Eliminating GPS Dependancy for Wide-Area Synchrophasor Applications

Dan Lutter, Allied Partners

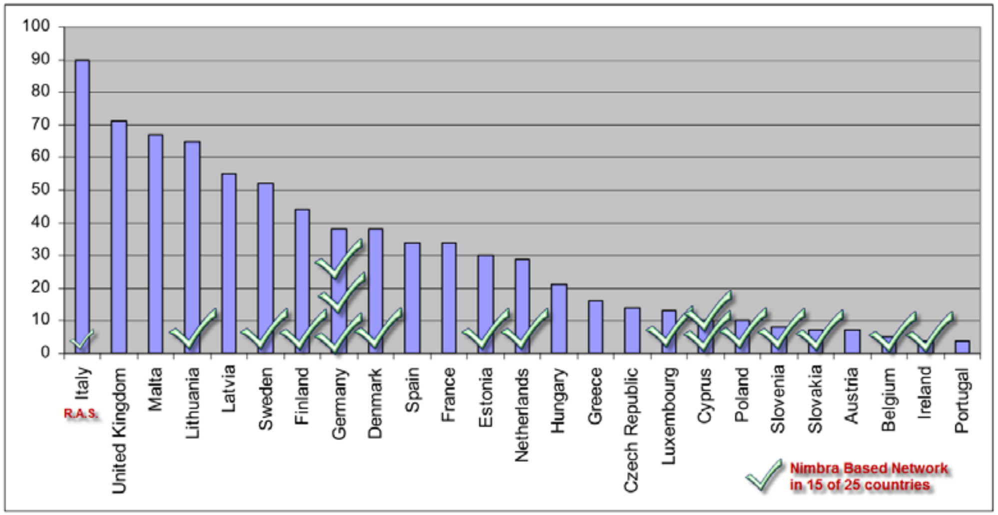
Net Insight developed Time Transfer function to enable GPS independent digital TV distribution

net insight™

Time Transfer proven in 13 large DTT implementations

- Norway
- The Netherlands
- Korea
- Germany x 3
- Slovakia
- Finland
- Denmark
- Estonia
- East Europe
- Lithuania
- China (multiple reg)
- Italy (RAS)
- Ireland
- Luxemburg
- Mauritius
- Japan
- Brasil
- Sri Lanka
- Argentina
- Sweden
- Belgium
- Slovenia
- Eastern Europe
- Cyprus 1
- Poland
- Cyprus 2
- Marocco

Fig 2: National Channels on DTT networks in the EU



Source: MAVISE June 2011

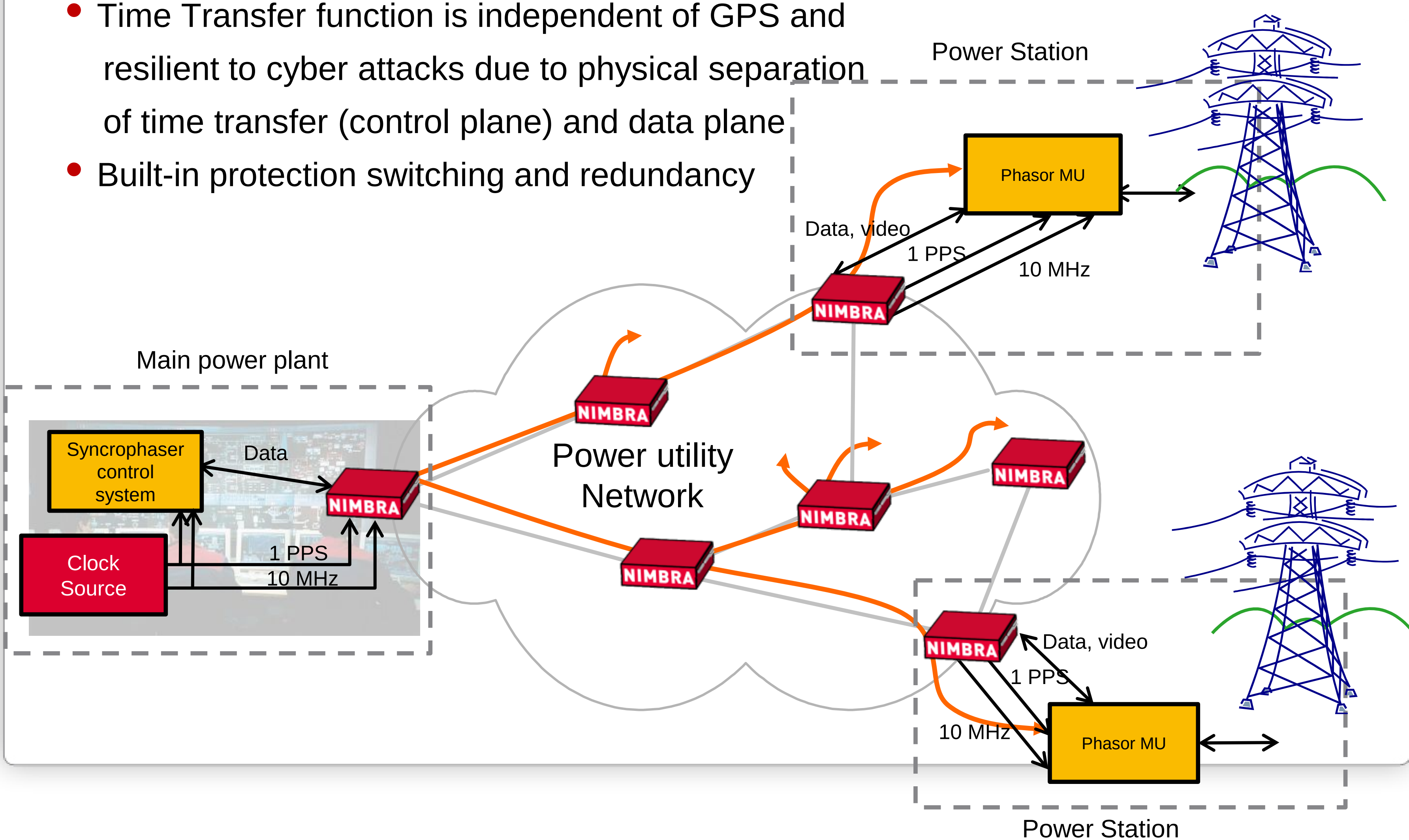
[ ] = TT

Time Transfer for GPS-independent Network Clocking

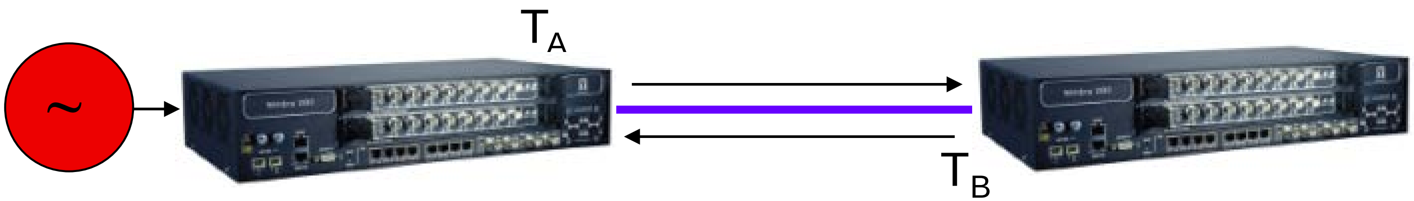
How does it work?

Time distribution for Phasor measurement

- Time Transfer maintains absolute time across the network (~1 us)
- Time Transfer function is independent of GPS and resilient to cyber attacks due to physical separation of time transfer (control plane) and data plane
- Built-in protection switching and redundancy



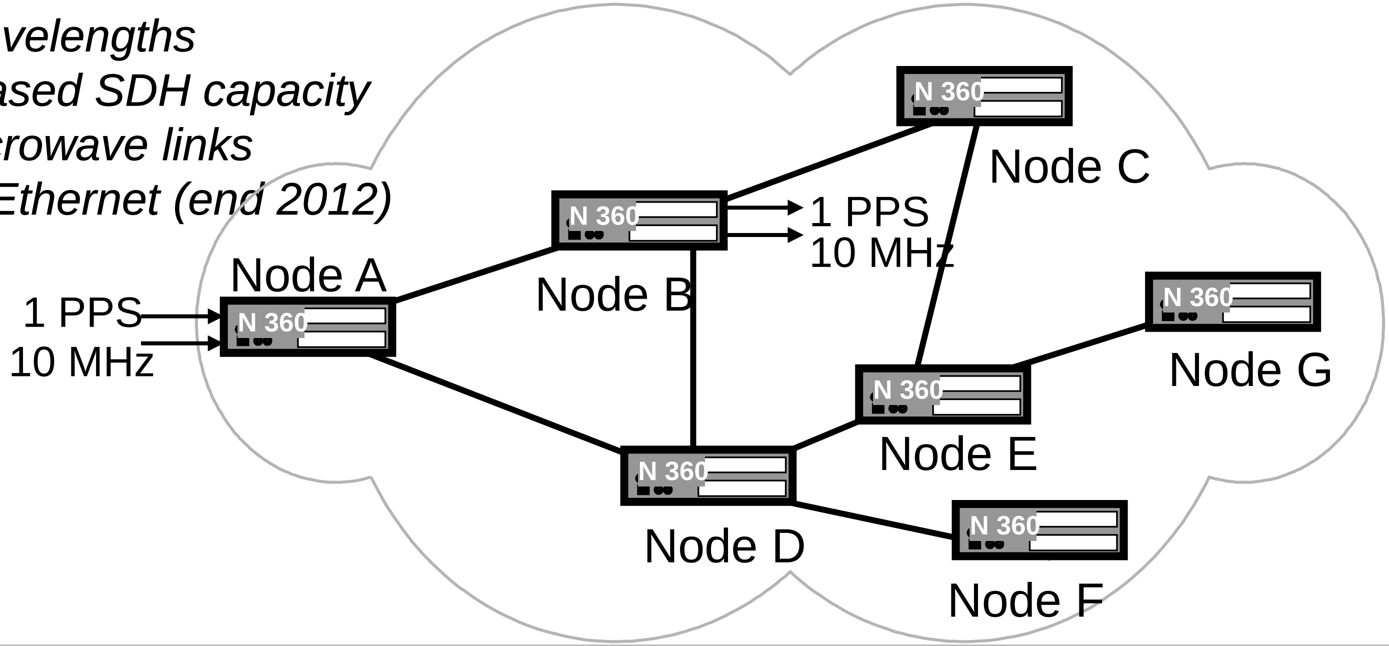
Two-Way Time Transfer (TWTT), general principles



- On each link and both ways a signal is sent telling what the internal clock of the sending node is
- The local clock compares the “incoming time” with its own
- By comparing the two time differences the clocks may be adjusted so the time is exactly the same in both nodes

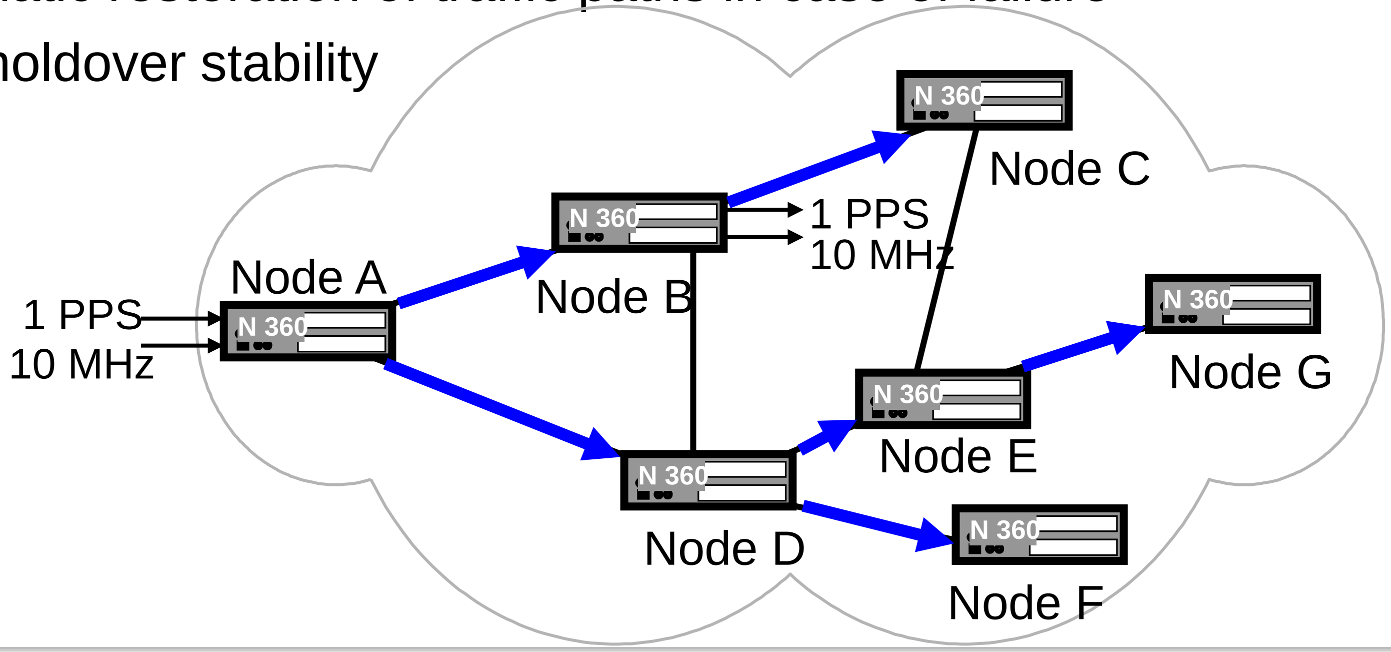
Two-way time transfer in a Nimbra network

- Separated 512 kbps control channel dedicated for time transfer signaling between nodes
  - Cannot be interferred by data or other signalling traffic
- TT channel protocol carries time stamps, correction factors, etc.
- Asymmetric links and equipment delays supported
- Works on any topology and over
  - *Dark fiber*
  - *Wavelengths*
  - *Leased SDH capacity*
  - *Microwave links*
  - *IP/Ethernet (end 2012)*



Two-way time transfer in a Nimbra network, cont.

- Synchronization link by link down the network
- Internal sync protocol determines time transfer paths
- Redundant reference clocks supported at separate locations
- Automatic restoration of time transfer paths in case of failure
- Automatic restoration of traffic paths in case of failure
- High holdover stability



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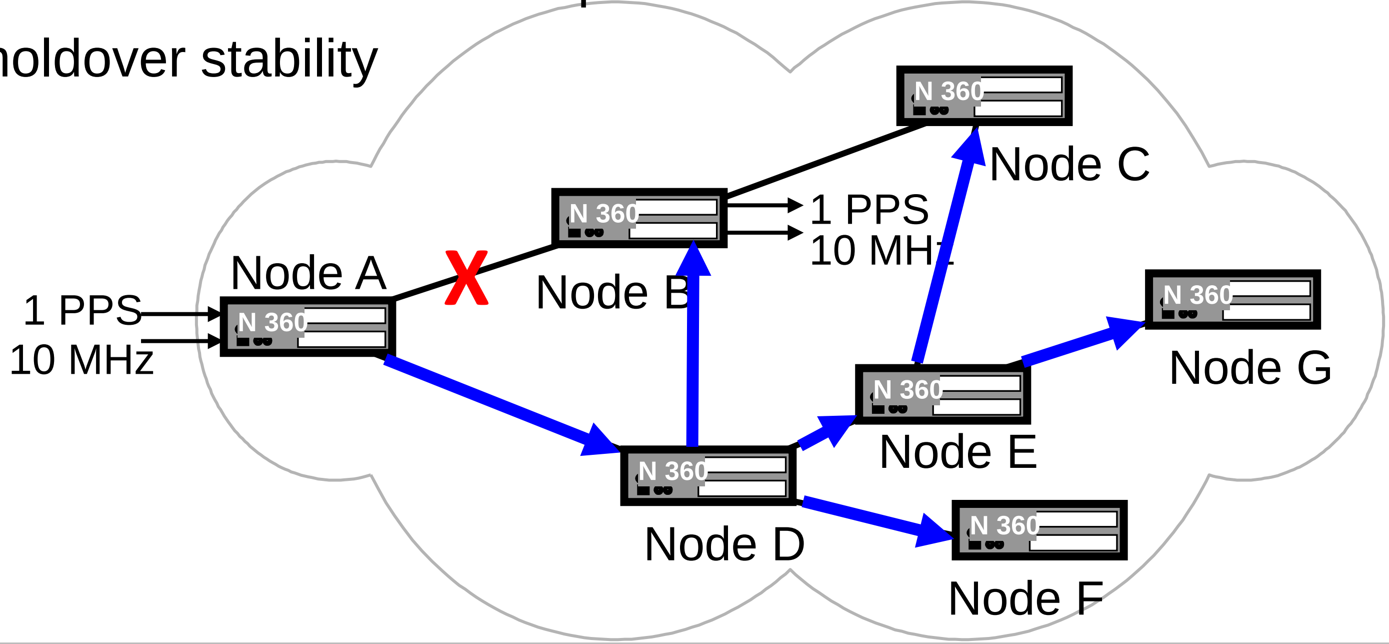
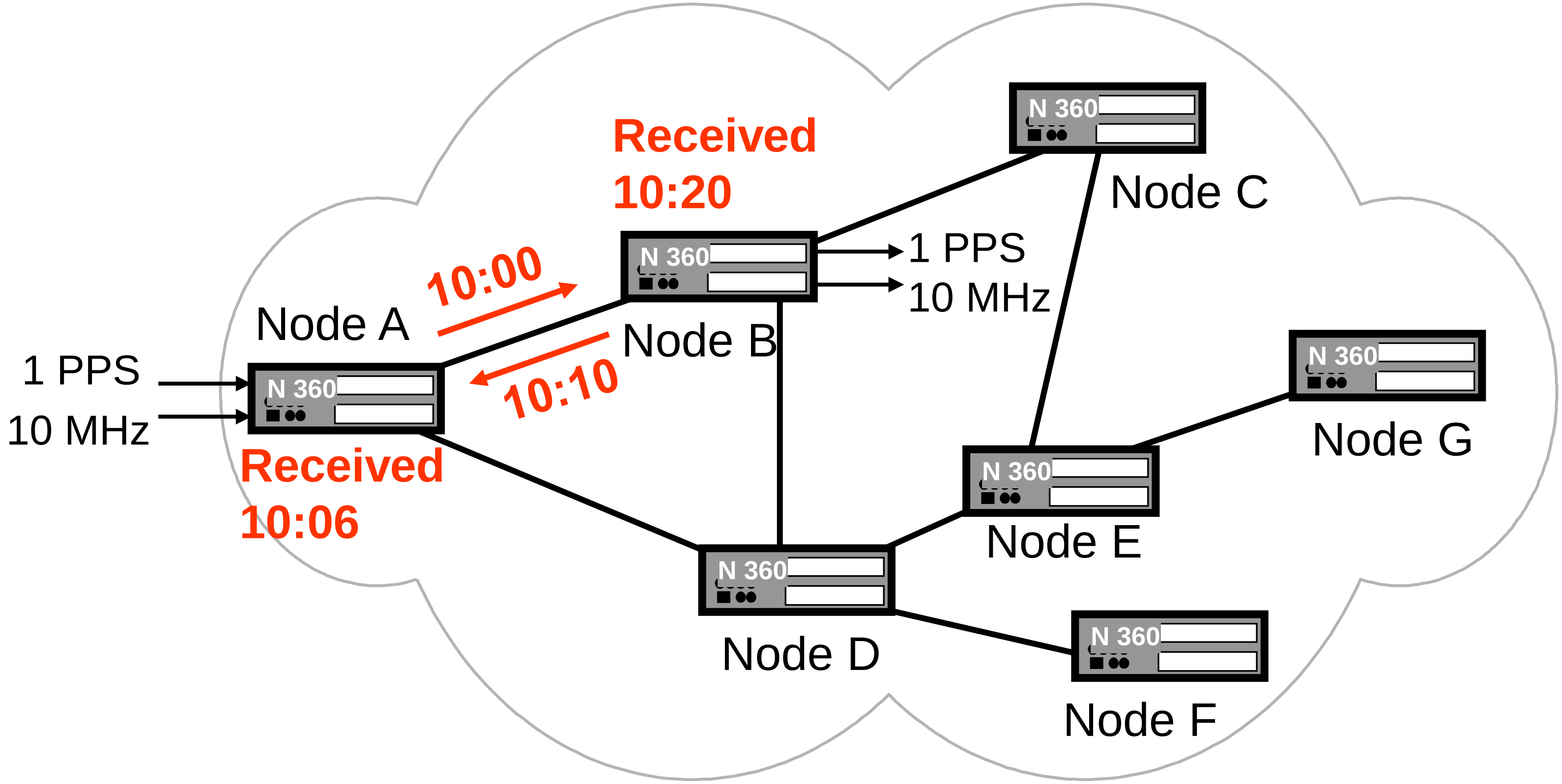
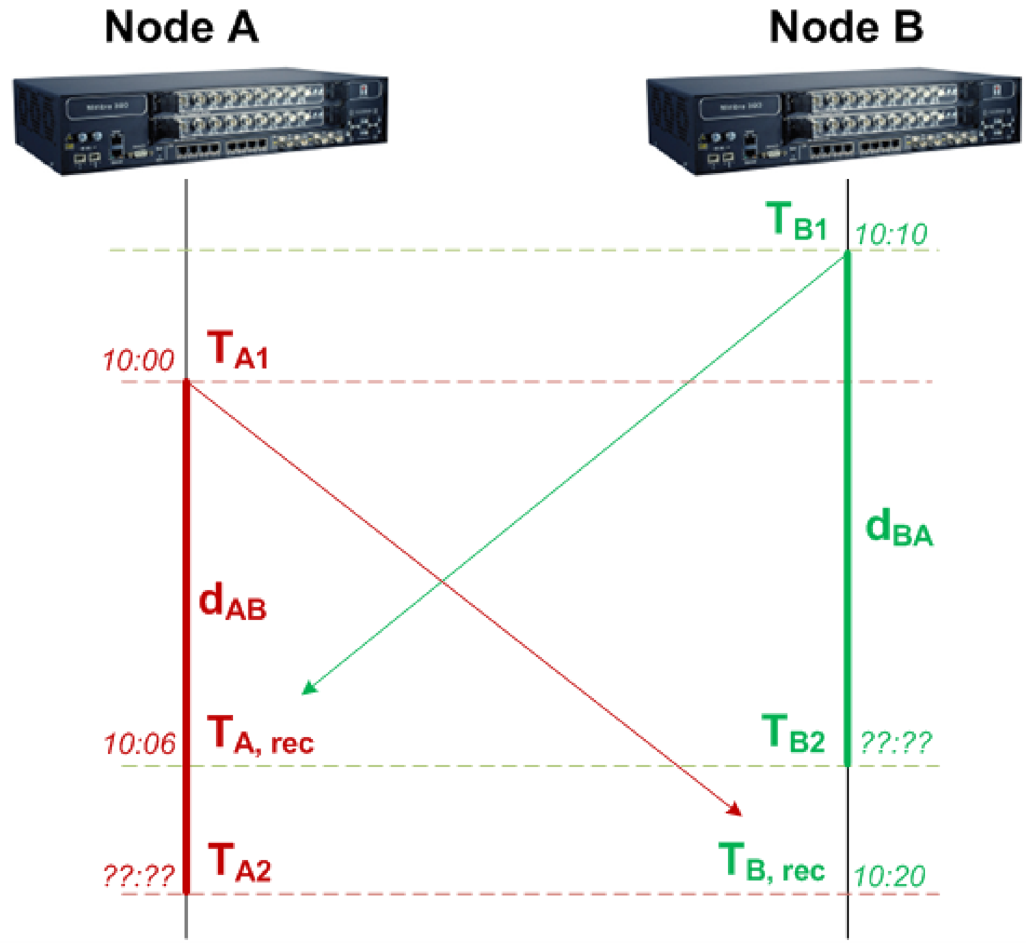


Example of two-way time transfer with symmetric delays



Two-way time transfer, basic maths

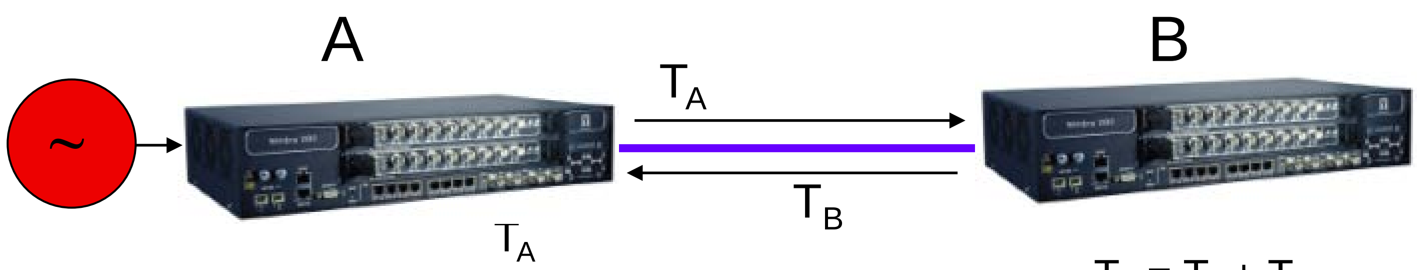


$$T_{A2} = T_{A1} + d_{AB}$$

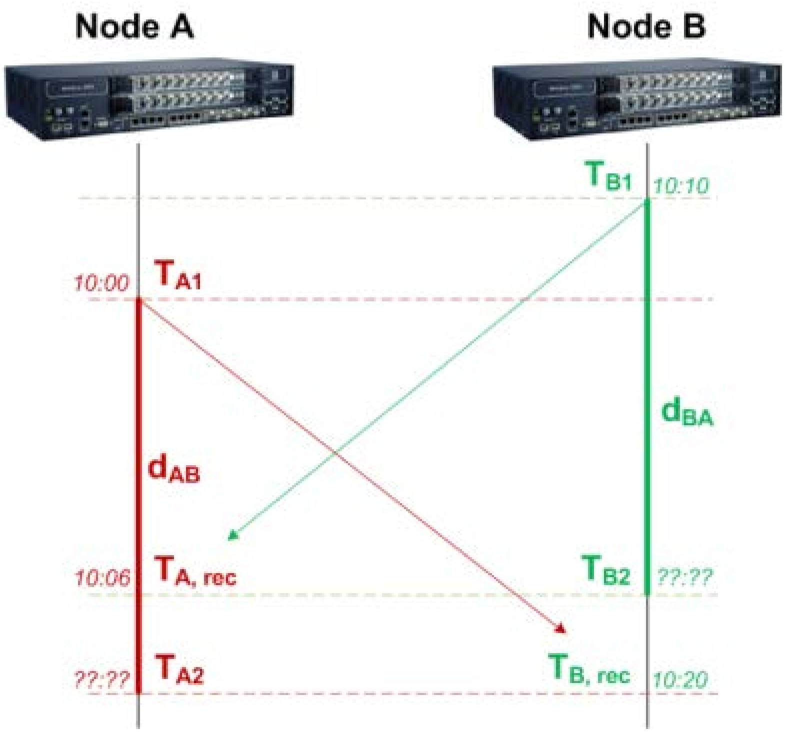
$$T_{B2} = T_{B1} + d_{BA}$$

$$T_E = ((T_{B,\,Rec} - T_{A1}) + (T_{B1} - T_{A,\,Rec}) + d_{BA} - d_{AB}) / 2$$

Two-way time transfer, basic maths



$T_B = T_A + T_E$

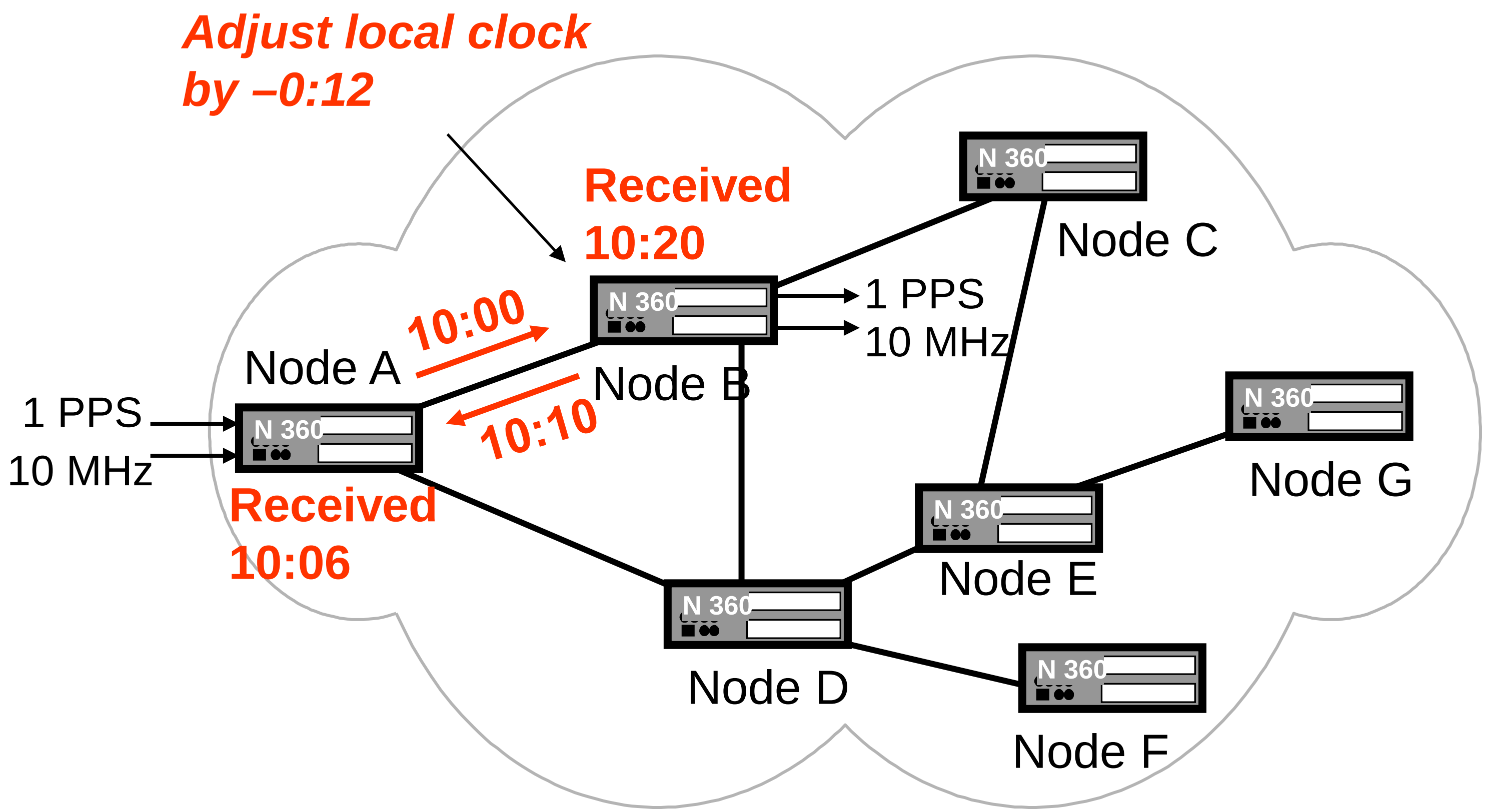


$$T_E = \frac{(T_{B,rec} - T_{A1}) + (T_{B1} - T_{A,rec}) + d_{BA} - d_{AB}}{2}$$

For symmetrical delays $d_{BA} = d_{AB} = d$

$d = T_{B,rec} - T_E - T_{A1}$

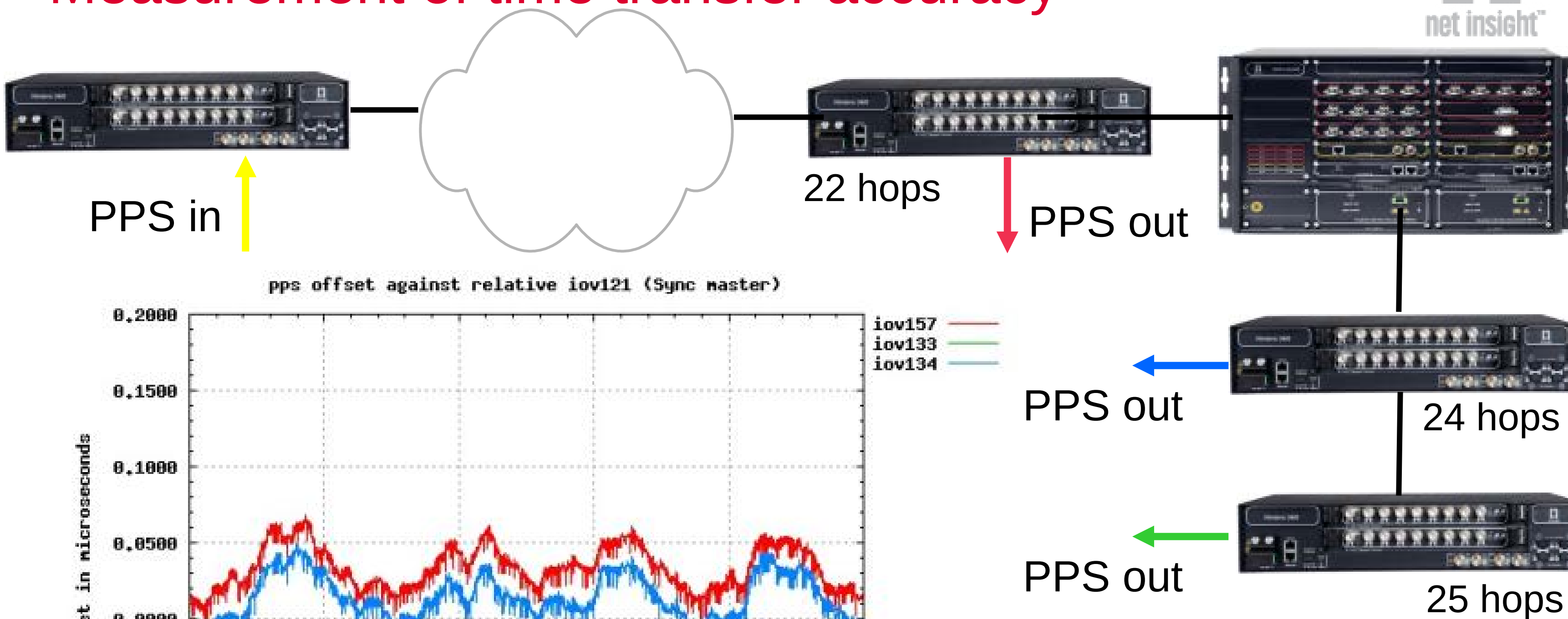
Example of two-way time transfer with symmetric delays

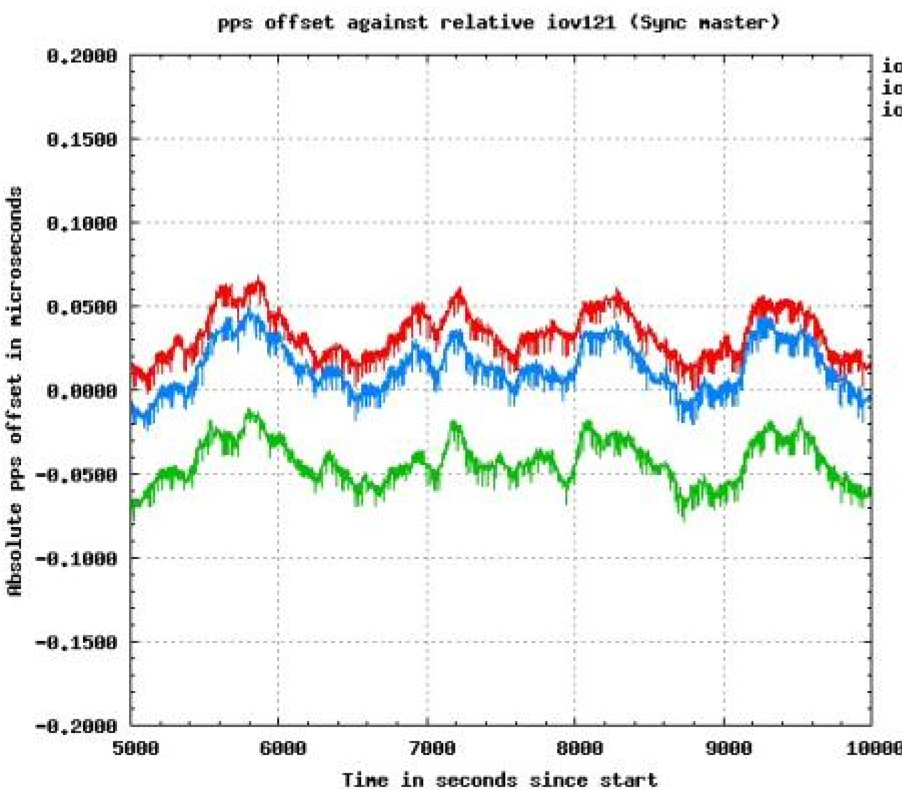


$$T_E = \frac{0:20 + 0:04}{2} = 0:12$$

d = 10:20 - 0:12 - 10:00 = 0:08

Measurement of time transfer accuracy

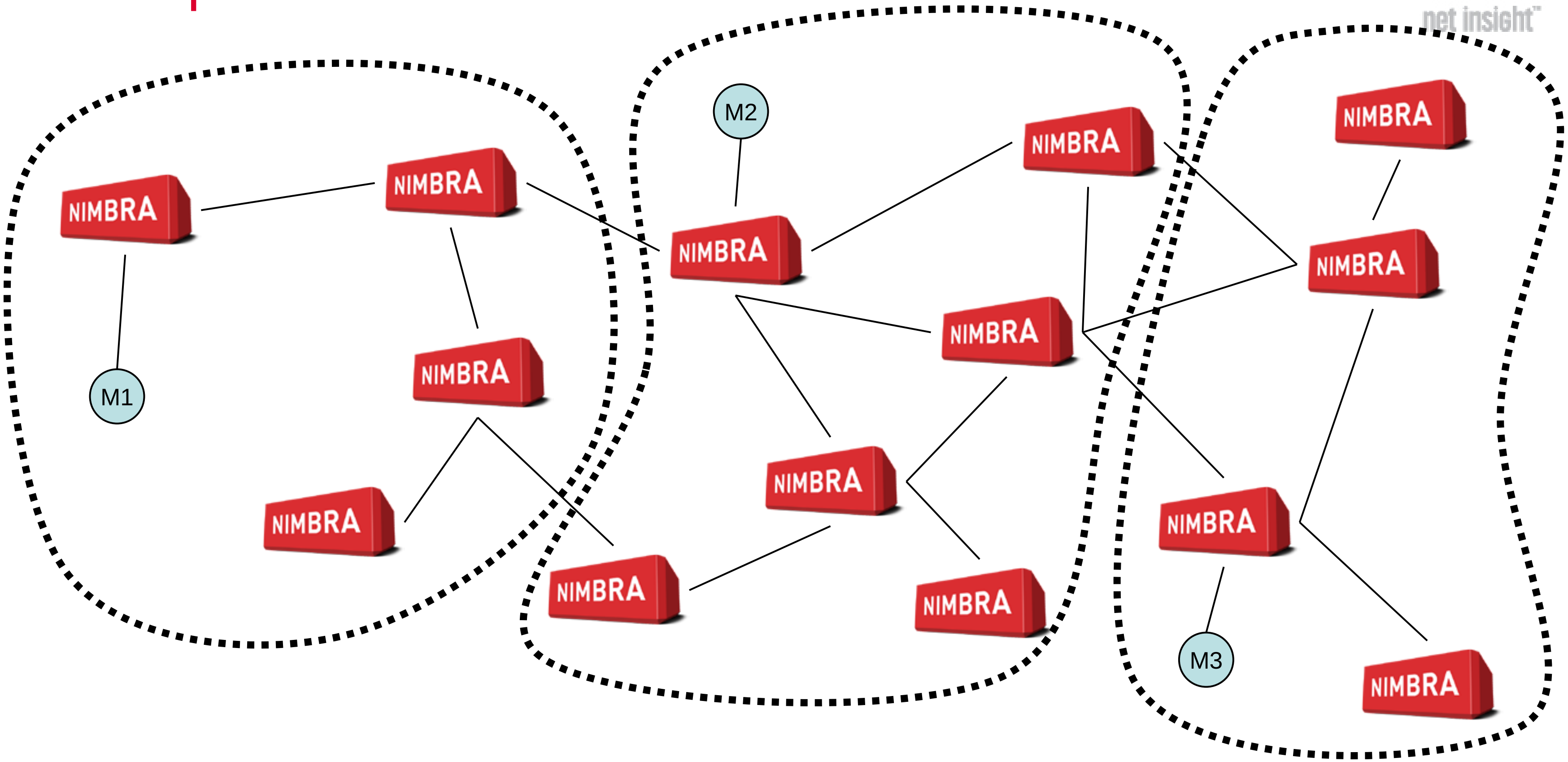




Specified performance
< 1.5µs after 10 hops

Measured (GX4.7):
< 100ns absolute PPS
offset after 25 hops

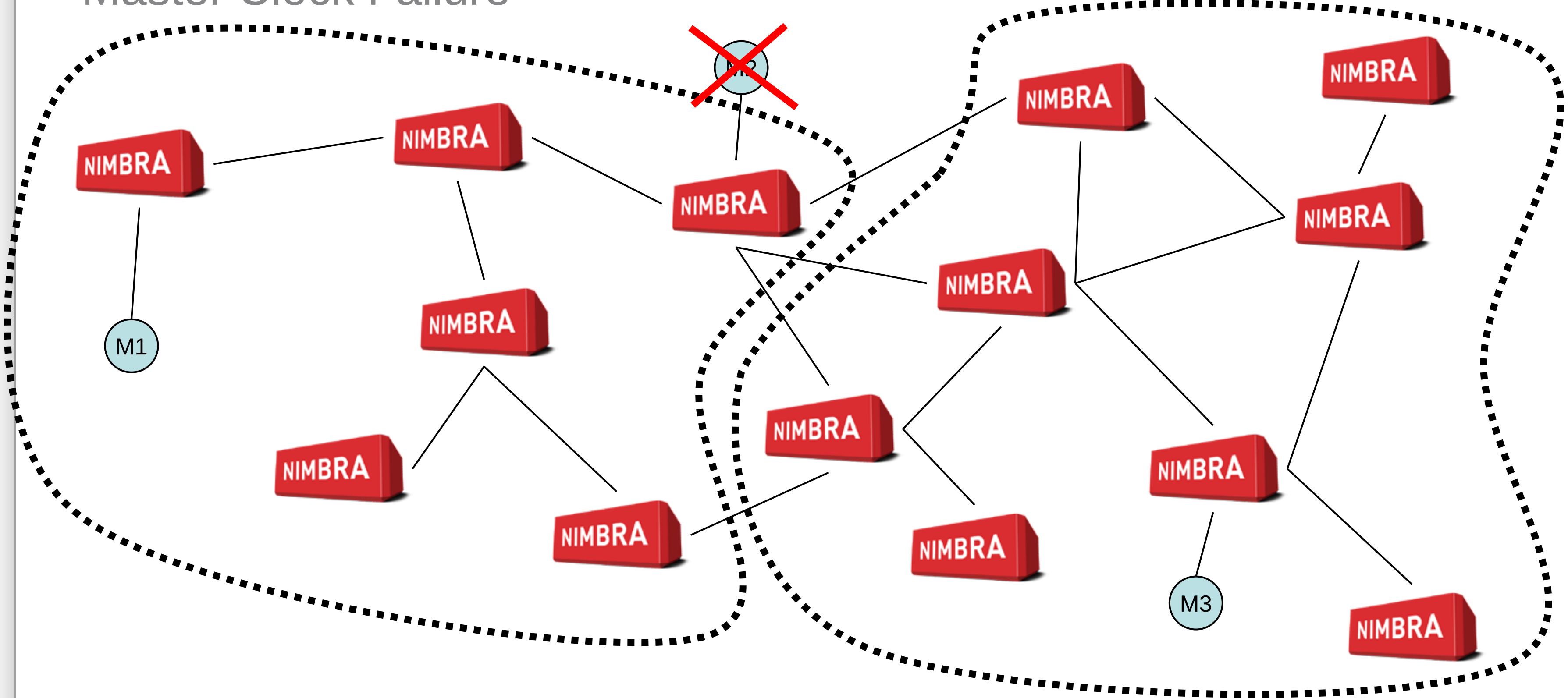
Multiple master scenario



- In this example three masters are used nominally. These will partition the network automatically based on a least hop to master basis.
- For equal hop-count to master, “tie-breaker” criteria are used to chose master
- See next slide for a failure of Master Clock 2 (middle section)

Multiple master scenario

Master Clock Failure



- Master Clock M2 is compromised or fails, detected on the clock inlet port
- Nodes synchronized to M2 will immediately go into hold-over and the synchronization protocol will automatically build new minimum spanning trees
- Transition in and out of hold-over mode is done without frequency or phase transients

Time Transfer in Smart Grid Applications

- GPS free time distribution using Time Transfer
  - Spoof and disturbance free time signal distribution (10 MHZ and 1 PPS) for syncrophasors and WAMPAC systems
  - More scalable and better security than e.g., IEEE1588
  - 13 national network implementations. Over 500 network nodes in Norway
- High Security and integrity
  - Mgmt and Time Transfer is physically separated from data transport
  - Resilient towards service denial and masquarading attacks, spoofing
- Real time properties for WAMPACs
  - Low and predictable delay suitable for teleprotection and synchropahsors
  - Real-time control loops over wide area
- High QoS video surveillance in same network

Easy and service-centric Management and Control

- Service Integrity
  - Different services are 100% separated from other services and from mgmt and time
- Sophisticated protection mechanisms to minimize any outage
  - Rerouting or 1+1 hitless protection switching selectable per service
  - Network protection and hold-over of Time Transfer signals
- End to End Performance Monitoring
  - Strong functionality for fault isolation and repair
  - Preventive fault management – FEC, resync, real-time link monitoring
- Easy operation and low OPEX
  - Reducing complexity and design
  - End-to-end provisioning and service protection

Summary

- Very highly-secure network
  - Service separation to avoid denial attacks
  - Isolation to avoid masquarading attacks, spoofing
- 100% QoS, enabling WAMPAC, SCADA, video surveillance, etc.
- GPS-free network-based time distribution for reliability
- Protection with multiple levels of availability
- Outstanding real-time properties – constant switch delay and zero packet loss to enable real-time control loops
- No risk integration of Enterprise IT traffic

Thank you for your attention!

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