Cisco Systems

White Paper

Reliable Signaling System 7 (SS7) Transport Over Satellite Links

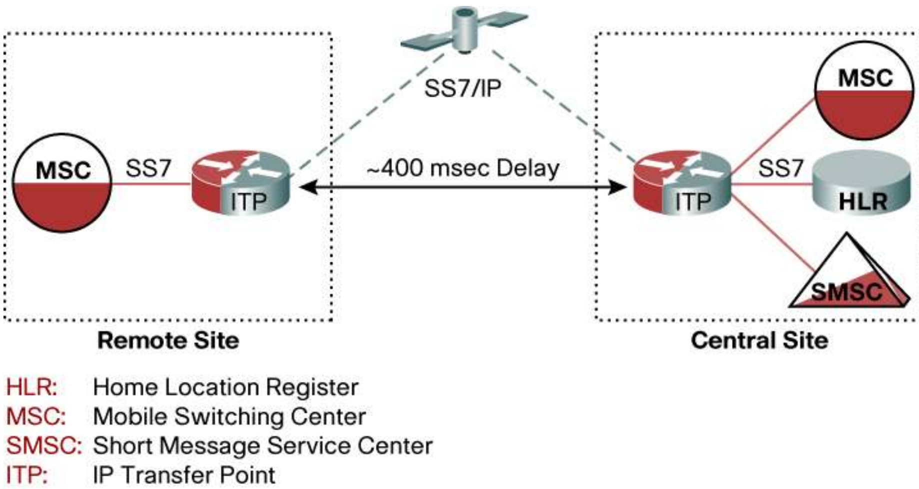
Executive Summary

Satellite networks have been used for years to connect two remote locations, usually separated by natural or other barriers that prevent the use of traditional communication technologies such as telephony or Internet networks. Satellite channels provide a flexible and rapid establishment of a communication link. This flexibility comes at a cost, because satellite links usually are more expensive and slower than traditional network links. Additionally, satellite channels must traverse a long distance from the transmitter up to the satellite station and back down to the receiver. This introduces a propagation delay that sometimes is in excess of a few seconds on the end-to-end links.

Many networking transport protocols are susceptible to large delays. Delays are common in lower bandwidth transport over a long-distance network. For example, a satellite connection is susceptible to delays because of the distance that a link must travel to reach the satellite in space and bounce back to Earth. Although Signaling System 7 (SS7) has some tolerance in link timers, this tolerance is not high enough to maintain a reliable link state and avoid link flap.

IP transport over satellite provides an efficient and higher availability alternative to time-division multiplexing (TDM)-based transport. With the benefit of Stream Control Transmission Protocol (SCTP), an SS7 link is converted to a Signaling Transport (SIGTRAN) link at one end of the link. SIGTRAN allows for SS7 protocol transport over IP (SS7oIP). When using a satellite IP link, the messages are transported reliably over the satellite link and with high tolerance to delay. Messages are retransmitted as TDM SS7 to reach the destination node in the SS7 network. SCTP’s configurable timers provide tolerance to high delays, at the same time maintaining sequenced delivery, multihoming, and multistreaming. This is suitable especially for SS7 transport over satellite links. However, not all SS7 over IP is equal. The IETF has issued standard protocols to address the conversion of SS7 to SS7 Over IP by using adaptation layers (translation layers) to eliminate the unnecessary protocol layers during transport. Circuit emulation, or simply encapsulating all SS7 traffic over IP without any translation of SS7 messages, does not necessarily reap the full benefit of IP transport over satellite networks. An intelligent adaptation layer will eliminate unnecessary limited protocol layers and replace them with more tolerant protocol layers. Message Transfer Part 2 (MTP2) Peer-to-Peer Adaptation layer (M2PA) along with SCTP provide this reliability and efficiency of transporting SS7 over IP. Figure 1 depicts an SS7 over IP transport over satellite link.

Figure 1
Benefits of SCTP Over Satellite Links



Overview of Satellite Technology

As a result of top secret and military applications, satellite networks are now part of the daily activities of most people. From trucking companies streamlining their delivery and tracking systems to television and radio entertainment programs and daily banking information, satellites have facilitated these important applications. The well-known Global Positioning System (GPS) is a type of satellite system deploying 24 units orbiting the planet Earth. What differentiates satellite networks from other networks is the capability to reach remote areas that are otherwise unreachable. Satellite phones have become a standard tool in numerous expeditions and have become a necessary safety item to pack for mountain climbs or deep ravine explorations.

Satellite communication networks rely on custom-built satellite systems with thousands of transponders placed in the “thin air” atmosphere at or around 22,000 miles from the Earth’s surface. As satellites are released, they maintain orbital balance with gravity, thus remaining at the same distance from Earth and not getting lost in space. A satellite that does not follow a specific path or orbit is not very useful. Therefore, satellites usually have minirockets that guide them and keep them on track. For a satellite to follow its orbit around Earth in 24 hours, normally it follows a specific orbital velocity. Different elevations and orbital paths may require higher or lower speeds.

The transponders in a satellite system act as repeaters. They receive the signal, they then amplify (enhance) it and retransmit it back to Earth, relaying the messages between two remote locations on Earth that are otherwise unreachable.

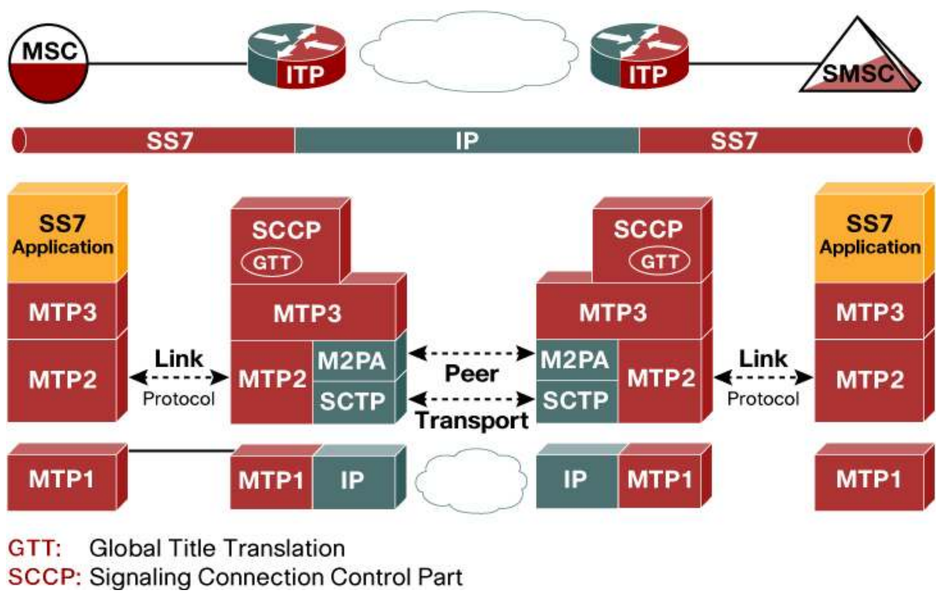
Because of the long distances involved, messages transmitted from Earth to satellite and back experience a phenomenon called “propagation delay.” Propagation delay is the amount of time, determined by the speed of light and distance, it takes to send a message over a transmission link from one end to the other. A typical delay of a satellite link is about 200-300 milliseconds (ms) in each direction. For a message to be delivered from point A to point B on Earth’s surface, there is a delay of about 400-600 ms. This delay may be significantly larger when atmospheric, geographic, and weather variables are involved.

Because of this delay, sensitive communication protocols that have stringent and specific delay tolerance may suffer quality over satellite communications. This is experienced today in telephone networks when voice or signaling messages are transmitted over satellite links. A degradation in the quality of service (QoS) is caused either by the inability of delivering a control message (SS7) or by experiencing voice delay to levels that are not tolerated in some cases. SCTP has proven superior to traditional TDM links when additional satellites are a detriment to successful SS7 transport.

The SS7 protocol was designed to be transmitted over highly reliable and available networks. Typically, a satellite link is not the most appropriate type of network connectivity used for SS7 transport. In many cases, however, satellite is the only available type of connectivity. SS7 links have rigid timing and delay requirements. A link's acknowledgement timer may expire when a message is sent over satellite but not acknowledged. This causes the link layer in SS7 (MTP2) to issue a link failure indication to the network layer (MTP3), resulting in a link disconnect. MTP2 acknowledgment timer (T7), for example, may be configured between 0.5-2 seconds. Although this type of tolerance may be adequate for a "clean" satellite link, in reality this type of delay limitation frequently causes "link flap" (link up/down). Link flap is undesirable behavior and operators try to avoid it in their SS7 networks. Figure 2 highlights the difference between traditional TDM SS7 protocols and SIGTRAN protocols, in this case specifically, MTP2 Peer-to-Peer Adaptation Layer. Note that MTP3 and its users are not affected by the change of the underlying transport protocols.

Figure 2

STP MTP2 Peer-to-Peer Adaptation (M2PA) Protocol Architecture



The Use of SCTP For SIGTRAN

SCTP is a connection-oriented, point-to-point protocol that provides transport for all the SIGTRAN adaptation layers. SCTP is somewhat similar in concept to TCP, which is the transport protocol commonly used today for the majority of Internet traffic. SCTP, however, is a more reliable protocol that provides more enhanced functions than TCP and is used for SIGTRAN traffic. The primary benefit of SCTP is its reliability, high availability, and flexibility. These features are highlighted in SCTP's capabilities to support message sequencing, flow and congestion control, multistreaming, and multihoming. These features enable SCTP to excel in transporting SS7 over satellite. An SCTP-based SS7 link can tolerate higher levels of network delays and packet loss compared to TDM-based links. SCTP also provides a more reliable transmission protocol for sensitive applications, such as, SS7 than TDM-based transport. These features offer the following benefits:

- *Message sequencing*—SCTP ensures predictable and sequenced delivery of SS7 Message Signal Units (MSUs) delivered over a single association. Each SS7 link is referenced by an association and each association may support multiple independent streams. This function is essential to providing a reliable delivery of MSUs.
- *Flow and congestion control*—SCTP provides an acknowledgement mechanism and assigns a Transmission Sequence Number (TSN) when it detects gaps. SCTP end-nodes determine congestion and packet loss in the network. Selective Acknowledgment enables end-nodes to selectively request retransmissions of dropped packets.
- *Multistreaming*—Unlike TCP, SCTP provides sequencing for packets with each stream. Higher layers can invoke their own streams within a specific link (association). This allows a flexible flow-control and avoids the blocking phenomenon that is similar to TCP's "head of line." When there is buffering due to packet loss on a specific stream, other streams are unaffected.
- *Multihoming*—A unique feature of SCTP is the ability to use more than one IP network for one specific association. This provides the capability of multiple redundant paths for a single SIGTRAN link. Multihoming in SCTP can hand over traffic to the alternative IP network when congestion is detected without any upper-layer knowledge. This ensures that MTP3 routing does not have to go through its own congestion procedures or changeover and changeback if the congestion level is still tolerable.

Key Issues

SCTP Slow-Start

Some SCTP implementations inadvertently may fall for a slow-start condition. This may occur when packet delay and ultimately packet loss is experienced in the network and is mistakenly identified as network congestion. In this scenario, the sender may be requested to reduce the congestion window and change to a slow-start state. The congestion control algorithm may cause poor utilization of the available resources; therefore, an enhanced congestion control algorithm and configuration may be necessary. Some vendors provide the capability to change congestion window parameters, allowing for simplified and efficient usage of the available channel by SCTP.

The parameters used to enhance SCTP transmission over satellite links follow:

- *Congestion window* (cwnd) is the upper bound of data a sender can transmit before receiving an acknowledgement.
- *Slow-start threshold* is a variable used with the congestion window to override the slow-start condition if such condition is experienced.
- *Initialization timeout* (init-timeout) is the timer used to determine how long an SCTP endpoint will wait for a response to a setup message before retransmitting. The init-timeout parameter should be adjusted for the expected round-trip delays expected on the satellite channel.
- *Retransmit timeout* (RTO) should be adjusted to accommodate for round-trip delays. Round-trip times for satellite channels may vary but typically are around 300-400 ms. In certain conditions, this delay may exceed 500 ms. The RTO should be adjusted to a value above the round-trip delay measured.
- *Initialization congestion window size* (init-cwnd-size) is a parameter that specifies the initial window size used by the sender. When configured, the receiver's init-cwnd-size should match this value. This parameter circumvents the slow-start scenario. Interface memory buffers, as well as SCTP receive buffers, should be taken into consideration and adjusted when changing the value of init-cwnd-size.
- *Idle congestion window rate* (idle-cwnd-rate) is used when the endpoint does not transmit data on a given transport address. The cwnd of that transport address is decreased to max (cwnd/2, 2*MTU) per retransmission timeout. The idle-cwnd-rate allows the administrator

to control the rate at which the cwnd is decreased due to being idle. Using the idle-cwd-rate, the cwnd is decreased to max (cwnd/idle-cwnd-rate, init-cwnd-size) per retransmission timeout.

- *Fast congestion window rate* (fast-cwnd-rate) is a parameter that allows the administrator to control the rate at which the congestion window is decreased for fast retransmit.
- *Retransmit congestion window rate* (retransmit-cwnd-rate) is a parameter that allows the administrator to control the rate at which the slow-start threshold is reduced and provides for the setting of the cwnd.
- *SCTP receive buffers* allow the SCTP subsystem within a SIGTRAN node to have available memory to store packets when an SCTP association is congested.

Quality of Service

The ability to set QoS bits in the IP traffic carrying SCTP is essential to successful delivery when the media is shared with other IP traffic. QoS marking would ensure SCTP traffic a higher grade of service at the IP router level to ensure faster routing than other IP traffic. This is necessary only when other IP traffic shares the link or when different levels of service are needed among different SCTP links.

Conclusion

Satellite communication channels allow operators to reach otherwise unreachable locations. This comes with the price of significant delays in the transmission channel. Legacy SS7 links may experience link failure, causing links to go up and down over a satellite link, a phenomenon usually referred to as link flap. SS7 OVER IP provides a reliable transport protocol (SCTP), ensuring successful delivery of SS7 messages and higher availability of the SS7 links between nodes.

In many cases a single link may have to traverse two satellite hops, which could make it impossible to establish a successful link alignment between two end-points. This excessive delay causes the traditional MTP2 layer to fail, which in turn prevents the SS7 messages (MTP3 and up) from successful delivery. With IP and SCTP used as an alternative to MTP2, SS7 messages are delivered successfully without seeing link failure. The flexibility of SCTP timers allows this to take place.

Operators have been adopting SS7 OVER IP for many SS7 transport links and, in particular, when satellite is used as a transmission channel. SS7 OVER IP is becoming the norm in SS7 transport networks, providing a flexible, reliable, and less expensive alternative to legacy TDM-based SS7 transport.

For Further Information

http://www.cisco.com/en/US/products/sw/wirelssw/ps1862/index.html

The Cisco® IP Transfer Point (ITP) is a product for transporting SS7oIP networks. Cisco ITP allows mobile operators to efficiently transport increasing volumes of SS7 traffic by offloading the traffic from the traditional STP network to an SS7oIP network. Cisco ITP also positions the mobile operator for enhanced return on investment (ROI) and profits by providing the infrastructure for IP-enabled service control points (SCPs) and revenue-generating IP services.

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