# Team Project: Resilience in Optical Access Networks

Introduction

Our society has an increasing demand for broadband information and to satisfy this need telecommunications operators are now planning to provide optical fibres directly to offices, schools, factories and individual homes. Once fibre to the home (FTTH) becomes a reality, many new services will be available and the impact on society will be revolutionary because optical fibre can convey far greater capacities than any other means.

FTTH networks will mainly be in the form shown below:
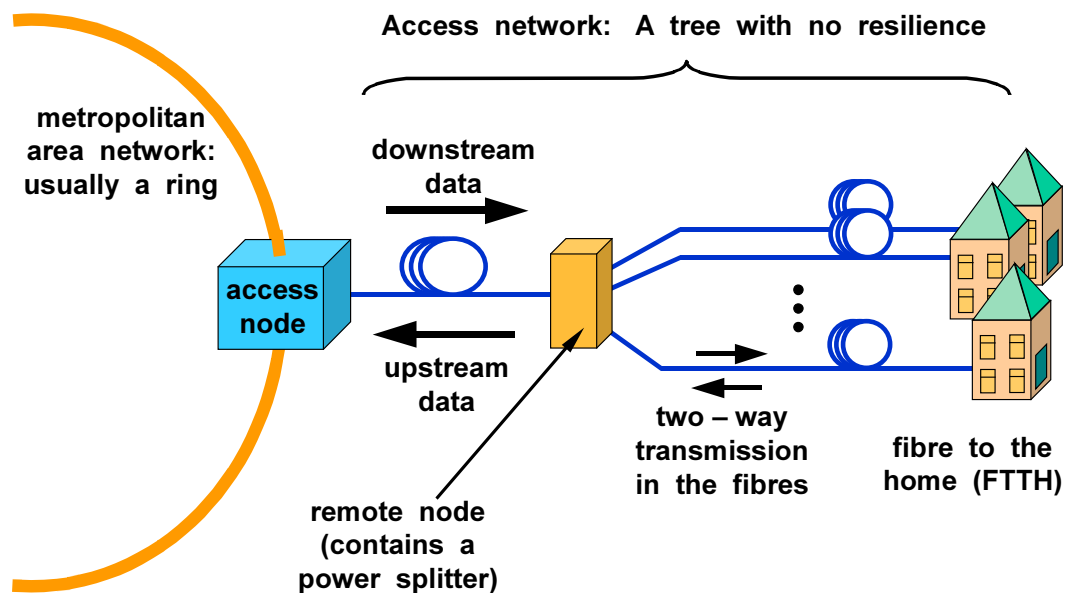
The diagram shows how the access network is a "tree" topology in which the fibre between the access node and the individual customers is bi-directional (it propagates light in both directions). The reason is cost: it is cheaper than using two unidirectional fibres.

Unfortunately, the simple tree design of optical network creates a significant problem for some customers. Consider the case of a small business that depends on the internet to deliver content to its customers. If the fibre network fails, the small business becomes disconnected from the internet and so loses custom, which could be very serious. If the failure occurs downstream of the remote node, one customer is affected. However, is the failure is between the access node and the remote node, all of the customers suffer a loss of service. The disruption is great and the customers lose faith in the dependability of the telecommunications operator.

The reality of life, especially in our cities, is that there are many construction works to build new underground car parks, to repair electricity cables and water pipes or to build new offices. See the photograph below:

Accidents frequently occur during the work and sometimes telecommunications cables are destroyed as a result. In the past the consequences were not too serious because people did not depend so much on telecommunications services but this is now no longer the case. Schools, hospitals, government offices and even individual homes now rely on having high bandwidth services twenty four hours per day. This raises the question: How can we adapt our networks so as to offer the ability to withstand failures? It is a difficult question because in nearly every case providing a "resilient" infrastructure is expensive.

The Project: Overview

Your goal is to find out as much as possible about resilient optical access networks. The information that you obtain will come from four main sources:

- Technical journals such as Photonics Technology Letters, Journal of Lightwave Technology and Electronics Letters (in English only).
- International scientific conferences. The proceedings, which are usually in English, are often available on-line.
- Standards documents, especially those of the International Telecommunications Union (ITU), some of which are available in Spanish.
- The internet (but please note that this will be the least important of the four sources because Google searches will seldom provide useful documents).

You should use up-to-date documents, especially those published within the last three years. For this reason, text books are unlikely to be helpful.

A number of proposals to provide resilient networks have been presented. Some of them might be very beneficial and others might have severe disadvantages. Therefore, when you do this project you will be required to critically appraise the alternatives that have been proposed in the technical literature. You are training to be an engineer – in other words, someone who solves problems. You must therefore learn to think for yourself.

The Project: Tasks

The tasks proposed here can be adapted according to the number of students participating. In all cases, you must work as a team and reach a common set of conclusions that are supported by evidence.

- ITU Standards: What do the ITU standards documents say? Differentiate between time division multiplexing (TDM) and wavelength division multiplexing (WDM).
- The Technical Literature: What has been published in the main optical communications journals in the last three years? There are many papers on optical access networks but how many of them mention the word "resilience"?
- The Need for Resilience: What can you find out (e.g. from the internet) about the telecommunications services and categories of customers that will be most seriously affected in the event of a complete loss of service?
- Categories of Failures: The above discussion has been about one type of failure only – when the fibre has been cut. However, there are other kinds, such as failures of optical amplifiers and failures of node equipment. Do these change your conclusions?
- Your Own Proposal (Optional Task): This is an ambitious task that will be difficult to do. Can you propose a novel network design of your own?
- Summary and Categorisation: Provide a list of options for resilience, stating their advantages and disadvantages. Perhaps the best way to do this would be to compile a large table.

The Benefit of this Project to You

This project is about optical access networks, which is the current "hot topic" in optical telecommunications. Networks operators are very interested in the subject and they are recruiting engineers to work in this area. As an example, three of last year's graduates plus one project student from this university have recently been employed by British Telecom (BT) to work on access technologies. The project will provide you with the chance to learn about a technology that will make a major impact on all of our lives and simultaneously help your future employment prospects.

Conclusion

This project is on how to provide resilience for optical fibre access networks. You will be required to appraise the literature critically and summarise the various schemes that have been proposed. Your final report should preferably have clear conclusions and, if possible, recommendations. The project will provide you with knowledge and skills that will be useful to you in future.