Zeitschrift: Comtec : Informations- und Telekommunikationstechnologie = information and telecommunication technology

Herausgeber: Swisscom

Band: 78 (2000)

Heft: 6

Artikel: Packet over SDH : more than big pipes?

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DOI: https://doi.org/10.5169/seals-876450

Exploration Programmes:
Corporate Technology Explores Future Telecommunications

Packet over SDH, more than big Pipes?

Due to the phenomenal growth rate of IP based traffic and of Internet users, future telecommunication transport networks need to be optimised for the transport of IP. Traditionally, IP has been transported over ATM/SDH/WDM. However, in this protocol stack much functionality is redundant and therefore there is a large effort of vendors and standardisation organisations to propose new mechanisms that streamline the transport of IP over optical networks. In the frame of the EURESCOM P918 project: "Integration of IP over optical networks", thirteen possible network architecture alternatives were identified, studied, and documented. The three most promising approaches were selected for detailed evaluation, Packet over SDH (POS), Gbit Ethernet (GbE), and Dynamic Packet Transport (DPT). This article focuses on the strengths and weaknesses of POS.

The Programme "Network Architectures & Technologies" explores the emerging IP functionalities supporting fixed and mobile services, and identifies key solutions to engineer and plan next generation packet based networks. The objective is to achieve cost reduction in network investment and operation and to transfer new network capabilities into revenue generating converged network services.
With its Exploration Programmes, Corporate Technology is exploring telecommunication technologies and new service possibilities with a long-term view of 2–5 years. Further, the expertise built up in the course of this activity enables active support of business innovation projects.

The motivations of incumbent operators to migrate their legacy infrastructure towards a next generation packet based network are cost savings and translation of new technologies into revenue generating services.

JEAN-CLAUDE BISCHOFF, BERNE

With the ongoing trend of an exponential traffic increase, the multitude of new traffic patterns, the shift from traditional Time Division Multiplex (TDM) networks to multilayer packet networks, and the increasing customer demand for mobile and converged services, incumbent operators will be confronted with a full range of issues to be solved when migrating the existing legacy network infrastructure to a new IP-based network architecture.

POS will be seriously threatened by the emergence of 10 Gbit Ethernet, unless it can offset its higher initial capital cost by lowering operational cost and/or by superior management capabilities.

The IP core network deployed by Swisscom for its future network architecture widely uses the POS protocol. POS is one of the three most promising approaches for transporting IP over optical networks, selected in the frame of the EURESCOM P918 project, "Integration of IP over Optical Networks", for detailed evaluation [1, 2]. This article gives a short description of the POS protocol and highlights its major strengths and weaknesses.
The article is based on results achieved in the EURESCOM P918 project. Corporate Technology has actively contributed to the produced documents and is involved in the experimental assessment of the selected architectures. However, this article does not fully reflect the common technical position of all the EURESCOM Shareholders/Parties.

Description of POS

Standardised mapping for IP into SDH using Point-to-Point Protocol (PPP) and High-level Data Link Control (HDLC) has been defined in IETF [3]. Packet over SDH or IP over SDH refers essentially to the addition of SDH interfaces to a router that terminates the PPP. IP datagrams are encapsulated into PPP packets. PPP provides multi-protocol encapsulation, error control and link initialisation control features. The PPP-encapsulated IP datagrams are then framed using the HDLC protocol [4] and mapped byte-aligned into the SDH Synchronous Payload Envelope (SPE) (fig. 1). The main function of HDLC is to delineate the PPP-encapsulated IP datagrams across the synchronous transport link. An HDLC frame FCS (Frame Check Sequence) is computed to provide error detection and the resulting packet is byte-stuffed. The beginning and the end of the HDLC frame are marked with a flag. Two contiguous consecutive frames are separated by one flag only. The HDLC frame is then scrambled to ensure adequate numbers of transitions before the final SDH framing. POS doesn't use the multiplexing function of SDH. Linking multiple containers together results in a single container into which the payload is mapped, providing higher interface rates. This mapping is also referred to as a "concatenated" SDH payload. POS uses such concatenated SDH pipes for transport.
The line card in the IP router performs the PPP/HDLC/SDH framing. The outgoing optical signal is suitable for transmission over optical fibre either into a neighbouring IP router, an SDH network element, or a WDM transponder (fig. 2).

Strengths

POS is based on SDH, which is a mature and well-proven technology. It is possible to build very high capacity links thanks to the support of high bit rate interfaces (up to 2,5 Gbit/s with STM-64, soon 10 Gbit/s with announced STM-64 POS interfaces) and to the compatibility with WDM interfaces developed for SDH networks. The POS protocol does not intro-

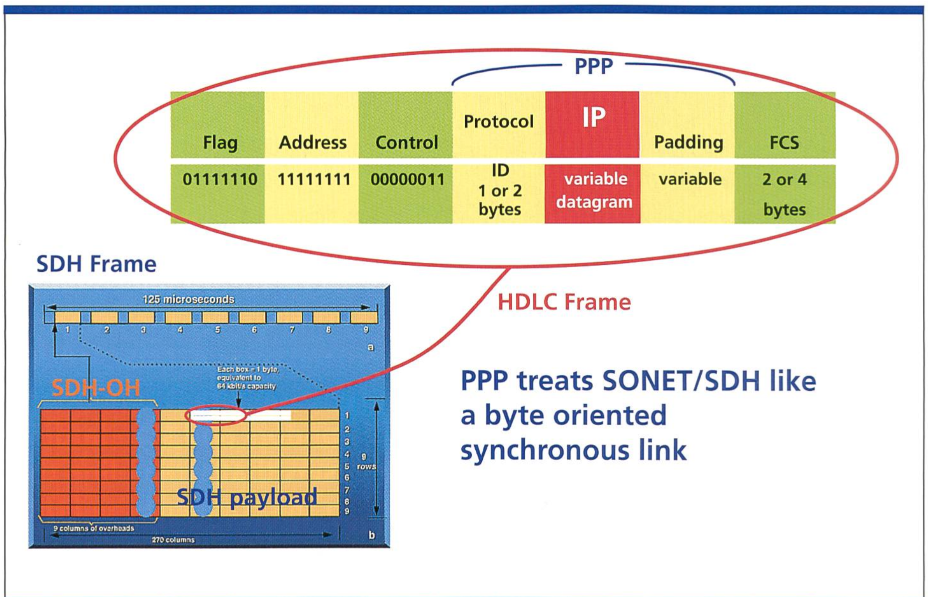

Fig. 1. Framing of IP datagrams (the information field in the drawing) in the SDH payload. The IP datagram is encapsulated in an HDLC frame that is delimited by flags. In the drawing the HDLC frame is not terminated by a flag because in the SDH payload two contiguous consecutive HDLC frames are separated by one flag only.

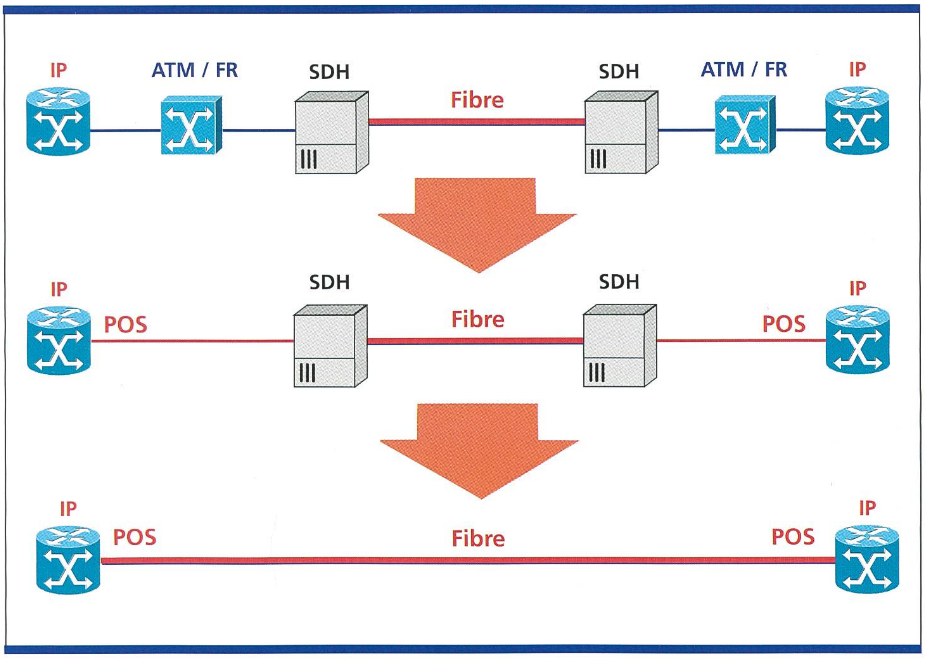

Fig. 2. Trend towards the use of POS interfaces and the direct interconnection of routers by dark fibres or optical wavelengths.

duce any limit on the link lengths, the number of nodes and clients.
The bandwidth efficiency is good: the PPP encapsulation adds 2 bytes, the HDLC framing plus byte stuffing adds 7 more bytes. In addition to the SDH framing overhead (app. 3%), the overhead for a 350 bytes IP packet is as low as 6%. For comparison, the overhead for the transport of such an IP packet over an ATM/SDH/WDM network is approximately 28% (fig. 3).
As POS offers only a framing mechanism for the transport of IP datagrams on point-to-point connections, there is no doubling of functionality: support for QoS is provided by layer 3 (IP) by using protocols such as DiffServ or RSVP; Multi Protocol Label Switching (MPLS) provides layer 2 switching, VPNs support and traffic engineering capabilities. Protection may be implemented at different levels: in the optical layer, at the SDH level or, in the future, by using MPLS protection.
The last strong point of POS to be mentioned is that it is an open technology that is available on many different products from many different vendors.

Weaknesses

The major weaknesses of POS are due to the use of flags to delimit HDLC frames:

- The POS robustness in bad BER conditions is low because a single bit error can result in the loss of two HDLC frames.
- As the IP payload must be searched for flag-like bit sequences, the HDLC framing mechanism is processing-intensive and may impair the evolution of POS towards very high bit rates: 10 Gbit/s interfaces will be very expensive and it will be a real technical challenge to realise 40 Gbit/s interfaces.
- The replacement of flag-like bit sequences results in variable packet size expansion. This interferes with traffic engineering and QoS management mechanisms and, in the worst case, the efficiency may drop below 50% (because each flag-like byte is replaced by a sequence of two bytes).

Further, POS does not offer any multiplexing mechanism. The number of POS interfaces and physical links necessary to build a network with a meshed topology is very large. Not only is this very costly but it could even be unmanageable.

Conclusions

POS is a sound solution for realising efficient high speed router connections. It is presently the best solution for very high speed best effort IP networks. POS establishes a point to point connection between two routers. It does not support any multiplexing capability, it cannot reserve bandwidth for some given traffic, nor provide any switching capability. Therefore, it is only in association with MPLS that it offers more than big pipes and becomes really attractive. MPLS provides layer 2 switching capability, traffic engineering capability and VPNs support. POS is not used in the access network where its deployment is hindered by its high cost. In the backbone, its scalability towards very high bit rates may be limited by the processing intensive HDLC framing protocol and with 10 Gbit/s, it may well reach its upper limit.

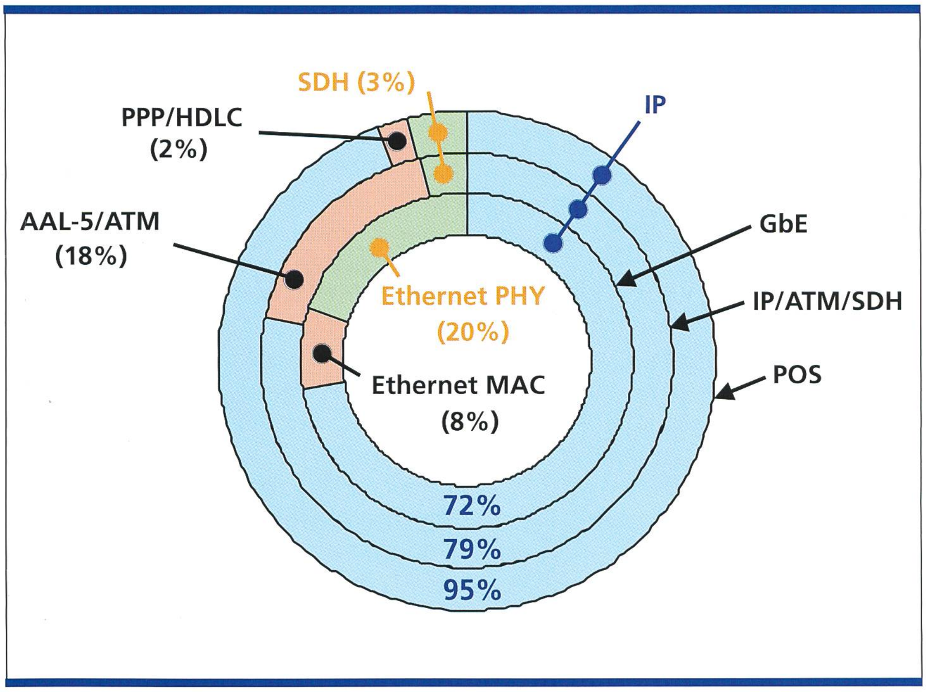

Fig. 3. Overhead for the transport of IP using the POS, ATM/SDH and Gbit Ethernet protocols. 100% is the line rate.

Outlook

POS is at the beginning of its life cycle. When used with MPLS, it may dominate the WAN market. However, it will face a strong competition from Gbit Ethernet. 1 Gbit Ethernet is dominating in the LAN today and some traditional WAN telecommunication equipment suppliers are actively participating to the specification of 10 Gbit Ethernet that should appear on the market within the 2 coming years. The price of 10 Gbit Ethernet is expected to be well below that of POS and the introduction of this technology may have a profound impact on the economics of high-speed telecommunication transport networks in the LAN and in the WAN. The success of POS in the future will depend on the cost of operation and therefore on the quality of the offered management systems. 8.4

The authors gratefully acknowledge the support of EURESCOM for carrying out this work and express a special thank to all P918 participants, i.e. British Telecom, CSELT, Deutsche Telekom, France Telecom, KPN, OTE, Swisscom AG, Tele Danmark, Telefonica, Telenor, Telia.

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Zusammenfassung

Die aussergewöhnliche Wachstumsrate von IP-basierter Übertragung verlangt nach einer entsprechenden Optimierung zukünftiger Transportnetze. IP wird heute über ATM/SDH/WDM übertragen, was eine bedeutende Redundanz der Protokollfunktionalitäten mit sich bringt. Daher bemühen sich Hersteller und Normierungsgremien um neue, schlanke Mechanismen für den IP-Transport über optische Netze. Im EURESCOM Projekt P918 wurden mehrere Alternativen angesehen und drei davon, POS (Packet over SDH), Gigabit Ethernet und Dynamic Packet Transport im Detail studiert.
POS bietet sich für die effiziente Verbindung von Routern mit hoher Geschwindigkeit an und stellt die heute beste Lösung für "Best Effort" IP Netzwerke sehr hoher Geschwindigkeit dar. MPLS (Multi Protocol Label Switching) ist das ideale Komplement zu POS, um viel mehr als einen "dicken Schlauch" offerieren zu können. POS hat das Potential, den zukünftigen WAN Markt zu dominieren, allerdings erwächst von der Gbit-Ethernet-Technologie starke Konkurrenz. Der zukünftige Erfolg von POS wird von den Betriebskosten und der Qualität der angebotenen Managementsysteme abhängen.

Abbreviations

BER	Bit Error Rate
GbE	Gigabit Ethernet
HDLC	High Level Data Link Control
MPLS	Multi Protocol Label Switching
POS	Packet Over SONET/SDH
PPP	Point to Point Protocol

Jean-Claude Bischoff *has a diploma in Electrical Engineering from the Swiss Federal Institute of Technology in Lausanne (EPFL, 1982). After a stay as visiting research engineer at Bell Communications Research (N.J., 1986–87), he returned to EPFL where he obtained a Ph.D. for his work on high-speed opto-electronic devices (1988). Jean-Claude then worked as scientific collaborator at EPFL and as research engineer at Rolex (Geneva) before joining Swisscom in 1991. Since then he has been active in the domains of optical fibre characterisation and broadband networks, especially ATM, and is now mainly involved in the EURESCOM projects P918 and P1014, "Integration of IP over Optical Networks: networking and management" and "IP over WDM Optical Transport Networks: experiments and technical guidelines".*