FROM HOST-REMOTE TO NEXT-GENERATION

A review of the technology options for telephone companies to transition from traditional host-remote architectures to packet-based networks.

A MetaSwitch™ White Paper

MetaSwitch
A DIVISION OF DATA CONNECTION

SUMMARY

Traditional telephone switching systems support the concept of "host-remote" operation, whereby lines are terminated by equipment in remote locations that is under the control of a host switch – but potentially with the ability to operate independently of that switch if the control link is cut. With the emergence of next generation networks, a distributed "softswitch" architecture offers the same ability to reliably deliver services across a wide geographic area with several improvements over the previous generation of equipment. Most important among these are: multiple levels of emergency standalone operation; open interoperability; connectionless trunking in a packet network; distributed PSTN connectivity; and host site redundancy.

NOTICE

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1. BACKGROUND

Telephone companies, particularly those outside of densely populated urban areas, are faced with the challenge of delivering reliable service to subscribers across a large geographical area.

The last generation of digital switching systems developed a range of proprietary solutions to this problem that were extremely powerful considering the limitations of the underlying TDM transport mechanisms. Deployed in a "host-remote" architecture, legacy switches could be effectively deployed in dozens of central offices (COs) across thousands of square miles, all managed from a central location. Over time, the majority of digital switch deployments came to be of this type.

In recent years, next generation "softswitches" have started to replace traditional switches, due primarily to their lower cost and the benefits of converged packet-based networks (which are many but outside the scope of this paper). While some such switches have essentially squeezed legacy, proprietary designs into a smaller form factor, we contend that the true promise of next generation switching lies in an open, distributed, packet-based softswitch architecture.

For service providers trying to understand the impact of softswitching to their networks, one stumbling block is all the new terminology generated by vendors and standards bodies. This masks the fact that the traditional host-remote approach is not entirely displaced, but actually embraced and improved upon, in next generation networks. This paper explains how the two relate, the benefits of moving to a truly open packet host-remote architecture, and the practical steps involved in such a migration.

2. LEGACY HOST-REMOTE ARCHITECTURE

While the term “host-remote” is widely used, in reality it covers a variety of deployment models and products, with varying levels of capability, depending on the vendor. The following discussion attempts to draw out the key common features of the different architectures – specific vendors’ implementations will vary in how closely they can deliver all the capabilities described.

In general, a host-remote network comprises a primary Class 5 switch in the telephone company’s main office (the “host”), with a number of “remotes”. The remotes might be one or more of the following.

- A remote switch, in a satellite switching office.
- A line termination shelf, in a remote line switching office.
- A digital loop carrier “remote terminal” in a cabinet or smaller remote office.

Figure 1 shows these components in an example host-remote network.

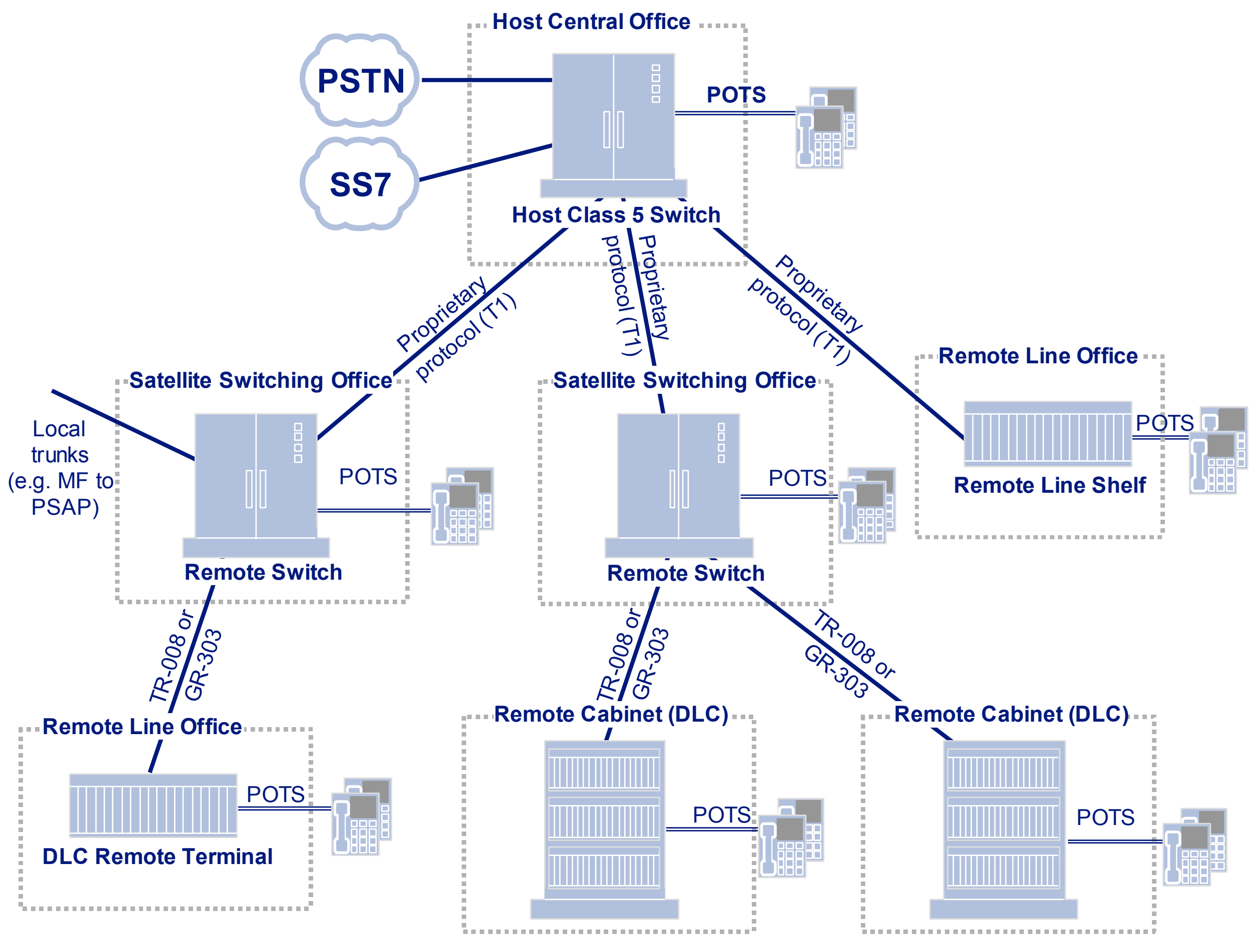

Figure 1: Example Legacy Host-Remote Network

2.1 REMOTE SWITCH

A remote switch operates under the control of the host in normal operation. Remote switches range in capability from basic to full-fledged Class 5s, but generally have the following characteristics.

- **Analog line termination**. A remote switch typically terminates subscriber lines directly.
- **Upstream trunking**. A remote switch has digital trunks connecting it to the host switch.
- **Off-switch or "side door" trunking.** In addition to its trunks to the host, remote switches may have either MF or SS7 trunk connections to other switches, including external (PSTN) connectivity or connections to other remote switches in the telephone company's own network.
- **Control of downstream DLCs.** Some remote switches can control downstream digitial loop carriers (see section 2.3).
- **Emergency standalone.** In the event that the umbilical to the host switch is lost, remote switches have an "emergency standalone" (ESA) operation mode. When operating in ESA mode, subscribers continue to receive dial-tone and are able to make calls within the switch's local calling area. This is particularly useful for enabling uninterrupted access to emergency (911) services.[*]

The connections between a host and its remote switches are typically proprietary, meaning that a remote switch must be purchased from the same vendor that provided the host. This "vendor lock-in" has resulted in restricted technology choices and may (at least in part) explain the high maintenance and upgrade fees associated with legacy equipment.

A remote switch may subtend other remotes in multiple levels. This has the advantage of extended network reach, but the disadvantage that too many dedicated "up and down" connections result in an inefficient network topology.

[*] The ability to perform standalone switching operations is also a crucial test for the National Exchange Carrier Association (NECA) categorization of a network purchase as a switch (and not simply a line termination device) – which has commercial implications for NECA members.

2.2 REMOTE LINE SWITCHING OFFICE

A remote line switching office contains a line shelf that terminates analog lines and operates under the control of its upstream switch (either the host or a remote switch).

Like a remote switch, a remote line shelf has emergency standalone switching capability. However, unlike a full remote switch it does not have any trunking capability. Therefore, in emergency standalone mode, it is only possible for subscribers to call other subscribers within the same end office.

2.3 DIGITAL LOOP CARRIERS

Like a remote line shelf, a digital loop carrier (DLC) terminates analog lines and converts them to digital signals (TDM) under the complete control of the host switch, without any trunk interfaces save for its connection to the 'upstream' switch. However, DLCs may be deployed in remote cabinets or offices, and do not generally have any standalone switching capability.

DLCs communicate to the host via proprietary or standard protocols such as TR-008 and GR-303 (or, outside of North America, V5.2). In addition to backhauling the access lines over TDM circuits, these protocols support operations, administration, maintenance and provisioning (OAM&P) to varying degrees. Depending on the protocol, over-provisioning of circuits is also possible allowing, for example, a single T1 (24 channels) to support 96 lines (using a 4:1 over-provisioning ratio).

3. ELEMENTS OF A NEXT GENERATION HOST-REMOTE NETWORK

3.1 ACCESS GATEWAYS / BROADBAND LOOP CARRIERS

Known variously as 'line access gateways', 'access gateways' or 'broadband loop carriers' (BLCs), the next generation remote terminal provides a one-for-one replacement of traditional DLCs and/or line shelves in a remote line switching center, with the choice of TDM or packet-based backhaul.

In addition to their voice line termination capabilities, BLCs often provide integrated DSLAM functionality and fiber termination (optical network terminal) allowing an upgrade path to Fiber-to-the-Premises (FTTP). Many BLC vendors offer, or are planning to offer, emergency standalone capability, as described in section 4.1.

BLCs may also integrate a small number of trunk interfaces – from 1 to 4 T1s per chassis – resulting in a flexible hybrid remote supporting line termination, broadband services and local trunking.

3.2 TRUNK GATEWAYS

Trunk gateways perform the job of converting from one transport type to another – typically from a packet network to a TDM network. When deployed in a remote C.O. in conjunction with an ESA Call Agent (see Section 4.1) they can perform all the functions of a traditional remote switch, with standalone switching capability including E911 trunks.

One test of a softswitch's openness is the ability to work with such gateways from different vendors. This is more than an academic exercise, as there becomes an increasing gulf between the vendors whose core strength lies in software for call control and subscriber services, and the commoditization-driven hardware business – much as the first generation of word processors have been replaced by software from one vendor running on industry-standard PC hardware from another.

Figure 2: A Trunk Gateway (MetaSwitch MG3510)

3.3 CALL AGENTS AND SIGNALING GATEWAYS

In a softswitch network, a Call Agent contains the call processing logic, together with subscriber configuration information that allow it to process calls and deliver services. Unlike a traditional Class 5 switch, where this capability is embedded in the same hardware as the physical interfaces, the Call Agent is typically implemented on a separate network entity, although it may also be integrated with the media gateway into a single chassis. Industry-standard servers are typically used in preference to chassis-based designs, for their higher performance, lower cost and greater ease of maintenance.

Figure 3: A Call Agent Server (MetaSwitch CA9020)

When considering the host-remote architecture, the Call Agent is a key component, since it contains the "intelligence" that has to be distributed around the network in a resilient, yet easily managed, way.

Call Agent servers are typically deployed in an active-passive mated-pair configuration, with a "primary" replicating state changes to a "backup". To be carrier-class, such configurations should ensure they present a single IP address to the rest of the network, so that a switch-over from primary to backup is transparent to all the gateways and other IP endpoints (otherwise a switch-over results in a storm of messages that will flood any sizeable carrier network).

Since the Call Agent is responsible for connections to other switches and the PSTN, as well as to subscribers, it needs to interface to the signaling network. Part of this functionality resides in the Call Agent software, with the physical 'Signaling Gateway' interface typically being a blade in one or more Media Gateways, or a standalone entity. It is also possible for it to be hosted on a T1 card in the Call Agent itself – but this restricts network design since it means that signaling links (which might be needed in various places in the network) must be homed in the same location as the Call Agent (which is typically hosted in a single central location).

4. OPEN PACKET HOST-REMOTE ARCHITECTURE CAPABILITIES

In section 2, we saw that the key capabilities delivered by traditional host-remote networks are:

- remote line (and, in some scenarios, trunk) termination, across a large geographic area
- emergency standalone of remote sites
- centralized call control and management.

Having outlined the elements of a next generation network in section 3, we now look at how such a network can deliver an open packet host-remote architecture – and the new, enhanced capabilities that it brings.

4.1 MULTI-LEVEL EMERGENCY STANDALONE

A traditional host-remote network has one level of emergency standalone – the remote switch, when separated from the host, can continue to provide limited switching capabilities to subscribers from the same office. In a softswitch network, additional levels of ESA become possible.

BLC Standalone

- BLC vendors are implementing standalone functionality so that, if the BLC loses connectivity to the Call Agent, it will continue to provide basic switching within its chassis. Many major access vendors are working with MetaSwitch to enable seamless configuration of the BLC's ESA capability, so that service providers need only provision subscribers (for both normal and ESA operation) at the switch level.

Access/Trunk Gateway Standalone

- An "ESA Call Agent", shown in Figure 4, extends the single backup Call Agent to multiple instances across the network. A low-cost industry-standard server takes over the switching responsibilities for the isolated area. A key requirement for the ESA Call Agent is that it continues to serve all subscribers – whether on GR-303 DLCs, IP BLCs, Integrated Access Devices, or IP phones. (MetaSwitch's ESA Call Agent is planned for 2006.)

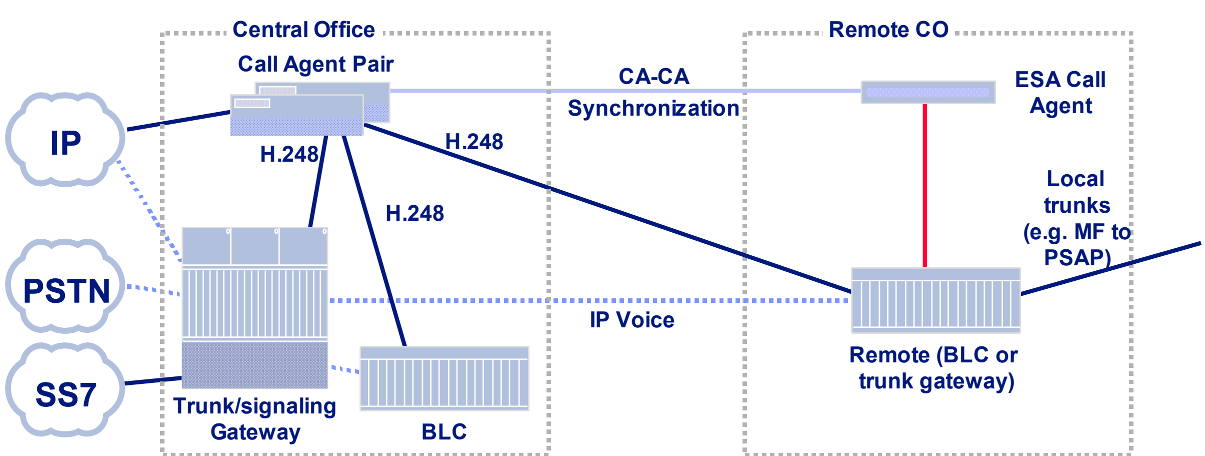

Figure 4: An ESA Call Agent in a Next Generation Network Remote Office

Remote Softswitch

- For some deployment scenarios, integrated standalone softswitches (Call Agent and Media Gateway together) deployed in multiple locations are the preferred option. Provided the softswitch platform capabilities are sufficiently advanced, this division of the network into multiple Call Agent domains can be made to work as well in practice as a network with a single centralized Call Agent. The following softswitch characteristics are key to the success of such an approach.

  - Integrated STP and SS7 point code proxy functionality (see section 5) allow the remote switches to share a single SS7 A-link and point code of the host.

  - An intelligent management system ensures that all administration can be streamlined from a central location. For example, when changing the configuration of a particular phone line, the MetaSwitch EMS allows the operator to simply enter the directory number, without having to specify the switch on which it is located (providing it is in the EMS server's management domain).

  - Both IP (SIP) and TDM trunking can be configured between the separate switches. Thanks to advanced routing algorithms, all the network convergence benefits of a centralized Call Agent are then possible.

  Such a configuration, shown in Figure 5, addresses the question of Emergency Standalone by each site having independent switching function all the time, so it is not impacted by loss of the host (other than any signaling links or trunks routed through that host).

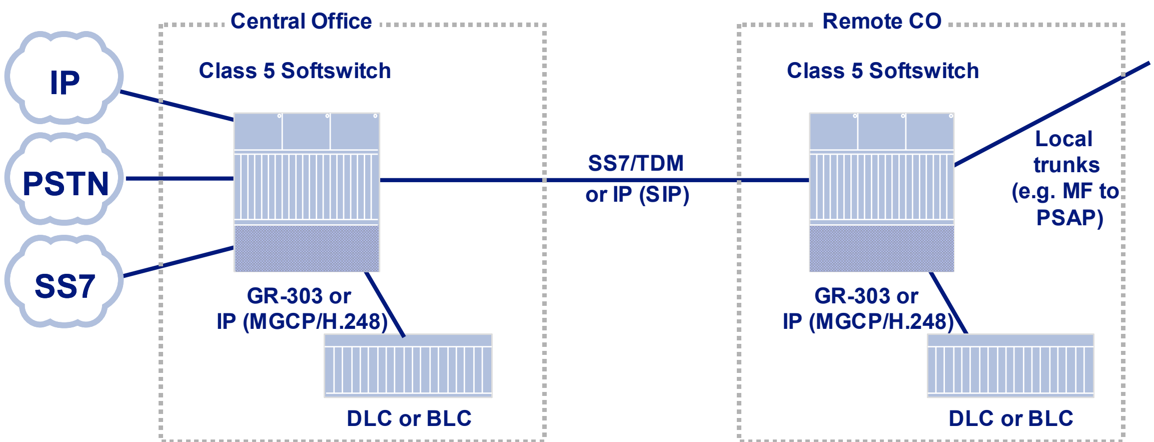

Figure 5: A Remote Standalone Softswitch

The above strategies give much greater flexibility that traditional host-remote networks to tailor the ESA design to match the network requirements, by allowing functionality to be gradually degraded as particular network resources go offline – rather than a simple "all or nothing" approach. This is particularly valuable as it allows a carrier to tune to level of ESA provided for each location according to the level of network redundancy at that site and the local regulatory (e.g. municipality or PUC) requirements.

4.2 CONNECTIONLESS TRUNKING

In a traditional network, trunks between a host and its remote consist of dedicated circuits, as shown in Figure 6. Each circuit has a specified origination and destination, and can only be used for that exact route. This leads to networks that have built-in, unavoidable inefficiencies and management overheads.

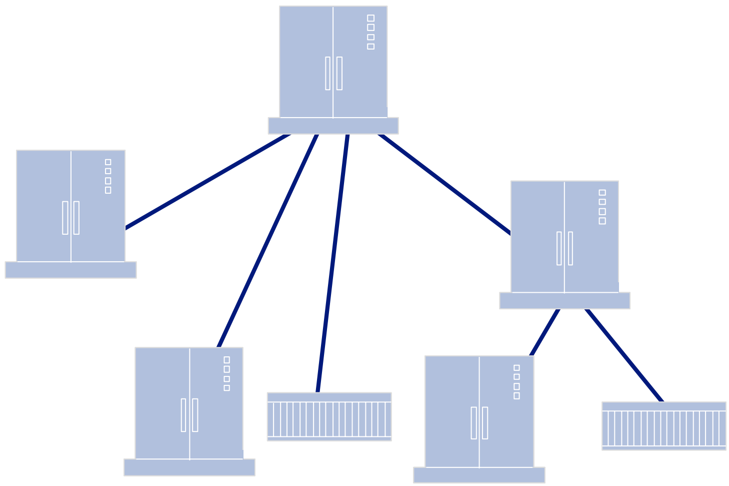

Figure 6: A Connection-oriented Legacy Switching Network

The use of packet trunking between softswitches separates the establishment of temporary point-to-point connections from the management of the network bandwidth, as shown in Figure 7.

In the real world, packet trunking across a carrier network is not as simple as designing a small office Ethernet LAN. Underlying the seemingly flat packet network are in fact a combination of point-to-point trunks, different transport technologies, and gateways that terminate specific TDM links. Any softswitch solution has to take this into account. For example, MetaSwitch allows preferences (weighting) to be applied to particular routes/destinations, and also will not decide where to route the IP traffic to a trunk gateway (even to a specific card within that gateway) from an endpoint until it knows the TDM trunk for which it is destined.

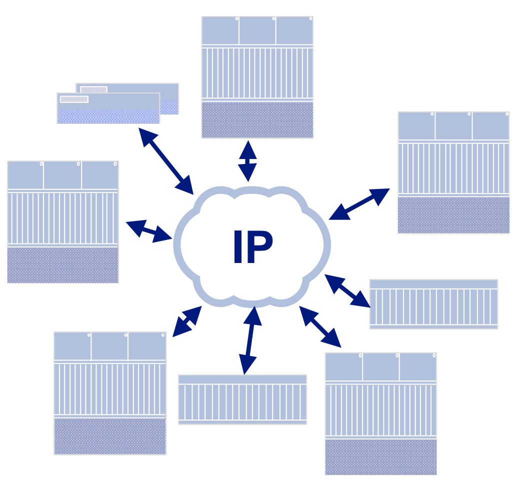

Figure 7: A flat "connectionless" network structure using IP trunking between sites

4.3 DISTRIBUTED PSTN TRUNKING

As was mentioned above, there are likely to be multiple signaling links and trunks brought into a network on multiple media gateways. A well-designed softswitch is able to make use of any of these links, depending on availability (with defined rules of precedence), wherever they are located in the network.

This enables remotes to support trunking (ISUP, MF, PRI or even SIP) at the local end office level, while having the ability to fall back to trunks on other remotes, or the host, in the event that the local trunk connectivity is lost.

4.4 HOST SITE REDUNDANCY

Traditional Class 5 switches offer very high levels of reliability – and have to, because they are a single point of failure in the network. This aspect of their design is highlighted when an entire host CO is lost – for example, due to fire, terrorist action (such as the September 11, 2001 attacks on the World Trade Center towers) or severe weather (such as hurricanes experienced across many states in the Southeast). In such catastrophic scenarios, service might be affected for days or weeks until an entire new switching center can be reconstructed.

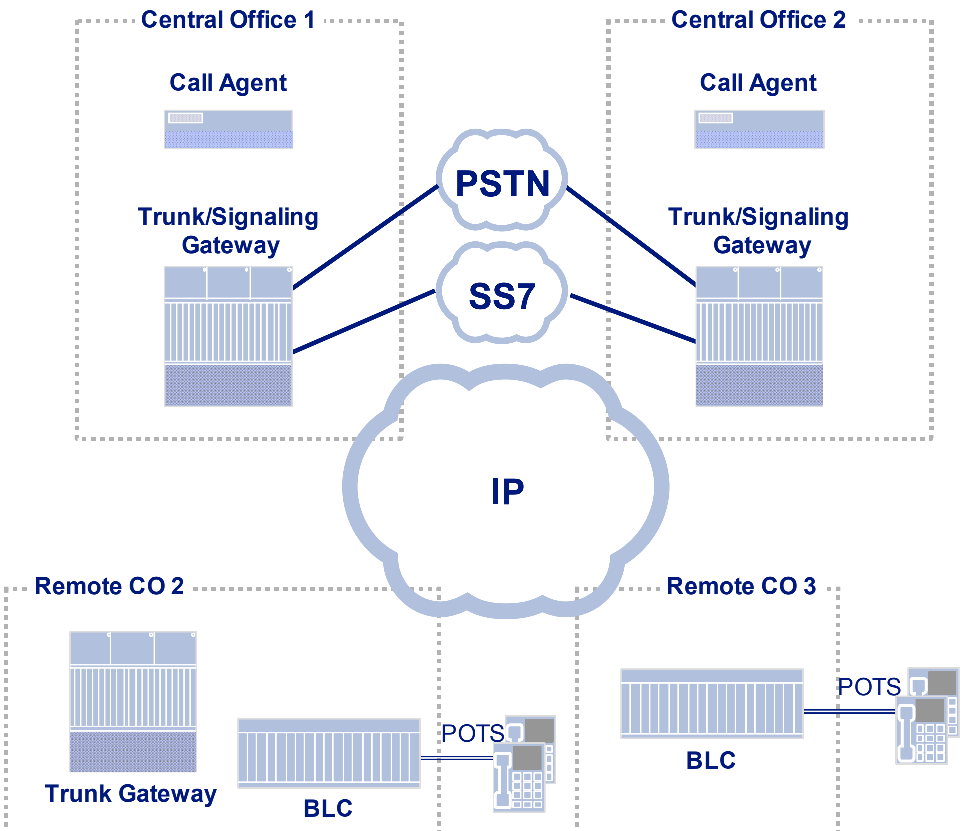

Figure 8: A Site-Redundant Host Configuration

An open softswitch architecture allows service providers to distribute the traditional monolithic host switch across multiple geographic sites, any of which can be taken out of the network without disrupting service to subscribers. For example, in Figure 8, either Central Office 1 or Central Office 2 could be taken out entirely, and the subscribers served from the remote offices would not lose service.

4.5 OPEN INTEROPERABILITY

As mentioned earlier, one test of a truly open softswitch architecture is whether Call Agents from one vendor can interoperate with trunk gateways and BLCs from another vendor. That statement naturally extends to the ESA capabilities. For example, MetaSwitch works closely with hundreds of different pieces of gateway and access equipment to ensure ongoing interoperability, which includes the ESA Call Agent and BLCs' native ESA features.

4.6 CENTRALIZED MANAGEMENT

In an open packet host-remote network, call processing is located in a central call agent, greatly simplifying the configuration of the network. In effect, the entire network, which might have comprised dozens or even hundreds of separate legacy switches, can become a single "virtual switch", making management easier and reducing operating expenses.

4.7 COMPACT FOOTPRINT / LOW POWER

A key benefit of next generation switching technologies is the smaller footprint and lower power requirements. For example:

- The MetaSwitch CA9020 call agent server is just 2 rack units high, yet has sufficient processing power to handle the call load of a network of 200,000 subscribers.

- The MetaSwitch MG3510 media/signaling gateway chassis is just 12 rack units high, and scales in capacity from 16xT1 to 42xT3. Even when fully loaded, it consumes only 1500W – or about 1 Watt per 100 subscribers[*]!

This opens up whole new possibilities for where systems can be located, and makes possible "overlay" deployments, where new switches are deployed alongside existing ones. Such deployment strategies are discussed further in the next section.

[*] Calculation assumes 28,000 concurrent call chassis with 140,000 subscribers (5:1 oversubscription).

5. HOST-REMOTE MIGRATION STRATEGIES

5.1 REMOTE CO BLC

Driven by the need to offer high-bandwidth services to subscribers, many service providers elect to migrate to a packet-based network starting at the edge, with a broadband loop carrier. These typically support both TDM (TR-008 or GR-303) and IP (MGCP, H.248, or SIP) switch interfaces, allowing them to be deployed initially alongside a legacy switch and migrate to a softswitch architecture. However, where upgrades are required to the existing switch for additional capacity or, for example, to add support for GR-303, it is likely to be more cost-effective to deploy a softswitch at the same time.

5.2 HOST SWITCH OVERLAY

In this scenario, a softswitch is deployed in the central office alongside the existing host Class 5 switch. The new softswitch typically takes over the SS7 links (and possibly also PSTN trunks) from the existing switch and, acting as an STP and/or tandem, provides connectivity to the rest of the network.

Figure Figure 9 and Figure 10 show a legacy network before and after the deployment of a softswitch using this model.

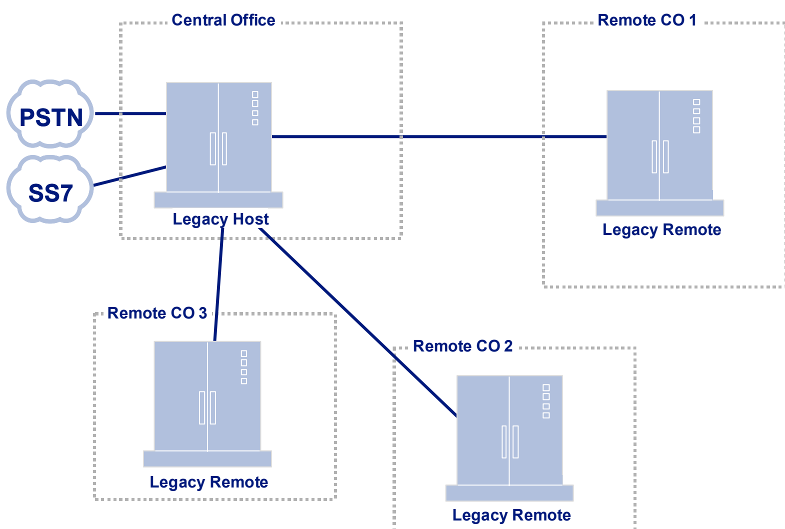

Figure 9: A Legacy Network with 3 Remote Sites, Before Softswitch Deployment

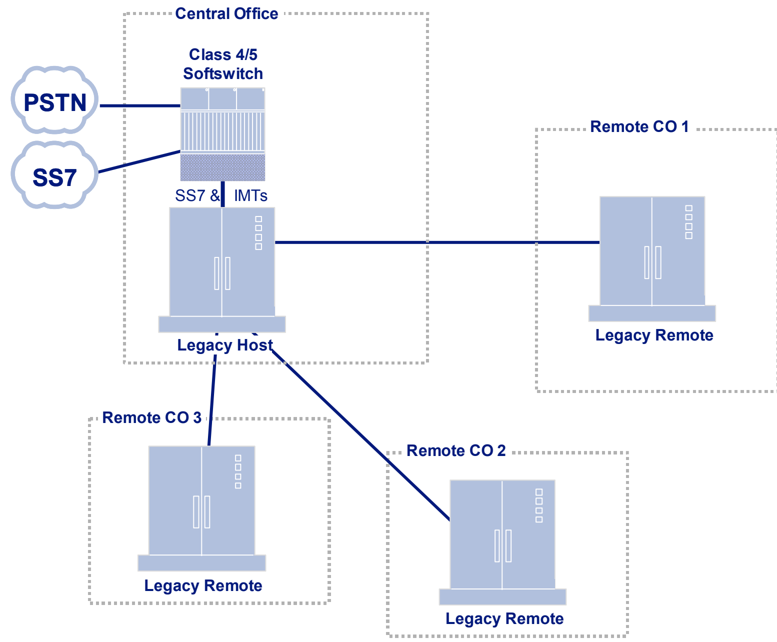

Figure 10: Legacy Network After Host Overlay Softswitch Deployment

Note that a softswitch designed for this type of application should be able to act as an "SS7 point code proxy", taking over the old switch's point code and communicating to it on a private SS7 address (point code). The rest of the network then sees no change when the new softswitch is deployed – but the service provider can migrate subscribers to new softswitch-hosted services, and remote COs to an open packet-based architecture as shown in Figure 11. (In this particular example, the integrated softswitch deployed for the first stage is migrated to a distributed call agent / media gateway architecture as remote media gateways are brought into the network.)

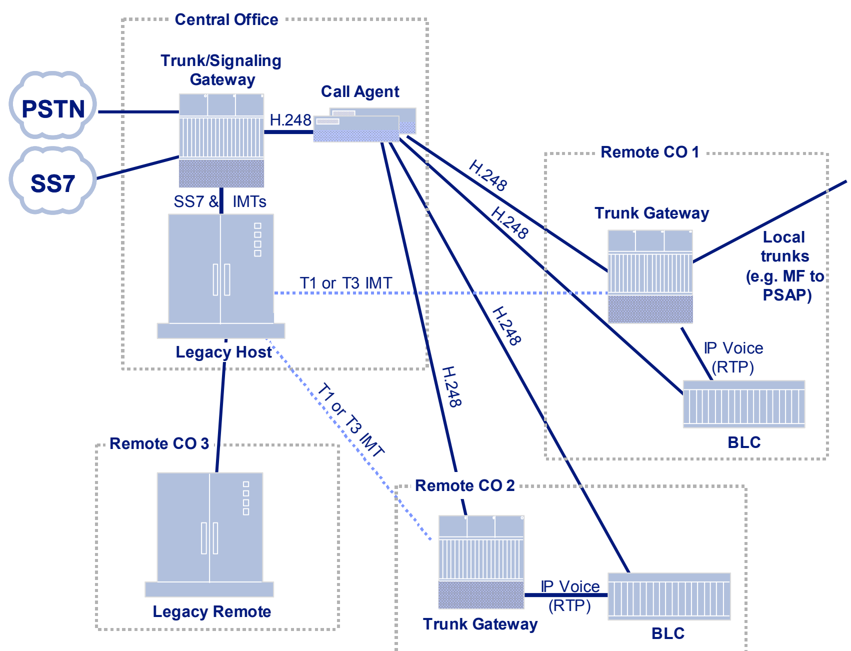

Figure 11: Host Overlay Network with Two Remote Offices Migrated

5.3 REMOTE SWITCH OVERLAY

In this overlay scenario, the host and most remotes are retained in the network, and one CO is selected to “cap and grow” with a softswitch, but retaining existing DLCs. This requires the softswitch to support the appropriate DLC protocol (e.g. GR-303).

SS7 F-links and trunks are provisioned from the new softswitch remote back to the legacy host (or, if this is not possible, a separate set of A-links and/or trunks must be provisioned to the PSTN). This could be a standalone softswitch (as shown in Figure 12) or a media gateway controlled by a centralized call agent, depending on the ultimate target architecture.

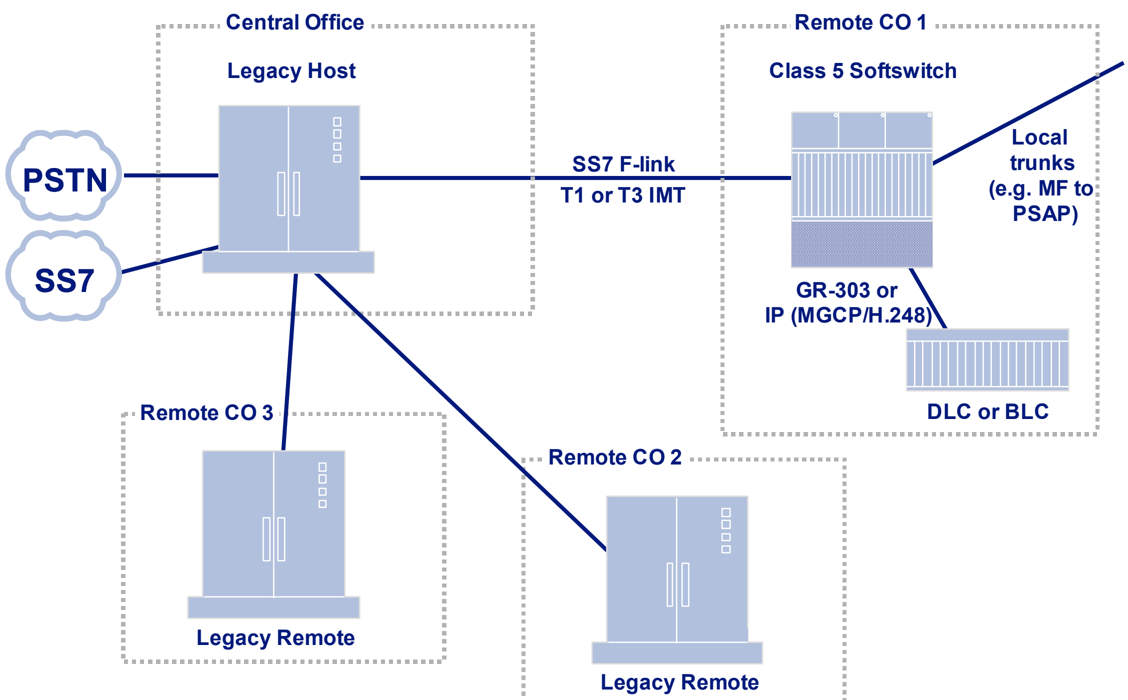

Figure 12: Replacing a Single Remote with a Softswitch

Over time, more COs can be replaced (either with standalone softswitches, or a distributed architecture controlled by a central call agent, as shown in Figure 11) until the service provider is ready to remove the legacy host entirely.

5.4 TO COLLAPSE OR NOT TO COLLAPSE?

For many providers, a significant benefit of distributed softswitch technology is the ability to “collapse” the network – that is, take an existing network of multiple switches and replace it with a single “virtual switch” consisting of a call agent and multiple media gateways.

However, service providers should be wary of any solution that forces them down this route. While a network consisting of a single virtual switch has many technical benefits, there are also reasons why some deployments will stick with a looser-coupled network of independent standalone softswitches.

- Commercial considerations – such as collocation requirements or NECA settlements.
- Limited or unreliable IP bandwidth between sites. A call agent – media gateway connection requires an IP connection for control, with specific bandwidth requirements. For some remote locations where IP connectivity is an issue, it may therefore make sense to have a separate standalone switch.

As mentioned in Section 4.1, even in the case where separate switches are deployed, a well-designed softswitch solution should provide an Element Management System interface that merges the entire network, and hides the underlying complexity from the user.

6. ABOUT METASWITCH

As a division of Data Connection, MetaSwitch leverages over 23 years' experience supplying communications technology and support to leading service providers including Verizon, SBC and BT, and major equipment vendors including Cisco, Lucent, Nortel and Siemens.

Our unparalleled expertise is derived from success developing world-leading products including the core protocols (MGCP, Megaco/H.248, MPLS, IP Routing, SIP, …), applications (unified messaging, conferencing, …) and next generation switching technology (MetaSwitch Class 5 Softswitch). The MetaSwitch Class 5 softswitch is easy to deploy and enables carriers to deliver reliable, toll-quality packet and TDM services in the access and backbone networks, with a full range of Class 5 subscriber services, Class 4 capabilities, and wide interoperability.

Data Connection is a relentlessly profitable and stable private company, creating a basis for long-term investment and growth that ensures our ability to fund ongoing product investment and deliver first-class customer support.

MetaSwitch has offices in Alameda (California), Dallas (Texas), Tampa (Florida), Reston (Virginia), and Enfield (North London), Chester and Edinburgh in the UK.

For further information on how MetaSwitch can help service providers implement a successful host-remote migration strategy, visit **www.metaswitch.com**.

7. CONCLUSION

For many years, legacy host-remote architectures have successfully solved the problem of reliably delivering service to subscribers spread across a large area. However, they were not without their disadvantages – the network inefficiencies inherent to dedicated TDM links, and most importantly the vendor lock-in that results from proprietary solutions.

For service providers seeking to exploit the advantages of a converged network and next generation softswitch technologies, it sometimes seems as if the baby has been thrown out with the bath water, and the lessons learned from the success of legacy host-remote systems have been lost. The opposite is the truth: the leading softswitches on the market today do support host-remote operation, and the best of them in fact address a number of shortcomings of the legacy systems.

Migrating from an existing network to an open packet-based host-remote architecture without compromising functionality or reliability is entirely possible today. And, as has been demonstrated, this migration can be implemented in easy-to-manage steps so that service providers can adopt the technology, and deploy the new services it enables, at a pace that suits them.

GLOSSARY

BLC	*Broadband Loop Carrier*
CO	*Central Office*
COT	*Central Office Terminal*
DLC	*Digital Loop Carrier*
DSL	*Digital Subscriber Line*
ESA	Emergency Standalone
GR-303	A digital signaling protocol used between DLC and Class 5 switches in North America
H.248	An ITU protocol for media gateway control, also known as Megaco
ISDN	*Integrated Services Digital Network*
ISUP	*ISDN User Part*
Megaco	An IETF protocol for media gateway control, also known as H.248
MF	*Multi-Frequency*
MGCP	*Media Gateway Control Protocol*
OLT	*Optical Line Terminal*
ONT	*Optical Network Terminal*
POTS	*Plain Old Telephone Service*
PRI	*Primary Rate Interface*
PSTN	*Public Switched Telephone Network*
RT	*Remote Terminal*
RTP	*Real Time Protocol*, a media-bearing protocol for Voice over IP
SIP	*Session Initiation Protocol*
SS7	*Signaling System 7*
TDM	*Time Division Multiplexing*
TR-008	A digital signaling protocol (widely replaced by the more efficient *GR-303*) used between DLC and Class 5 switches in North America
V5.2	A digital signaling protocol used between DLC and Class 5 switches outside of North America

