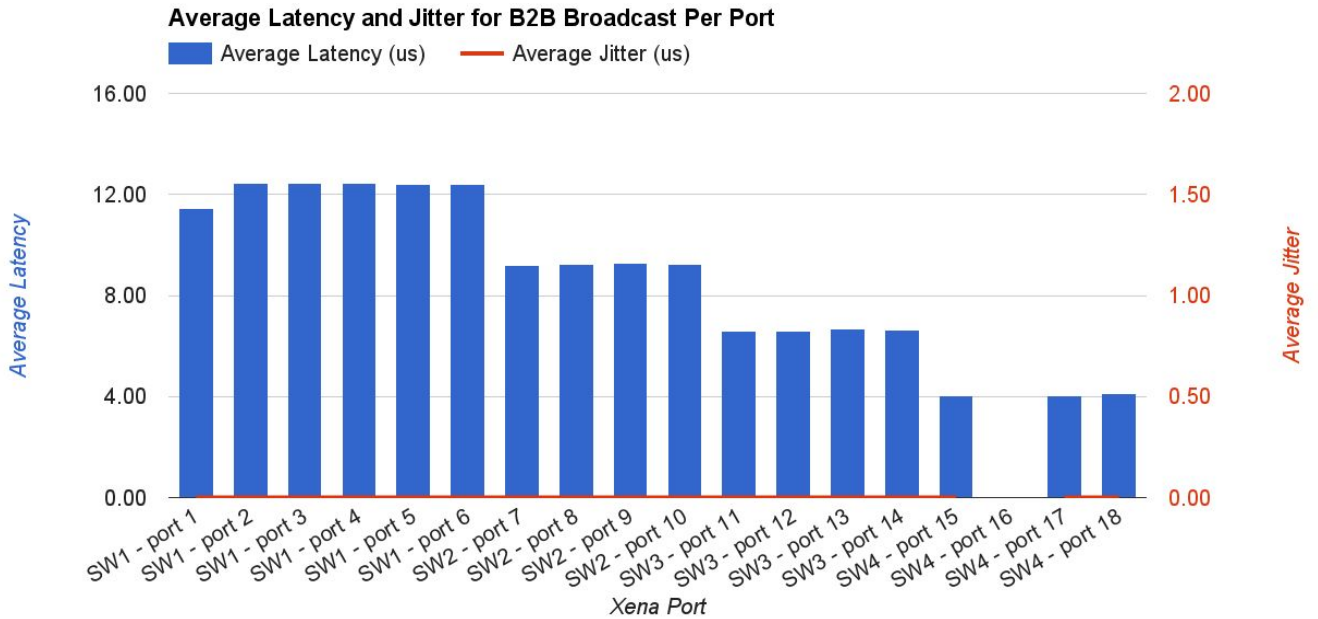


The maximum latency of the unicast stream from port 17 to port 1 via 4 WR switch is approximate 24us. The maximum jitter is 14us. They meet the DM Unicast requirements of the WR network for FAIR.

### 2.1.3.4 Latency and Jitter of B2B Broadcast frames

For the B2B Broadcast frames, the latency and jitter of the stream from port 16 to other ports are measured.

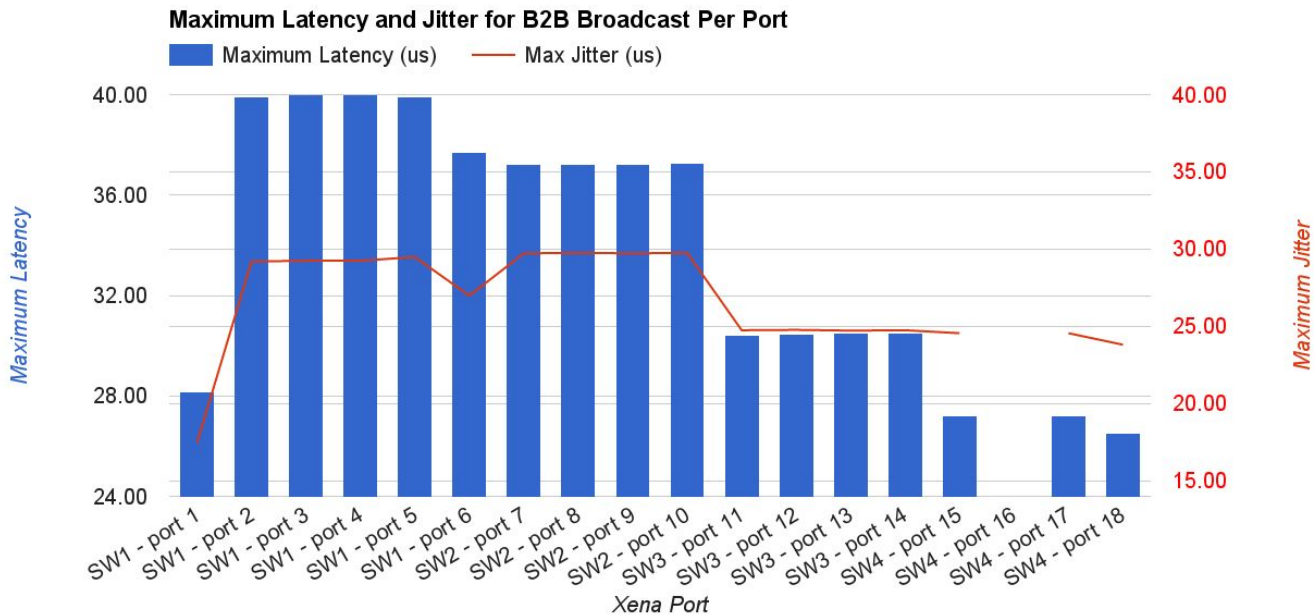
#### 2.1.3.4.1 Average Latency and Jitter



Layer of WR Switches	Avg Latency	Avg Jitter
1	4us	0us
2	7us	0us
3	10us	0us
4	13us	0us

They meet the B2B Broadcast requirements of the WR network for FAIR.

2.1.3.4.2 Maximum/Minimum Latency and Jitter



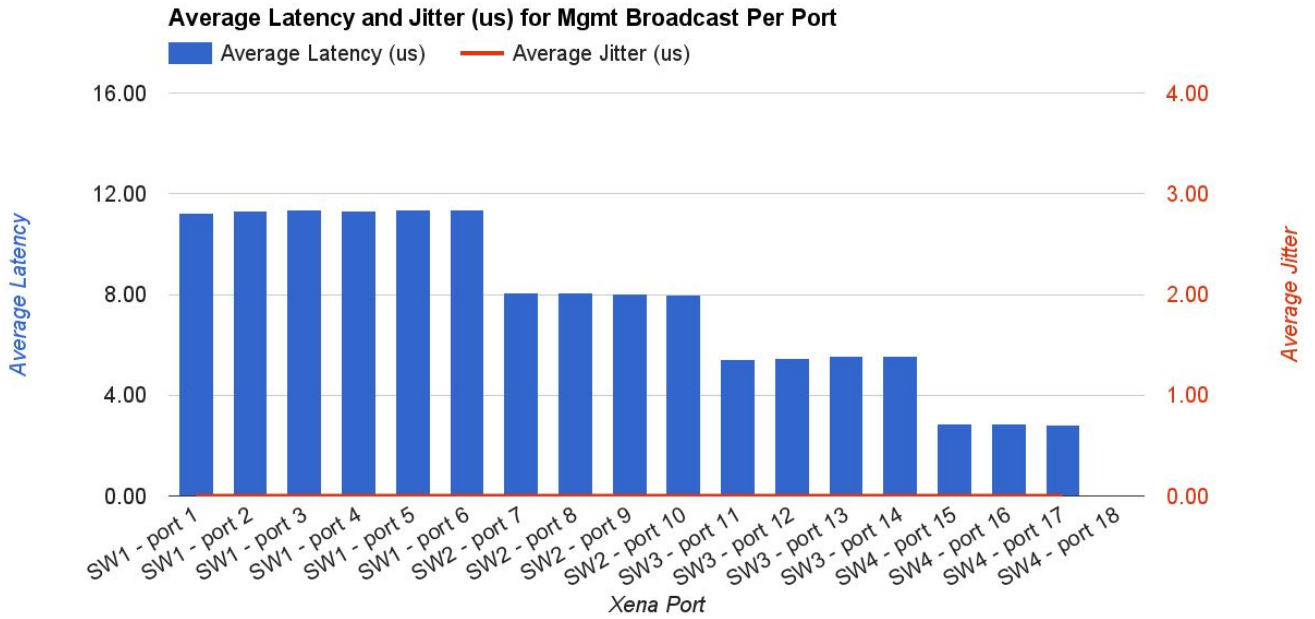
Layer of WR Switches	Max Latency	Max Jitter
1	27us	25us
2	31us	25us
3	38us	30us
4	40us	30us

They meets the B2B Broadcast requirements of the WR network for FAIR.

2.1.3.5 Latency and Jitter of Mgmt Traffic frames

For the Mgmt Traffic frames, the latency and jitter of the stream from port 18 to other ports are measured.

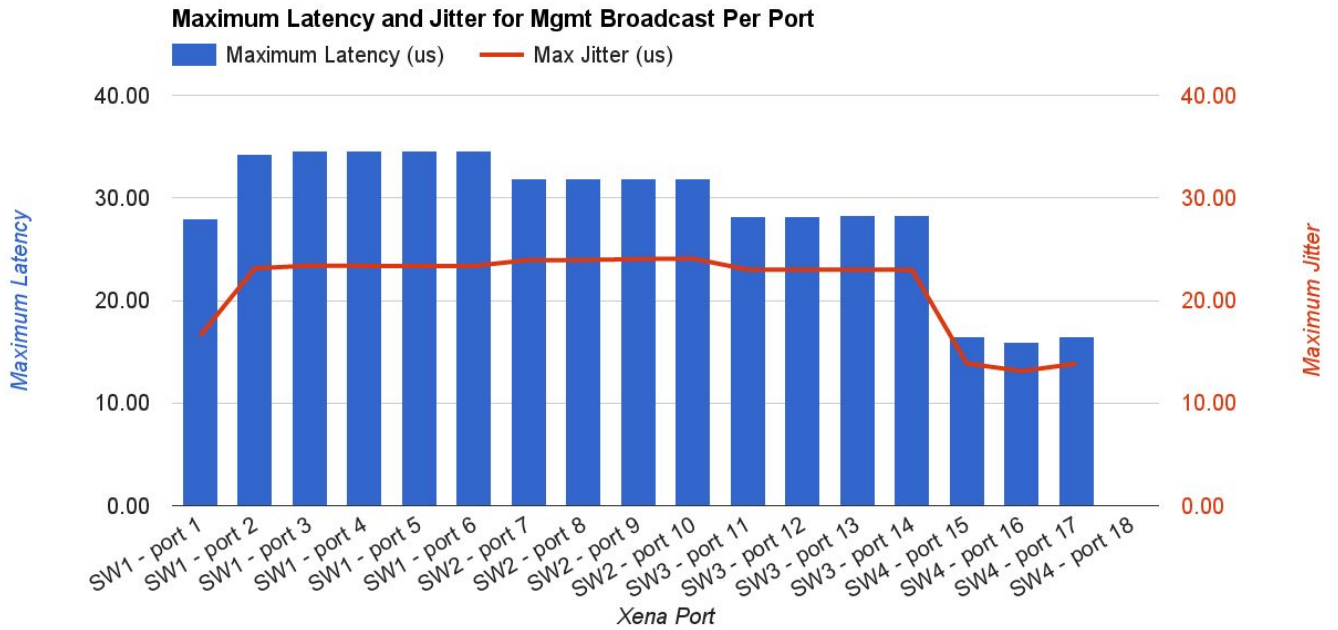
2.1.3.2.1 Average Latency and Jitter



Layer of WR Switches	Avg Latency	Avg Jitter
1	3us	0us
2	6us	0us
3	9us	0us
4	12us	0us

They meet the Mgmt Traffic requirement of the WR network for FAIR.

2.1.3.2.2 Maximum/Minimum Latency and Jitter



Layer of WR Switches	Max Latency	Max Jitter
1	17us	13us
2	29us	24us
3	32us	24us
4	35us	24us

They meets the Mgmt Traffic requirements of the WR network for FAIR.

## 2.1.4 Result and Conclusion

- Frame loss rate: The 4 layers WR switch network losses frames of DM Broadcast, DM Unicast, B2B Broadcast, B2B Unicast and Mgmt Traffic.

	DM Broadcast	DM Unicast	B2B Unicast	B2B Broadcast	Mgmt Traffic
Frame Loss Rate	0.044%~0.054%	0.053%	0.056%	0.045%~0.057%	0.054%~0.056%

- Misorder frame Rate: The 4 layers WR switch network has misorder frame of DM Broadcast, DM Unicast and B2B Broadcast traffic.

	DM Broadcast	DM Unicast	B2B Unicast	B2B Broadcast	Mgmt Traffic
Misorder Frame Rate	$0\sim 7.3\times 10^{-7}$	$7.1\times 10^{-6}$	0	$0\sim 9.5\times 10^{-6}$	0

- Latency and jitter

	DM Broadcast	DM Unicast	B2B Unicast	B2B Broadcast	Mgmt Traffic
Average Latency	3us/switch	3us/switch	3us/switch	4us/switch	3us/switch
Maximum Latency	30us/switch	12us/switch	6us/switch	27us/switch	17us/switch
Average Jitter	2ns/switch	0ns/switch	1ns/switch	0ns/switch	0ns/switch
Maximum Jitter	28us/switch	9us/switch	4us/switch	25us/switch	13us/switch

Although the latency and jitter meet the requirements of the FAIR WR network, the 4 layers WR network without VLAN can not be used because of the following reasons.

- 1) There exists the frame loss of DM Broadcast, DM Unicast, B2B Broadcast, B2B Unicast and Mgmt Traffic frames.
- 2) There exists the misorder frame error of DM Broadcast, DM Unicast and B2B Broadcast traffic.

## 2.2 Test of 4 WR switch network with VLAN

Test Date and Time:	2016-08-10, 10:19
Test Duration:	02:55:17 (h:m:s)
Test WR switch	Seven Solutions

A VLAN<sup>11</sup> is a group of timing nodes in the WR network that is logically segmented by function or application, without regard to the physical locations of the timing nodes. For the WR network for FAIR, three VLANs with different priority are applied. Here we list all VLANs based on their application. According to the importance of the frames, we assign FAIR WR network traffic to proper VLANs and priorities.

- DM Broadcast VLAN - VLAN 7 with priority 7 is used for this VLAN in the test
- DM Unicast VLAN - VLAN 7 with priority 7 is used for this VLAN in the test
  - DM Unicast
  - B2B Unicast
- B2B Broadcast VLAN - VLAN 6 with priority 6 is used for this VLAN in the test
- Mgmt Traffic VLAN - VLAN 5 with priority 5 is used for this VLAN in this document

### 2.2.1 Test Setup

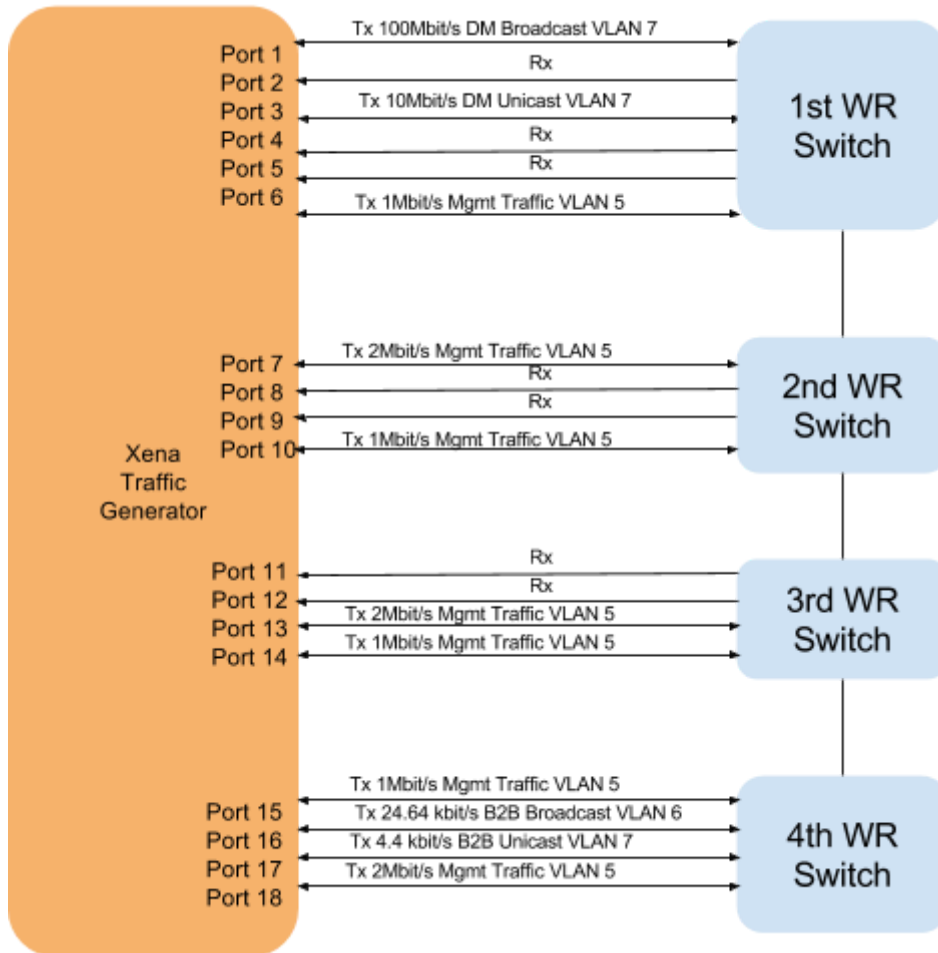
Switch	Traffic Gen. Xena Port	Traffic	VLAN	Prio	App
1 Layer WR Switch	Port 1	Tx 100 Mbit/s 110 bytes	7	7	<b>DM Broadcast</b>
	Port 3	Tx 10 Mbit/s 110 bytes	7	7	<b>DM Unicast</b>
	Port 2, 4 & 5	Rx Traffic	-	-	Xena Measurement
	Port 6	1 Mbit/s 64 - 1518 bytes	5	5	Mgmt Traffic
2 Layer WR Switch	Port 7	2 Mbit/s 64 - 1518 bytes	5	5	Mgmt Traffic
	Port 8 & 9	Rx Traffic	-	-	Xena Measurement
	Port 10	1 Mbit/s 64 - 1518 bytes	5	5	Mgmt Traffic

<sup>11</sup> Virtual Local Area Network  
[https://en.wikipedia.org/wiki/Virtual\\_LAN](https://en.wikipedia.org/wiki/Virtual_LAN)



3 Layer WR Switch	Port 11 & 12	Rx Traffic	-	-	Xena Measurement
	Port 13	2 Mbit/s 64 - 1518 bytes	5	5	Mgmt Traffic
	Port 14	1 Mbit/s 64 - 1518 bytes	5	5	Mgmt Traffic
4 Layer WR Switch	Port 15	1 Mbit/s 64 - 1518 bytes	5	5	Mgmt Traffic
	Port 16	24.64 kbit/s 110 bytes	6	6	<b>B2B Broadcast</b>
	Port 17	4.4 kbit/s 110 bytes	7	7	<b>B2B Unicast</b>
	Port 18	2 Mbit/s 64 - 1518 bytes	5	5	Mgmt Traffic

All ports of 4 WR switches are assigned to three VLANs, VLAN 5, VLAN 6 and VLAN 7. The configuration of the ports is in our repository<sup>12</sup>.

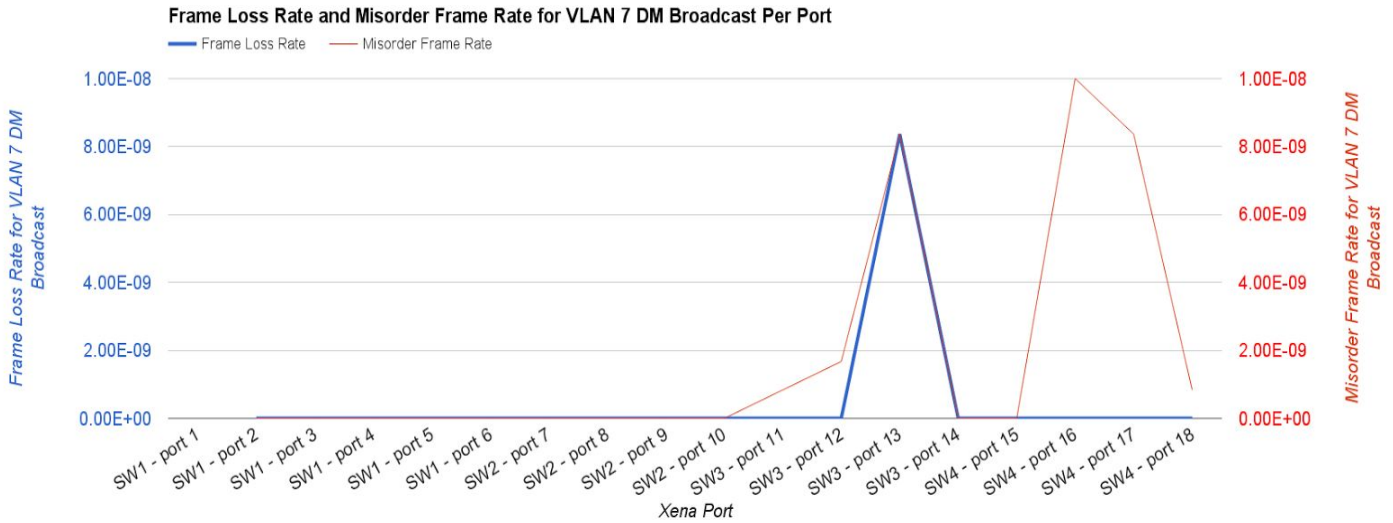


<sup>12</sup> [https://github.com/GSI-CS-CO/network\\_testing](https://github.com/GSI-CS-CO/network_testing)  
network\_testing/GSI\_Use\_Case\_test/Test\_with\_VLAN/Configuration/Switch/VLAN\_config.sh.txt

## 2.2.2 Frame Loss Rate and Misorder Frame Rate Test Result

### 2.2.2.1 Frame Loss Rate and Misorder Frame Rate for VLAN 7 DM Broadcast

The frame loss rate and the misorder frame rate of the stream from port 1 to other ports are measured.

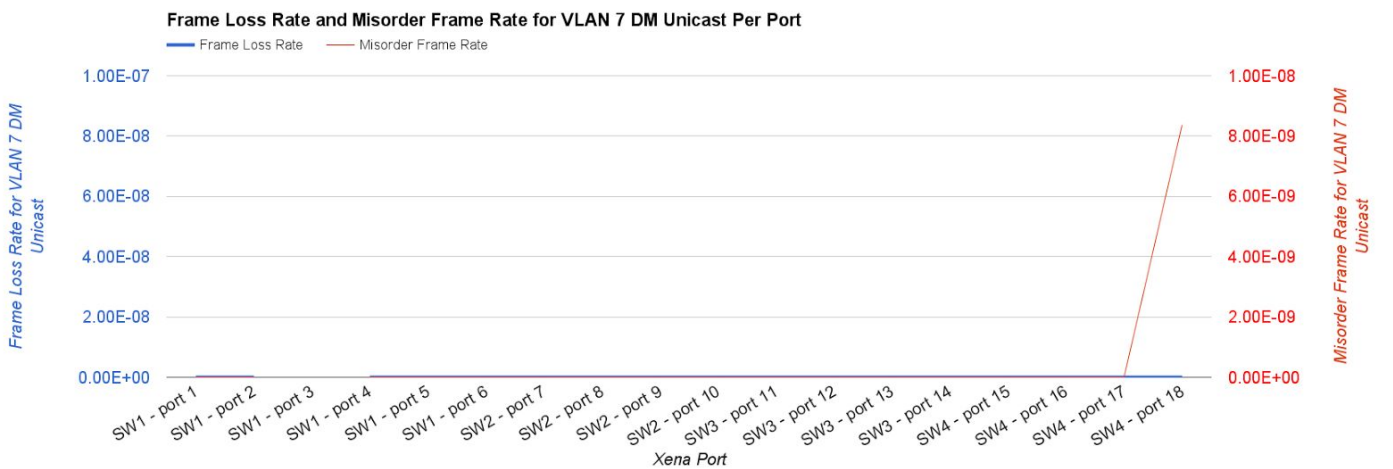


For the WR switch 1, 2 and 4, the frame loss rate of every port is 0. For the WR switch 3, the frame loss rate of port 13 is  $8.4 \times 10^{-9}$ . It does not meet the DM Broadcast requirements of the WR network for FAIR.

For the WR switch 1 and 2, the misorder frame rate of every port is 0. For the WR switch 3, the misorder frame rate of each port is between 0 and  $8.4 \times 10^{-9}$ . For the WR switch 4, the misorder frame rate of each port is between 0 and  $1.0 \times 10^{-8}$ . It does not meet the DM Broadcast requirements of the WR network for FAIR.

### 2.2.2.2 Frame Loss Rate and Misorder Frame Rate for VLAN 7 DM Unicast

The frame loss rate and the misorder frame rate of the stream from port 3 to port 18 are measured.



There is no frame loss of the stream. It meets the DM Unicast requirements of the WR network for FAIR.

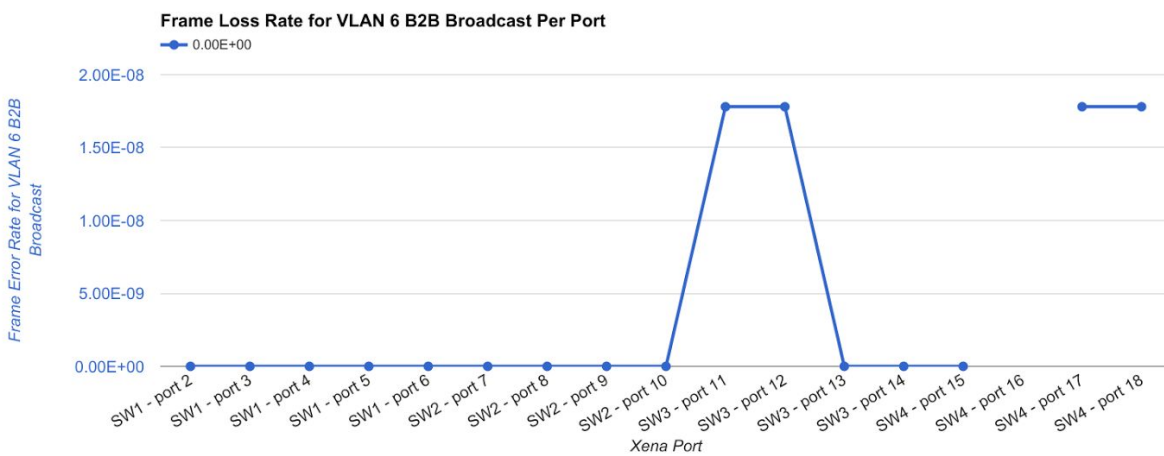
The misorder frame rate of the stream from port 3 to port 18 is  $8.4 \times 10^{-9}$ . It does not meet the DM Unicast requirements of the WR network for FAIR.

### 2.2.2.2 Frame Loss Rate and Misorder Frame Rate for VLAN 7 B2B Unicast

The frame loss rate and the misorder frame rate of the stream from port 17 to port 1 are measured. There is no frame loss and no misorder frame error.

### 2.2.2.2 Frame Loss Rate and Misorder Frame Rate for VLAN 6 B2B Broadcast

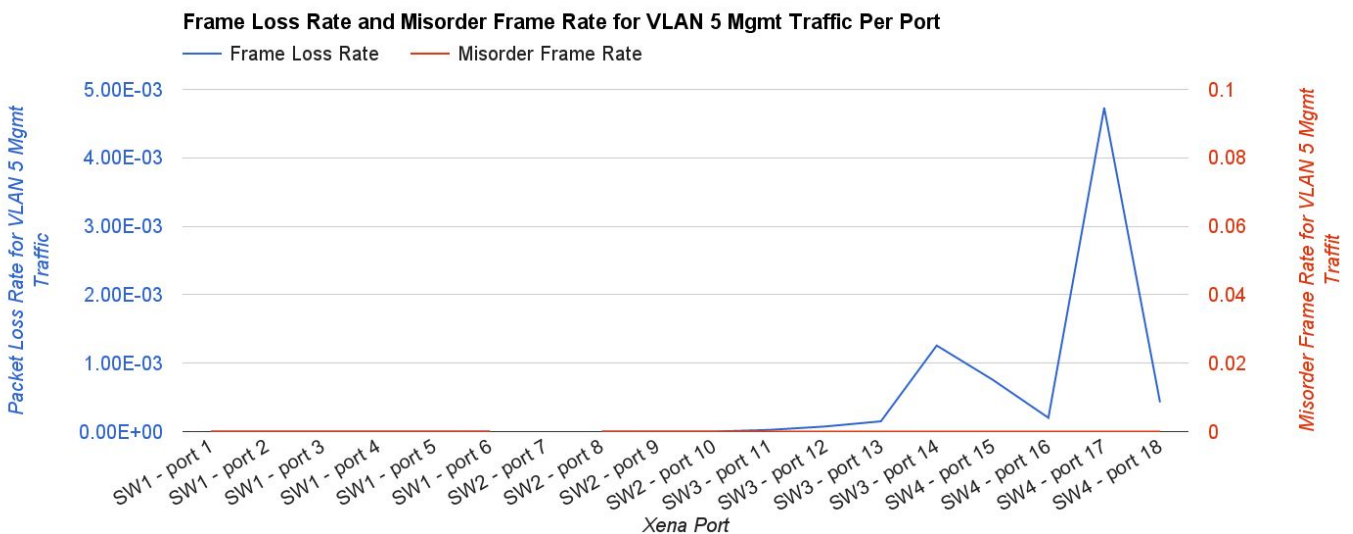
The frame loss rate and the misorder frame rate of the stream from port 16 to other ports are measured.



There is no misorder frame and the lost frame is  $1.8 \times 10^{-8}$ . The lost frame doesn't meet the requirement.

### 2.2.2.2 frame Loss Rate and Misorder Frame Rate for VLAN 5 Mgmt Traffic

The frame loss rate and the misorder frame rate of the stream from port 7 to other ports are measured.



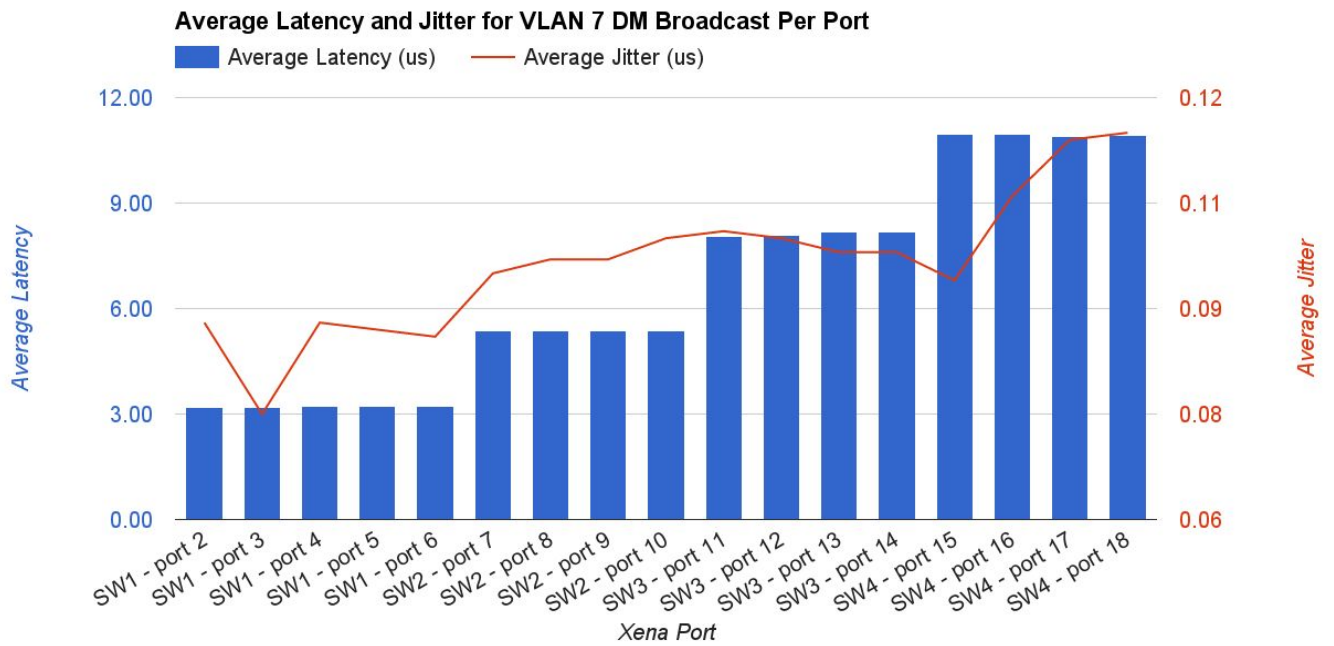
For the WR switch 1 and 2, the frame loss rate of every port is 0. For the WR switch 3, the frame loss rate is between  $2.5 \times 10^{-5}$  and  $1.3 \times 10^{-3}$ . For the WR switch 4, the frame loss rate of port 13 is between  $2.0 \times 10^{-4}$  and  $4.8 \times 10^{-3}$ . There exists no disorder frame error for all ports.

## 2.2.3 Latency and Jitter Test Result

### 2.2.3.1 Latency and Jitter of VLAN 7 DM Broadcast

The latency and jitter of the stream from port 1 to other ports are measured.

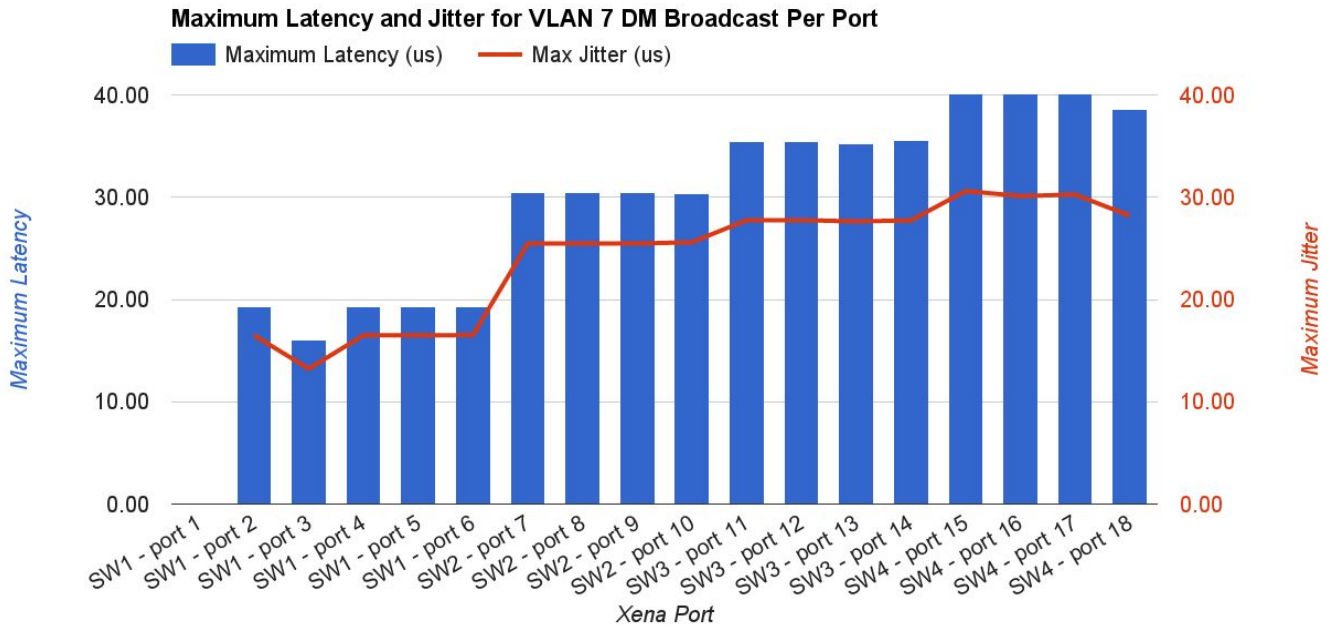
#### 2.2.3.1.1 Average Latency and Jitter



Layer of WR Switches	Avg Latency	Avg Jitter
1	4us	0.09us
2	5us	0.11us
3	8us	0.11us
4	11us	0.12us

They meet the DM Broadcast requirements of the WR network for FAIR.

### 2.2.3.1.2 Maximum/Minimum Latency and Jitter



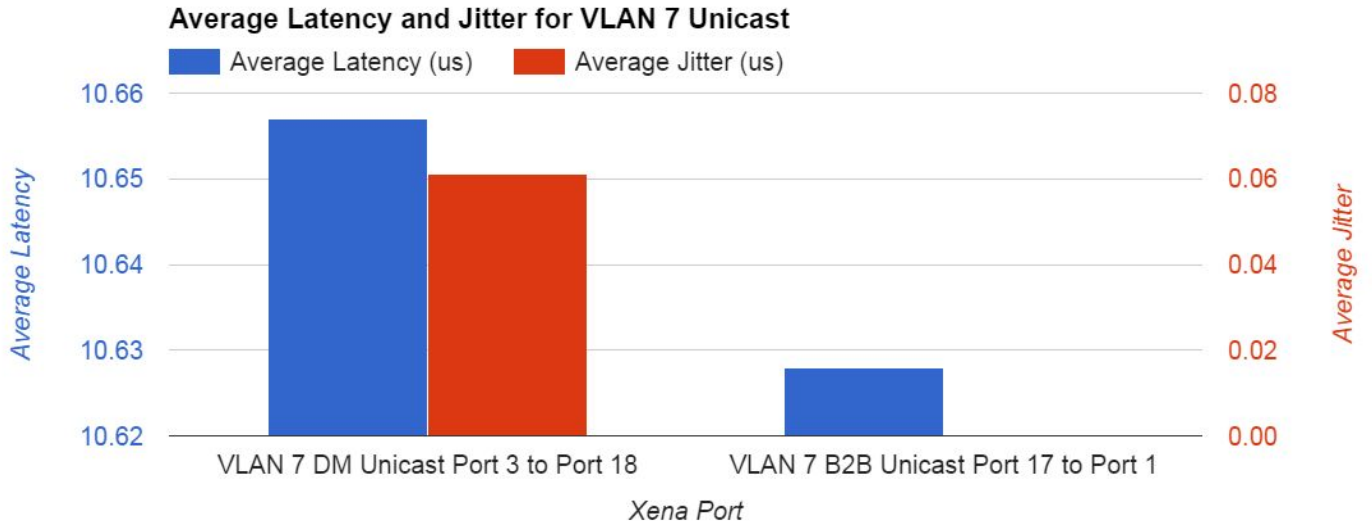
Layer of WR Switches	Max Latency	Max Jitter
1	20us	17us
2	31us	26us
3	36us	28us
4	42us	31us

They meets the DM Broadcast requirements of the WR network for FAIR.

### 2.2.3.2 Latency and Jitter of VLAN 7 DM Unicast

For the VLAN 7 DM unicast, the latency and jitter of the stream from port 3 to port 18 are measured. For the VLAN 7 B2B unicast, the latency and jitter of the stream from port 16 to port 1 are measured.

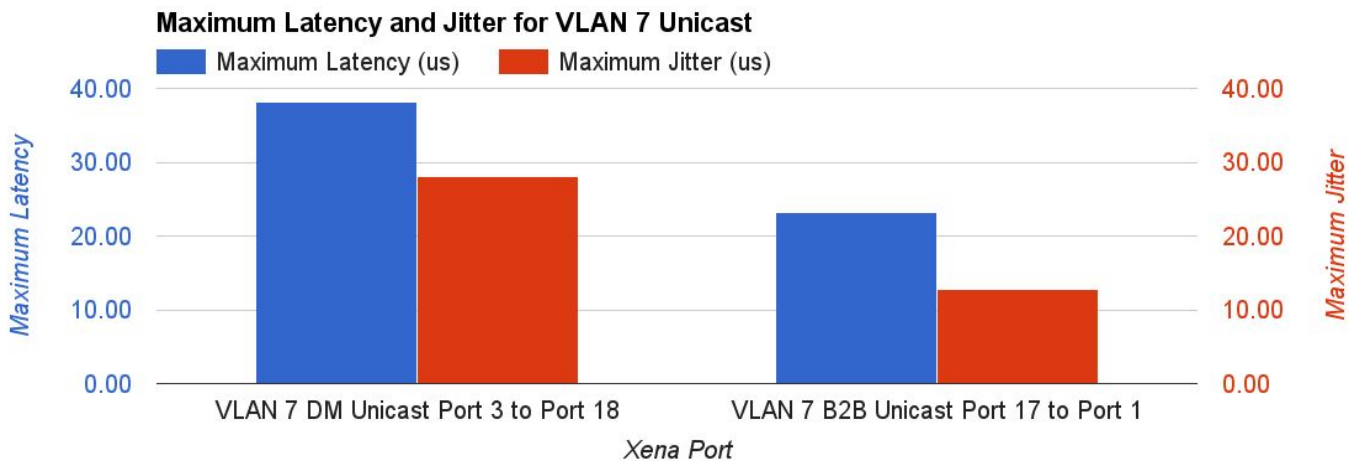
### 2.2.3.2.1 Average Latency and Jitter



For the DM Unicast frames in VLAN 7, 4 WR switch network has approximate 11 us average latency and 60ns average jitter. They meets the DM Unicast requirements of the WR network for FAIR.

For the B2B Unicast frames in VLAN 7, 4 WR switch network has approximate 11 us average latency and 0ns average jitter. They meets the B2B Unicast requirements of the WR network for FAIR.

### 2.2.3.2.2 Maximum/Minimum Latency and Jitter

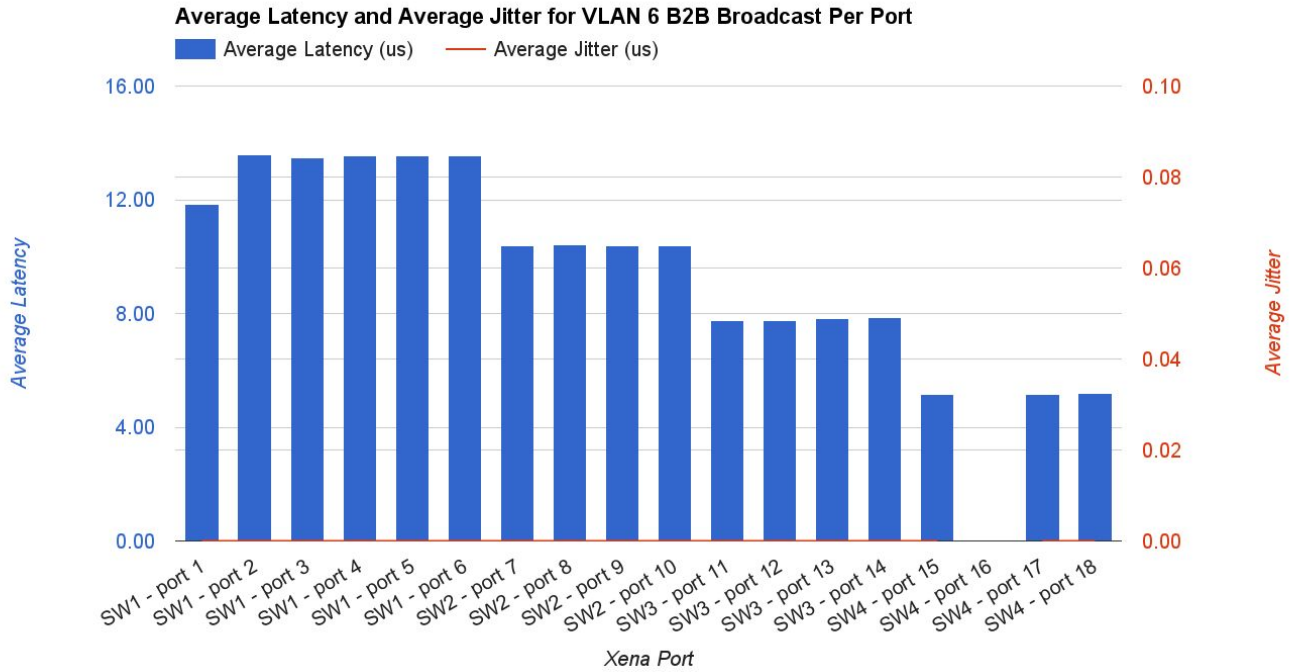


For the VLAN 7 B2B unicast, the maximum latency for 4 WR switch network is approximate 23 us and the maximum jitter is 13us. For the VLAN 7 DM unicast, the maximum latency for 4 WR switch network is approximate 39 us and the maximum jitter is 28us. It meets the DM Unicast requirements of the WR network for FAIR.

### 2.2.3.3 Latency and Jitter of VLAN 6 B2B Broadcast

The latency and jitter of the stream from port 16 to other ports are measured.

#### 2.2.3.3.1 Average Latency and Jitter

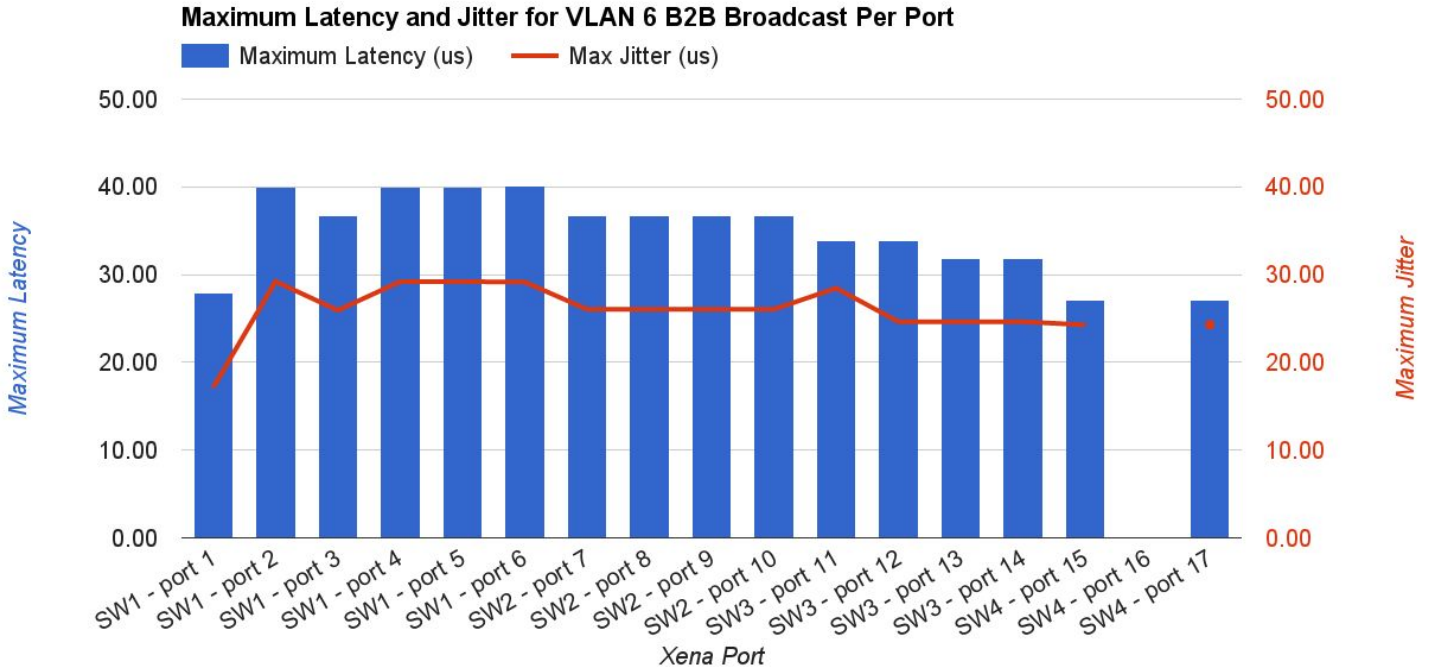


Layer of WR Switches	AvgLatency	Avg Jitter
1	6us	0us
2	8us	0us
3	11us	0us
4	14us	0us

The port 1 does not receive the higher priority 100Mbit/s VLAN 7 frames, so the average latency of the port 1 is relative shorter. The average latency and jitter meet the B2B Broadcast requirements of the WR network for FAIR.



2.2.3.3.2 Maximum/Minimum Latency and Jitter



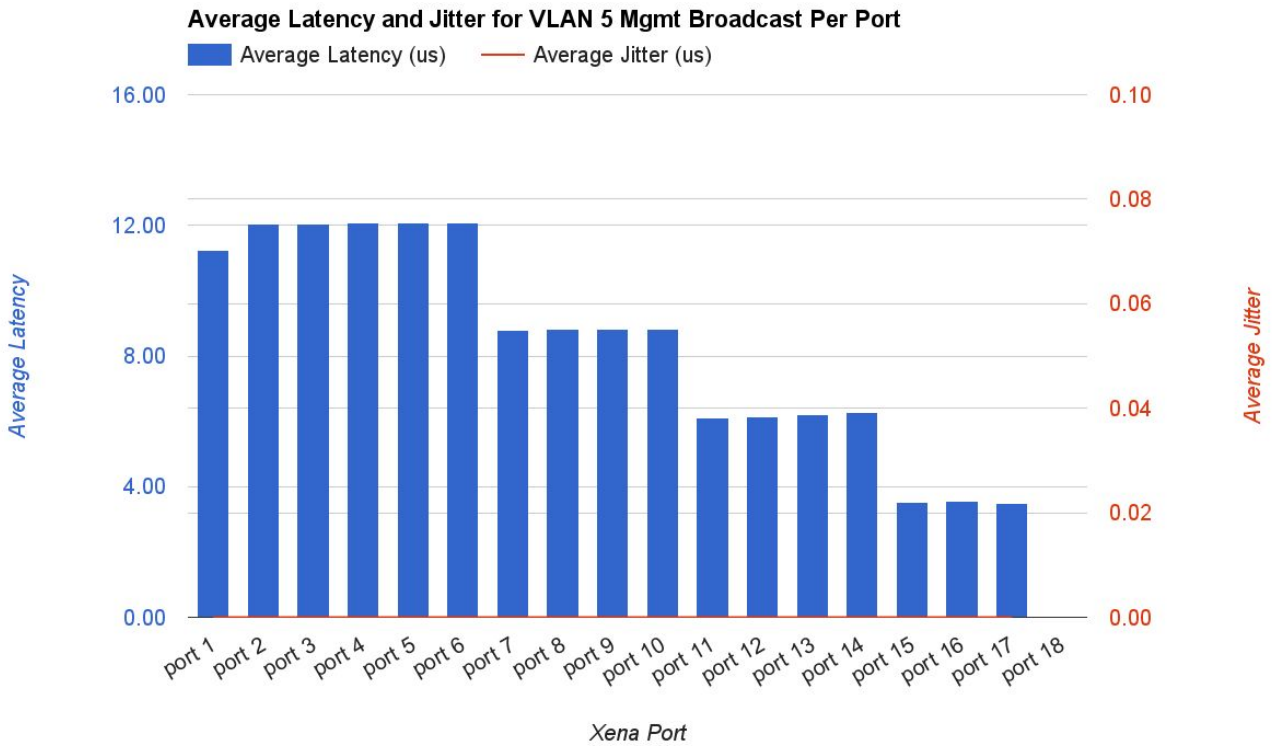
Layer of WR Switches	Max Latency	Max Jitter
1	28us	25us
2	34us	25us
3	37us	27us
4	41us	30us

They meet the B2B Broadcast requirements of the WR network for FAIR.

### 2.2.3.4 Latency and Jitter of VLAN 5 Mgmt Traffic

The latency and jitter of the stream from port 18 to other ports are measured.

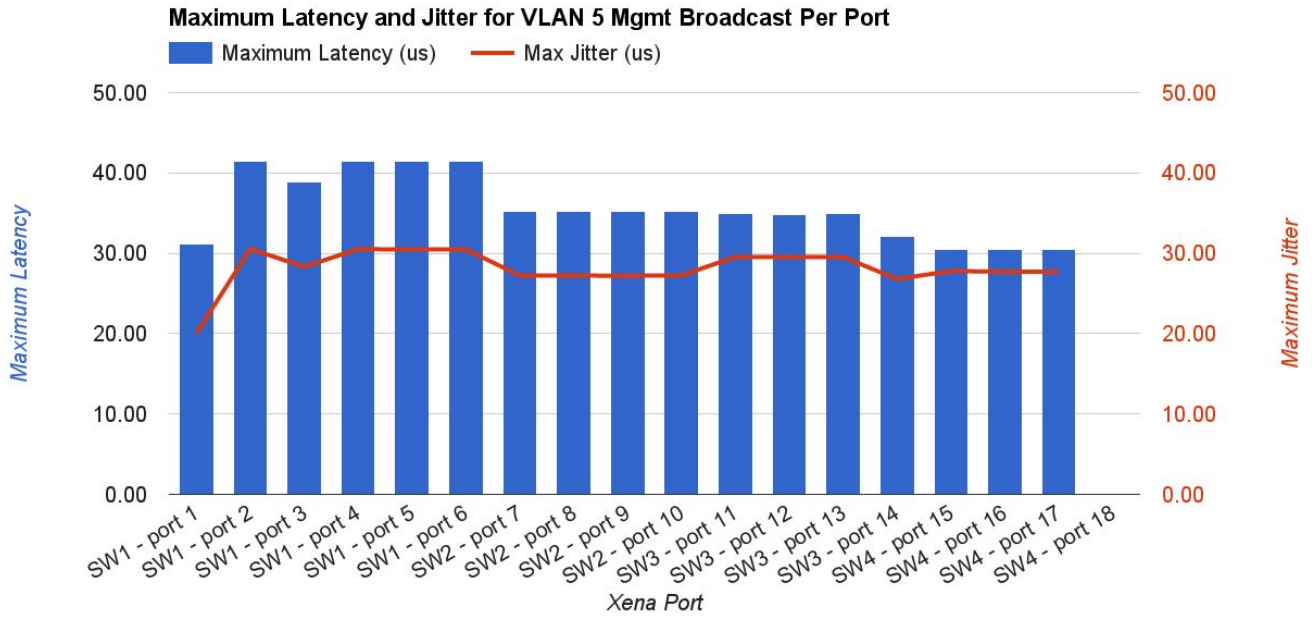
#### 2.2.3.2.1 Average Latency and Jitter



Layer of WR Switches	Avg Latency	Avg Jitter
1	4us	0us
2	7us	0us
3	10us	0us
4	12us	0us

They meets the Mgmt Traffic requirements of the WR network for FAIR.

2.2.3.4.2 Maximum/Minimum Latency and Jitter



Layer of WR Switches	Max Latency	Max Jitter
1	31us	28us
2	35us	30us
3	36us	28us
4	42us	31us

They meet the Mgmt Traffic requirements of the WR network for FAIR.

## 2.2.4 Result and Conclusion

- Frame loss rate: The 4 layers WR switch network has the frame loss of Mgmt Traffic and DM Broadcast traffic.

Frame Loss Rate	DM Broadcast VLAN 7	DM Unicast VLAN 7	B2B Unicast VLAN 7	B2B Broadcast VLAN 6	Mgmt Traffic VLAN 5
	0%~ $8.4 \times 10^{-7}$ %	0%	0%	$1.8 \times 10^{-6}$ %	0%~0.48%

- Misorder frame Rate: The 4 WR switch network has misorder frame of DM Broadcast and DM Unicast traffic.

Misorder Frame Rate	DM Broadcast VLAN 7	DM Unicast VLAN 7	B2B Unicast VLAN 7	B2B Broadcast VLAN 6	Mgmt Traffic VLAN 5
	0~ $1.0 \times 10^{-8}$	$8.4 \times 10^{-9}$	0	0	0

- Latency and Jitter

	DM Broadcast VLAN 7	DM Unicast VLAN 7	B2B Unicast VLAN 7	B2B Broadcast VLAN 6	Mgmt Traffic VLAN 5
Average Latency	4us/switch	3us/switch	3us/switch	6us/switch	4us/switch
Maximum Latency	20us/switch	10us/switch	7us/switch	28us/switch	31us/switch
Average Jitter	100ns /switch	15ns/switch	0ns/switch	0ns/switch	0ns/switch
Maximum Jitter	17us/switch	7us/switch	4us/switch	25us/switch	28us/switch

From the viewpoint of the latency and jitter, the 4 layers WR network with VLAN meets the requirements. But it can not be used because of the following reasons.

- 1) There exists the frame loss of DM Broadcast and B2B Broadcast.
- 2) There exists misorder frame error of DM Broadcast and DM Unicast traffic.

## 2.3 Comparison of the 4 layers WR switch network without VLAN and with VLAN

Although neither the 4 WR switch network without VLAN nor that with VLAN meet the requirements of the FAIR timing network, there are some improvement of the 4 layer WR network with VLAN compared with the 4 layer WR network without VLAN.

- 1) DM Broadcast and B2B Broadcast traffic have fewer frame losses.
- 2) DM Unicast and B2B Unicast traffic have no frame losses.
- 3) DM Broadcast and DM Unicast traffic have less disorder frame errors.
- 4) B2B Broadcast traffic has no disorder frame errors.
- 5) Although the maximum latency of the DM Unicast, B2B Unicast and B2B Broadcast frame is almost same as that of the 4 layers WR network without VLAN, the maximum latency of the DM Broadcast frame is shorter.