

# Cheaper & Deeper

[Trends in network synchronisation delivery]

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## Objective

- To discuss the trends associated with synchronisation delivery
- Core network synchronisation is well-established and managed as a service platform (within BT)
- Primary focus is the last mile (or so) within the context of future architectural changes



## Introduction

- What are the characteristics of today's networks?
- Why is synchronisation important?
- What performance do I need and where?
- How does technology affect performance? - examples
- Future thinking?
- Summary

## Characteristics of today's networks

- Cost effective – built on 2 'R's (Realism & Return)
- Aimed to deliver customer satisfaction
  - Performance expectations beyond the SLA?
- Opportunistic
  - Seek to provide new 'value added' services
  - Niche
- Virtual
  - Not necessarily operator owned
- Highly inter-connected &  
complex mix of technologies

## Why is synchronisation important?

- In support of customer services, applications & technology
  - Traditional POTs (network interconnection)
  - TDM private networks
  - Mobile carrier frequency maintenance and handover
  - Real Time Video
  - Public/private Infrastructure
  
  - SDH
  - TDM
  - ATM CBR
  - CES IP
  - ATM SRTS

## What clock stability do I need and where? – ‘rough guide’

- Source(s) > ITU-T G.811  $1 \times 10^{-11}$
- In core (SSU, SASE, BITS)  $1 \times 10^{-10}$ 
  - simplifies network design & operations
  - monitoring point
  - faster fault finding
  - network protection by stopping fault propagation
  - simplifies distribution by shortening chains
- Network elements > ITU-T G.813  $4.6 \times 10^{-6}$
- In the CPE - as the QoS requires
  - Based on:
    - ITU-T G.822 slip rate objective
    - Knowledge of supported services

## How does technology affect synchronisation performance? 1

- Synchronous (TDM) technologies
  - Issues
    - **few, will deliver!**
    - **however correct design & configuration mandatory**
    - **cost (real or perceived)**
  - Advantages
    - **physical layer management & QoS**
    - **well understood, proven, established in standards**
    - **efficient for large bandwidths**
    - **flexibility & SDH functionality improving with GFP & LCAS**

## How does technology affect synchronisation performance? 2

- Asynchronous, 'bursty' technologies
  - Issues
    - **variable delay/discards affect synchronisation transfer**
    - **doesn't naturally suit some applications**
    - **potentially attractive solutions still being standardised**
  - Advantages
    - **potentially cost**
    - **well suited to suit some applications**
    - **common service platforms?**

## What have we got now?

- An established mix of technologies, with known interfaces that largely inter-work
- Cut and paste core network designs that are largely internationally applicable
- Established, bandwidth rich fibre core networks with, economies of scale and no significant synch. transport issues
- An access network where cost per bit is key and synch. performance is less easy to achieve (without fibre)
- ICT convergence encouraging progression to core MPLS backbones

## Converged platform synchronisation issues

- Architectural
- Potential loss of terrestrial synchronisation distribution
- Potential increases in absolute & variable delay
- Loss of 3<sup>rd</sup> party synchronisation transport?

## Converged platform synchronisation issues - Standards

- E2E Circuit emulation standards not mature
  - ITU-T Y.tdmpls standard (IPmux)
  - ITU-T Y.vsmpls standard (Vmux)
  - **IETF** - proposed common draft for circuit (TDM) over Packet, called SAToP,
  - **MPLS/FR** - two implementation agreements: TDMoMPLS (AAL1) and Voice Trunking over MPLS (AAL2)

## Access network synchronisation delivery issues

- How can we effectively & economically continue to:
  - Meet ITU-T G.823 traffic synchronisation requirement
  - Meet the mobile services synch. requirement (  $5 \times 10^{-8}$  )
- But:
  - Deliver private circuit services, full duplex 0.5 to 10 Mbps
  - Converge to a common platform for delivery
  - Support all existing and deliver new services
  - Overcome any potential synch. transfer issues for copper delivery

?

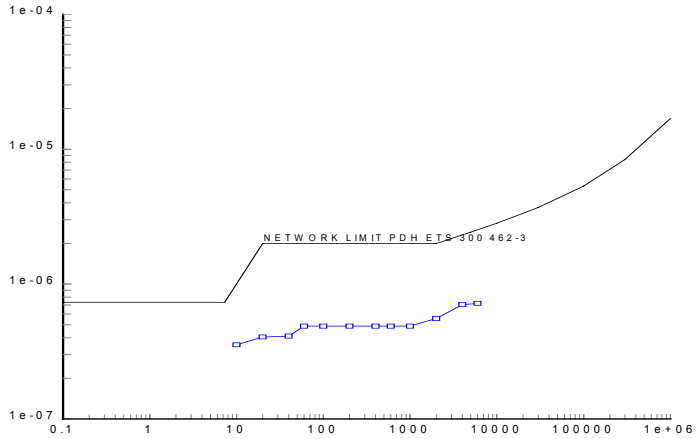
## Possible solutions

- Fibre, PONs etc
- Point to point/multipoint microwave
- Circuit Emulation of Services (CES) over copper
  - HDSL
  - SHDSL
  - different clock recovery techniques

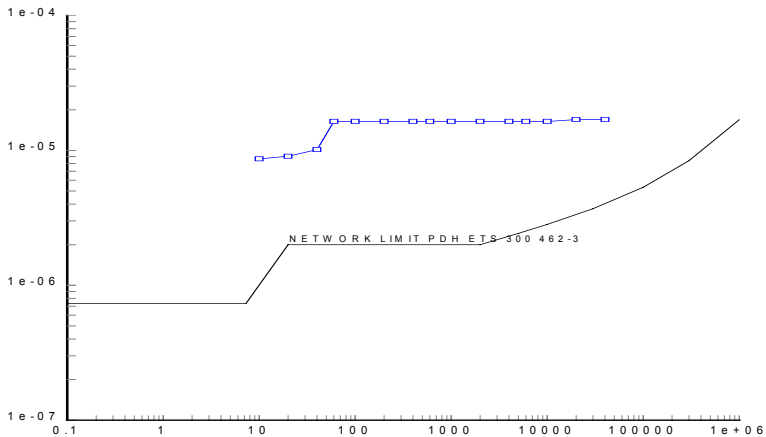
## HDSL – High Speed DSL

- Restrictive planning rules (1:N pair usage ratio)
- Variable synchronisation performance

# HDSL E1 MTIE plot (mainland European example 1)

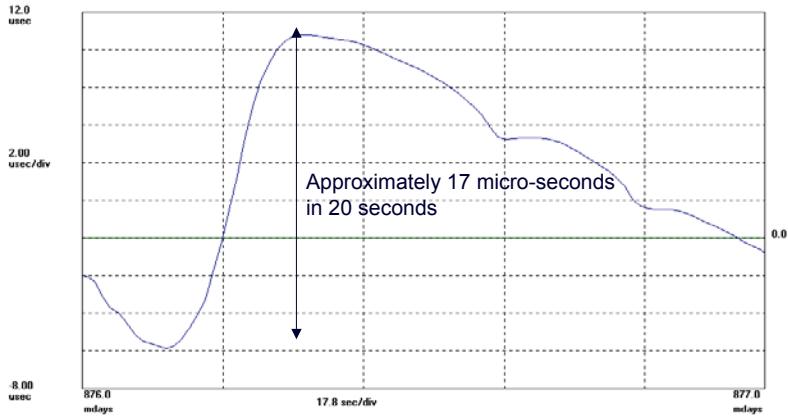


# HDSL E1 MTIE plot (mainland European example 2)

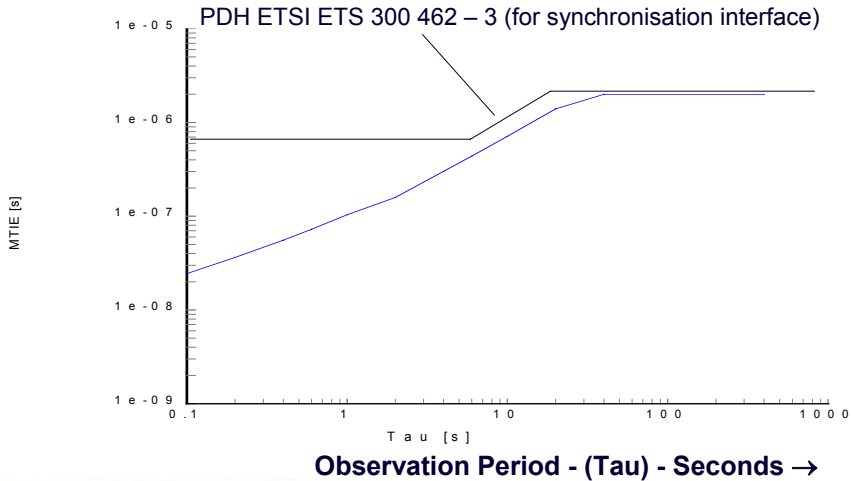


# HDSL – E1 PDH TIE

Mainland European example : expanded phase observation



# BT CWSS (ISDN) E1 MTIE (proprietary 'HDSL' like)



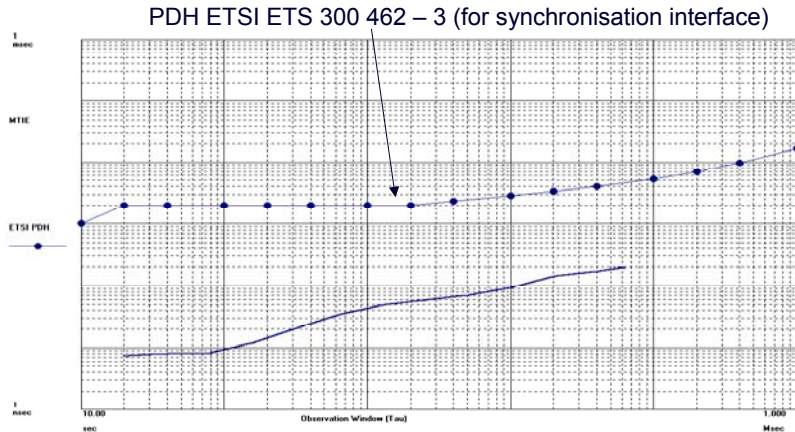
## SHDSL - Symmetric HDSL

- 2-wire E1 for up to 2.3 Mbps (4-wire circa 4 Mbps)
- Reasonable drive distance PoP to Customer
- Limited planning restrictions (unlike HDSL)
- Standards – G.SHDSL
- Acceptable synch. performance?

## SHDSL E1 over SDH

- 'Realistic' test environment
  - 5 Node SDH ADM & DXC network 10 Km fibre links
  - 2-3 Km copper simulator with 'typical network' noise settings
  - Standard BT synchronisation configuration

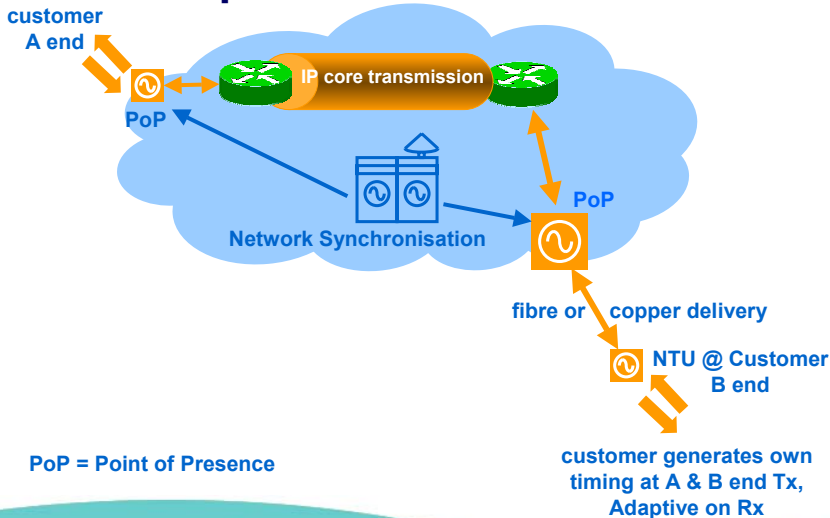
## SHDSL – SDH Delivery - MTIE



## CE Clock recovery techniques

- **Network clock recovery**, customer must loop time at the master and receiving end to recover network timing and clock out the data.
- **Adaptive**, the receiving end monitors buffer depth and maintains clock rate accordingly.
- **SRTS**, patented technology (Telcordia Technologies Inc.), master end TXs the difference between data clock rate & network clock to the slave: the slave output clock is then updated with the difference between that and the local network clock. Network endpoint clocks (PoPs) need to be close in terms of frequency!

## CES Adaptive Mode



Ingenuity works BT Exact



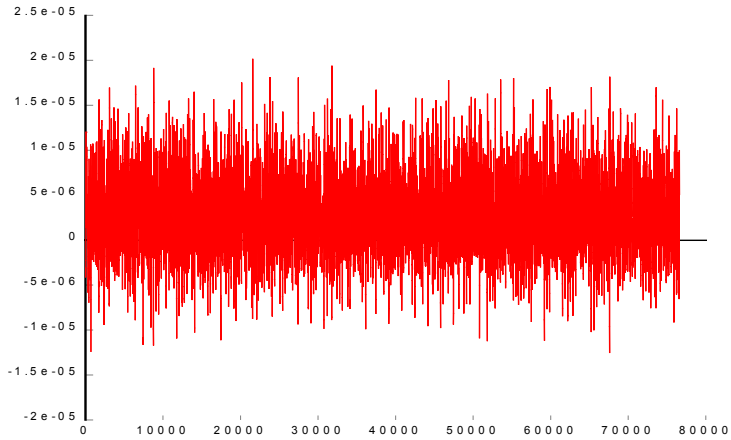
## CES Adaptive Recovery

- 'Ideal' laboratory test environment
  - All appropriate network elements were closely 'frequency locked' to the same clock source (including the customer data!)
  - No contention in the aggregation or core IP network
  - No copper line 'noise' simulation (few metres copper only)

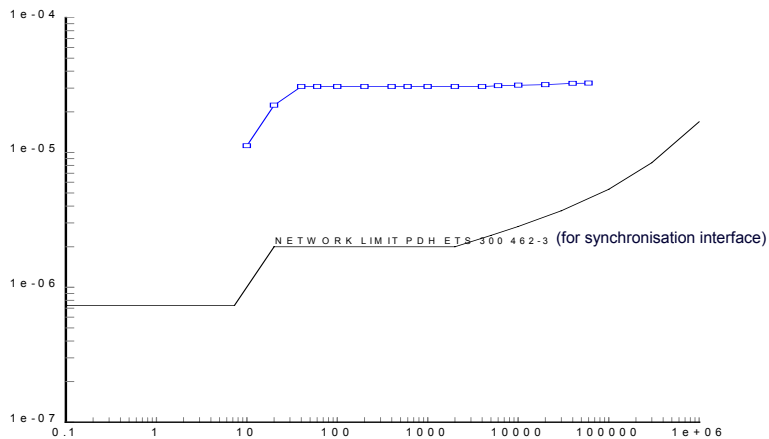
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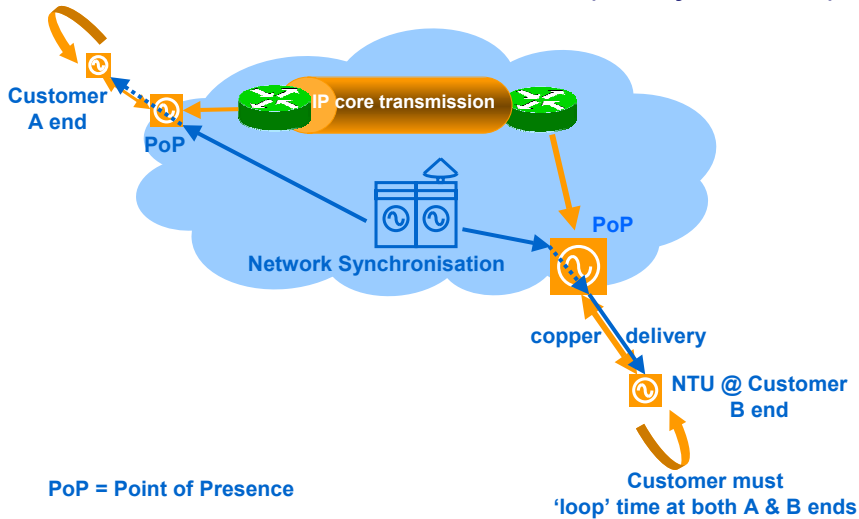
## CES Adaptive Mode TIE (over SHDSL)



## CES Adaptive Mode MTIE (over SHDSL)



## CES Network Recovered (near synchronous)



Ingenuity works BT Exact



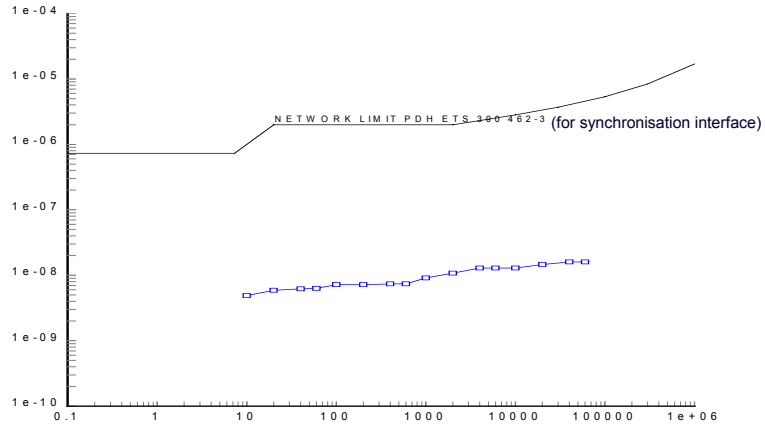
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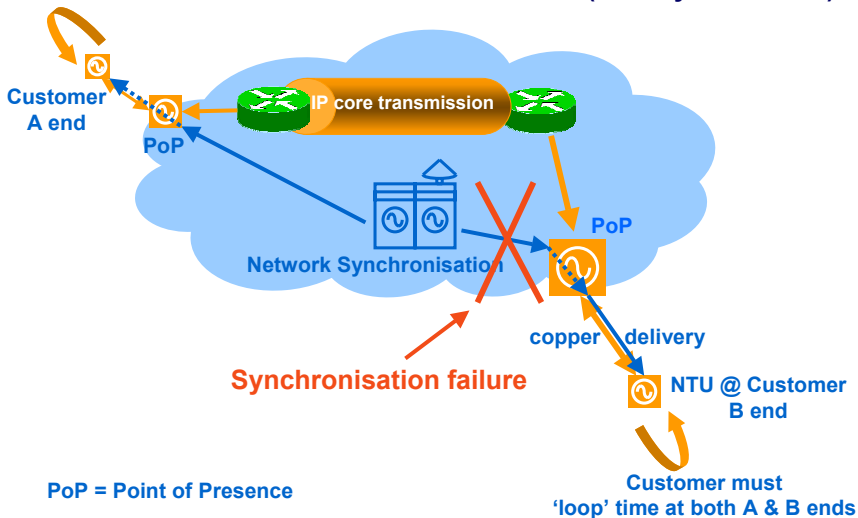
Ingenuity works BT Exact



# CES Network Recovered (over SHDSL) in a 'perfect' laboratory environment - MTIE

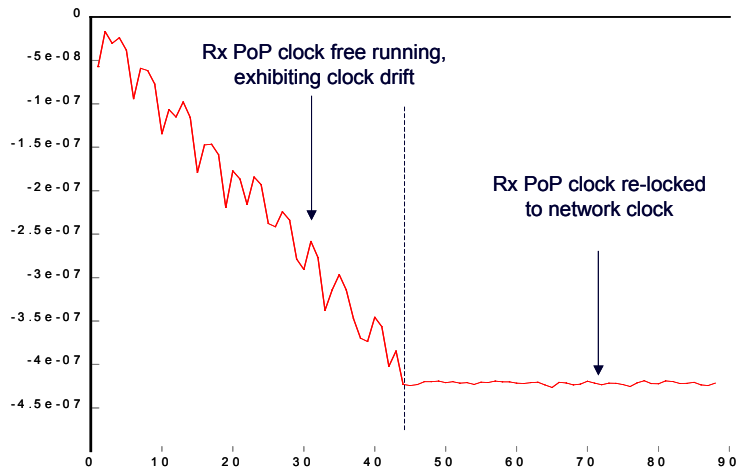


# CES Network Recovered (near synchronous)



## CES Network Recovered (over SHDSL)

### example of failure and recovery of network clock - TIE



## Conclusion from observations

- Performance can vary considerably
- Dependent on:
  - Technology
  - Manufacturer's implementation
  - Configuration
  - Copper environment

## Future thinking?

- Will customers always require synchronisation for their applications?
  - Particularly mobile?
- Re-timing technology
  - Can we ever fully rely on off-air synchronisation to provide at the circuit endpoints?
- What we need is
  - Cheap high stability oscillator, to put in customer premises equipment & maybe even mobile handsets.....

## On my wish list.....

- NIST Chip Scale Atomic Clock
  - Stability reported as approximately ten millionths of second per day drift, equating to approximately 1 part in  $10^{-10}$
  - Two free running oscillators based on this technology would slip a 2 milli-second buffer every 57 days....acceptable?
- 'IP' solution for periodically maintaining this miniature time flywheel to ITU-T G.811
- Creates a hi-stability miniature flywheel for timing/re-timing applications

## Summary

- Existing
- Converged (packet/cell) network direction
- CE & SHDSL
  - Attractive low bandwidth service delivery solution?
  - Synchronisation performance dependant on a number of variables
- Future requirements & solution?

## Summary

First ITSF

Synchronisation Network Objective:

“conformant, predictable, resilient operation”

The future is challenging!