Time and Synchronization in Telecoms
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TIMING ISSUES IN ACTIVE PROBING AND PASSIVE MONITORING MEASUREMENTS

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Context of this presentation
IP Performance Measurement

- Talking today about Real Time Clock (RTC)
- Time synchronization amongst network elements who are geographically spread into a large area (multiple countries)
- Transport over packet network
- Practical considerations only – things we can do now.

High Accuracy Synch (<1 ms)	Low Accuracy Synch (>1 ms)
• Active Performance Measurements (IP SLAs) • Passive Performance Measurements (NetFlow) • Interface Counters (to get a snapshot on multiple routers) • Routing Convergence Measurement	• Logs • Error messages • Security Certificate Validation • Etc…

Timestamping accuracy

- Timestamping is happening in many places for routers.
- Accurate *timestamping* is a problem we can solve today
  - Interrupt-level timestamping (in the interface driver)
  - Hardware-assisted timestamping (proprietary/chips/ASICS)
- Sub-ms accuracy is not a problem for a software based approach.
- Microsecond accuracy is our objective for hardware timestamps
- Works great for round-trip delay, delay variation, etc…
- Router's clock will not drift significantly for short measurement windows

Synchronization issue…

- When timestamps from distinct network elements are combined, time synchronization is needed.
- #1 problem we have with IP SLAs (active probing) and one-way delay measurement.
- How do you trace packets without a uniform time?
- The timestamps error margin is far smaller than the synchronization error margin with NTP!

- As we keep improving the timestamping accuracy, there is a need to improve time synchronization at the same time.

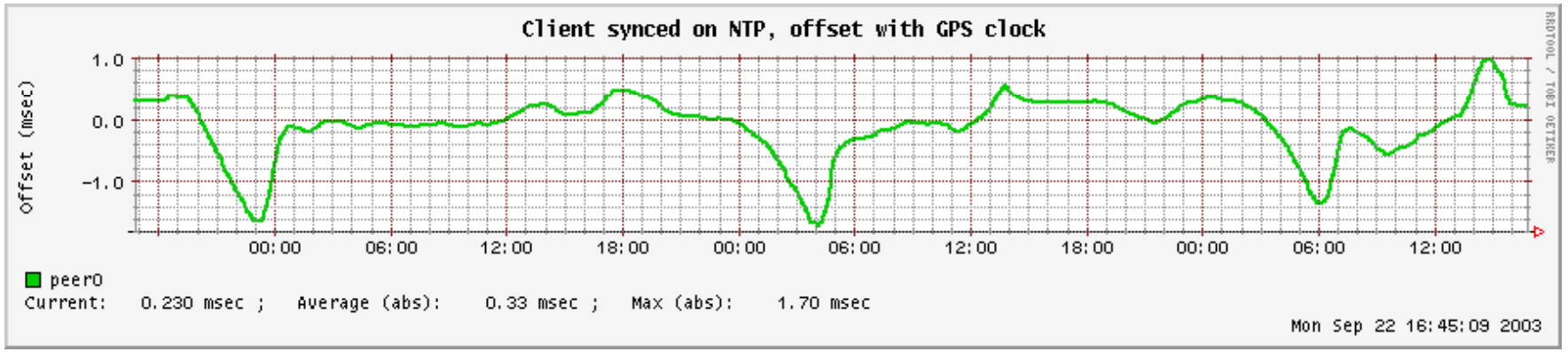
Today's solution: NTP over WAN

- NTP is not a good solution over wide area networks (WAN) links, who are subject to rerouting, asymmetry, loss, jitter and other last minute surprise.
- Flaw 1: NTP assumes the transmission delay is symmetric, which cannot be proved. If it is proved symmetric, then why bother measuring one-way delay?
- Flaw 2: NTP aim for long-term accuracy, but we need short term accuracy!

  RFC2679: "Ordinary application of NTP may allow synchronization to within several msec, but this depends on the stability and symmetry of delay properties among those NTP agents used, and this delay is what we are trying to measure."

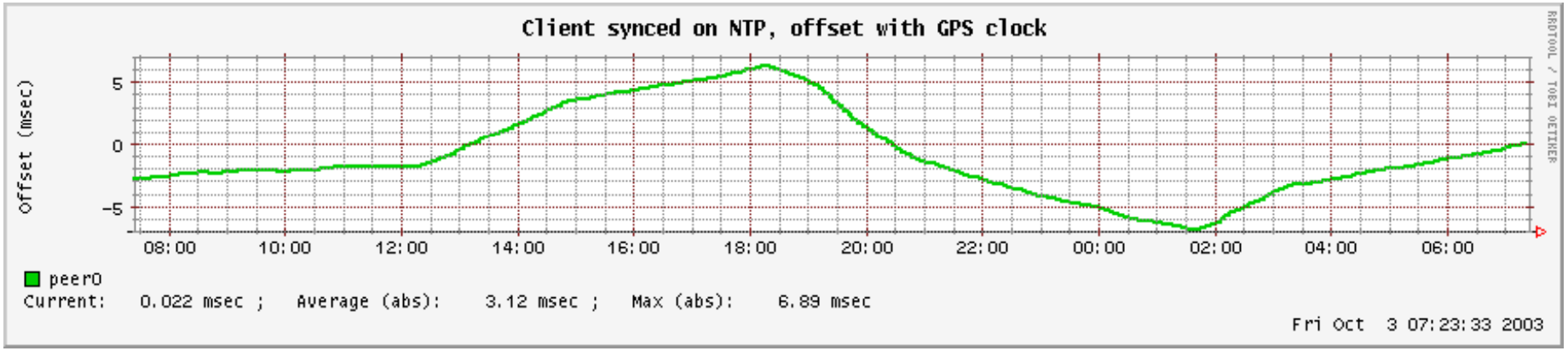
NTP – Accuracy on LAN or High Speed Networks

- Linux NTP client synchronized with another NTP server on the same LAN at 100 Mbps full duplex.
- The NTP offset was compared with GPS clock (http://www.cnssys.com/).
- No impairment: delay < 0.5 ms, jitter < 0.1 ms.
- After 72 hours, offset on average was 0.33 ms, worst case was 1.70 ms.



NTP – Accuracy on WAN Links

- Delay 32 ms each way
- Jitter 6 ms gaussian each way
- No packet loss
- Offset:
  Maximum = 6.89 ms
  Average = 3.12 ms



NTP Myths

- I have NTP, so I'm fine with time synchronization.
  This involves more than just enabling a feature.
- I have a stratum 2 clock, so it's very accurate.
  There is no direct relation between stratums and accuracy. The path between stratums is key.
- If I expedite NTP traffic through a dedicated QoS class, a very good accuracy can be achieved.
  This is true if and only if the jitter and loss are kept at very low value. If it may be possible over a LAN link, there's no deterministic way to asses such a condition at all times over WAN links
- I'm synchronized with a small offset, so I am OK.
  Maybe … unless the transmission delay is asymmetric, in which case NTP wrongly assumes OneWayDelay = RoundTripDelay / 2.

Conclusion for NTP

- NTP is a good thing, but aims for **long term accuracy**, stability.
- Does not provide clock stability (clock discipline), but tries to correct its instability (drift) using nano-increments / nano-decrements.
- Troublesome on asymmetric paths.
- Not accurate enough on typical WAN links for sub-ms accuracy
- Good candidate for ms-level LAN synchronization

Other solutions today?

- GPS time source are excellent, reliable, and cost effective time source. We always recommend them, but…

Antenna requires clear sky view in most cases: installation can be difficult and expensive, involving contractors etc....

Window-patch antenna exists, but do not always works

- CDMA (based on wireless mobile network) time source offer best of both worlds when possible.

- Synchronization between clocks and routers either via NTP over LAN, or 1PPS/RS232 data feed.

Looking forward to …

- IEEE1588 v2: I will not expand here, covered here by Silvana Rodrigues, Max Gasparroni.
  In a nutshell:

  The protocol will be applicable to systems communicating by local area networks supporting multicast messaging including but not limited to Ethernet. […] The protocol will support system-wide synchronization accuracy in the sub-microsecond range with minimal network and local clock computing resources.

- How can IEEE1588 alleviate unstable conditions over WAN links is yet to be analyzed.
  [Personal note: anyone here can help me dig this out?]

Looking forward to…

- Idea: re-using interface clocking, where available, as a time-base for the real-time clock (RTC) accuracy. Probably more accurate than a free-running, non-ovenized crystal.

  Network frequency synchronization disciplines the local RTC clock.

  NTP for true time synchronization.

  A simple yet efficient combination

Issues Summary

- The industry is pressed to deliver super accurate timestamps (sub ms), but the synchronization is hard to achieve at this level over a standard ‘packet network’.
- The synchronization problem is often overlooked, both by customers and equipment vendors.
- The ‘NTP myth’: careful deployment is necessary, blindly tuning on NTP will lead to unpredictable results.
- GPS source is the best, but installation is not always straightforward nor cheap because requires antennae with line of sight visibility to the sky.

Thank you for your attention!
Questions?