Trusted Timing & the Network Core

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UTS

NTP Hierarchy

Stratum-1

Stratum-2

Stratum-3

Stratum-4
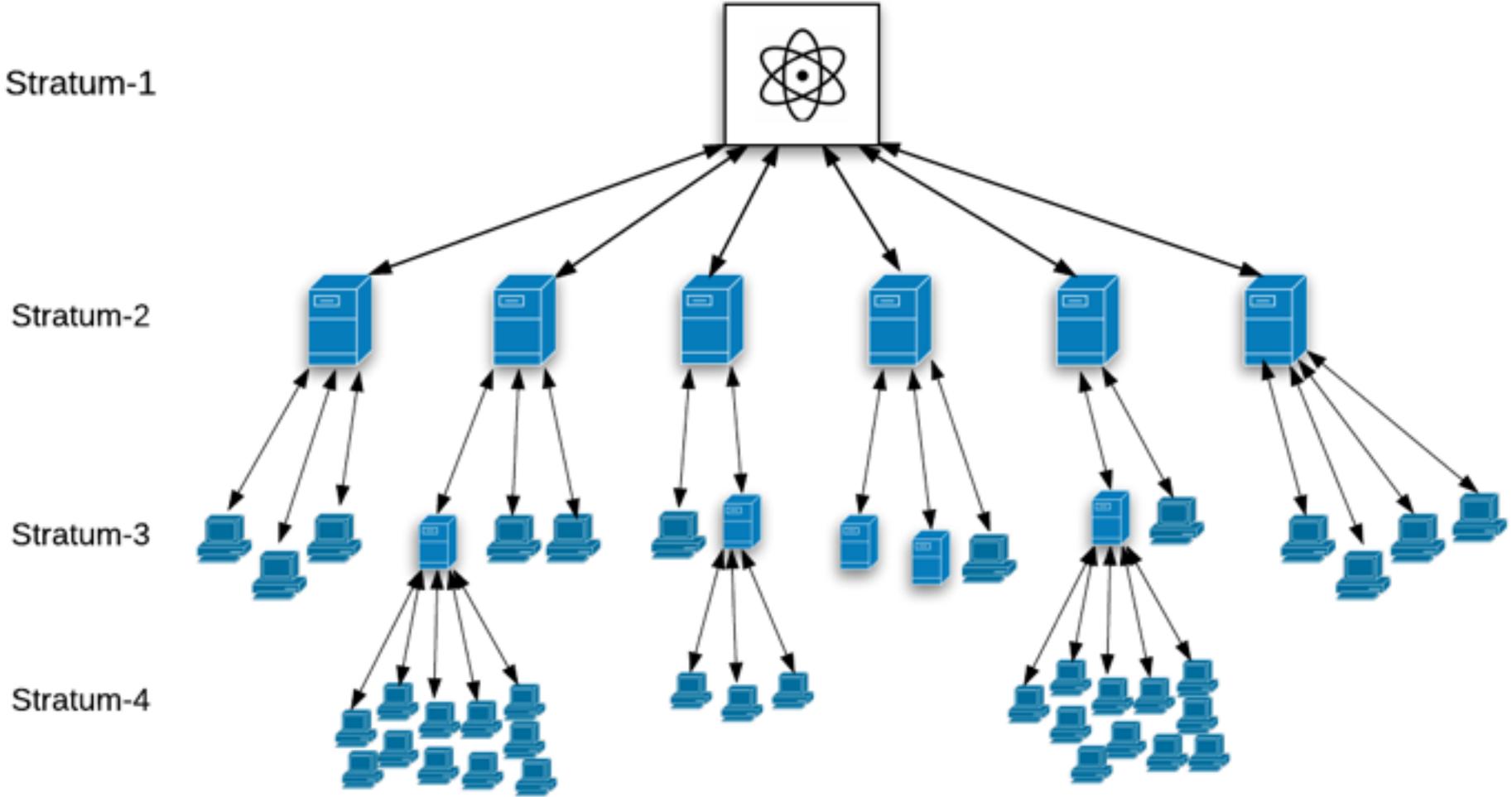
What Could Possibly Go Wrong?

NTP Hierarchy — take II

Stratum-1

Stratum-2

Stratum-3

Stratum-4
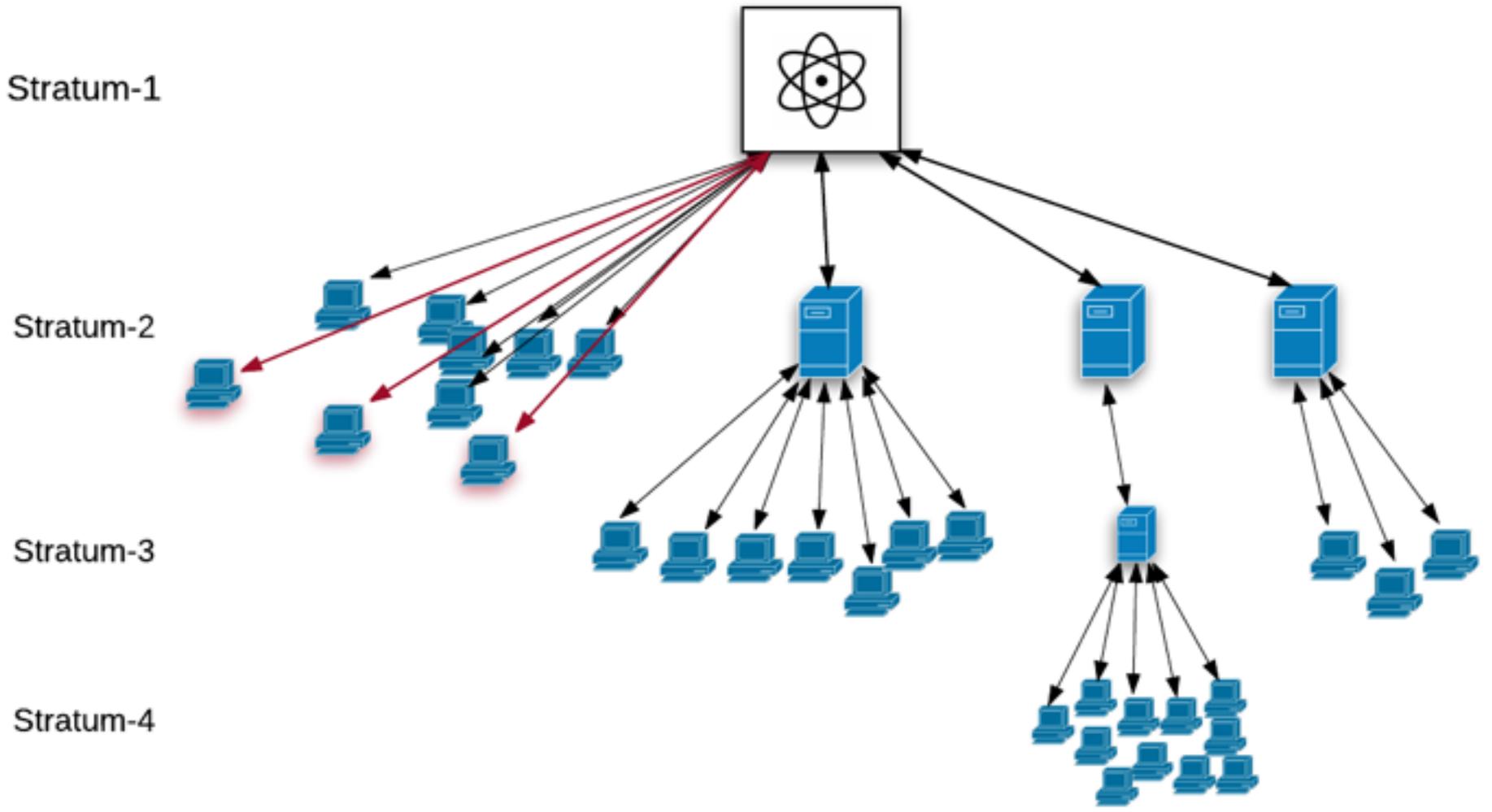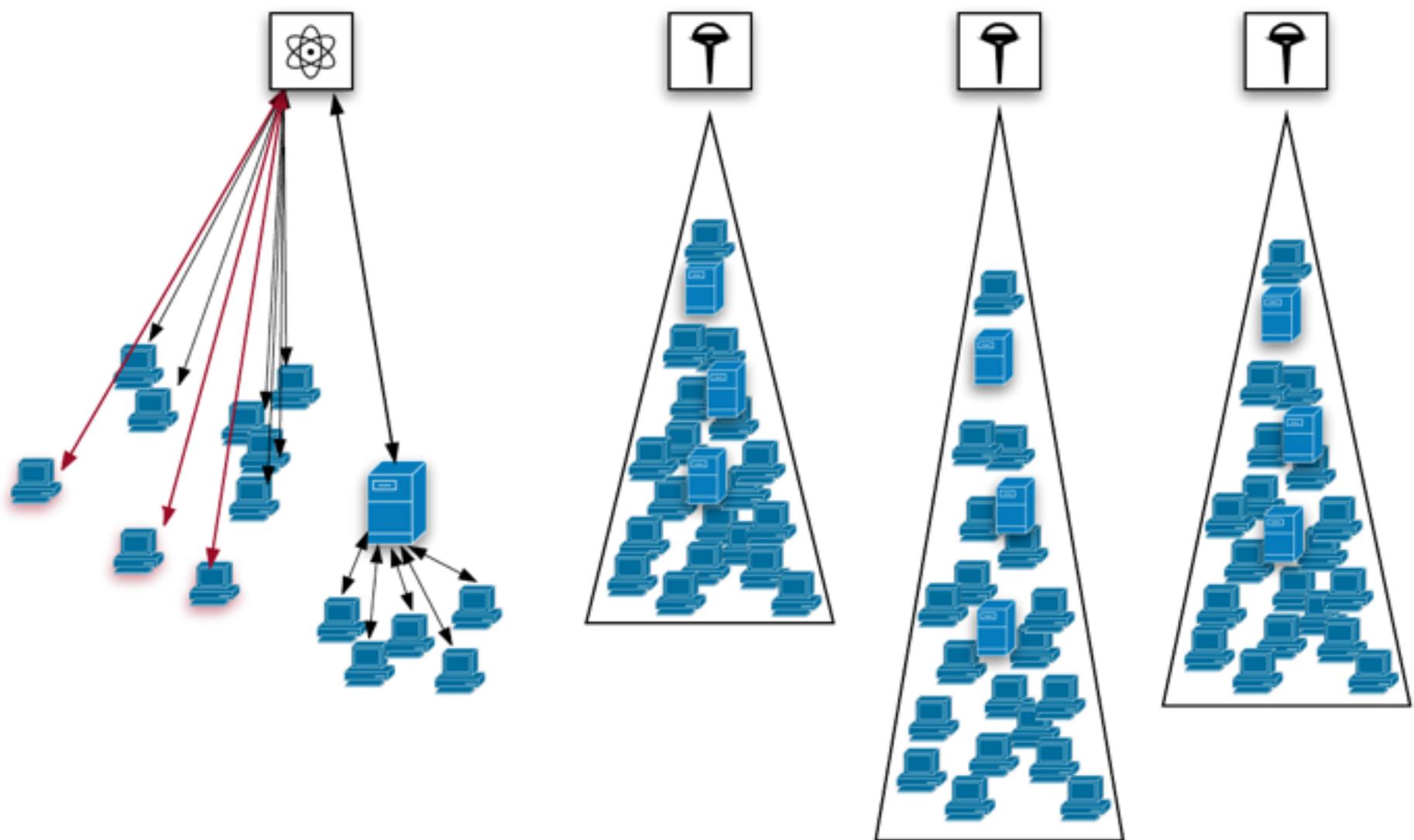
NTP Forest

NTP Forest, with Tree-rot
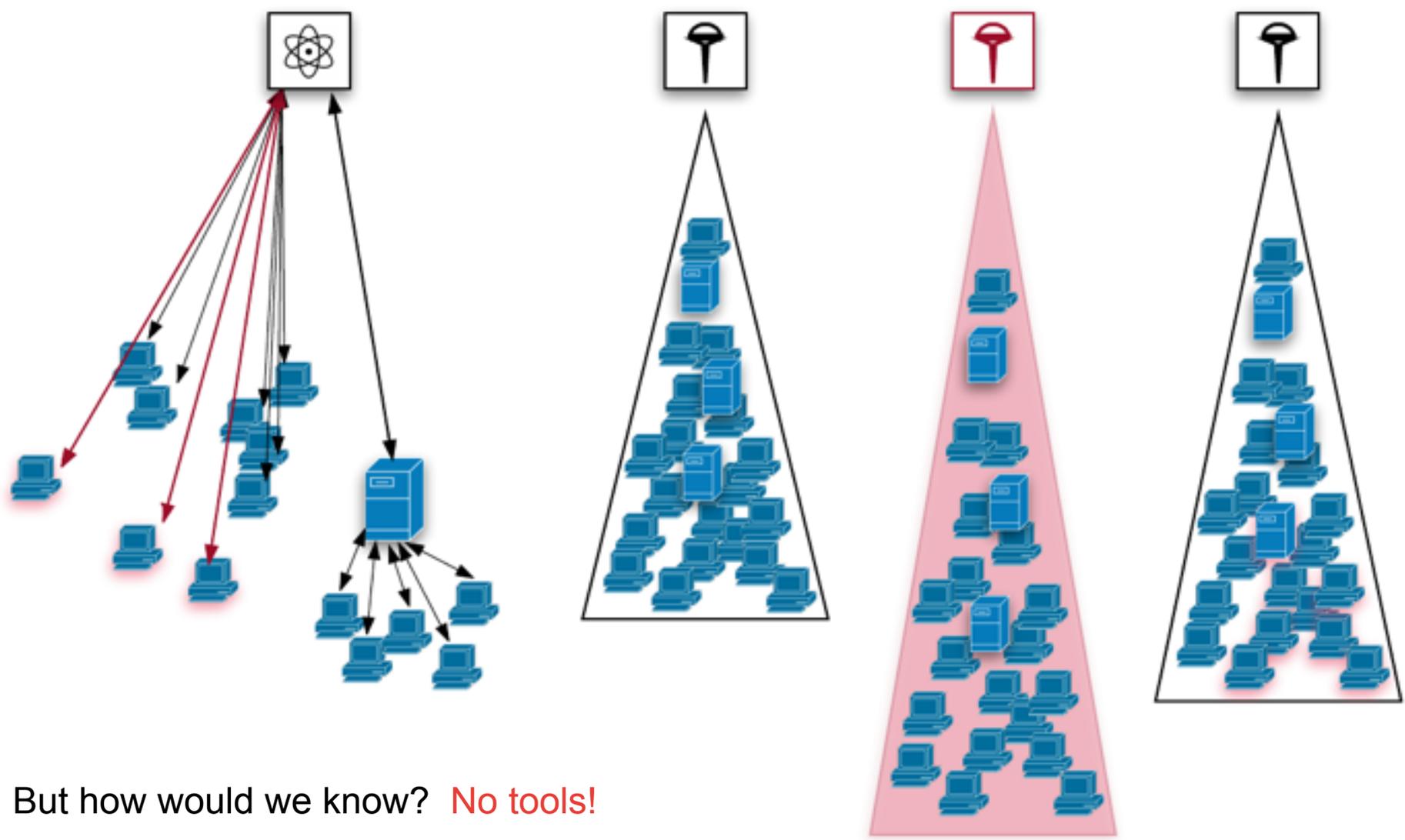
But how would we know? No tools!

▶ Option A: Australia's Top Clock at the NMI

Option B: Raspberry Pi + GPS `hat'

▶ Path Asymmetry: single client – server

Fundamental Ambiguity:

Only ClockError(t) − $A/2$ identifiable from timestamps

$$r = d{\uparrow} + d{\downarrow}$$
$$A = d{\uparrow} - d{\downarrow}$$
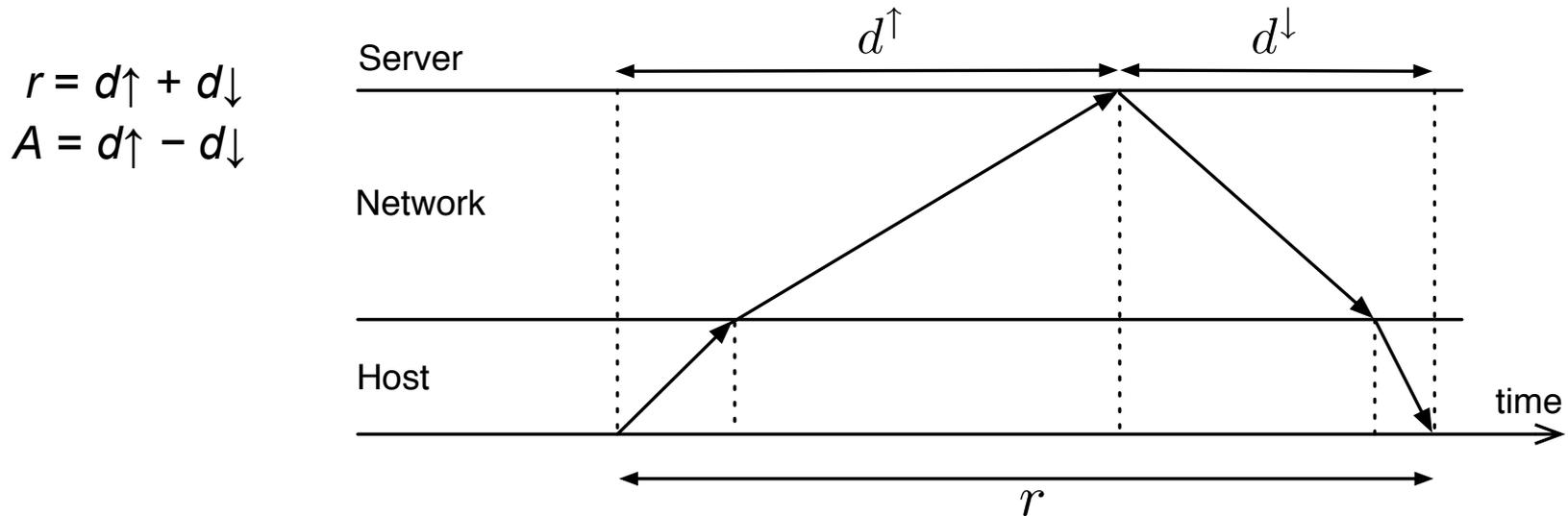
- **Impact on (absolute) client Clocks**
  - A unknown: generally assume $A=0$
  - But! bounded by minimum RTT : $A \in (-r, r)$
  - Creates constant errors from 1μs to 100ms
  - Causes jumps when server changed

Server Anomalies are Real

No RTT `events':
- ➜ no routing changes
- ➜ no major congestion

Large Asym events:
- ➜ R(i) should bound A(i)
- ➜ can't be routing
- ➜ can't be congestion
- ➜ must be server

Longitudinal study (2011,2015)
Out of 102 servers, 37
bad over entire period !
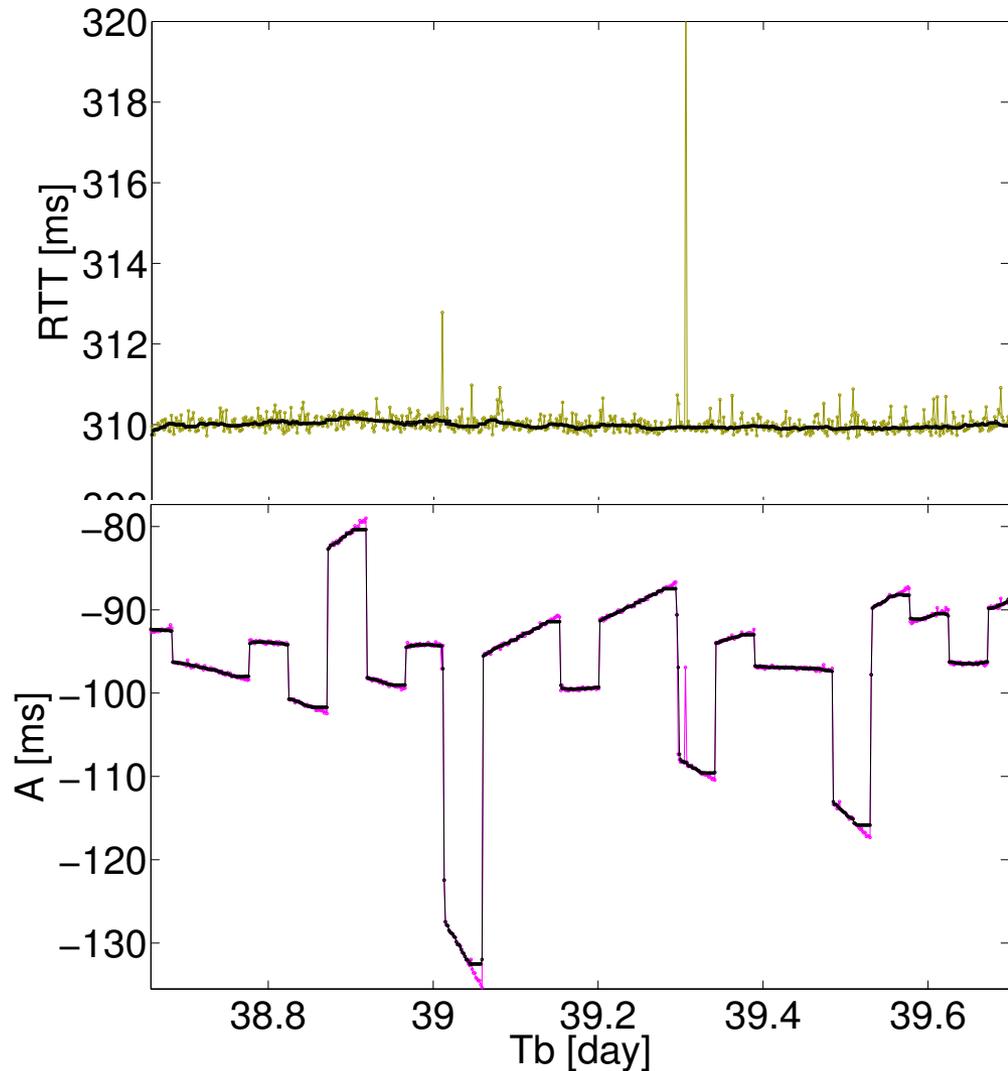
Idea Behind NTC ('DNS for timing')

- **Deal with multiple key problems in one architecture**
  - ◉ Dysfunctional `hierarchy'
  - ◉ No effective cross validation across the Stratum-1 roots
  - ◉ No sync-friendly server selection or load balancing
  - ◉ No trust (malicious or incompetent? who cares)
  - ◉ Failure to address path asymmetry errors

Meshed Stratum-1 + Privileged Stratum-2
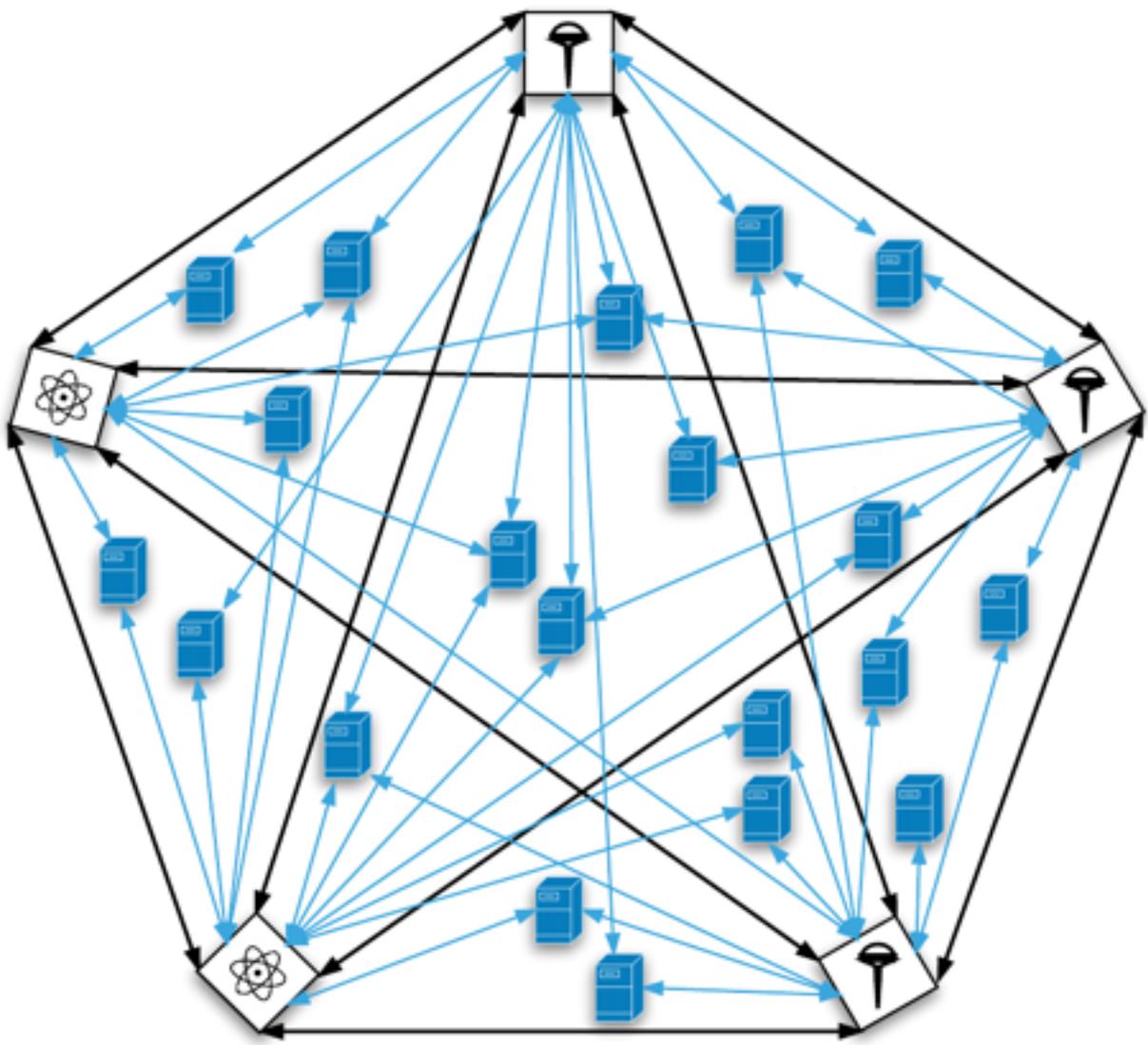
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- **Architecture**
  - NTC Fuses Stratum-1's and privileged Stratum-2's into a unified layer
    - Rare Stratum-1's NOT public
    - Many more Stratum-2's
      - public
      - located within network provider's networks
    - Self vetting using SHM and voting algorithms
  - Asymmetries
    - directly measurable within Stratum-1 mesh
    - achieved throughout the NTC by calibration
    - improved to clients via multi-server measurements, network models, optimised coordinated defaults

Meshed Stratum-1 + Privileged Stratum-2

NMI and AARNet have agreed to support public trails.