UTC and NIST Time

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Outline

- What is UTC?
- What is UTC(NIST)?
- Traceability
- Network Time Service (now)
- Network Time Service upgrade
- Remote System prototype
- Summary
Coordinated Universal Time (UTC)

- Computed by the International Bureau of Weights and Measures (BIPM, Paris)
  - Clock data contributed by National Laboratories
    - NIST, USNO, ...
- UTC is a purely paper time scale
  - No physical clock realizes UTC
UTC(NIST)

- Time scale maintained at NIST in Boulder, Colorado based on data from local atomic clocks
- UTC(NIST) is steered to UTC based on data received from the BIPM
  - Difference typically < 10 ns.
- UTC(NIST) is reference time for all NIST time services
Time Traceability - 1

- An unbroken chain of measurements from the end-user application back to the national reference time scale
- Each link in the measurement chain characterized by time delay and uncertainty
Time Traceability - 2

- Technical traceability:
  - Doing the right thing

- Legal traceability:
  - Being able to convince a judge and jury
    - Adequate log files
    - External monitoring

End-point traceability often difficult

Legal traceability often inadequate
GPS Traceability

- Broadcast data are predictions
  - Satellite time → System Time → UTC(USNO)
  - Satellite orbit (geometrical range)
- Troposphere correction (6 ns – 20 ns)
- Real-time offset up to 25 ns
Default Traceability

- Default traceability boundary:
  - GPS and other satellite systems
    - Signal in space
  - Internet and telephone time services
    - Server output
- Output of user equipment, end-user application not traceable by default
  - Unknown calibration, software latency, ...
- Full traceability generally requires active participation at all levels
NIST Network Time service (Now)

- 20 servers at various locations in the US
- Linked by telephone lines to UTC(NIST) in Boulder
- Millisecond-level service (mostly NTP)
  - Depends on network connection
  - MD5 and SHA-1 authentication supported
- About 230,000 requests per second
- 400+ registered users for authenticated services
Service Upgrade (next 3 months)

- Stand-alone remote systems at 3 sites
- Increased capacity, increased accuracy
- Time accuracy at the systems < 25 ns
- Local time reference
  - Independent of real-time GPS
  - Isolated from network attacks and failures
- All systems multiply redundant
  - No single point of failure
Prototype of Remote system

- Operating at NIST radio station WWV in Fort Collins, Colorado since 2005
  - 4,354 days
- System outages (all causes)
  - 162 minutes
  - Available fraction: 0.999 97
- Transmitted time error > 25 ns
  - 8 minutes
  - Available fraction: 0.999 999
No steering
Summary

- **Upgrade to NIST time services**
  - Remote reference accurate to < 25 ns
  - Independent of real-time GPS or external calibration link
  - Prototype Integrity, Availability
    - >99.99% based on 11 years of data
  - NTP, PTP, ...
    - Service accuracy limited by downstream links

- **Remote site location can be anywhere**
  - Minimize downstream delay uncertainty