IPCLOCK

InSync

Achieving 1µsec Accuracy with Distributed Master Architecture

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The Challenge - Achieving 1µsec Accuracy

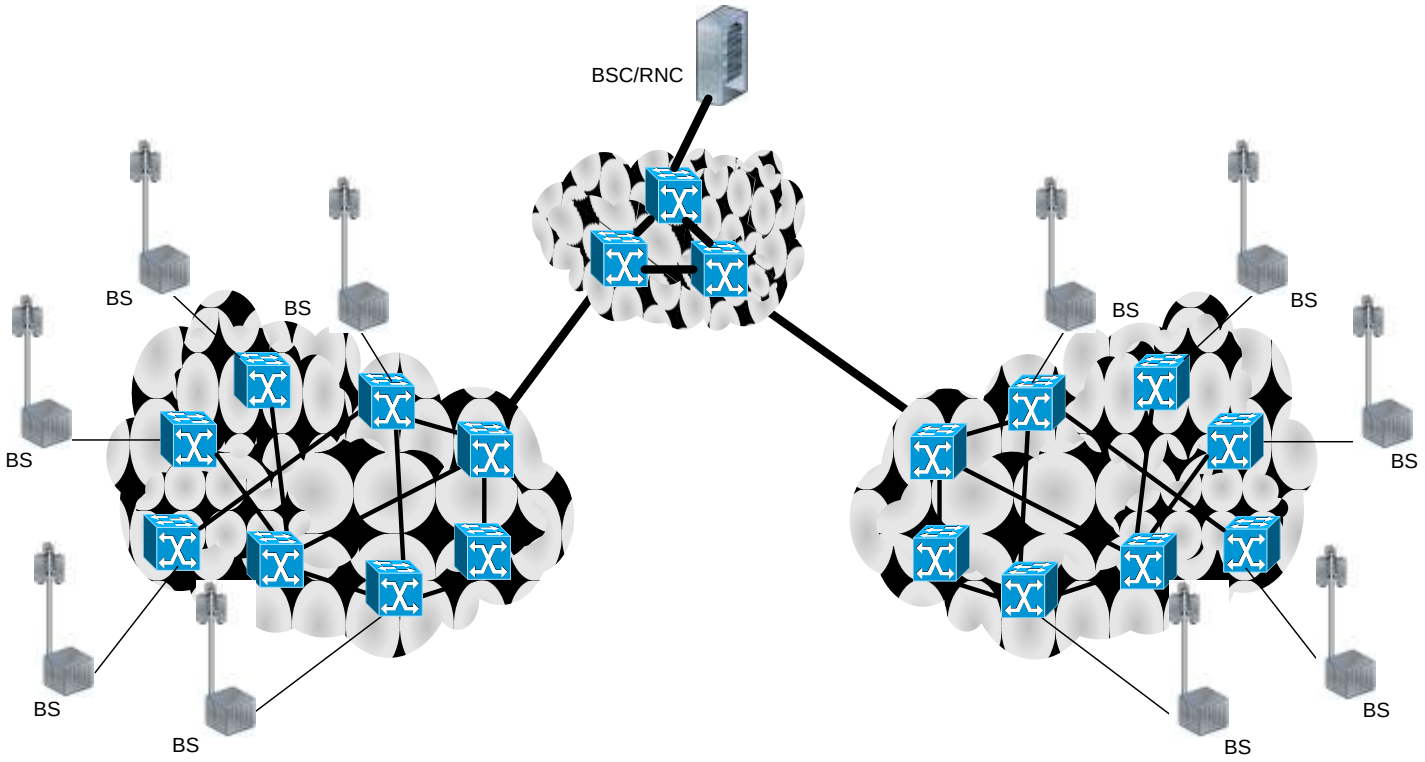
- 1µsec accuracy can be achieved today under ITU-T G.8261 conditions using good servo
- However in real life the network conditions may be more challenging then G.8261
  - Traffic may be more then 80%
  - Larger number of hops
  - Lower speed links
  - Asymmetrical links
  - links may include Radio links, GPON, DSL
  - Equipment failure
- Such network conditions lead to
  - Higher PDV (Packet Delay Variation)
  - Larger asymmetry

The Potential Solutions

- Better Servo
- Over Provisioning
- GPS Everywhere
- BC – Boundary Clock
- TC – Transparent Clock
- Distributed Master architecture – Localized Master

Getting the Master closer to its Slaves (shorter communication path) improves the synchronization performance

Typical Application Example
Cellular Backhaul



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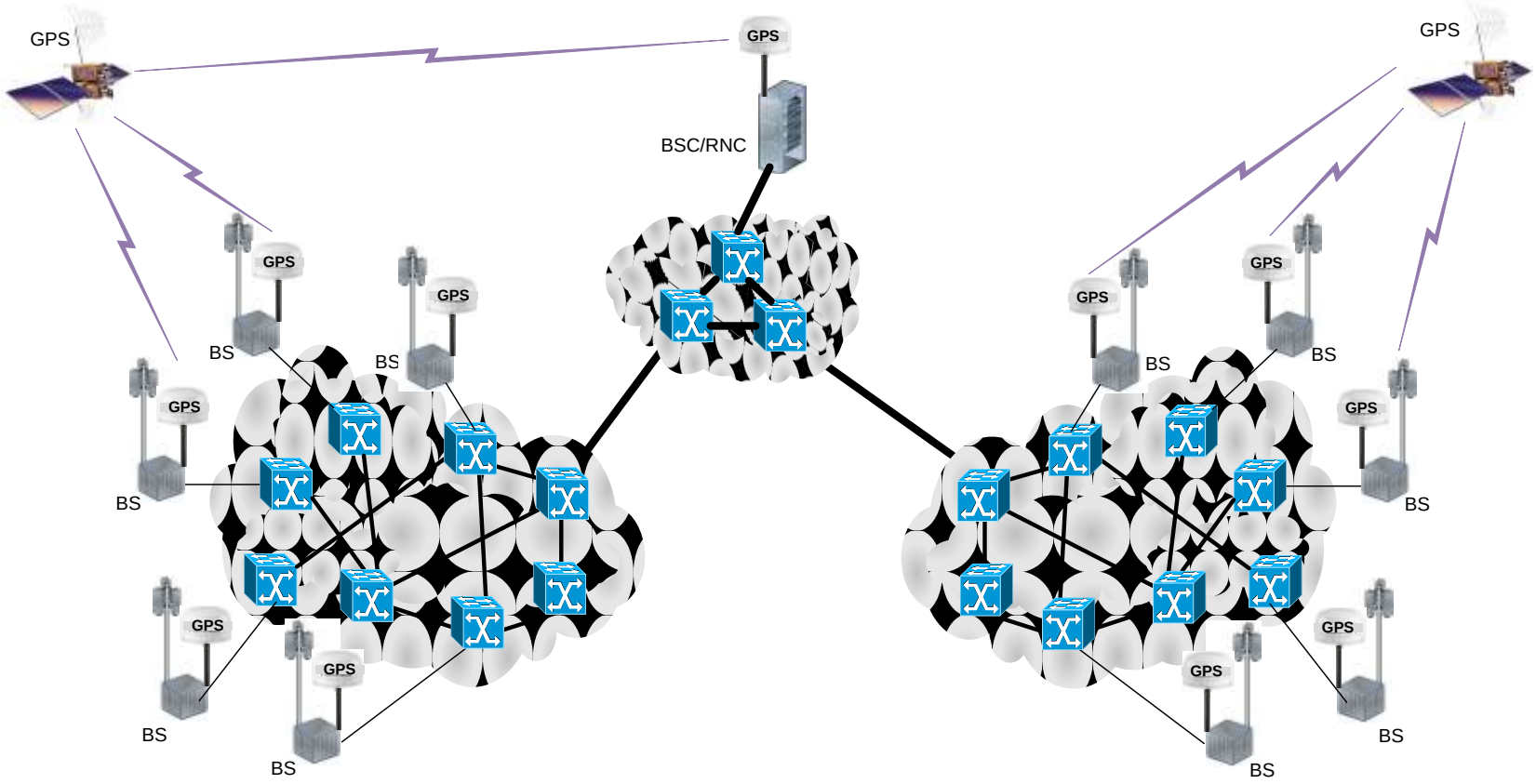
Typical Application Example
GPS Everywhere



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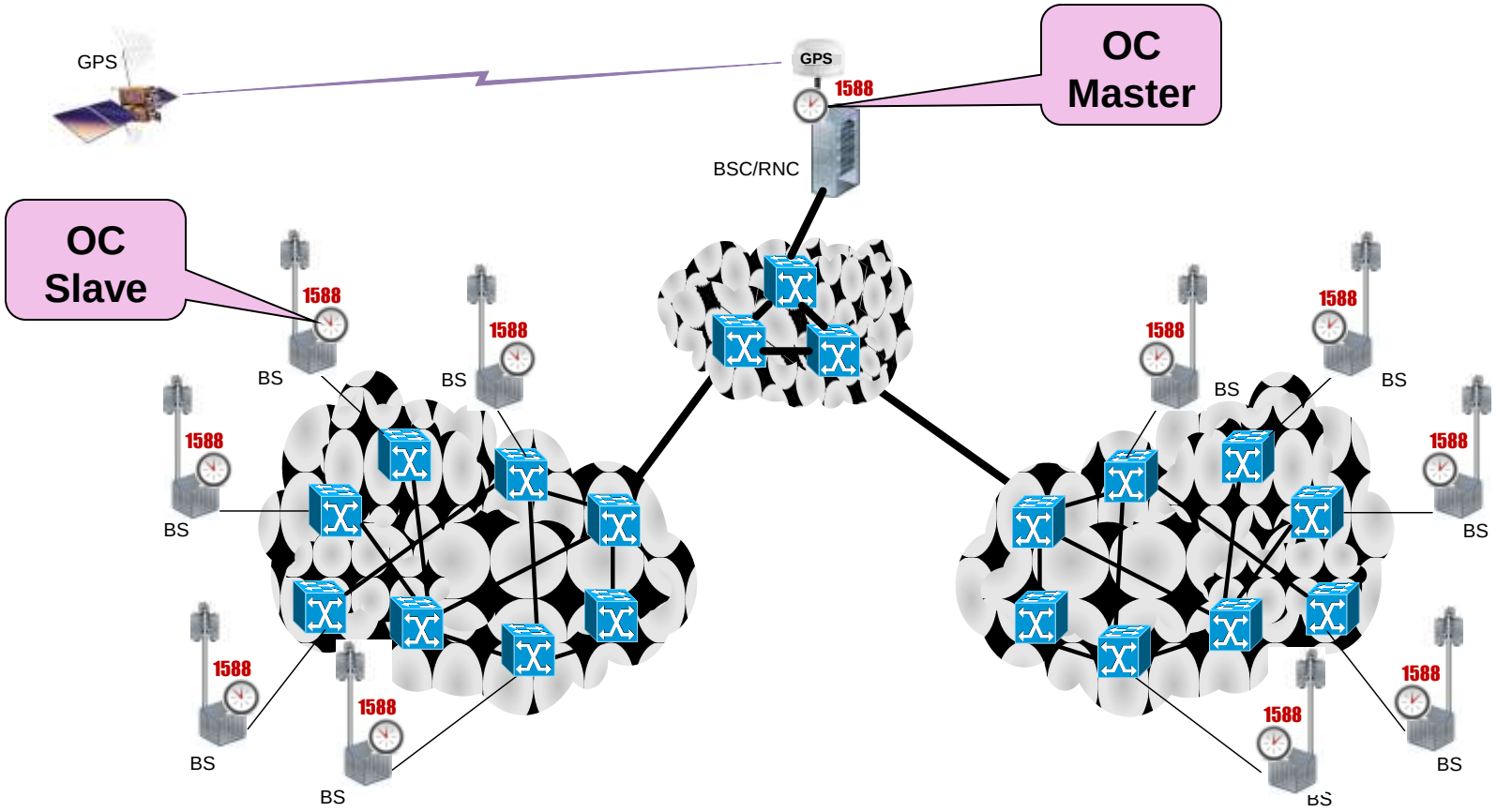
Typical Application Example
Centralized IEEE1588 Master Architecture



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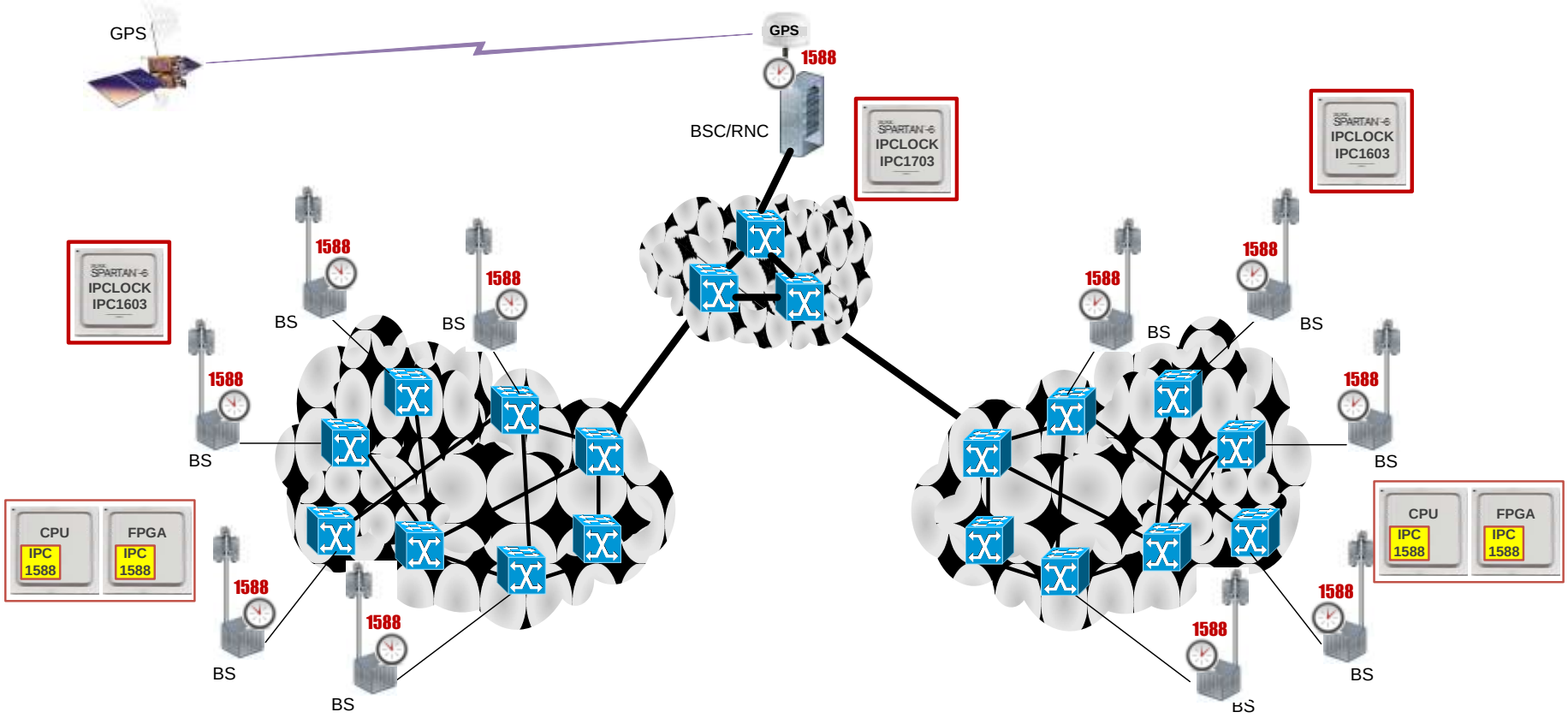
Typical Application Example
Centralized IEEE1588 Master Architecture



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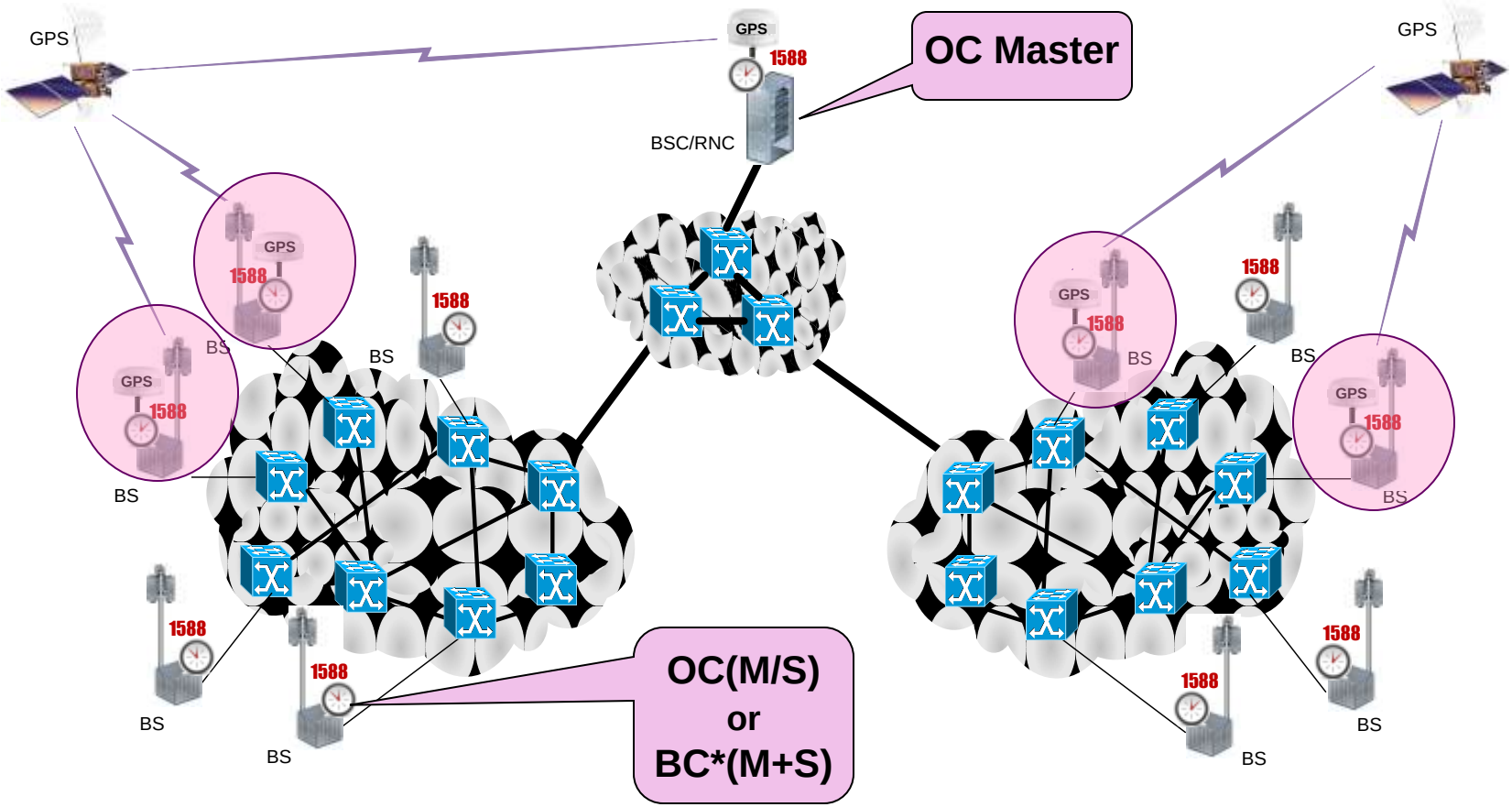
Typical Application Example
Distributed IEEE1588 Master Architecture



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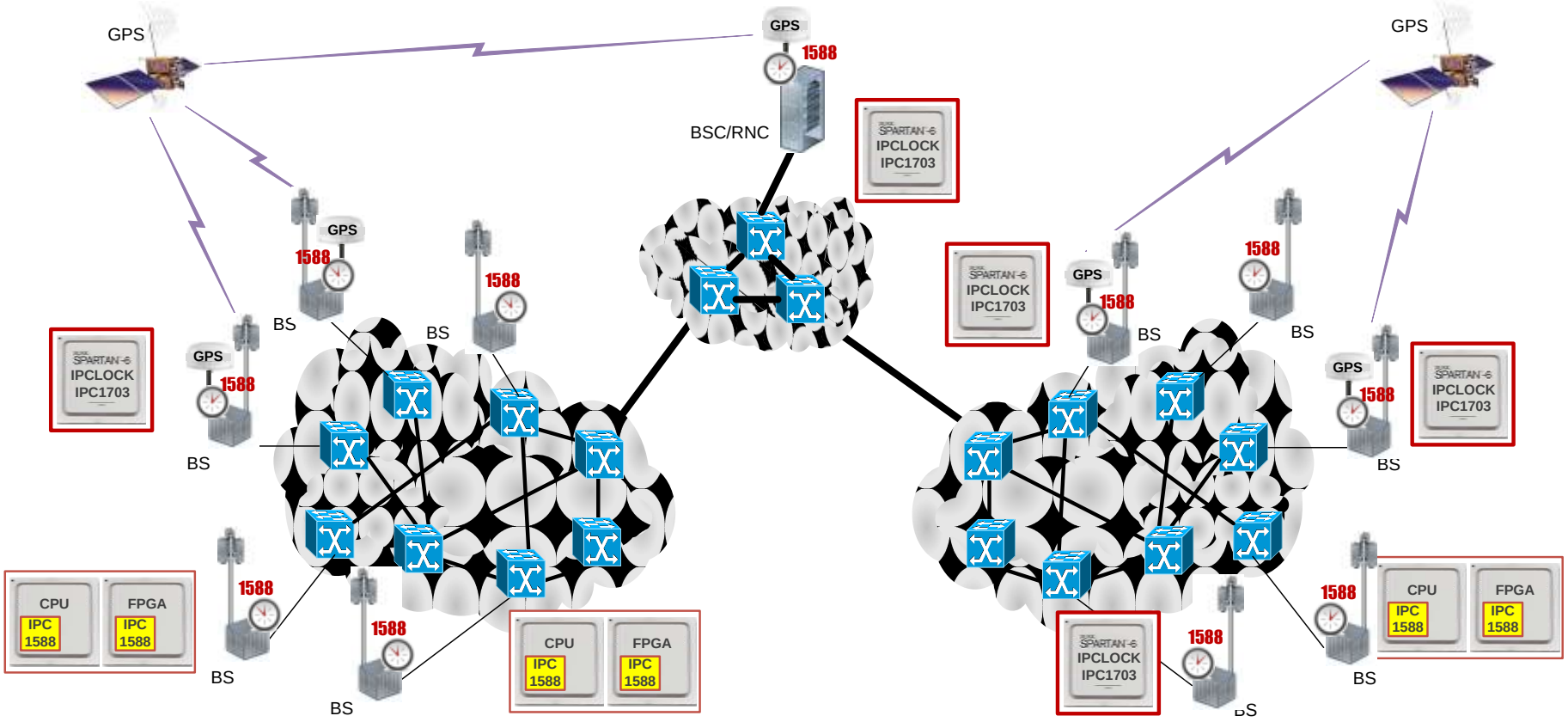
Typical Application Example
Distributed IEEE1588 Master Architecture



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What Makes Distributed Master Architecture Attractive?

- Hops - Smaller number of hops
  - Lower PDV
  - Lower asymmetry
- BMC
  - More alternatives
  - Enhance BMCA - NPM (Networks Performance Monitoring)
- Distance - Smaller
- Bandwidth - Smaller
- Scalable
- Robustness & Protection
  - No single point of failure (switches / links)
  - 1588 provide backup for GPS

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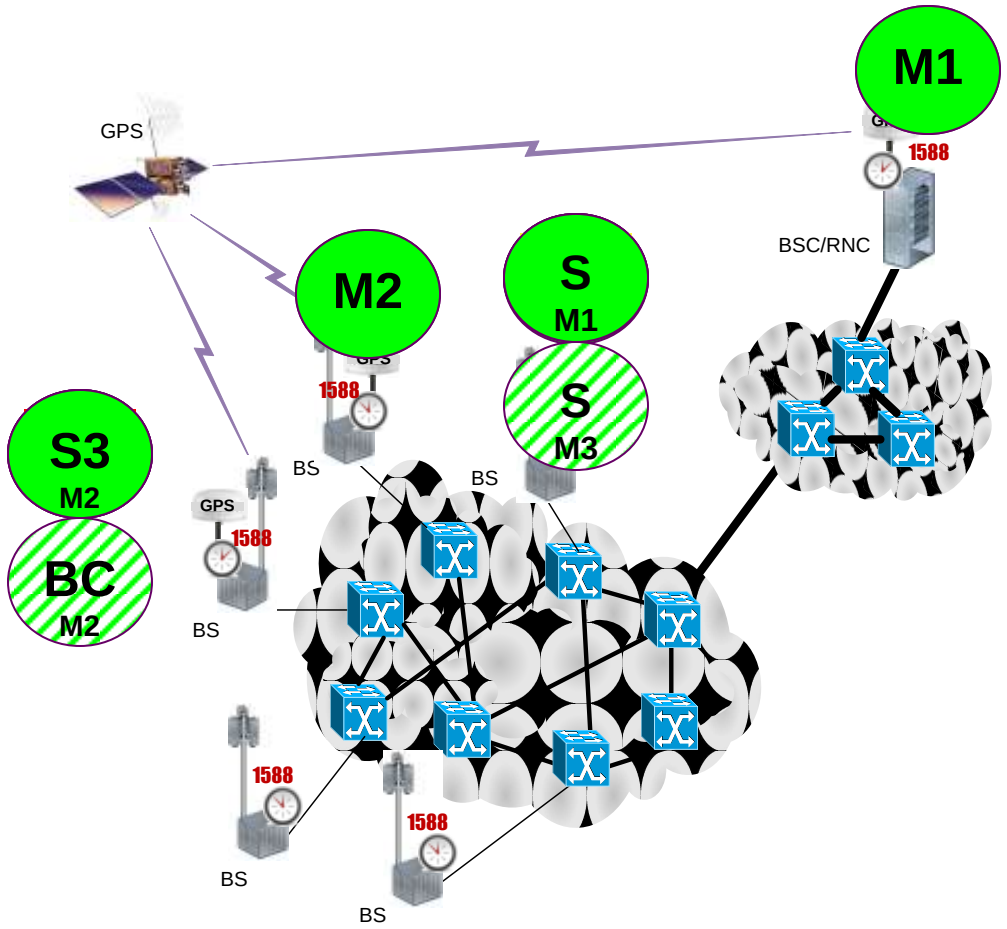
Distributed IEEE1588 Master Architecture Operation & Protection



- Slave: Master learning stage
- Slave BMCA selects Master #3
- Master #3 GPS failed. Slave moves into HO
- Case Node #3 = OC
  - Slave BMCA selects Master #1
  - "Master #3" switches to be a Slave and its BMCA select Master #2
- Case Node #3 = BC
  - "Master #3" switches to BC mode and BMCA selects Master #2. Slave BMCA stays with Master #3

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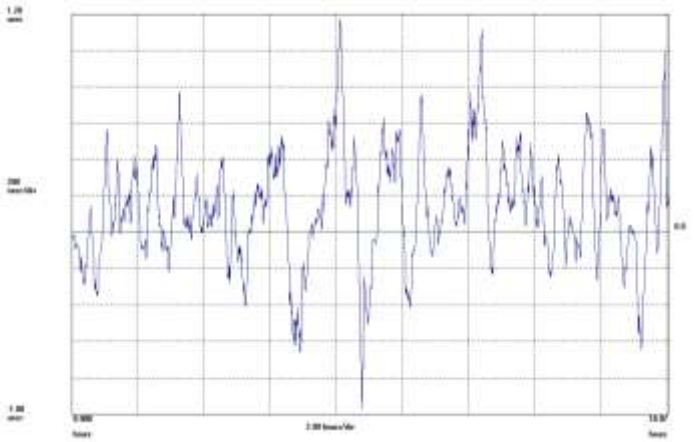
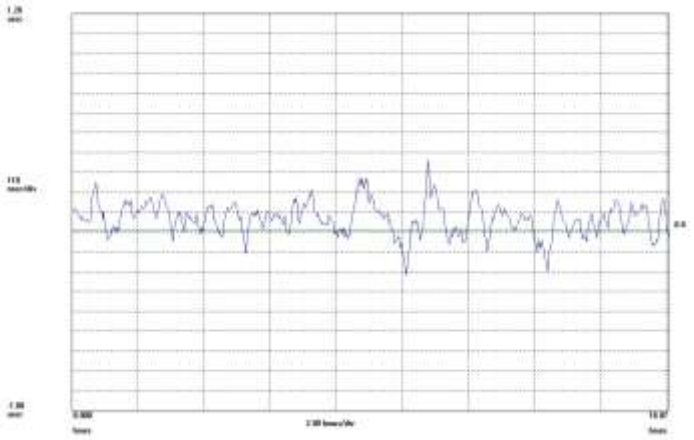
Customer Trial
Cellular Backhaul – Metro Stations Coverage

- Centralized Master
  - GbE Ethernet Ring
    - 5 GbE switches
    - 2 Access routers
  - FE Switch
  - Single Master
  - 46 Slaves
  - Measure time ~18 hours
  - Max TIE: -970nsec/**+1.2µsec**



- Distributed Master
  - **No GbE Ethernet is required**
  - **No Access routers are required**
  - 2x FE Switch
  - 5 Masters
  - 8-10 Slaves per Master
  - Measure time ~18 hours
  - Max TIE: -250nsec/**+390nsec**



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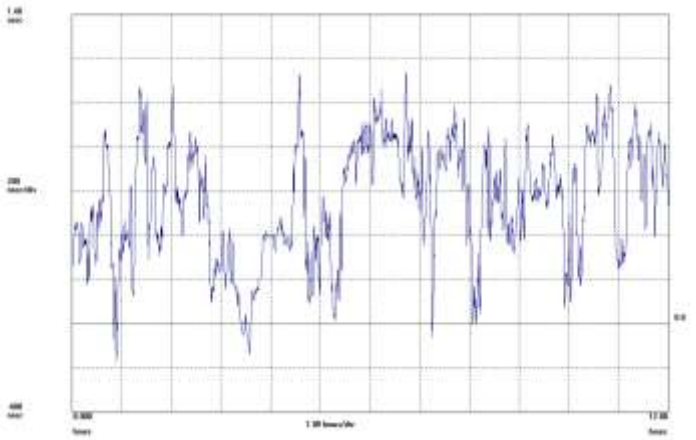
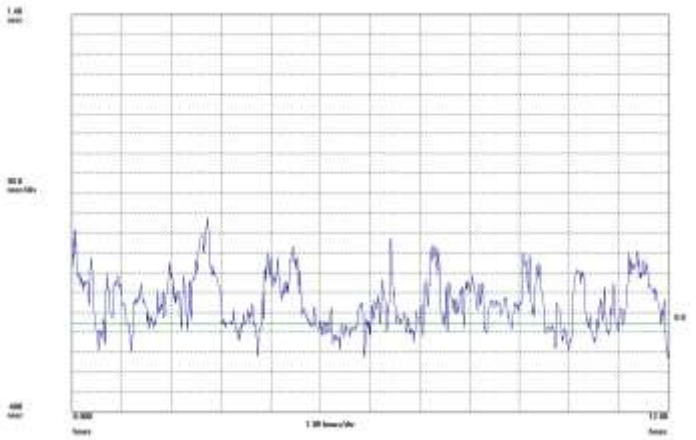
Customer Trial
Corporate In-Building WiMAX Pico Coverage

- Centralized Master
  - LAN
    - 3 Routers
    - 3 GbE Switches
    - 2 FE Switches
  - Single Master
  - 38 Slaves
  - Measure time ~12 hours
  - Max TIE: -270nsec/**+1.14µsec**



- Distributed Master
  - LAN
    - **No Routers**
    - 1 GbE Switch
    - 2 FE Switches
  - 4 Masters
  - 7-12 Slaves per Master
  - Measure time ~12 hours
  - Max TIE: -160nsec/**+480nsec**



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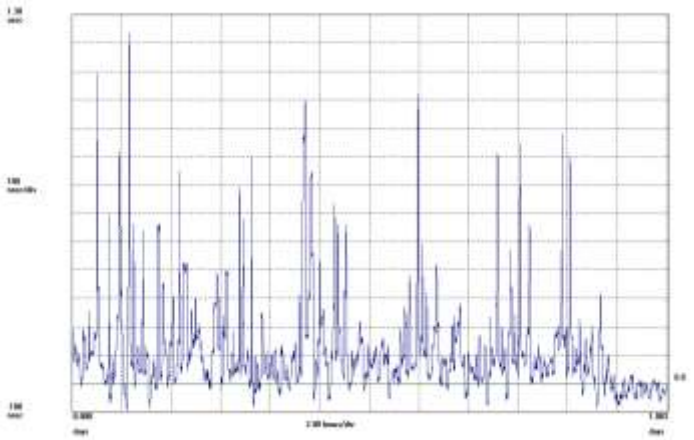
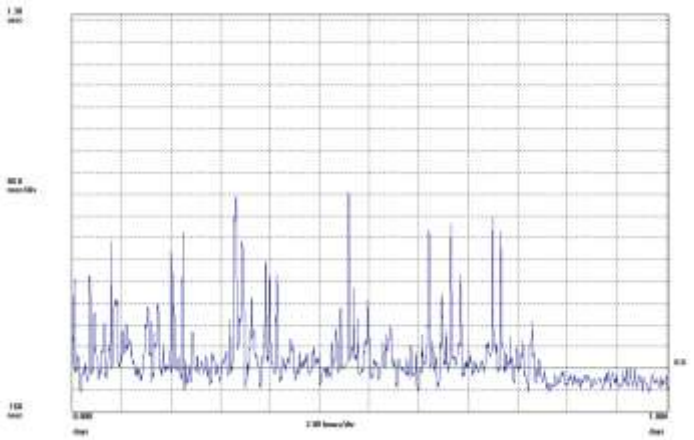
Customer Trial
Cellular Backhaul – GPON in the Last Mile

- Centralized Master
  - Metro Ring
    - 5 GbE Switches
    - 2 Routers
  - GPON in the last mile
    - 40km Fiber
    - Two-way 100% Load
  - Measure time ~24 hours
  - Max TIE: -100nsec/**+1.2µsec**



- Distributed Master
  - **No Metro Ring is required**
  - GPON in the last mile
    - 40km Fiber
    - Two-way 100% Load
  - Measure time ~24 hours
  - Max TIE: -200nsec/**+650nsec**



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Distributed Master Architecture Baseline Requirements

- Low cost
  - Low cost GPS / GPS ready timing solutions
    - GPS ready
      - GPS circuit included
      - Add cable + Antenna + Installation and you have GPS timing
  - Low cost 1588 OC (slave / master)
  - Low cost 1588 BC* (slave + master)
  - Low cost embedded grandmasters (GPS+OC or GPS+BC)
- GM better be integrated in the Telecom equipment
  - Switches, Routers, Multiservice MPLS Access Switch, Base-stations
- Enhanced BMCA (Best Master Clock Algorithm) – NPM (Network Performance Monitoring)

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Comparison

Solutions	Pros	Cons
Better Multi Engines Servo	All…	None… The problem - currently it doesn't exists…
Over Provisioning	Improve performance	Cost Interim solution
GPS Everywhere	Good performance	All known GPS limitations
BC – Boundary Clock	Scalable Improve performance	Cost. Infrastructure replacement. All or nothing
TC – Transparent Clock	Improve performance	Cost. Infrastructure replacement. All or nothing
Distributed Master architecture	Improve performance Focused investment Protection Scalable	Increase the number of GPSs

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Conclusions

- Achieving 1µsec accuracy is challenging
- 1µsec accuracy can be achieved today under ITU-T G.8261 conditions using good servo
- But life may be more complicated then G.8261
- Operators may adopt a one or more alternatives in order to improve the synchronization
- Distribute Master architecture - A highly attractive approach
- IPClock products and roadmap support all those alternatives

Questions ?

Thank You !

www.ip-clock.com

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