High availability is at the forefront of the service provider's selection criteria for routing systems. It is a requirement that has become more critical due to the unprecedented growth of IP services and their increasing use for mission-critical services. Alcatel has been investing in and delivering high availability routing and signaling solutions for several years. This paper discusses high availability routing options and how Alcatel's advanced offerings diminish vulnerability and alleviate the effect of a lengthy outage on IP networks.

PSTN Modernization in a Broadband Access Network

The way voice services are delivered to end users is changing at the same time as fixed line operators are faced with the declining profitability of their cash cow: voice services. Operators are focusing their investment on broadband networks capable of offering services that generate new revenues and differentiate them from their competition (e.g., IPTV, next-generation communication services). New access networks must enable new and legacy voice services, reduce the cost of operations and still allow for aggressive build-out of broadband subscriber coverage. Only IP/Ethernet-based access can assure all those aspects at once. The ISAM platform makes this possible with unequalled network topology, flexibility and PSTN-class quality enhancements.
**EXECUTIVE SUMMARY**

In countries with a saturated fixed voice market, the revenue from public switched telephone network (PSTN)-based voice services is declining at a rapid pace resulting from subscriber churn to mobile services and cheaper long distance using voice over IP (VoIP) alternatives. At the same time many PSTN networks are becoming obsolete. Operators need to have a plan to keep their service running smoothly while spare part inventory is running low and while they migrate their voice services to a new voice access network. The net result of this is the quickly deteriorating profitability of the PSTN.

The investment in a new PSTN has to be combined with an investment in the two clear growth areas for fixed line operators: broadband access and video service networks. The transformation of the high-speed access network into a fiber-rich IP/Ethernet-based access network supporting voice, data and video services is high on the agenda for many fixed line operators.

Combining both the migration from traditional voice to next generation networks (NGNs) with the rollout of a fiber-rich IP/Ethernet-based triple play access network is the only economically viable option for many operators. A fully converged access network results in operational savings, while the operator only need invest in one network instead two diverging networks.

The Alcatel intelligent services access manager (ISAM) family is a native IP/Ethernet platform for fully converged triple play broadband access. The ISAM voice package extends this platform to support legacy voice services. With it, Alcatel is the first equipment vendor to offer an IP broadband access family enabling operators to deploy fully converged next generation access networks.
# TABLE OF CONTENTS

**Why Operators are Modernizing the PSTN** ............... 1
- Ensuring Voice Services Stay Profitable in the Long Run .......... 1
- PSTN Obsolescence Is Imminent .......................... 1
- Consolidating PSTN CO Locations .......................... 1
- New Broadband Triple Play Pushes Operators’ Investment .......... 1

**The Way Out: Converging Voice and Data Access** ........... 2
- One Investment to Cover Both Needs .......................... 2
- IP/Ethernet as Target Platform ............................... 2
- Gradual Migration of PSTN Services to the Broadband Access Network .......... 2

**The ISAM for PSTN Modernization** .......................... 4
- The ISAM Philosophy ...................................... 4
- Gradual PSTN Migration with the ISAM Family .................. 4

**ISAM Architecture for Voice** ................................. 6
- ISAM Voice Package Components and Key Features .............. 6
- ISAM Voice Package in the NGN End-to-End Solution ............ 6
- Flexible Gateway Architecture for All Network Options .......... 8
- Carrier-Class PSTN over IP Networks .......................... 8
- Key ISAM Benefits When Deploying PSTN Services .............. 9

**Summary** ...................................................... 9
Why Operators are Modernizing the PSTN

ENSURING VOICE SERVICES STAY PROFITABLE IN THE LONG RUN
Three distinct factors have caused PSTN-based revenue to shrink steadily over the last few years:
> Decrease in the number of conversation minutes per subscriber (mainly as a result of mobile competition)
> Decrease in the average price per minute (as a result of competition from fixed carriers)
> Decrease in the subscriber base (as a result of churn to mobile-only or to competitive operators)

In addition, the operating costs remain flat at best, with a trend to grow as the network becomes older and obsolete. There will be a point in time when the operating cost of running the network can no longer be justified based on the revenues that the network is generating.

PSTN OBSOLESCENCE IS IMMINENT
Many operators have invested in time division multiplexing (TDM)-based systems over the last 30 years — either narrowband digital loop carriers (DLCs) or PSTN switches. Some of these networks are reaching the end of their life, resulting in a lack of spare parts and a lack of a competent workforce to operate the equipment.

It is clear that a gradual replacement of these networks should be planned to make sure that in the future voice services can continue to be guaranteed with acceptable quality.

CONSOLIDATING PSTN CO LOCATIONS
NGN network architecture offers an opportunity to reduce the number of manned voice central office (CO) locations to a minimum.

The tendency to move out of the CO with broadband access equipment to support higher bandwidths (e.g., with VDSL2) has led several operators to rethink their network design. They are now looking at designs based on many small unmanned locations in cabinets and few larger, manned COs with softswitches.

From an operational point of view this allows a reduction in the cost of operating voice networks. In addition, operators can sell or reduce in size many locations (sometimes valuable real estate located in high-cost business districts and downtown areas), generating a cash inflow that can be used to further invest in core activities.

NEW BROADBAND TRIPLE PLAY PUSHES OPERATORS’ INVESTMENT
The fixed operator’s key strategic focus is the rollout of a triple play-capable broadband access plant to:
> Offer services that can offset the revenue loss from the voice service (e.g., Internet protocol television [IPTV], video-on-demand [VoD])
> Stay competitive against competitors based on cable and/or local loop unbundling (LLU)

With this focus in mind, operators worldwide are looking at alternative communication services, driven by two basic needs:
> Push new services with higher average revenue per user (ARPU) for voice, rather than investing in replacing a black phone
> Formulate a defense strategy against new forms of communication that are modifying end users’ expectations, and so avoid churn from:
  ¬ cheaper voice offered by entrants that only buy VoIP
  ¬ added service offers: integrated communications, integrated directory, buddy lists, gaming, conference calls, web-based service self-profiling, etc.
  ¬ bundling with other services such as video or high-speed Internet (HSI)

The increasing demand for these services is expected to generate a continuous subscriber migration from the traditional PSTN to packet-based service-aware networks capable of delivering the new service offer. The majority of operators today are already focusing their infrastructure investment in these new networks.
The Way Out: Converging Voice and Data Access

**ONE INVESTMENT TO COVER BOTH NEEDS**
Voice migration is not the only large investment in fixed access networks today. Most fixed line operators are heavily investing in building out a broadband access infrastructure for high-speed data and video services.

Given the restricted amount of resources available and given the fact that most operators are moving toward a converged access network, it does not make sense for them to balance the investment between their voice migration and the broadband access projects.

Every euro cent spent on migrating the voice access network should result in the creation of a broadband access footprint and every euro cent spent in broadband access should allow the voice lines to be migrated to NGN later on.

**IP/Ethernet as Target Platform**
Operators around the world have agreed that IP and Ethernet technologies will be the technologies to enable new services and, as such, they are also the appropriate ones to converge the legacy services on NGNs.

Different ways to migrate the PSTN to VoIP are available in the market. All of them are intended to accelerate the convergence of the core network, anticipating the (smooth) subscribers’ adoption of new IP telephony (PC or session initiation protocol [SIP] terminal-based), and all of them are supported by products available in the Alcatel portfolio:

> Analog telephone adapters (ATAs) allow connection of traditional phones to broadband access lines. They are a good solution for broadband subscribers willing to sacrifice some of the plain old telephone system (POTS) benefits (such as lifeline or home wiring flexibility) in exchange for low-cost PSTN. However, this is not a cost-effective solution for mass migration of PSTN subscribers into the converged core.

> Access Gateways (AGWs) adapt the TDM links of PSTN concentrators or local exchanges into the NGN. They can help to reuse existing access far from the end of life, but they extend the coexistence of separate networks for each type of service. They are, therefore, not economical for network extensions or plant modernization.

> The so-called NGN DLCs or 3G DLCs combine a traditional TDM cross-connect for legacy services with a broadband switch with ATM and Ethernet uplinks. They are NGN-oriented, because they incorporate IP multicast capabilities for video delivery and a VoIP server gateway for PSTN emulation on a converged network. They may be a good idea for the few operators who wish to continue to grow their PSTN subscriber base before they effectively eliminate their local exchanges, which can be done later.

> IP/Ethernet broadband access platforms (IP BAP) are the fastest way to eliminate the growing cost and shrinking revenue of the PSTN. They aggregate all kinds of service lines, including legacy subscriber interfaces, from IP-enabled line cards aggregated at a Gigabit Ethernet (GigE) core. This approach ensures minimum delay for voice, minimum cost regardless of the service mix, the same operations for any service, and pure IP/virtual LAN (VLAN) quality of service (QoS) control end to end. Optional servers can interface legacy aggregation networks in the transition.

Figure 1 compares a converged access system that is natively built on IP technology with integrated access built on a diversity of different access nodes.

If all of the systems can be used in a fully converged IP/Ethernet network with an NGN softswitch, there is still the need to over-invest in overlaid networks and manage different technologies, which increases the operating cost. The end result is not a fully converged network.

A better practice is to deploy access nodes based on the target IP/Ethernet platform and add functions that support the different legacy requirements. If this is done, the operating cost and capital cost will decrease each time one additional step is taken to migrate legacy services on the IP/Ethernet platform. At the end of the migration cycle, the result of this strategy will be a fully converged network.

**Gradual Migration of PSTN Services to the Broadband Access Network**
The only profitable way of migrating from PSTN to NGN is gradually, taking into account the different investments made in voice and data networks.

Different migration steps should be taken (see Figure 2):

> Introducing new VoIP services based on a VoIP home gateway, replacing the legacy PSTN line
> Replacing obsolete PSTN equipment, typically with PSTN and NGN support in broadband access nodes, which prevents continuing spending on the PSTN
> Modernizing the PSTN when renewing access plant for video or bandwidth-hungry services:
  - by using FTTU in greenfield deployments and delivering the POTS/ISDN line from the optical network terminal (ONT) (e.g., NTT, SBC, Bell Canada, Telstra, Austria Telecom)
by deploying video-capable access, including remote fiber to the node (FTTN), provided with POTS/ISDN interfaces (e.g., Bell South, KPN, Swisscom) or customer premises equipment (CPE)-based voice gateways.

> After the previous actions a minority of voice-only subscribers will remain connected to the PSTN with a basic service demand. At this point in time, modernizing these lines with PSTN simulated services will have a positive business case just based on operating expenditure (OPEX) savings.

By ensuring that the access platform of choice supports each of these different stages in the PSTN migration, operators will significantly lower the capital expenditure (CAPEX) and OPEX associated with an NGN transformation.
The ISAM for PSTN Modernization

THE ISAM PHILOSOPHY
Alcatel developed the Intelligent Services Access Manager (ISAM) family of products with four key factors in mind:

> Native IP/Ethernet platform
  - all features implemented on a wire-speed IP platform
  - native IP QoS with strict priority for voice and video services
  - all legacy protocols translated to IP packets on a line card level (e.g., POTS services)
> Capable of 100 percent triple play deployment:
  - IPTV, VoIP and managed communications
  - with full topology versatility for coexisting CO, remote units or fiber to the user (FTTU). This allows the operators to bring fiber to the most economical point, using different deployment architectures for greenfield, copper rehab or copper reuse.
  - no internal bottlenecks delivering gigabit capacity per line card, and incorporating GigE and 10 GigE aggregation and high-capacity subscriber lines (ADSL2plus, VDSL2)
> Able to scale operations: moving from mere subscriber provision/deprovision to service subscription over a growing variety of services:
  - proliferation of operator home equipment requires home network management
  - access, network and service platform management for integrated end-to-end provisioning and supervision with appropriate operations support system (OSS) support
  - network analyzer for diagnosis and test
  - help desk and customer service infrastructure
> Able to support legacy: ATM aggregation, PSTN services, special services via SHDSL CPE

GRADUAL PSTN MIGRATION WITH THE ISAM FAMILY
The ISAM family gives the operator a flexible mix of network topologies according to the video delivery needs. On top of that, it offers the ability to deploy a network ready for PSTN and VoIP subscriber lines. This potential can be commissioned at a later time, when the operator determines that OPEX savings will be worthwhile.

Thus, the NGN path can be walked in a stepwise manner, as the different service demands support the economics of the deployment:

1. All operators are offering or about to offer VoIP as an alternative telephony offer: second line flat rate, videoconferencing, integrated multimedia (messaging plus conferencing), self-service profiling, etc.

> The Alcatel ISAM family offers superb QoS by reserving a separate Layer 2-specific queue for voice, with strict priority over any other service, guaranteeing minimum transfer delay. In addition, it offers optional IP forwarding at DSL line termination (LT) level, supporting Layer 3 priority (DiffServ).

2. The necessary investment can be leveraged to enable a lower cost modernization of the obsolete PSTN or to lower OPEX (unified training, network management, spares and software upgrades for broadband and narrowband, and simpler bundled service offer with customer self-profiling options).

> The ISAM family is designed to support video penetration in flexible deep-fiber scenarios for optimum reuse of copper plant, and subscriber reach with high capacity. The ISAM family also supports, over the same platform, the deployment of legacy PSTN interfaces to facilitate network convergence without subscriber offer discontinuity.

3. As PSTN infrastructure becomes amortized, obsolete, or difficult to maintain, the operator will face the to need sporadically replace some local exchanges or remote switches with new equipment, or pay very high maintenance costs to keep them alive.

> The ISAM family offers cost-effective extensions for PSTN-only interfaces to replace complete exchanges or TDM access.

4. The last step is to fully converge to reduce OPEX (no more need for TDM equipment operation) of the remaining installed base. At some point in time, OPEX savings will justify the replacement of even the newest local switches and TDM access.
The Alcatel ISAM family consists of:

> Stand-alone DSLAMs of medium/large size such as the Alcatel 7302 ISAM, or small size, such as the Alcatel 7330 ISAM Fiber-To-The-Node (FTTN), ideal for integration in street cabinets. Both of them can directly interface the aggregation network, or be stacked for traffic aggregation. They incorporate four upstream and downstream priority queues for different services both at the line card level and at the aggregation level. Strict priority to voice service is ensured by a dedicated queue.

> Subtended from any of them, the remote expansion module (REM) or sealed expansion module (SEM) units allow extensions with higher capillarity. Both products are line card extensions that allow the shortening of the copper loop for a limited number of subscribers. The SEM is an environmentally hardened module for pole or wall mounting to be used with multiple dwelling units (MDUs), and the REM is an indoor module ideal for fiber-to-the-building (FTTB).

> For greenfield deployments or where copper rehabilitation is needed, the Alcatel 7342 ISAM Fiber-to-the-User (FTTU) is a system with the same capabilities as the 7302 ISAM, but specialized on gigabit passive optical network (GPON) LTs for fiber loops down to a variety of residential and business ONTs.

Figure 3 - The Alcatel ISAM Family

1. Introduce VoIP over broadband services  
   - Strict priority QoS to guarantee delay/jitter

2. Converge during deep fiber rollout  
   - Voice gateway in CPE/CO/OSP

3. Replace obsolete PSTN  
   - PSTN only to re-use existing broadband investment  
   - H.248/SIP gateway to ensure feature parity

4. Converge remaining PSTN on broadband  
   - PSTN only to re-use existing broadband investment

<table>
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<tr>
<td></td>
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<td>ONTs</td>
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<td>FTTU</td>
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ISAM Architecture for Voice

ISAM Voice Package Components and Key Features
As shown in Figure 4, the main components of the ISAM Voice Package are:

> An IP voice packet server (IVPS) that interfaces with the NGN softswitch through a Megaco/H.248 signaling interface
> New line termination (LT) boards to interconnect with POTS lines (POTS-only LT [POLT] card) or ISDN lines (basic access LT) [BALT] card
> Combo boards to provide POTS and any digital subscriber line (xDSL) from a single port (48 ports/slot)
> Pre-cabled shelf for combo lines, which maintains service mix flexibility but delivers voice and xDSL service to the same subscriber, reducing the number of connections among shelves and the main distribution frame (MDF)

> Architecture compatible with the standards under preparation by 3GPP and ETSI on IP multimedia subsystem (IMS) and Telecommunications & Internet Converged Services & Protocols for Advanced Networks (TISPANs); ready for flexible evolution compatible with the top level trends of these workgroups

ISAM Voice Package in the NGN End-to-End Solution
The ISAM Voice Package integrates with the rest of the Alcatel portfolio to offer end-to-end solutions for the NGN (see Figure 5). Layered on other Alcatel portfolio products intended for PSTN growth or PSTN legacy migration, such as the Alcatel 1540 Litespan or the Alcatel 1000 Line Gateway (LGW), the Voice Package positions the ISAM family as the access gateway for NGN deployments focused on the immediate introduction of triple play services. The ISAM is the optimum product for triple play NGN access in multivendor solutions where the softswitch is provided by a third-party vendor.

Figure 4 - ISAM Voice Package Components
Figure 5 - General Architecture of the Alcatel NGN Class 5 Solution
**FLEXIBLE GATEWAY ARCHITECTURE FOR ALL NETWORK OPTIONS**

**Any location, any size, any access technology**

The ISAM family is suitable for large nodes in COs and mid-size nodes in street cabinets, as well as any possible combination of services from pure POTS to pure DSL. For scalability reasons, the Voice Package allows a number of outside plant nodes to be clustered into one single H.248 interface to the softswitch for up to 10,000 subscribers.

**Easy migration from legacy networks**

In short-term replacement scenarios, the capability to interface ATM aggregation networks, as well as to provide legacy data services such as ATM or TDM is a must. The 7302 ISAM achieves this by means of the hybrid ATM-IP NT (HYNT), capable of providing an interface to both networks, and the SHDSL LT card, which can interface with CPE delivering the majority of the TDM data services. However, its superb wire-speed capacity and the capability to integrate Layer 3-aware line cards when needed is already there with no extra upfront investment. Operators pay only for what they use.

**CARRIER-CLASS PSTN OVER IP NETWORKS**

One of the key concerns of operators when thinking of NGN replacement for the PSTN is how their current level of services will be affected. The experience with DSLAMs as well as in 3G mobile networks shows that the majority of the bottlenecks affecting the service quality are in the access.

The unique architecture of the ISAM Voice Package is designed to break all those bottlenecks:

- **Voice traffic prioritization:**
  - The voice traffic is organized by the line card into IP packets with the highest IP priority, and these packets are delivered to the highest priority VLAN queue of the ISAM. This is a strict priority queue to guarantee minimum delay for voice traffic.
  - When entering the core for long distance traffic, the IP QoS guarantees at least the same level of performance as long distance VoIP (Class 4). In the future, IMS extensions to bandwidth control on the core networks can even improve that quality, and the ISAM processing hardware is ready to support admission control.

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**Figure 6 - ISAM Voice Package Network Architecture**
ISAM call control and traffic dimensioning.

- The ISAM incorporates a separated call control engine that can be centralized for as many as 10,000 subscribers distributed in a number of access nodes (either 7302 ISAM or 7330 ISAM FTTN). This signaling gateway, the IVPS card, is not overloaded with payload processing, which is done in the line card itself, but only deals with the signaling events.
- The IVPS supports up to 1,024 simultaneous standard calls, with 102 calls (10 percent) reserved for emergency use. Its call processing capacity can reach up to 12 call attempts per second.
- Dimensioning the traffic supported by the access network and the call processing speed is as simple as defining the number of IVPS cards to be used, or, in other words, the number of lines that the operator wants to associate to each IVPS.

In this way, an operator can decide to have non-blocking local PSTN just by using one IVPS card every one-and-a-half ISAM shelves, a quality outperforming any local exchange.

**KEY ISAM BENEFITS WHEN DEPLOYING PSTN SERVICES**

The ISAM Voice Package makes voice PSTN migration easier while enabling a full triple play offer in an all-IP scenario with the deployment of multimedia services such as IPTV, VoD, music on demand and video telephony.
- Cost-effective choice of fiber to the most economical point
- PSTN/ISDN subscriber interfaces available from any of the options
- Full feature parity in any network architecture
- Non-blocking traffic capacity guaranteed by the available bandwidth, the separation of payload and signaling traffic paths, and the QoS capabilities. The operator will be able to dimension their traffic capacity from full availability (1 erlang per subscriber supported) to the desired statistical limit as they decide (normally 0.2-0.2 erlang/ subscriber in the traditional PSTN).
- Full compatibility with the management of any type of access, including the legacy DSL lines deployed from the Alcatel 7300/7301 Advanced Services Access Manager (ASAM)
- Management extensions for voice service provisioning based on subscriber management, network analysis for preventive maintenance, home device management, or customer care support

**Summary**

Operators focused on broadband growth cannot ignore the need to reduce the growing PSTN costs. As such, convergence of legacy services into the new deployments is the best way for a fast transition. Therefore, investment in broadband infrastructure must contemplate the support of PSTN services, and investment in PSTN infrastructure must be done using platforms capable of supporting the new services.

The Alcatel ISAM family is a bottleneck-free IP platform designed for full support of the most demanding broadband services in all network scenarios. Its voice package contains PSTN/ISDN subscriber interfaces that can be deployed while growing the broadband services coverage, thus facilitating a fast transition to a converged network.

Modernizing PSTN during the deployment of triple play services is a good opportunity to minimize deployment costs, and the Alcatel ISAM family is the ideal platform for full video implementation, with support for all types of deployment scenarios.