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Architectures for Internet Traffic Off-Load from the PSTN/ISDN Network

This paper explains how telecommunications companies can cope with the increased load on public switched telephone network/integrated services digital network (PSTN/ISDN) resources due to the constant growth of Internet traffic. The key bottlenecks of the present mode of operation are identified and an overview is given of the possible post-switch Internet traffic off-load architectures for the redirection of Internet traffic from the PSTN/ISDN network towards a packet-switched data network. Finally, a migration strategy towards a given target post-switch Internet traffic off-load architecture is discussed.

Introduction

The constant growth of users with dial-up Internet access via the PSTN/ ISDN network continuously increases the load on the resources of the PSTN/ISDN network. This could ultimately give rise to congestion problems in this network that could affect other users.

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Solving these congestion problems would require the purchase and the deployment of additional equipment and/or the adaptation of modified engineering rules for both PSTN/ISDN switches and trunks. Off-loading Internet traffic from the PSTN/ISDN network towards a packet-switched data network may be an alternative and less expensive solution.

This paper explains how telecommunications companies can cope with the problems mentioned above. First we give a description of our current Internet protocol (IP) access network architecture. The key bottlenecks of the present mode of operation are identified. Next we give an overview of the possible post-switch Internet traffic off-load architectures, followed by an analysis of the key advantages and disadvantages for each architecture. Finally we discuss a migration strategy towards a given target Internet traffic off-load architecture.

Current Situation: IP Access via the PSTN/ ISDN Network

The following section gives a short description of the current IP access network architecture where points of presence (PoPs) of Internet service providers (ISPs) are connected to local exchanges with primary rate access (PRA) interfaces.

The route of an Internet call through the PSTN/ISDN network is shown in Figure 1. During Internet access a PSTN/ISDN connection is set-up between the modem of an Internet user and the remote access server (RAS) of the ISP. The Internet call is routed through the local PSTN/ISDN network, possibly via a local exchange-remote unit (LE-RU), towards ingress local exchange-basic unit (LE-BU).

From the ingress LE-BU, the Internet call originating exchange, Internet calls are routed via one (or more) toll exchange(s) towards an egress LE-BU, the Internet call terminating exchange. The egress LE-BU is connected to the RAS by means of PRA interfaces. The RAS is located in the PoP of the ISP. Alternatively, the RAS is connected (by means of a leased line) to the ISP data backbone network.

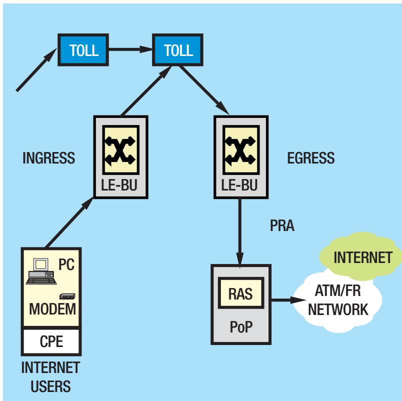
In the Belgacom case, the connection is to an asynchronous transfer mode (ATM) access switch of the ATM/ frame relay (ATM/FR) data backbone network. From there, IP packets are routed to the central router of the ISP towards the Internet.

Key Bottlenecks of the Current Situation

Due to the continuous increase of users with Internet access via analogue modems or via the ISDN, a constant growth of Internet traffic has been observed in the PSTN/ISDN network.

Internet traffic increases the load on the resources of the PSTN/ISDN

Figure 1—Internet access via PSTN/ ISDN network



network, because of the constant growth and particularly because Internet calls have a much longer call duration than voice calls for which the PSTN/ISDN network was designed. This could ultimately give rise to congestion problems in the PSTN/ISDN network that could affect other PSTN/ISDN users.

The problems occur in different areas:

- ingress exchanges (basic units (BU) + remote units (RU)) that connect subscribers;
- toll exchanges;
- egress exchanges that connect the ISP modem pools; and
- trunks between these exchanges.

Solving these congestion problems would require the purchase and the deployment of additional equipment and/or the adaptation of modified engineering rules for both PSTN/ ISDN switches and trunks.

Off-loading the Internet traffic from the PSTN/ISDN network into a packet switched data network may be an alternative and less expensive solution, because circuits set-up in the PSTN/ISDN network for Internet traffic are not actively used during the entire call.

Internet Traffic Off-load

In this paper the interception of Internet traffic to be redirected from the PSTN/ISDN network (which is circuit-switched and optimised for voice traffic) towards the ATM/FR network (which is packet-switched and optimised for data traffic) we will call *Internet off-load*.

This includes the use of existing features and capabilities of the PSTN/ ISDN network to obtain this goal, such as the use of intelligent network/ Signalling System No. 7 (IN/SSN7).

The following section provides an overview of the different Internet traffic off-load architectures considered.

Internet Traffic Off-load Architectures

Pre-switch off-load architectures

A first approach consists of intercepting the Internet traffic at the line side of the (ingress) switch and redirecting it out of the PSTN/ISDN network into a packet-switched network. These architectures are often called *pre-switch off-load* architectures. An example of such architecture is xDSL (the range of digital subscriber line technologies).

Post-switch off-load architectures

A second approach consists of the interception of Internet traffic after the (ingress) switch. These architectures are called post-switch off-load architectures. Internet traffic is allowed to pass through the (ingress) switch before being redirected out of the PSTN/ISDN network into the packet-switched network.

This paper focuses on post-switch off-load architectures.

Introduction of IN functionality and optimisation of Internet traffic routing

In this scenario, existing features and capabilities of the PSTN/ISDN network are used for optimising the routing of Internet traffic through the PSTN/ISDN network.

The introduction of IN functionality allows improved control of the routing of Internet traffic through the PSTN/ISDN network; that is, the telecommunications company can define to which egress exchange the Internet traffic is routed.

Internet traffic routing can be optimised following several approaches:

- *Definition of Internet areas:* In this case the PSTN/ISDN network is divided into a number of Internet areas. If one can arrange that the PoPs of the ISPs are located in an Internet area in order to reach the Internet users of that area, one is able to limit the number of interzonal links for Internet traffic.
- *Definition of egress exchanges:* If one can ensure that the PRAs of the RAS in the PoPs are connected to one (or more) well-defined egress exchange(s) within the Internet area under consideration, one can also limit the number of zonal and interzonal links for Internet traffic within a given Internet area.

This will ultimately lead to a significant reduction of the operational cost, because one has to manage a limited number of trunks for Internet traffic.

Internet off-load via the PSTN/ ISDN network

In this scenario, the number of PSTN/ISDN exchanges between the ingress exchange and the PoP is reduced, bypassing (intermediate) toll exchanges and/or the egress exchanges. Direct links can be provided between (important) ingress exchanges and egress exchanges.

Internet off-load via the ATM/FR network

In this scenario, the remote-access server is moved from the egress exchange to the ingress exchange, optimising the transmission network resources by the use of a packet-switched ATM/FR network.

Trunk interfaces between the PSTN/ISDN switch and the remote access server

So far the interfaces between the PSTN/ISDN switch and the remote access server have been PRAs. However, both switching- and data-network vendors have proposed an evolution towards trunk interfaces. In the latter case interworking between the RAS and the SSN7 network is required.

The SSN7 gateway functionality can reside in a standalone device but can also be integrated in the RAS.

Integration of a remote access server into the PSTN/ISDN switch

One switching network vendor has proposed an integrated/post-switch Internet traffic off-load architecture.

In a first step the vendors have proposed the functional integration of an external remote access server with PRA interfaces between the PSTN/ISDN switch and the RAS. In a second step the IP PoP is fully integrated in the PSTN/ISDN switch.

The key advantages and disadvantages of the post-switch Internet off-load architectures are summarised in Table 1.

Internet Traffic Off-Load Migration Scenarios

In the following section we will discuss a migration scenario towards a target Internet traffic off-load architecture. We will explain how Belgacom will cope with the problems mentioned above. We will show how Internet traffic off-load will be combined with the introduction of IN routing and a special number for Internet access to distinguish Internet traffic from other traffic.

The following network architecture evolutions have been identified:

Table 1: Advantages and Disadvantages of the Post-Switch Internet Off-load Architectures

Architecture	Advantages	Disadvantages
Introduction of IN functionality and optimisation of Internet traffic routing	Optimised routing of Internet traffic in PSTN/ISDN network.	Access numbers of ISPs have to be changed. PRAs of ISPs have to be connected to a limited number of well defined egress exchanges.
Internet off-load via the PSTN/ISDN network	Optimised utilisation of PSTN/ISDN network resources. Reduction of trunk interfaces.	PRAs of ISPs have to be connected to one (or more) (ingress) exchanges.
Internet off-load via the ATM/FR network	Optimised utilisation of transmission network resources. Packet switching.	ISPs have to move RAS towards ingress exchanges.
Trunk interfaces between the PSTN/ISDN switch and the remote access server	No need for PRA interfaces between PSTN/ISDN switch and RAS (that is, the possibility to connect RAS to (pure) toll exchange). Internet supplementary services due to interworking with IN/SSN7.	Increased complexity; the need for SSN7 gateway.
Integration of a remote access server into the PSTN/ISDN switch	No need for PRA interfaces between PSTN/ISDN switch and RAS. Internet supplementary services.	Less flexible than a standalone solution.

Phase 1: 078/17xxxx access;
Phase 2: off-load via PSTN/ISDN network; and
Phase 3: off-load via the ATM/FR network.

Phase 1: 078/17xxxx access
Belgacom will introduce a special Internet tariff linked with a special, non-geographic 078/17xxxx number. For this purpose Belgacom has divided the PSTN/ISDN network in a number of Internet areas. An ISP to which a 078/17xxxx number is allocated has to be present in an Internet area to reach the Internet users of that Internet area; that is, the PRAs of the RAS in the PoP have to be connected to one (or more) well-defined egress exchanges of the Internet area under consideration. Furthermore, IN functionality will be introduced to route Internet traffic. Internet traffic is separated from ordinary PSTN/ISDN traffic in so called *service switching point/advanced freephone service points* (SSP/AFS). The choice (number and localisation) of SSP/AFS points is optimised for the PSTN/ISDN network; for example, SSP/AFS functionality in toll exchanges and ingress LE-BUs with direct links to egress LE-BUs.

Internet traffic is routed towards the egress LE-BUs (the equivalent of an Internet call terminating exchange) as follows:

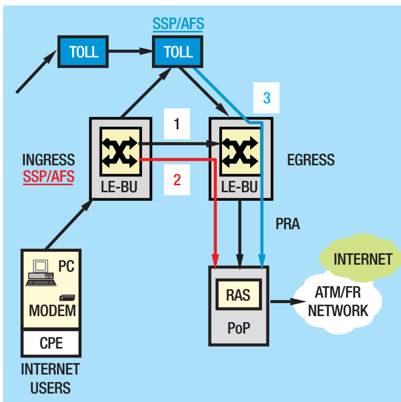
- Internet traffic from ingress LE-BUs with direct links to egress LE-BUs is routed via the direct link to the egress LE-BU towards the PoP (plus overflow via toll exchange); and
- Internet traffic from adjacent zones within an Internet area (or from ingress LE-BUs with no direct links to egress LE-BUs) is routed via SSP/AFS toll exchange and egress LE-BU towards the PoP.

Phase 2: off-load via PSTN/ISDN network
As Internet traffic increases, congestion problems will move from the egress exchanges towards the ingress exchanges. In this case application of Internet traffic off-load via PSTN/ISDN is appropriate, as described in a previous section. This implies a reduction of the number of (intermediate) PSTN/ISDN exchanges in the route of Internet traffic from the Internet user towards the PoP of the ISP.

This can be done in several ways, as shown on Figure 2:

- If the Internet traffic from a given ingress LE-BU towards the PoPs of a number of ISPs connected to the same egress LE-BU is sufficient high, we can foresee a direct trunk between the ingress LE-BU and the egress LE-BU, bypassing the intermediate toll exchanges (see Figure 2, box 1).
- If the Internet traffic from a given ingress LE-BU towards the PoP of a given ISP is sufficient high, we can connect one or more PRAs of the PoP directly to the ingress LE-BU, bypassing the egress LE-BU for these PRAs. The PRAs should have a sufficient filling ratio (see Figure 2, box 2).
- If the Internet traffic from a number of ingress LE-BUs towards the PoP of a given ISP is sufficient high and if the Internet traffic is collected in a toll exchange, we can connect one or more PRAs of the PoP directly to the toll exchange, bypassing the egress LE-BUs for these PRAs (see Figure 2, box 3).

Figure 2—Off-load via PSTN/ISDN network



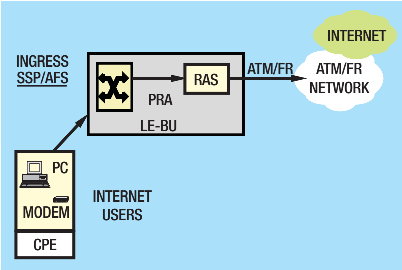


Figure 3—Off-load via ATM/FR network

The solutions described above are more cost efficient because of the more efficient use of trunk interfaces on the PSTN/ISDN switches.

Note that because of the introduction of the 078/17xxxx number, the application of the Internet traffic off-load strategy stays transparent for the customers of the ISPs under consideration.

Key issues to determine whether an exchange (toll or local exchange) is suitable for Internet traffic off-load will be, among other things, the amount of Internet traffic to be off-loaded in the switch, the availability of SSP/AFS functionality in the switch, the availability of PRA interfaces in the switch and the impact of switching consolidation.

Phase 3: off-load via ATM/FR network

Suppose that a number of PRAs of the PoP of a given ISP are already connected to a given ingress LE-BU, so that the switching network resources can be considered to be optimised for these PRAs. Then the next step will consist of the optimisation of the transmission network resources. This can be done in the following way (see Figure 3).

The RAS (connected to the PRAs under consideration) is moved from the PoP of the ISP towards the ingress LE-BU. This supposes that the ISP is willing to leave the administration of the modem pool to the telecommunications company.

Additionally, modem pools located in ingress LE-BUs can be shared between different ISPs. The RAS is still connected to the LE-BU by means of PRA interfaces, but in this case the Internet traffic is off-loaded from the PSTN/ISDN network to the ATM/FR network at the ingress LE-BU.

The solution mentioned above is more cost efficient due to the more efficient use of transmission capacity (due to the use of statistical multiplexing) between the ingress LE-BUs and the PoP of the ISP which is now directly connected to the ATM/FR network.

The issue whether or not to integrate IP PoPs into PSTN/ISDN switches has to be seen as a final step towards a target Internet off-load architecture, only to be taken under consideration when the modem pools of the ISPs are already moved towards the ingress LE-BUs in areas where a large amount of Internet traffic has to be off-loaded and if the ISPs are ready to leave the administration of their modem pools to the telecommunications company.

Conclusion

Off-loading Internet traffic from the circuit-switched PSTN/ISDN network towards a packet-switched ATM/FR network may be an alternative, simplified, more flexible and less expensive solution than the present mode of operation. This includes the use of existing features and capabilities of the PSTN/ISDN network such as the use of IN.

In the discussion of the migration strategy towards a target Internet traffic off-load architecture, this paper has shown how Internet traffic off-load can be combined with the introduction a special number for Internet access to distinguish Internet calls from other calls.

As Internet traffic increases, the off-load point will move from the egress switches (Internet call terminating switches) towards the ingress switches (Internet call originating switches).

The key issue in determining whether an exchange is suitable for Internet traffic off-load will be the amount of Internet traffic to be off-loaded in the switch.

Glossary

AFS Advanced freephone service
FR Frame relay
ISDN Integrated services digital network
ISP Internet service provider
LE-BU Local exchange—basic unit
LE-RU Local exchange—remote unit
PoP Point of presence
PRA Primary rate access
PSTN Public switched telephone network
RAS Remote access server
SSP Service switching point
IN Intelligent network
SSN7 Signalling System No. 7

Bibliography

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Biographies

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Jan Verbeke graduated in 1990 from the University of Gent as a civil engineer in electronics. In 1995 he received his Ph.D. degree in electrical engineering with specialism in optical communications. He joined Belgacom in 1995 in the Research and Development department. In 1996, he joined the Backbone Network Strategy group. Since 1998 he has been working in the Data Networks group.

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