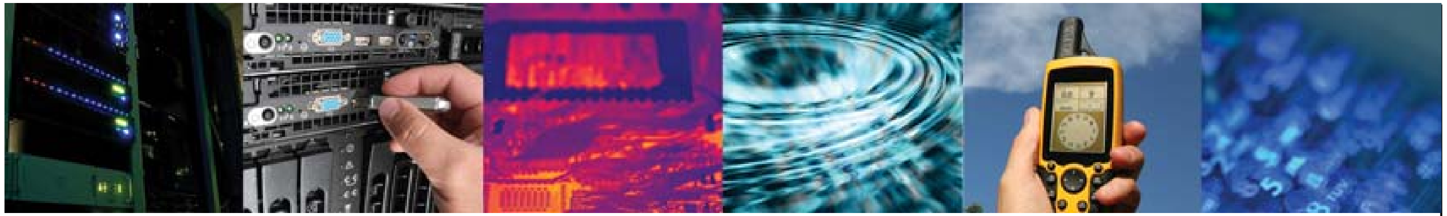

An Analysis of Different Technology Scenarios for SLA Development and Sync Transport in NGNs

ITSF 2007
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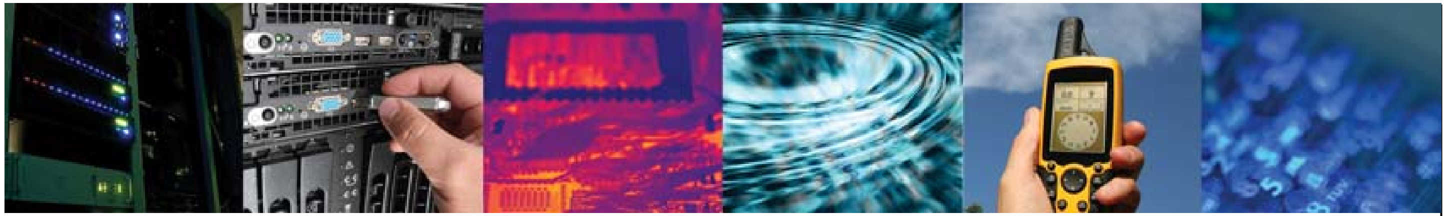
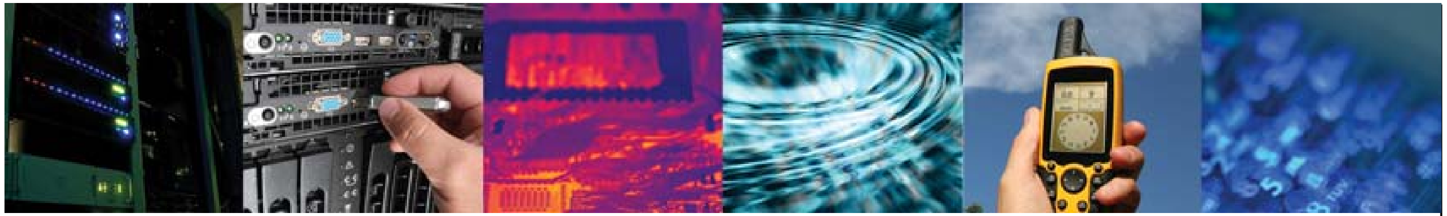


This presentation:

- Introduction – are we there yet?
- Where we're going
- Where we are
- SLA development



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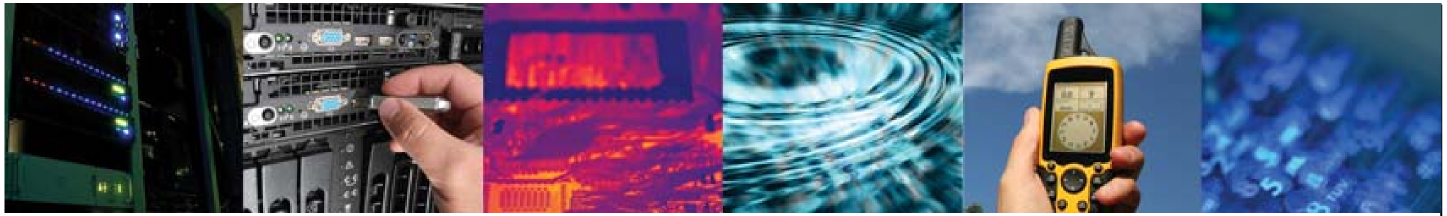

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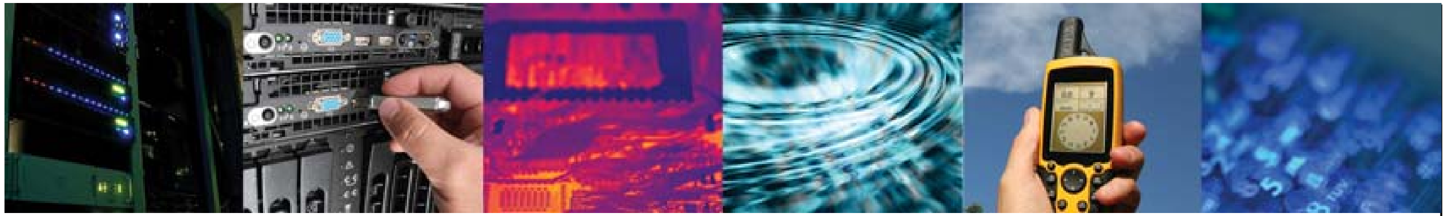

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- “…from a TDM circuit connection paradigm to an IP data connectionless model, …”

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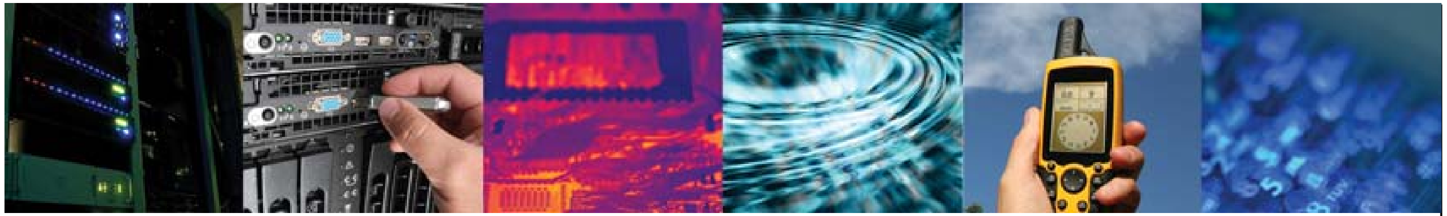

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- “…from a TDM **circuit connection** paradigm to an IP **data connectionless** model, …”

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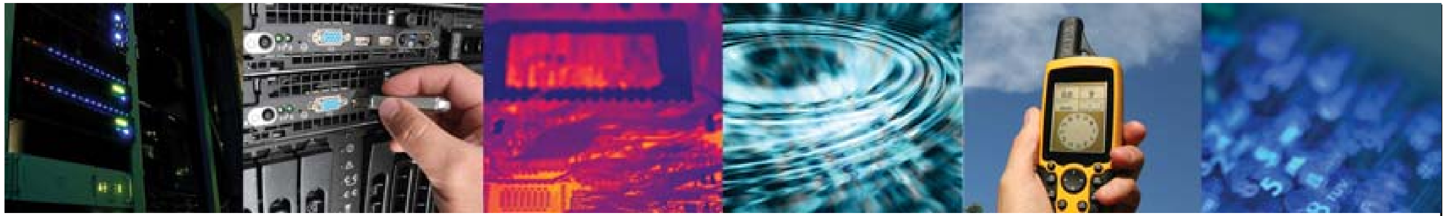
TECHNOLOGY



- "As carriers and suppliers strive to transition from today's legacy circuit paradigm to tomorrow's packet future, …"
- "…from a TDM circuit connection paradigm to an IP data connectionless model, …"
- "… concept of connection-oriented packet networks… third mode of networking…"

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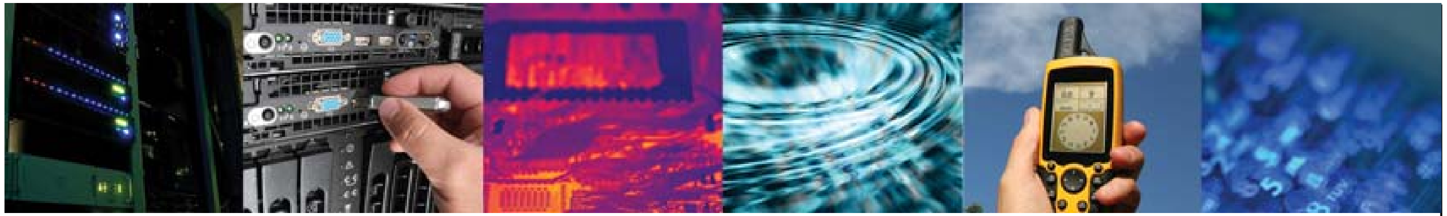

The NGN Evolution - Evolved

- The Brave New World – “PANS”
- New Services & Applications demand greater bandwidth/more efficient use of resources
- Timeslot alignment

- Time Aware Network Nodes
  - Enabling new network behaviours
- Hybrid Silicon NTP/PTP/SyncE
  - The NIC becomes Time/Frequency aware
  - …combine with SETS/GNSS/LF
  - High Sensitivity GPS + 1µS + Network Assist

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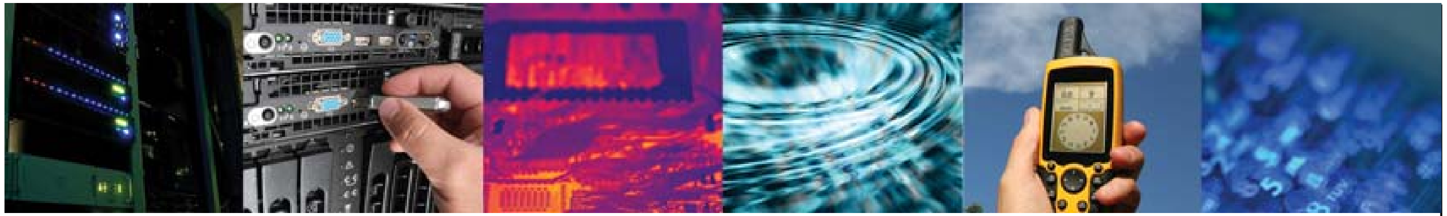
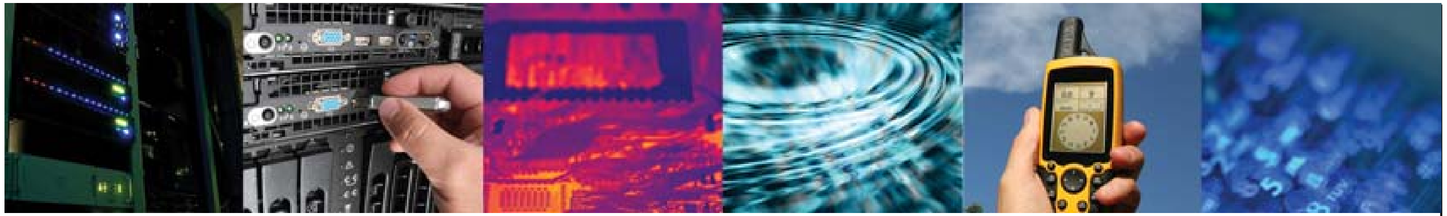


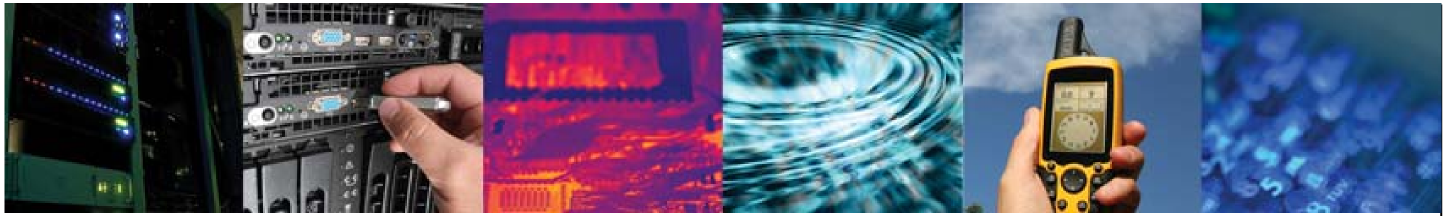
The Dilemma…

- Migration to a non-sync friendly transport
- Packet in the core and the access layer
- Lower cost but…
  - Newton's 3rd Law – To every action there is an equal and opposite reaction
  - Sync transport compromised
- Evolving in-band sync transport solutions e.g. IEEE 1588, NTP, Proprietary (ACR).
- Work quite well, but not 100%. e.g. struggle with some PDV issues
  - Constraining or Engineering the network
- Is it acceptable to work (say) 99.99% of the time?



Technologies

- Inter-node Time & Timing transfer
  - Packet in the core network
    - SyncE, PTP
  - Packet in the access network
    - PTP & NTP
    - SHDSL
    - ACR
- Intra-node Time & Timing transfer
  - UTI
- Network Engineering
  - PBB-TE & T-MPLS
- Sources?
  - Cs, Rb, GNSS, LF, CSAC?



“Packet” in the core network

- SyncE may be available as a frequency reference
  - SDH-like – same issues, timing loops etc.
- PTP (Core)
  - BC or TC @ every node
    - Effectively removes PDV
  - Nodes without PTP “assistance” introduce PDV
- NTP

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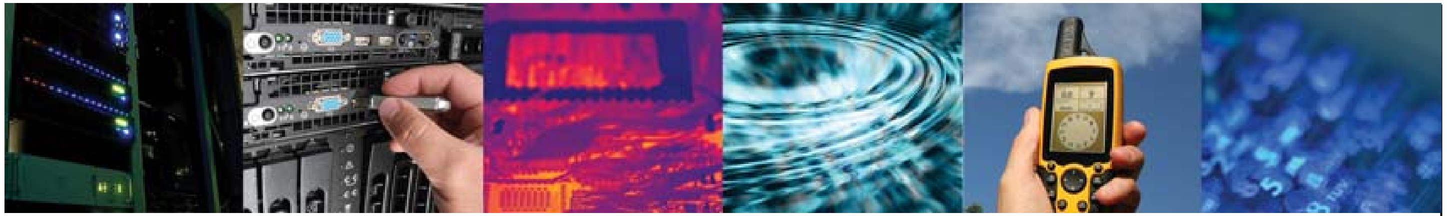
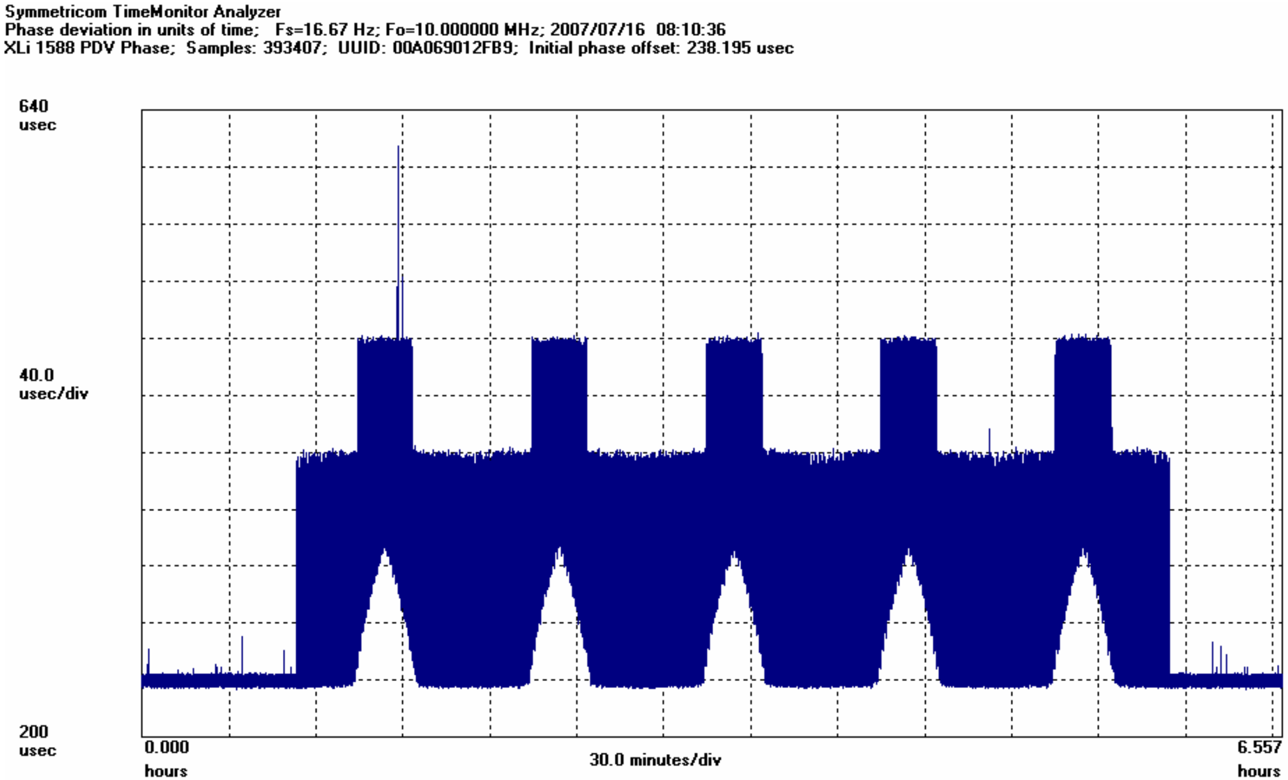


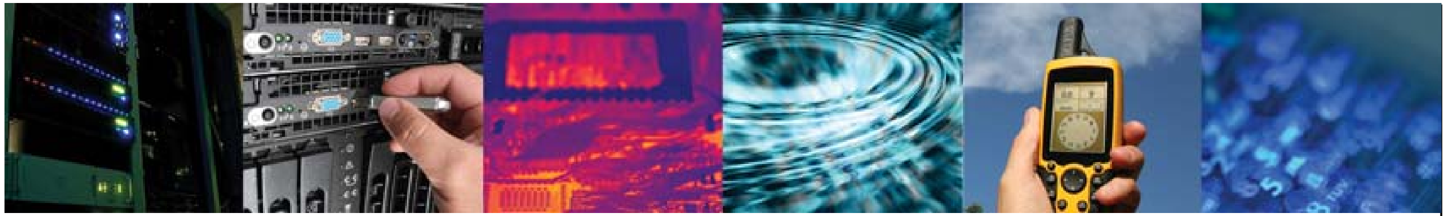
Packet in the access network

- PTP
- NTP
- xDSL last mile
  - Could support PTP/NTP over IP to NTE
  - If supported, NTR could time E1/T1 from modem

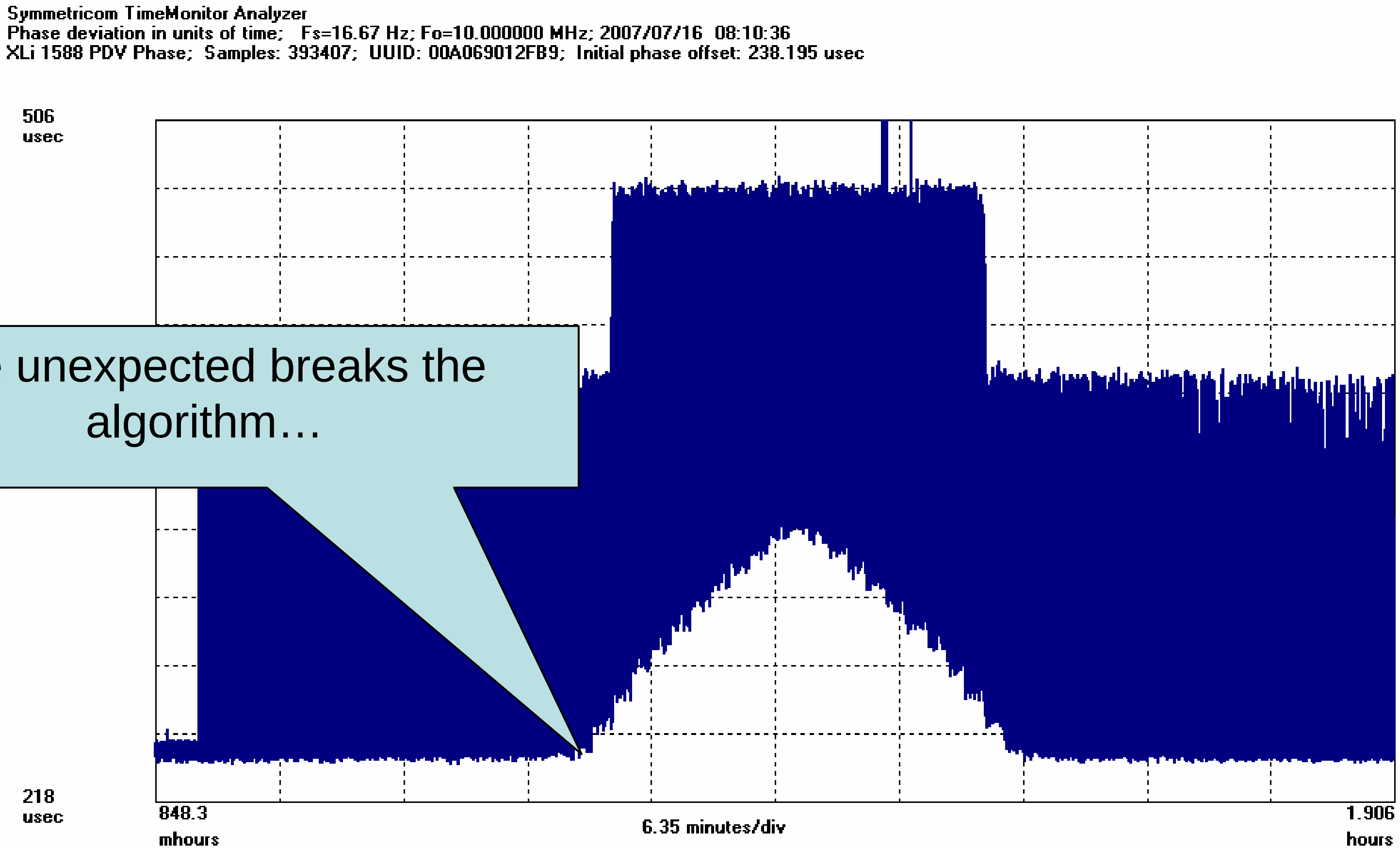
PTP & NTP

- Typical PDV profile under ramp traffic loading

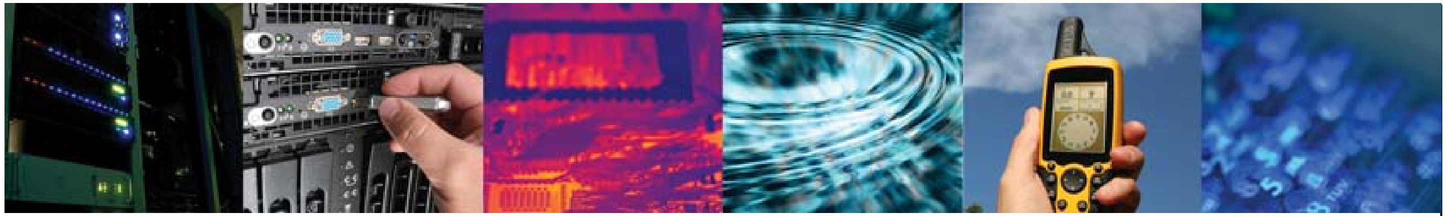




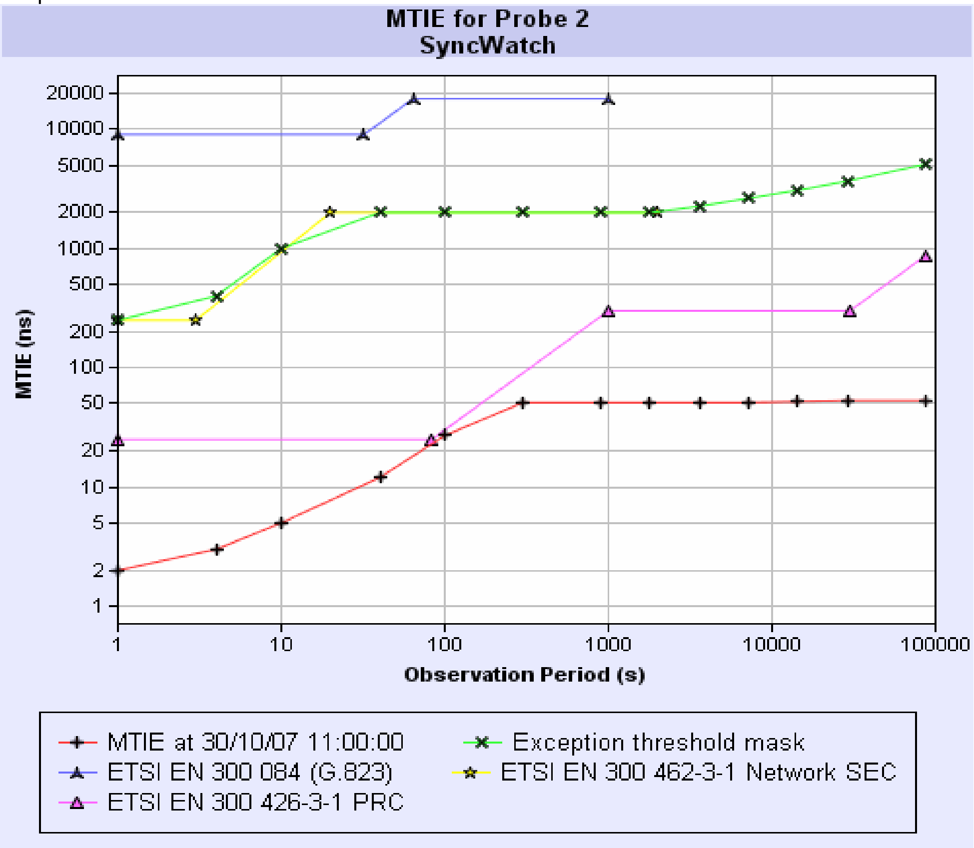
Zoomed in…

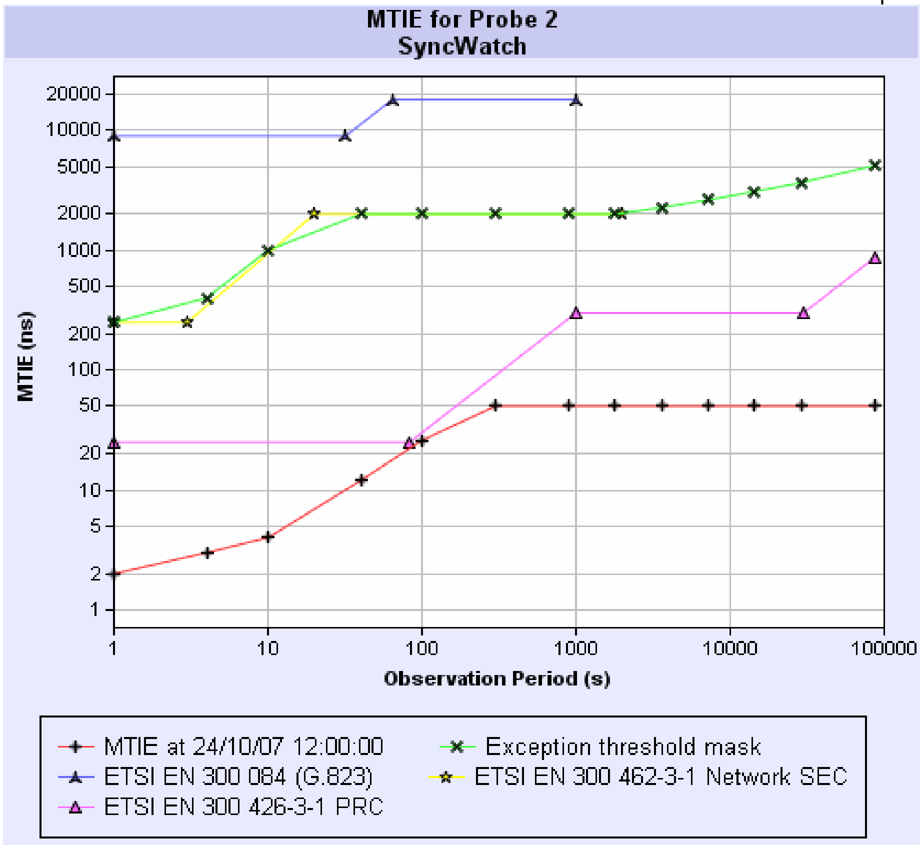


The unexpected breaks the algorithm…



xDSL - SHDSL – “NTR”





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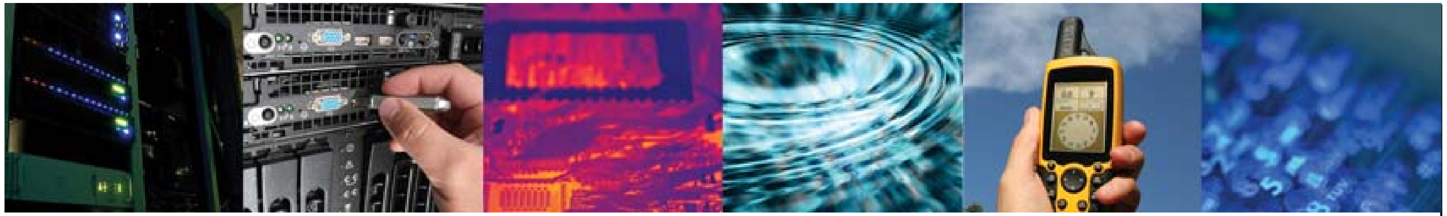
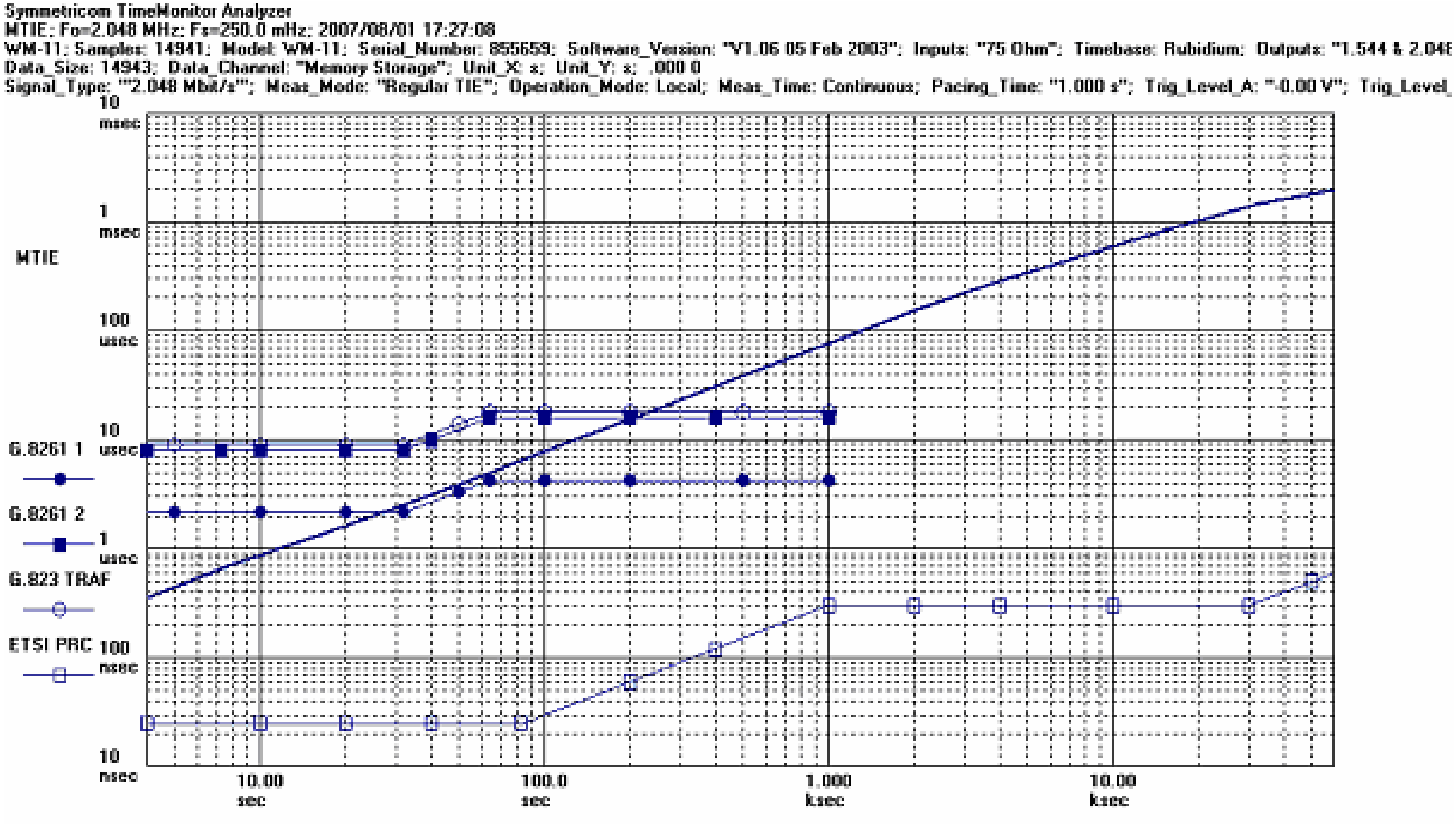
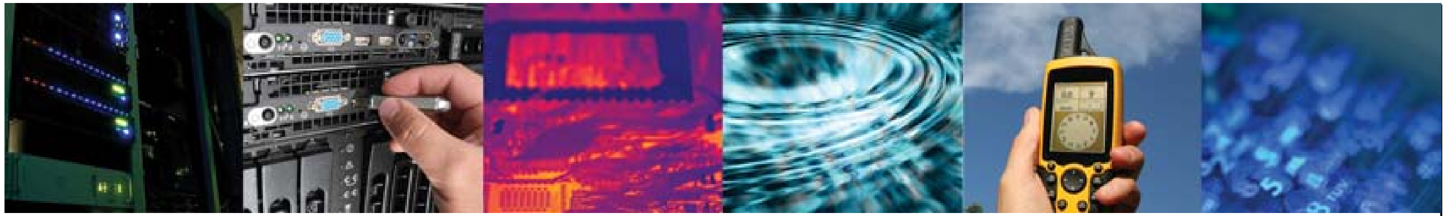


ACR – network overload





UTI

- Dedicated out-of-band two-way timing signal
- Can utilise existing wiring (CAT3/ CAT5)
- Replaces existing SSU “send and pray” distribution
- Low cost client in NE

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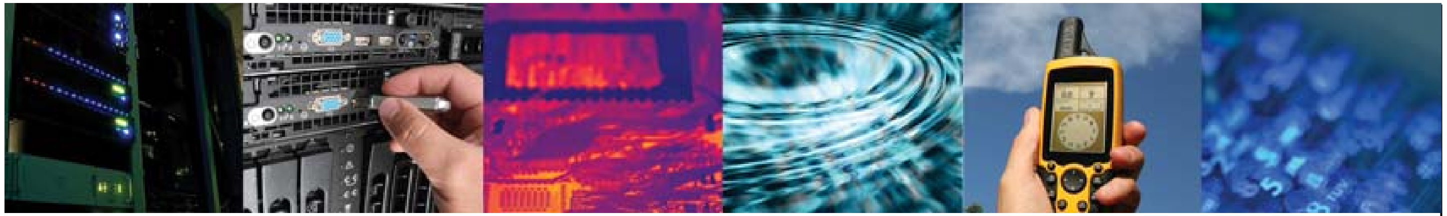
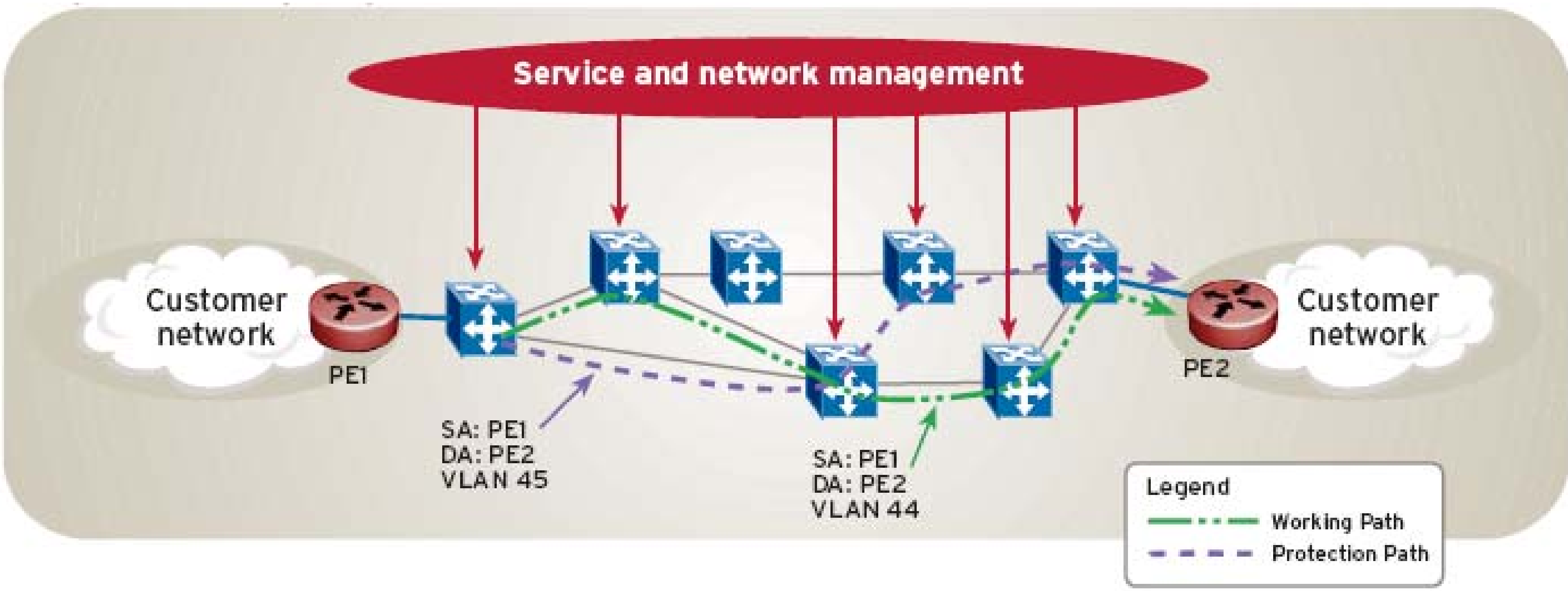


Traffic Engineering

- PBB-TE and T-MPLS
  - Both attempt to make Ethernet a connection oriented medium
  - Remove certain auto-learning mechanisms
  - Constrain the network path
  - Constrain the PDV
  - Bring predictability and trunks to the PSN

PBB-TE



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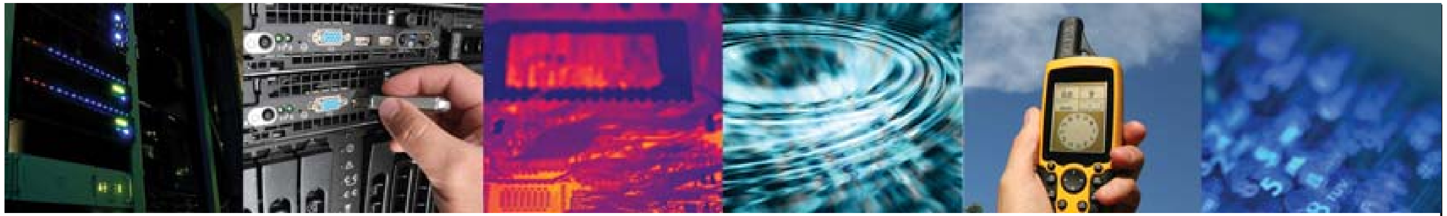
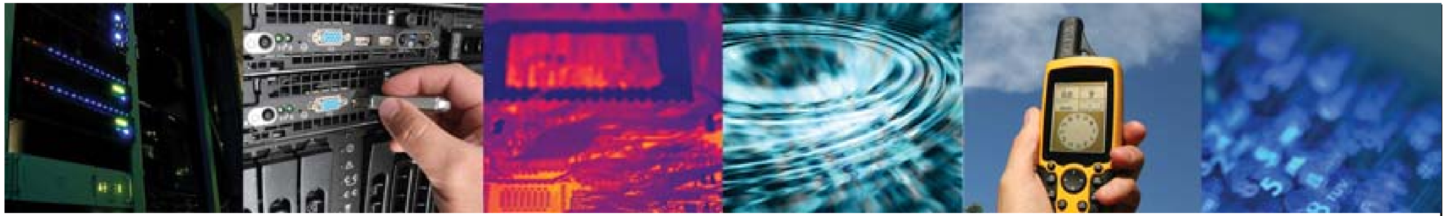


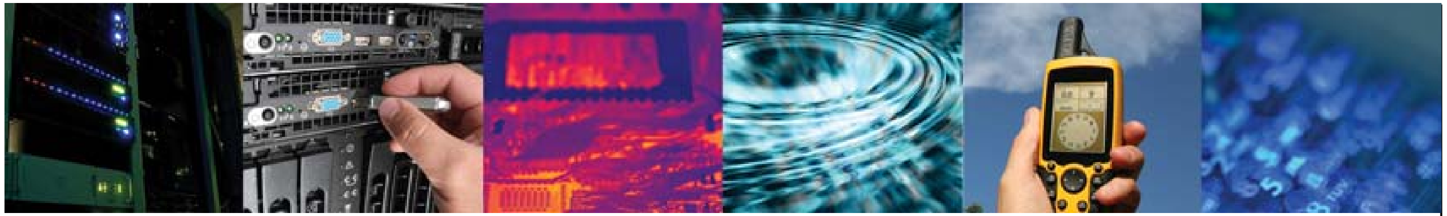
Time and Timing at the edge - filtering

- Classic Base-Station technology
  - OCXO is probably there – why not use it?
  - NTP/PTP PDV filtered by long loop time-constant
  - Base station manufacturers starting to integrate packet solutions (NTP/PTP) into “clock recovery” function.



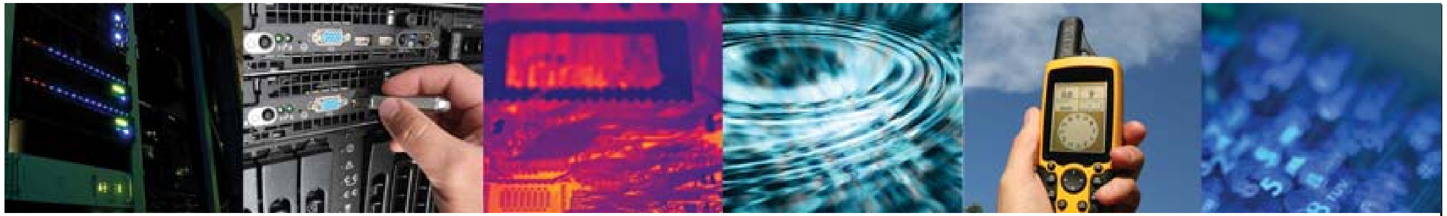
Time & Timing at the edge - injection

- GNSS at every BTS
  - GPS/GLONASS/Galileo
  - Aids/Enables LBS
  - Aids Network efficiency in TDD systems
- Other off-air reference
  - LF transmissions eLORAN/MSF/DCF-77
- Small Form Factor Atomic references
  - Freq. only
  - Used with NTP/PTP



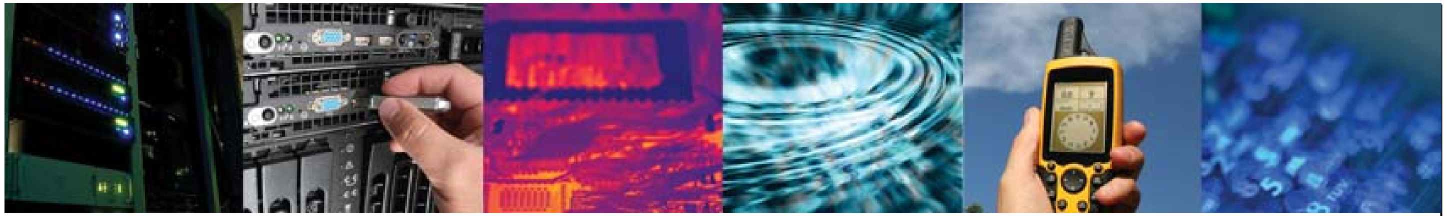
UTC at every node?

- Time as an enabler in the new network
- New SLA metrics
  - One-way packet delay
- New Support Paradigm
  - Fault/event tracking



SLA development

- Physically layer metrics
  - TIE/MTIE
  - TDEV
- Packet Layer metrics
  - PDV
  - PDF
  - microbursts
  - minTDEV



SLA Development

- Lab Testing
  - Provides bounds for Network Engineering Limits
- Live Trials
  - Tests these bounds for “real-world” effects
- Technology Deployment
  - With permanent SLA monitoring
  - Permanent PDV/MTIE monitoring
  - Integrate SLA monitoring into “business as usual”
    - 802.3ah/802.1ag/Y.1731
    - RFC4656/2544

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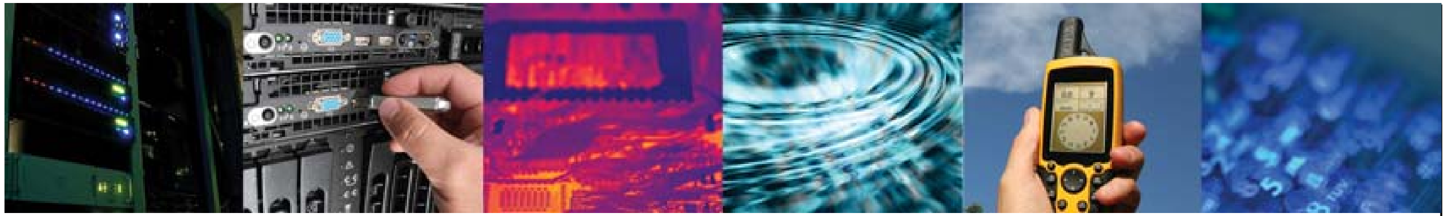
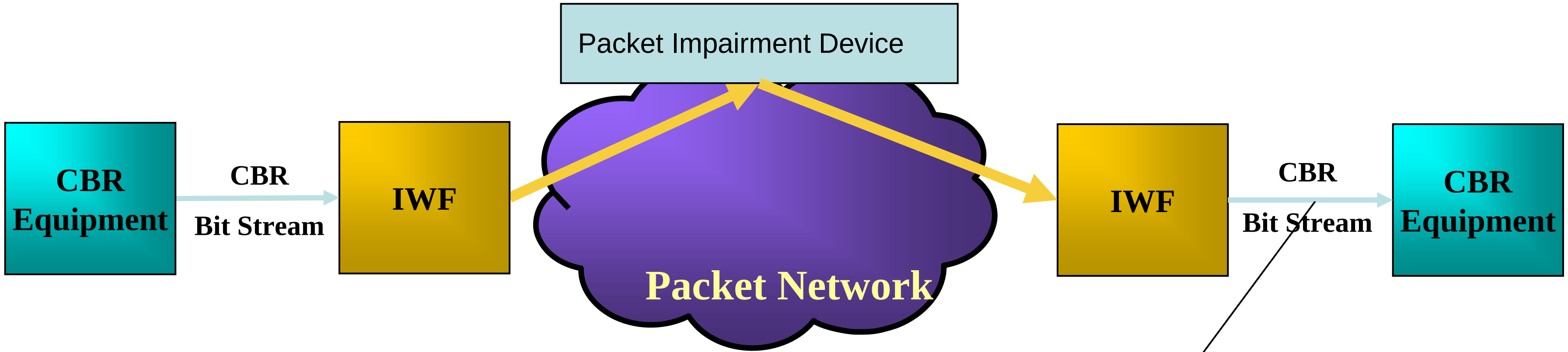
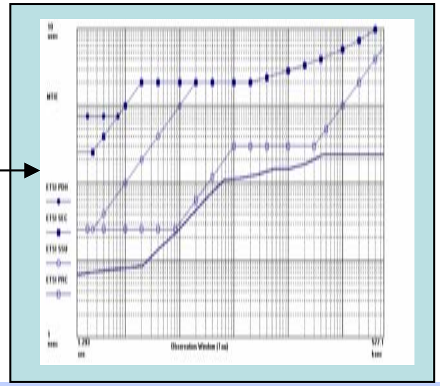
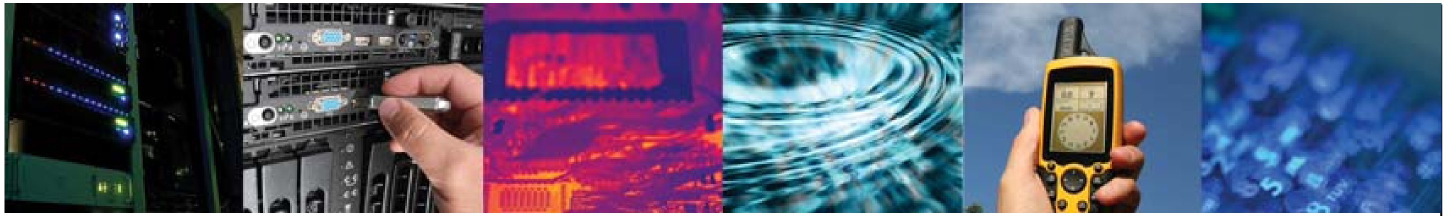


SLA development - CES

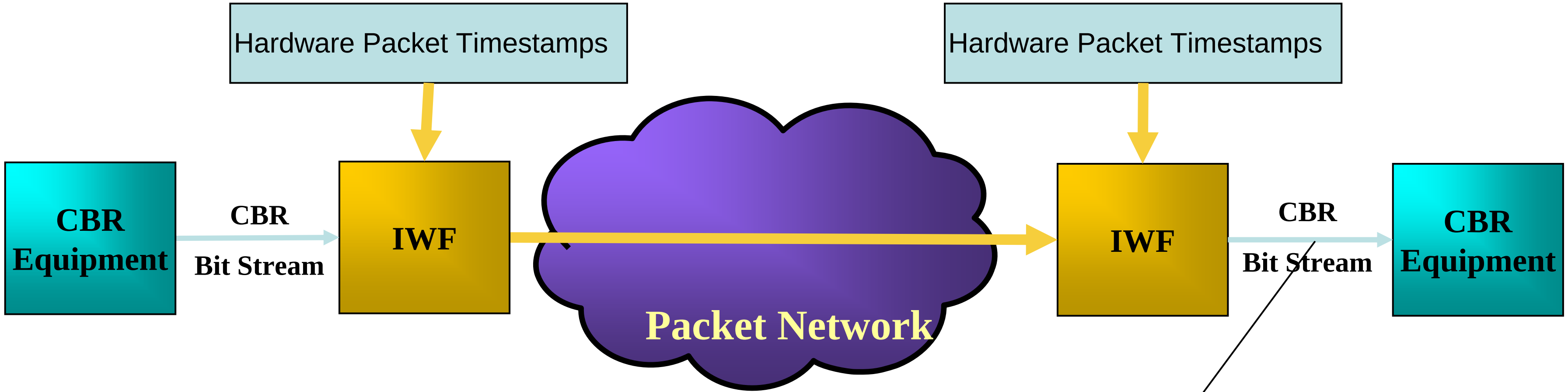


- Close coupled Packet Delay Variation and TIE/MTIE monitoring
- Bounding PDV on its associated MTIE/TDEV
- Application susceptibility

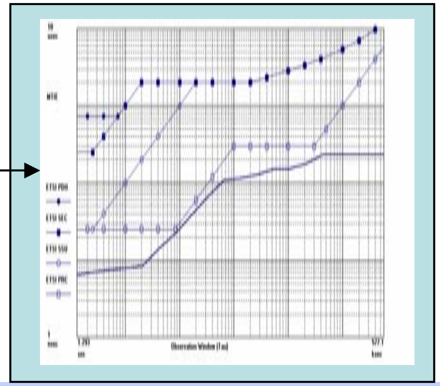


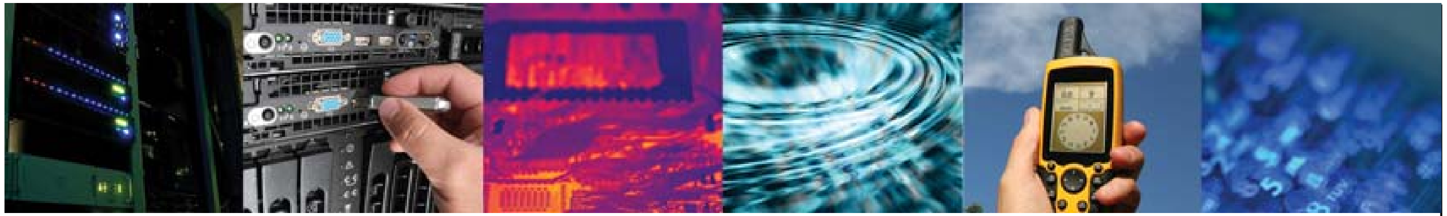


SLA development – NTP/PTP



- Close coupled Packet Delay Variation and TIE/MTIE monitoring
- Two-way PDV monitoring
- Application susceptibility

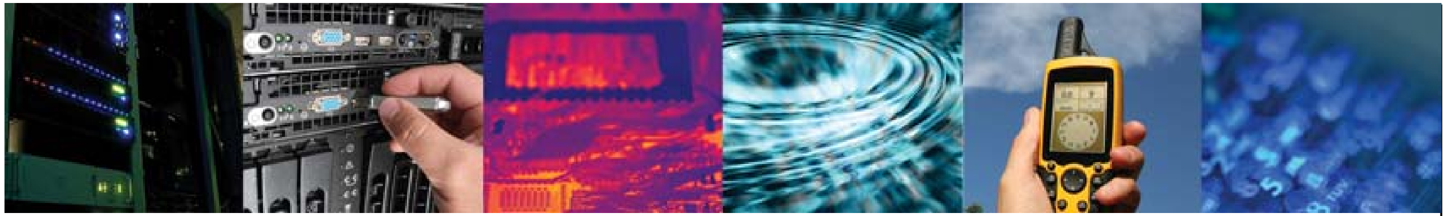




SLA basis

- MTIE/TDEV – standards masks
  - Based on well-known, established Telecom Metrics
  - Measurements at the physical layer
- PDV/minTDEV – new masks
  - Based on packet/IP metrics
  - One-way delay, Packet Delay measurements
- Application susceptibility
  - ***"test it 'til it breaks"***

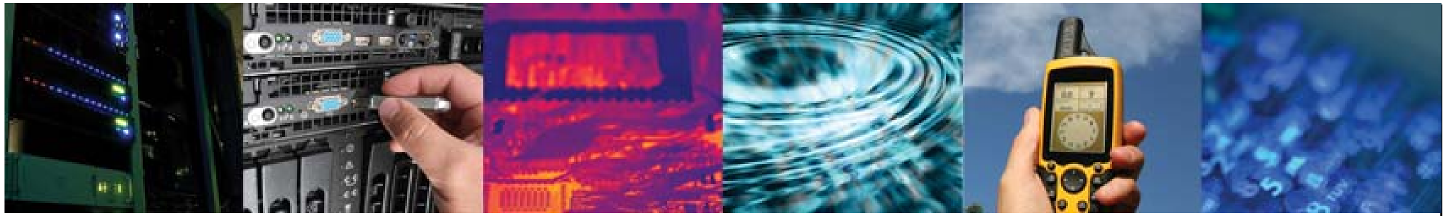
- …a set of parameters that bound acceptability



Will applications work 100% of the time under stress?

- Will NGN sync transport deliver time and timing which will guarantee 100% availability?
- Consider….
  - Step changes in traffic loading
  - Asymmetrical networks
  - Dynamic architecture changes
- PBB-TE solves some of these for in-band sync

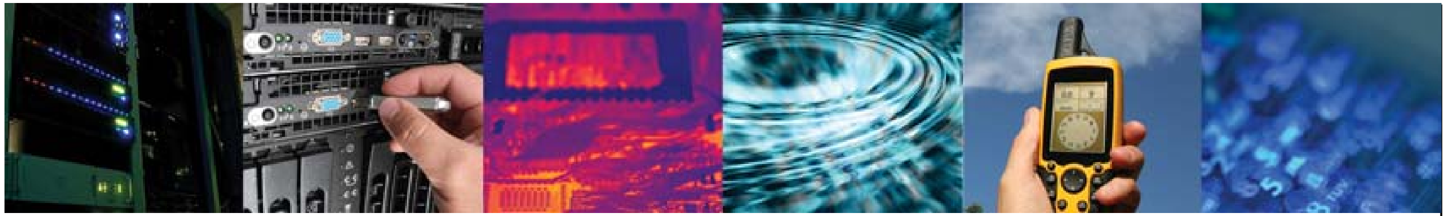
- Let’s allow for some degradation
- What should we allow?
- How many sync anomalies per day (which are potentially traffic affecting) can we allow?



What is an Acceptable Availability %

- Recent Network SLA by client on a global operator demanded six nines!
- 99.9999% Availability
- ~2.5 seconds per month per link!
- If 10000 links = 25000 seconds aggregated outage
- If they miss the target the fine is $2.5m

- System X took more than 100 minutes to fully recover after a sync anomaly!



Synchronisation Availability Standard

- Sync anomaly may or may not impact service
- SAS defines an agreed MTIE between operator and client
- If MTIE exceeded during an observation window – we treat this as an anomaly – MTIE Error
- MER Standard – MTIE Error Rate Standard
- At WSTS 2005 Ian Wright proposed 15 minute observation windows
  - 1 MTIE error per 15 minutes?
  - 1 MTIE error per 24 hours (=96 windows)?
- BERT - Bit Error Rate Tester
- MERT – MTIE Error Rate Tester

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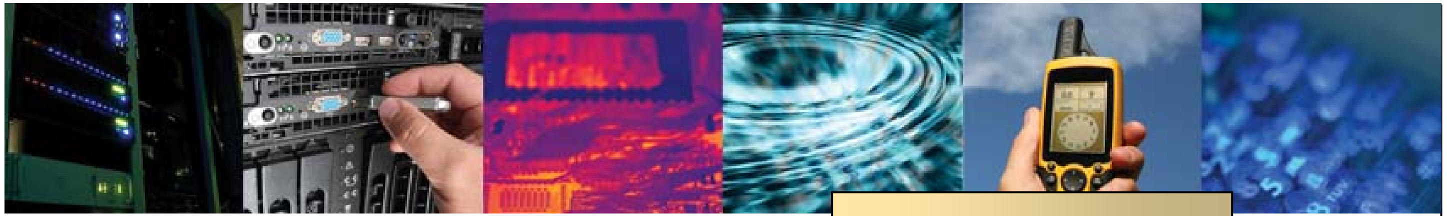
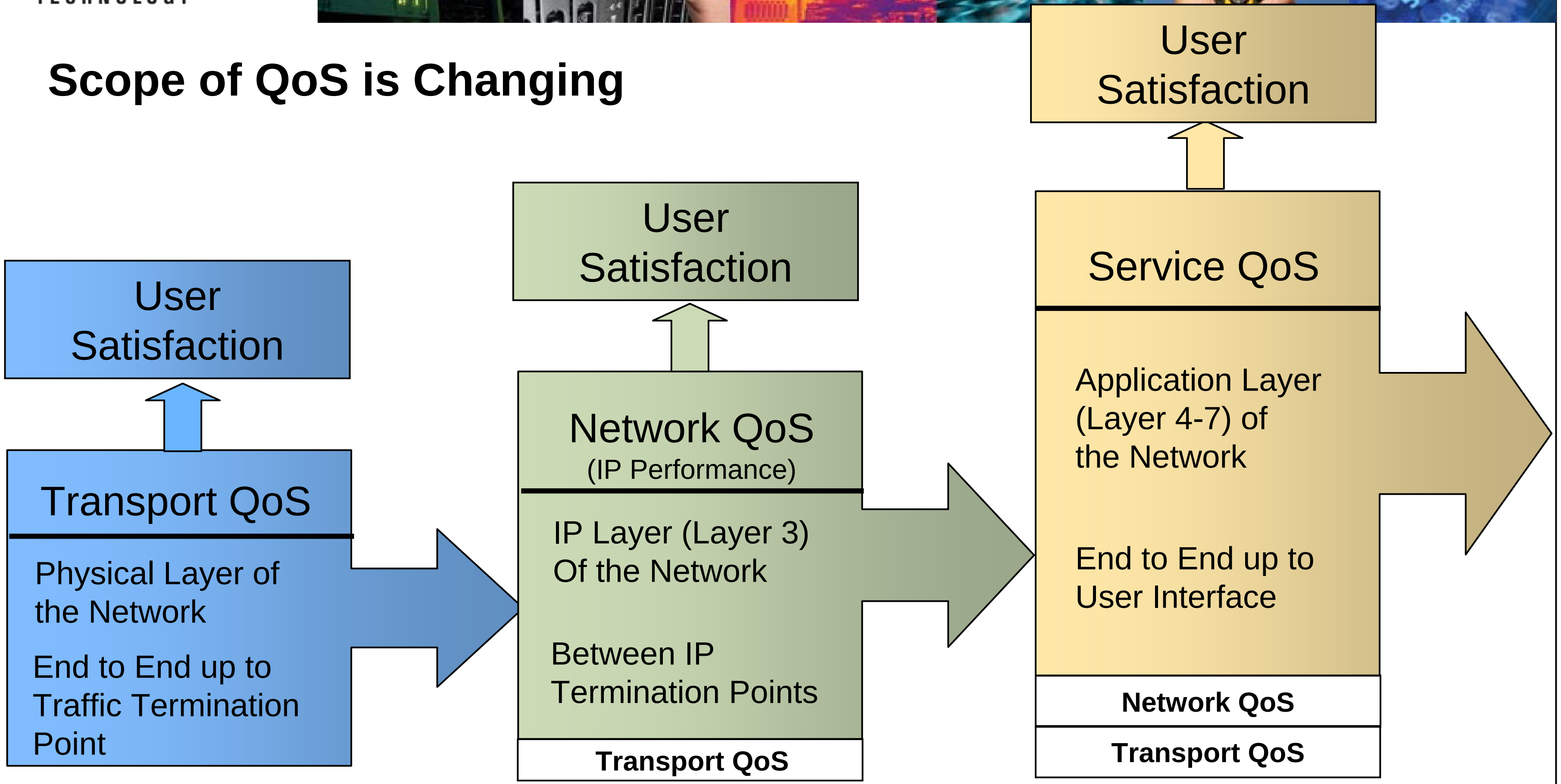
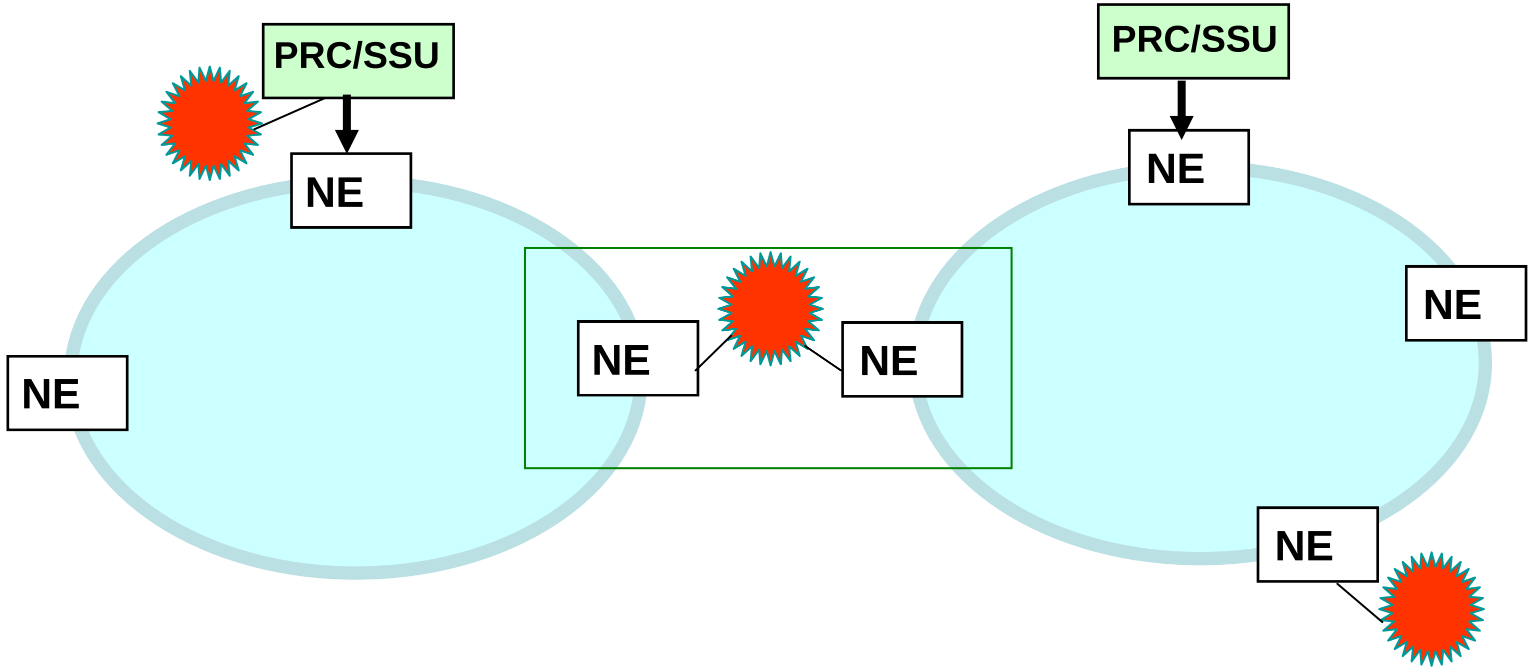


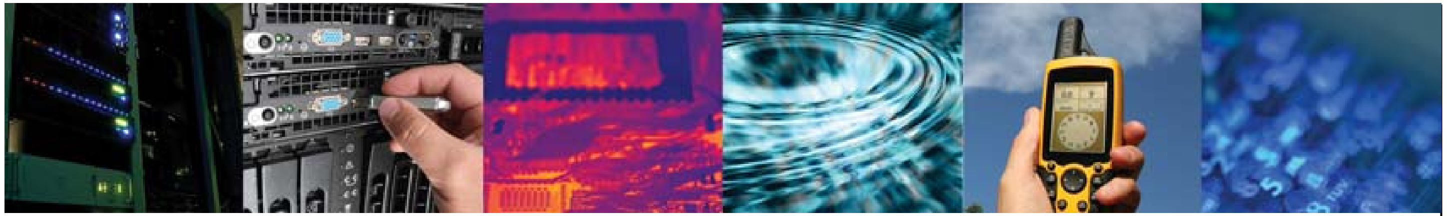
Scope of QoS is Changing



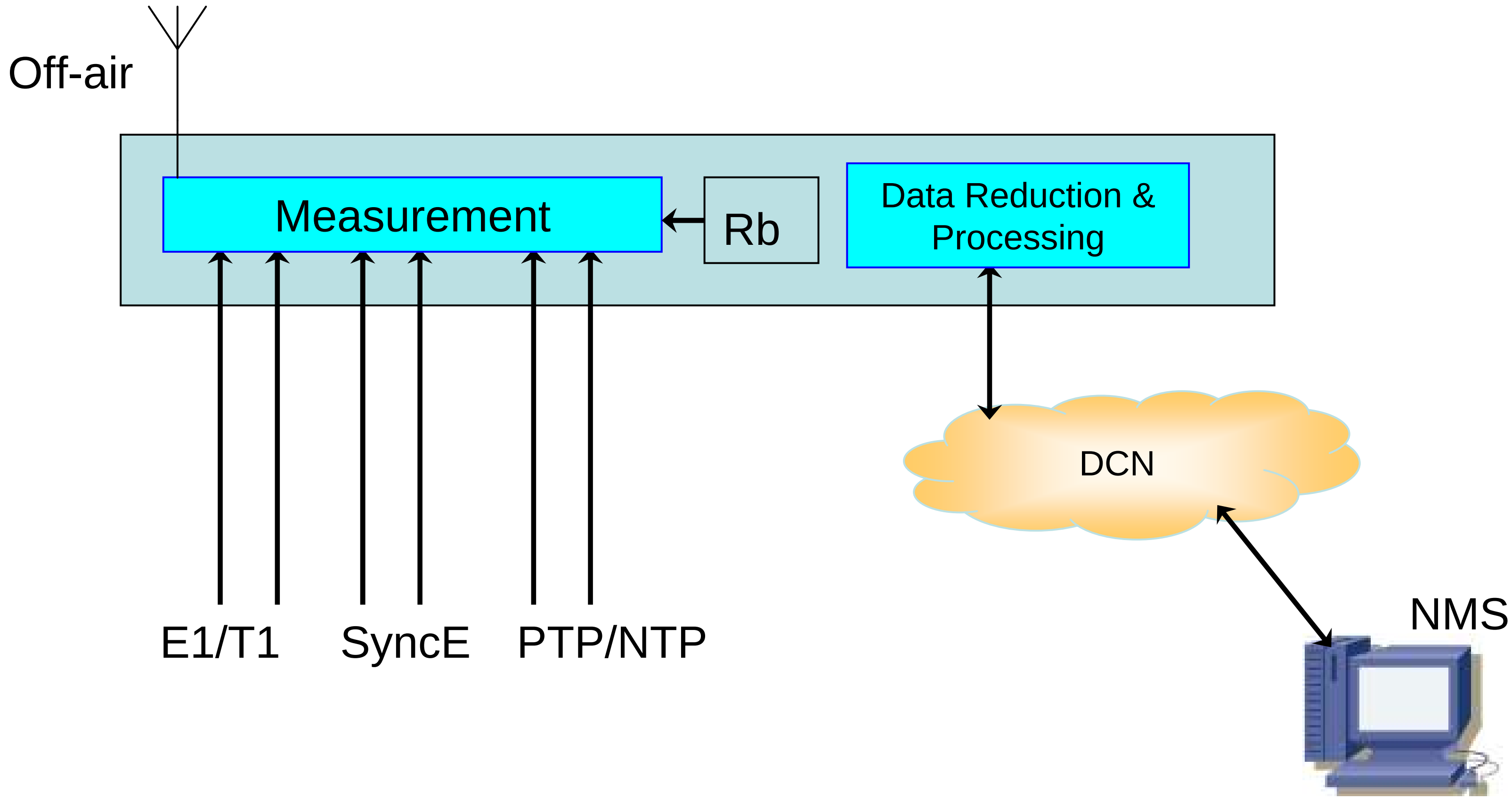
- **User Judgment / Expectation of Quality at the Client / Application Layer Has Not Changed**
- **Underlying Technology, Systems and Terminals of Service Delivery Are Changing**
- **New Methods of Specifying, Signaling, Assuring and Measuring QoS / QoE Are Needed**

Probes to Build SLAs





Global Probe for SLA measurement



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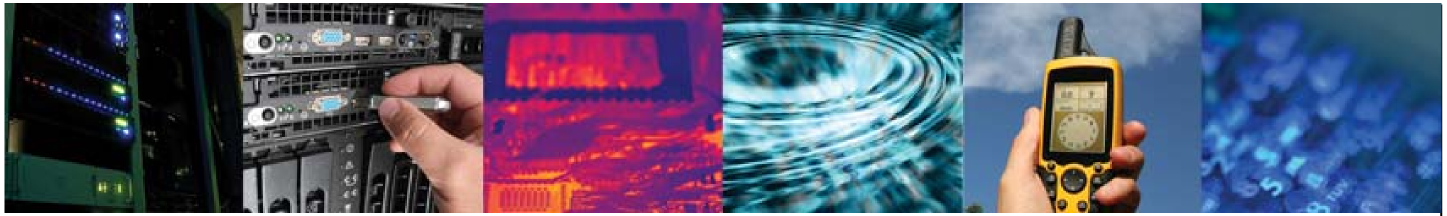

Summary

- Physical layer sync still offers the best guarantee of QoSync
  - SSU, SyncE, UTI
- Timing over Packet – “ToP” - NTP/PTP
  - Layer 2/3 with hardware assistance
  - Layer 3 with OCXO filter
- Adaptive
  - Need OCXO?
- Proliferation of PRS
  - More GNSS etc. at the edge
- Network Engineering
  - PBB-TE & T-MPLS assist ToP

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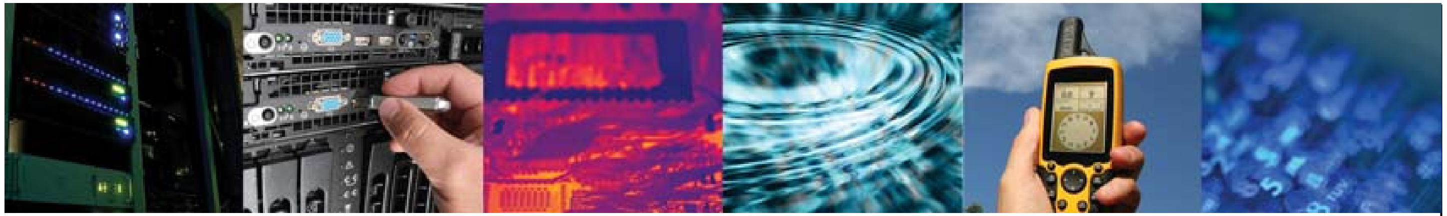
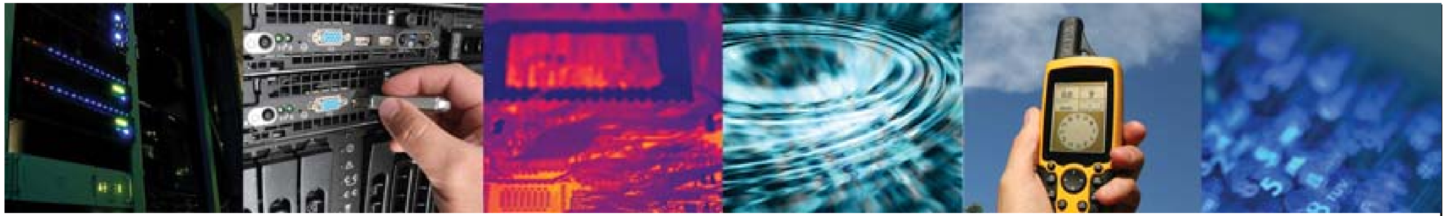


Summary

- SLA development requires real-time and permanent measurement nodes and data processing/storage
- Measurement nodes either integrated into NEs (e.g. SSU, routers/switches with PDV monitoring) or standalone probes.



Thank You & Questions

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