



# INTERNATIONAL TELECOMMUNICATIONS SYNCHRONISATION FORUM

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ITSF2005 was a great success bringing together key industry experts in Telecommunications Synchronisation together with operators and equipment suppliers. With over 120 attendees, more than ever before, the event provided the opportunity to discuss the latest sync and timing challenges facing telecommunications operators and the options available to tackle them.

The key issue at the conference was synchronisation in Next Generation Networks and it was clear that “Time” as well as “Timing” needs to be better understood and managed in these networks, if this is not done then crucial applications will suffer major quality of service issues. Such applications includes Mobile Networks where a move to packet access offers potential benefits from a cost and flexibility perspective but will cause a disruption in the sync delivery mechanism..

## Workshop

The conference began with a Workshop to introduce new people to the field of synchronisation and those conference delegates who needed a refresher. Many of the top experts in the field of synchronisation technology and networks gave presentations. These included:

Marc Weiss from NIST outlined the future of the GPS system which is currently a fundamental part of many telecom sync networks and explained the move to use two separate RF frequencies accessible by non military users which will enable enhanced performance

Peter Whibberley from NPL explained the synchronisation of the future of Galileo Systems, the European equivalent of the US GPS system, which will use Galileo Time Service Provider taking feeds from key European Metrology labs to provide steering to Galileo System Time.

Mike Garvey of Symmetricom explained the operation of Atomic Clocks used in telecom networks and introduced the work being done on Chip Scale Atomic Clocks which may have an important roll to play in the Networks of the future.

## Keynote speech Synchronisation Networks Today and Tomorrow Andy Reid - Chief Network Services Architect – BT, UK

The main conference was started with a welcome from the ITSF Chairman, Charles Curry of UK based Chronos Technology followed by a scene setting paper from Andy Reid of BT who looked at some of the fundamental principles of Networks citing some the early work done by Claude Shannon; with a network revolution occurring what are the underlying principles and what is information, there are three basic types of information:

- A Message – a single selection from the lexicon

- A File – an open-ended sequence of selected words from the lexicon
- A Stream – an open ended sequence where the relative time of each selected word is significant

It is for the requirements of the stream that we need timing/synchronisation to facilitate transfer of word times information (with sufficient accuracy).

When we move to packet networks, synchronisation is not required for standard resource partitioning as it was in TDM networks but Sync is necessary at the edge to assist integrity of stream transport. There will also be new requirements like those to optimise CDMA or enable Location based services. Synchronisation is not a requirement itself but a “*means to an end*”.

## **Panel Session**

The keynote paper was followed by a panel session chaired by ITSF Chairman Charles Curry (Chronos, UK) and consisting of Gurdip Jande (Symmetricom, USA): representing manufactures of Sync Equipment, Andy Reid (BT, UK): representing service providers, and Andy Sutton (Three, UK): a major user of network services. The panel explored synchronisation in Next Generation Packet Networks and raised the issue of their ability to deliver synchronisation that is fit for purpose at the edge of the network.

Andy Sutton talked about “liquid bandwidth” and “cost capacity decoupling” in order to push faster and more feature rich services into and out of the mobile handset. These can only be achieved with the cost benefits and flexibility of packet technology but that came with contingent problems for sync. Gurdip emphasised that the specialist sync equipment manufacturers were aware of these issues and would have the solutions in place to meet these challenges. Andy Reid warned that there is only so much improvement that can be achieved and that the task may be too great for some of the in-band solutions being proposed in the industry at the moment.

## **Session 1 – Chairman – Charles Curry – MD Chronos Technology Ltd**

### **Classic Wireline Network Core Sync Architecture Goran Pjevac Serbia Telecom**

Telekom Serbia is the National telecommunication operator and Internet Provider. Their network consists of Switching elements, a transmission network and an access network. The services they provide include fixed and mobile voice, data - over TCP/IP, Frame Relay, ATM, GPRS and ADSL. And offer additional services including IN, VPN and IVR.

Goran explained the make up of their network and the key technologies for transport: at the National Level they use SDH STM 64, at the Regional Level STM-16 and at the Local Level mostly PDH with some analogue systems. At the National and regional level they have 180 SDH NE and a Total of 7500 km Cable Length and 150000 km Fibre Length. From a synchronisation perspective they use a Master – slave Hierarchy.

Timing from the main PRC sync is distributed around SDH rings with SSUs in larger rings taking timing from the ring and passing it back around the ring. An example of the sync distribution and priorities on one of the rings was given. The main PRC site has Caesium and GPS sources, whilst two types of SSU are deployed a Transit SSU with Rubidium technology which also has a GPS source and a Local SSU using OCXOs. A network management system is deployed to operate, maintain and monitor the performance of the synchronisation network. Network Time Protocol (NTP) is used for the Distribution of time, from Stratum 1 servers to different clients including Unix or Windows OS in fixed and mobile network elements, gateways, routers and billing system.

Goran explained their migration to next generation networks and the importance of Synchronisation to maintain QoS in these networks.

### **Classic Wireless Network Sync Architecture Oscar Pastor, Amena (Spain)**

Amena commenced operations in 1999. Like many Mobile operators worldwide they don't have their own transport network but lease bandwidth from a national carrier – in this case Telefónica and another licenced operator - Auna. Amena take a Sync reference from the Telefónica Network for inter-exchange local offices whilst other sites were initially deployed without G.811 assured clock references.

At the switching sites, the sync network was structured in a tree form with one node as the core and other nodes connected by the shortest route. Sites without G.811 reference, took their timing from the E1s coming from Telefónica or Auna.

For the GSM network this scenario functioned without major problems. Synchronism became a minor issue with network configuration priorities. Problems were usually resolved “on the fly” and it always took a lot longer to track down the origin of the problem than to fix the problem itself.

Whilst GSM was stated as a more robust system than UMTS with respect to synchronisation, they have suffered problems such as poor handover in the GSM Network. Now however in deploying the UMTS network for service launch, they have experienced sync problems with RNCs as well as with Node-B stability.

Measurements at the incoming paths of different sites and nodes confirm the fact that there were sync problems. A slide showing the effects of bad sync reference quality at RBS input over the Handover success showing a poor performance (approx 50% failure) when the synchronisation was poor and near 100% after the synchronisation was optimised. Oscar observed that they now need to distribute the sync reference signal over the whole UMTS/GSM network and have selected a distributed GPS synchronized PRC network architecture.

The Sync Network covers all Switching Centres and the main points of concentration (POC). From a sync perspective the POC regenerates the signals, synchronises the local nodes and synchronise the nodes downstream of the POC.

At the switching centres GPS was selected as the first PRC/SSU reference with a backup reference available from a sync feed from an external operator. Whereas at the POC, GPS is used as the unique PRC/SSU reference. The network element synchronisation configuration is as important as the sync network itself. Proper values for sync quality thresholds must be set. A synchronization source priority table must be set up without creating timing loops.

In conclusion Oscar stated that all Telecom Networks must have a “Network Synchronization Plan” otherwise all investment in sync is wasted. The reference distribution topology within a site must be a “Star” and the reference distribution between sites in the Network must be a “Tree”. Care must be taken to avoid synchronisation loops when using SDH ring transport and periodic supervision of configuration parameters is recommended.

### **Hot Topics in Sync – Sync in Packet networks and activities in standardization** **Stefano Ruffini - Manager of Ericsson Synchronization Center - Ericsson, Italy**

As mobile networks evolve towards 4G, Wimax (IEEE 802.16) to carry timing critical services and migrate from circuit switched to packet switched networks, Stefano questioned, what are the synchronization issues concerning these changes? Key issues will be the transport of real time services (e.g. VoIP) carried over packet networks and the transport of TDM over packet switched networks – circuit emulations service (CES).

The classical PSTN network is a synchronous network (synchronized by a Primary Reference Clock, PRC). The A/D and D/A converters in both ends use “the same” 8 kHz sample-clock. Stefano then asked when we migrate to Ethernet networks how will we pass this 8 KHz sync reference over Ethernet?

Mobile networks also have key requirements including a maximum delay for correct protocol interworking (5 ms - 30 ms) and the need to distribute sync to the Node Bs (50 ppb on the radio interface). This has been traditionally achieved using E1 / T1 or STM-1 but as we move to packet access how do we distribute sync over Ethernet? One option being proposed is a synchronous Ethernet physical layer. Currently the stability requirement for Ethernet is only +/-100 ppm, clearly totally unacceptable for a mobile application. A synchronous Ethernet layer must be able to help when a better sync quality is required but when is it really needed?

In the short to medium term, SDH or SONET may still have to be used in order to continue to fulfil a role in sync distribution. When interworking between TDM and packet (e.g. TDM over IP) the sync requirements at the network interfaces must be fulfilled to better than ITU-T G.823 or ITU-T G.824. Sync distribution over packet can be an issue (e.g. over Ethernet) and new methodologies are under study based on the use of

time stamps. Whilst a synchronous the Ethernet physical “PHY” layer may be available in the long term this will have a significant impact on existing Ethernet technology implementation.

Stefano looked at the activities in the Standards raising the issues of how existing Standards should be applied in packet networks and are they always needed for all applications. He asked what alternative methods may be required to distribute sync in a packet network environment (e.g. adaptive methods) and questioned how a network operator could be confident that the network will correctly operate in these cases.

Key work is underway in the international standards with the development of the ITU-T Study Group 15 (SG15) Question 13 (WP13) recommendation “G.pactiming: Timing and Synchronization aspects in Packet Networks”. The latest draft was released during interim meeting in Sophia Antipolis 20-22 September 2005 and the next meeting to be held in Southampton (UK), end of November with G.pactiming planned to be consented by SG15 in February 2006. The basic scope of G.pactiming is to analyse the synchronization aspects in packet networks and outline the minimum requirements for the synchronization function of network elements in point-to-point & multipoint Ethernet, connection-oriented MPLS and connectionless IP networks.

There are two different sync aspects to be considered:

- How to recover the timing to maintain constant bit rate (CBR) service QoS
- How to distribute sync in a packet network

The remaining challenges facing the work on G.Pactiming are:

- How can a packet network be modelled
- What are the typical network architectures?
- What are the typical traffic characteristics (load, constant versus variable bit rate (CBR vs VBR), etc.),
- How do we “measure” if a specific packet network is suitable to carry synchronization (e.g. via adaptive methods)
- What would be the maximum allowed wander generated in a CES island?
- What is the role of synchronous Ethernet PHY?

## **Session 2 – Sync in Next Generation Networks (Technology & Manufacturers)**

### **Session Chairman – Mike Gilson - BT**

#### **Technology options for Sync Delivery in Next Generation Networks**

**Silvana Rodrigues - System Architect - Zarlink, Canada**

Silvana set the scene for the session raising the key issues for synchronization in packet networks. Network infrastructure is converging to asynchronous packet-based architecture and traditional T1/E1 is being replaced by Ethernet, however Synchronous applications require accurate timing to be distributed over packet networks e.g. Wireless backhaul. It's difficult to transition timing-sensitive services to packet based architecture without packet-based precision timing references. Cost-sensitive applications will benefit from transmitting synchronization across packet networks instead of using either GPS, expensive oscillators if there is no access to a PRS clock

Packet Switched Networks (PSN) were designed to handle asynchronous data. The evolution of all services to Packet Networks will increase the need for transporting synchronization over these networks. Hybrid packet and switched networks where part of the end to end service is packet switched and part circuit switched will require synchronization with packet-based synchronization technology needing to distribute and recover network synchronization. The asynchronous network needs to encode the server clock frequency/phase information and transmit it over the public switched network (PSN) and then recover “Telecom” quality synchronization signals from this packet reference.

Key methods of timing distribution over packet networks were introduced:

**Adaptive Clock Recovery.** ACR is based on averaging the arrival rate of the packets over a period of time. This can be based on inter-arrival time of the packets and/or the fill level of the jitter buffer. There is no need for common reference clock with this method. It can work in conjunction with a QoS mechanism and

offers the potential for better performance for layer 2 networks but requires careful handling of Packet Delay Variation (PDV). PDV feeds through as a frequency variation, High-frequency jitter can be filtered out relatively easily, but wander is more difficult to filter.

**IEEE-1588** – Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems designed to synchronize real-time clocks in a distributed system is another timing distribution method. It was originally intended for local area networks (LAN) using multicast communications (including Ethernet) and designed to work within a building or factory typically for industrial automation and test and measurement systems (e.g. synchronized printing presses). It has targeted accuracy of microsecond to sub-microsecond and the Standard was approved on September 2002 and published on November 2002.

The use of IEEE-1588 for timing distribution in telecom networks is currently under investigation and solutions to a number of issues need to be incorporated in a revision of the protocol. Maximum refresh interval is 1 per second and it is difficult to maintain performance in a loaded network with this low a packet sync rate and an inexpensive oscillator. A significant limitation of IEEE-1588 is that it relies on a symmetrical network and does not have provision for redundancy support. The current implementation requires IEEE-1588 boundary clocks in all switches/routers but such boundary clocks are not available in current telecom networks. A reduction in packet size is also required to reduce bandwidth usage and the ability to support additional distribution methods beyond multicast.

**NTP** is another timing distribution protocol for use in packet networks. NTP version 3 is described in RFC 1305. NTP was designed to synchronize computer clocks over IP network. From a telecoms perspective it has poor precision with an accuracy in the order of milliseconds. NTP version 4 is under development at IETF with a Working Group formed in November 2004. It will be backwards compatible with NTP3 and NTP2. NTP4 represents a significant revision of NTP3 with the aim to improve accuracy and reliability, add redundancy and advanced security features and allows support for IPv6

Silvana highlighted some of the key issues and tradeoffs in sync over packet solutions: Increasing the rate of timing packets will increase performance but bandwidth usage is required to be as low as possible. There are issues with the drift rate of the local oscillator used to recover timing against its cost. The architecture of the network will have an influence on the solution including the number of nodes, which layer they operate at, the network loading and packet delay variation. Causes of delay variation on a packet network include: Random delay variation (e.g. queuing delays), low-frequency delay variation (e.g. day/night patterns), routing changes, congestion effects, systematic delay variation and network disturbances. Network outages will occur and holdover capability is important to cope with network outage; packet error and packet loss must also be handled appropriately.

Other methods of distributing synchronisation independently of the packet network are GPS, Loran C, dedicated cable and in the future Galileo and synchronization through the Ethernet physical layer.

The ongoing evolution to Packet Networks will most likely increase the need for transporting synchronization over these asynchronous networks and the quality of the clock at the last node depends on the care taken in planning the synchronization chain. Synchronization planning will be necessary taking into account impairments in the packet network.

### **Circuit Emulation services over IP/Ethernet** **Tim Frost, Zarlink Semiconductor System Architect, UK**

Tim addressed Circuit Emulation services over Packet (CESoP) and defined this as the seamless transmission of traffic, timing and signalling of TDM-based connections across a managed Packet Switched Network (PSN). With the PSN invisible to source and destination but emulating a circuit-switched network, and re-creating the TDM circuit at the far end.

Some basic synchronisation options were described:

- **Adaptive Clock Recovery:** where only the packet information is used to recover the timing for the service clock at the far end.
- **Differential Clock Recovery:** Where a common reference clock is available and information about the difference between the common clock and the service clock is carried over the packet network.

- **Combination Clocking Scheme:** In this case an Adaptive Reference Clock is distributed out of band from the CESoP but within the packet stream to the end application and this is used as the common clock to allow differential Clock recover of the service clock.

Tim analysed the different cases in G.pactiming looking at the different wander requirements in each case. He also looked at mobile applications where CES could be used to distribute T1/E1s to GSM or UMTS base stations over a packet access network, reducing TDM leased line costs. The requirement of a <50 ppb frequency accuracy on the air interface in practice, was stated as requiring 15-20 ppb at the CES Inter Working Function.

Tim also looked at a laboratory evaluation test set-up for circuit emulated services to confirm they will perform in real networks. His test network consisted of an array of seven 100 Mbit/s Ethernet switches with 6 random traffic sources at 10 Mbit/s with all random size packets and 4 burst traffic sources at up to 75 Mbit/s with bursts between 0.1 and 5 s of maximum size packets.

Disruptive Events were also tested:

- **Traffic modulation:** (e.g. periodic variations of traffic density).
- **On/off modulation:** Burst traffic at 75% (85% total traffic) for one hour, 0% for one hour. This test demonstrates the stability on sudden changes in network conditions and the wander performance in the presence of low frequency PDV.
- **Slow ramp in PDV:** over time slow ramp pattern 1% increments, 10 minutes per step with the ramp pattern repeated for 90 hours (> 3.7 days). Slow ramp from 0% to 75% burst traffic and back (85% total traffic). This test demonstrates wander performance in the presence of extremely low frequency PDV.
- **Routing changes:** This test is achieved by bypassing two switches for a period, then restoring them. It demonstrates stability under routing changes in network (causing step changes in delay).
- **Network Overload:** bursting up to 90% (>100% total) for periods of 10, 100 and 1000s network outages. This test demonstrates stability under severely overloaded conditions.
- **Network Outages:** Break network connection for varying periods, this test demonstrates stability during temporary network outages.

The conclusion was that CES is a valuable technique for transporting TDM services over packet networks although careful design is required to ensure potentially disruptive effects in the packet network are properly handled. Good performance results were shown over the test network, meeting the stated requirements for both wireline and wireless telecom applications.

### **Technology options for Sync Delivery in Next Generation Networks** **Alon Geva - Algorithms team leader - RAD Data Communications Ltd, Israel**

Alon explained why packet loss was not an issue in his slides although he skipped the detail due to lack of time to concentrate on the packet delay variation (PDV) issues. He explained that if there are many switches (routers) in series then the 'law of large numbers' implies that the PDV distribution will be Gaussian however when the number of cascaded switches is low, truncation of the distribution caused by zero delay queuing events is evident.

Alon introduced some mathematical analysis into the problem. The most common network impairment that appears in asynchronous networks is PDV, and the non-deterministic nature of packet propagation time from source to destination. A common assumption is to model the PDV as a random white Gaussian process with a fixed mean and standard deviation

It can easily be shown that embracing this assumption with reasonable standard deviation values (at least several milliseconds) would limit the achievable clock recovery performance to traffic interface levels but not synchronisation interface limits. However, the PDV distribution for many network scenarios can be shown to deviate from Gaussian behaviour, and this "non-Gaussianity" may be exploited in order to attain MTIE/TDEV wander generation in conformance with synchronization interface masks.

With Gaussian PDV modelled, as the clock recovery bandwidth is made narrower, the PDV noise effect decreases, but degradation caused by the local reference performance increases. If the local oscillator is not of sufficient quality e.g. a TCXO then the performance will degrade as the bandwidth is reduced beyond a certain point depending on the sigma of the PDV. Meeting the G.823 limit at 1000 seconds is only possible if the sigma of the CDV is below 3ms. However if a truncated distribution can be assumed with a number of packets getting through the network with a minimum delay an alternative algorithm can be used realising enhanced performance.

### **IEEE 1588 – Changes to the Standard and Results of Field Trials** **Dave Tonks - Principle Engineer, Semtech, UK**

IEEE 1588 is being widely adopted by the Test and Measurement and Industrial Automation industries to synchronize processes which are dispersed around a LAN. IEEE 1588, as defined in the current standard, is not suitable for extensive use within Telecom applications. However, with the appropriate additions, it promises to be a very good way to distribute both time and frequency around large packet networks. Many of the changes required for this are also desired by the other industries using IEEE 1588 and the IEEE has authorised a PAR to augment the standard. This paper presents some of the progress which has been made to date. The paper also presents the results of extensive testing of an IEEE 1588 system in telecom applications.

There are limitations of the current standard, and proposed solutions including the current use of multicast messaging which prevents widespread adoption of IEEE 1588 in telecom applications. Multicasting the Sync messages from the Master to the numerous slaves is appropriate, but using multicasting also for the Delay-Request and Delay-Response messages would consume excessive bandwidth on the access links, particularly when coupled with the long message format so far defined and the higher message rates required to overcome delay-variation in a telecom network. To avoid this problem, the new standard will introduce short unicast messages which can be transmitted at a higher rate without consuming excessive bandwidth. The current messages will be retained, but can be sent at a much-reduced rate; their purpose is to maintain backwards-compatibility with Version 1 equipment and to provide the necessary configuration information to allow new slave clocks to join the network with good autonomy.

The current use of a single Master clock may not suit a telecom network. Although several clocks in a network may have the right qualities to act as the Master clock, the best master clock algorithm of the current standard means that only one of them at a time can be promoted to the role. In a telecom network, the promotion of a clock to the Master role on failure of the current Master may invoke an excessively-long period of instability given that extensive delay-variation ranges can be expected; it would be preferable to have at least one additional Master clock running and talking to the Slaves.

Results of a field trial were presented, performed on an extensive live network in the USA. The behaviour of the IEEE 1588 clocks was correlated with the behaviour of the network so that the impacts of, for example, variations in loading or path-switching events could be studied. The trial was conducted as a loopback over metro type devices, there was some doubt expressed about how this would work over an access type network where symmetrical networks may not be the case due to firewalls, ADSL and other asymmetric bandwidth connectivity to wholesale applications.

### **A Quantitative Study of Timing over Packet Networks** **Michel Ouellette- Systems Architect, CRO Office, Nortel, Canada**

Nortel's goal is to study the timing aspects over packet networks and share their experiences & observations.

Michel presented a number of applications:

**PBX Backhaul over Ethernet:** Moving to a packet network exposes several synchronization issues. There are some proprietary links which have "special" synchronization requirements, Digital Enhanced Cordless Telephone (DECT) systems for instance require some level of synchronization for call setup, handover and the air interface.

**Wireless Cell Site Backhaul (BTS/Node B):** RF Synchronisation (radio frequency) requiring accuracy of 50ppb over 667  $\mu$ sec. Michel stated that base stations need a response time of less than 30 minutes and that Internal Cell Site Link Synchronisation using High-speed serial links (HSSL) could be an issue and that some of these Mobile requirements need to be understood and reinforced in the Standards bodies.

**Giga Passive Optical Networks (GPON):** These access networks require traceability to PRS for DS1 Emulation (Voice/Leased Line) and this must be maintained in future requirements when migrating to Ethernet backhaul. Network Synchronization is required at the OLT and ONT and must comply with and fulfil ITU recommendations and requirements/metrics for traffic and/or synchronous interface. Synchronous DS1 delivery will use the GPON network timing and Asynchronous DS1 will use differential timing PRS clock distribution to central/remote OLTs (backend). The OLT will use a clock from a BITS, DS1, OC3, PRS, or from adaptive timing whilst the ONT will get timing from the OLT over the GPON plant.

Michel presented tests & measurements from Circuit Emulation and Precision Timing solutions. They tested with a baseline scenario and a native-Ethernet Metro network scenario which was over-provisioned, under-provisioned and also with packet-based impairments metro network.

When testing they monitored for:

- TDM buffer slips
- Convergence time
- Frequency accuracy
- Holdover capabilities
- Low-frequency components
- Latency variation, end2end delay
- Overflow/underflow events

And tested against

- Clock source switching
- Temperature variation
- Routing impairments
- Packet/frame loss
- Packet delay variation distribution
- Symmetric & asymmetric network
- Network congestion/modulation
- Fixed and variable packet size
- Different points of traffic injection

#### **Baseline test**

This was done with the Circuit emulation boxes connected back-to-back and no packet-based perturbations. This tests the loop filters, oscillators and clock recovery engine in the cleanest possible environment. Results were presented against the synchronous Interface mask, ITU-T G.824, MTIE, Section 6.2.2, Table 5 Figure 3.

#### **Metropolitan ring configuration**

These tests were carried out on a 20 kilometre network with mesh and ring elements and a total of 10 elements running fast Ethernet, gigabit Ethernet, STS-1 and OC192 links and different protocol flavours available (RPR, native-Ethernet, SONET, DWDM). Sophisticated and configurable packet-network impairments through live traffic traces, SmartBITS and IXIA traffic generators. The network supports prioritization and a number of traffic management mechanisms for QoS. The network is a Layer 2 managed-network maintained by Nortel IS department and carrying live traffic from other labs

Results from 4 vendors were presented; only 1 CES vendor met synchronous interface requirements at the time of the testing (Q1'05), although some claiming they could meet ITU G.824. Since then, some CES vendors have worked on improvements.

Measurements of packet latency were presented with the results coming from a live network. Traffic based on the Tolly Group variable packet size distribution used as source of background traffic with packet distribution/weight as follows 64 bytes 55%, 78 bytes 5%, 576 bytes 17%, 1518 bytes 23%. It was shown that distribution of packet latency shifts as network loading increases.

Dynamic conditions such as variable frame size also have an impact on clock recovery engines, and need to be factored/evaluated. Results of 24 hours MTIE versus network load and frame size were presented as were TIE of a CES service as VoIP calls were added and removed.

The impact of differential delay on inverse multiplexed ATM (IMA) between T1 circuits were also discussed and it was explained that IMA circuits can suffer due to excessive differential delay when circuit emulated. In one test, link recovery was only possible by disconnecting/reconnecting Ethernet links which cleared/realigned the de-jitter buffers of the IWF.

A snapshot of results from on-going tests on precision timing solutions over a Metro Network topology has started with the results so far looking positive.

Results were also given for a differential service using a network clock from GPS. The results were again obtained again using Metro Network Test Topology, with 90% loading. The results met the Synchronous Interface Mask showing an MTIE of about 150 nsec after 24 hours. The tested solution locks within 15 seconds to different frequency offsets. In testing so far the performance has been immune to dynamic conditions found in network (delay variation, drops, frame size, etc.).

In conclusion Michel stated that some solutions for timing over packet are looking promising, but testing is important. Differential timing is recommended when a reference clock exists (e.g, in the GPON case) but no standards for interoperability exist yet. Adaptive timing recovery is maturing, and at least one solution is looking promising so far (out of 4 vendors studied) but understanding packet-based network impairments is not sufficient, without considering the needs of the legacy products/services.

Issues still exist in:

- Fully understanding the impact of packet traffic on timing
- Need for hypothetical reference model (packet network topologies)
- Protocol for distributing synchronization (IEEE 1588)
- Test scenarios & measurement procedures
- Redundancy/holdover aspects, oscillators
- Synchronization requirements, synchronization chains
- Configuration terminology, Interoperability

### **Paper on Sync over Packet Networks to set scene for Panel session**

**Vandana Upadhyay - Senior Director Business Development, Symmetricom, USA**

IP and TDM networks will coexist for some time to come and timing and synchronization requirements exist for all networks, both traditional ("TDM") and Next Generation ("IP"). Networks must be engineered to meet the most stringent requirements for transport and services (existing and proposed). In "all IP" networks, an accurate timing reference is needed for A/D conversion at the end-points (e.g. Set-top-box, IAD, ONU/ONT) for the interworking function for Circuit Emulation and for end applications.

Different services will require different QoS and service level agreements and services must co-exist without impacting each other. For example, you can't drop a voice call when a movie starts playing, or vice versa, a mix of services on a single connection must be able to change dynamically as users start and end sessions.

There are and will be new requirements for synchronization. Vandana presented simulation results from a number of cases:

- Case 1: 8 hops over GigE with 15% to 20% variable loading
- Case 2: 8 hops over GigE with 70% to 80% variable loading
- Cases 3&4: 3 and 5 hops over GigE with 70% to 80% variable loading
- Case 5: ADSL2 speed last mile link supporting Ethernet, with 50%to 98% variable loading

The results showed that as network congestion varies significantly with time it impairs performance and that G.823 & G.824 requirements are only met in two scenarios:

- Networks with very low capacity utilization
- <3 hops between 1588 clock and client (GigE case)

It was also shown that in telco access networks where ADSL links are typically deployed, IEEE 1588 does not meet G.823 or G.824 requirements. This is because of the assumption in IEEE 1588 of a symmetrical network.

Performance testing results encouraging, yet performance degrades quickly as:

- Hops increase
- Link speed decreases -Lower speed ingress/egress links can significantly impact time transfer
- Network loading (traffic)

## **Panel Session**

The panel of session speakers discussed packet sync implications it was clearly stated that there were sync problems to be overcome in Next Generation Networks and whilst solutions are potentially available, these need to be tested and proven. The panel was asked if synchronisation was required in Next Generation Networks, “ No, unless you want a decent quality of service” was Vandana’s strong answer.

## **Day 2 – Wednesday 19<sup>th</sup> October**

### **Day 2 – Session 3 - Sync in Next Generation Networks (Users & Applications) – Chairman – Martin Kingston - Orange**

#### **Defining Sync Quality in Access Networks, Sync as a service, Sync Transport in Next Generation Networks Andy Sutton - WAN Specialist, Three UK**

Andy addressed the distribution of synchronisation in next generation networks the move towards new access technologies and the needs of the end user applications. He questioned could synchronisation be supplied to applications at the edge of the network and would this be part of the general service offering or will sync be supplied as a service only to those customers who need it? He also introduced the concept of Hybrid backhaul where not all bandwidth to the end user is via a packet network and this could be an interim step towards all Ethernet/IP transport.

Andy defined his view of what a next generation network is “A Next Generation Network will be packet based and optimised through traffic engineering”

Andy presented the typical Mobile Network transport architecture of today with the access transport layer provided by E1 PDH circuits, point to point microwave and leased lines; the metro transport network typically using SDH (STM-1) and structured VC-12 or ATM VC-4 connectivity and the core transport network using SDH over DWDM, ATM & MPLS.

The TDM bearers throughout the access transport network today are  $n \times E1$  with TDM aggregation using PDH/SDH mux. In UMTS (R99/R4) ATM bearers are used to supply  $n \times E1$  (UNI/IMA) with TDM/ATM aggregation into ATM VC-4 at concentration points named “Transmission High Sites” in Three’s network. The service to the base station is carried over a VBR-rt using AAL-2 multiplexing.

In UMTS (R5) IP bearers are used this could be via  $n \times E1$  (multi-link PPP) using a PPPmux or via Ethernet. A Hybrid backhaul may be deployed for cost-optimised high speed data traffic over an Ethernet access link and a 2Mbit/s circuit providing synchronisation and other services.

A typical Transmission High Site will have a GPS receiver synchronising an ATM switch. Whilst a typical core site’s synchronisation will consist of a GPS receiver feeding an SSU with back up from Caesium feed over the core WDM network.

Andy questioned what happened when the E1s currently delivering synchronisation are no longer used. Will GPS be used or will sync be carried over layer 1, 2 or 3? He stated the decision will be based on the most cost-effective solution for the network operator taking into account both capital and operational expenditure (capex/opex); in the interim a hybrid solution may be the most attractive with at least one E1 to the base station supplying sync, but with larger bandwidth requirements like HSPDA being supplied by Ethernet access.

#### **Sync for support of Legacy services Kishan Shenoj - Chief Technologist, Symmetricom**

ITU-T Workshop on Next Generation Networks (July 2003) concluded that all legacy services will be supported for several years.

“TDM” requires sync (frequency) for transport data integrity but “IP” may not require sync (frequency) to maintain transport data integrity. However supporting real-time services requires sync (frequency) at the conversion points (e.g. ADCs and DACs, C2P IWFs) and this is true regardless of transport mechanism. A

Common misconception is that since the transport process does not require sync, it is “not necessary”; this however overlooks the requirement of the service being transported.

Voice-band services need synchronization, the A/D converter at one end of the network needs to have a common clock with the D/A converter at the other end of the network. If this is not the case impairments are introduced which will most adversely affect voice-band data (Fax, modem) and real-time video. If there is a frequency difference ( $\Delta f$ ) then eventually buffers will overflow or underflow. The end-to-end slip rate budget as defined in G.822 is the existing network requirement and this requires less than 5 slips in 24 hrs which equates to clocks better than  $\sim 7$  ppb. The frequency difference will also cause a Pitch Modification Effect (PME) which can be considered to be analogous to Doppler. This frequency shift gives a tight requirement for fax and modem services of  $\Delta f < 1 \times 10^{-7}$  although this requirement is still under study. The V-series requirements are for a transmitter accuracy better than 100 ppm and a receiver acceptance that is better than 100 ppm; this allows no impairment by the network. Some assumptions need to be made. If we assume 95% of modems have a 5% additional acceptance margin and assume normal distribution, then accommodating 99.999% of modems we need a  $\Delta f < 0.005$  ppm (5 ppb).

Kishan presented a case study where poor/dropped Fax and modem not connecting was the symptom. The Integrated Access Device (IAD) was not getting network synchronisation and this was causing failure of Fax's in the customer premises. The solution was to deploy a retimer to feed good sync into the IAD and then the Fax modem operation was fine.

Kishan also explained the impact of increased buffer sizes and delay taking the example of a V.90 connection. Typical round-trip delay for V.90 must be less than 80 ms (40 ms one-way end-to-end). The delay components are packetization (20 ms typical), network minimum delay and jitter buffer size which needs to be larger than the packet delay variation. There also needs to be a playout buffer to prevent slips during the call and the sum must be less than 40 ms (“typical”). For an 8 min call ( $\sim 500$  sec) the play-out buffer size to prevent a slip during the call is:

- $\sim 5$  ms if  $\Delta f = 10$  ppm ( $\pm 5$  ppm)
- $\sim 50$   $\mu$ s if  $\Delta f = 100$  ppb ( $\pm 50$  ppb)

There is a trade-off between jitter buffer and play-out buffer size, if  $\Delta f$  is significant, the call will be cut short because of packet loss (large playout buffer  $\Rightarrow$  small jitter buffer) or because of buffer overflow/underflow (large jitter buffer  $\Rightarrow$  small play-out buffer).

### **Mobile Network requirements a Manufacturer's perspective.** **Antti Pietilainen - Nokia Research Center, Senior R & D engineer. Finland**

At present, PDH E1s (2048 kbit/s) and T1s (1544 kbit/s) carry backhaul of GSM/UMTS base stations but new high bit rate services have the potential of increasing backhaul bandwidth significantly. Ethernet may provide a cost effective means to increase the bandwidth but two synchronization problems arise

- How to synchronize remaining PDH interfaces?
- How to synchronize air interface and data clock?

For this migration to packet networks, a scenario was introduced. Currently high-quality clock is distributed across the SDH/PDH network; when packet networks are introduced, the legacy base stations should continue to work whilst the RNC/BSC and base stations support packet transport. ITU-T recommendations set limits on the magnitude of jitter and wander at network interfaces to avoid generation of bit errors, uncontrolled slips and other abnormalities and for proper design of the equipment. The wander may not exceed the given values anywhere in the network. Thus, a circuit emulation link, for example, may consume only part of the wander budget.

In the GSM synchronisation specification 3GPP TS 45.010 it is specified that the BTS shall use a single frequency source of absolute accuracy better than 0.05 ppm (5ppb) for both RF frequency generation and clocking the timebase. The same source shall be used for all carriers within the BTS. For the pico BTS class the absolute accuracy requirement is relaxed to 0.1ppm

In the WCDMA specification 3GPP TS 25.104 it is specified the same source shall be used for RF frequency and data clock generation. The modulated carrier frequency of the BS shall be accurate to within the 0.05ppm accuracy range observed over a period of one timeslot. Relaxed accuracy requirements have been introduced in Release 6 for local and medium range Base stations:

- Local Area BS (Introduced in Release 6)  $\pm 0.1$  ppm
- Medium Range BS (Introduced in Release 6)  $\pm 0.1$  ppm
- Wide Area BS (this spec referred to all BS until Release 5)  $\pm 0.05$  ppm

Some reasoning behind these requirements are that the mobile must be able to successfully decode signals with a frequency offset and the largest factor in this offset is caused by Doppler shift. The frequency error of the base stations adds to the Doppler shift in the frequency seen by the handset. If maximum allowed velocity is decreased the base station offset can be relaxed. However, too large relaxation to base station offset may cause some problems with the mobile handsets. Therefore, the maximum error of local area base stations has been limited to 0.1 ppm leading to relatively high allowed velocity. The table below was presented:

Type		GSM 900 MHz	GSM 1800 MHz	WCDMA 2100 MHz
Mobile must tolerate offset		295 Hz	340 Hz	591 Hz
Wide	Velocity & Doppler	250 km/h & 250 Hz	130 km/h & 250 Hz	250 km/h & 486 Hz
	0.05 ppm contrib.	45 Hz	90 Hz	105 Hz
Local	Velocity & Doppler	205 km/h & 205 Hz	80 km/h & 160 Hz	196 km/h & 381 Hz
	0.1 ppm contrib.	90 Hz	180 Hz	210 Hz

WiMAX has synchronisation requirements, in unsynchronized OFDMA (orthogonal frequency division multiple access); the physical layer requires a 2-ppm frequency accuracy. In frequency synchronized OFDMA the physical layer requires an accuracy of a few ppb. The exact values vary with, for example, FFT size and channel bandwidth. 3.9G systems will probably require similar stability as GSM/WCDMA namely 0.05 ppm frequency stability at wide-area base station and 0.1 ppm frequency stability at local-area base stations.

Time synchronization is required in certain cellular systems, CDMA2000 requires time synchronization at  $<3 \mu\text{s}$  ( $< 10 \mu\text{s}$  worst case) whilst WCDMA TDD mode requires  $2.5\mu\text{s}$  time accuracy between neighbouring base stations (i.e.  $<1.25 \mu\text{s}$  of UTC). At present, WCDMA TDD has not been implemented. 3.9G systems may require time synchronization, at 1 ms or better accuracy (even 1 s level). The WiMAX (802.16) time synchronized OFDMA physical layer requires an accuracy of a few microseconds. The exact values vary with, for example, FFT size and channel bandwidth. Additionally location determination typically requires time synchronization.

In packet networks frequency traceable to a primary reference clock can be reconstructed at a base station by sending timing packets from the primary reference clock to the base station. A residual uncertainty of 1 ms in packet delay converts into a frequency uncertainty of 0.05 ppm if timing packets are averaged for a duration of 20,000 seconds. During this time the wander of the local oscillator must be a small fraction of the 0.05 ppm budget.

Some analysis was presented on packet network delay looking at buffer sizes and hence working out the maximum delay variation. Typical delay variation in a relatively small, high-speed network is of the order of 100  $\mu\text{s}$ , which is acceptable for pursuing 0.05 ppm accuracy. During severe network congestion, delays may become very long due to the size of the router queuing buffers. Antti questioned whether the only solution was to give high priority tag timing to the packets?

Antti addressed how to define service level agreement SLA for packet delivery? For packet delivery performance, it would typically be based on loss, delay and delay jitter, however, for synchronization purposes this may not be enough. Key issues were the stability of typical packet delay and the minimum delay value. SLA class definitions and requirements for packet timing might not coincide and new definitions may be required in SLAs and route changes may be difficult to handle. However, in a relatively small network, this may occur very rarely. Antti questioned was it acceptable to be slightly out of sync for some time after a rare event?

Antti observed that in order to achieve microsecond time accuracy end-to-end, intermediate nodes need to support synchronization at the hardware level. For packet transport service providers, although cellular operators are important customers, the majority of revenue may come from elsewhere. Therefore an operator will not upgrade all network nodes to be (for example) IEEE1588 compliant unless the cost increase is marginal. However the operator can expect increased revenue from these customers by providing accurate timing service. Time synchronized systems will probably need GPS receivers forever.

The number of features being introduced into IEEE 1588 is increasing endlessly and some features might not be required by cellular networks; for example

- Fault tolerance: Equipment protection and network protection can be used instead to achieve adequate robustness.
- Security: There are other means to protect operator traffic from outsiders so this application layer security feature may not be needed.
- PTP protocol over MPLS: Increases complexity but brings only marginal increase in performance.

In conclusion three requirement levels have been introduced:-

- 50-ppb frequency accuracy at the RF interface.
- G.823/G.824 wander mask.
- Time synchronized systems.

A packet timing standard is required and proprietary technologies do not live long so a Standards based solution is required. IEEE1588 is a good candidate because it provides similar features to NTP and adds accuracy in a Standards compliant network.

A timing solution and mobile network vendors' needs must be defined together with the SLA parameters of the packet network, in order to ensure the specified performance of the mobile network.

### **Sync for Next Generation Network Equipment** **Laurent Montini - Consulting Engineer, Cisco, France**

Laurent observed that there is a dichotomy between applications and packet switched networks, historically, a "clock" was an intrinsic part of the data transmission network, however today, packet switched networks (PSN) transmit traffic to/from applications but do not need themselves need "synchronization". Some applications however require synchronization to work properly, but would the applications require the PSN to be synchronized or does the PSN only need to provide a synchronization service to those applications? Perhaps synchronization should become another type of data traffic?

Certain applications would need an accurate clock, examples of current applications that potentially require synchronization are cellular base stations, legacy services: E1, fax, modem, media gateways and video equipment. A PSN with synchronized transmission should enable introduction of new applications. For example wide area precise information gathering. However the presentation focused on the network elements and architecture requirements and not on the applications and possible benefits of synchronization to those applications.

Telecom Networks often provide synchronized services to the customer. Generally, Operators manage their own synchronisation and transmit that synchronization with the data to their customers. Some customers will manage their own clock but if they take clock from the Operator the service must comply with the customer's synchronization requirements. Failing to get the right quality of sync can cause failure of the application or at least degrade it. Different synchronization services may demand different network requirements, the network equipment design/conception and the network architecture. Sync was explored in a number of network scenarios including mobile applications.

Synchronization transmission over non-synchronous interfaces will need a new protocol and equipment will need new hardware and software to initiate/terminate such a protocol. The protocol can be unicast/multicast, end-to-end/hop-by-hop and the protocol design will impact the network design.

Some or all nodes of the PSN need to transmit the synchronization information and the Service Provider nodes must participate in the synchronization architecture by supporting a SYNCOP protocol. Either only edge nodes will participate (connected to application) or edge and some core nodes or all nodes must participate. Alternatively synchronization may just be between customer nodes and the PSN just forwards the SYNCOP session.

Laurent observed that telecom network design and SLAs are already key with low latency queuing being used for voice. Will SYNCOP protocol be OK with same QoS as voice or will the QoS need to be better?

For Sync distribution in the PSN - will it be a media independent standard protocol be used or multiple protocols with IWFs. For redundancy and resiliency multiple clock sources and multiple clock locations will be required reachable via alternate paths.

The operation needs to be designed and managed and performance quality is more important than plug & play. There must be control and monitoring mechanisms allowing security with trusted or non-trusted domains, the trusted domain will ease design for better accuracy.

In summary a network needs the ability to transmit appropriate SYNCOP sessions to continue the support of existing non-packet services and to enable new services and applications. A platform requires a local clock distribution mechanism to support synchronization distribution and enable participation in SYNCOP architecture. The protocol providing the mechanism to transmit an accurate clock over a packet based network will depend on the telecoms requirements and there are issues with media independency or IWF and each of these elements will influence the design of the others

## **Day 2 – Session 4 – Sync & Network Operational Issues – Chairman – Dominik Schnewly , Senior Engineer– Oscilloquartz SA**

### **The Impact of Recent Advances in Optical Networking on Synchronisation. Jean-Loup Ferrant - Standardisation manager & synchronisation expert in Alcatel Optical Network Division, Alcatel, France**

The current synchronisation networks are mainly based on the SDH technology which has been specified to be a good medium for the transport of timing. New technologies are now deployed in transmission networks in addition to SDH. In the last 5 years, many new technologies have been deployed in networks:

- Point-to point WDM systems, then G.709 Optical Transport Networks (OTN)
- 10 Gbit/s Ethernet with two types, LAN and WAN
- Multi Service Provisioning Platform (MSPP) combining TDM and Ethernet interfaces,

This paper presented the issues raised by this evolution on the transport of timing and reviewed the solutions that are available.

DWDM and CWDM were discussed, these systems are almost transparent to the timing of the client signal and do not add specific constraints on the synchronisation network. OTN was then discussed, the main difference between OTN and WDM is that OTN is a network application and not a point-to-point one like WDM.

OTN is plesiochronous, the ITU has stated that there is no need for the OTN to carry synchronisation, since there is already one network layer that does it, namely SDH. The drawback is that when the OTN does not transport the SDH client, it cannot transport timing. If SDH is no longer present, GPS could be used to provide timing and in future synchronisation of Ethernet might be the right answer since the main non-SDH client of OTN is 10GBE. However currently the 10GBE-WAN is plesiochronous if the 10GBE WAN is the only payload of an OTN system, there is no possibility to transport synchronisation through the system. Another issue to be resolved is that most 10GBE interfaces are LAN type and the 10GBE- LAN cannot be mapped transparently into OTN. Discussion are ongoing in ITU-T to find an alternative solution but it is proving difficult to achieve.

The OTN must be transparent to CBR client timing with each OTN NE has its own free-running clock ITU Recommendation G.709 specifies a justification scheme to adapt client and G.709 frame rate. OTN timing issues have been specified in G.8251 which allows up to fifty 3R regenerators. G.8251 states that each SDH island of the G.803 reference model can be replaced by an OTN island. An OTN island may be up to 1 mapping NE plus 9 ODUk multiplexing OTN NEs.

MSPP have STM-N ports, they are SDH NEs. They can be synchronised by STM-N or external synchronisation ports. They have an internal SDH clock that can be used to synchronise STM-N ports.

Data ports are terminating asynchronous frames, inserting and extracting packets. Links between SDH and data can be done via CES or GFP. CES may transport PDH or SDH VC's through packet networks whilst GFP, Generic Framing Procedure, allows transport of data signals into SDH or OTN

New transport technologies, WDM, OTN and MSPP do not raise new synchronisation issues. The only synchronisation issue is raised by the introduction of plesiochronous data signals in transport networks which may prevent transport of synchronisation where it is needed.

CES may be a solution for applications using only Ethernet switches. Other methods are under investigation, for example: 1588 for telecom networks, TDMoIP, etc

A more general solution will be the synchronisation of Ethernet signals in transport networks, this assumes:

- A clock must be defined for transport Ethernet equipment.
- Ethernet chip vendors must provide access to the received clock
- All NEs must be equipped with a clock
- A traceability indicator must be defined and implemented

## **Planning Methods and Tools for Today's Synchronisation Networks - David O'Connor, Managing Director, Horsebridge, UK**

Synchronisation is a support utility for the transport network. The Quality of Service (QoS) of the network is directly related to the quality of network synchronisation. Synchronisation units are not cheap and do not directly generate revenue. Investment in synchronisation equipment alone does not guarantee good network synchronisation. 95% of all synchronisation functionality in any network lies in the traffic elements. Synchronisation investment is wasted without careful deployment and careful deployment means careful planning.

David defined what a synchronisation should plan include:

- The techniques employed in the network to distribute synchronisation.
- Any limitations imposed by the behaviour of the network elements.
- Any assumptions made by the author – the Sync Planner.
- As far as possible, a description of the sync configuration of every sync transporting element.
- Predicted single points of failure.

The Sync Plan has three distinct purposes:

- It should be used at implementation (or re-implementation) as the configuration instructions for the sync plane of every element in the sync network.
- It should be used throughout the operation of the network to allow Network Operations to make informed decisions when changing the configuration of the network.
- It should provide enough information to enable root cause analysis to be performed in the event of a sync failure.

There is no single, correct way to synchronise a network, there are only shades of good & bad. There must be no software tool which will automatically design a Sync Plan with today's multi-vendor, multi-technology networks the task is just too complex and a Sync Planner is still required.

David defined his 6 step methodology (commandments):

- 1) My Sync Plan should ensure the distribution of suitable clocking signals to each and every piece of network equipment requiring synchronisation during steady state network conditions.
- 2) As far as possible, my Sync Plan should ensure the distribution of suitable clocking signals to each and every piece of network equipment requiring synchronisation during any single network failure condition.
- 3) Ensure my Sync Plan identifies the optimum investment in synchronisation equipment.
- 4) My Sync Plan should be as simple as possible to understand, implement and maintain.
- 5) My Sync Plan should be comprehensively documented to suit the purposes of those who need it use.
- 6) My Sync Plan should be regularly re-evaluated.

David presented three case studies from different Networks where poor synchronisation planning had lead to major network problems.

**Case 1:** network with sporadic Pointer Justification Events but no other network alarms so problem not investigated until customers complained. The Sync Plan was written in the, “early years” and was never reviewed. Unplanned network growth had occurred. The implementation teams, without clear direction, had configured many holes in the SSM system. Every time a fibre loss occurred or a fibre was taken down for maintenance, automatic reconfigurations generated isolated sync islands and in some cases created timing loops. No accurate Sync Plan existed meaning no meaningful root cause analysis was possible.

**Case 2:** A fibre break occurred, traffic re-routed automatically. Soon afterwards an apparently unrelated network SASE reported performance alarms and a pointer justification event storm blew up. The storm covered 25% of the network. Interconnect partners reported sync problems.

Network Operations were under extreme pressure to identify and rectify the fault as soon as possible. The Sync Plan only documented a set of theoretical configurations and these were not clearly extrapolated to actual network elements. There was a serious design flaw which meant that when a fibre was lost a traffic element automatically re-configured to take sync from an adjacent SASE. The inter working between the two elements caused a timing loop. The SASE was a sync regenerator for 25% of the network. Although Network Operations could see many sync performance failures and a significant event storm the root cause was not obvious. The Sync Plan author no longer worked for Network B and no one had assumed responsibility for sync.

**Case 3:** a geographically large network covering many remote areas using a combination of fibre and microwave paths. Path loss was not an uncommon event and although traffic was reasonably resilient, almost every path loss caused synchronisation related alarms; PJE and Holdover. In an attempt to correct these issues, Network C invested more and more heavily in synchronisation equipment until their ratio of sync to traffic elements in their core became 1:10, but still the sync problems kept coming. On analysis it was found that, although SSM was deployed, virtually every single traffic path was a single point of failure and many potential timing loops were inherent in the network. There was no formal Sync Plan – only a Power Point presentation. After re-planning the single points of failure could not be totally eradicated, due to the topology constraints, but were reduced by 80%. Network C believed that deploying sync equipment equated to sync planning and quite literally paid the price. No one had responsibility for network synchronisation and there was no sync distribution strategy at all.

In conclusion David argued that Network Synchronisation and Planning in particular, deserves a higher profile than it currently enjoys with most Operators. Operators who address synchronisation generally have robust, stable, high quality networks whilst Operators who fail to address synchronisation, fire fight the symptoms without ever resolving the causes. The evidence of good Sync Planning is the absence of QoS affecting issues.

## **Network Management - Dilip Dhanda, Product Line Manager – Network Management Systems Symmetricom, USA**

Dilip explained the basic functions of a Synchronisation Management System and explained the value proposition to the network operator.

A Synchronisation Management System can deliver reduced OPEX; this is achieved through fewer alarm escalations as the management system flags and identifies the problems. It allows the automation of regular tasks, and pro-active management. It enables the implementation of cost-effective processes/actions providing archives and extensive logs; also enabling quick trouble shooting and root cause analysis and effective problem resolution whilst reducing field visits.

A synchronisation Management system can also deliver reduced CAPEX by centralising operations allowing efficient planning and utilization and the rapid deployment of new NEs giving faster return on investment. It enables utilization of hidden assets through advanced inventory control and allows the sharing and building sync expertise across technicians, operators and network planners. It secures, protects and allows leverage from previous investments.

From a business case perspective the Direct and Indirect Benefits are:

- Efficient Maintenance
- Outages avoided
- Automation eased
- Pro-active Monitoring
- Reports & analysis

- Drastic reduction in escalated alarms
- Better visibility and control of sync inventory
  - “Lost assets” become visible
  - Capacity of existing infrastructure
  - Centralized view of all sync assets
- Pro-active scripts and automation
  - Automatic action saves time money and leverages experts
  - Rapid configuration of new sync elements
- Performance, Reliability and Availability (Fail-over provision)

Important Trends outside the standards are Web centric allowing remote access and/or a distributed NOC. Also the automation of tasks and processes and the integration into other Network Management Systems for example by the use of Northbound interfaces.

## **Manage or Die,? the Case for Synchronisation Performance Management, Greg Mason, Technology Lead - Synchronisation & Transport Solutions, BT, UK**

Greg’s presentation consisted of asking and answering a number of key questions.

Greg first asked the question: “Why manage synchronisation?” and stated it was part of the business case! (due diligence) required to reduce overall cost of ownership by reducing service downtime and increase business confidence enabling contract renewal. It allowed an understanding of network performance and the efficient use of synchronisation equipment. It also minimised expenditure by reducing resource used in chasing faults and allowed automating of processes and evidence based SLAs.

Then he addressed “What should management deliver?” explaining it should deliver an overall view of the network status (health) allowing the control of network & service, providing performance results which are logged as evidence, activity levels, an input to assessing operational cost, centralised and efficient functionality and a be a fault finding tool

Next he addressed “What is synchronisation performance monitoring?” and answered that it is the act of observing (& recording) digital data flow, a QoS measure similar to packet loss or BER and is an integral part of network management providing a tool to maintain the network (evidence for decisions), but it needs an up-to-date view of synchronisation & service network topology & connectivity and therefore needs a good relationship with network operations.

Who should be involved? There must be an owner who wants to see right value (performance vs cost) but be your champion, first line (alarm management) and second line support. There needs to be business-as-usual action management and processes with the supplier (contract support) management and escalation to 3rd line support platform owner. Third line support, “buck stops here”, provides network design, process & procurement support.

Synchronisation performance monitoring – when? Monitoring is required when assessing new network equipment/service when commissioning and acceptance testing new networks or network extensions. When there are problems it is important to confirm synchronisation at fault or NOT at fault.

How (performance measurement)? Performance monitoring is an integrated SSU function allowing permanent (static) network/service monitoring. This is achieved by using unused input reference ports but these must not be enabled. This is achieved by sticking to a fixed allocation at each site so that everyone is aware as to which are the ports which are monitor-only. These monitor-only ports can be used for fault-finding but not every point can be monitored so dedicated synchronisation test equipment is also required and can be used possibly for network/service monitoring but is largely used for commissioning/remote fault-finding.

Greg presented a number of case studies that highlighted the benefits of synchronisation monitoring. He then went on to look at a converged network monitoring strategy? And stated the same principles apply – but more so?

These new networks have potentially a more complex structure with a greater degree of software control. Synchronisation will be an issue as the packet generation rate is created by the edge device clock and if the ingress rate is different to PSTN IP Gateway (PIG) clock then buffer overflow & packet loss will result and real time services will be effected including voice, video streaming & conferencing [protocol sensitivity]. Applications

may drop 'exceeded time to live packets' and problems may be seen with secure links - for example financial transfers?

So where will synchronisation be needed? It will be needed where flow rate is controlled or generated? In principle at the PSTN IP Gateway (PIG), media servers, critical edge devices controlling packetisation and at large routers with future 'Synchronous Ethernet' interfaces. Some TDM interfaces will still persist on large routers with SDH interfaces and SDH VC4 switches still maintained for specific QoS dependent services.

### **Sync as part of the service - Service Level Agreements for Synchronization Delivery - Ian Wright, Professional Services Manager, Chronos Technology Limited, UK**

The paper looked at how Sync could be supplied as a service. If sync were provided as a service it needs to be monitored and service level agreements (SLAs) put in place. The paper discussed issues associated with Sync Service Level Agreements. Issues such as "How do we measure performance?" and "How do we define synchronisation availability?" were addressed. It discussed how to measure sync quality for an SLA and highlighted problems with the standard mechanisms used i.e. MTIE and TDEV; one being worst case and the other being average, but a key issue was that there was no definition of the measurement period or if any windowing should be used. It is also necessary to define synchronisation unavailability in a similar way we do with basic circuits.

It was proposed to use MTIE as this was a well-understood metric and the fact that it is worst case lends its self to SLA definition, however a period to measure or reset the measurement is required. A "strawman" proposal was put forward.

For simplicity and ease of measurement, the proposal was to base the SLA on the number of times a particular MTIE mask was exceeded in a given period of time. This period was proposed as 15 minutes. MTIE should be continuously evaluated and any occurrence of the MTIE being exceeded during the 15 minute period should be counted. This is to prevent temporary instability leading to a high count. The MTIE algorithm should be reset after it is exceeded but not more regularly than once every 15 minutes.

It was also proposed that there should be some differentiation between a long term >1 hour and short term MTIE exceptions and that availability based on failures or consecutive MTIE exceptions should be defined.

### **Wrap-up session**

The conference concluded with a panel discussion with all four session Chairmen from the two days. The conference agreed that there were sync problems to be overcome in Next Generation Networks and whilst solutions are potentially available, these need to be tested and proven. It was agreed to hold the ITSF again next year as the area of Next Generation Synchronisation is developing rapidly. The aim is to hold it in another part of Europe to gain a wider audience from other countries and Prague has been identified as a probable venue with 14<sup>th</sup>-16<sup>th</sup> November as the probable date.

If you need further information you may contact the Steering Group via the ITSF web site

[www.telecom-sync.com](http://www.telecom-sync.com)