

Enabling a Converged World™

# **Testing Timing Synchronization for IP/Ethernet Mobile Backhaul** Nov 2011



Market Drivers & Technology Review

- Test Requirements and Examples
- Industry Programs





#### Market Drivers: All IP/Carrier Ethernet (CE) Mobile Backhaul

- Mobile broadband traffic
- HSPA+
- LTE planning
- Mobile backhaul cost reduction
- IP RAN deployment
- Fixed Mobile Convergence (FMC)



Source: Mobile Backhaul Equipment and Services, Infonetics, July 16th 2009



#### Infonetics: Global Service Provider Survey (March 2011)

- I00% of service provider respondents deployed IP/Ethernet somewhere in their backhaul network in 2010
  - Most deployments were 'hybrid', retaining TDM for voice due to clock synchronization requirements
- 79% of service providers plan to move to a single Ethernet mobile backhaul for carrying all traffic
- I50 operators are actively deploying a single (no TDM), all-IP/Ethernet backhaul in 2011



### 58% of respondents deploying IEEE 1588v2 by 2013

# IEEE 1588v2 achieves synchronization requirements for IP/Ethernet Mobile Backhaul



#### IEEE 1588v2

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- Enables frequency, phase and time-of-day synchronization
- Improves clock accuracy and stability to satisfy wireless standards



Clock

- Clock info is distributed using dedicated timing packets (PTP) between Master and Slave (Master-Slaves)
- IEEE 1588v2, introduced two new logical device types that are commonly built into switches and routers:

Grandmaster

Reference 1. **Boundary Clocks** (Improve system scalability) Packet Backhau 2. **Transparent Clocks** (Correct for network delays) Transparer ansparent Clock Transparent Clock

**IEEE 1588v2 Transparent Clocks** 



- Ethernet switches between the Master and Slave introduce asymmetric and variable packet delays, which impair accuracy!
- Transparent Clocks (TCs) are switches that insert a Correction Factor into PTPv2 packets
- This mitigates the effect of the switch's own packet residence time (forwarding delay)
- However

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- Correction factor errors are real
- May impair slave clock tracking
- Ixia measures CF error and latency asymmetry in real time





Boundary Clocks (BCs) act as slaves to one domain, and masters to others

- This scales better in large systems and also mitigates the residence time problem
- However...
  - Scalability is a huge challenge when there are many slaves and other control-plane traffic
  - Best Master Clock Selection can go wrong, leaving slaves in disagreement about the time





# Market Drivers & Technology Review Test Requirements and Examples

Industry Programs



#### Conformance and Validation

- Verify proper protocol exchange
- Verify synchronization with expected results
  - Synchronization with impairments (within the allowed thresholds)
  - Negative testing: loss of synchronization outside the allowed thresholds
- Verify Grand Master Selection algorithm

#### Interoperability

• Ensure different vendor implementations can interwork

#### Scalability Tests

Benchmark ability to achieve synchronization across many nodes (1000's)

#### 'Multi-dimensional' Performance Testing

- Verify PTP Message prioritization under max rate data traffic load:
  - Testing PTP traffic prioritization and delivery under different traffic loads while characterizing synchronization parameters
- Validate Transparent Clock Correction Factor
  - Measure correction factor under different traffic loads



#### Example: Conformance and Validation Test Best Master Selection

Do downstream nodes select the best master?



#### Example: Multi-vendor Interoperability Test IEEE 1588v2 (Ordinary Clocks)

CEWC 2011: EANTC Interoperability Showcase (Amsterdam, Sept 2011)



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PTP Protocol Interoperability Test

Source: EANTC Whitepaper www.eantc.com

- Success interoperability achieved between Ericsson, NSN and Ixia (Slave Emulation)
- Interoperability not achieved between other vendors due to differing features



Add slave nodes until clock drifts out of tolerance





#### Ixia/Alcatel-Lucent Case Study and Live Demo (MWC 2011, Barcelona)

#### **Objective:**

Demonstrate the scalability & accuracy of the 7705 SAR boundary clock implementation under network traffic load

#### **Results:**

- ✓ Synchronization to Grandmaster Clock
- ✓ Synchronization with 100 Slave Clocks
- ✓ Traffic forwarding requirements met
- ✓ Robust under negative conditions





#### Example Multi-dimensional Performance Test : 1588v2 Boundary Clock Implementation

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💬 😂 Overview (Total: 2)		2 138.120.195.51(Card1)Port3 - 0200001	Successful	SLAVE	-21,385	66,40D	1 aa dab sod: H1: Fe: DD: D1: D4	DD: 21: D5: Ff: fe: Bac a8: 62	200,001	1 140,330	-144,695	-1	189,810
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(Tabal: D)	_	10 138.120.195.51/Card1/Port3 - 0200009	Successful	SLAVE	-100	39,440	1 18:37:38:ff:fe:a8:00:00	DD: 21:05:ff: fe: Bac all: 61	200,009	2 4,540	-4,630	a	44,040
Synchronization (Total: 0)	_	11 138.120.195.51/Card1/Port3 - 0200010	successful	SLAVE	279	35, 375	1 16(37) 36(ff) fe( a6( 00( 0)	00 21 05 M fei Sai abi 6.	200,010	z +,850	-1,585	0	11,275
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🚺 bia Slaves		14 138.120.195.51/Card1/Port3 - 0200013	Successful	SLAVE	85	39,475	1 18:37:38:ff)fera8:00:04	001211051ff1fe18ara816L	200,013	2 3,825	-3,630	0	43,205
		15 138.120.195.51/Card1/Port3 - 020001+	Successful	SLAVE	-90	39,510	1 18:37:38:ff) fei a8:00:05	00:21:05:11 fei Bai aBi 61.	200,01+	2 4,670	-4,770	0	43,970
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		17 138.120.195.51/Card1/Port3 - 0200016	Successful	SLAVE	-25	39,505	1 18:37:38:fft fei a8:00:07	001211051ff1fe18ara8161	200,016	2 4,770	-6,035	0	44,250
		18 138.120.195.51/Card1/Port3 - 0200017	Successful	SLAVE	-185	39,520	1 18/37/38/ff/fe/a8/00/08	001211051ff1fe18a1a816L	200,017	2 4,970	-6,035	0	44,170
		19 138.120.195.51/Card1/Port4 - 0400000	Successful	SLAVE	125	30,655	1 88 00 cd ff fei 04 00 01	00 1a f0 ff fei ed 32 fi	+00,000	3 137,745	-137,805	0	168,575
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		26 138.120.195.51/Card1/Port4 - 04000007	Sucomful	SLAVE	-10	25,060	1 aaddb scf: ff: fe: D4: DD: D1	DD: 1 a: FD: FF: Fe: eck 32: FL	400,007	4 3,975	-4,035	a	29,200
		27 138.120.195.51/Card1/Port4 - D4000005	Successful	SLAVE	-65	25,085	1 aaddb scf: ff: fe: D4: DD: D2	DD: 1 ac fD: ff: fe: eck 32: fl.	400,008	4 4,340	-4,400	a	29,375
		28 138.120.195.51/Card1/Port4 - 0400009	Sucomful	SLAVE	a	25,085	1 aaddbacf:ff:fe:D4:00:03	DD: 1 ac FD: FF: Fe: exh 32: FL	400,009	4 3,960	-3,945	a	28,960
		29 138.120.195.51/Card1/Port4 - D400010	Successful	SLAVE	-55	25,08D	1 aaddbscf:ff:fe:D4:DD:D4	DD: 1 a: FD: FF: Fe: exh 32: FL	400, D1D	4 4,485	-4,455	a	29,520
		30 135.120.195.51/Card1/Port4 - 0400011	Sucomful	SLAVE	55	25,070	1 aaddboof:ff:fe:D4:DD:D5	DD: 1 ac FD: FF: Fe: eck 32: FL	400,011	4 4,815	-4,765	a	29,935
		31 138.120.195.51/Card1/Port4 - D400012	Sucomful	SLAVE	5	25,135	1 aaddboof:ff:fecD4:DD:D6	DD: 1 ac FD: FF: Fe: exh 32: FL	400, D12	4 4,710	-4,710	a	29,765
		32 138.120.195.51/Card1/Port4 - 0400013	Sucomful	SLAVE	-55	25,110	1 aaddb scf:ff:fe:D4:DD:D7	DD: 1 a: FD: FF: Fe: eck 32: FL	400,013	4 4,46D	-4,590	a	29,630
		33 138.120.195.51(Card1(Port4 - D400014	Successful	SLAVE	-30	25,065	1 aaddboof:ff:fe:D4:DD:DB	DD: 1 ac FD: FF: Fe: eck 32: R.	400,014	4 4,495	-4,475	a	29,525
		34 138.120.195.51/Card1/Port4 - 0400015	Successful	SLAVE	-55	25,060	1 aaddb scf: ff: fe: D4: DD: D9	DD: 1 ac fD: ff: fe: ecb 32: fl.	400,015	4 4,475	-4,555	a	29,550
		35 138.120.195.51/Card1/Port5 - 0600000	Successful	SLAVE	-55	30,790	1 we dolp sould fift feet DEx DDx D1	DD: 1 ac fD: ff: fe: 67: pc: a*	600,000	5 116,200	-113,025	a	147,015
at Configuration		36 130(120,195,51)Card1(Port5 - 0600001	Successful	SLAVE	-25	30,740	a we dolp south H1: Her: DS: DD: D2	DD: 14:HD:H: He: 67:00: a7	600,001	5 119,105	-111,435	a	149,755
		37 136.120.195.51[Card1/Port5 - 0600002 38 139 139 155 \$1/Card1/Dort5 - 0600002	Successful	SLAVE.	-03	50,720	<ol> <li>aia 200 ccit H1 He: D5: D0: D3</li> <li>a deb sock H1 Fe: D0: D3: D4</li> </ol>	DD: 1 at FD: H1 fer 6.7; pc; af	600,002	5 109,850	-110,005	-2	141,465
etice		38 136 120 195 51 Cardi / Date - 0600003	Successful	SLAVE.	-34,403	30,210	and and account the set of the se	DD: 1 as fD: ff: fac 6.7: are a?	500,003	5 110,025	-110,350	-2	140,000
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a Meser		Page 1 of 3 Oots	al rows   1061										
	5												

Figure 7. Per slave statistics showing over 100 slaves synchronized

Source: www.ixiacom.com/1588test

#### **Example Multi-dimensional Performance Test :** 1588v2 Boundary Clock Implementation



Figure 8. Real-time measurement of offset, path delay, and traffic throughput

Source: www.ixiacom.com/1588test

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#### Example Multi-dimensional Performance Test : 1588v2 Boundary Clock Implementation



Source: www.ixiacom.com/1588test

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#### Ixia/Alcatel-Lucent Case Study and Live Demo (MWC 2011, Barcelona)

#### **Objective:**

Demonstrate transparent clock functionality under network load

#### **Results:**

- ✓ Correction Field modified for 200 slave clocks
- ✓ Synchronization operation verified



Source: <a href="http://www.ixiacom.com/1588test">www.ixiacom.com/1588test</a>



#### **Example Multi-dimensional Performance Test :** 1588v2 Transparent Clock Implementation

🟦 😂 🔚 🦄 Protocol Wizards 📑 📷	4 L2-L3 T	raffic 🕨 📕 📲 Application Traffic		🐈 New QuickTas	t 🕤 😭	🥐 🕨 🖉	@ Clear Stati	tic 🕑 Clear OP/DP State		
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Port Statistics	2	133 120 195 51 /Card 1/Port 14 - 40000	Successful	SLAVE SLAVE	-190	70,864	1	astburghtfife(16:00:01	astbookfreits:00:01	
Ty-By Frame Bate Statistics	3	133 120 195 51 (Card1/Port14 - 400001	Successful	SAVE	-196	70,000	1	aa:bb:rd:ff:fe:16:00:02	aarbbrod:ff:fe:15:00:01	
Port CPU Statistics		138.120.195.51 (Card1)Port14 - 400002	Successful	S AVE	-130	70,504	1	eachbard:ff:fe:16:00:00	aa:bb:cd:ff:fe:15:00:01	
Protocols (Total: 4)	5	138,120,195,51/Card1/Port14 - 400004	Successful	SLAVE	-342	71,270	1	aa:bb:od:ff:fe:16:00:05	aa:bb:cd:ff:fe:t5:00:01	
Duerview (Total: 2)	7	138,120,195,51/Card1/Port14 - 400005	Successful	SLAVE	20	71,064	1	aa:bb:cd:ff:fe:16:00:06	aa:bb:cd:ff:fe:15:00:01	
III Protocol Summary	8	138.120.195.51/Card1(Port14 - 400006	Successful	SLAVE	200	70,890	1	aa:bb:cd:ff:fe:16:00:07	aa:bb:cd:ff:fe:15:00:01	
III PTP Per Session	9	138,120,195,51/Card1/Port14 - 400007	Successful	SLAVE	-278	70,976	1	aa:bb:cd:ff:fe:16:00:08	aa:bb:cd:ff:fe:15:00:01	
E-Outbentirate (Total: 2)	10	138.120.195.51/Card1/Port14 - 400008	Successful	SLAVE	220	71,250	1	aa:bb:cd:ff:fe:16:00:09	aa:bb:cd:ff:fe:15:00:01	
EVER DOuth (Total: 2)	11	100.120.195.01/Card1/Park14 400009	Successful	QLAVE	224	70,970	1	earbbrod:Ff:Fe:10:00:0a	aarbbred:FF:Fe:10:00:01	
	12	138.120.195.51/Card1/Port14 - 400010	Successful	SLAVE	-28	71,022	1	aa:bb:cd:ff:fe:16:00:0b	aa:bb:cd:ff:Fe:15:00:01	
Min PTP - Al Ports	13	138.120.195.51/Card1/Port14 - 400011	Successful	SLAVE.	80	70,964	1	aa:bb:cd:ff:fe:16:00:0c	aa:bb:cd:ff:fe:15:00:01	
My custom group (Total: 1)	14	138,120,195,51/Card1/Port14 - 400012	Successful	SLAVE.	-174	71,134	1	aa:bb:cd:ff:fe:16:00:0d	aa:bb:cd:ff:fe:15:00:01	
Will Custom Graph?	15	138.120.195.51/Card1/Port14 - 400013	Successful	SLAVE	218	71,314	1	aa:bb:cd:ff:fe:16:00:0e	aa:bb:cd:ff:fe:15:00:01	
Cotom a opre	16	138.120.195.51/Card1/Port14 - 400014	Successful	SLAVE	72	71,508	1	ae:bb:cd:ff:fe:16:00:0F	aa:bb:cd:ff:Fe:15:00:01	
	17	138.120.195.51/Card1/Port14 - 400015	Successful	SLAVE	368	70,934	1	aa:bb:cd:ff:fe:16:00:10	aa:bb:cd:ff:fe:15:00:01	
	18	138,120,195,51/Card1/Port14 - 400016	Successful	SLAVE	562	71,090	1	aa:bb:cd:ff:fe:16:00:11	aa:bb:cd:ff:fe:15:00:01	
	19	138.120.195.51/Card1/Port14 - 400017	Successful	SLAVE	196	70,698	1	aa:bb:cd:ff:Fe:16:00:12	aa:bb:cd:ff:Fe:15:00:01	
	20	138.120.195.51/Card1/Port14 - 400018	Successful	SLAVE	158	71,032	1	aa:bb:cd:ff:fe:16:00:13	aa:bb:cd:ff:fe:15:00:01	
	21	138.120.195.51/Card1/Port14 - 400019	Successful	SLAVE	-466	71,230	1	aa:bb:cd:ff:fe:16:00:14	aa:bb:cd:ff:fe:15:00:01	
	22	138,120,195,51/Card1/Port14 - 400020	Successful	SLAYE	4	71,044	1	aa:bb:cd:ff:fe:16:00:15	aa:bb:cd:ff:fe:15:00:01	
	23	138.120.195.51/Card1/Port14 - 400021	Successful	SLAVE	-34	70,938	1	aa:bb:cd:ff:fe:16:00:16	aa:bb:cd:ff:fe:15:00:01	
Test Configuration	24	138.120.195.51/Card1/Port14 - 400022	Successful	SLAVE	-76	70,972	1	aa:bb:od:ff:fe:16:00:17	aa:bb:cd:ff:fe:15:00:01	
Statistics	25	L38,L20,L95,5L/Card1/PortL4 - 400023	5uccessful	SLAVE	230	70,972	1	aa:bb:cd:ff:fe:16:00:18	aa:bb:cd:ff:fe:15:00:01	
- Manakes	26	138.120.195.51/Card1/Port14 - 400024	Successful	SLAVE	356	71,316	1	aa:bb:cd:h:he:16:00:19	as:bb:cd:H:he:15:00:01	
Analyzer	27	138.120.195.51/Card1/Port14 - 400025	Successful	SLAVE	-274	71,112	1	aa:bb:od:ff:fe:16:00:1a	aa:bb:od:ff:fe:15:00:01	
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g Data Miner	E	4 4 1 🕨 🕨 Page 1 of 6 (tot:	al rows : 201)							
	2									

Figure 15. Real-time statistics for emulated grandmaster and 200 slave clocks

Source: <a href="http://www.ixiacom.com/1588test">www.ixiacom.com/1588test</a>



## Market Drivers & Technology Review

#### Test Requirements and Examples

Industry Programs





#### Completed MEF Work

MEF 22 – Mobile Backhaul Implementation Agreement Phase I

#### MEF Current Work

- Carrier Ethernet for MBH: 2011-2014
- Work in progress: supporting 4G (MBH IA Phase II)
- Whitepaper: "Best Practices for Carrier Ethernet Multiple Classes of Service in the Mobile Backhaul" (coming Dec 2011)
- Whitepaper: "Synchronization for Mobile Backhaul" (coming Nov 2011) (Co-authors: Alcatel-Lucent, Ixia, Calnex)



The defining body for Carrier Ethernet A global industry alliance accelerating the worldwide adoption of Carrier Ethernet networks and services.

The MEF develops Carrier Ethernet technical specifications and implementation agreements to to promote interoperability and the deployment of Carrier Ethernet worldwide.

Five attributes distinguish Carrier Ethernet from familiar LAN-based Ethernet for ubiquitous, standardized, carrier-class Services and Networks.





- The telecommunications industry is recognizing the need for conformance and certification for IEEE 1588 and the related ITU-T G.8265.1 telecom profile
- The IEEE 1588 Conformity Certification is the inaugural IEEE Conformity Assessment Program
- Led by industry leaders in timing and network synchronization including service providers, equipment and component manufacturers and test & measurement experts together with authorized test lab lometrix
- Ixia is on the Committee of Experts in the 1588 Conformity Alliance
- Recent activities conducted by the Alliance include the development of a comprehensive IEEE 1588 (G.8265.1) test suite
- For more information:

http://www.ieee-isto.org/icap-program

Email: certification@iometrix.









- IP/Ethernet Backhaul is necessary to support growth of mobile traffic
- Timing synchronization is the last hurdle for carrying mobile voice
- Testing must precede 1588v2 deployment in order to:
  - Evaluate tradeoffs between timing accuracy, scalability and performance
  - Ensure network-wide interoperability
  - Reduce risk to voice service reliability, quality, and SLA violation
- Test equipment is more cost-effective/reliable than building real configurations
  - Shortens the time to market of 1588v2 implementations
  - · Accelerates deployment of CE mobile backhaul





- MEF: Carrier Ethernet for Mobile Backhaul (Tutorial): <u>http://netevents.tv/output/meftv/webinar/register/register.aspx?id=2</u>
- EANTC Public Test Reports and Interoperability Showcases: <u>www.eantc.com</u>
- Isocore Public Test Reports and Interoperability Showcases: <a href="https://www.isocore.com">www.isocore.com</a>
- Mobile Backhaul Test Library: <u>http://www.ixiacom.com/solutions/mobile\_backhaul/library/index.php</u>
  - Webinar: Testing Challenges with Mobile Backhaul
  - IEEE 1588v2 Test Plan
  - Case Study: 1588v2 Performance Testing (Alcatel-Lucent 7705 SAR)
- Ethernet Synchronization Black Book (Test Methodology): <u>http://www.ixiacom.com/blackbook/index.php</u>