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GPS-independent time distribition for mobile backhaul networks

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Time Transfer Deployments

Single Frequency Networks for Digital Terrestrial Television

- Net Insight has near 15 years of DTT SFN delivery experience
- DTT SFN Networks require an operational phase accuracy of +/- 1000 ns

Globally Deployed National Networks

- 30 countries use Nimbra MSR for DTT

GNSS-Independent Network Solution

- Currently 15 countries use Time Transfer to become GNSS independent
- Independence also includes using Time Transfer as a primary or secondary sync. source

Industry Approved Solution

- Recognized by major transmitter vendors

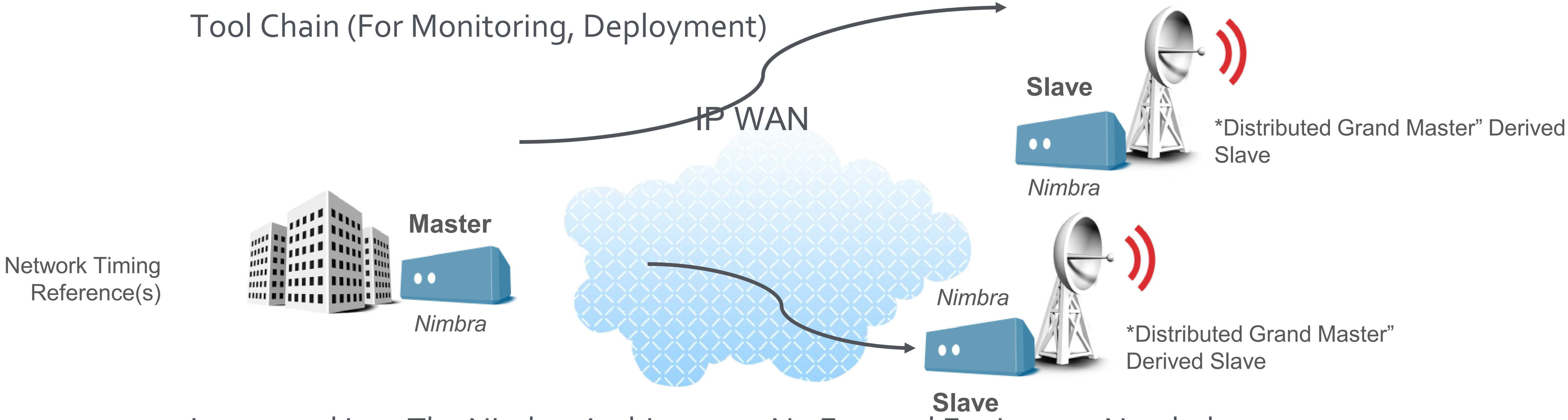
Background to Development of Time Transfer Technology

- Today's society is becoming increasingly dependent on GPS timing for many critical everyday services e.g. digital TV, digital radio, mobile networks
- GPS Properties:
- + High accuracy
- - Possible to externally jam or spoof the signals
- Many countries interested in finding a robust time and frequency transfer method complementing the GPS system
- So far difficult to find an economically feasible alternative providing the accuracy needed (~1 µs)

Integrated Time Transfer solution

Accurate Time Transfer Over IP Networks
- 1 PPS, 10 MHz & PTP*

Tool Chain (For Monitoring, Deployment)



Integrated Into The Nimbra Architecture, No External Equipment Needed

Secure, Resilient, Cost-effective

*RM

Synchronization Requirements

Level of accuracy	Time error requirements (Note 1)	Typical applications (for information)
1	500 ms	Billing, alarms
2	100 μs	IP Delay monitoring
3	5 μs	LTE TDD (large cell)
4	1.5 μs	UTRA-TDD, LTE-TDD (small cell) WiMAX-TDD (some configurations)
5	1 μs	WiMAX-TDD (some configurations)
6	x ns (Note 3)	Various applications, including Location based services and some LTE-A features (Note 2)

NOTE 1 – The requirement is expressed in terms of error with respect to a common reference.

NOTE 2 – The performance requirements of the LTE-A features are under study. For information purposes only, values between 500 ns and 1.5 μs have been mentioned for some LTE-A features. Depending on the final specifications developed by 3GPP, LTE-A applications may be handled in a different level of accuracy.

NOTE 3 – For the value x, refer to Table II.2 of Appendix II.

Main Focus

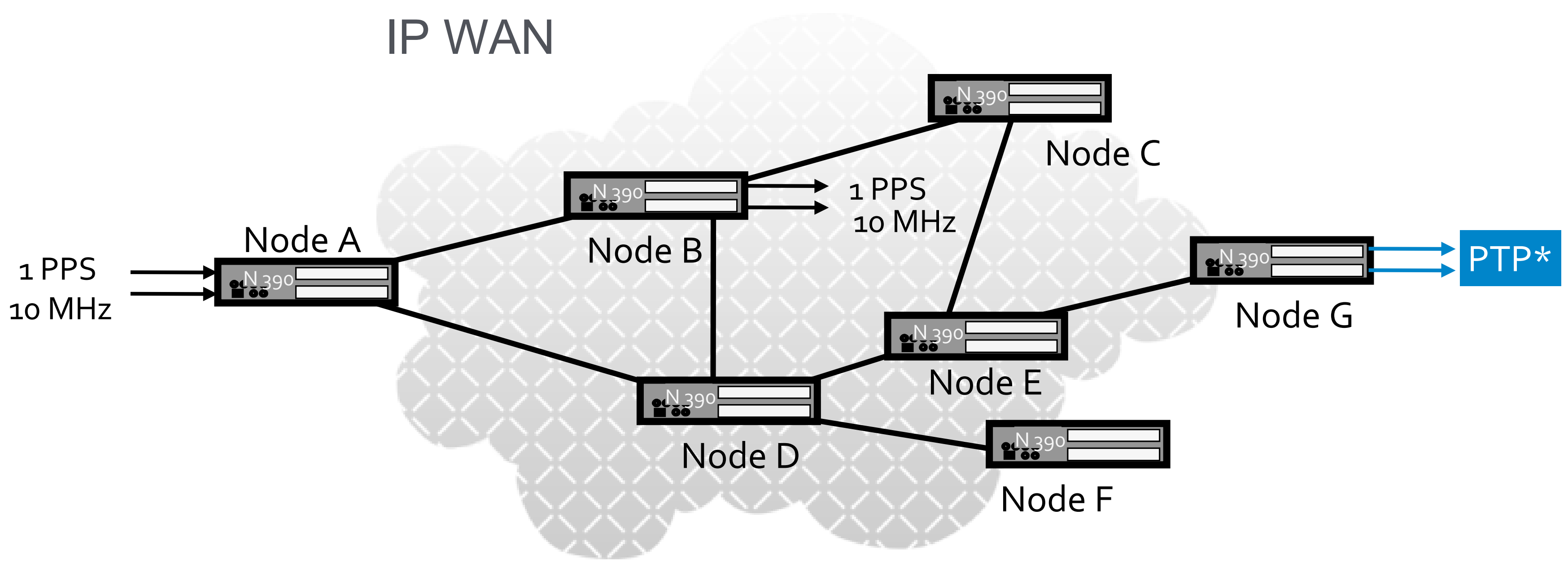
Table 1 from G.8271 (Time and phase requirement classes)

Current work in ITU-T addressing new and more stringent sync requirements

- e.g., as applicable to fronthaul, and 5G applications)

Source MEF IA 22.2.1

Two-way Time Transfer In A Nimbra Network



TT protocol carries time stamps, correction factors, etc.

Asymmetric link and equipment delays supported

Works on any topology and over

- IP (MPLS, Carrier Ethernet, etc.)
- Wavelengths (unprotected)
- Microwave links
- Dark fiber
- Leased SDH capacity (not cross-connected)

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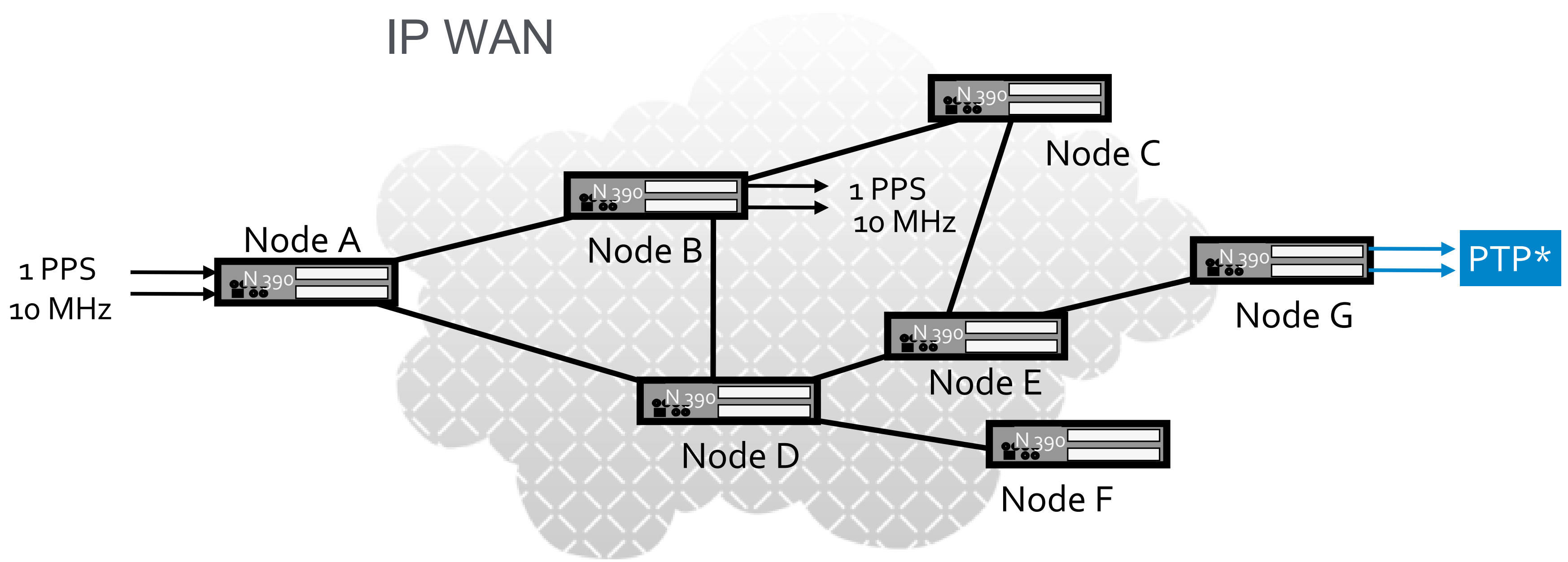
Two-way Time Transfer In A Nimbra Network



Synchronization link by link down the network

Dynamic sync routing protocol (DSYP) determines time transfer paths

Standby reference clocks supported

Automatic restoration of time transfer paths in case of failure

Automatic restoration of traffic paths in case of failure

Hold-over capabilities built-in to the nodes

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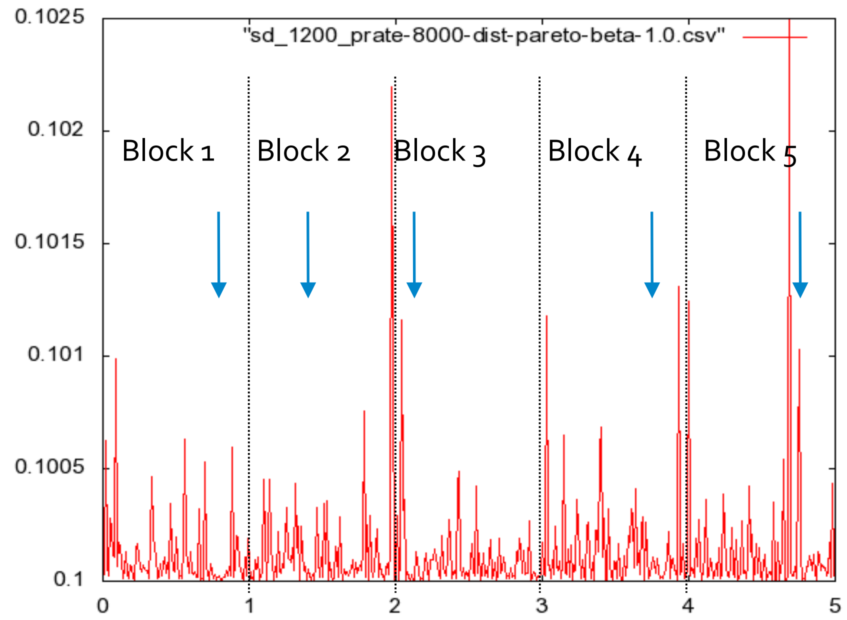
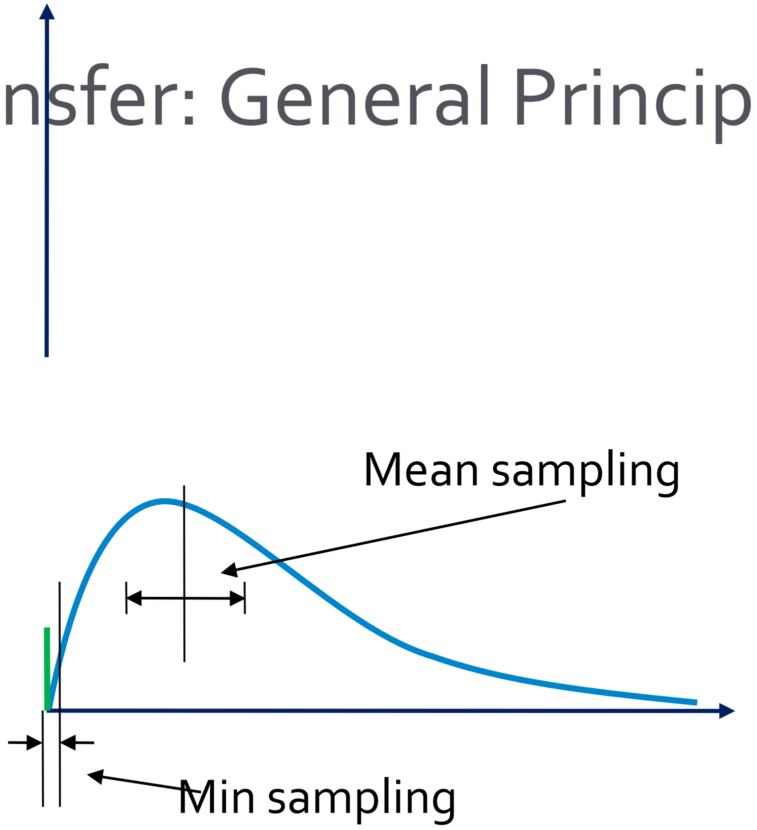
Two-way Time And Frequency Transfer: General Principles



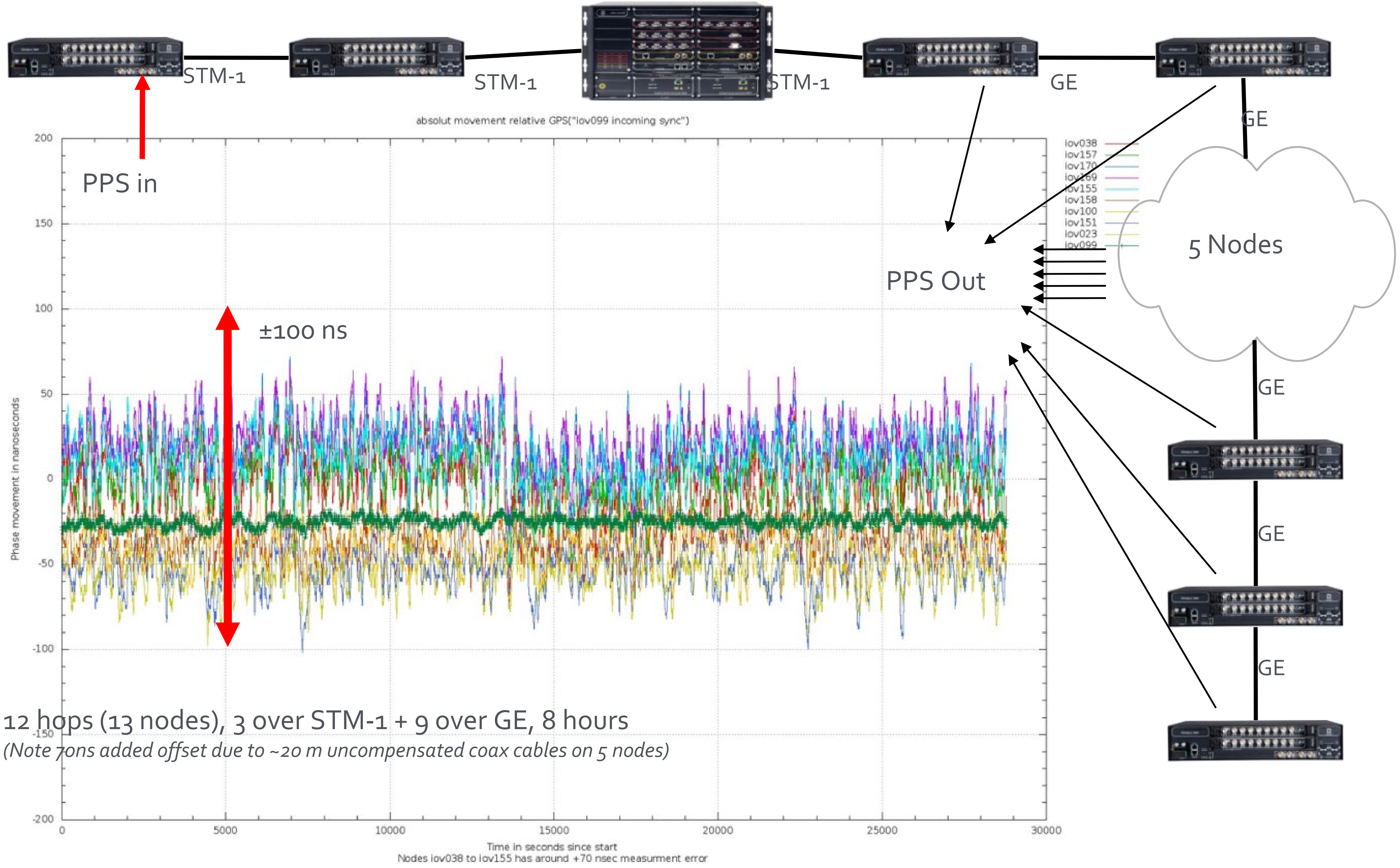


New algorithm that pre-selects time-stamps to use for clock recovery.
Min algorithm selects packets with lowest delay within a block.

Advantages:

- Some packets are not subject to queues or head-of-line blocking. If these are selected, PDV is effectively zero.
- More compact distribution around min, than around mean
- The standard mean sampling algorithm has a fundamental flaw, that is that the distribution mean is very sensitive to the load ρ of the network or link. Hence wander on the recovered clock is inevitable.

Measurement of Time Transfer Accuracy



12 hops (13 nodes), 3 over STM-1 + 9 over GE, 8 hours

(Note 7ons added offset due to ~20 m uncompensated coax cables on 5 nodes)

0.1% Percentile Packet Delay Variation Monitor

Part Of The IP Trunk Packet Delay Variation Monitoring

- Peak-to-peak
- 99.9% percentile
- RMS
- 0.1% percentile

A measure of the jitter/wander of the fastest packets

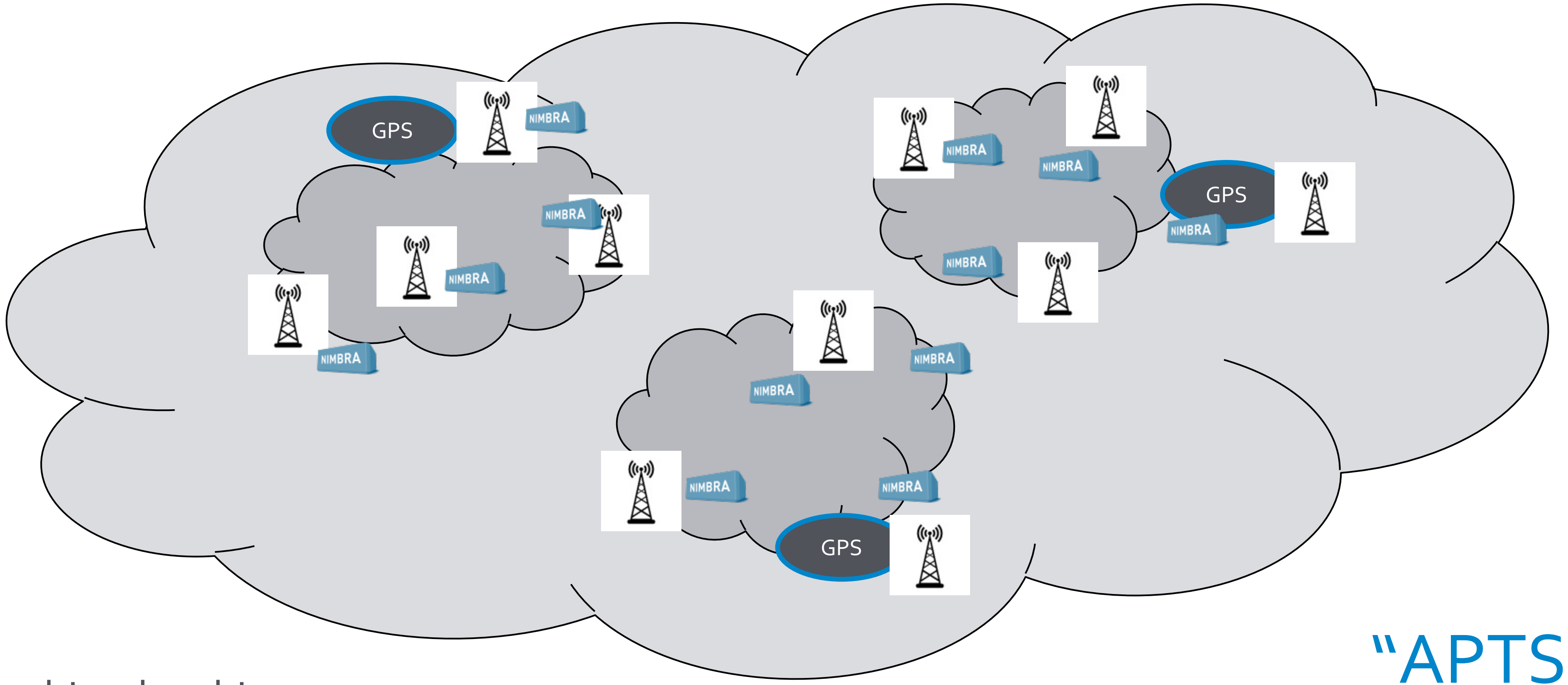
The fastest packets are used for clock recovery

$\Rightarrow$The 0.1% percentile PDV will be strongly correlated to the recovered clock quality!

We're not there yet, but we'll most probably be able to say:

"To provide sub-microsecond TT accuracy our 0.1% jitter must be below 5 us, now it's above 20. By better engineering the transmission, the needed synchronization accuracy will be achieved"

Combined Architecture For Enhanced Performance : Supported by MSR

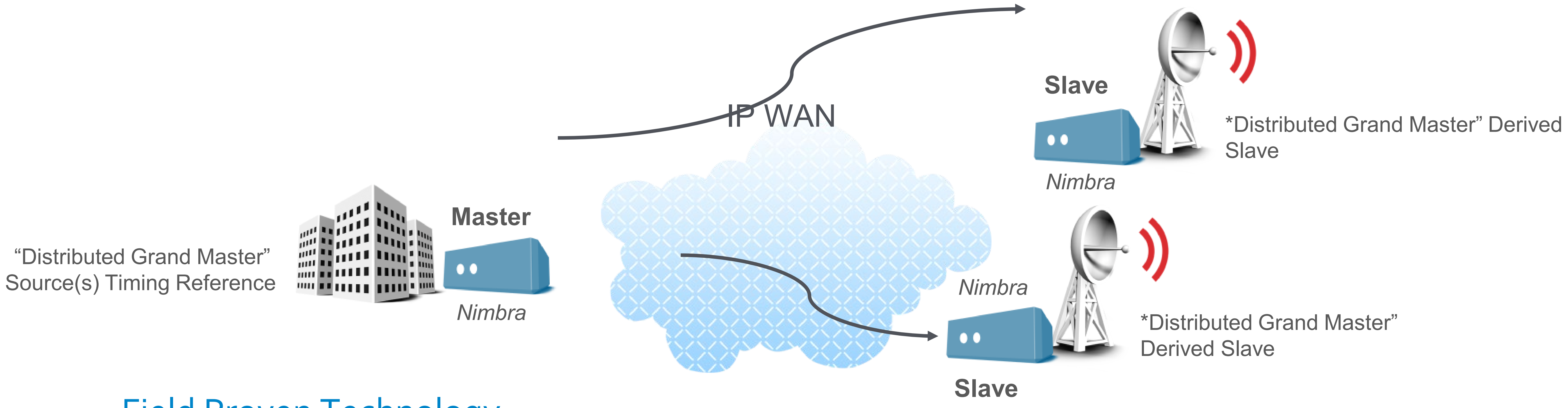


"APTS+" solution

(Assisted Partial Timing Support: ITU-T Q13/15 G.8271 rec)

- Seamlessly combined architecture
- GPS act as timing head-ends
- Nimbra synchronizes to "closest" head-end automatically
  - Minimizes master-slave chain degradation
- In case of head-end, node or link failure the network automatically reconfigure to slave on the remaining head-ends

Time Transfer over IP: Conclusion



Field Proven Technology

- Based on same basic technology as TToSDH that is used in numerous DTT networks

Strongest Technical Solution

- Based on MSR synchronous operation
- Rich time stamp statistics, min sampling and state-of-the-art PDV suppression

Lowest CapEx/OpEx Costs

- Built into the equipment, no external cabling, antennas etc.
- Simple to configure and maintain

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