WDM networks and Gigabit Ethernet : a successful combination

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Exploration Programmes:
Corporate Technology Explores Future Telecommunications

WDM Networks and Gigabit Ethernet: a Successful Combination

In the framework of the Eurescom project P1014, Corporate Technology led the way for delivering Gigabit Ethernet over a single wavelength between Swisscom and France Telecom premises over 745 km. Main project objectives were to assess the conformance to standards, to analyse performance in a real multi-vendor environment and to identify problems and solutions related to the interconnection of different equipment. The project established the Gigabit Ethernet link and produced technical guidelines for IP/WDM network integration and deployment.

The Exploration Programme "Broadband Communication Opportunities" explores new broadband service and communication opportunities enabled by the new 10 Gigabit Ethernet technology, managed all-optical networks, the evolution from ADSL to broadband heterogeneous access networks (fixed and mobile/wireless) and peer-to-peer network models.
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.

Traditional service networks and service providers have to redefine themselves to stay alive in the next century of communications. Swisscom needs to understand the future broadband value chain and to find a position

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in it which permits participation in the new emerging markets. Proposals for broadband services and their implementation are needed to generate new revenue streams and to protect the network investments.
If Ethernet performs as future killer protocoll, as its proponents claim, operators who deploy it early on will have a decisive competitive advantage in terms of CAPEX, OPEX and service quality. If current centralised client-server architectures move towards peer-to-peer network models, e-business value chains will change tremendously. In a peer-to-peer world there will be less room for traditional ISPs. Moreover, managed optical networks will give Swisscom a competitive advantage for offering new wavelength services and dynamic bandwidth brokering.
In this context, the transmission of IP based data becomes more and more important. Various solutions are available on the market today and proposed solutions for integrating IP over WDM need to be analysed and tested.

Corporate Technology and France Telecom were pioneers in delivering a Gigabit Ethernet service over 745 km using a single wavelength for the whole path.

Networking and management aspects of the IP technology on an optical network have been studied in theory in the previous Eurescom project P918 [1, 2], whereas Eurescom Project P1014, called TWIN, looked at the practical integration aspects. TWIN focused on three network scenarios:

- IP over SDH over WDM, where SDH is only used for framing purposes on point-to-point connections;
- IP over DPT over WDM, where DPT (Dynamic Packet Transport) is a layer 2 switching solution for a flexible IP transport network proposed by Cisco;
- IP over Gigabit Ethernet over WDM, where Gigabit Ethernet is only used for framing purposes on point-to-point connections.

The project ran a test campaign to assess the three different protocol stacks through experiments on four laboratory testbeds and field trial networks. The results obtained allow the drafting up of guidelines and network engineering rules for near and medium-term IP/WDM network deployment.
In this article, details of the methodology used for assessing and comparing the different architectures are given. In particular, details are provided of the interconnection between France Telecom's field trial network and Swisscom's laboratory network. A 745 km long Gigabit Ethernet link was set up for the interconnection over a single wavelength throughout the whole path, without 3R regeneration.

Objectives and Methodologies

In order to demonstrate an end-to-end IP/WDM connection across a long distance link, and also to gain crucial information regarding the operator's interconnection, it has been decided to interconnect the laboratories of Swisscom and France Telecom. This interconnection

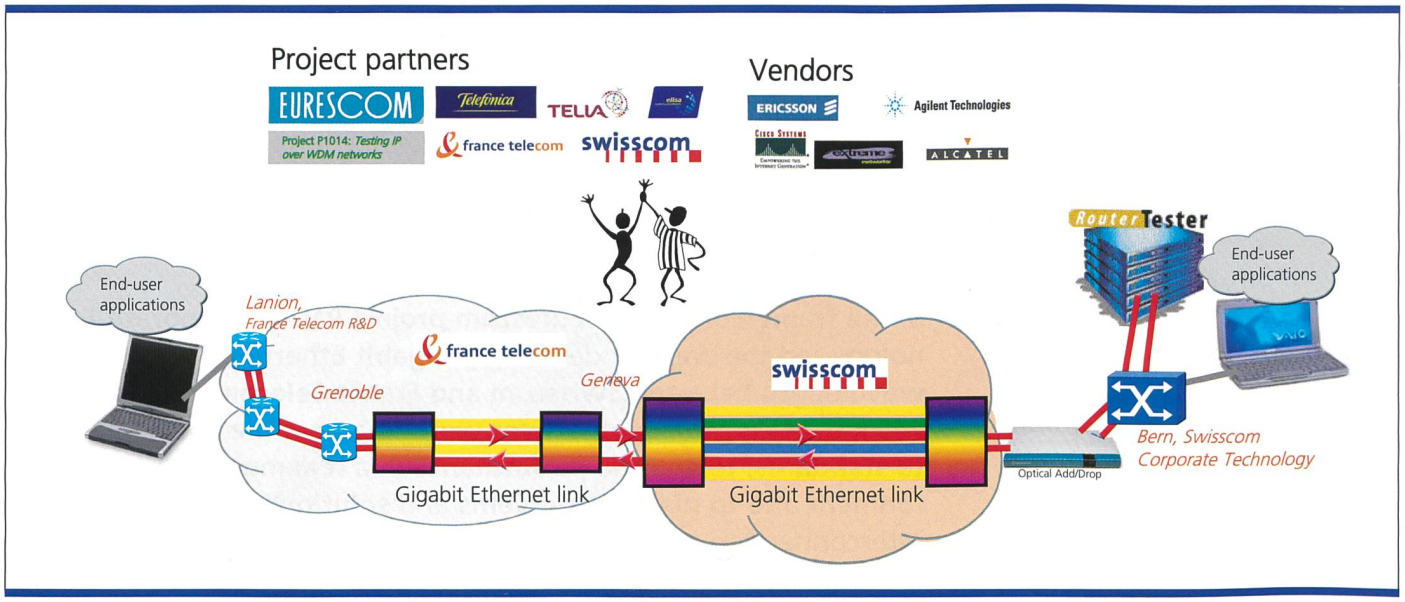

Fig. 1. Gigabit Ethernet over a WDM link between Swisscom and France Telecom premises.

used WDM equipment already deployed as far as possible, i. e. it ran over the Swisscom WDM backbone and France Telecom links. The interconnection was done using native Gigabit Ethernet protocol. This new protocol is not yet commonly utilised over long distance links and taking advantage of it across different networks and infrastructures is considered to be a challenge. However, other options that consider encapsulating Gigabit Ethernet over other protocols (like SDH) have been discarded as being out of the scope.

The project partners (Telia Research from Sweden, Elisa Communications from Finland, France Telecom R & D, Telefonica R & D from Spain and Swisscom Corporate Technology) have made available their existing testbeds for the project. The testbeds show a large variety in size (WAN or MAN), in the supplier equipment chosen, the protocols used, and also regarding the network of the operator they had to fit in. This large variety enabled us to compare the different solutions used to provide basically the same functionality almost independently of the particular realisation (vendor).

The description of the testbeds and field trials are described in detail in the first deliverable of the Eurescom project P1014 [3].

We have identified and defined tests in seven different categories:

- *Qualification tests:* These tests are needed to verify that the environment is correctly set up and ready to perform more sophisticated tests.
- *Conformance tests:* These tests verify that the equipment deployed complies with the relevant standards.
- *Performance tests:* These tests provide a better understanding of system performance. They are grouped according to the different layers involved.
- *Management tests:* Network element management tests are performed in order to verify the possible parameter configuration, to verify the alarm handling, and to validate any information gathered by the system under test.
- *Application tests:* End-to-end application tests were used to demonstrate the possible utilisation and capability of the network.
- *Interoperability tests:* The interoperability tests verify that different vendors equipment can work together and that different operators can operate together.
- *Concept validation tests:* These tests support the validation of the network concept. They address topics like scalability and dimensioning.

Detailed Description of the WDM Link

First, a wavelength from the Swisscom site in Bern to the site of France Telecom in Grenoble had to be identified that was free (or could be freed) on each backbone network. The wavelength selected was channel 31 of the ITU-T grid, which corresponds to 1552.53 nm (193.1 THz). Then all equipment in this path had to be identified and a feasibility study was performed including power budget computation and OSNR calculation. Figure 1 shows the interconnection as it was realised. The switch in Bern was an Extreme Networks switch (Summit 1i) and the PCs running the different applications were connected to this switch. In turn, the switch was connected to a Cisco Systems 15200 that acted as a channel Add/Drop for channel 31. Its interfaces were configured to be Gigabit Ethernet. Then the transmitted signal went through an Alcatel 2R WLA transponder, followed by an Alcatel WM1686 multiplexer that already belongs to the operative backbone of Swisscom. On the Swiss receiver side the Cisco 15200 was directly connected to the Alcatel WM1686 demultiplexer of the backbone.

On the backbone the signals were preamplified and post-amplified at each multiplexing and demultiplexing equipment. Between the multiplexing and demultiplexing stages there was no 3R regeneration. There was a fibre bridging on the path between the equipment, but without regeneration and no amplification. The connection between the French and Swiss networks (between Geneva and Anemasse) was over a separate fibre not carrying any other traffic. Between Anemasse and Grenoble a WDM link of France Telecom was used. Finally, in Grenoble the WAN network of France Telecom R&D was connected via a router. In the reverse direction, from Grenoble to Bern, the transmitter side of the router was connected to an Alcatel 2R WLA transponder operating at channel 31, which in turn was connected to an Alcatel WM1686 multiplexing unit.

The results of transmission tests over this configuration when the router at Grenoble was shortcut on the physical level (a loop-back was installed, shortcutting the router) show that the total length is 745 km. That is the maximum distance that we tested for Gigabit Ethernet on one single wavelength, without 3R regeneration (just 3 Alcatel 2R WLA transponders were used). The average latency was 3601.55 microseconds, and the test was run for 568 182 165 packets transmitted, that were all received without any errors.

Results

At the end of the project three documents will be delivered: A document with technical guidelines for IP/WDM networks integration and deployment, a document grouping all the tests defined and the test results, and finally a less technical public document that concludes the project.

A testing infrastructure is now in place at Corporate Technology for MAN and WAN Gigabit Ethernet. New tests with different vendors can be run on demand. Further, the project has allowed to build a team with an appropriate knowledge of IP and optical networks at Corporate Technology for giving support to Swisscom Business Units for introducing Gigabit Ethernet services in their portfolio to satisfy customer needs.

Conclusions

There is an increasing demand for Gigabit Ethernet services due to its low cost for the customer. Swisscom is able to deliver Gigabit Ethernet services to its customers over the existing WDM backbone. Other solutions, not using the existing optical infrastructure, could be even more efficient, but in terms of time to market, the tested solution is the easiest and most effective one.

The first ones to offer Gigabit Ethernet services at a reasonable price will gain the market position in Switzerland. The Eurescom TWIN project (P1014) has proved the feasibility of such services over the current infrastructure.

Outlook

Further work will consist of extending the support to the Swisscom Business Units that want to introduce Gigabit Ethernet in their portfolio, and of using the testing infrastructure to prove the feasibility of the given solutions. 6

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[2] Deliverable 4 of Eurescom P918: "Integration of IP over Optical Networks: Networking and Management, Proposal for testbeds and experimental assessment".

[3] Deliverable 1 of Eurescom P1014: "TWIN – Testing WDM IP Networks: Testbed description and test suites for IP/WDM experiments". Presented at the Second Hungarian WDM Workshop, "Roadmap to next generation optical networks workshop", Budapest, Hungary.

Pointers

http://www.eurescom.de/public/projects/p1000-series/p1014/

http://ctep.swissptt.ch/ep35
(Closed User Group access only)

http://ctep.swissptt.ch/ep35/projects/strong/strong-en.htm
(Closed User Group access only)

Zusammenfassung

Die Übertragung von IP-basierten Daten wird für die Telekommunikationsanbieter immer wichtiger. Heute sind verschiedene Lösungen auf dem Markt. Die vorgeschlagenen Lösungen für die Integration von IP über WDM müssen analysiert und getestet werden. Das Eurescom-Projekt TWIN (P1014) untersucht die praktischen Aspekte der Integration. Die Arbeit im Projekt TWIN wurde auf drei Netzwerkszenarien eingeschränkt: IP über SDH, IP über DPT und IP über Gigabit-Ethernet.
Im Rahmen des Projekts wurde eine Testserie durchgeführt, um die drei Protokollstacks in vier Laboreinrichtungen und in Feldversuchsnetzen zu testen. Die erhaltenen Resultate erlauben es, Richtlinien für die nahe und mittelfristige Entwicklung von IP/WDM-Netzen aufzustellen.
Bedingt durch niedrige Kosten für den Kunden existiert eine zunehmende Nachfrage nach Gigabit-Ethernet-Diensten. Der erste Service Provider, der Gigabit-Ethernet-Dienste zu einem angemessenen Preis in der Schweiz anbietet, wird auch gleich die grössten Marktanteile gewinnen. Das TWIN-Projekt hat bewiesen, dass es möglich ist, solche Dienste auf der bestehenden Netzinfrastruktur anzubieten. Swisscom kann den Kunden Gigabit-Ethernet-Dienste über ihr WDM-Fernnetz anbieten. Andere Lösungen, die nicht auf der aktuellen SDH- und WDM-Infrastruktur basieren, wären zwar effizienter, aber bezüglich "time to market" ist die getestete Lösung die einfachste und effizienteste.

Abbreviations

2R	Re-amplifying and Re-shaping equipment
3R	Re-amplifying, Re-shaping and Re-timing equipment
CAPEX	CAPital EXpenditures
DPT	Dynamic Packet Transport
IP	Internet Protocol
ISP	Internet Service Provider
ITU-T	International Telecommunication Union / Telecommunication Standardisation Bureau
MAN	Metropolitan Area Network
OPEX	OPerational EXpenditures
OSNR	Optical Signal to Noise Ratio
PC	Personal Computer
SDH	Synchronous Digital Hierarchy
TWIN	Testing WDM IP Networks project
WAN	Wide Area Network
WLA	Wavelength Line Amplifier
WDM	Wavelength Division Multiplexing