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Common Systems, Synchronization: AT&T Global Network Synchronization Strategic Plan

Abstract

Presents a strategic plan for the AT&T synchronization network

Audience: AT&T Global Engineering Support, Network Planning and Engineering, Global Operations Advanced Technical Support, *Network Operations - Mobility*
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Introduction

The AT&T Global Network Synchronization Strategic Plan (AGNSSP) is a high level document intended for those AT&T Network personnel engaged in the planning, engineering, installation, turn-up and test, and maintenance of the AT&T synchronization network. It includes discussion on Primary Reference Source (PRS) implementation strategy, interoffice synchronization reference distribution to sites where PRS is not available, intraoffice timing distribution, loop/access network synchronization, CPE synchronization, and disaster recovery. The implications of emerging synchronization technology in Next Generation Networks (NGN) will be discussed in the appropriate sections.

This document is not a tutorial. It is written for those personnel who are already trained and experienced in concepts such as the digital timing hierarchy and strata levels in telecommunications synchronization networks. References will be made to standards documents where appropriate. These standards documents are available for review in APEx.

This document does not cover the administrative tasks, details of funding, or roles and responsibilities associated with network synchronization. Information on the processes and procedures for synchronization equipment product evaluation and performance testing is not in scope for this document. Refer to the AT&T approval process for product evaluation methods and procedures.

This document does not address any details of alarming and remote surveillance of synchronization equipment. Refer to ATT-801-601-900, Common Systems Alarm Standards Practice, at http://ebiz.sbc.com/alarms/Welcome.cfm.

This document supersedes and replaces all previous synchronization plans created for the various regions and the 13 state synchronization plan. Issue 4 of this document also replaces and supersedes AT&T Wireless Network Operations Policy Letter 0065, Version 4, Synchronization of Network Elements, issued August 1, 2003.

Additional resources for network synchronization planning and engineering can be found in the Transport Infrastructure Deployment Guidelines (IDG), section 9 and NetView, section 2.8. The IDG is filed in APEx at AT&T-TELCO-002-003-001. NetView is filed in APEx at AT&T-TELCO-002-217-001.

1. Reason For Current Issue

DATE	ISSUE	DESCRIPTION
February 24, 2009	4	Supersede and cancel Wireless Network Operations PL-0065. Update status of NGN sync including NTP and PTP. Update recommendations on implementation of Derived DS1.

2. Network Synchronization Overview

The first generation network synchronization architecture was developed in the 1980s as telecommunications network providers began to deploy Time Division Multiplexed (TDM) digital switching systems and digital special services over digital loop carrier. Implementation of Synchronous Optical NETwork (SONET) based transport systems in North America and Synchronous Digital Hierarchy (SDH) based systems in Europe further stimulated the deployment of a network synchronization architecture. This architecture was designed to deliver a precision frequency reference that is traceable to an international standard, and is well documented in standards that have been developed and accepted by the world wide telecommunications industry.

The emergence of Internet Protocol (IP) based transport systems has introduced to need for precision Time of Day (ToD) synchronization in order to time align the various elements used in the IP based transport and access systems. As we move further into real time services delivered via IP, such as TDM services aggregation and U-verse video, we see an increasing need for higher levels of precision in the ToD references. And the displacement of TDM/SONET transport in the access network with IP and Ethernet facilities will require a new type of synchronization transport between the edge office and the remotely located access system. Unfortunately, IP transport technology has far outpaced the development of synchronization standards. At this time, there are no relevant telecommunications industry standards for the architecture needed to deliver precision ToD or for the transport of precision time and frequency synchronization across Ethernet.

In Issue 4, the overview section of this document has been subdivided into three sections to separately address the traditional precision frequency based synchronization network, the emerging needs for precision ToD and for delivery of synchronization over Ethernet, and the path forward for AT&T.

2.1. Precision Frequency Synchonization

The AT&T interoffice synchronization network is a hybrid arrangement that complies with the principles of digital network synchronization found in Telcordia GR-436-CORE. As presently deployed, it is designed to deliver a precision frequency reference that is traceable to an internation standard, Universal Coordinated Time (UTC). It is a hybrid in the sense that it has elements of a pleisiochronous network and a synchronous network. AT&T presently has multiple PRS sources (more than a thousand) and also has sites that are timed from a remotely located PRS via interoffice distribution of a synchronization reference. Experience has shown that pleisiochronous operation, using PRS systems that meet the requirements of GR-2830-CORE, is a very stable and robust method of network synchronization. Modern PRS systems, when operating normally, will easily exceed Stratum 1 requirements by one or two orders of magnitude. Note that GR-2830-CORE and GR-436-CORE do not address interoffice delivery of precision ToD.

AT&T intraoffice synchronization networks are designed and operated in accordance with the architecture known as Building Integrated Timing Supply (BITS), also found in Telcordia GR-436-CORE. The network element used to accept a Stratum 1 traceable reference and distribute synchronization to network elements within the site is a Timing Signal Generator (TSG), more affectionately referred to as the ‘clock’. Telcordia GR-1244-CORE defines the timing interfaces and the clock (oscillator) requirements for network elements connected to a TSG. Note that GR-1244-CORE does not address the current generation of router based network elements that have 'no-standard' timing interfaces such as RJ45 jacks on the front of modules. We are encountering an increasing number of systems being deployed in AT&T that do not comply with traditional standards for interconnection to a TSG. Examples include the Juniper M320, Nortel Media Gateway 9000, and Ciena Core Director.

2.2. Precision Time Synchronization - Network Time Protocol

Network Time Protocol (NTP) was developed many years ago as a means to set the time of day clocks in servers and computing devices. In the past, NTP was only used in telecom networks as a means to set time of day in network elements for correlation of alarms and events. The was no need for high precision or for high capacity. If a network element did not receive an update when requesting the current time of day from the NTP server, it simply sent another request.

The evolution of telecommunications networks from TDM and SONET/SDH based transport to IP based transport is driving a need for increased capacity for NTP, and increased precision. The need for capacity is driven by the sheer volume of the elements needing a ToD reference. The emerging need for precision in ToD is being driven by the use of IP networks to deliver carrier class real time services such as TDM over Ethernet and U-verse video. Perfomance monitoring of high speed IP backbone systems operating at 1 Gigabit per second and 10 Gigabits per second will require a very high level of ToD precision.

Unfortunately, the telecommunications industry standards bodies have failed to address this emerging aspect of synchronization. There are no nationally or internationally recognized standards that address precision ToD architecture. Current standards, such as GR-2830-CORE and GR-436-CORE are silent on ToD. And, at present (January 2009), there is no significant activity underway in any standards body or at Telcordia to address delivery of precision ToD in a telecommunications carrier network.

Because there are no industry standards for ToD/NTP architecture, there has never been any development of a standard architecture for delivering ToD/NTP in the AT&T transport and switching network. As a result, there are several stand-alone solutions deployed in AT&T to deliver NTP for various products and services such as the BellSouth Regional Internet Backbone (BRIB), Hosted E911 Services, U-verse, and femtocell, in addition to the corporate communications network.

2.3. Synchronization Over Ethernet

The implementation of Ethernet based transport in the access plant will drive a need for a method to deliver synchronization to the remote equipment over the Ethernet facility. This synchronization reference is needed by the remote solution in order to deliver carrier class TDM based services such as T1 cellular backhaul and T1 private line.

There are two generally accepted methods for delivering a synchronization reference over Ethernet - 1) Synchronous Ethernet, and 2) Precision Time Protocol.

Synchronous Ethernet is similar to SONET Derived DS1 timing; synchronization is extracted at the receiving network element from an optical line rate that is synchronized to a Stratum 1 traceable reference. In other words, the launching router is BITS timed, and the optical transceiver launches the outgoing signal at a synchronized transmission rate. Synchronous Ethernet (SE) is favored by European telecommunications carriers. A major disadvantage of Synchronous Ethernet is that all routers and all receiving network elements in the synchronization chain must be compatible with SE, and equipped with SE compatible optical interfaces. A second disadvantage of SE is that Synchronization Status Messaging is required to manage the traceability of the SE derived timing reference. And SE can not deliver precision ToD. AT&T is not pursuing Synchronous Ethernet as a means for delivering synchronization over Ethernet transport at this time.

Precision Time Protocol (PTP) is a method for delivering synchronization references for precision time and/or frequency at layer 2 of an IP network. It utilizes the protocol developed in IEEE-1588 V2 to 'packetize' the synchronization data. The PTP is sent from a server device into a router, and from the router to a client device at the receiving network element, where the synchronization reference is reassembled into a format useable by the network element. The routers in this application do not require any external timing, the existing optical line cards will work, and SSM is not required because the PTP packets include tracebility information. PTP is the method selected by the AT&T Labs access product team for delivering synchronization to remotely located GPON Optical Line Terminal (OLT) nodes. OLTs located in a Central Office will be externally timed via a DS1 clock signal sourced from the TSG, and will not require PTP.

2.4. Next steps for NTP and PTP in AT&T

The Global Engineering Support/Common Systems/Synchronization team is actively engaged with AT&T Labs to develop and document a standard architecture for delivering ToD/NTP and PTP to all AT&T network applications. This architecture will be based upon, and leverage, the next generation synchronization equipment being deployed in the network. In the interim, pending delivery of the new architecture plan, all ToD/NTP/PTP requirements for new systems, products, and services in AT&T network must be referred to GES/Common Systems/Synchronization support for evalaution and a recommendation for implementation. The goal is to discontinue having overlay networks added for ToD/NTP/PTP.

Note that the Symmetricom TimeSource 3500 (TS3500) GPS/PRS is a Stratum 0 (zero) ToD source as well as a Stratum 1 frequency reference. The TS3500 is approved for use in AT&T. The Symmetricom TimeHub 5500 and SSU-2000/2000E Timing Signal Generator (TSG) platforms can be equipped with NTP/PTP server blades to deliver NTP and/or PTP out of the same platform as is used to deliver traditional frequency references. The NTP/PTP Product Approval Team will be launched early in 2009 to issue a Product Approval Notice for these server blades.

Cesium Primary Reference Sources are time agnostic. They can not be used as a time of day reference source for NTP or PTP.

3. Classification of Sites

AT&T sites shall be classified as follows for purposes of synchronization planning, engineering, and provisioning. The classifications are based on the primary assumption that the site houses AT&T network equipment requiring frequency and/or time synchronization meeting Stratum 1 (ST1) criteria for a frequency reference and Stratum 1 for a time reference. The site may be a traditional Central Office (CO), or may be a Point of Presence (POP).

3.1. End Site

A CO with 25,000 or fewer switched access lines, and is not a facility hub (less than 200 DS3’s not associated with end office function). The access lines may terminate in a stand alone narrowband switch, a remote narrowband switch, a Media Gateway serving as the local access, or the CO may house a host switch office with subtending narrowband or Media Gateway remotes if the aggregate of switched lines is 25,000 or less.

3.2. Standard Site

A CO with more than 25,000, but less than 75,000 switched access lines, including narrowband and Media Gateway served remote sites, and is not a major facility hub.

3.3. Critical Site

A CO or Point of Presence (POP) site meeting any of the following criteria;

- Toll/Intertoll Tandem
- Federal Aviation Agency or military circuit hub
- SS7 Signal Transfer Point
- 911/E911 Tandem
- End office with 75,000 or more switched access lines
- Mobile Telephone Switching Office (MTSO)
- Major facility hub with large number of DS3's or equivalent transport facilities not associated with end office function
- All International sites
- Network Operations Center

3.4. Super Critical Site

Any network site housing more than one of the functions of a Critical Site.

4. Primary Reference Sources

There are two fundamental principles for the deployment of PRS in the AT&T Network –
1. All frequency and time synchronization references used in the AT&T synchronization network shall be sourced from AT&T PRS systems. AT&T does not accept synchronization references from any external network. The only exception to this policy shall be as a temporary measure in the event of a major outage of AT&T synchronization references as discussed in the section on Survivability and Disaster Recovery.
2. The ultimate strategy for the evolution of AT&T's synchronization network is the 'flattening' of the network by deploying PRS at every site. The goal is to reduce dependence on interoffice distribution of synchronization references. When our strategic goal of PRS at every site is reached, interoffice distribution of synchronization references will be required only for restoration of a failed PRS.

4.1. PRS Types

There are three types of PRS systems currently deployed in the AT&T Network –

1. Cesium PRS (Cs/PRS) – A stand alone device that provides a frequency reference to meet or exceed specifications for Stratum 1. Cs/PRS systems are time agnostic; they can not provide a Time of Day (ToD) reference. But, the intrinsic stability of these systems provides a frequency reference that meets Stratum 1 criteria relative to a frequency reference derived from a source traceable to the international standard Universal Coordinated Time (UTC).

2. Global Positioning System (GPS) based PRS (G/PRS) – These systems utilize a purpose built antenna and receiver designed to use the Global Positioning System satellite constellation as a source for deriving frequency and time references that are traceable to UTC. There are two types of G/PRS systems available for telecommunications network synchronization –
• Network PRS – Utilizes a Rubidium local oscillator
• Office PRS – Utilizes an oven controlled crystal local oscillator
G/PRS systems can provide a Stratum 0 time reference as well as a Stratum 1 frequency reference. This may well become a major factor in PRS deployment as the AT&T network migrates to ethernet based Next Generation Network transport technology.

3. LOng RAnge Navigation (LORAN) system based PRS (L/PRS) – LORAN C based systems utilize an antenna and purpose built radio navigation system receiver to derive a Stratum 1 traceable frequency reference. L/PRS systems currently deployed in the AT&T network are Manufacturer Discontinued (MD), and are at end of life. There is no L/PRS product currently available for the North American telecom industry.

Generic performance requirements for PRS systems are found in GR-2830-CORE. See section 2.4 for a discussion of Network PRS vs. Office PRS.

4.2. PRS Sector

A PRS sector is a geographic entity within the AT&T network that is administered as an independent synchronization network. That is, all clocks within each sector must be traceable to an AT&T PRS system within that sector. The sector boundaries may be formed from LATA boundaries. Urban areas with high density may be divided into multiple sectors. Once sectors are established, synchronization references are not transported across sector boundaries except as discussed in the section on Survivability and Disaster Recovery.

A synchronization map (or other form of documentation) will detail the locations of PRS systems within each sector, and the facilities selected for interoffice transport of synchronization references to those sites that are not PRS equipped. The synchronization map is critical to the ongoing maintenance of the synchronization sector and is a critical element of the Survivability and Disaster Recovery plan.

Beginning March 1, 2009, AT&T Mobility and AT&T Core sites must be integrated with the wireline sites into the PRS sector plan and synchronization map.

Note that the concept of PRS sector is not discussed in GR-436-CORE.

4.3. PRS Deployment

Going forward, PRS deployment in AT&T shall include a technology diversity mix of 10 to 20 percent Cs/PRS per sector. **Wireless MTSO sites are exempted from the Cs/PRS mix requirement because the wireless network is nearly 100 percent completed with G/PRS. (Note - this was in the original document.)** PRS technology diversity is required to provide a core of Cs/PRS systems to serve as anchor systems in the event of a widespread and extended GPS outage. In areas that have not deployed Cs/PRS in the past, Cs/PRS systems will be required to be deployed at a greater mix than 20% to close the technology diversity gap. PRS systems should be deployed first to those sites designated as Super Critical and Critical. These sites are natural anchor points for the sector. As the PRS deployment matures, PRS systems should be deployed at Standard sites, then to end office sites.

Dual PRS systems may be considered for Super Critical sites, but are not required. Dual PRS systems, where employed, shall be a Cs/PRS and a G/PRS for technological diversity. Going forward, the practice of deploying dual G/PRS systems is discontinued.

Network PRS systems, such as TimeCesium 4500, TimeSource 3500 equipped with a Stratum 2 (ST2) Rubidium oscillator, and TimeProvider 1100 equipped with dual ST2 Rubidium Input/Output/Clock (IOC) modules may be deployed at any AT&T network site.

TimeProvider 1100 systems equipped with dual Quartz IOCs are Office PRS systems. Office PRS systems may only be deployed at Standard Sites and End Sites. Timing references sourced from an Office PRS may not be extended to any network sites other than subtending remote CO locations. The only exceptions shall be in the case of disaster recovery, and in such case, will be a temporary solution.

Note that the definitions of Network PRS and Office PRS refer only to the type of oscillator installed in the PRS, and the resulting bridging mode performance. Refer to GR-2830 for more information on the performance specifications for Network PRS and Office PRS.

All systems installed for PRS and NTP sources must be approved by AT&T Common Systems. Exceptions for non-approved equipment must be submitted for a waiver per GES standards.

It should be noted that this PRS deployment strategy will require a complete rework when the scope and nature of Primary Reference Source needs for precision ToD are better defined. That is because Cesium PRS systems are time of day agnostic. Only

GPS/PRS systems can provide a UTC traceable ToD reference. Subsequent changes to this section may include a revision to the policy regarding dual PRS so that sites already equipped with a Cs/PRS may also be equipped with a G/PRS when the need for precision ToD is identified at that site.

4.4. G/PRS Antenna Considerations

A wall mount antenna is the first choice for new G/PRS systems, if the system supports this option. Wall mount antennas are not exposed to lightning if they are installed under the lightning 'cone of protection'. Primary surge protection is not required on wall mounted antenna leads if the wall mounted antenna is correctly installed under the cone of protection. If you are not certain the wall mounted installation will meet the cone of protection criteria, consult with the Electrical Protection or Grounding Subject Matter Expert for your area.

Roof mounted antennas are less desirable because of additional cost and complexity associated with fall safety hazards and lightning protection. Contact AT&T Environmental Health and Safety for assistance evaluating safety issues associated with a new roof mounted antenna installation.

5. Interoffice Distribution of Synchronization References

InterOffice Facilities (IOF) are used to distribute a Stratum 1 traceable frequency synchronization reference to those sites that are not PRS equipped. As the AT&T PRS deployment progresses and new PRS sites come on line, the need for reference distribution will decline.

The need for precision time references in NGN has not yet been developed. It is not known at this time if precision time reference sources will be required at edge sites, or if precision time references can be distributed between sites. This discussion focuses solely on distribution of a ST1 traceable frequency reference, and will be updated when the requirements for precision time references are determined.

5.1. IOF Transport Facility Selection

Going forward, the only approved facility for IOF transport of a synchronization frequency reference in AT&T is Optical Carrier-N (OC-N) derived Digital Signal-1 (DS1). The transport facility selected shall be the highest order system available in the facility cross section. If a transport system used for derived DS1 is rolled into a higher order Synchronous Optical NETwork (SONET) system, the derived DS1 must be reconfigured to the higher order system, or a PRS placed. The objective is to keep the OC-N derived DS1 out of the SONET transport payload. The synchronization map must record the current assignments of transport systems used for synchronization distribution.

When SONET systems used for OC-N derived DS1 are rolled into a Wave Division Multiplexing (WDM) or Dense Wave Division Multiplexing (DWDM) system, it is strongly recommended that a PRS be placed to eliminate the need for synchronization distribution. The WDM/DWDM system adds complexity to the administration of synchronization reference distribution. And it is possible that active DWDM transponders could adversely affect jitter and wander on the OC-N transport systems and any OC-N derived DS1 references.

Going forward, the following rules for use of Derived DS1 timing reference distribution shall apply; Distribution of synchronization via SONET OC-N derived DS1 shall be from one direction around the SONET ring. It is preferred that there be only one facility link between the PRS site and the site receiving a Derived DS1 synchronization reference. Where this is not feasible, limit Derived DS1 chains to 6 or fewer links, and place a PRS where needed, as funding permits. There shall be no line timed nodes in the Derived DS1 chain. Dual SONET OC-N derived DS1s shall not be employed as a working configuration. Use of SONET OC-N derived DS1 is not approved in AT&T as an in-service back-up to PRS inputs to a TSG. Existing arrangements are grandfathered.

The standard framing for derived DS1 shall be D4/SuperFrame. The section on Intraoffice Timing Distribution will discuss reference inputs to a TSG in detail.

The use of Synchronization Status Messages (SSM) to manage OC-N derived DS1 is not approved in AT&T. AT&T and Telcordia testing of SSM revealed numerous performance and interoperability issues. Going forward, SSM will not be employed to manage IOF OC-N derived DS1 on new applications. Where SSM is currently employed to manage IOF OC-N derived DS1, the systems may be maintained subject to the following;
1. The synchronization map must include tables indicating the correct SSM threshold settings for each PRS, Timing Signal Generator (TSG), and each network element that is configured for SSM in the timing input. Failure to correctly option each element can lead to a disastrous outage.
2. The sector plan must give priority to placing new PRS systems and eliminating SSM managed IOF derived DS1.

Asynchronous DS1 facilities (traffic bearing or dedicated) in current use for synchronization reference transport may remain in service, but must be replaced when the asynchronous system is scheduled for retirement. The retirement and removal of asynchronous systems and equipment shall not be delayed in order to avoid reconfiguring the synchronization distribution. In such cases, the preferred solution is to place a new PRS. The second choice solution is OC-N derived DS1.

Traffic bearing DS1's mapped into SONET payload shall not be used for IOF transport of a ST1 traceable frequency synchronization reference. An exception is made for those remote switch systems that have no external timing connectivity, and must use the incoming trunk systems for a timing reference. The use of retimer/buffer devices on such systems is discussed in detail in the Intraoffice Timing Distribution section. In the event of a major, catastrophic loss of synchronization references, a temporary exception can me made as described in the section on Survivability and Disaster Recovery.

6. Intraoffice Timing Distribution

AT&T sites shall follow the BITS concept of intraoffice timing distribution as described in GR-436-CORE. All systems installed for TSG applications must be approved by AT&T Common Systems. Exceptions for non-approved equipment must be submitted for a waiver per GES standards. The Symmetricom SSU-2000/2000E systems were evaluated and approved by AT&T Mobility and cT, and have been deployed in the network. SSU-2000/2000Es are grandfathered as AT&T approved TSG systems.

6.1. Master TSG

There shall be only one Master TSG in any AT&T site, going forward. The master TSG shall be the only system in the site receiving a ST1 traceable input reference, either from a collocated PRS system, or via IOF distribution. Dual master TSG configurations, which have been employed to resolve issues such as BITS timing of a #4ESS toll tandem equipped with ST2 oscillators, shall not be implemented going forward. Any such arrangement in place shall be corrected upon removal of the #4ESS or re-mastering of the site.

All other TSG devices in the site shall be either an expansion shelf connected to the master, a remote master shelf, or an expansion shelf connected to a remote master shelf.

Sites that house multiple network entities, such as wireline and long distance, will be evaluated on a case by case basis to make the best use of the available resources and bring the site into BITS concept compliance.

6.2. TSG Diversity

The concept of diverse TSG systems (e.g.: Red and White systems) is not approved in AT&T. Going forward, new systems will be configured per standard BITS concepts. Existing diverse TSG systems are grandfathered, but shall not be duplicated when the site is upgraded to new TSG technology.

6.3. Timing Inputs - Master TSG

The AT&T standard for reference inputs to the master TSG is DS1, D4 SuperFrame (D4/SF). The use of Extended SuperFrame (ESF) and SSM on inputs to a master TSG is not approved for new AT&T master TSG systems. Existing systems configured for ESF and SSM on the reference inputs are grandfathered. The reference inputs can be sourced from a collocated PRS, or from a single IOF OC-N derived DS1.

The AGNSSP relies upon the bridging mode performance characteristics of G/PRS systems, and the holdover performance characteristics of TSG systems, to provide a maintenance interval to repair or replace a failed input reference. A fundamental advantage of a collocated PRS is the elimination of records administration for IOF transported synchronization references. In short, the collocated PRS reduces administration and maintenance issues to managing on-site systems. Adding an OC-N derived DS1 reference as a back-up reference where PRS is also available requires all of the administration of a system referenced solely from OC-N derived DS1. Further, the back-up OC-N derived DS1 will cause network problems if the TSG inputs are not correctly optioned. Going forward, OC-N derived DS1 shall not be used as an in-service back-up to PRS inputs. Where such back-up references to PRS inputs have been connected to intelligent TSGs, they shall be disabled as TSG inputs. It is acceptable to maintain the connection, and monitor the derived DS1 input using the performance monitoring capabilities of the intelligent TSG.

6.4. Timing Inputs - Remote Master TSG

The timing input reference to a remote master TSG must be two 64 kbps/8 kbps Composite Clock (CC) signals sourced from the master TSG system. The two CC sources must be assigned to diverse output cards in the serving TSG, and must be diversely routed, per AT&T TP-76400 and TP-76300. This requirement is waived at Core network (Classic T) sites that will never have DS0 connectivity requirements.

The use of DS1 inputs to a remote master TSG to carry SSM from the master TSG to the remote master TSG is not approved in AT&T. Existing systems, and additions to existing systems so configured are grandfathered.

6.5. Selection of Oscillators

Going forward, ST2/ST3E and ST2E/ST3E mixed oscillator operation is not approved in any AT&T application. Oscillators shall be deployed in matched pairs.

Master TSG systems in Super Critical and Critical sites shall employ only Stratum 2 (or Stratum 2E for DCD master TSGs) clock modules equipped with Rubidium oscillators. Going forward, ST2 Rubidium oscillators are not approved for deployment in next generation remote master shelves. Existing installations with ST2 oscillators in TimeHub 5500 remote master shelves are grandfathered. Consideration should be given to replacing ST2 modules in TH5500 remote master with ST3E when planning other synchronization network rearrangements in that site. The recovered ST2 modules could then be redeployed to a new master system.

DCD remote master systems in Super Critical and Critical sites should be evaluated to determine the criticality of connected network elements. Remote master DCD shelves with critical loads should be equipped with redundant Remote Track and Hold Circuit modules (RTHC).

Master TSGs at Standard sites may employ ST2/2E or ST3E oscillators, as follows;
• The timing hierarchy must be observed. If the Standard office is part of a sync distribution chain, the oscillators in the master TSG must be of equal or greater Stratum level than all down stream office master TSGs. ST3E is permitted in a composite clock fed remote master system if it is a next generation platform that supports phase alignment. RTHC is recommended for all DCD remote master shelves in standard offices.
• If synchronization distribution is limited to that site, and to subtending remote switch sites, ST3E is permitted in the master system.

Stratum 3E oscillators shall be used in End site master TSGs. End sites will not be used to distribute timing to any other site except subtending remotes.

ST3E clock modules are not permitted, and shall not be used, in any AT&T DCD remote master shelves. Critical network elements, such as D4 channel bank systems supporting SS7 A-Links, shall not be assigned to a remote master system that does not employ phase holdover.

6.6. Other Plug-In Module Issues - DCD

DCD-400 systems must be equipped with a Fuse and Alarm module. The FA module completes the path for discrete alarms. If that slot is vacant, the alarm loops are open.

DCD-400 systems should be equipped with a MCA-2 matrix controller module. MCA-2 provides superior protection, compared to MCA, against port alarm initiated switch-to-protect and detection of slowly decaying output signal voltage on output cards. This recommendation is waived for Core sites (Classic T) that have ‘split backplane’ DCD shelves with no relay matrix or hot spare functionality.

6.7. TSG Modernization

When a new next generation TSG is placed in a site, the installation and cutover must include establishing next generation technology as the site master TSG, and the conversion of an existing DCD master shelf that will remain in service to a remote master equipped with RTHC modules. Where there are existing remote masters, and the site will be remastered such that the original site master is converted to a remote master, special attention must be given to the subtending remote master(s). Each remote master that subtended the original office master should be cut over to be sourced from the new master TSG system.

Replacement of DCD master TSGs that also provide 5 MHz local oscillator function for a DCD-LPR PRS will also trigger replacement of the DCD-LPR with a Cs/PRS or G/PRS.

At Super Critical and Critical sites, consider removing all DCD systems when implementing sync modernization, if funding levels permit.

6.8. Network Element Synchronization

Every network element that requires synchronization, and is equipped with timing input ports, shall be timed from the site TSG system. An exception has been granted to those DSLAM systems which have timing input ports, but have been loop timed from the ATM switch. Note that some equipment equipped with timing input ports does not require external timing for the AT&T application, and no timing leads from the TSG are installed. Examples include the routers used for U-verse/Lightspeed aggregation. If timing leads are required for a network element, the Common Systems Interconnect drawings, found in WoodDuck, will detail the interface specifications. The Common Systems Quick Reference guide also provides information on timing inputs to network elements. All timing cables shall be single pair, red jacketed type 1175A cable. An exception is made for Legacy T, which can continue to use gray jacketed type 1175A cable to avoid confusion with red jacketed power cables.

6.9. Application of Retimer/Buffer Devices

Experience has shown that the Stratum 3 clock systems employed in remote narrowband switch systems can tolerate the wander and jitter associated with SONET transported DS1 umbilical trunks, provided that the SONET transport is correctly configured, and all network element timing is ST1 traceable. Therefore, retimer/buffer devices are not mandatory on DS1 umbilicals to remote narrowband switch modules. Retimer/buffer devices may be installed where recommended by Advanced Technical Support. Existing retimer/buffer device installations are grandfathered.

Other applications of retimer/buffer devices may include external timing of DS1's sourced from multiplexer systems that do not support external timing connections. One such example is the Rockwell-Collins systems used for Consumer Services Automatic Call Distributor systems in AT&T Southeast.

The Symmetricom TimeProvider 1100 can be configured with DS1 retimer/buffer modules. The Spectracom TEK-150 is a stand alone DS1 retimer/buffer device.

Retimer/buffer devices 'filter' wander and jitter from the DS1 by passing the incoming signal through a 125 microsecond elastic store. The outgoing traffic bearing DS1 is then forced to the same frequency as the synchronization reference input to the device. The elastic store is large enough to filter the wander and jitter common to SONET transport mapping/demapping and the occasional positive and negative pointer adjustments. If the DS1 has continuous frequency offset from nominal, either positive or negative, the retimer/buffer will slip DS1 frames at a rate directly proportional to the offset. Such offsets can occur when the source system (e.g. host switch) clock is in holdover, or a mapping/demapping SONET network element is in holdover or internal timing. In short, retimer/buffer devices can not correct for abnormal network operation. Frame slip alarms from a retimer/buffer device may be due to network impairments at a network site other than the site of the retimer/buffer device.

6.10. Conceptual BITS

The BITS concept requires all network equipment requiring synchronization be timed from the TSG system in that site. This includes narrowband access line switches, TOPS switches, tandem switches, etc. Some switches are timed from incoming facilities, rather than the TSG system. This arrangement is known as conceptual BITS. Where this situation exists, the sector synchronization plan must include the elimination of conceptual BITS on a programmed basis. Synchronization jacks and T-Carrier Bridging Office Repeaters (TBOR) associated with the conceptual BITS arrangement shall be removed. The only exceptions for maintaining a conceptual BITS arrangement will be those remote switch systems that do not have, and do not need, retimer/buffer devices.

6.11. Timing Leads to Collocator or Affiliate Equipment

At a collocator's or an affiliate's request, and where an applicable tariff, Interconnection Collocation Agreement (ICA) or an Affiliate Agreement are in place, AT&T will supply a DS1 timing reference or multiple DS1 timing references to the collocator or affiliate, subject to the pricing of applicable tariffs or ICA. Past AT&T practice has been to require that a TBOR be installed in the timing circuit, between the AT&T TSG and the collocator's or affilate's equipment. Effective May 1, 2008, the installation of TBOR on collocator or affiliate timing leads is disapproved in AT&T No new TBOR hardwired equipment shall be placed for timing leads to collocator or affiliate equipment. No new TBOR plug-in modules will be placed, even where hardwired capacity is available.

Dedicated timing output cards are not required. Timing leads for collocator or affiliate equipment may be assigned to any available port on a TSG output card.

Additional details on methods and procedures for providing timing leads to collocators and affiliates are found in section 18 of AT&T-TELCO-002-316-002, Compliance Implementation: Collocation Provisioning Guidelines (CPG) Method & Procedures, and AT&T-TELCO-812-000-028, AT&T Synchronization Standards - Timing Leads for Collocators and Affiliates.

7. Loop/Access Network Synchronization
7.1. Current Technology

All Time Division Multiplexed (TDM) and SONET loop and access network elements located in an AT&T Central Office shall be timed from the site TSG. This includes all Digital Loop Carrier, Next Generation Digital Loop Carrier, and Broadband/Gigabit Passive Optical Network (PON) Optical Line Terminals (OLT). BITS compliant timing of these systems is crucial for interoperability with switch and transport systems. Some systems require composite clock timing for phase alignment. Others require composite clock timing and DS1 timing. Consult the Common Systems interconnect drawings for details. Loop and access TDM and SONET network elements located in remote terminals and customer's premises shall be loop timed or line timed, as appropriate to the specific platform. The use of SSM to manage timing within loop and access SONET rings is recommended. SSM shall not be delivered on the timing inputs to the network element. Therefore, the highest order SSM produced in the ring will be Synchronization Traceability Unknown (STU).

7.2. Future Technology

Synchronous Ethernet and Precision Time Protocol are the two techniques under study for future deployment in the access plant. See section 2.3.

8. SSM Implementation in IOF SONET Rings

As previously stated, the use of SSM to manage synchronization references between PRS equipped sites and other network sites is not approved in AT&T. SSM will not be delivered from the TSG system into network elements except as noted in the section on IOF Transport Facility Selection. However, the use of SSM to manage timing within IOF SONET rings is recommended. Because SSM is not delivered on the timing inputs to the network element, the highest order SSM produced in the ring will be Synchronization Traceability Unknown (STU).

9. Customer Premise Equipment Synchronization

Incumbent Local Exchange Carrier (ILEC) furnished point-to-point private line services, such as DS1, are isochronous, meaning the synchronization is a function of the terminal equipment. This terminal equipment is collectively referred to as Customer Premise Equipment (CPE). Examples of CPE with TDM interfaces are digital Private Branch Exchanges (PBX), and routers used for Voice over Internet Protocol. Isochronous operation works fine, so long as the CPE device produces a signal that meets the frequency standards for transport over ILEC infrastructure (typically ST3 or better), and the customer traffic is not interconnected to another network that is ST1 traceable.

If such interconnection is required, the customer must synchronize their equipment to a ST1 traceable reference. A common technique is to loop time their CPE from an ILEC or Interexchange Carrier furnished facility, such as a Primary Rate ISDN circuit, or a channelized DS1 that they know will be ST1 traceable. This is a permissive use of network services, and is in widespread use.

There are other options to synchronize a customer’s network. The customer may install a PRS. Where appropriate tariffs apply (e.g. SmartRing, AccuRing), AT&T may supply a synchronization reference to a customer by way of a D4/SF framed derived DS1 sourced from an AT&T SONET network element located at the customer’s premise.

10. Synchronization Network Element Management System
10.1. Present Mode of Operation

The first generation of synchronization equipment, Symmetricom’s Digital Clock Distributor, was hardware based. There were only a few provisioning options, set with switches. Maintenance was limited to replacing modules. We are now well into deployment of the second generation of synchronization equipment, most of which is processor driven. These are intelligent network elements that can be remotely provisioned and interrogated for maintenance and trouble diagnosis.

At present, AT&T does not have infrastructure in place to fully capitalize on the remote provisioning and maintenance capabilities of these network elements. Each of the wireline regions is using different methods for accessing sync network elements via AT&T internal TCP/IP networks. AT&T Core is using an Element Management System (EMS), Symmetricom’s TimePictra, but is not fully exploiting all the capabilities.

10.2. Future Mode of Operation

The integration of Layer 3 operations centers, which utilize Simple Network Management Protocol (SNMP), may well prove to be a significant driver for implementation of Sync EMS. This EMS would provide the 'bridge' between the present Layer 0/1 Operational

Support Systems (OSS) which utilize TL1 over TCP/IP to NMA, and the Layer 3 SNMP OSS.

If a synchronization EMS is fully implemented, all AT&T intelligent synchronization network elements in wireline, wireless, and core networks will be managed by a common EMS. However, there is no funding available to proceed at present.

11. Survivability and Disaster Recovery

As discussed in a prior section, the AGNSSP relies on the bridging mode characteristics of G/PRS systems and the holdover characteristics of TSG systems as the primary defense against interruptions in a synchronization reference. A G/PRS equipped with a Rubidium oscillator will provide a minimum of 72 hours of output in bridged mode. That interval can be extended, if desired. Stratum 2/2E oscillators in a TSG can provide about 30 days of stable output while in holdover. Stratum 3E oscillators can provide at least 7 days of stable holdover. These bridging mode and holdover mode characteristics provide a maintenance interval to implement repair, or replacement, of a failed synchronization reference.

11.1. Synchronization Reference Recovery Strategies

If there is any doubt that a failed reference can be restored before expiration of the holdover period, the reference shall be temporized using one of the following methods, in preferred order:

1. If a derived DS1 back-up reference is already in place, verify from the sector synchronization map that the source of the derived DS1 is suitable for the receiving location. The source must not violate the stratum hierarchy, and must not form a timing loop. If the source is acceptable, reconfigure the TSG to use the back-up source.

2. Use a portable PRS such as Cesium III, FTS-4040, or TimeSource 2700 CDMA PRS.

3. Determine if an appropriate SONET derived DS1, sourced from the same PRS sector, can be provided to supply a Stratum 1 traceable signal to temporarily replace the failed PRS. The following rules for Derived DS1 shall be observed –
• The source office TSG for the derived DS1 shall be of equal or greater Stratum level to the office TSG receiving the derived DS1.
• The source office TSG for the derived DS1 shall not be in a timing loop with the office TSG receiving the derived DS1.
• There shall be no line timed network elements between the derived DS1 source office and the receiving office.
• The derived DS1 shall be sourced from the highest order OC-N system available between the source office and the receiving office.

All network elements on the ring selected for derived DS1 shall be audited to insure sync options are correct and that no node is in holdover or internal time. If derived DS1 is a viable option, the synchronization planner and maintenance engineer shall work cooperatively with the LFO-In to place a derived DS1 timing cable and option the SONET network element for ‘sync out’.

4. If a derived DS1 can not be sourced from within the same sector, determine if a suitable derived DS1 can be sourced from an adjacent sector.

5. In a worst case scenario of a widespread and long term outage of the GPS

constellation, extreme measures may be required. In such a case AT&T would work cooperatively with other telecommunications carriers to exchange synchronization references across service area boundaries. The preferred method would be via OC-N derived DS1. A last resort solution would be to use a traffic bearing DS1 sourced from a Stratum 1 traceable network element. Such an arrangement could require that ST2/2E clocks be replaced by ST3E clocks to accommodate a less than pristine input reference. Any such emergency restoration arrangements will be removed as soon as normal sync traceability can be restored.

12. Reference Documents

Telcordia GR-436-CORE Digital Network Synchronization Plan

Telcordia GR-2830-CORE Primary Reference Source for Digital Synchronized Networks: Generic Requirements American National Standards Institute (ANSI) T1.101-1999

American National Standard for Telecommunications – Synchronization Interface Standard (Note – The Alliance for Telecommunications Industry Solution (ATIS) has replaced ANSI.)

The International Telecommunication Union – Telecommunication Standardization Sector (ITU-T) is emerging as the dominant forum for international telecommunications standards. There are several ITU-T recommendations (standards) that are relevant to telecommunications synchronization. These recommendations contain information that mostly parallels North American standards such as ANSI T1.101, GR-1244, etc. Note that ITU-T recommendations address Synchronous Digital Hierarchy (SDH) networks, but North American standards do not. Ongoing telecommunications synchronization standards work at ITU-T is performed in a technical sub committee called Question 13, Study Group 15 (Q13/SG15).

The AGNSSP does not reference any ITU-T recommendations at this time, but that is subject to change as new standards for synchronization in NGN emerge.

Following is a list of ITU-T synchronization recommendations relating to telecommunications network synchronization –

G.810 Definitions and terminology for synchronization networks
G.811 Timing characteristics of primary reference clocks
G.812 Timing requirement of slave clocks suitable for use as node clocks in synchronization networks
G.813 Timing characteristics of SDH equipment slave clocks (SEC)
G.8261 Timing and synchronization aspects of packet networks
G.8262 Timing characteristics of synchronous ethernet equipment slave clocks (EEC)

13. Contact List

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14. Revision Log

DATE	ISSUE	DESCRIPTION
February 25, 2009	4	Cancel and supersede Wireless Network Operations PL-0065, update status of NGN sync including NTP and PTP. Update recommendations on implementation of Derived DS1.
August 18, 2008	2 & 3	Revise section 6.11 per request of Common Systems Collocation Team. Note - Issue 2 not released.
April 10, 2008	1	Initial release

Acronyms

A.1. Document Specific Acronyms

A.2. Acronyms Dictionary

Refer to ATT-000-000-020, Acronyms Dictionary.