# Nimbra - communication platform for the SmartGRID

## Real-Time and High Integrity communication for SmartGrid applications

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# Nimbra MSR – Our background is real-time but for TV and media

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**Nimbra network platform is a result of research at KTH in Stockholm**

"*Broadcast clients have shown a tremendous desire to take advantage of the reliability and quality benefits of a Nimbra network*" – ESPN

# Trends of the SmartGRID

- Security – Intrussion and hacking attacks, GPS independence
- System reliability and protection
  - *Outage of a medium size European country (like Sweden) cost 1 B$/day*
- Smart Grid optimization
- Distributed automation
- Full WAMPAC  - Wide Area Monitoring Protection and Control
  - Synchrophasors - PMUs
  - Real-time control

# Why a Nimbra solution for in SmartGrid Networks

## Smart Transport for Smart Grids

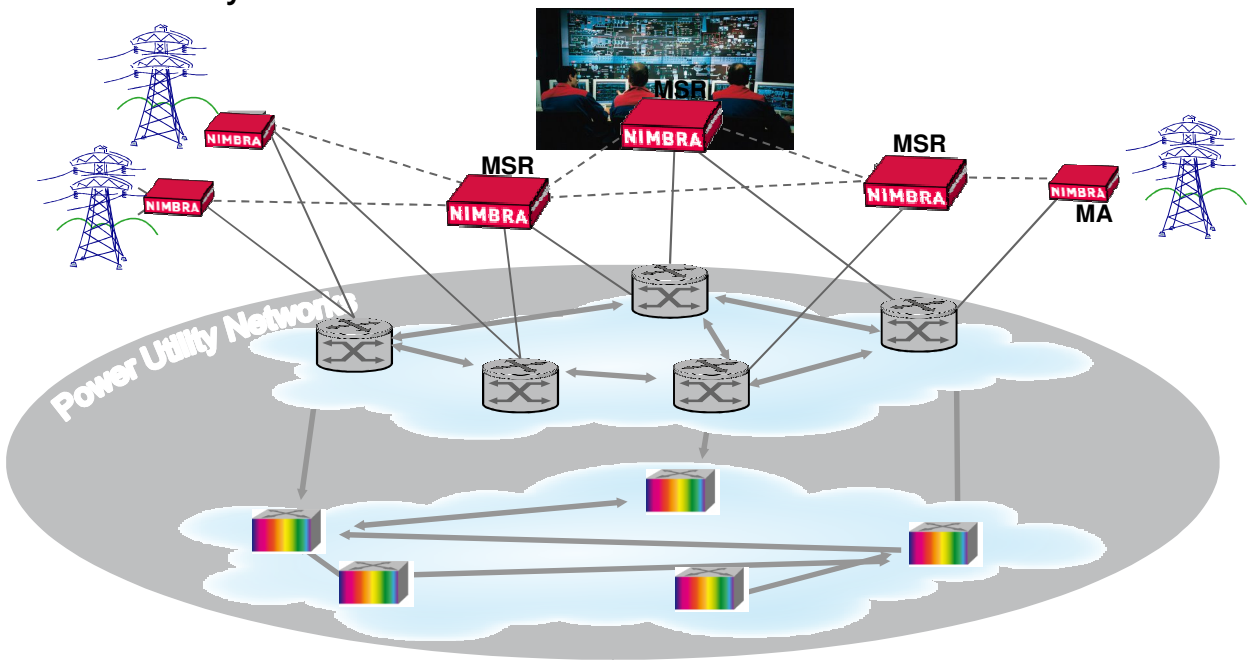
- GPS free time distribution using Time Transfer
  - Spoof and disturbance free time signal distribution (10 MHz and 1 PPS) for syncrophasors and WAMs
  - More scalable and better security than e.g., IEEE1588
    - 15 national network implementations. Handling over 500 transmitters in Norway
    - Complementing IEEE1588 over wide area networks
- High Security and integrity
  - Mgmt and Time Transfer is physically separated from data transport
  - Resilient towards service denial and masquerading attacks
- Real time properties for WAMPACs
  - Low and predictable delay suitable for tele protection and synchrophasors
    - Real-time control loops for full WAMPAC
- Multi-service network including High QoS video surveillance and PMU collection

# Qos Requirements for Smart grid Communication

| Application | Data capacity | Latency allowance | Jitter allowance. | Time sync | Reliability | Security |
|---|---|---|---|---|---|---|
| Smart Metering (PLC/BLP) | Low per feed/ Aggregated high | High (s) | High (>10ms) | (100 ms) | Medium | High |
| SCADA | Low per feed | Low (100ms) | Low | (1 ms) | High | High |
| PMU (synchrophasors) | Low per feed | Very low (20 ms) | Very low | (< 5 us ) | Very high | Very high |
| Intersite rapid response (E.g.,Teleprotection) | | Very low (10 ms) | | (1 ms) | | |
| WAMPAC (closed loop) | Medium | Very low | Very low | (1 us) | Very high | Very high |
| Distributed Energy mgmt (DER, PEV, storage) | Medium | Low | Low | | High | High |
| Video surveillance | High/medium | Medium | Low | (10 ms) | High | High |
| Corporate Data | Medium | Medium | Medium | No | Medium | Medium |
| Corporate voice | Low | Low | Low | | High | Medium |

# Network architecture for communication for the SmartGrid

- Secure, reliable real-time multiservice network solution
- Securing the communication over IP/MPLS (operator) and optical
- Strict separation of communication needs
- Easy and advanced network mgmt with non-stop control
- Time and sync distribution




SmartGrid Overlay

IP/MPLS Core

OpticalTransport

# Full controlled Networking for SmartGrid
# IPT QoS Ethernet

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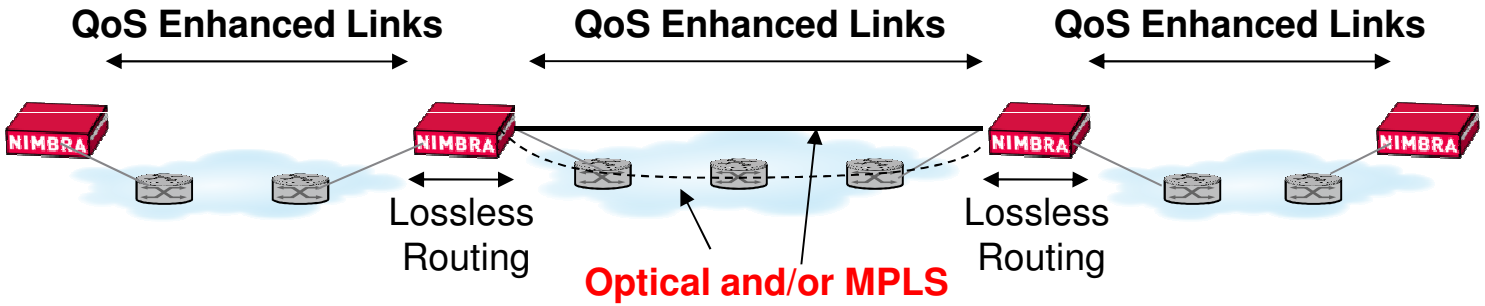
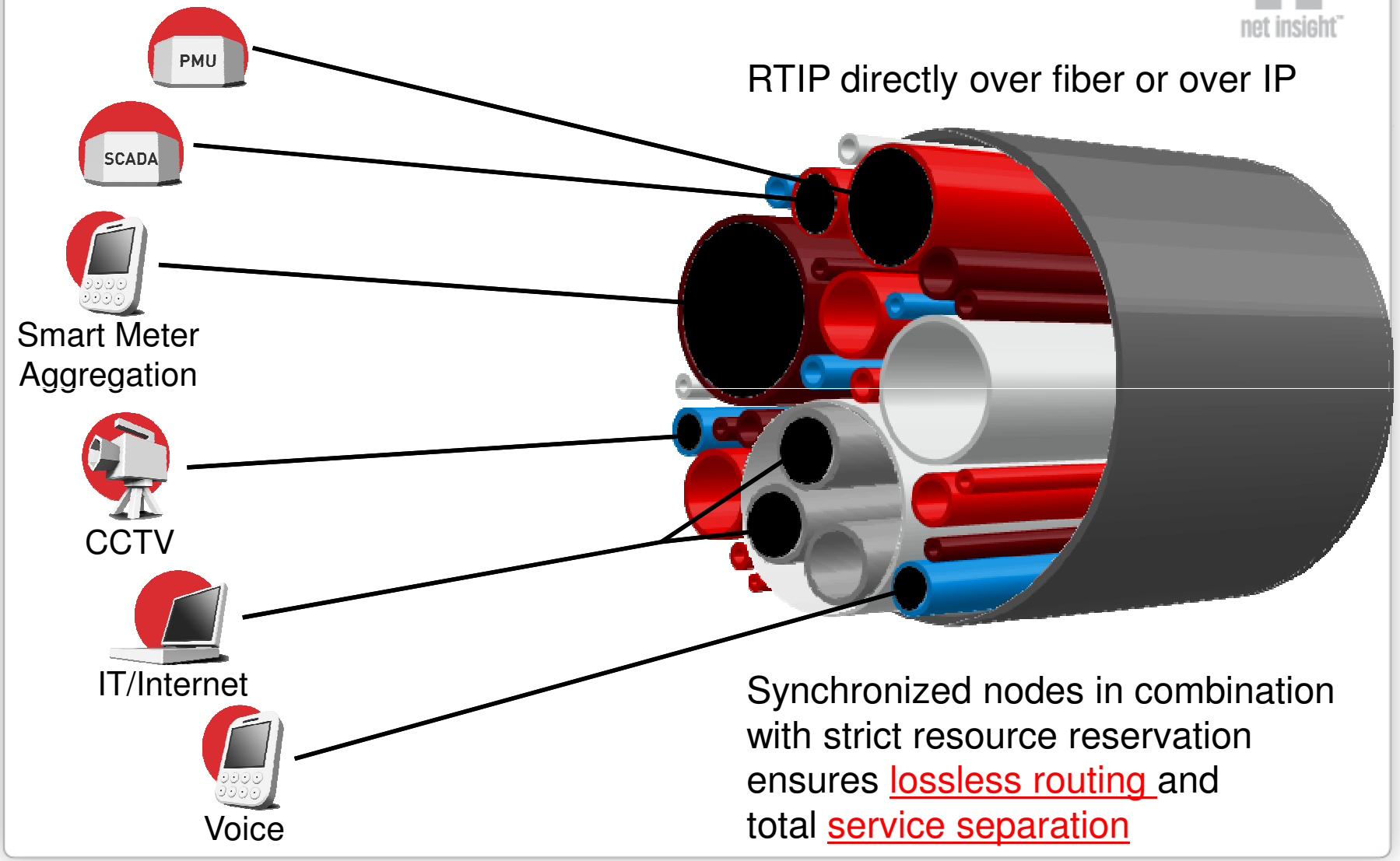
**Service-Centric Network Management**
**Provisioning, Monitoring and Protection**




**OoS Enhanced Links**
**Forward-error correction, Traffic Shaping and Resynchronization**

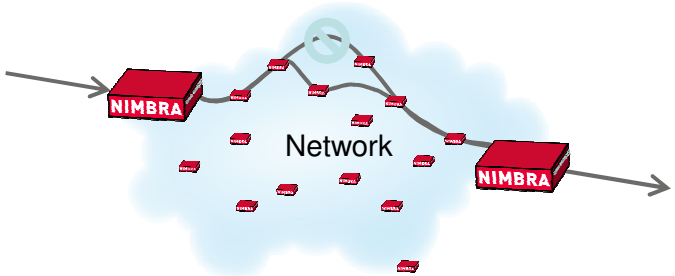
Improves the performance of the IP traffic for data transfer, data collections, real-time control system, etc.

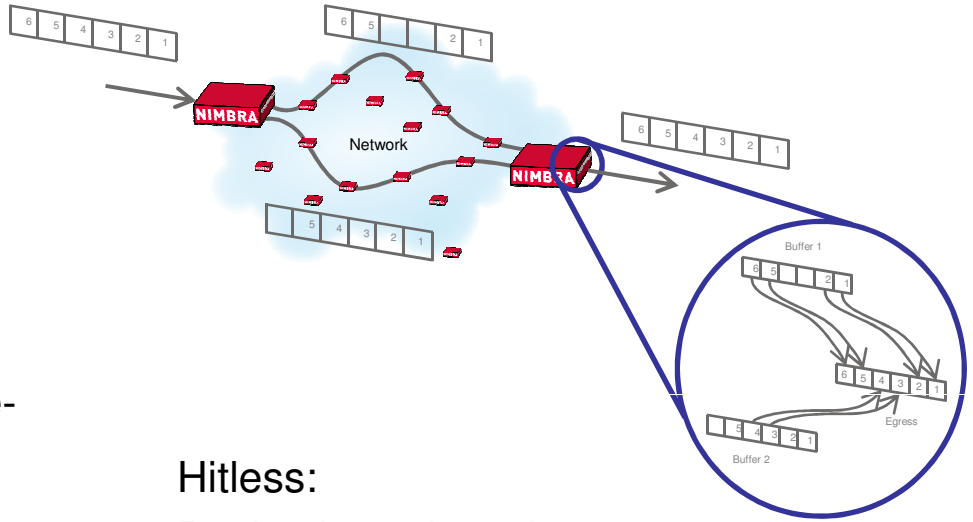
# Services are separated in end-to-end channels



# Per service Restoration or Hitless switch over

## Offers extremely high reliability and flexible design




Restoration:

- In case of failure, the network will re-establish the service
- Re-establishment time depends on network topology and complexity
  - Typical values are between ~100 ms and ~1 s
  - Restoration is resource-aware to not create new congestion
- Use prioritized list of static routes or dynamic routing
  - Strict or loose source routes
  - or a combination thereof; for instance dynamic routing as last option

Hitless:

Packet based services

- For L2 Ethernet transport
- Sequence counters on packages
- Configurable max latency (buffer depth)

Stateless protection mechanism

- Diminishes the notion of primary and secondary path

Completely Hitless Switching

- Frequency + phase + packet sequence remains intact

# Service Aware Networks with lossless routing

Nimbra MSR nodes can run over any infrastructure (IP, optical)

Scalable GPS independent Time Transfer

100% QoS and constant delay ensures full WAMPAC.

QoS and multicasting enables SCADA, WAM and video surveillance

Enhanced security features to avoid network denial and masquerading attacks

# Nimbra

## - Timing solution for the SmartGrid

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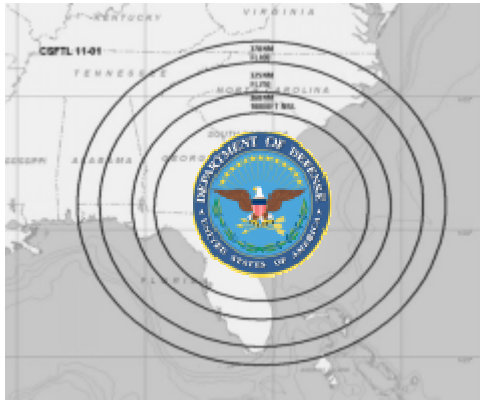
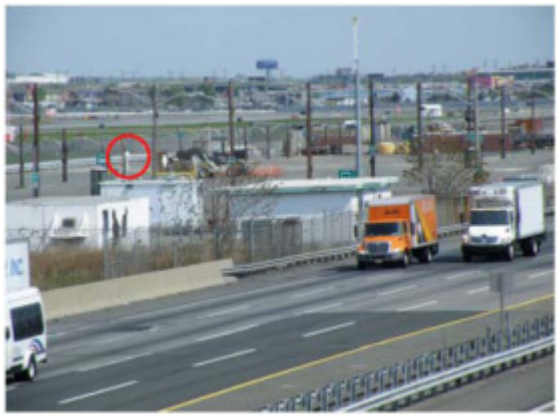
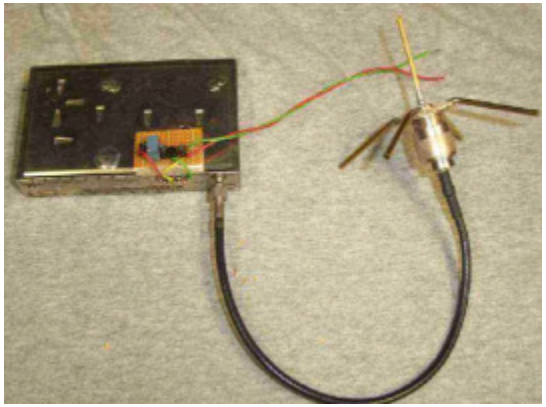
# Are we too reliant on GPS?

- GPS issues due to U.S. Department of Defense (DoD) ‘tests’
- The Newark Airport jamming incident

*“The interference threats to GPS are very real and promise to get worse. Failure to act will be a serious abdication of our responsibility”**





* National Executive Committee for Space-Based Positioning, Navigation, and Timing (PNT) comments

# Commercial Jammers…

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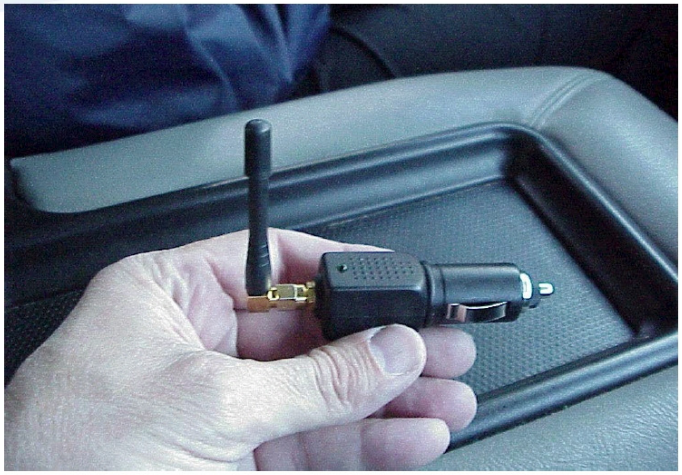
## Commercially Available GPS Jammer
(so called "Personal Privacy Device")



FAA NextGEN

## … and a few more "Personal Privacy Devices"

$110 Ebay

$69
The Jammer Store

$335 EBay

$40 GPS&GSM
www.chinavasion.com

$55 Ebay

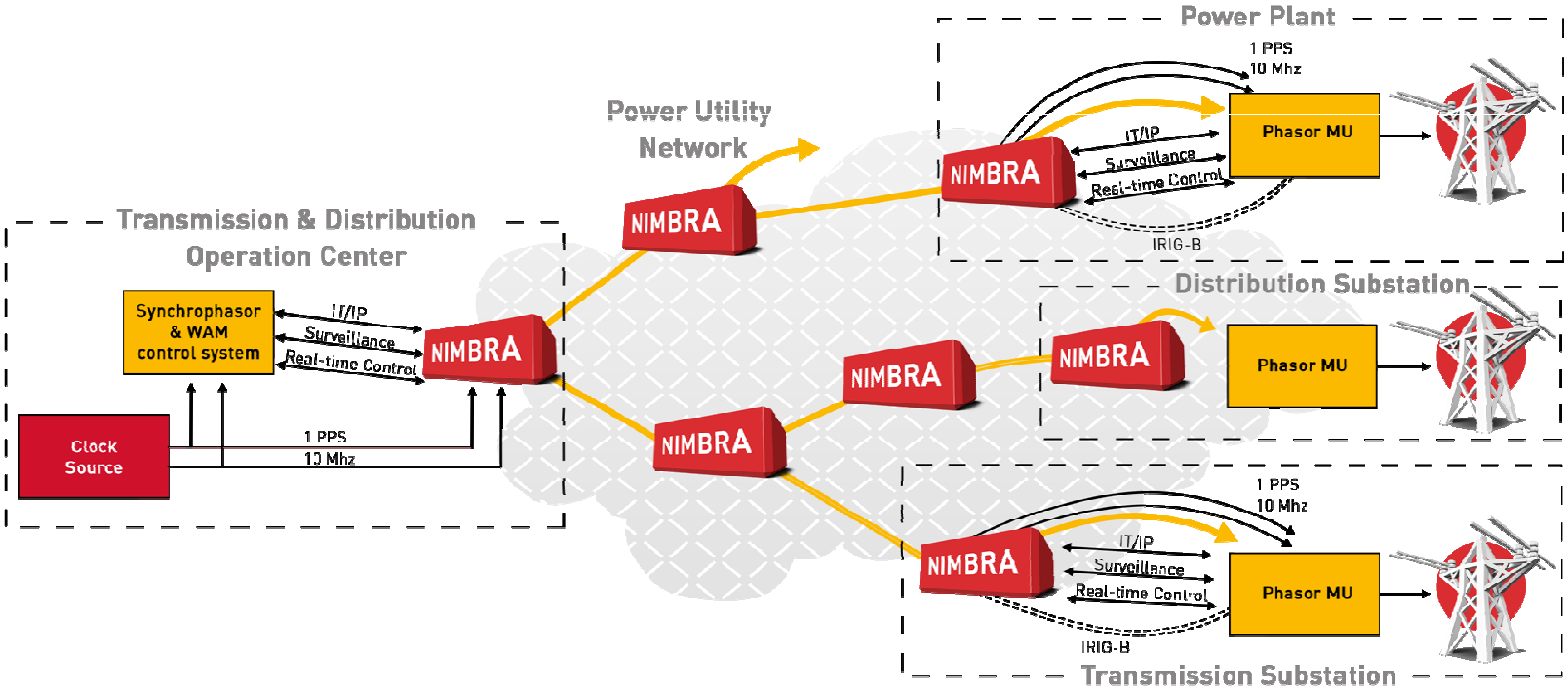
$83 GPS&GSM
www.Tayx.co.uk

$152 Ebay

FAA NextGEN

# 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



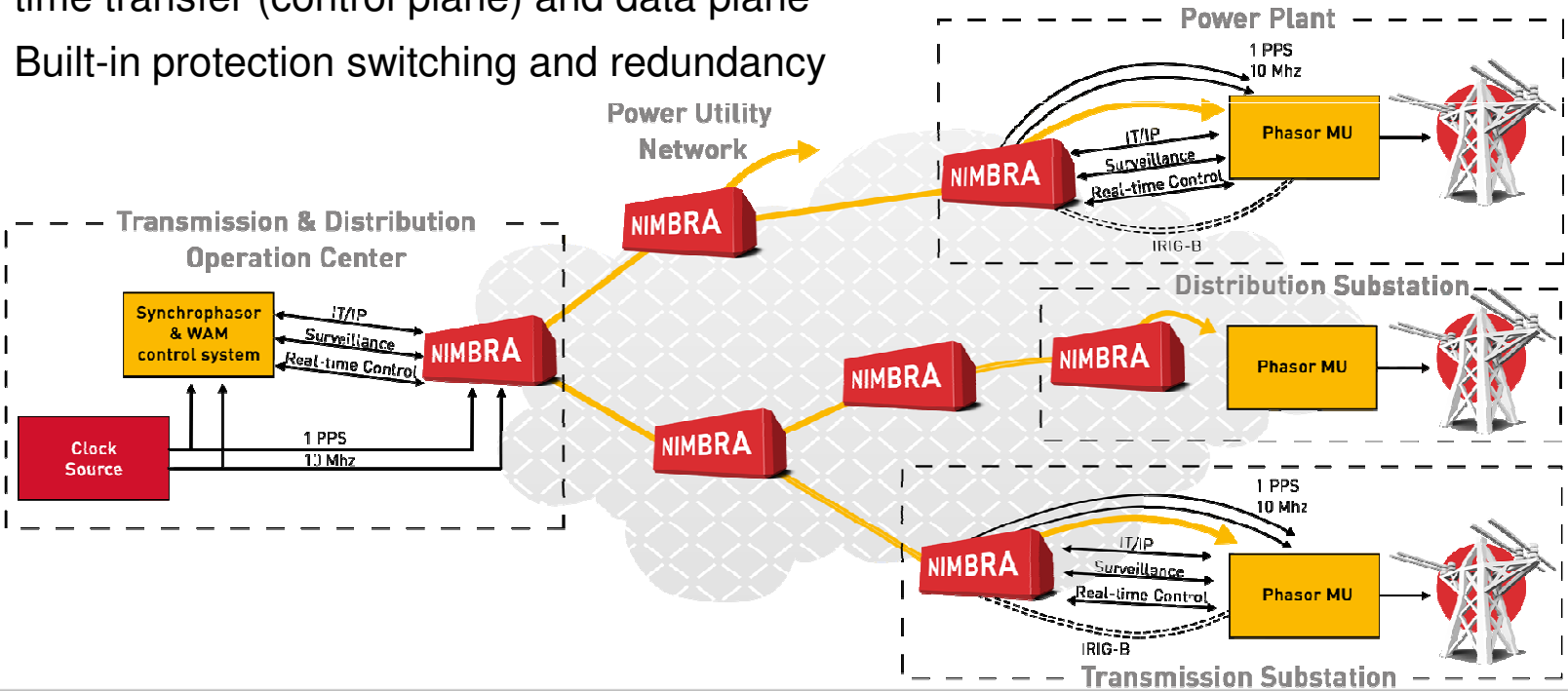
# Nimbra TT vs IEEE 1588 PTP

| | Time Transfer | IEEE 1588 | Comments |
|---|---|---|---|
| Accuracy target | ~ 1µs | ~ 1µs | Advantage in TT is that all trunk packets are used for timing information, providing more timing information than having a low BW clock stream only as in IEEE 1588. |
| Scalability | High | Medium | TT networks are used for nationwide DTT networks, while IEEE 1588 are deployed for Mobile Backhaul (Access) Networks |
| Complexity | Low/Medium | High | • IEEE 1588 – Grandmaster clocks, Boundary clocks, Transparent clocks, "clock planning"<br>• TT – Two levels of clocks, management integrated into Nimbra equipment |
| Equipment | Built-in functionality | Generally Separate equipment | Space / Power / Management / CAPEX / OPEX constraints to consider |
| Protection | Strong both for node/link failures and clock sources | Needs careful planning and relies on other equipment for protection | Even more important over wide area networks |
| Security | High | Low/Medium | • IEEE 1588 – Data plane transport subject to DoS attacks, MAC spoofing etc<br>  • PTP Annex K defines an experimental security protocol for PTP, but still vulnerable to DoS and replay attacks<br>• TT/MSR – All time transfer signaling in control plane and un-accessible to users (DoS on the IP trunk level must still be considered) |

*Security issues especially important since much of the driving forces for implementing fiber based time transport instead of using GPS/GLONASS is just – security…*

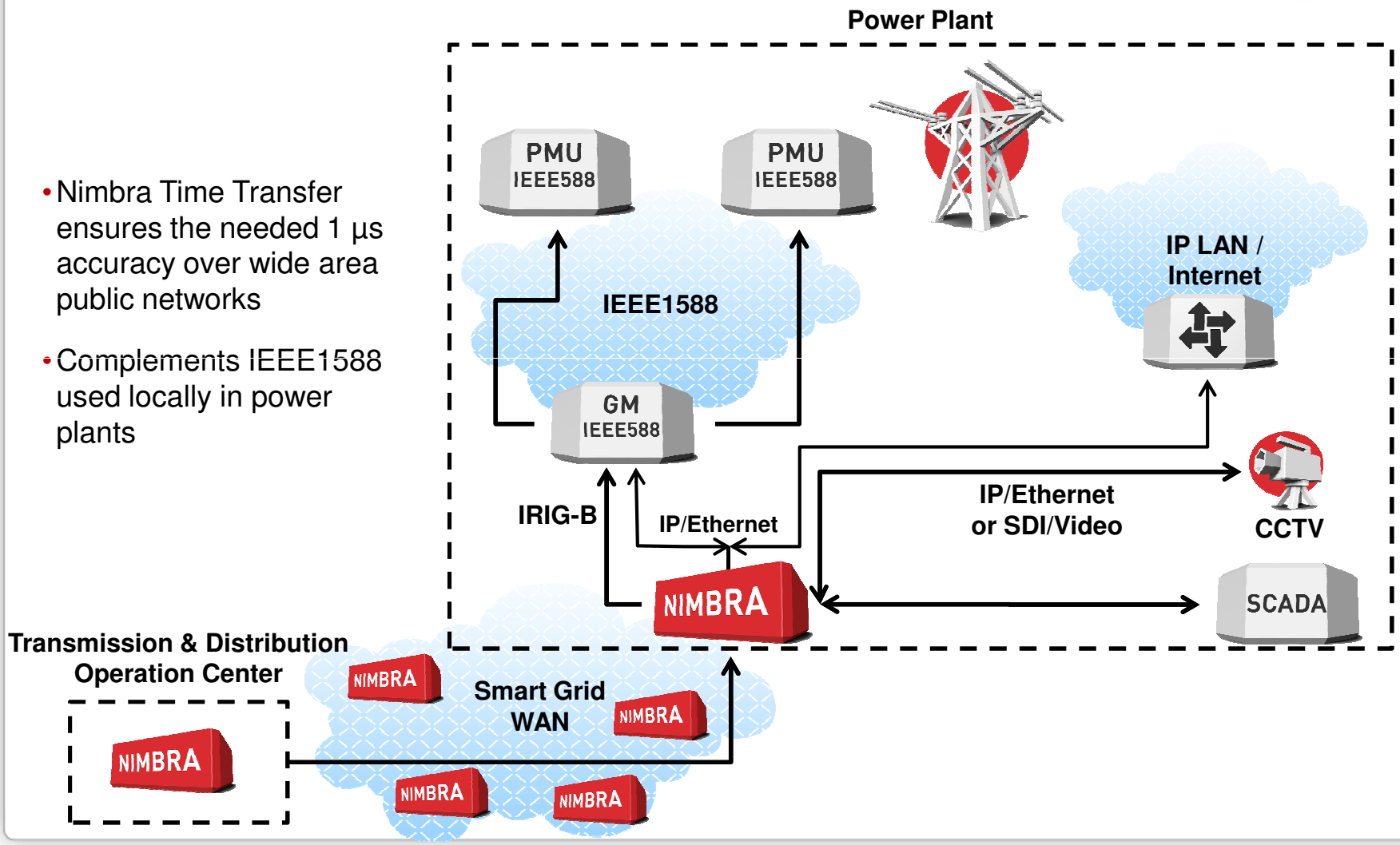
# Time distribution for Phasor measurement

- Exact time (~1 us) is critical in power transmission systems
- GPS time distribution is vulnerable to attacks
  - Spoofing, Jamming and weather dependent
- Net Insight offers an integrated Time Transfer function 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

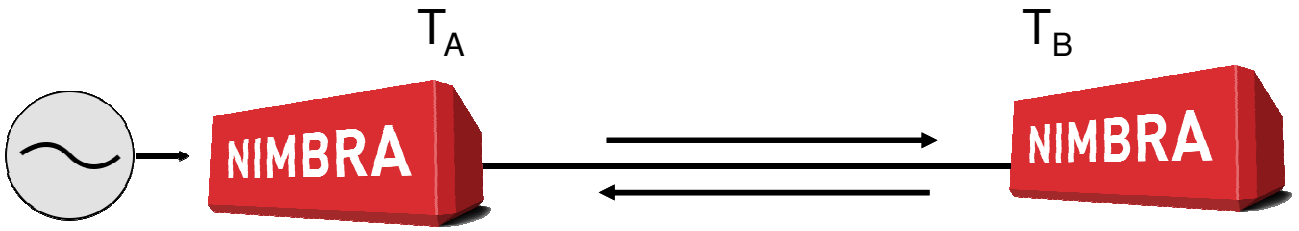


# Complementary solution using Nimbra TT in WAN

- Nimbra Time Transfer ensures the needed 1 µs accuracy over wide area public networks
- Complements IEEE1588 used locally in power plants



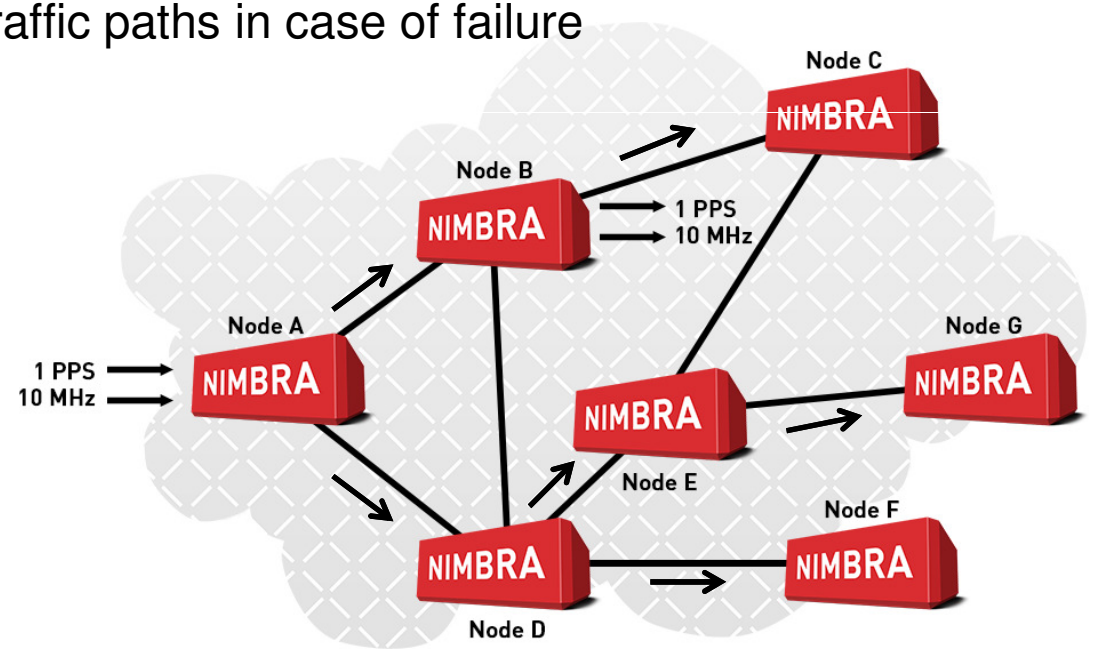
# Two-Way Time Transfer (TWTT), general principles




- 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, 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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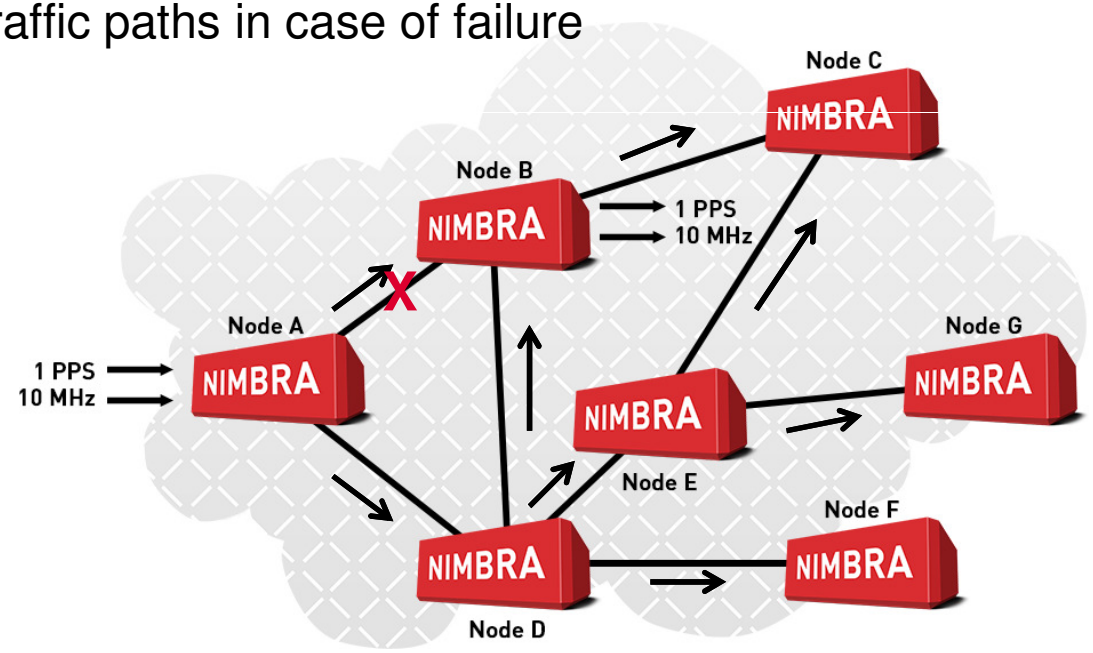
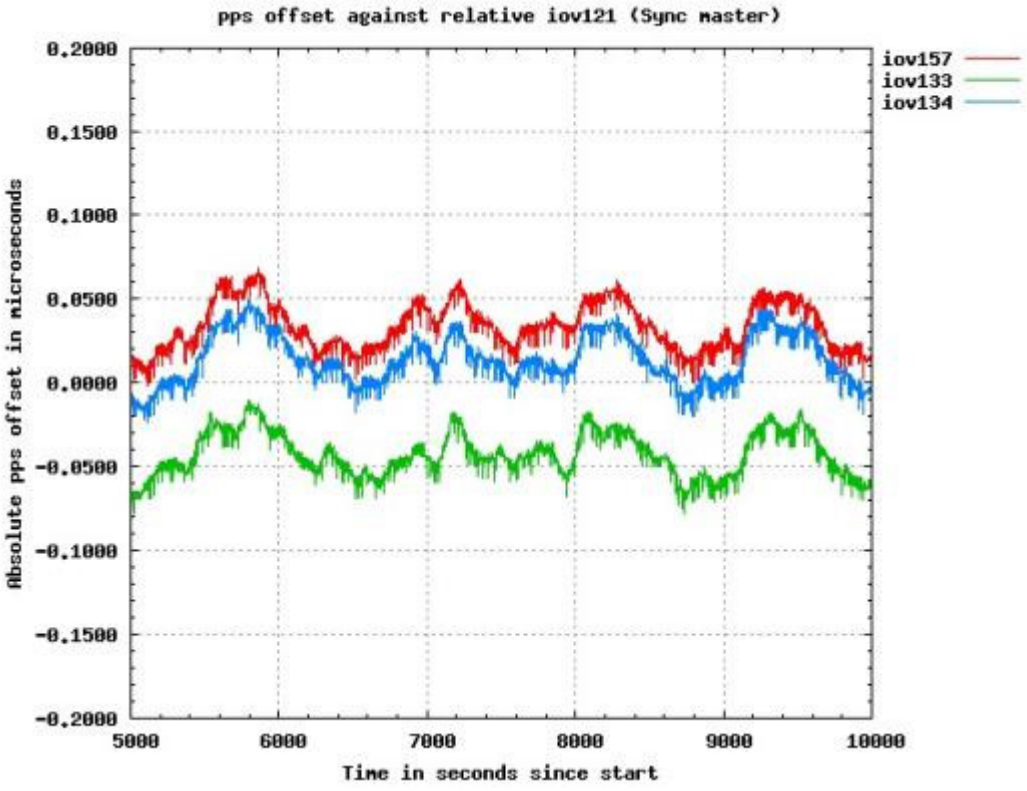


# Resiliency to attacks

- Spoofing
- Jamming – multiple clock sources
- Bad clock signals
- Denial attacks
- Masquarading attacks – ”cyber spoofing”

# Measurement of time transfer accuracy


Specified performance
< 1.5µs after 10 hops

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

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

## Time Transfer proven in 14 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

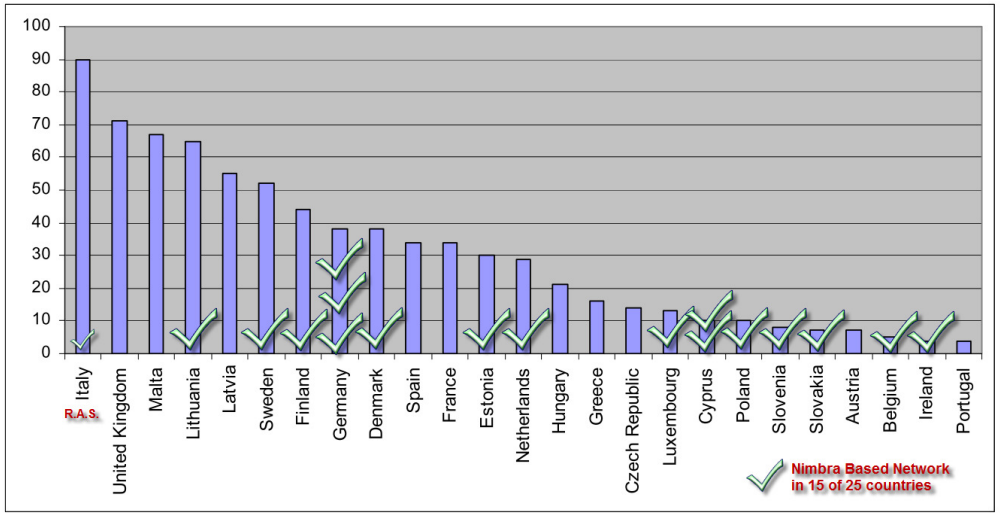
= TT

Worlds largest DTT network

World's only GPS-free DTT SFN networks

Worlds 1st all-IP DVB-T2

**Fig 2: National Channels on DTT networks in the EU**




Source: MAVISE June 2011

# Summary

- Very high security network
  - Service separation to avoid denial attacks
  - Isolation to avoid masquarading attacks
- 100% QoS enabling WAMPAC, SCADA and video surveillance
- GPS independent time distribution integrated 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
  - Enabling SmartGrid applications
- No risk to integrate Enterprise IT and video surveillance traffic

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Always delivering content integrity
Always simplifying complexities
Always redefining efficiency