Results from IST projects working on advanced optical networking and the IST OPTIMIST thematic network

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EXTENDED ABSTRACT

Introduction

The IST OPTIMIST project is a thematic network project entitled *"Optical Technologies in Motion for the IST Programme*" and funded within the FP5 of the EU research programme. IST projects funded in the FP5 working in the area of Optical Technologies and Photonic Networking can be mainly found in KA4 (Essential Technologies and Infrastructure), in FET (Future and Emerging Technologies) and in the RN (Research Networks). As the R&D effort spent on photonic technologies is thus scattered over several parts of the FP5 programme, the first aim of the OPTIMIST project was to create a thematic network actively clustering the IST projects working in this technological area. The main objectives of the OPTIMIST thematic network are thus the initiation of a concertation process in-between the projects of the thematic network, the fostering of synergies and consensus building and the support for the creation and endorsement of European policies through the collection of "Technology Trends in Photonic Technologies and Optical Networking". More information on the IST OPTIMIST thematic network can be found at http://www.ist-optimist.org.

Within this paper the OPTIMIST project wants to highlight the results obtained and the demonstrations realised by the IST Optical Networking projects. In view of the interest by the NREN community in advanced optical networking technologies and as this community often acts as 'first adapters' of new technologies, the OPTIMIST project wants to assist in the dissemination of these IST research results. Next to this the OPTIMIST project wants to act as a broker in between the RTD projects and the NREN operator community stimulating the fostering of new ideas, the early implementation of research results and bringing together possible users and developers of advanced optical networking techniques.

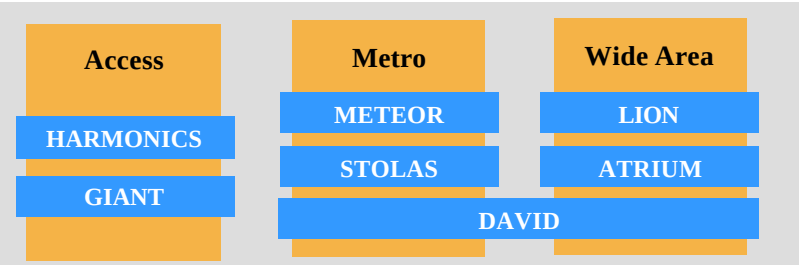
IST FP5 Research on Advanced Optical Networking Techniques.

The identification of Technology Trends and possible Evolutionary Scenarios has been one of the major tasks of the OPTIMIST consortium members. These views and ideas are being collected during interactive workshops with the Thematic Network projects involved, during interaction with other photonic projects and or organisations at large and through the study of public available research results in general. The main application domain that has been studied so far is the area of telecommunications.

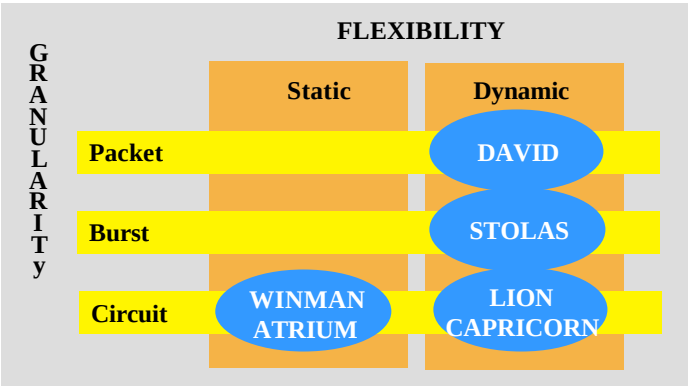
Mapping the work of the IST projects against these technology trends identified, is an essential task which assists in the clarification of the EU RTD situation, identification of weaknesses which should get re-enforced attention in the research programmes and/or of strong points which should be supported at large.

At the time of writing the OPTIMIST thematic network clusters over 40 IST projects working in the area of Photonic Technologies and Optical networking. The majority of these projects are active in the research and development of optical components, materials and technologies in general. The application domain of some of these projects even stretches beyond the area of communication networks. Some 12 projects focus on the area of Advanced Optical Networking Techniques. Projects such as ATLAS, FASHION and TOPRATE focus on Ultra high-speed transmission, exploring the possibilities of the OTDM techniques. Each of these projects again has yet another focus with respect to investigation of networking aspects, the influence of integrated components in high-speed point to point transmission, investigation of physical limits, etc.

With respect to the networking area we can distinguish projects mainly focusing on the area of the Access Networks (HARMONICS, GIANT), on the Metro section (METEOR, STOLAS, DAVID) an/or on the Wide Area network (LION, ATRIUM). This is illustrated in figure 1.



When looking at the type of optical network studied other similarities/ commonalties can be distinguished within the IST research. Some projects focus more on the far-future technologies such as packet and burst switching offering very high flexibility and small granularity in the network, (DAVID, STOLAS). Other projects focus on the optimisation of the management of multi-layer networks and service differentiation strategies (WINMAN, ATRIUM). Again other projects develop control plane strategies for these types of networks, offering a distributed control approach for network provisioning and resilience (LION, CAPRICORN). This is illustrated in figure 2.



It is clear that looking from a high level viewpoint to all these projects results, comparing strategies, obtained results and engaged technological challenges can bring added value to the out-come of the FP5 IST research programme. A listing and a very short description of these 12 IST projects focusing on advanced optical networking can be found in the annex section of this paper. By May 2003 some of these projects will already have finished or other projects will be well advanced in reaching their objectives. The presentation at the conference will focus on these project results and on the analysis thereof.

Conclusion

An overview was given of the IST FP5 projects working in the area of Advanced Photonic Networking aspects. The sum of these projects span a large range of diverse aspects valuable within the realisation of future optical communication networks. During the presentation focus will be given to the results obtained and demonstrations realised by these projects.

The OPTIMIST project wants to act as a dissemination forum in general and as a broker towards the NREN community in specific. More information on the OPTIMIST thematic network activities and on the IST projects working in the area of Photonic Technologies and Optical Networking can be found on www.ist-optimist.org.

ANNEX: Overview of IST Optical Networking projects

The following wants to give a short overview of the running IST Optical Networking projects. Below only a short flavour of the main project objectives are given. More information on these projects can be found on OPTIMIST website http://www.ist-optimist.org. The projects are listed in alphabetic order.

- IST-1999-10626 **ATLAS**

All-optical Terabit per second LAmbda Shifted transmission
Francesco Matera (mat@fub.it)
The aim of is to investigate transmission techniques at very high capacity over long distances (500-1000 km), taking into account the behaviour of some fundamental devices such as the optical wavelength converters. Fibre-optic WDM transmission over 500 – 1000 km with an aggregate capacity of 1 Tbit/s will be pursued by adopting return-to-zero signal format and the dispersion management technique. 40 Gbit/s and 80 Gbit/s in-line optical wavelength converters will be experimented to investigate the role of the wavelength converters in optical transport networks.

- IST-1999-20675 **ATRIUM**

A Testbed of Terabit IP Routers Running MPLS over DWDM
Thomas Berger (thomas.berger@alcatel.be)
The ATRIUM project is a research networking project which has as major objective the creation of a testbed of IP routers running MPLS over DWDM. A range of traffic algorithms and protocols have been tested to run on the Alcatel A7770 RCP Advanced Terabit Router in a Diffserv capable network. Today this network is connected through the GEANT network to some EU NREN's and advanced networking tests are running over the network.

- IST-2000-28616 **CAPRICORN**

Call Processing in Optical Core Networks
Bernd Stilling (bernd.stilling@icn.siemens.de)
The objective is to design and to implement an optical DWDM core network with call processing capabilities. A novel control plane will be defined and implemented which enables the exchange of signalling and routing information between optical network nodes as well as signalling information between IP core routers and optical network

nodes. The novel control plane will also be able to react on network faults by providing distributed optical restoration. In addition, CAPRICORN will define and implement means for topology auto-detect and auto-link configuration capabilities in optical networks.

- IST-1999-11742 **DAVID**

Data and voice integration over WDM

Lars Dittmann (ld@com.dtu.dk)

The project wants to study a Packet-over-WDM network solution, including traffic properties and management, based on optical packets and asynchronous transmission over metro and backbone distances. The project will capitalise on both optics and electronics to find out the optimum combination to reach multi-Tb/s capacity. On the metro side, a buffer-less network is considered using a medium access control protocol. The backbone will be based on 10 Tb/s multi-layer (wavelength and packet) opto-electronic medium access control protocol with opto-electronic packet routers, incorporating core and edge functions.

- IST-2000-28765 **FASHION**

Ultrafast Switching in High-Speed OTDM Networks

Eckhard Meissner (eckhard.meissner@icn.siemens.de)

OTDM point-to-point transmission and time-domain routing will be investigated for single-channel data rates of 160 Gbits/s and higher. The transmission reach is planned at 500-1000 kms allowing wide all-optical networks. Supported by the analysis of physical system limitations, network concepts including economical considerations will be developed for mixed wavelength-division multiplexed (WDM) and OTDM multi-terabit systems. Time-domain add-drop multiplexers will be developed including an assessment of their impact on the transmission performance.

- IST-2001-34523 **GIANT**

GIgaPON Access NeTwork

Brecht Stubbe (Brecht.Stubbe@alcatel.be)

In this project a next-generation optical access network optimised for packet transmission at Gigabit/s speed will be studied, designed and implemented. The studies will take into account an efficient interworking at the data plane and control plane with a packet-based metro network. Innovative transmission convergence and physical medium layer subsystems will be modelled and developed. A cost-effective architecture will be selected and implemented in a lab prototype.

- IST-1999-11719 **HARMONICS**

Hybrid Access Reconfigurable Multi-wavelength Optical Networks for IP-based Communication Services

Jeroen Wellen (jswellen@lucent.com)

A common dynamically reconfigurable fibre infrastructure is proposed, deploying flexible wavelength routing integrated with flexible time slot allocation in a new Medium Access Control protocol. This infrastructure feeds various last-mile access networks, and provides capacity on demand while accounting for QoS requirements of user traffic. Both

a wireless HIPERLA2 and a twisted-pair VDSL user access network enabling QoS-differentiated IP traffic will be set up.

- IST-1999-11387 **LION**

Layers Internetworking In Optical Networks
Antonio Manzalini (Antonio.Manzalini@cselt.it)
Project main objectives regard the definition of architectures and functional requirements of ASON/GMPLS networks; the evaluations of integrated resilience strategies for IP over Optics; optical network planning; the development of a complex IP/MPLS over ASON/GMPLS test-bed, and specifically the design and implementation of an optical Control Plane, NNI signalling and a management plane enabling an end-to-end view over different domains with different management technologies (e.g. SNMP, WBEM, CORBA).

- IST-1999-10402 **METEOR**

Metropolitan Terabit Optical Ring
Jens Buus (Buus@compuserve.com)
An experimental network, which will be based on an optical ring with transmission of 40 DWDM channels at bit-rates up to 40 Gbit/s, will be realised. The optical network will demonstrate the concept of service transparency, enabling transport of various types of services while not requiring a truly optically transparent network. The required functionalities such as: management at the optical layer, performance management, quality of service, protection schemes etc. will be realised. Novel optical add-drop multiplexer configurations, high-speed transmitters and receivers modules will be designed, fabricated and implemented in the experimental system within the field trial.

- IST-2000-28557 **STOLAS**

Switching Technologies for Optically Labeled Signals
Ton Koonen (a.m.j.koonen@tue.nl)
The use of optical packet routing can significantly increase the network throughput. Marking packets with optical labels enables routing along transparent end-to-end optical paths. With the pervasive usage of IP-based terminals, multiple optical addressing levels are needed for advanced routing and traffic engineering. The STOLAS project aims to improve the throughput of packet-switched networks by novel optical routing techniques based on stacked optical labels.

- IST-2000-28657 **TOPRATE**

Terabit/s Optical Transmission Systems based on Ultra-high Channel Bit-rate
Eugen Lach (Eugen.Lach@alcatel.de)
The aim is to achieve multi-Terabit transmission in one fiber (combining OTDM with WDM) and the investigation of basic system limitations reaching ultimate transmission capacity over one optical transmission channel (640 Gbit/s and above). The project will investigate these limitations from a transmission-channel point of view but also from the network point. For that both N DWDM channels of >160Gb/s and 1 channel of >640 Gb/s will be transmitted. At the same time high speed components (RZ sources, DEMUX etc) will be implemented.

- IST-1999-13305 **WINMAN**

WDM and IP Network MANanagement

Harold Balemans (winman-contact@list.lucent.com)

The overall aim is to offer an integrated network management solution that is capable to provide end-to-end IP connectivity services derived from Service Level Agreements (SLAs). From implementation point of view, the project will address the separate management of IP and WDM networks. Per technology domain the integration of the management at Network Management level will be developed. An Inter-Domain Network Management System (INMS) as a sub-layer of the Network Management Layer will be implemented to support IP-connectivity spanning different WDM sub-networks and to integrate the management of IP and WDM transport networks.