Title:	**Optical Networks for the Future Internet**
Project code:	D00I99I (Fondef)
Area :	Information Technologies
Main disciplines:	Telecommunications, Optical Broadband networks
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Chilean Firms:	Telefónica Manquehue S.A., Cisco Systems Chile S.A.
Foreign Institutions:	CANARIE Inc.
Foreign Firms:	IMPSAT

ABSTRACT: "Needless to say, there is no better known physical medium than fiber, and no signal source better than light to meet these new and emerging requirements." (editorial IEEE Comm. Mag., Vol 38, Nº 3, Mar, 2000). One of the most recent developments in this field has been optical transmission using Wavelength Division Multiplexing, WDM, by which means information can be transmitted on multiple wavelengths in one fiber strand. The global use of the Internet Protocol, IP, on the other hand, has been envisioned as the most important platform to move data over the network, regardless of the nature of its source. The aim of this 2 year project is to combine IP and WDM technology in a cost-effective way for developing countries. The network will be used as a scalable R&D optical telecommunication laboratory that considers four WDM/GbE (WDM/Gigabit Ethernet) nodes – three in Santiago and one in Valparaíso –linked by means of "dark fiber" provided by companies associated to the realization of the project.

EXPECTED RESULTS: The aim of this project is the deployment of a scalable optical network to support R&D in that field and the development of applications using IP protocol directly on the dark fiber using WDM technology. It will also be a showcase for new developments in optical networks for industry, government and universities. To manage the network and associated laboratories a Research Center for Optical Networks will be created. It will issue recommendations for the migration of the actual optical networks to the ones being developed by this project and will provide training for industry, government and other public or private organizations.

MAIN PROJECT IMPACTS

Socio/economic: Societies, public and private organizations will profit from broadband network capabilitties with better cost-performance relationships than the existing ones. New applications that demand high transmission bandwidth can be developed with this technology and tried out on an experimental basis over this network.

Scientific/technologic. The development of a permanent laboratory for experiments in short and long-haul fiber optic links will provide the necessary background for the creation of a Center of Research for Optical Networks. This Center will provide scientists and engineers that work in optical technology a means to exchange experiences and formulate new projects. It will be a training center for professionals working in optical technology. The participation of leading organizations in the development of community networks, equipment and service providers of international status like Canarie, Nortel, Cisco and ManquehueNet, Impsat, respectively, will improve the selection of the necessary equipment for the development of the network and facilitate know-how transference.

Institutional: For Reuna, a university consortium network provider, the introduction of WDM technology will foster the development of new broadband applications. Researchers will be able to perform R&D in WDM technology by means of a dedicated optical network and optical network laboratories. Participation of CANARIE, IMPSAT, ManquehueNet and Cisco Systems will help to focus applications on industry needs and demands, besides of providing Network infrastructure.

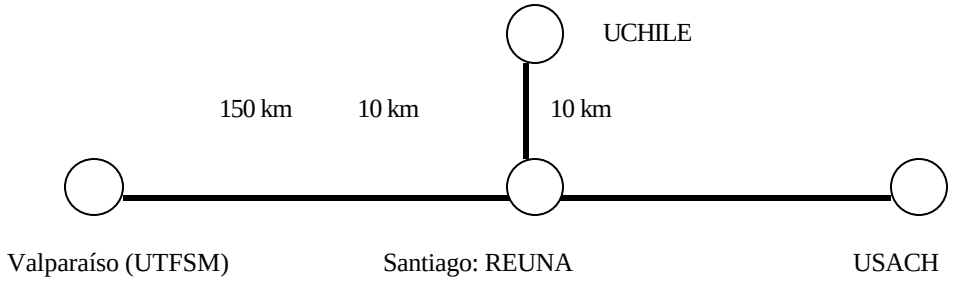
RECENT DEVELPOMENTS

On December 7th, 2001, the project was formally inaugurated. Government and industry representatives attended the presentation. After a short introduction from Dr. Walter Grote, who outlined the objectives, network structure and participants of the project, Bill St. Arnaud from Canarie, Canada, joined us with a videoconference. He shared his points of view for a project of this nature and encouraged everybody to put their best effort for a fruitful

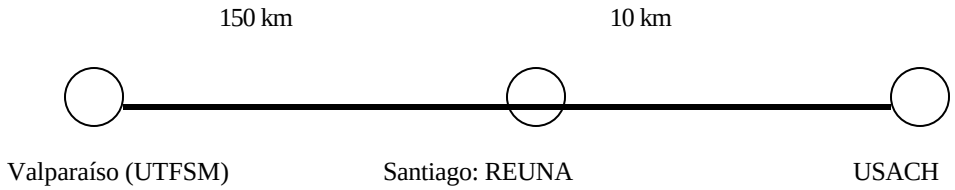
deployment of a broadband multimedia testbed based on optical networks. The ceremony concluded with a remark from Florencio Utreras, the General Manager of the University Network Consortium, REUNA, thanking all organizations that made this project possible.

NETWORK OUTLINE

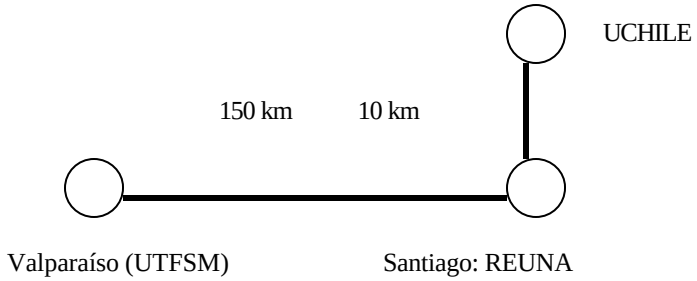
Project team members have studied several proposals for the optical network. Some of them, although very attractive from a technical point of view, do not match our finances. Therefore our proposal keeps some basic features that will fulfill the main objectives of the project at a reasonable cost. Here is the network structure we came up with:



There are 2 major applied research topics to be covered with this project: one of them related with the physical layer, and one related with the application layer. At UTFSM and USACH, research will be conducted on the transmission issues using optical fiber and devices. This means that the network, from this point of view, can be looked upon as one transmission link from UTFSM to USACH.

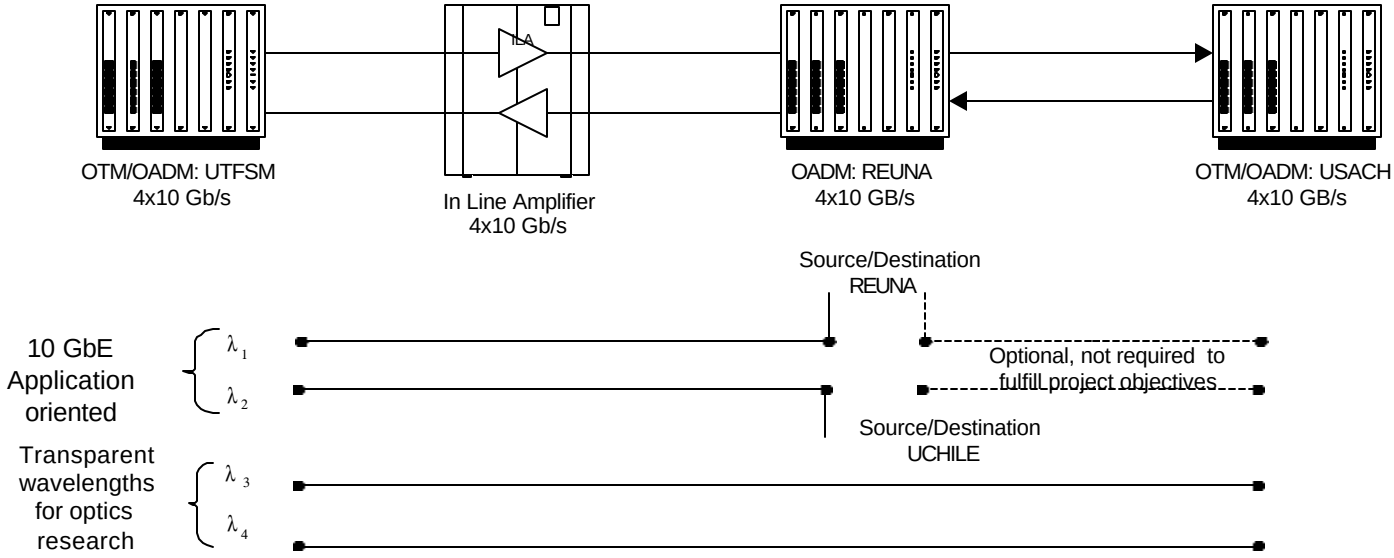


At REUNA, UCHILE and UTFSM trials on research on applications will be carried out. Therefore, from this point of view, the network will look like the following.



Fiber is scarce in the 150 km stretch from Valparaíso to Santiago and we will be lucky to get 2 strands of dark fiber. Thus we will focus on a star topology solution instead on one based on a ring structure. Between UTFSM (Valparaíso), REUNA and USACH in Santiago a long-haul DWDM backbone network will fulfill the objective of being able to carry on research on fiber optic communication systems based on this technology. UCHILE will be connected to REUNA using CWDM technology to emphasize the Metropolitan Area Optical Network solution.

As stated before, a long-haul DWDM backbone network to fulfill the research objective on fiber optic communication systems based on this technology will link UTFSM (Valparaíso), REUNA and USACH in Santiago. Also, the distance covered calls for a DWDM backbone solution for repeater placing. For network planning only 4 wavelengths are required: two for the UTFSM-USACH links to be used for research in fiber-optics communications, one to provide a link UTFSM-REUNA and finally one to provide a link for applicatons running between UTFSM-UCHILE. Here is how our DWDM optical network will look like with these considerations.



At both end points, UTFSM and USACH we will deploy OTM's (OTM: Optical Terminal Multiplexer) with 4 wavelengths. At REUNA, an OADM (OADM: Optical Add/Drop Multiplexer) with 4 wavelengths will be placed. Two wavelengths will be used to provide Gigabit Ethernet connectivity for the development of applications, whereas the remaining 2 ones will be left transparent for research on optical networks and connectivity. Between UTFSM and REUNA a 4 In-Line-Optical Amplifier will be placed, roughly at 75 km from each end point. Transmission rates to be considered are 10 Gb/s (or pick one of the following, according to what seems feasible to implement at the lowest cost with the equipment you will provide: 1.25, 2.5, or 10 Gb/s). We would like to get a proposal for all possible alternatives, in order to accommodate the proposal to our budget.

Just so as to make it very clear: since USACH will not work at the application layer but only on fiber optics communication research, there is no need for GbEthernet connectivity at USACH. For trials on the optical layer, at least 2 transparent lambdas will be required, end to end, from UTFSM to USACH. Therefore at most 4 wavelenghts will be required to fulfill our requirements. In fact, these wavelengths will only be used at the UTFSM-REUNA link. From REUNA to USACH, only 2 wavelengths are required. Additional wavelengths, if necessary to fulfill equipment requirements for the DWDM network, can be discussed on a per price basis to match equipment cost to our budget.

UCHILE will be connected to REUNA using CWDM technology to emphasize the Metropolitan Area Optical Network solution, which is supposed to be cheaper than a DWDM solution. This makes sense since in UCHILE only network applications will be developed, whereas in UTFSM, REUNA and USACH optical network research will be conducted as well. This way both objectives can be fulfilled at an expected lower total cost. Again, only 2 wavelengths are sufficient to provide application-related links and 2 additional transparent wavelengths for research on optical layer, making a total of 4 wavelengths.

For design purposes consider all optical fiber links conforming to G.652 specifications.

THE PROTOCOL ISSUE

Chilean carriers have implemented optical networks. DWDM technology has been incorporated into their network structure. Their networks carry IP as well. So, is there a possibility for this project to make a contribution in this

field? We think that there is. Normally the IP protocol is encapsulated in SDH, or even worse, IP is encapsulated in ATM, which in turn is encapsulated in SDH by different carriers. One nice feature that SDH provides is the fact that by using this protocol managment of the network is enhanced. However, considerable transmission overhead is incorporated. Therefore it is our aim to provide a solution that removes part of this overhead by transmitting IP over Ethernet and encapsulating it directly in WDM. Therefore the equipment provider should take into consideration, while building his solution, that we are not looking for the traditional carrier solution: we would like to avoid the use of the SDH protocol.

RELIABILITY ISSUE

Another aspect to be considered is the reliability of the network. Carriers normally have to comply with stringent requirements set by the telephone network operation. The network in this case has to be highly reliable, so that failure in links or nodes have to be overcome in less than 50 ms. This calls for standby equipment, which increases the operating cost. IP provides reliability in a different way. Basically it builds its reliability on the fact that for each packet, the route from source to destination can be different. Thus no redundancy for each link is required. Network recovery most probably will exceed the 50 ms threshold. But we think the user is very willing to accept this reduction of connectivity performance if: a) it happens only occasionally; b) it produces a significant decrease in the operational cost. The network that we are conceiving is one where this price reduction is an objective. Therefore we do not look for any other redundancy but the one provided by the network itself.

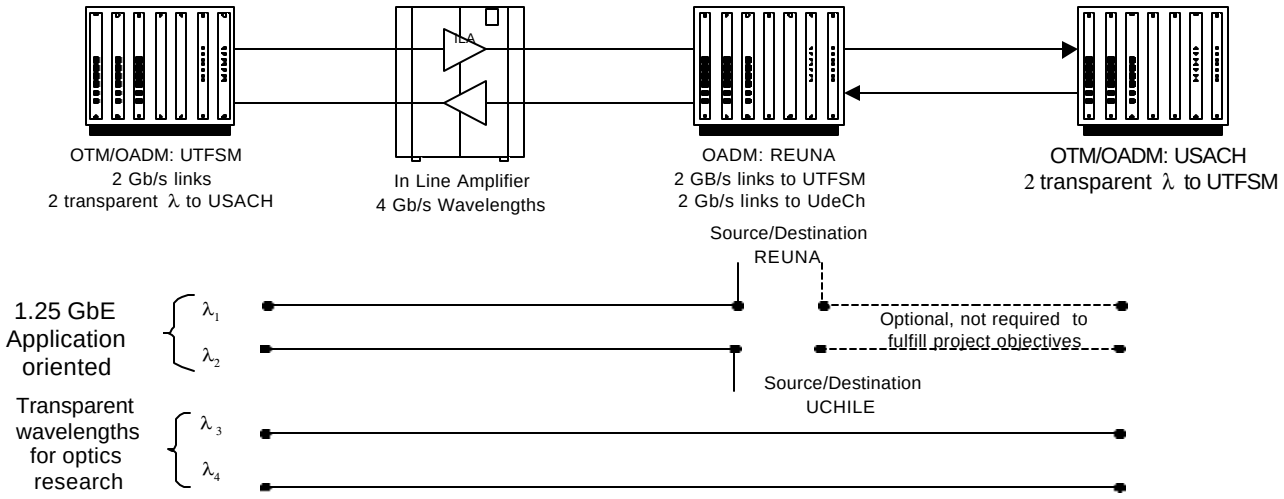
FINAL REMARKS

The original project proposal considered a more ambitious optical network, however, the projected budget was drastically reduced by the sponsor (the Chilean government). To accommodate the planning of the actual Optical Network to the reduced budget has not been easy and resulted in the minimum network configuration outlined above. Equipment providers should feel free to contact us if they think that they can provide us with a customized solution that reduces the overall cost, however, keep in mind that the proposal should fulfill the minimum requirements outlined before. Furthermore, donations from companies will be most probably be necessary to achieve the desired results. Two kinds of donations can be foreseen: straight or tax deductible donations to Universities. Straight donations have no restrictions. Tax deductible donations are only applicable for companies that have Chilean subsidiaries with profit in the Chilean marketplace and they must be issued in currency. This money can be used to purchase equipment.

A more detailed outline of the network can be found on next page.

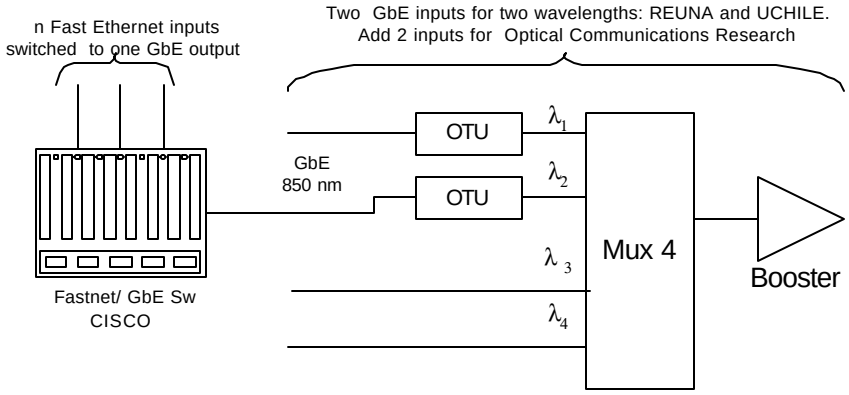
Optical Network for the Internet of the Future

This is the stripped down version that fulfills the basic requirements to fulfill the projects objectives.
Basic assumptions are: 1.25 GbE connectivity for applications running on 2 wavelengths, 2 additional wavelengths to perform applied research on fiber optic communications. Prepared by A.González, W.Grote, C.Henry and R.Olivares 20-03



OTM/OADM and GbE Access Equipment Detail at UTFSM

1.25 GbE access equipment at UTFSM, as for REUNA and UCHILE will be provided by CISCO a partner in the project. No specific CISCO switch has been defined yet. Focus on OTM conceptual block diagram please.



OADM and GbE Access Equipment Detail at REUNA

(Since no optics research will be performed at REUNA in the original project conception, the wavelengths dedicated to this kind of work are merely forwarded to their endpoint destinations: UTFSM and USACH)