

White Paper



Advantages of Voice-over-IP with IP-based multi-service access nodes (IP-MSAN)

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1 Abstract

This paper aims to explain to public network operators the applications and new functions, enabled by an IP-based multi-service access platform for telephony services. The white paper offers both technical and business arguments in favour of multi-service access networks, examines some applications and

looks at the past and future of IP-MSAN technology. We have merely scratched the surface of other applications, such as IPTV, broadband DSL or fibre-to-the-home (FTTH) that can be implemented with an IP-MSAN, as they have been explored in other publications.

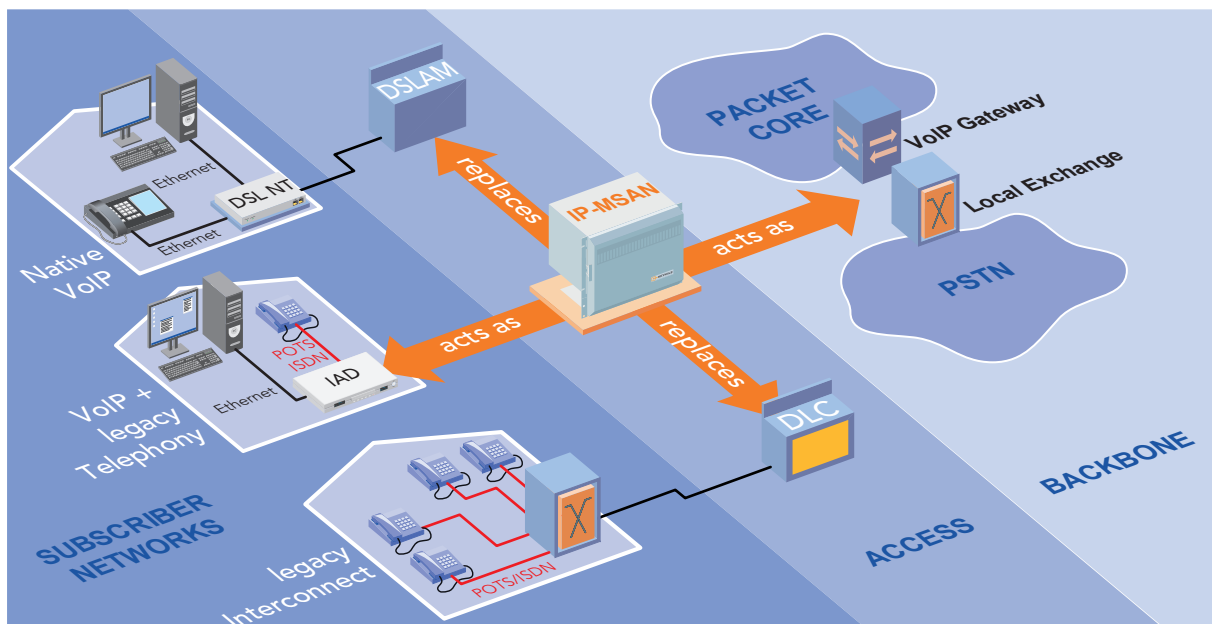


Figure 1: Overview of the IP-MSAN functionality

2 Operative advantages due to carrier-class properties

When procuring network technology in public networks, operators have two major sets of expenses to deal with: the purchasing price of the solution (capital expenses, CAPEX) and the running costs (operational expenses, OPEX.) Usually, CAPEX is relatively easy to identify and to compare, OPEX is not. The reason lies in the effects of using different solutions that are often not predictable beforehand.

A term often used by systems manufacturers is the expression carrier class. It signifies product properties that are specifically required in public networks. If network technology only fulfils a few carrier class aspects, it is often affordably priced, however high follow-up costs can occur. When using IP-MSANs which are usually applied in triple-play environments as access solutions, it is wise to ensure they have the following carrier class properties:

- **Tough ambient conditions:**
An IP-MSAN is often used in air-conditioned and almost dust-free rooms, but must also be tough enough to function perfectly in a demanding, harsh environment, such as outdoor housings. Even in mild climates, when the sun shines directly on the housings, they reach an operating temperature of over 50°C. In this environment, it is even more important that resistance to vibrations and humidity are higher than in air-conditioned surroundings.
- **Reliability and stability:**
all important components in the access solution (power unit, central card, gateway etc) that are vital for maintaining operation, should be designed so that they are redundant. The uplink connection should be redundant via two or more optical gigabit

- Ethernet links with automatic switching, should the call server (softswitch) or one of the paths fail because there is a malfunction in the line. It must be viable to carry out software and firmware updates while systems are operating and to monitor operating conditions using central sensors and alarms.
- Providing traditional telephony interfaces
An IP-MSAN supplies the subscriber with POTS and the ISDN interfaces, terminates them and in the network turns them into more cost efficient Voice-over-IP technology (VoIP.) The advantage is that end users can continue to utilise their traditional terminal equipment and the operator saves substantial running costs because no TDM is required (see the following chapters).
 - Using extremely long copper access lines:
Modern IP-MSANs can implement symmetrical 2 Mbps connections over copper lines that are 7 km long. In ISDN connections the lines can be over 10 km, in POTS over 20 km long.
 - Service quality:
When using advanced prioritising, filtering and queuing methods, voice, data and video signals in differing quality can be transmitted gradually to ensure end customers obtain the best service quality.
 - Central network management with measurement functions:
An access network, implemented with IP-MSANs, is operated centrally by a network management system. This provides the full set of management functions for FCAPS (fault, configuration, alarm, performance and security.) The management system should be intuitive to operate and have a graphical interface. However, there should be a command-line interface (CLI) to guarantee integration into an existing CLI if required. It should also be possible to trigger measurement functions from a central operating location in order for example to prepare a copper access line without time-consuming work on site.
 - Flexibility:
An IP-MSAN concept should allow for different chassis sizes for carrier class applications, so that usage is possible in different installation environments, i.e. indoor/outdoor, locally where the customer is situated etc. It should be possible to put the same cards in all chassis to enhance logistics and storage processes.
 - Support of various transmission media:
An IP-MSAN platform should support both copper wire and fibre optic transmission, because nowadays almost all networks are designed heterogeneously. This allows the operator pervasive use of a single IP-MSAN platform in different network architectures, such as fibre-to-the-exchange (FTTE,) fibre-to-the-curb (FTTC,) fibre-to-the-building (FTTB,) or fibre-to-the-home (FTTH) - as the picture shows.
 - Supporting migration:
When launching a new access platform it is not absolutely vital to port all traditional TDM services to packet-based ones. However, it must remain viable in the future as well to supply the full range of profitable services, responsible for generating most of the revenue and profits. In the fixed line network, such services are for example POTS and ISDN telephony services, as well as the 2 Mbps standard fixed line network connection, so that private branch exchanges can be connected for example. These services should also be available in an IP-based access network.

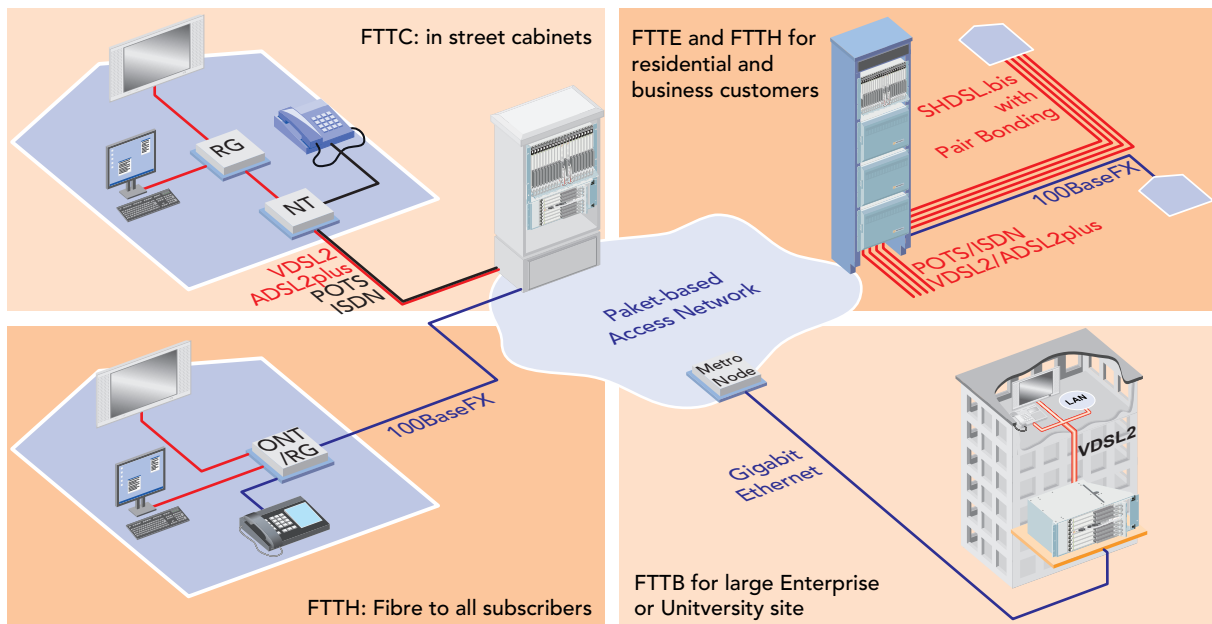


Figure 2: Multi-service does not just mean providing the most important service interfaces, but also the flexibility to be able, cost effectively, to use an IP-MSAN in various network scenarios.

- **Product continuity and support:**
This entails providing software updates, regular new functions, including full release documentation and long-term provision of spare parts etc.
- **Ethernet OAM (Operation, Administration and Maintenance):**
As Ethernet was originally not designed for operation in public networks, various attributes were missing initially that are required to achieve similar levels of operational reliability and manageability to SDH networks. As a result, several Ethernet OAM standards have been developed to introduce end-to-end monitoring and full management at several logical levels of an all-IP network. It should be easy to integrate an IP-MSAN concept in this type of environment.
- **Pay-as-you-grow access platform concept:**
in addition to the technical specifications, it is important not to forget the business side. The disadvantage of previous multi-service concepts was that the majority of the functions were integrated on the network ele-

ment's central card. There was no scalability in smaller sites because chassis types were not available, or joint usage of plug-in cards was not possible. The result was relatively high outlay at the beginning. Above all at the start of the rollout, operators might have thought that they were being asked to pay in advance for extended functions that they would only need to years later (if at all.)

It should be possible to scale a modern IP-MSAN concept for small and large numbers of subscribers so that it makes commercial sense. A pay-as-you-grow effect in the access node is for example often implemented by including the functions primarily in the subscriber subracks. As a result, the operator only pays when new subscribers are connected and therefore new revenue generated. The chassis sizes and central cards of an IP-MSAN should be adjusted to handle small numbers of subscribers and also for very large POPs (points of presence) with several thousand subscribers, in order to guarantee commercial success with the right port density.

Network operators should check all these carrier class attributes very carefully, so that the business case is not rendered obsolete after selecting the system because of the operating costs. If operators want to optimise CAPEX, they can consider opting for an access solution that fulfils fewer quality attributes than a carrier class IP-MSAN. However, they should be aware

of potential repercussions: OPEX follow-on costs, incurred as a result of troubleshooting, network downtimes and damage to image, are usually much higher. In this case, it is important to make a cost-efficient and future proof decision.

3 An IP-MSAN's telephony service

The chief aim of an IP-MSAN is to integrate all commonly-available groups of services in the fixed line network, i. e. voice, data and video and provide their services. We will now look at telephony in more detail. On the one hand because today the majority of sales are achieved with the standard telephony services and on the other, because of the potential for improvement in public networks. This is the area where operators need to take action.

In the voice exchange, many operators nowadays still use 64 kbit TDM technology. Use of the technology will continue in many areas for some time to come, due to the high level of investment and long periods of depreciation. As a result, in addition to state-of-the-art Voice-over-IP technology, modern IP-MSAN platforms will have to continue to use TDM interfaces – whether towards the subscribers, or to the exchange.

As the name IP-MSAN already suggests, this category of access solutions also includes IP functionality. Important are VoIP-gateway functions that convert POTS and ISDN subscriber interfaces into RTP (Real Time Transport Protocol) Ethernet packages and exercise control with H.248/MEGACO or SIP-signalling via a soft switch or call server. This sophisticated type of telephony saves substantial network operating costs, as Ethernet transmission technology is used and the traditional digital exchanges can be replaced by just a few soft switches. As far as subscribers are concerned, the same familiar services (i.e. POTS or ISDN) are implemented that the customer recognises from TDM technology. Ideally, subscribers will notice no difference after network conversion from TDM to IP and can continue to use their favourite terminal equipment (like DECT telephones, ISDN private exchanges, fax machines etc) without any problems.

However, many network operators have not, even today, migrated their TDM voice network entirely to VoIP technology. There are many reasons for this. To supply these providers with problem-free access to modern NGN technol-

ogy, advanced IP-MSAN concepts use a hybrid backplane architecture, which can also provide POTS and ISDN subscriber interfaces traditionally via a V5.2 uplink. The TDM interfaces use the TDM backplane in this architecture and the packet-driven interface boards the Ethernet backplane. Therefore, both TDM and Ethernet technology can be used without complex emulation technology. With hybrid boards that can access both backplanes, migration scenarios can be implemented easily and efficiently – without exchanging existing hardware. This option protects both the operators' investment and allows them to seamlessly migrate to the convergent All-IP world.

Migration scenarios such as these will be outlined in more detail in another KEYMILE white paper. The rest of this paper will concentrate on operation scenarios where a VoIP voice exchange (soft switch, call server etc) is already used exclusively.

3.1 Telephony solutions for private households and SOHO

Basically the demands of private households and the small office/home office (SOHO) as regards telephony services are similar. Residential properties these days usually still have POTS, but in the business segment, ISDN tends to be more popular because of the extra attributes it can offer.

Nowadays, both technologies are experiencing increasing competition due to Voice-over-Internet and Voice-over-DSL (VoDSL) because these services are usually cheaper, or in some cases even free of charge (see figure 2, case A.) In some cases they provide more functions than traditional telephony (e.g. with several telephone lines via one single copper line, video telephony etc.)

Nevertheless, in the future it will continue to be essential that network operators offer POTS and ISDN interfaces via copper lines in the private customer environment: (see Figure 3 at page 9, case C.):

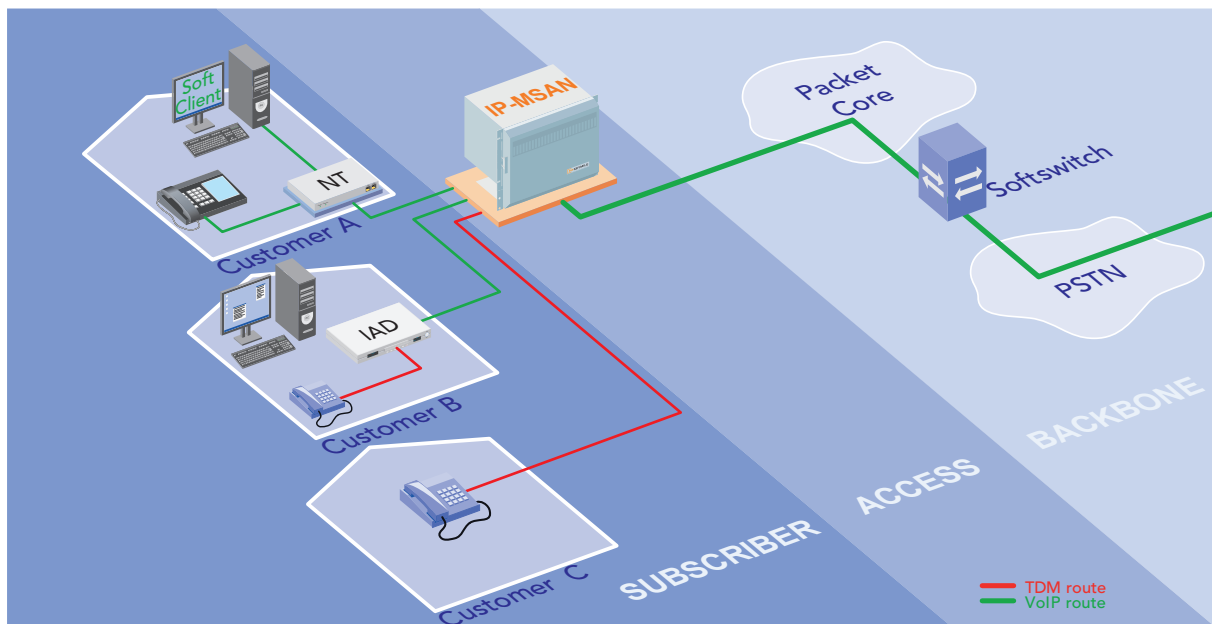


Figure 3: An IP-MSAN platform provides POTS, ISDN and VoIP telephony in one platform and turns them within the network into cost efficient VoIP technology.

- Legal stipulations:
The POTS connection is one of the primary services that must be provided.
- Budget stipulations in extending networks:
POTS and ISDN ports in the IP-MSAN are more affordable than DSL ports.
- Using existing exchange technology:
The existing TDM exchanges will continue to be used.
- Very long copper paths:
The maximum length of ADSL paths is approximately 7 km. Particularly in rural regions however, lines of more than 10 km are standard.
- Life line service:
In the case of telephone connections that need to be extremely reliable (emergency telephones, doctors, police stations, fire alarms, other alarms etc), VoDSL or even Voice-over-Internet is no alternative because the network terminations or telephones have to be supplied locally. The risk of malfunction (e.g. the power supply unit breaks) is too high in these cases - remote supply is absolutely vital.

With IP-MSANs, network operators can even apply the more attractive VoIP technology in the network for these difficult cases to save costs and use a homogenous all-IP network infrastructure in the network internally. The POTS and ISDN signals are terminated by the VoIP gateway in the IP-MSAN, turned into SIP or H.248/MEGACO signals and conveyed as IP packets through the backbone network.

Advantages for the network operator:

- The backbone can be completely switched to Ethernet.
- SDH backbone technology, with its inefficient use of bandwidths, can be switched off.
- TDM exchange technology can be replaced by more powerful and affordable soft switch technology.
- Operating costs are reduced significantly.
- The end customers do not notice the switch; they can continue to use their previous terminal equipment. This reduces the churn rate.
- Due to the lower operating costs, competitive products with the same margin can be achieved.

3.2 Telephony solutions for small to medium-sized enterprises (SMEs)

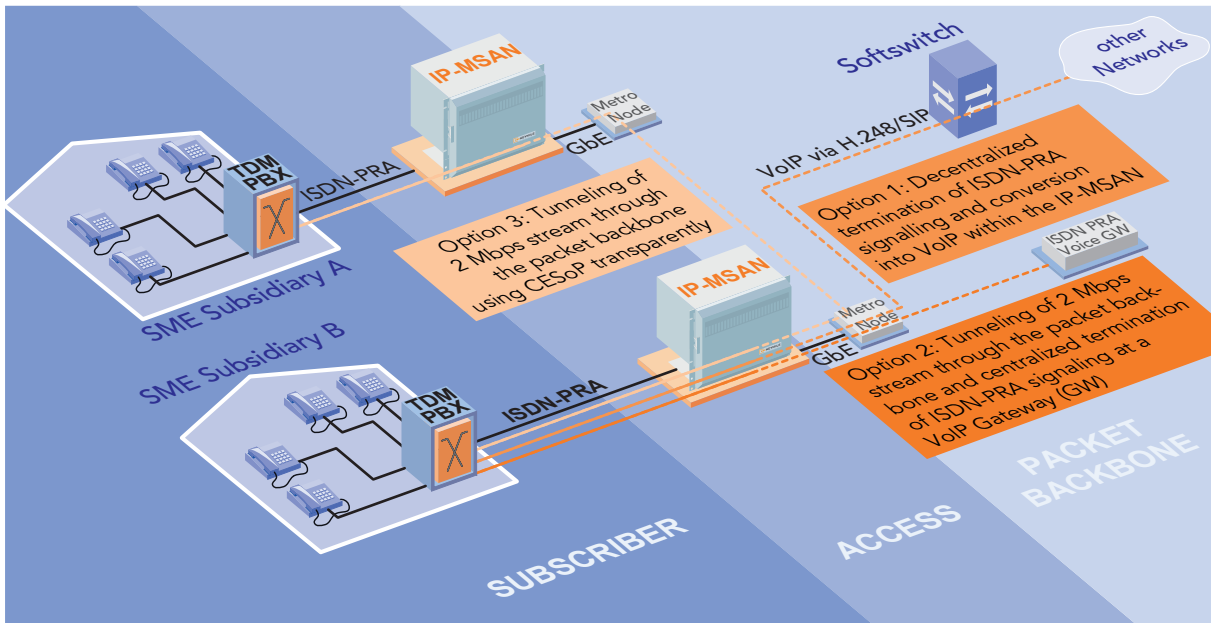


Figure 4: Network connection of two sites belonging to an SME with a private exchange

Many SMEs have a TDM private exchange that is connected to the public network with $n \times 2$ Mbps interfaces. Although nowadays modern VoIP based private exchanges already exist, there are good reasons why many SMEs still stick to the existing system. As a result, when planning the network, it is advisable to consider what the demands will be over the next few years.

In TDM networks, the TDM private exchange was terminated at the exchange or transmitted transparently to other places where the company is located. As Figure 4 at page 10 shows, modern IP-MSANs must provide several transmission alternatives.

Description	Advantage	Disadvantage
Option 1		
Termination of the ISDN-PRA signalling and implementation into VoIP signalling (SIP or H.248) in the IP-MSAN. In the core network, a telephone connection is entirely IP-based, the payload data is routed.	<ul style="list-style-type: none"> There is no TDM in the core network. Less complexity. Better usage of the bandwidths in the core network. 	<ul style="list-style-type: none"> VoIP gateway functions necessary in each access node.

Description	Advantage	Disadvantage
Option 2:		
Transparent tunnelling of the ISDN-PRA signalling via Circuit-Emulation (CESoP). Telephony signalling is only terminated in a dedicated ISDN-PRA gateway centrally and implemented in VoIP.	<ul style="list-style-type: none"> Only one or a few ISDN-PRA-gateway(s) are required in the exchange. In addition to ISDN-PRA, synchronised 2 Mbps TDM connections can also be carried put via CESoP.) 	<ul style="list-style-type: none"> CESoP gateway functions necessary in each access node. The bandwidth for TDM emulation must be reserved in the core network.
Option 3		
Transparent tunnelling of the ISDN-PRA signalling via Circuit-Emulation (CESoP) to another PBX at another of the company's locations. Telephony signalling is not considered.	<ul style="list-style-type: none"> See option 2 If several of the customer's premises are located on the same IP-MSAN, no data traffic has to take place on the core network at all. 	<ul style="list-style-type: none"> See option 2

3.3 Telephony solutions for large enterprises (LEs)

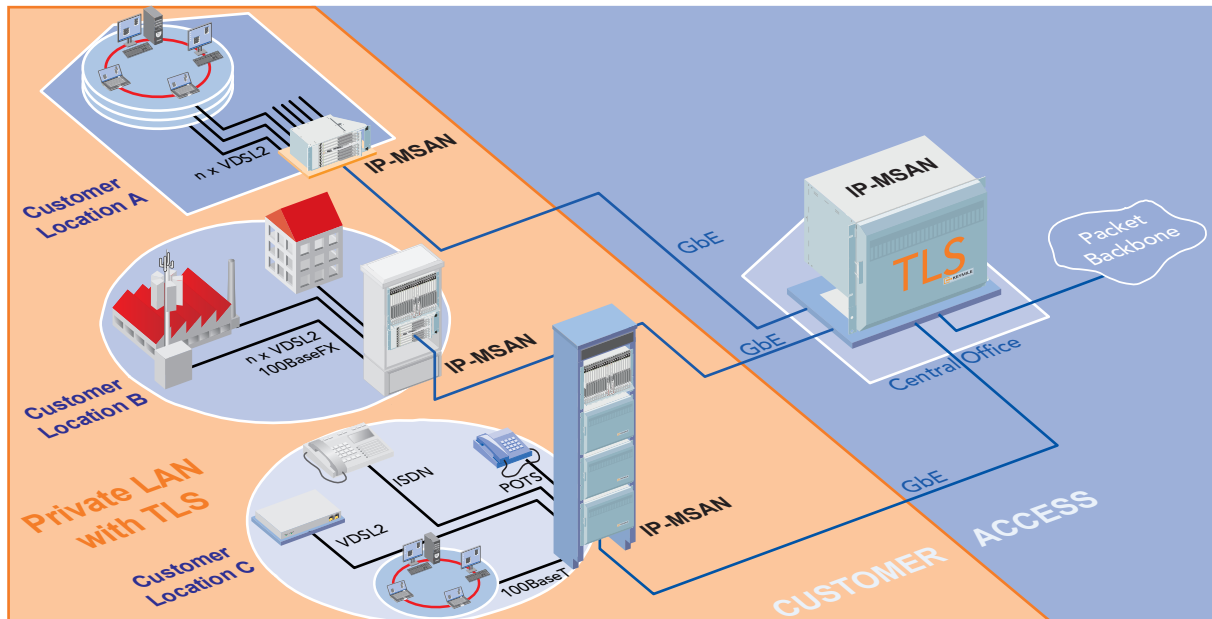


Figure 5: Example of a telecommunications network in a large enterprise in three different places

Figure 5 at page 11 shows an example of a network in a large enterprise in three different locations. There are very rarely ready-made network solutions for these types of applications, so customised solutions are nearly always required. Therefore it is advisable for public network operators to use the most flexible platform possible as CPE equipment that does not just support one or two services. The CPE solution must also be as flexible as possible, and as the figure shows, able to be installed in outdoor housings too, provide remote testing and measurement functions, support copper and fibre optic connections – or in other words have carrier class quality.

The following subscriber interfaces are required on a large company's premises:

- POTS/ISDN: as a substitute for private exchanges (see following chapter.)
- ADSL2plus: to connect remote places of work, or remote measurement or monitoring functions, for example video cameras.

- E1/G.703: to connect 64 kbps or 2 Mbps TDM equipment such as private exchanges, sensors, monitoring technology etc via copper wire.
- SHDSL: such as E1/G.703, only for long, lines of 100m to 8 km.
- 100BaseTx: To connect 100 Mbps LAN segments, servers or other IT components via Ethernet in-house cabling.
- VDSL2: such as 100BaseTx, but only for applications where standard Ethernet cabling is not sufficient because of the distance or the interference.
- 100BaseFt: like 100BaseTx, but with a fibre optic interface.
- 1000BaseFt: like 100BaseTx, but with maximum bandwidth of 1 Gbps.

3.4 Access technology for hosted PBX solutions

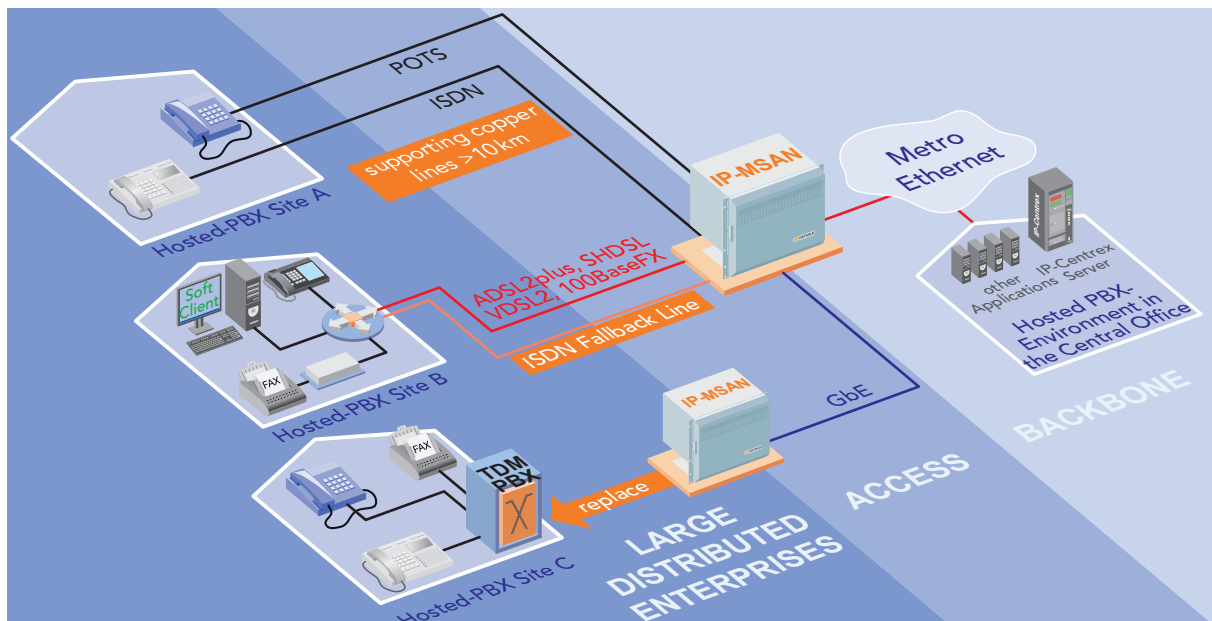


Figure 6: Advantages of using an IP-MSAN in hosted PBX applications

The definition of hosted PBX is that the functions of a private exchange are moved to the public network and are supplied by the service provider via a broadband connection. Technically this is usually implemented by an IP-Centrex application that is either integrated in the soft switch or operated on an application server.

The advantage of this business model to corporate customers is that no specially trained personnel is required. Another benefit is the fact that no investments need to be made in technology (PBX) and the communications costs are transferred from CAPEX to OPEX. The end customer can also enjoy new services that previously did not exist because they were too expensive or too complicated to execute. The following table shows some examples.

Examples and possible impact of hosted PBX applications		
New services	Impact	Advantage
Using new media and terminal equipment for communications purposes	<ul style="list-style-type: none"> The PCs or the laptop replaced the traditional hardware telephone using the VoIP soft client. The mobile phone plus VoIP client serves as terminal equipment and uses a WiFi connection. 	<ul style="list-style-type: none"> Reduction in costs for terminal equipment Employee flexibility increased
Job mobility increased in the company	As soon as a subscriber logs into the company LAN or WAN, whether it is from one of the company premises or remotely via a VPN connection, the employee can be reached worldwide under his extension number.	<ul style="list-style-type: none"> Employees can be reached on the phone more easily. Lower costs in comparison to mobile phone usage, above all abroad. Costs for office moves are reduced (changing the cabling etc.)
Connecting the IP-Centrex service with Office applications	<ul style="list-style-type: none"> Presence function: Other employees in a buddy list can see what the current present status of the employees is (for example logged in, absent, temporarily absent etc.) Additional communications functions such as voice/video mailbox as an e-mail attachment, instant messaging, white boarding, application sharing, conferencing etc. 	<ul style="list-style-type: none"> Increase in corporate productivity by raising the level of efficiency of each individual employee. Improvement in team working, due to different conference functions that integrate office and home workers.
Reliability	An IP-Centrex solution based on carrier class technology that was designed for use in public networks.	In comparison to private exchanges that require expensive and time-consuming servicing if hardware fails, an IP-Centrex solution is a lot more reliable. It is monitored and maintained centrally by the service provider and errors can be put right much more quickly.

As regards the implementation of hosted PBX applications in the public network, all of the previously mentioned customer applications and switching scenarios from the previous chapters can be applied. The key advantages of integrating an IP-MSAN into such applications are:

- Integration of traditional POTS and ISDN connections into IP-Centrex groups (see Figure 5 at page 11, site A): previously, a major problem posed by corporate-wide hosted PBX solutions was that it was not possible to operate a mixture of the TDM and VoIP terminal points easily in a single Centrex group. As the IP-MSAN makes the TDM subscriber interface towards an IPS Centrex application look like a VoIP subscriber, the old problem of the mixed Centrex groups is solved.
- Discarding TDM private exchanges in the corporate network (see Figure 5 at page 11, site C): A major obstacle in launching a company-wide hosted PBX service was often the fact that customers did not want (for financial reasons) or could not (for technical reasons) discard existing telephones or other terminal equipment.

By using POTS and ISDN interface cards, an IP-MSAN can replace TDM private exchanges, existing terminal equipment can be retained and from the point of view of the network, TDM and VoIP terminal equipment can be integrated into IP Centrex groups and therefore into the hosted PBX solution.

- Providing a broadband connection (copper and fibre optics) including an ISDN fallback line for hosted PBX locations (see Figure 5 at page 11, site B): in addition to providing the broadband connection (DSL or optical Ethernet) for company premises, which is used to convey both data and the VoIP voice traffic from the IP-Centrex group, IP-MSAN in the fixed network can provide one or several ISDN fall back lines. This connection becomes active if the broadband path fails and therefore guarantees company voice traffic. From the point of view of the network, the ISDN fallback line is converted by the IP-MSANs VoIP gateway into VoIP signalling. This allows integration into the IP-Centrex solution.

Both for the customer and the network operator, this method is a win-win situation: the customer enjoys the advantages of

IP-Centrex, but also continues to reap the benefits of reliability from the familiar TDM world. The network operator can put the

minds of critical customers at rest and still use 100% more efficient VoIP technology in the network.

4 Summary and perspectives

The outstanding success of VoIP technology in public and private networks is unstoppable. Using carrier-class IP-MSANs in the access networks exploits the advantages of two technological worlds. The IP-MSAN converts the existing POTS and ISDN connections into VoIP and at the same time implements broadband All-IP connections via copper or fibre optic lines. This allows operators to migrate their networks today already to more affordable, scalable and future-proof VoIP technology, without compromising on quality. For implementing corporate network solutions, such as hosted PBX telephony, the carrier class design of the IP-MSAN platform is perfect. Good arguments can be made to counteract customer scepticism re safety, quality and stability. Without doubt, IP Centrex applications, combined with IP-MSAN technology, can be implemented at the same service level quality as is the case for TDM services. The difference is that the new technology has significantly more benefits in terms of operation and usage. This is supported by Ethernet OAM standards, that (similarly to TDM traffic networks) offer end-to-end management and therefore support carrier class quality in terms of network operation.

During a network migration to IMS network architecture, setting up IP-MSANs is an important and necessary step and ideally prepares the access network for future conversion to All-IP. Thanks to the ETSI TISPA standard, in the future an IMS-Media Control Layer will be able to manage IP-MSANs as full network elements.

Finally, we should mention that many network operators worldwide have already recognised the benefits of using an IP-MSAN and will completely convert their access networks to IP technology in the next few years. From marketing and business standpoints, the potential to gain a competitive edge is extremely high. It is particularly important not to compromise when selecting the technology for the access network. Should the operator back the wrong horse when choosing the interface to the customer, the loss of image can be enormous.

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