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The NGI ONRAMP test bed: Regional Access WDM technology for the Next Generation Internet

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In the space of a few years wavelength division multiplexing (WDM) technology has evolved from a research topic to a core technology for long-haul communications. Spurred by the growth of the Internet, the competition to provide denser channel plans, higher bit rates and longer spans continues unabated in both the commercial and research arenas. Concurrent with this drive toward high capacity in the long haul market, and in some ways orthogonal to it, is the movement of WDM into access networks. As WDM networks are deployed closer to the user they require less capacity and range, but must also be less expensive, more flexible and more compatible with terminal equipment. For residential access, cost is of paramount importance. However, regional access networks serving medium and large businesses must strike a balance between competitive cost and high performance. The challenge in regional access networks is to provide interfaces to the enormous data pipes provided by WDM wide area networks that allow efficient and dynamic routing and multiplexing of diverse users, with the emphasis on Internet applications.

This challenge is the focus of the DARPA-sponsored NGI ONRAMP consortium, a pre-competitive consortium including MIT, JDS Fitel, Nortel Networks, Cabletron systems, AT&T and MIT Lincoln Laboratory. NGI ONRAMP is an acronym for the Next Generation Internet Optical Network for Regional Access using Multi-wavelength Protocols. The goal of the consortium is to design and build a regional access network which exploits WDM and other emerging technologies to support next generation Internet services. At least two types of service will be offered: all-optical service, which establishes an uninterrupted lightpath from source to destination, and IP service, which connects source and destination via IP routers. The phrase "IP over WDM" has become shorthand for the concept of a physical layer that efficiently transports TCP/IP by eliminating overhead in intermediate layers of the network. In support of IP and other types of traffic, the network will feature optical flow switching, MAC protocols to share wavelengths among bursty users, dynamic provisioning and reconfiguration, automatic protection switching, and a robust and responsive network control and management system.

In addition to study and architectural work on these subjects a test bed will be built in the Boston metro area to test and demonstrate the network services and features. Figure 1 shows a conceptual picture of the ONRAMP test bed. The feeder section is a two-fiber ring connecting four access nodes in the Boston area to each other and to the DARPA Supernet via the AT&T Local POP in Boston. Under normal operation, each fiber carries 8 ITU channels in opposite directions. In the event of a link failure, protection switches on either side of the failure route all 16 channels onto the same fiber to form a bypass loop. To ensure a robust control channel, control signals will be routed bidirectionally from every node, so that a redundant path is always available and is independent of protection switching. Each access node also has a distribution network associated with it; the architecture and features of these networks may differ from one node to the next.

Figure 2 is a diagram of the access node optics currently being built and tested. A full-scale access node contains a reconfigurable add/drop multiplexer, network control and management terminals,

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protection switching, and an IP router. Signals can pass between the feeder ring and the distribution network all-optically, via the add/drop multiplexer, or optoelectronically via the IP router. At least 4 pairs of WDM multiplexers and demultiplexers will be cascaded in the NGI ONRAMP feeder ring test bed, and in principle the network should be able to support 10 to 20 access nodes. Thus an important goal of the test bed is to understand how system impairments intensify in cascade. Components that would work well in a long haul WDM application, where the signal must pass through only one pair of WDM devices, may cause significant penalties when cascaded in the ONRAMP ring geometry. At OC192 rates, the most significant impairments caused by WDM components are expected to be crosstalk, caused by finite isolation between channel passbands, and distortion, caused by passband dispersion[1] and/or shape. Control and minimization of transients in the amplified ring is another important issue.

This paper will discuss recent work in the design and implementation of the ONRAMP test bed. The authors wish to acknowledge funding from the Defense Research Projects Agency (DARPA) under the Next Generation Internet (NGI) initiative.

[1]G. Lenz, B.J. Eggleton, C.R. Giles, C.K.Madsen and R.E. Slusher, J. Quantum Electron., **34**, pp. 1390-1402, 1998.

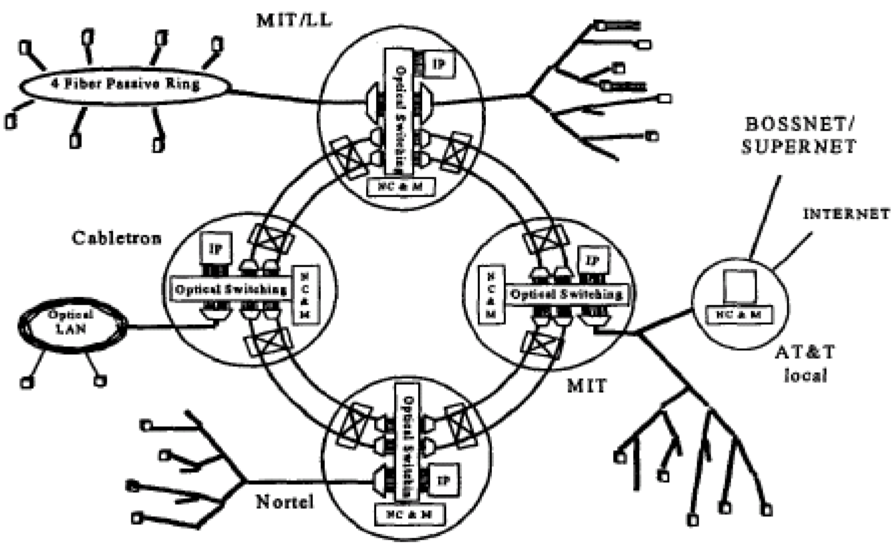

Figure 1. High level view of the ONRAMP test bed.

Figure 2. Prototype access node design, including reconfigurable add-drop multiplexer, control channel optics, protection switches, and IP router.