Enabling a Converged World™

Testing Timing Synchronization for IP/Ethernet Mobile Backhaul

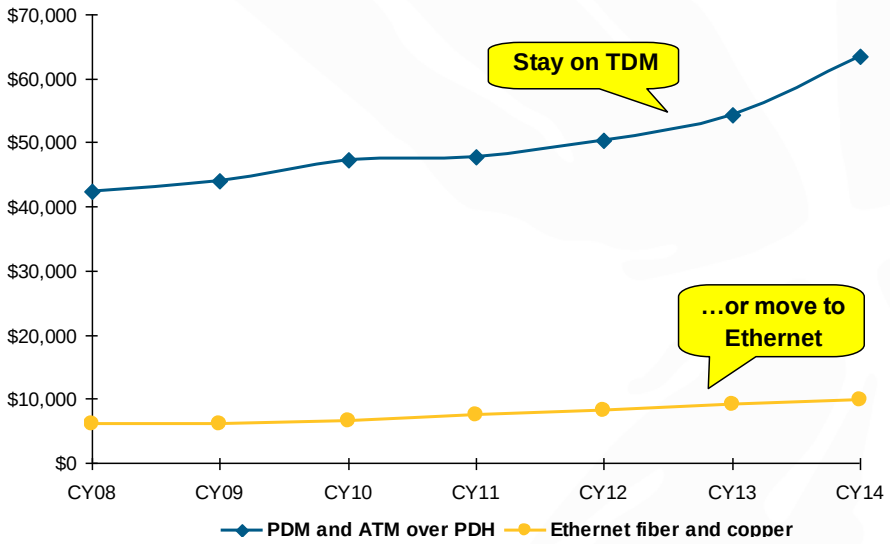
Nov 2011

Agenda

- 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)



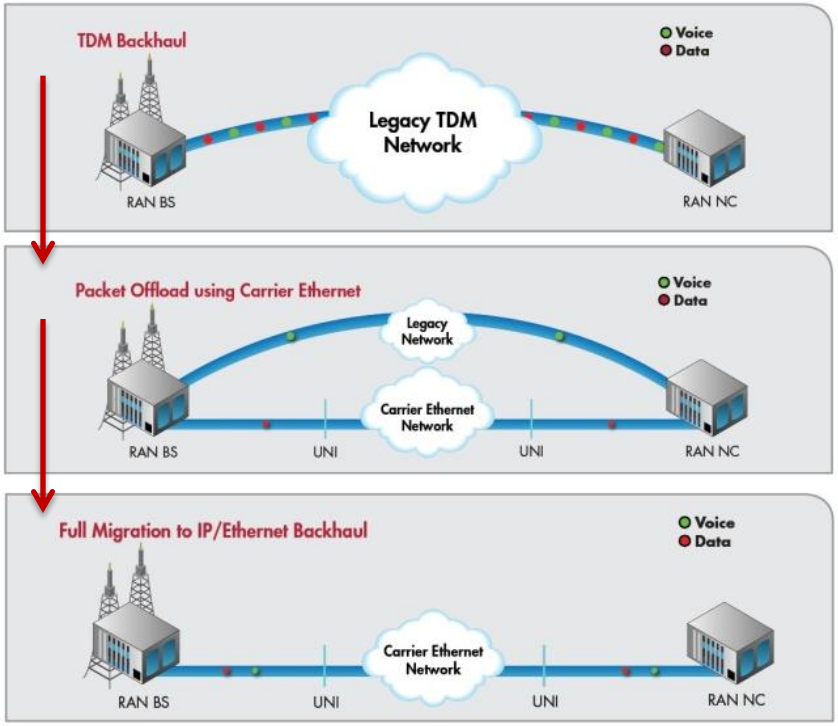
PDH vs Ethernet: Annual Mobile Backhaul Service Charges per Connection

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

IP/Ethernet Mobile Backhaul Deployment

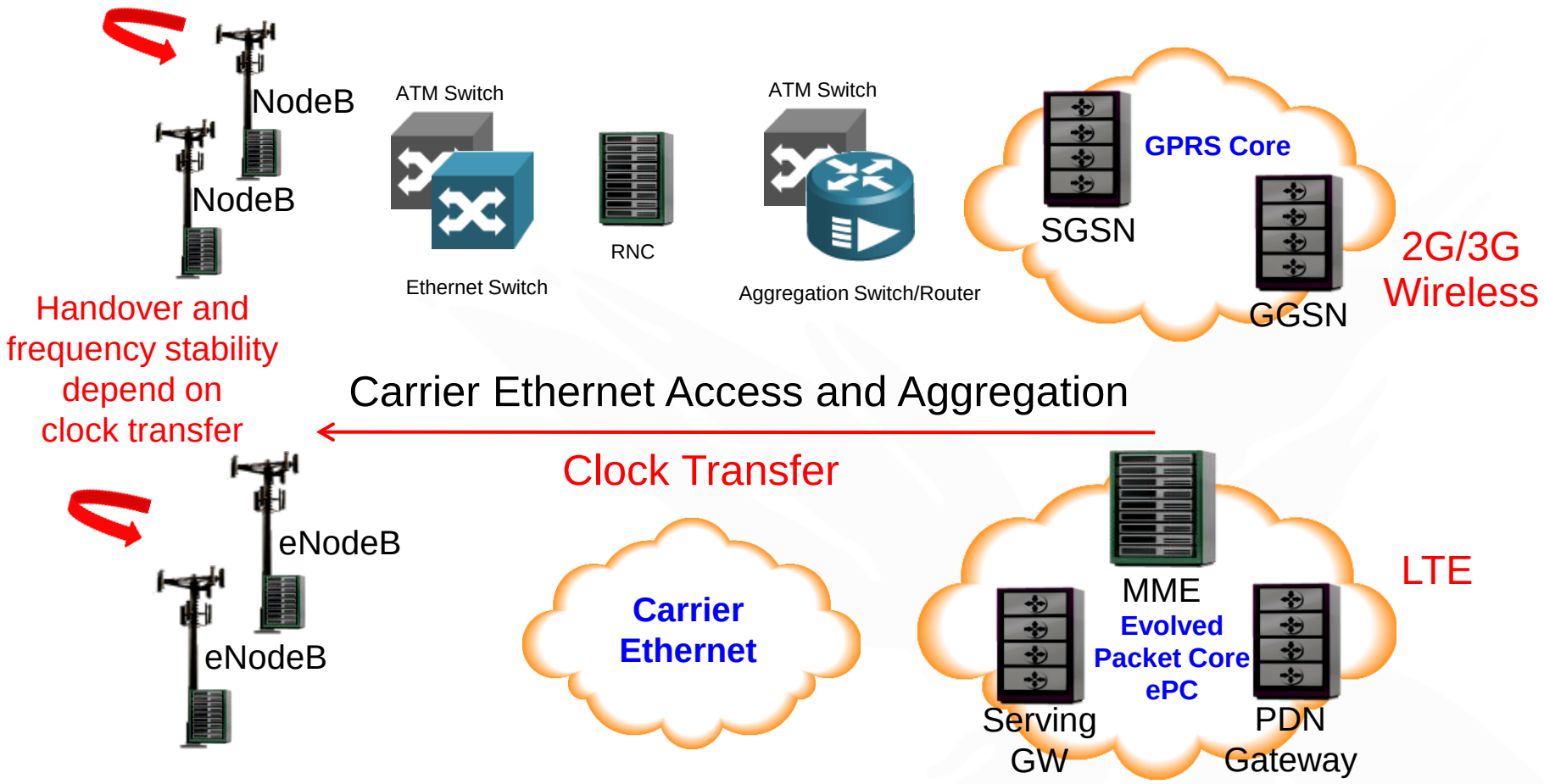
Infonetics: Global Service Provider Survey (March 2011)

- 100% 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
- 150 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

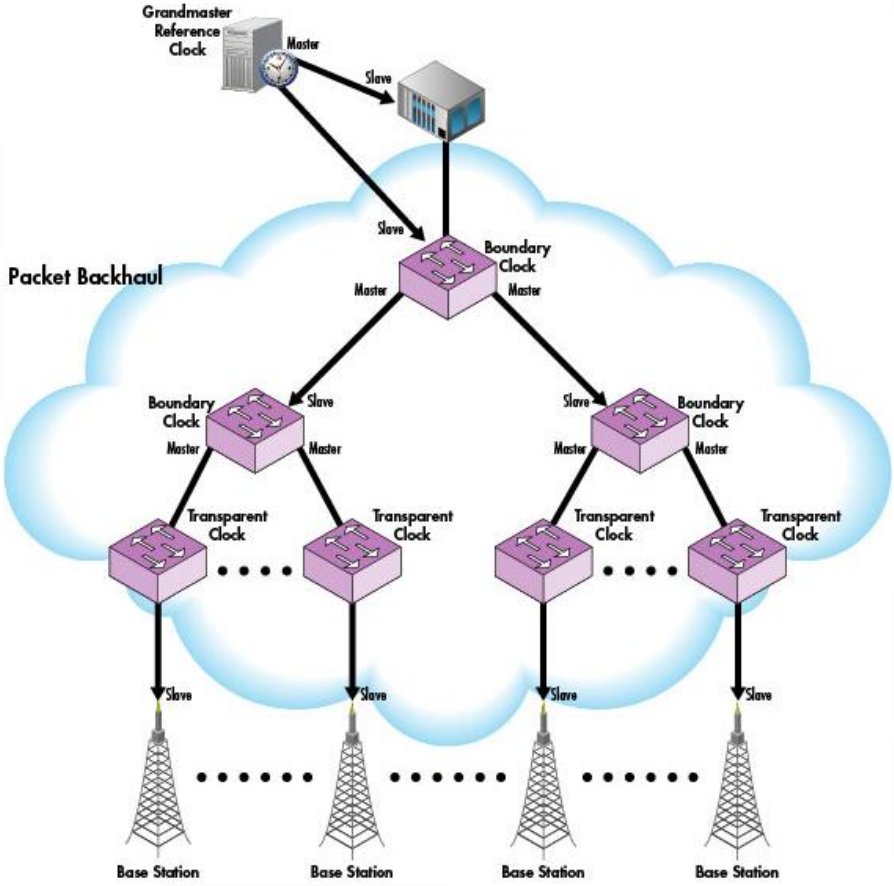
- Enables frequency, phase and time-of-day synchronization
- Improves clock accuracy and stability to satisfy wireless standards

Technology Review: IEEE 1588v2

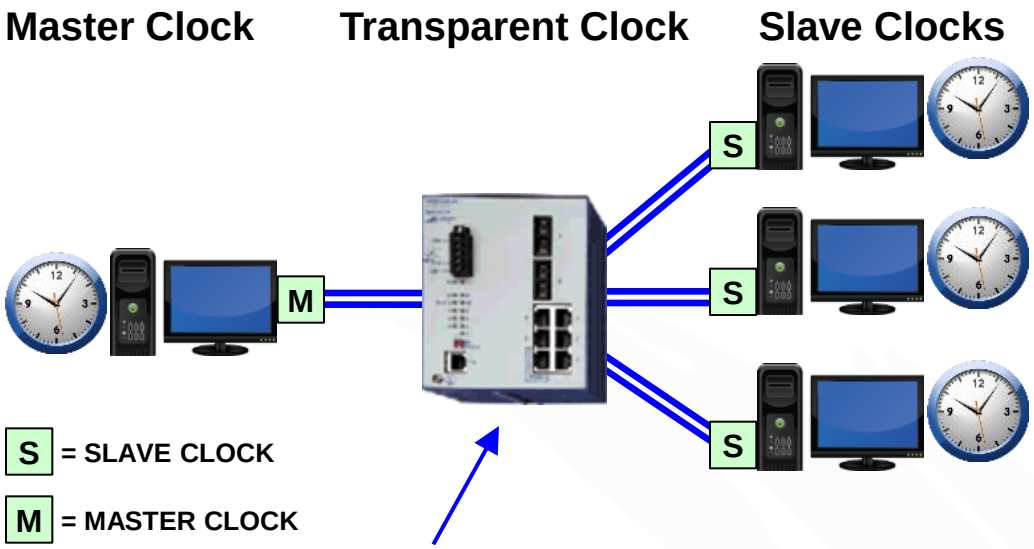
- Clock info is distributed using dedicated timing packets (PTP) between Master and Slave (Master-Slaves)
- IEEE 1588v2, introduced two new logical device types that are commonly built into switches and routers:

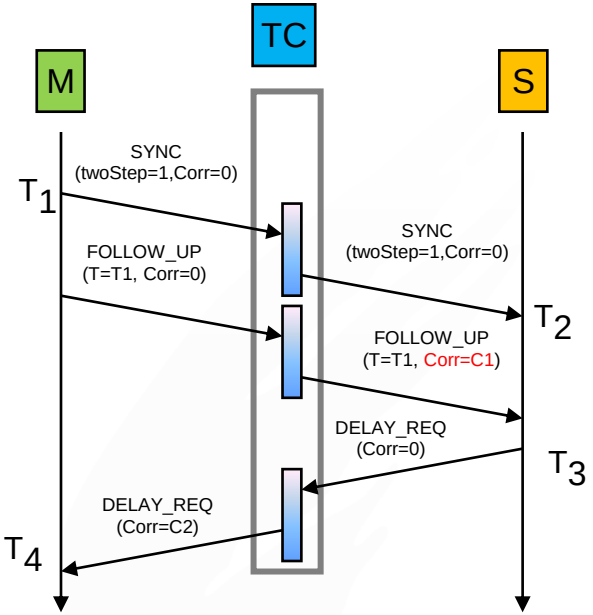
1. Boundary Clocks
   (Improve system scalability)

2. Transparent Clocks
   (Correct for network delays)



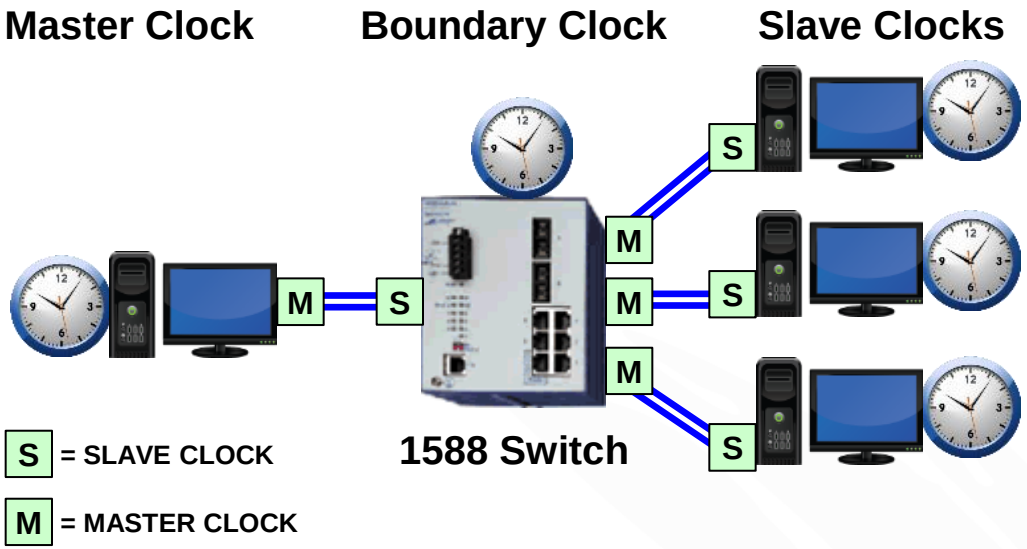
IEEE 1588v2 Transparent Clocks





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

IEEE 1588v2 Boundary Clocks



1588 Performance Issues =
*** Clock frequency drift**
*** Missed Call Handovers**
*** Network Downtime**

- 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

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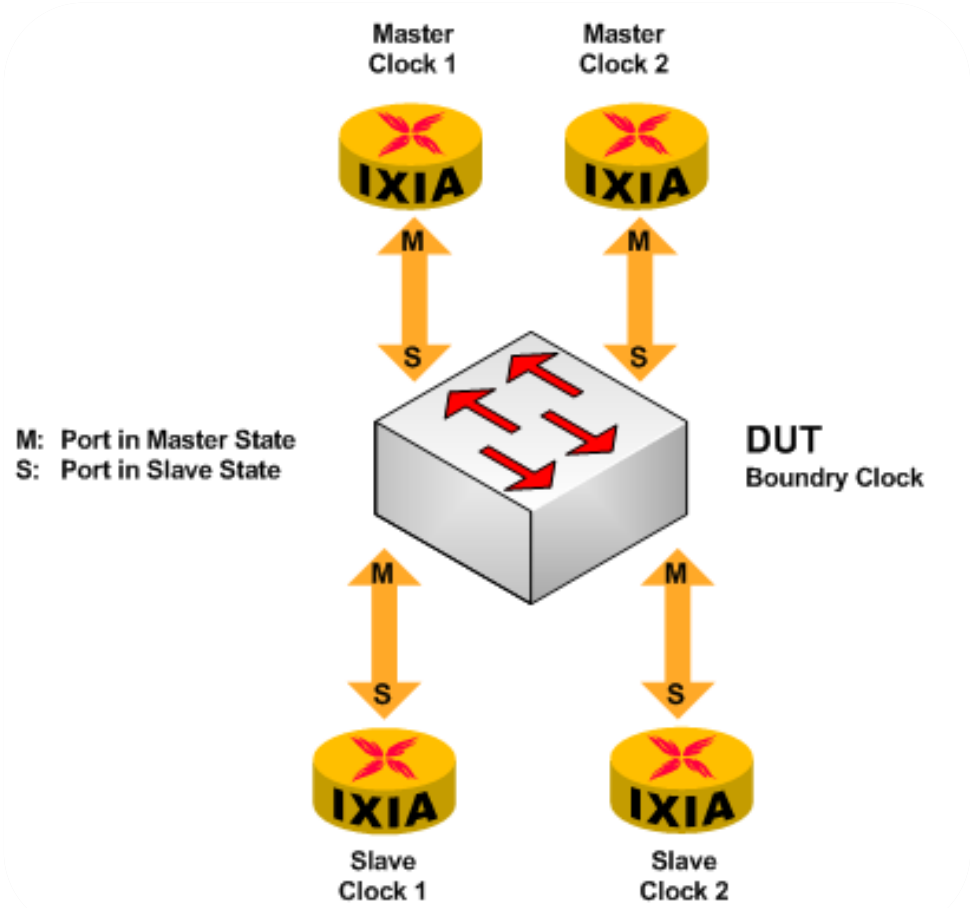
- **Test Requirements and Examples**
- Industry Programs

1588v2 Test Requirements

- **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

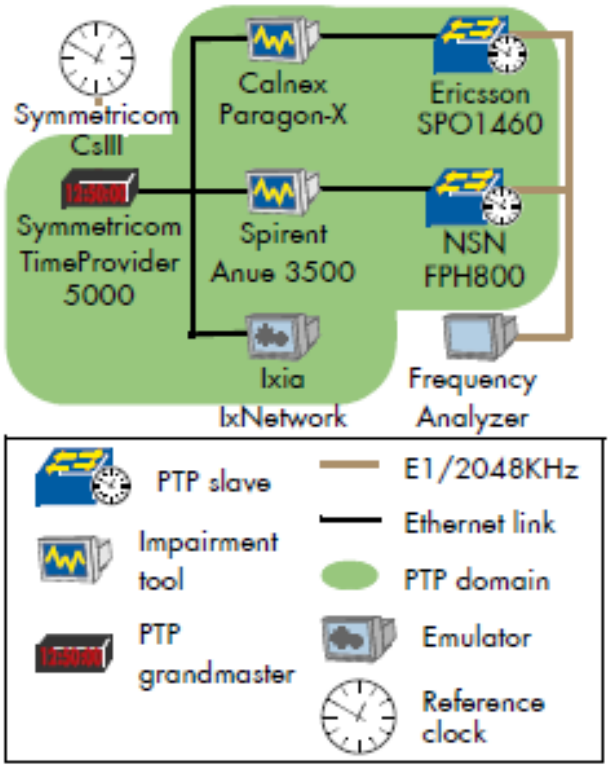
Example: Conformance and Validation Test
Best Master Selection

- Do downstream nodes select the best master?



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

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



PTP Protocol Interoperability Test

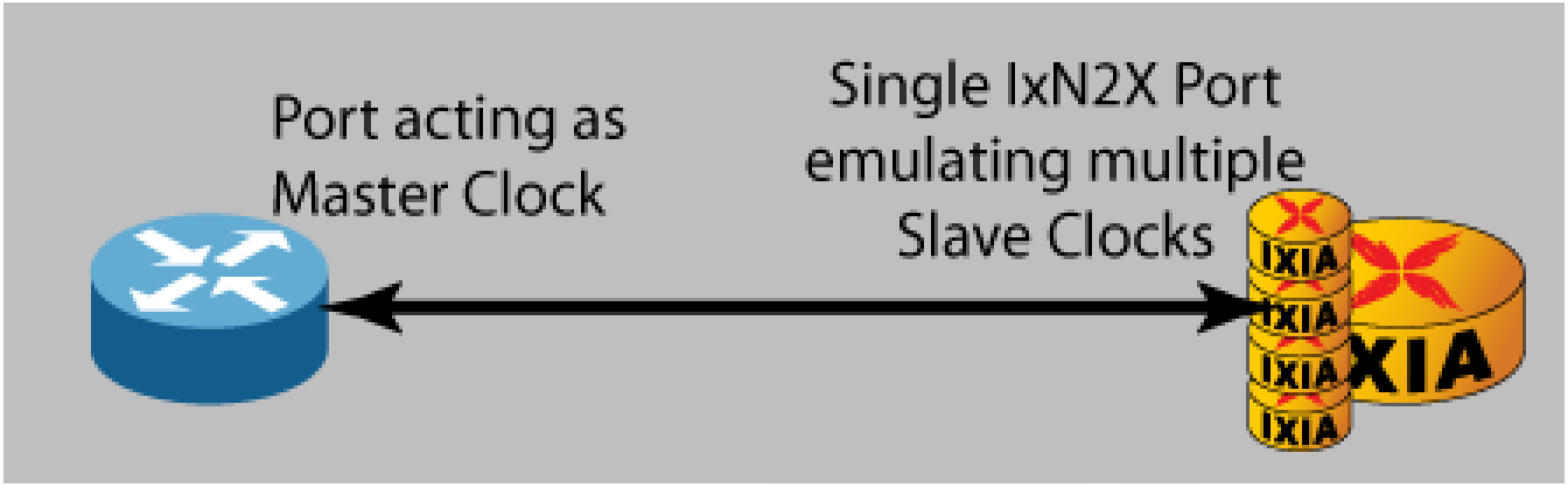
✓ Success interoperability achieved between Ericsson, NSN and Ixia (Slave Emulation)

× Interoperability not achieved between other vendors due to differing features

Source: EANTC Whitepaper www.eantc.com

Example: Scalability and Stress Test
Master Clock PTP Scalability

- Add slave nodes until clock drifts out of tolerance



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

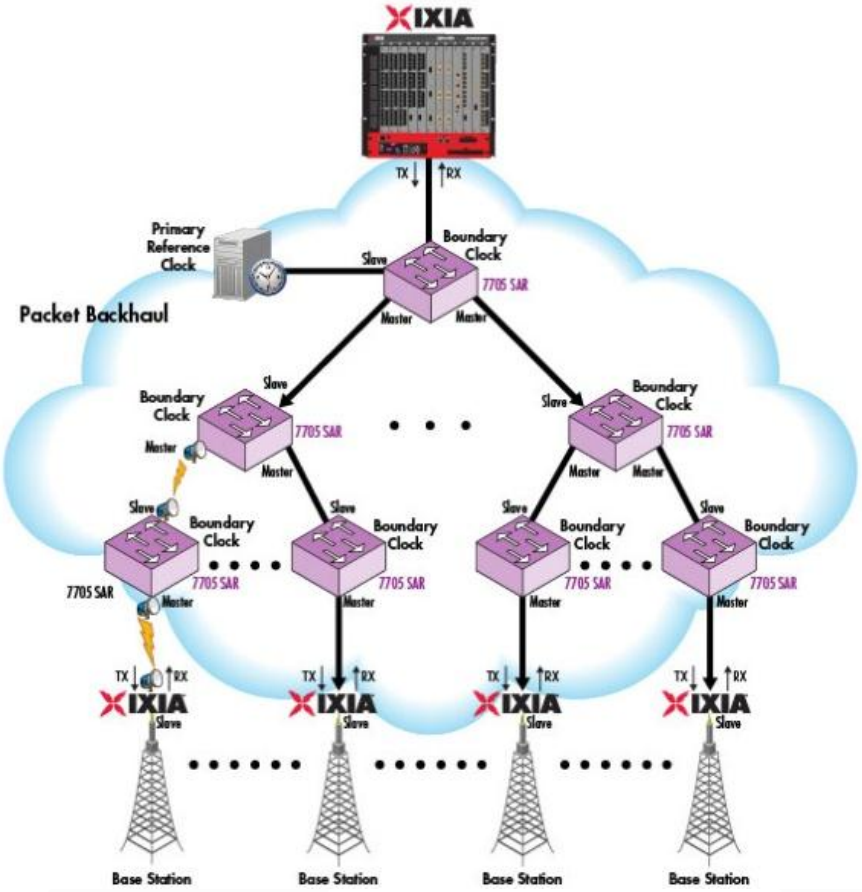
Ixia/Alcatel-Lucent Case Study and Live Demo (MWC 2011, Barcelona)

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



Source: www.ixiacom.com/1588test

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

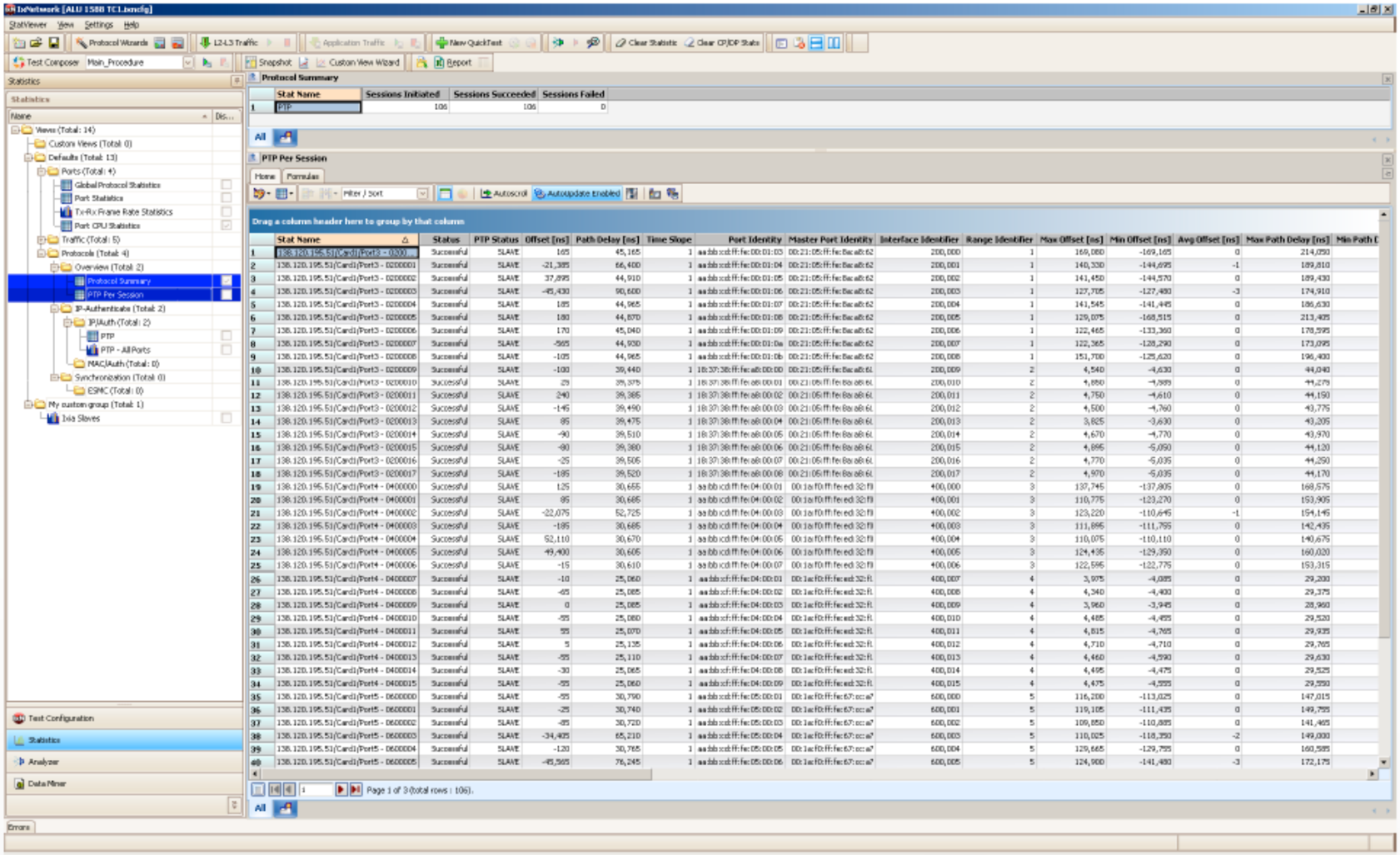


Figure 7. Per slave statistics showing over 100 slaves synchronized

Source: www.ixiacom.com/1588test

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

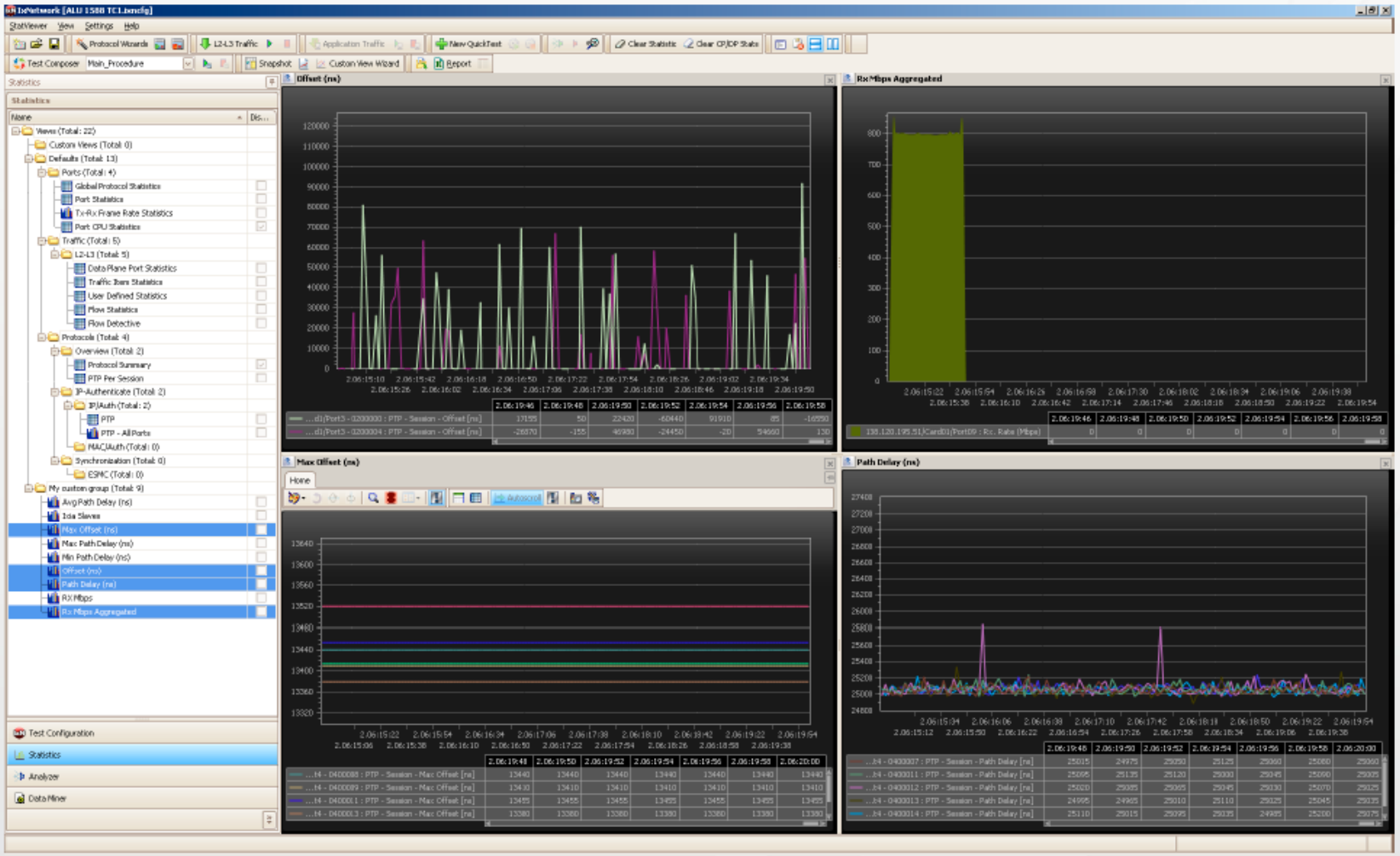


Figure 8. Real-time measurement of offset, path delay, and traffic throughput

Source: www.ixiacom.com/1588test

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

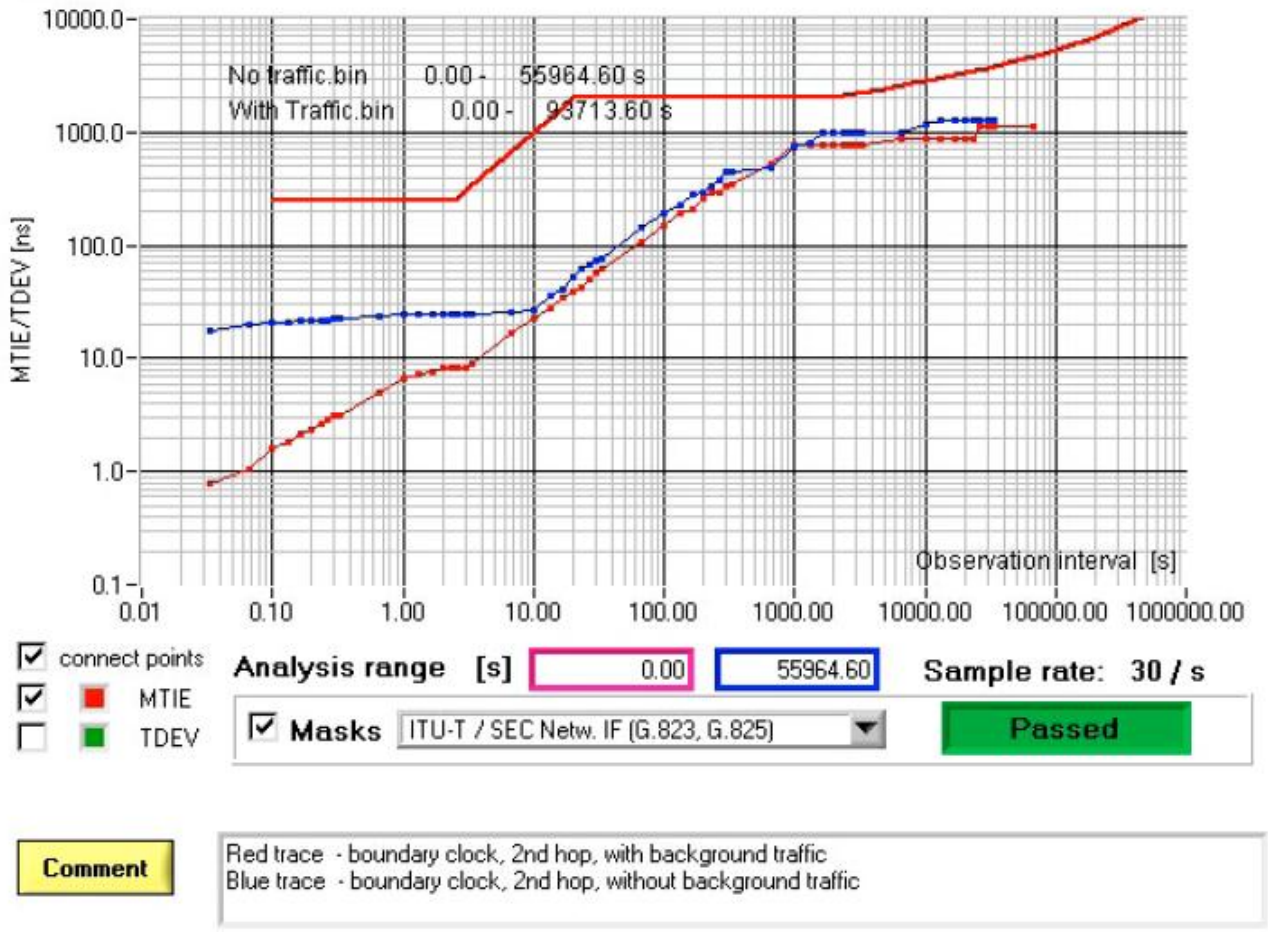


Figure 9. MTIE statistics

Source: www.ixiacom.com/1588test

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

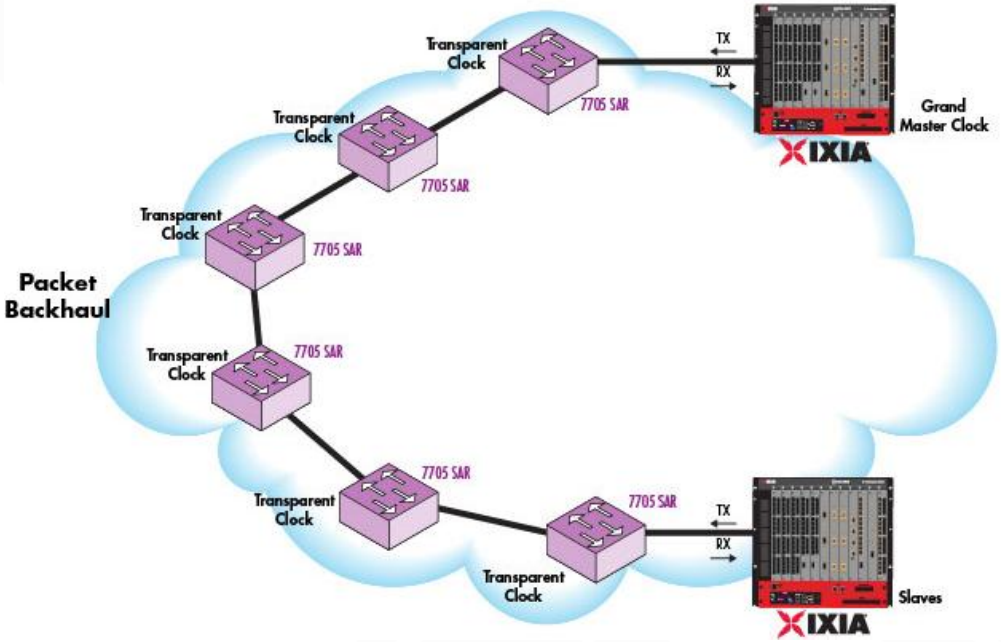
Ixia/Alcatel-Lucent Case Study and Live Demo (MWC 2011, Barcelona)

Objective:

Demonstrate transparent clock functionality under network load

Results:

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



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

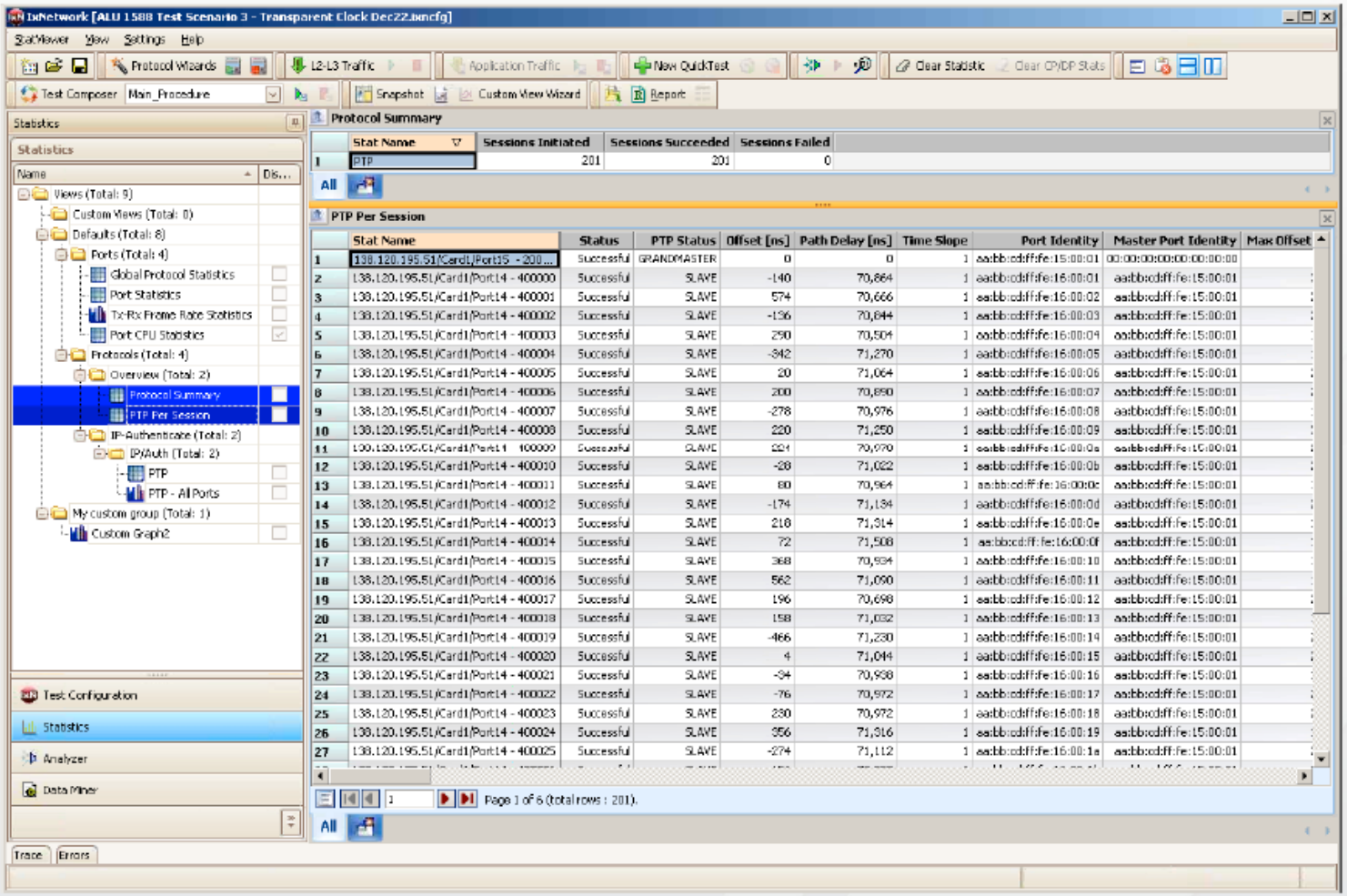

Figure 15. Real-time statistics for emulated grandmaster and 200 slave clocks

Source: www.ixiacom.com/1588test

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Metro Ethernet Forum (MEF)

- **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)

IEEE 1588 Conformity Assessment Program

- 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 Iometrix
- 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.

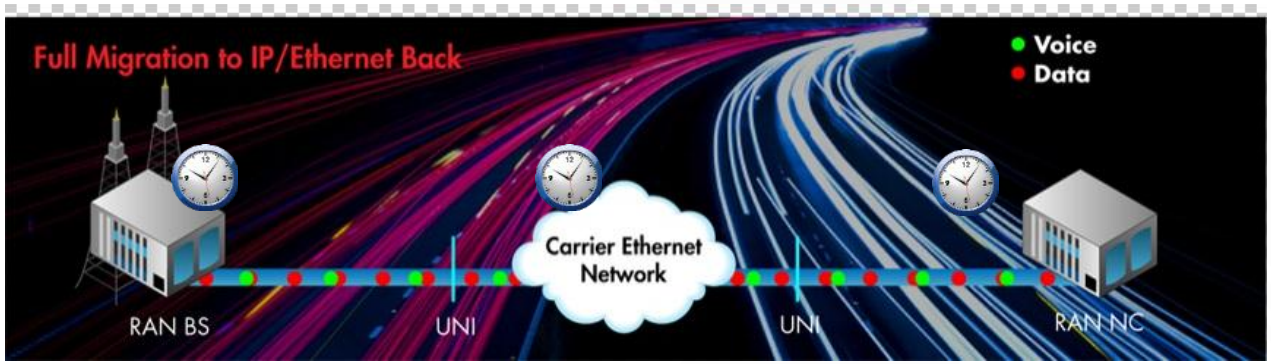
ICAP

IEEE CONFORMITY ASSESSMENT PROGRAM
IEEE 1588
CONFORMITY ALLIANCE

iometrix
THE STANDARD FOR TESTING

Summary…

- 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



Reference Materials

- MEF: Carrier Ethernet for Mobile Backhaul (Tutorial): http://netevents.tv/output/meftv/webinar/register/register.aspx?id=2
- EANTC Public Test Reports and Interoperability Showcases: www.eantc.com
- Isocore Public Test Reports and Interoperability Showcases: www.isocore.com
- Mobile Backhaul Test Library: http://www.ixiacom.com/solutions/mobile_backhaul/library/index.php
  - 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): http://www.ixiacom.com/blackbook/index.php