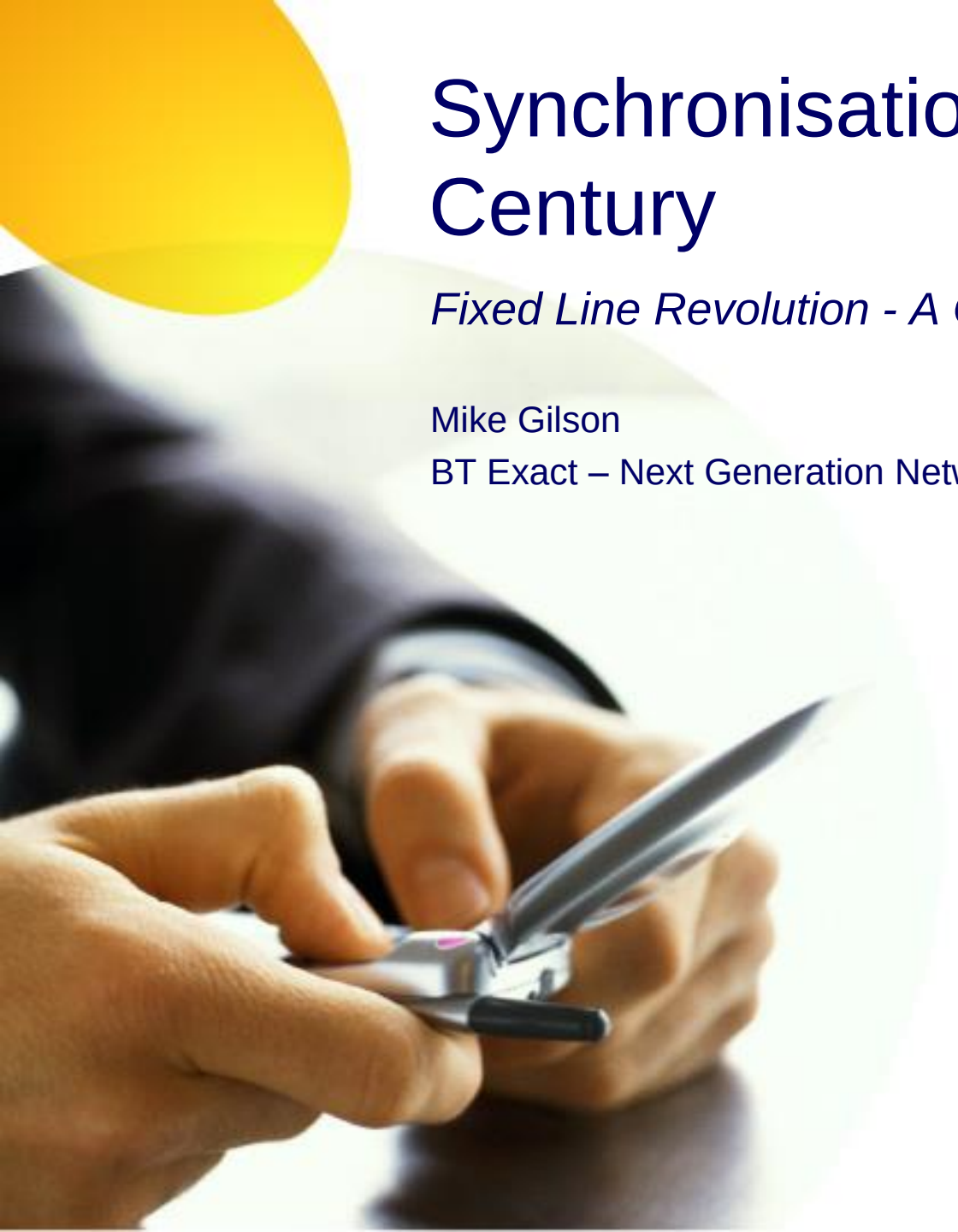
Synchronisation in the 21st Century

Fixed Line Revolution - A Carriers Perspective

Mike Gilson
BT Exact – Next Generation Networks



Agenda

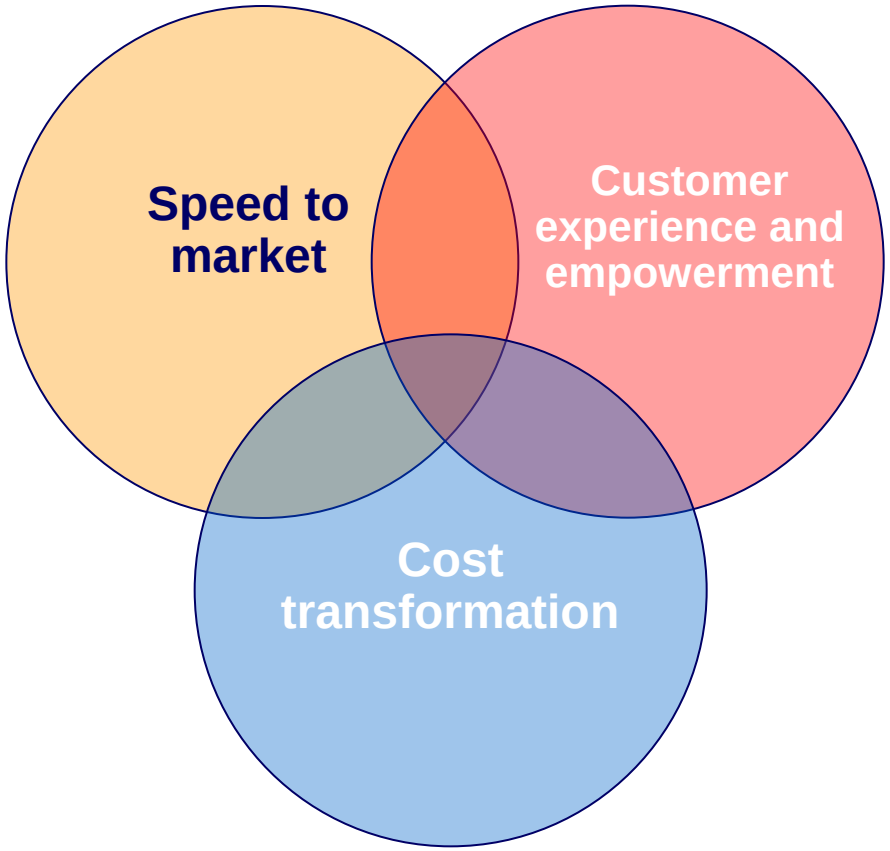
- 21st Century fixed line revolution
  - Do we need synchronisation
- Changing architecture
  - Generation & distribution
  - Some of the issues – The Layer problem
  - Some measurements on Layer 2 & 3 solutions
- Concentration on Layer 1 / Layer 2
  - Measurement & Technology Summary
  - Network & resource convergence
- Possible high level scenarios

Synchronisation - Why do we need it?

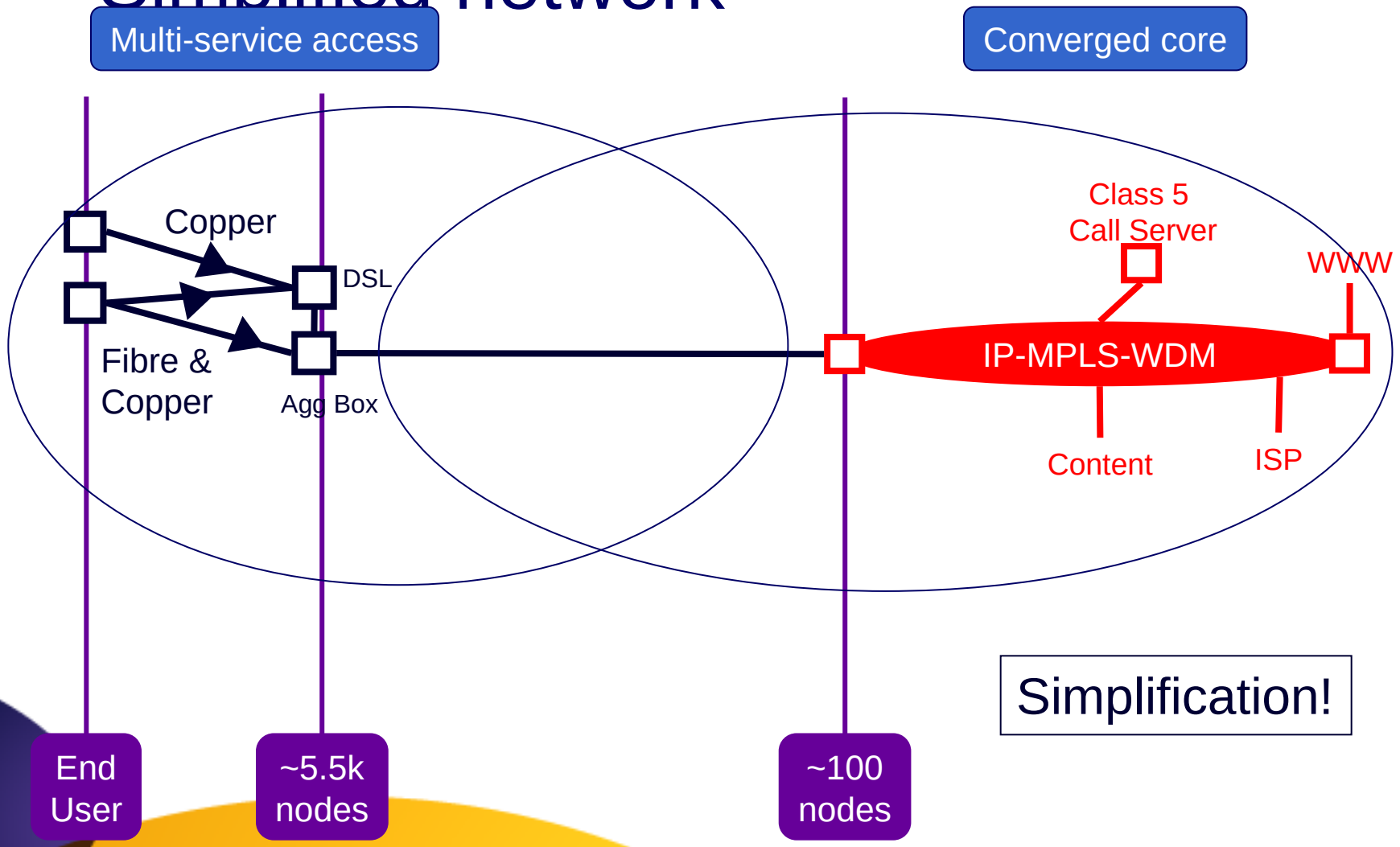
- The world is all packets – Sync not required!
- Life is not simple
  - Migration of 20C to 21C
  - Some applications require synchronisation
- What do we mean by synchronisation
  - Commonly held to be frequency (timing)
  - What about time?
- New applications
  - Requirement for Time & Timing
- Embed the building blocks -> enable the future

21C Rationale

- Convergence is gaining momentum
- Convergence needs an underlying infrastructure to deliver and support it
- Customers want more choice, flexibility and control
- Simplicity is key



Simplified network



Simplification!

Current thinking.
No implementation assurances

Services required

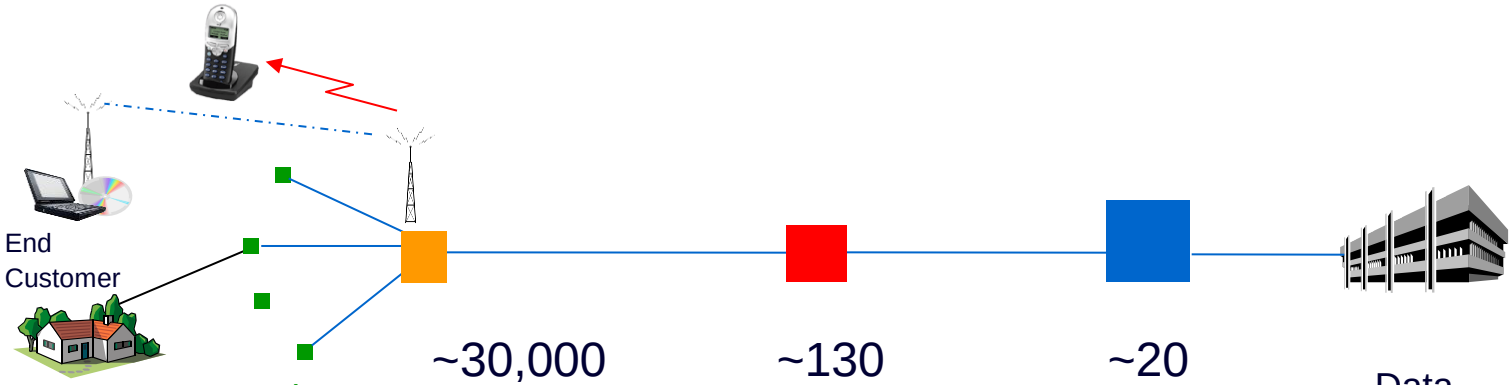
- Who knows?
  - Yet to be thought of!
- Our customers want
  - simple & complete services…
  - that enhance their lives…
  - allow them to…
  - carry out their business by…
  - using services, connecting to networks, seamlessly and simply!
  - cost reduction

Plug & Play

Gibson Digital Electric Guitar

- Does it matter if it needs sync
  - …to the sync industry yes…
  - …to the user no…
  - …they want to plug and play!
- The user doesn't know or care if the service requires sync…
- If sync is required we need to provide it in the plug and play connection.
  - *It may only be a small component in the overall service!*
  - *But have a big impact*

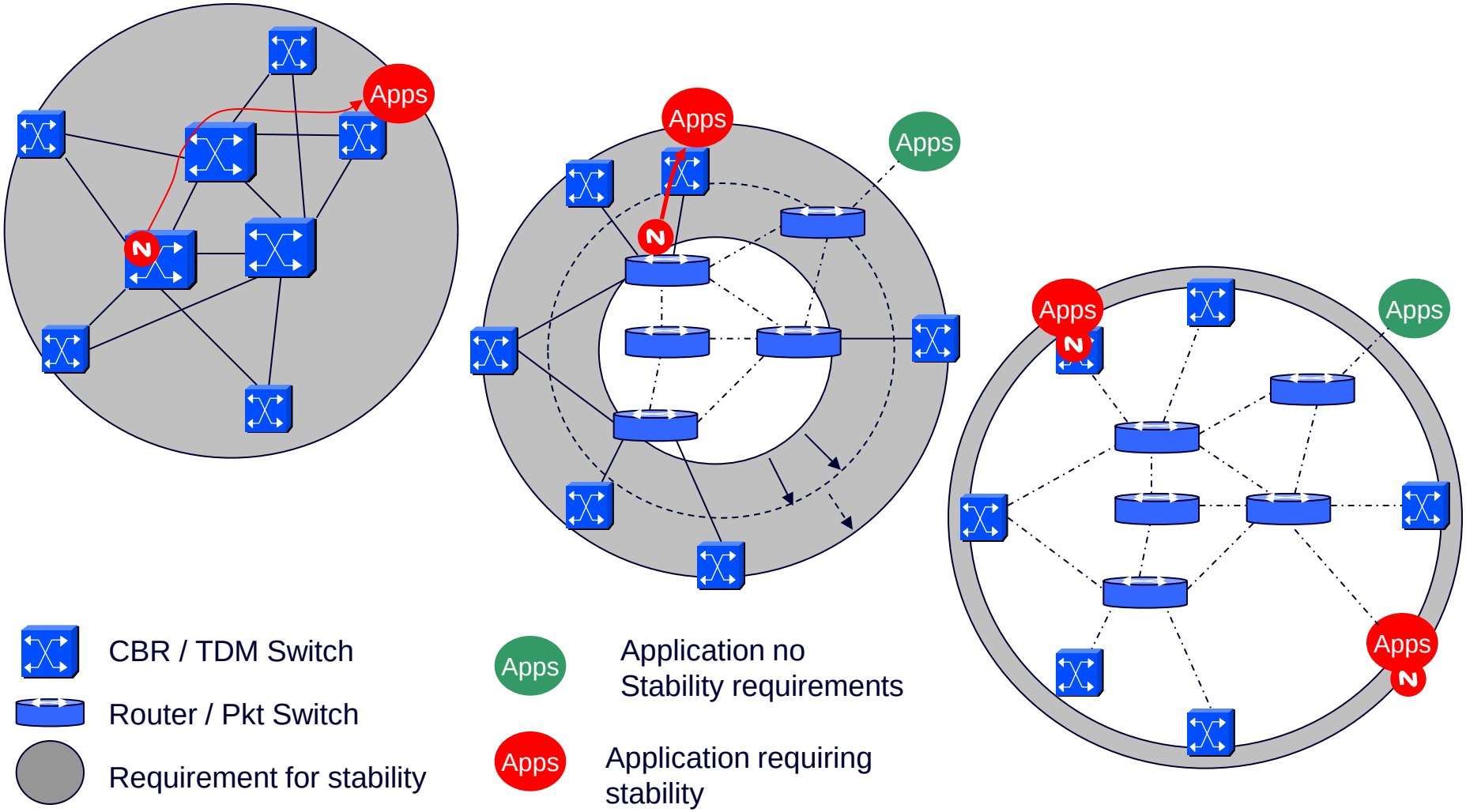
Reference & Distribution



Millions? ◄- - 5,000+ Nodes ◄- - - 100+ Nodes

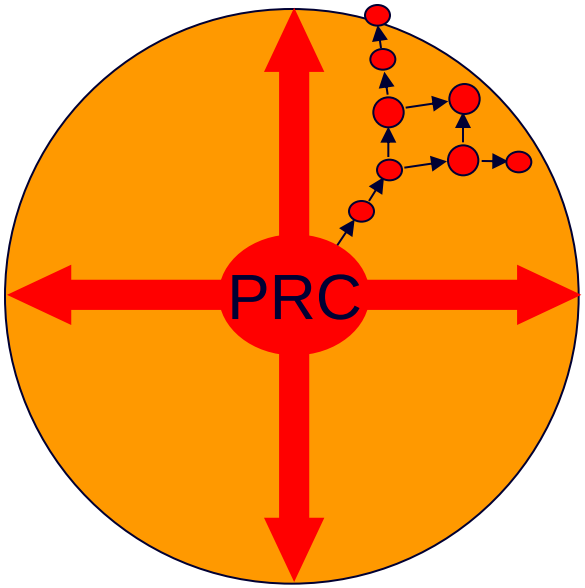
The Number Problem!

Evolving Network Architecture

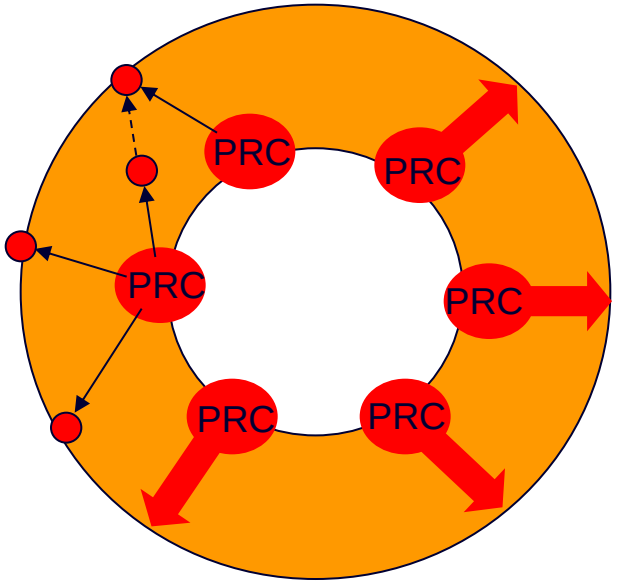


Edge Stability

"Jam in the Doughnut!"



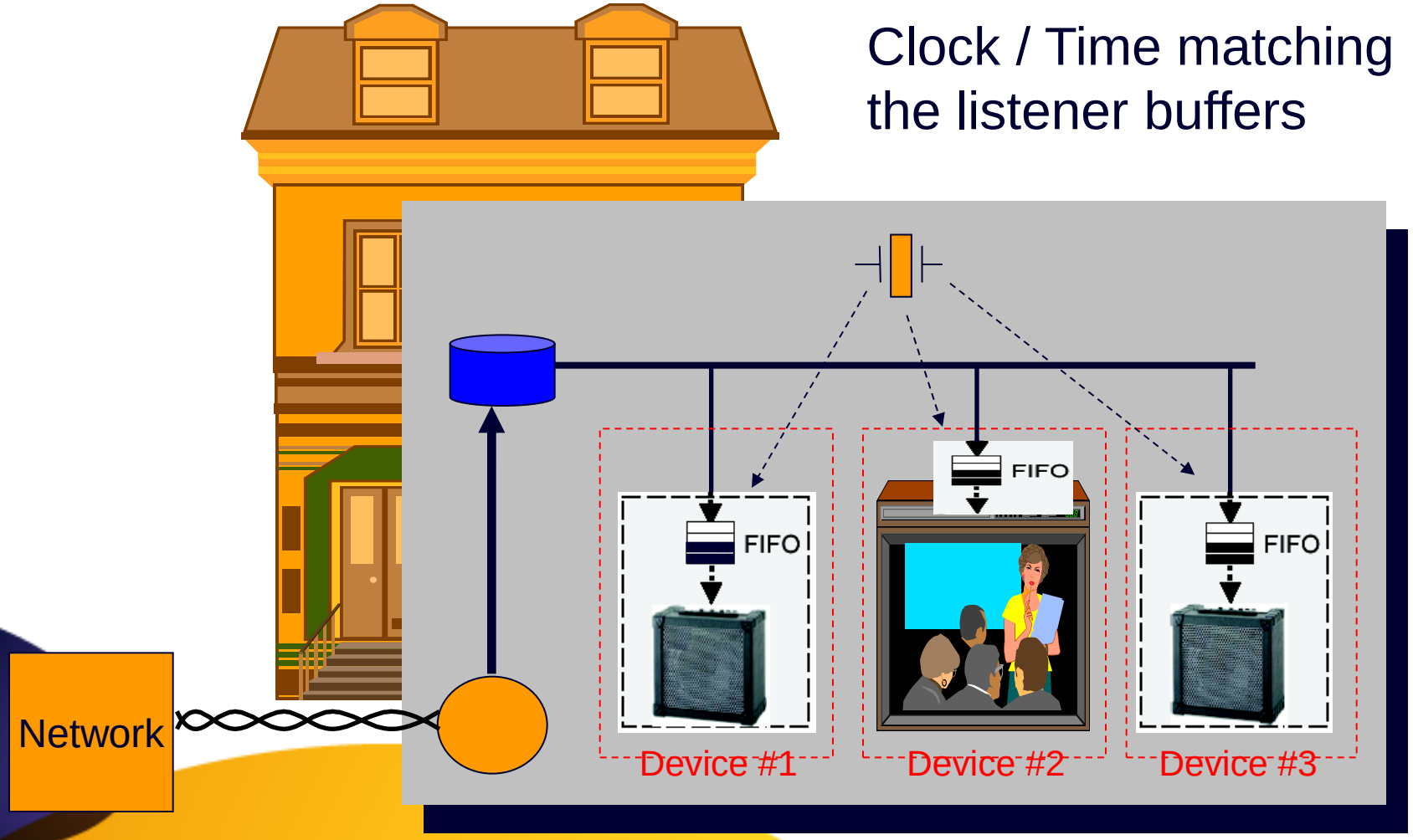
Jam in the centre



Jam at the edge -
……..more jam required!

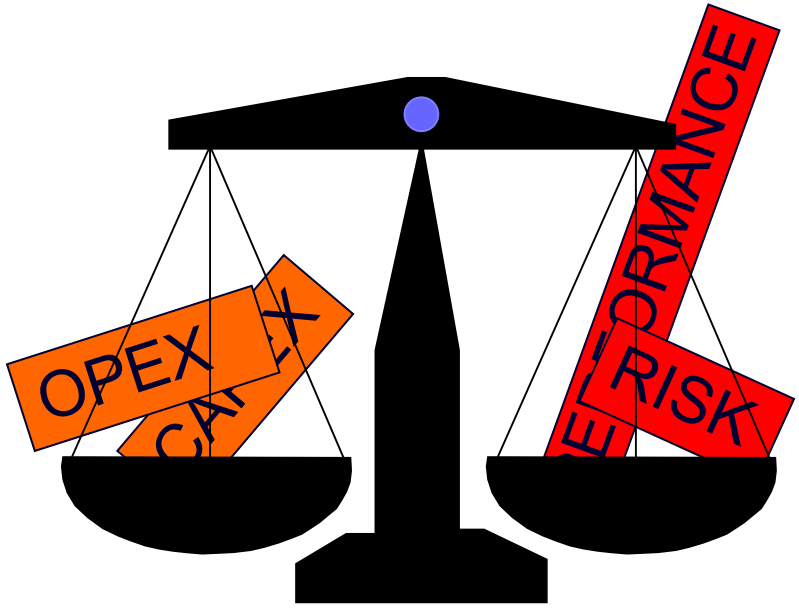
Residential Space - RES ETH

Clock / Time matching the listener buffers



Technology Choices & Trade Off

- If timing is required at the Application or Edge of the Network
  - Choices based on various factors
    - Reference generation
    - Reference distribution
    - Generation / Distribution balance
- Technology choices
  - Satellite based systems
  - Maintain an SDH / SONET Path
  - Packet Based Solutions
  - Synchronous Ethernet
  - Propriety



GNSS - The Cost of Off Air

- Architecture (Performance) Vs Cost
- Larger systems
  - CAPEX to Install and Ongoing OPEX
- Typically, 2% of installed base have issues…
  - Interference
  - Weather degrading install
  - Roof rearrangements - Do you own the roof?
- The Street cab
  - Engineer into the cab
  - The same problems as on the roof – on a micro scale
  - Consider the environment

The GNSS Environment

Offsite interference Issues!

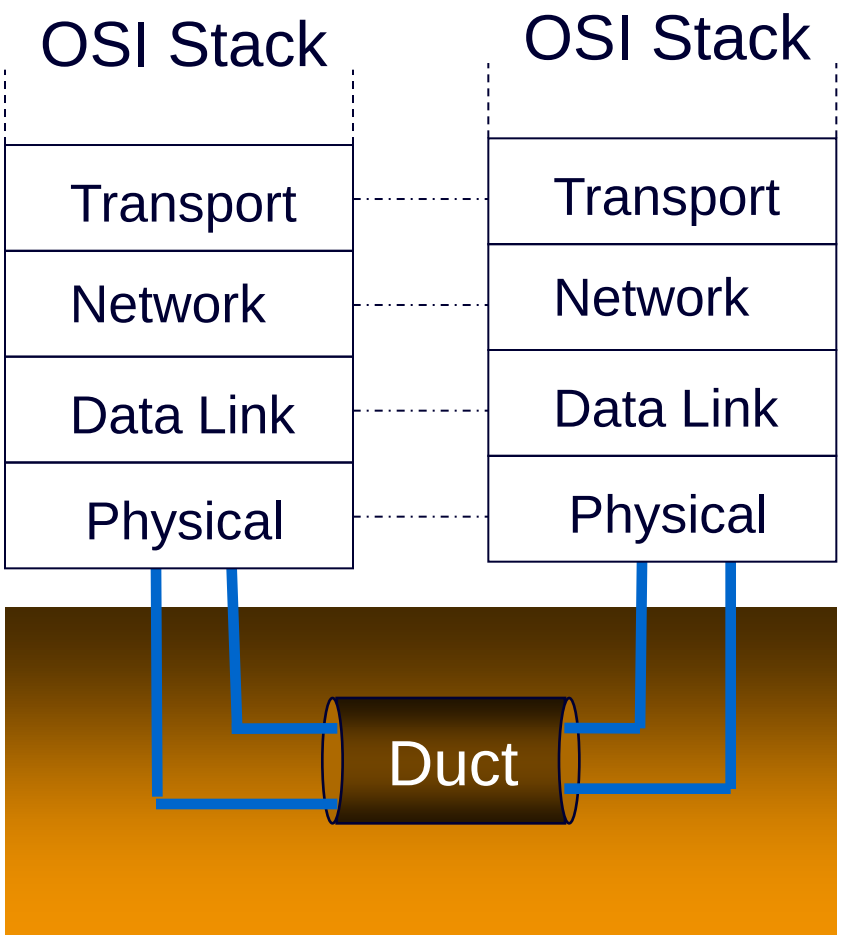
"A mix of interference & environmental issues"

Core - Edge Reference Distribution

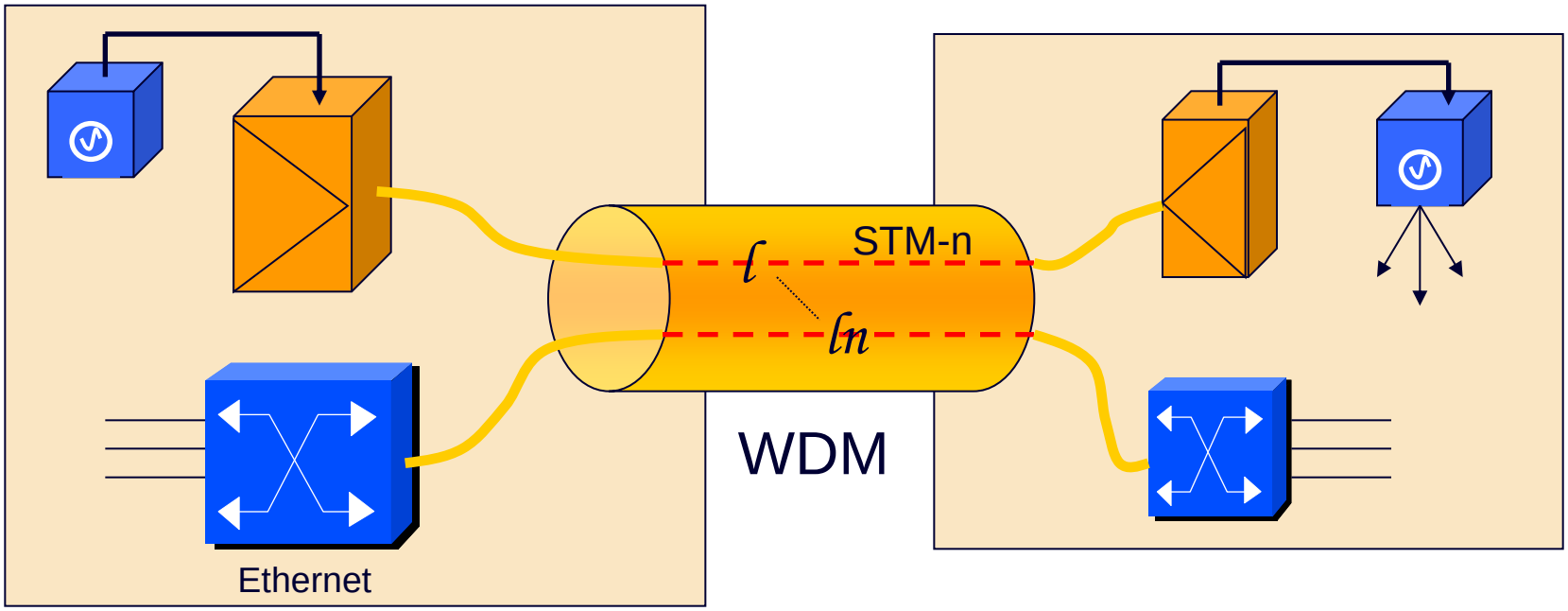
- TDM Technologies
  - SDH / WDM (Well understood transport)
- Ethernet (carrier scale)
  - Currently not synchronous to a network reference
- xDSL Technology
  - Symmetrical (fairly well defined performance)
  - Asymmetrical delivery creates challenges
- Optical Systems
  - GPON etc
- Packet based technologies
  - TDMoIP, CESoIP, SAToIP (bit rate limitation, load / delay)
  - NTP, IEEE1588

The Layer Problem

- "Science of the sensible"
  - Clock signals and oscillators are fundamentally analogue
  - Why translate from a stream with a given frequency to packets?
    - Unless you have to…
- Building up from the duct
  - Duct & fibre is a "given" & its stable
  - Physical Layer – next stable point
  - Adapting the frequency to a packet stream
- Performance inheritance



Layer 1 - Maintain The SDH Path



- Requires a wavelength to maintain synchronisation
- May require for TDM / low latency services
- CAPEX & OPEX costs

Layer 1 - Synchronous Ethernet

- Designed to robustly deliver synchronisation
  - frequency / phase (Takes the best from SDH)
- Essentially looks like SDH / TDM timing
  - Helps in the migration process – SDH transport to Ethernet Transport
  - Will inter-work with native Ethernet
- Does not change basic Ethernet Standards
  - Note: not native Ethernet / can not be supported over native Ethernet
- Requires hardware changes
  - Ethernet Silicon requires control silicon
  - message channel to support Sync Status Message (SSM)
- Changes some views on accepted functional modelling

Layer 2 / Layer 3 - Packet Solutions

- Layer 2 – Running over native Ethernet
- IEEE1588 – Precise Time Protocol (PTP)
  - Embed a 1588 solution within your network elements
  - 1588 is more than a Protocol, requires hardware changes
  - If you know frequency = very precise time
- Layer 3 – Running over native Ethernet
- CE TDM over Packet - flow combined with traffic
  - Contention with traffic, Variable performance, Stabilisation period
- CE TDM over dedicated links
  - Performance improvement – dedicated so traffic contention goes away
  - Same issues as maintain the SDH path – CAPEX & OPEX

Synchronisation Impact Summary

Network Impairment (Typical impairments that may occur)	**G.8261** Synchronous Ethernet - Layer 1	**IEEE1588** PTP - Layer 2
Increased Channel Utilisation	**None**	**Low impact**
Packet Reordering	**None**	**Low impact**
Error Injection	**None**	**Low (*)** Not tested
Asymmetric Delay	**None**	**Low impact**
Delay Variation	**None**	**High impact**
Asymmetric Delay Variation	**None**	**High Impact**
Dropped packets	**None**	**Low impact (*)**
Recovery Time (e.g. link fail)	**Fast recovery**	**Slow recovery (**)**
Route Change	**None**	**High impact (**)** Not Tested
Power up recovery time	**Fast recovery**	**Slow recovery**

Note

- Summarises impact on stable synchronisation i.e. ITU-T G.811
- High impact = breach of all ITU-T G.823 Standards
- (*) or (**) related

Technology Summary

Key Points	Synch Ethernet Layer 1	PTP – IEEE1588 Layer 2
Engine Cost	$'s	$'s
Inter-work with Native Ethernet	Yes	Yes
Operate over native Ethernet	No	Yes
New hardware required	Yes	Yes
Standardised	Yes – ongoing ITU-T G.8261 et al	Yes – ongoing IEEE1588v2
Traffic Impairment Impact	None	Yes
Architecture	Understood – "SDH Like"	Requires work
Bandwidth Required	None	Yes - Minor

High Level Architecture Solution

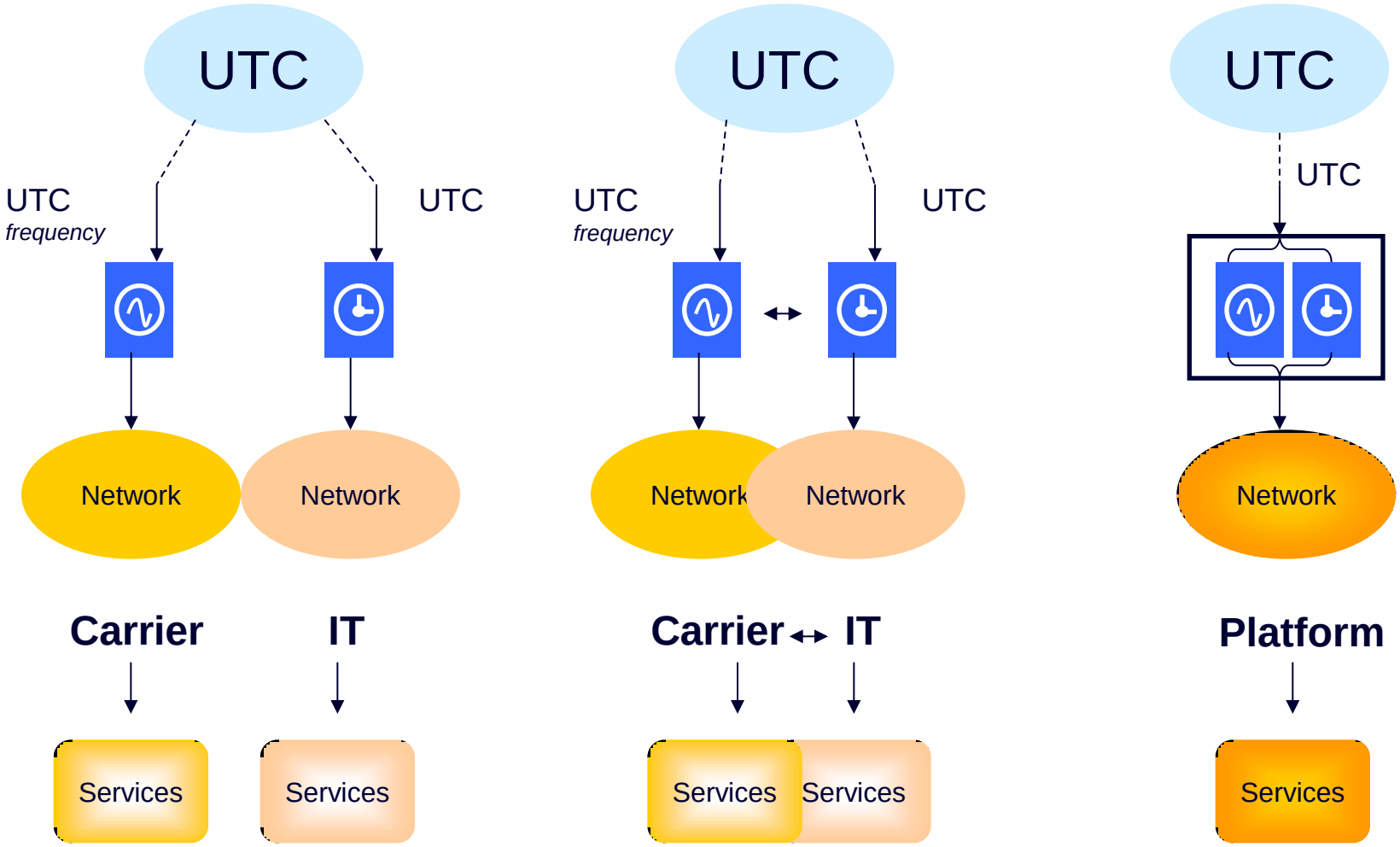
- Use appropriate solution in the appropriate place within architecture
- Frequency Recovery
  - Layer (x) solutions competing - There maybe good reasons
  - But not everywhere!
- Carrier scale Ethernet transport
  - Synchronous Ethernet - used to recover good frequency
  - May not be required at all points
  - Push highest level of frequency stability as far to edge as possible
- Native Ethernet transport
  - IEEE1588 can be used to transport frequency and time
  - However, performance trade off (frequency) due to impairments
  - May also impact recovery of time

Convergence & Complementary

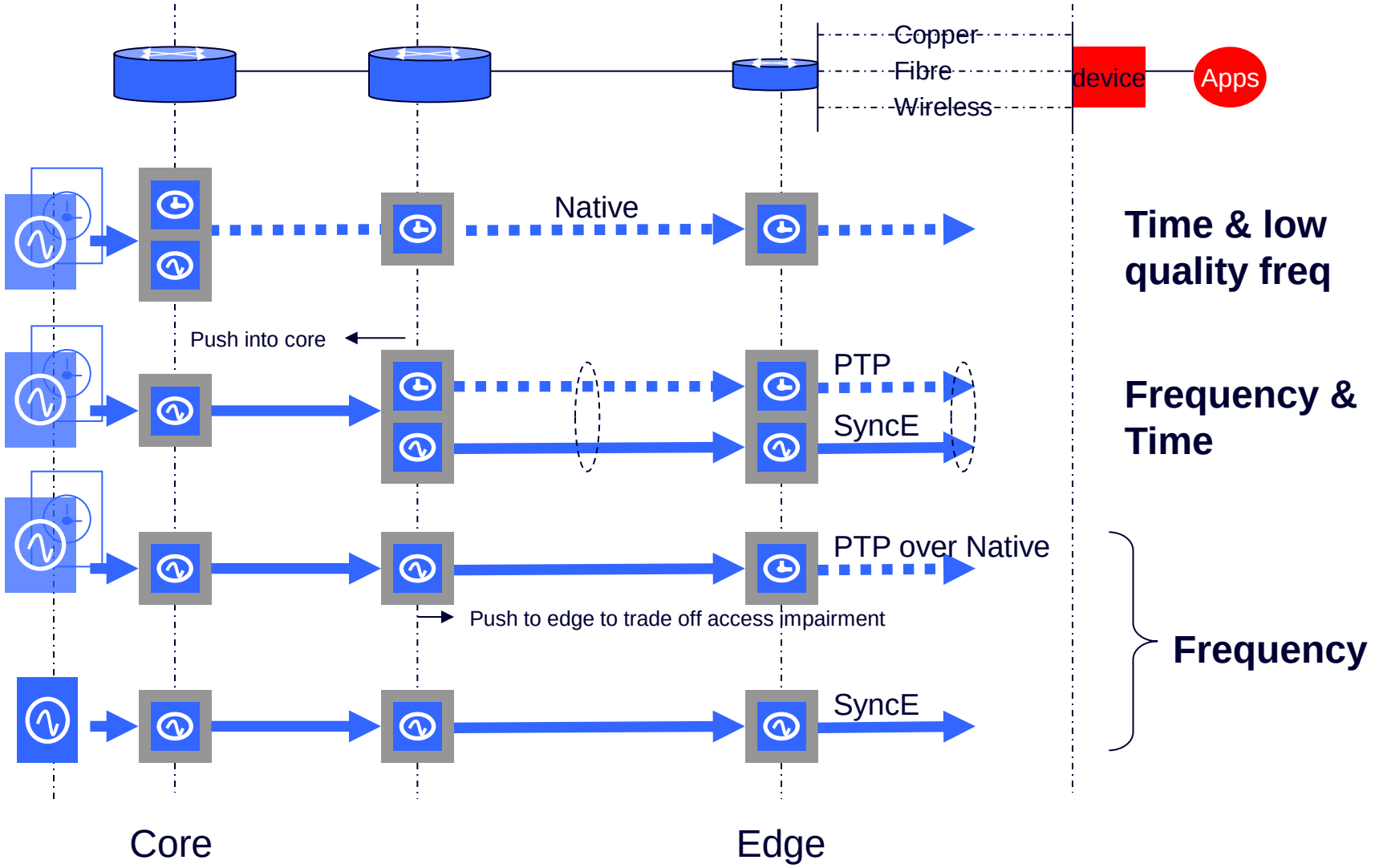
- Frequency and time are related – consider as a resource
- Networks
  - Carrier - traditionally required frequency
  - IT / computer networks – time

  } But these are converging
- Synchronous Ethernet
  - Can provide the frequency base in carrier scale networks
- IEEE1588
  - Time
  - If you have good frequency at the end points - Time lock becomes quicker
  - Can provide frequency base in native networks - limited
- Synchronous Ethernet & IEEE1588
  - should be seen as complementary
  - …in resolving the frequency and time solution

Network & Resource Convergence



Possible Scenarios



Conclusions

- Simplify the evolving architecture
  - Flexibility, cost base
  - Embed the time & timing components
- Its not a choice of one technology over another
  - Combination of technology
  - Packet techniques do work but use appropriately
- If we are building networks fit for the 21st Century
  - Yes build it to a cost…
- But
  - Embed the key components in the base technology
  - Understand that a few $'s additional cost may enable many future applications
  - Should not accept a lower quality base performance

Contact Details

Mike Gilson

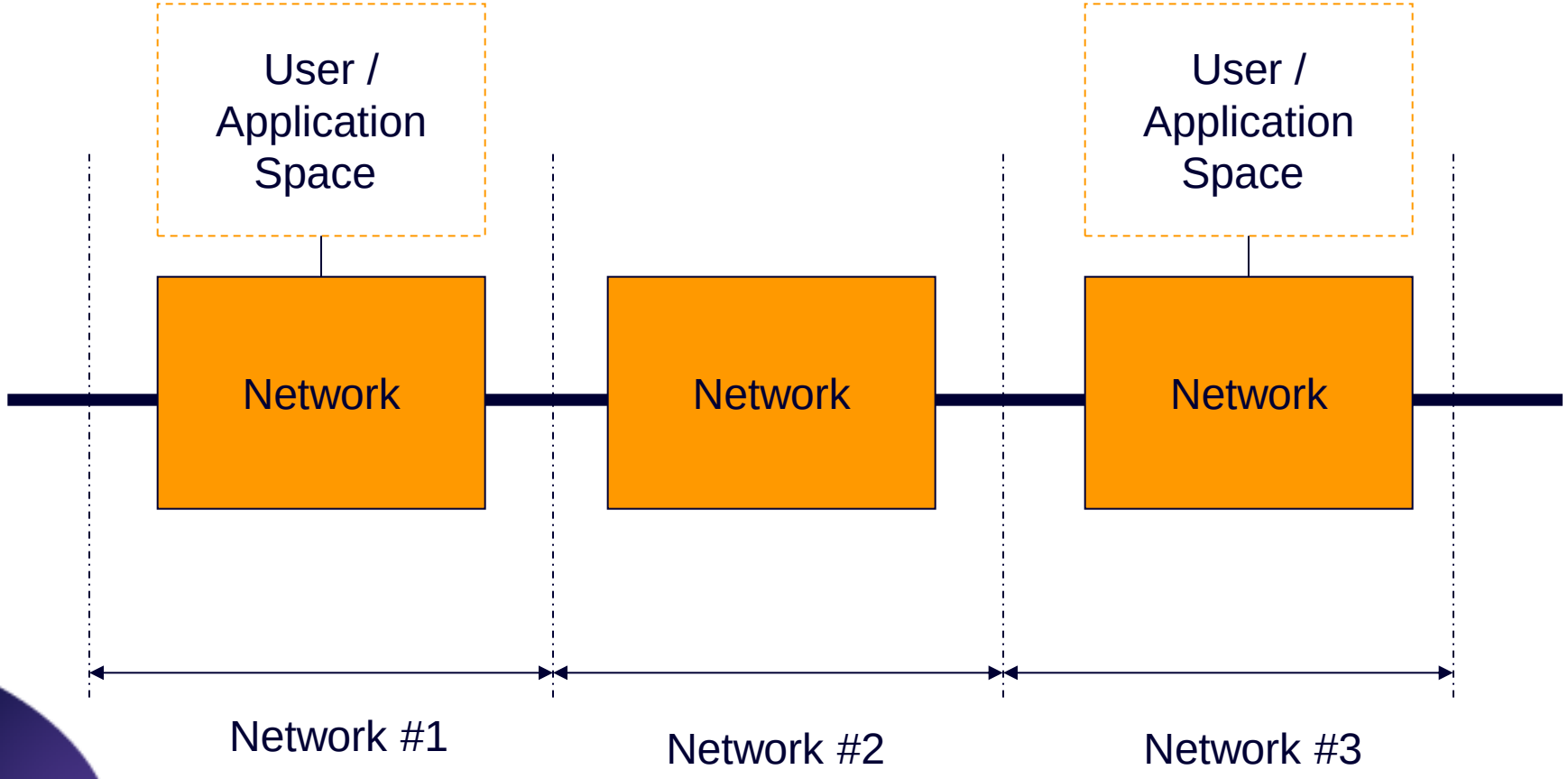
BT Exact
Pp11, Orion Building 5
Adastral Park
Martlesham Heath,
Ipswich
Suffolk IP5 3RE
UK

Tel: +44 1473 609575
Email: mike.gilson@bt.com

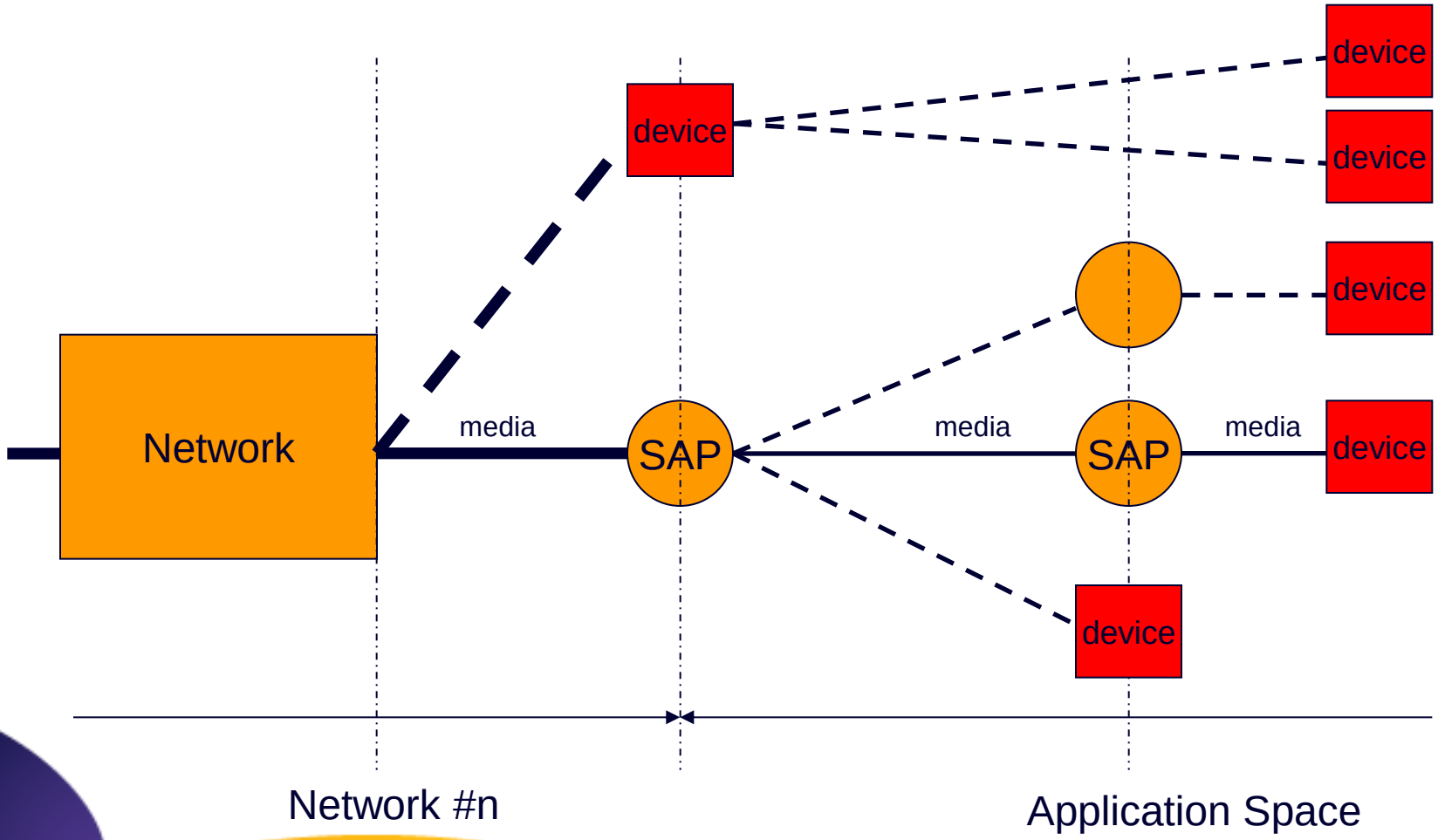
Sources of Network Reference

- Frequency and / or time generation
- The Primary Reference Clock (PRC)
  - Source of frequency stability and increasingly time
- The obvious choices
  - Caesium
  - Disciplined off-air i.e. GPS, Galileo (2010 onwards?)
- Less obvious
  - Low Frequency solutions – LORAN, MSF, DCF
  - High stability oscillator on a chip e.g. Caesium
- Some sources have time embedded

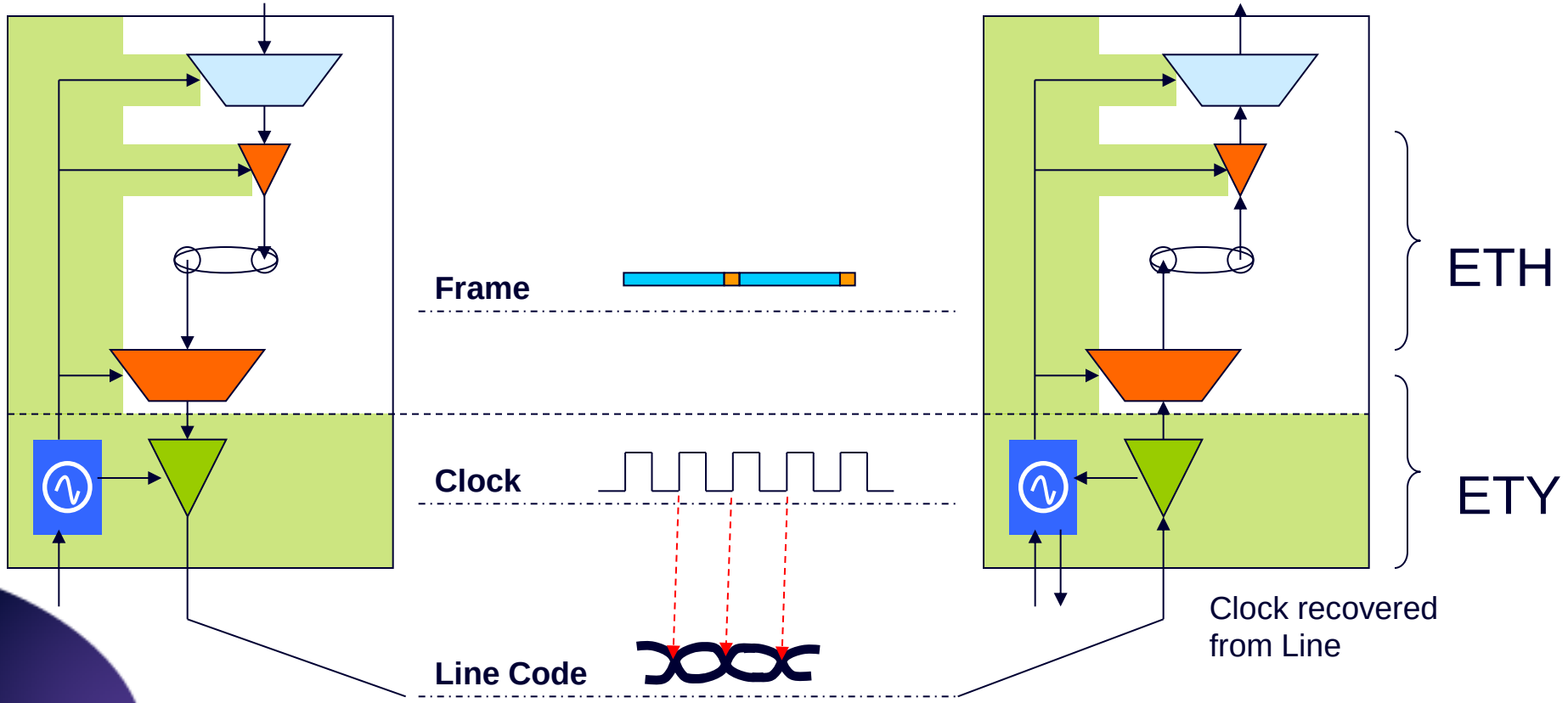
The Network Space



Application Space



Layer 1 Boundary

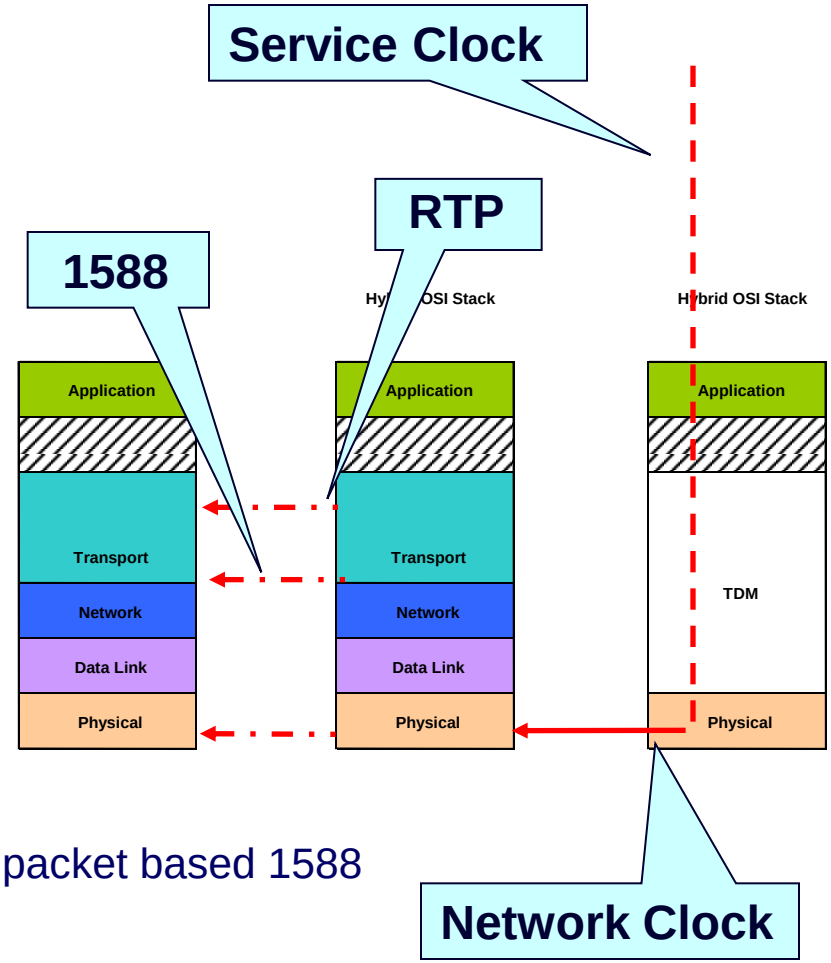


ETH = Ethernet ETH Layer
ETY = Ethernet ETY (Physical) Layer

Flows

Timing Flows

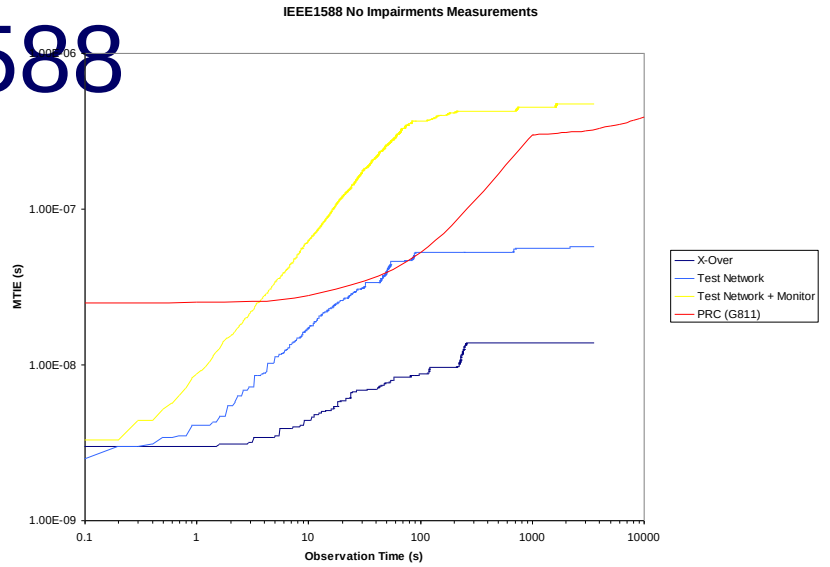
- Many timing flows now exist
- Physical (Network) timing flows
  - Network Clock, Ethernet PHY
    - e.g. point to point bit stream
- Service Timing flows
  - point to point bit stream
    - e.g. PDH / TDM stream,
- Message Flows
  - Based on packets
    - e.g. Time & Frequency dedicated packet based 1588
    - RTP flows to enable voice?
    - NTP flows / TOD flows

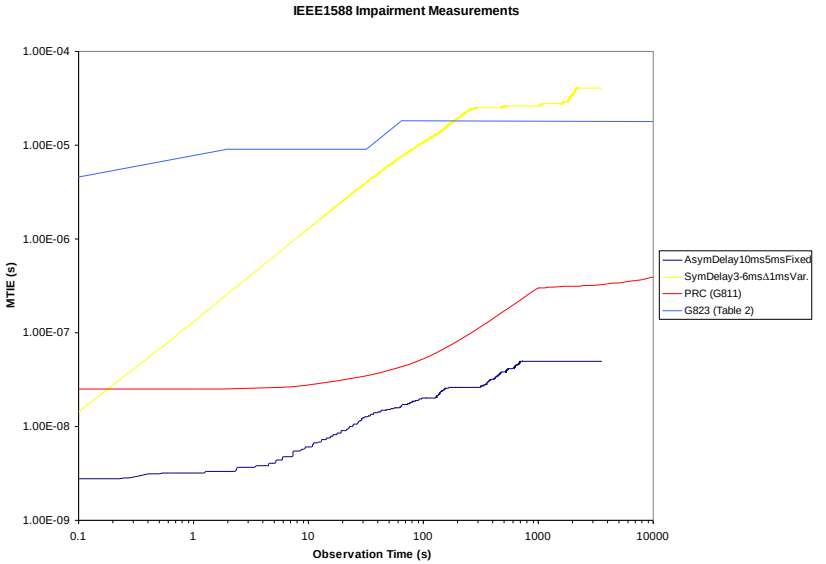


Note: This is not a real E2E Circuit

Layer 2 / 3 - IEEE1588

- Still evolving
  - Excellent performance achievable
- Performance
  - Fixed delay (symmetric / asymmetric) - very good
  - Varying Delay (symmetric / asymmetric) – degraded
  - Stabilisation period
- Security
  - Access to the packet flows
- Identify
  - Correct place in the architecture
  - Function (Frequency / Time or both)





Layer 3 - CE TDM Transfer

- TDM cct over corporate LAN with adaptive clock recovery
- Impact of
  - varying PDV
  - varying load
  - These are unknowns!
- High levels of low frequency wander
- Will impact performance
  - Buffer slips
  - Service impact