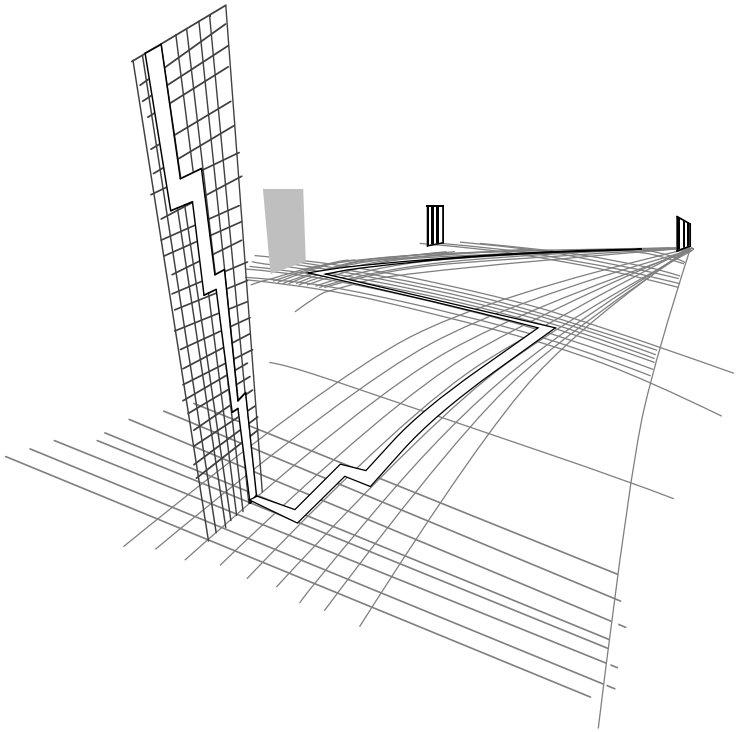
“Metric” Gb/s
on
XUNET West



Presented at the
XUNET Student Meeting
Chicago

February 13, 1994

by

Gary Armstrong

LLNL Principal Investigator:
Dr. William J. Lennon

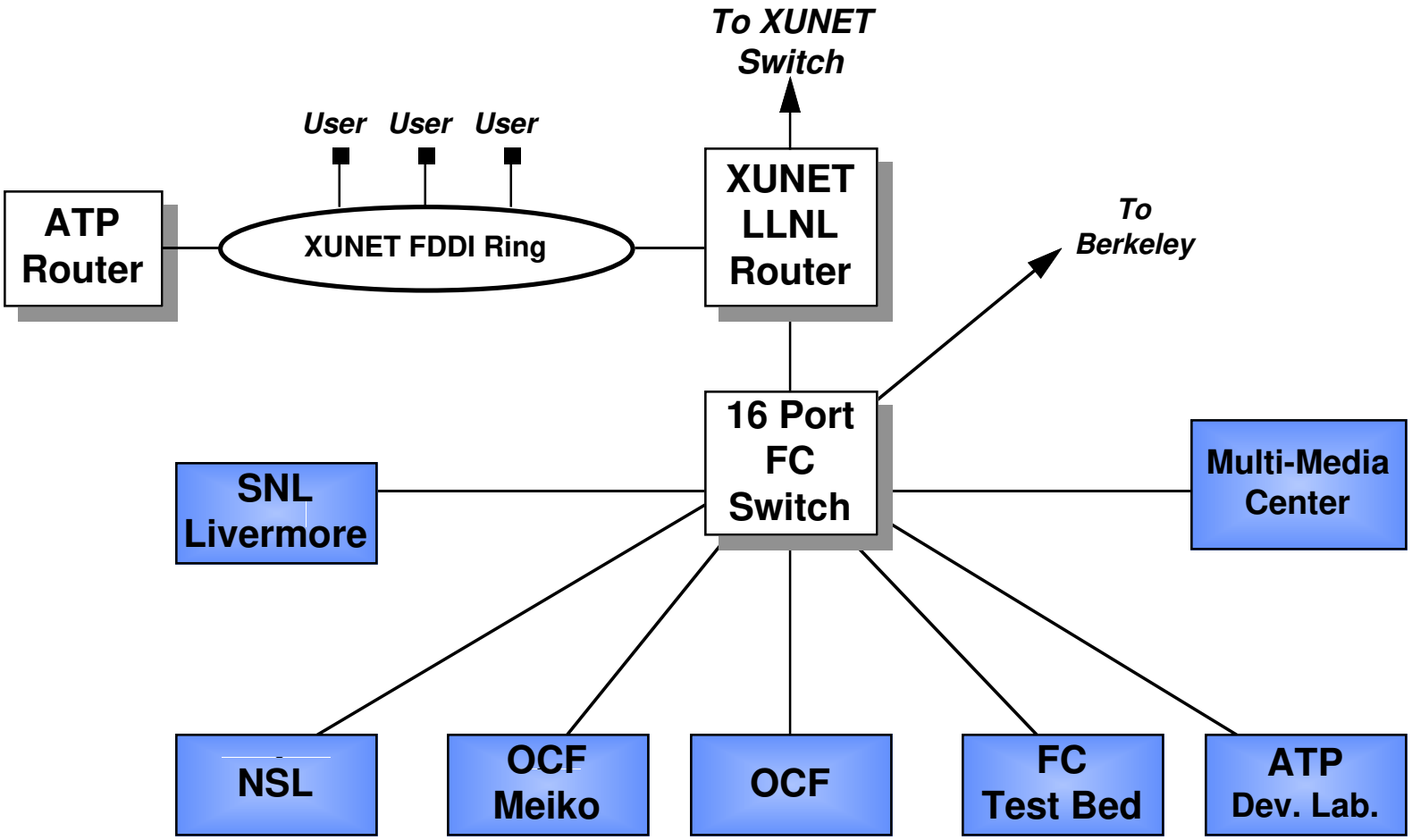
The Advanced Telecommunication Program (ATP) at LLNL

- LLNL Overview
- ATP LAN/WAN Activities
  - Fibre Channel
    - » Experimental LAN
    - » Standards Activities
    - » Fiber Channel Test Bed
  - Bay Area Giga-bit Network (BAGnet)
  - Optical Network Technology Consortium (ONTC)
  - Optical Amplifier Reliability Test (OART)
- XUNET “Metric” Gigabit Activity

LLNL is involved in a variety of Fibre Channel related activities.

- **Fibre Channel Standards - ANSI X3T11 Committee**
- **Fibre Channel Test Bed of interoperability testing**
- **Fielding an experimental Fibre Channel LAN**

XUNET-Fibre Channel LAN Infrastructure

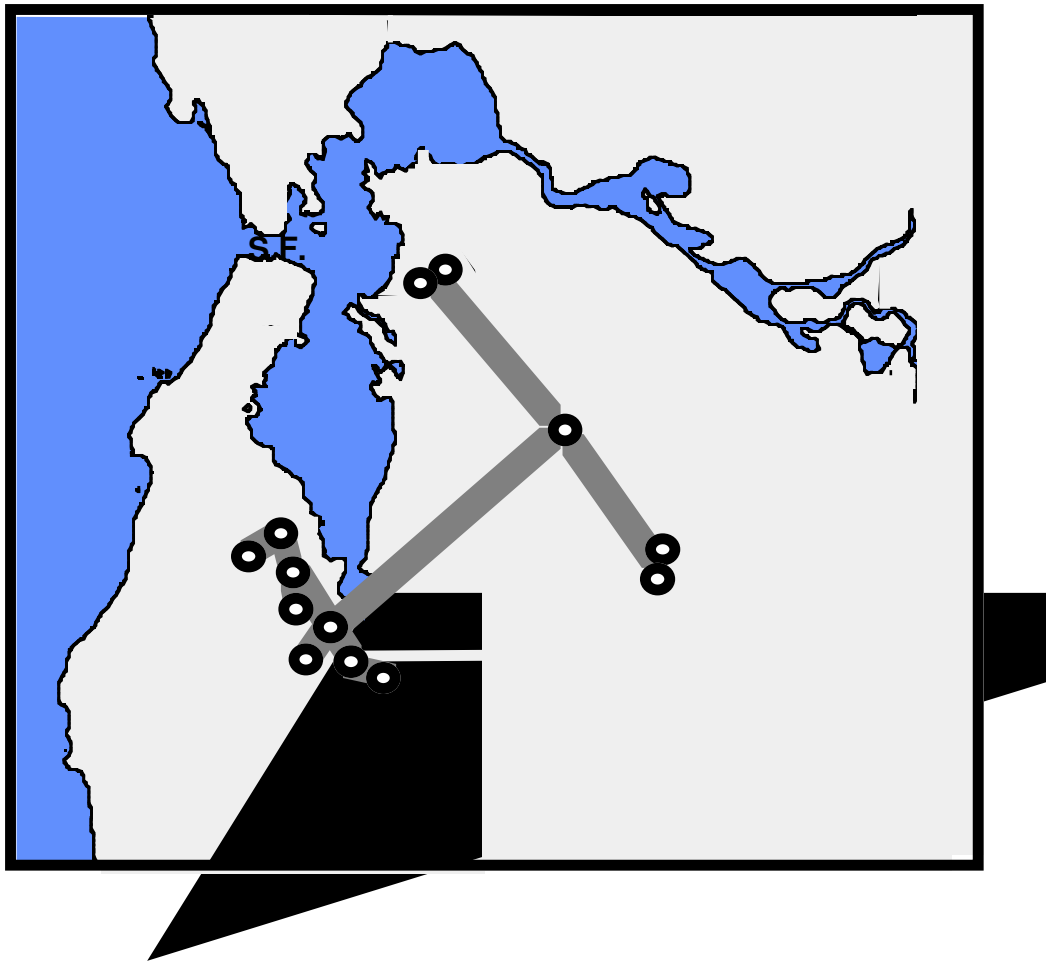


Installation Target:4/1/94

BAGnet

The BAGnet WAN has begun with the first connections between Xerox PARC and NASA/AMES

- **BAGnet is an ATM network which will host a number of pairwise collaborations.**
- **Tele-seminars will be a unifying application.**



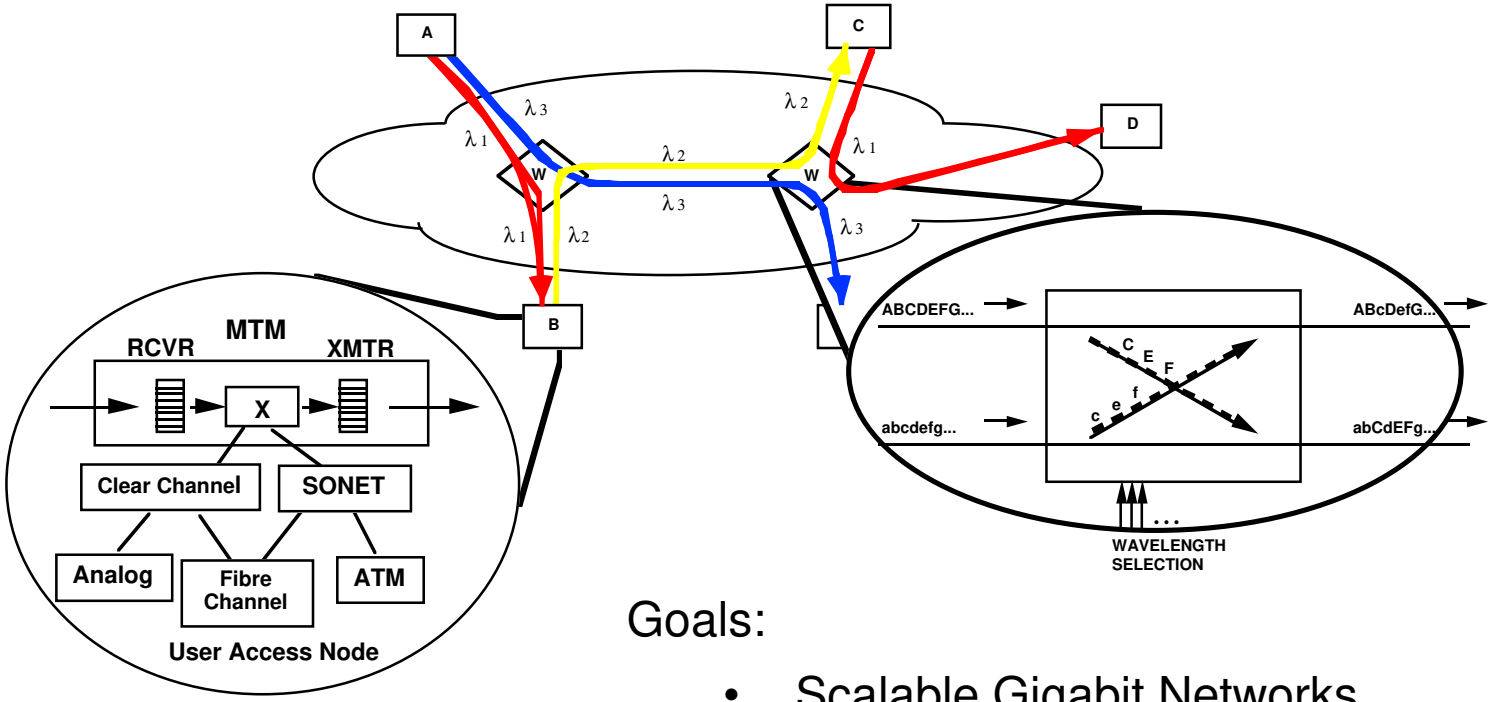
Players:

Apple	SGI
DEC	SRI
HP	SNL
LBL	Stanford
LLNL	UC Berkeley
NASA/AMES	Xerox PARC
PacBell	

XUNET

The Optical Network Technology Consortium (ONTC) is using optical switching and wavelength re-use to build a scalable, modular network

ONTC



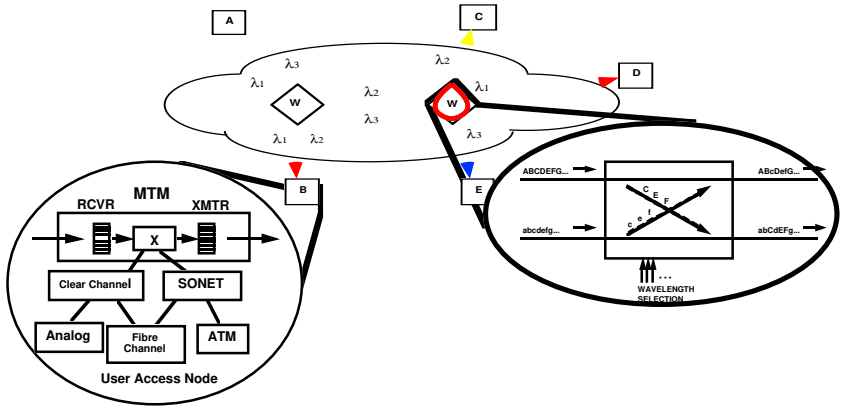
Goals:

- Scalable Gigabit Networks
- Flexible
- Survivable
- Transparent
- Easy to manage

We are successfully collaborating on the development of this technology

ONTC

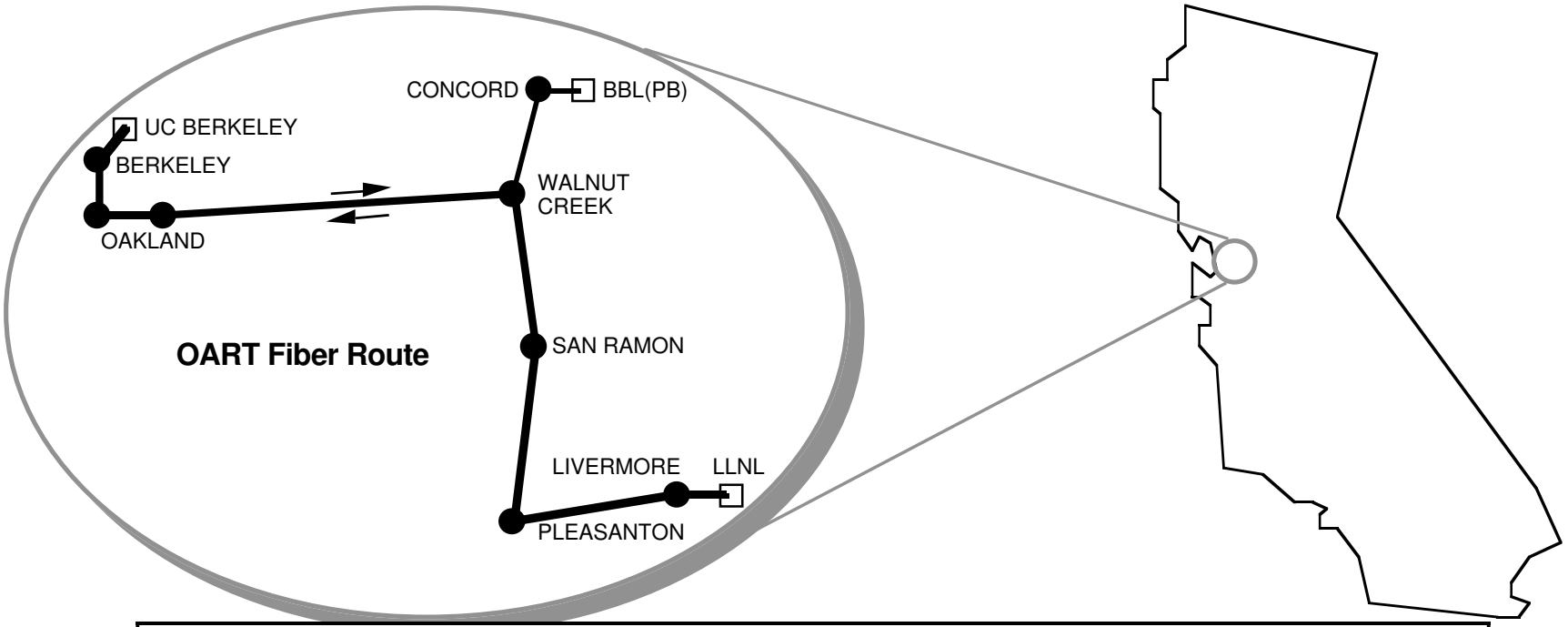
- **Phase 1 (ARPA BAA 91-14)**
  - **4 λ discrete devices**
  - **SONET (OC-3) access**
  - **4 λ 2 x 2 AOTFs**
  - **Demonstrate basic technology**
  - **Network architecture atudies**
- **Phase 2 (ARPA BAA 92-30)**
  - **8 λ laser arrays, receiver arrays**
  - **SONET (OC-48) access**
  - **8 λ 4 x 4 AOTFs**
  - **Network architecture studies**



ONTC Participants

Bellcore	Project lead and chief system designer
Northern Telecom	Physical network architect
Columbia	Control network architect
Hughes Aircraft	Rf sub-carrier designer
Rockwell	Transceiver array designer
United Technology	AOTF cross-connect designer
LLNL	High-speed terminal user and demo site

OART is a joint Pacific Bell / LLNL Project.



Project OART — Optical Amplifier Reliability Trial

Project OART is a field trial of fiber amplifiers in a 100 km fiber optic data link between Lawrence Livermore National Laboratory and the University of California at Berkeley. Using wavelength division multiplexed channels, data will be transported at Fibre Channel rates of 266 Mbit/sec & 1.062 Gbit/sec and XUNET ATM at 622 Mbit/sec.

Video will be carried on a separate channel over a 73 km segment of the link between Concord and LLNL.

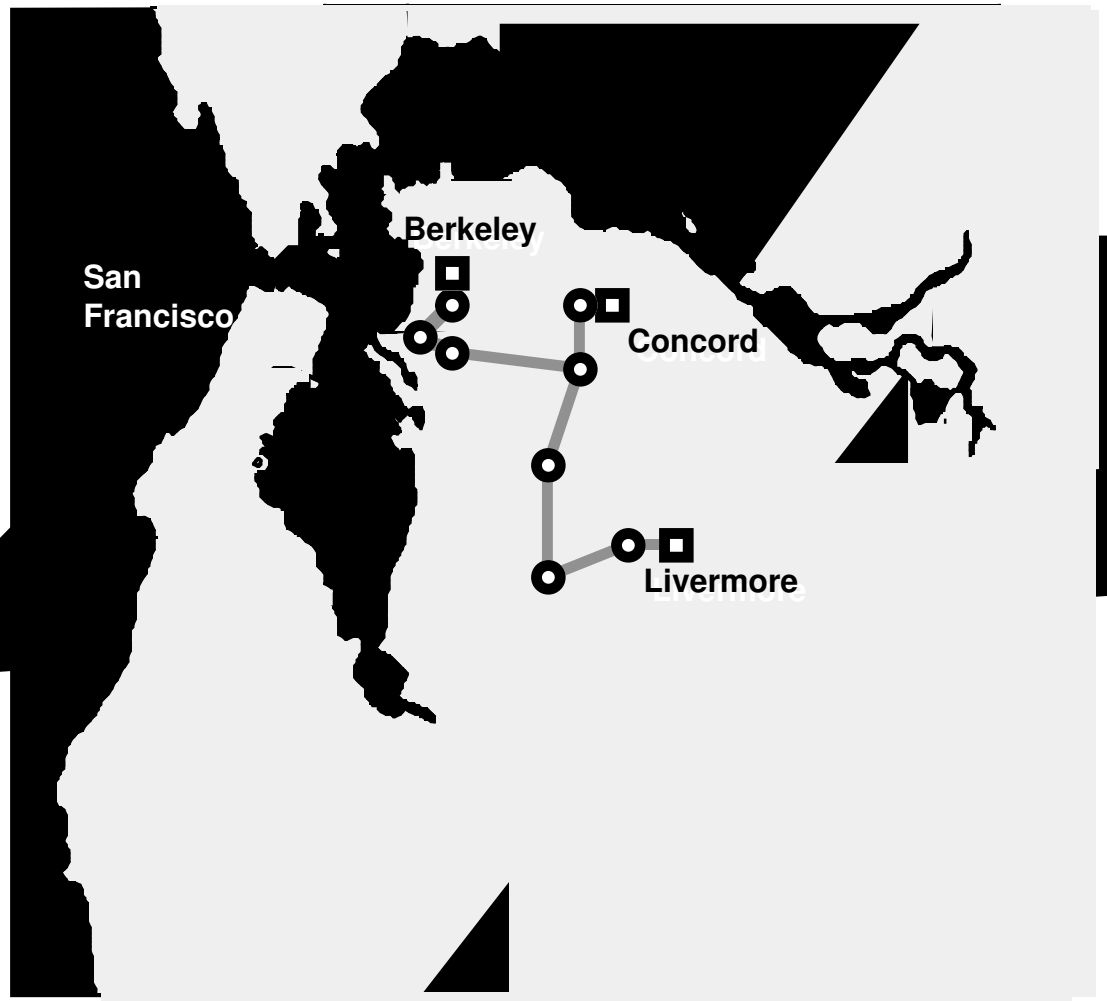
The OART experiment is motivated by new technology requiring much higher data link speed & capacity

- **Optical communications technology can now support multiple gigabit/second data channels on the same fiber**
  - **Erbium Doped Fiber Amplifiers (EDFAs) are devices that amplify optical fiber signals "independently" of speed and wavelength due to their extremely high gain bandwidth product (>> 100 GHz)**
    - » **Easily supports data signals as fast as tens of gigabits per second**
    - » **Supports multiple simultaneous channels on different optical wavelengths — Wavelength Division Multiplexing (WDM)**
  - **Optical link lasers and receivers are available that support speeds up to 2.5 Gbit/sec**

- **Data sources and data sinks are evolving to require much faster links to transfer data effectively**
  - **Animated simulations (computer movies) generated by supercomputers**
    - » **(1000 pixels x 1000 pixels)/frame x 32 bits/pixel x 16 frames/second = 512 Mb/sec !**
  - **High speed RAID disk farms**
  - **National databases**

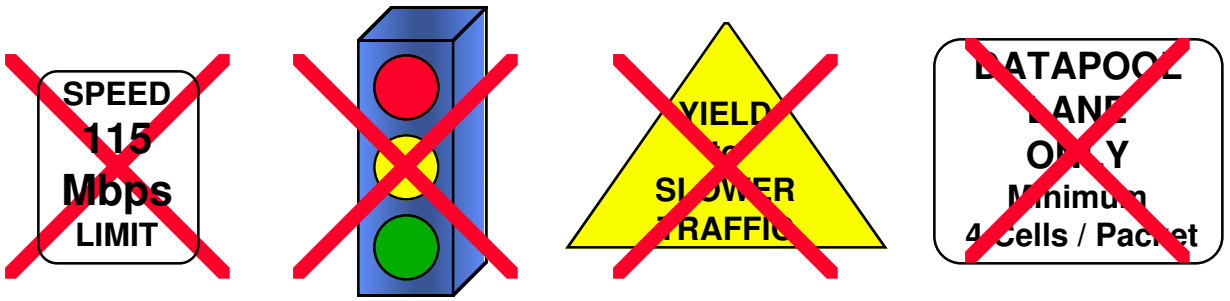
OART Regional Map

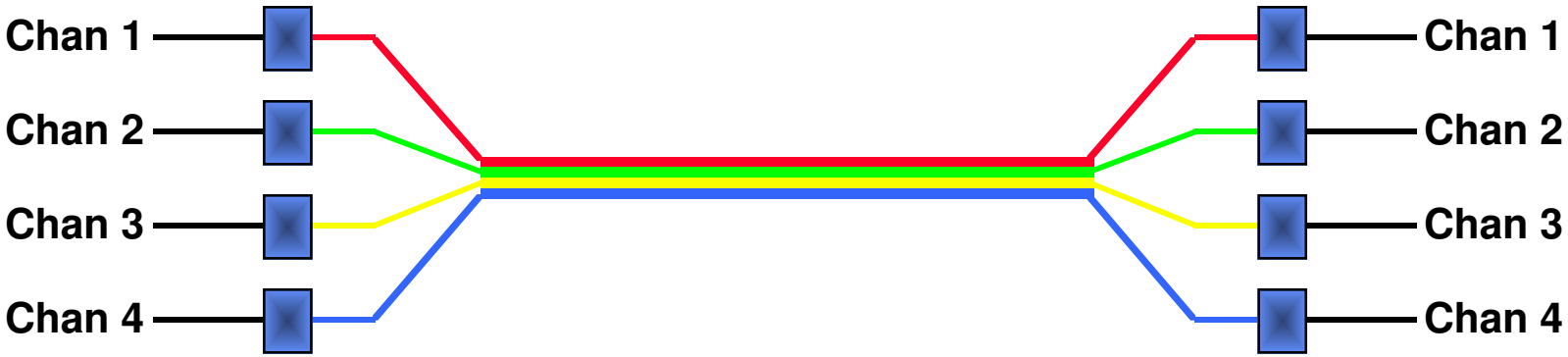
- Two fibers from UCB to LLNL — 100 km.
- Two fibers from Concord to Walnut Creek CO will be “muxed” onto UCB to LLNL line to allow video overlay — 75 km total.
- Fiber is non-dispersion shifted.
- The OART fiber route transits 8 Pacific Bell central offices.
- Livermore terminal end is in LLNL’s central office (B256).
- Berkeley terminal end is in Evans Hall (Dept of CS).
- Concord terminal end is in the Pacific Bell Broadband Laboratory.



Project OART provides a transparent 100 km path for four independent data channels

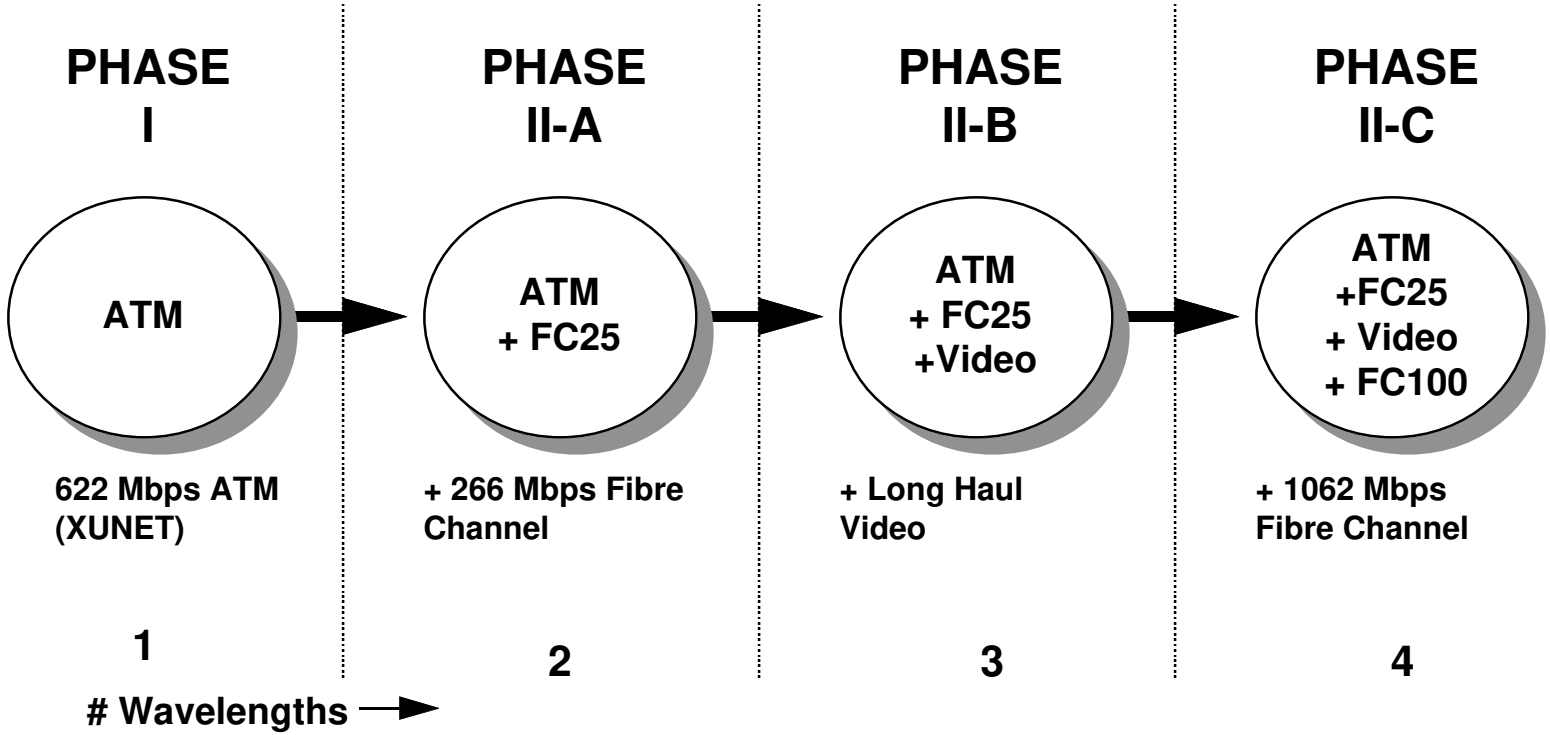
- **Wavelength Division Multiplexing allows a rich environment for WAN interconnect testing, with no dependence on:**
  - **speed**
  - **timing**
  - **format**
  - **content**





Multi-Wavelength Migration Path

- **The OART fiber link will evolve from a single wavelength to multiple wavelengths at various data rates.**



LLNL's XUNET ATM CRADA Objectives

- **LAN/WAN gateway "inter-networking"**
  - **Fibre Channel IP router**
  - **Exploit the OART WDM link to Berkeley**

- **LAN inter-connects "extension cords"**
  - **Fibre Channel to SONET adaptors**

- **Driving Applications**
  - **Scientific collaborations**
  - **Scientific visualization**
  - **Teleconferencing**

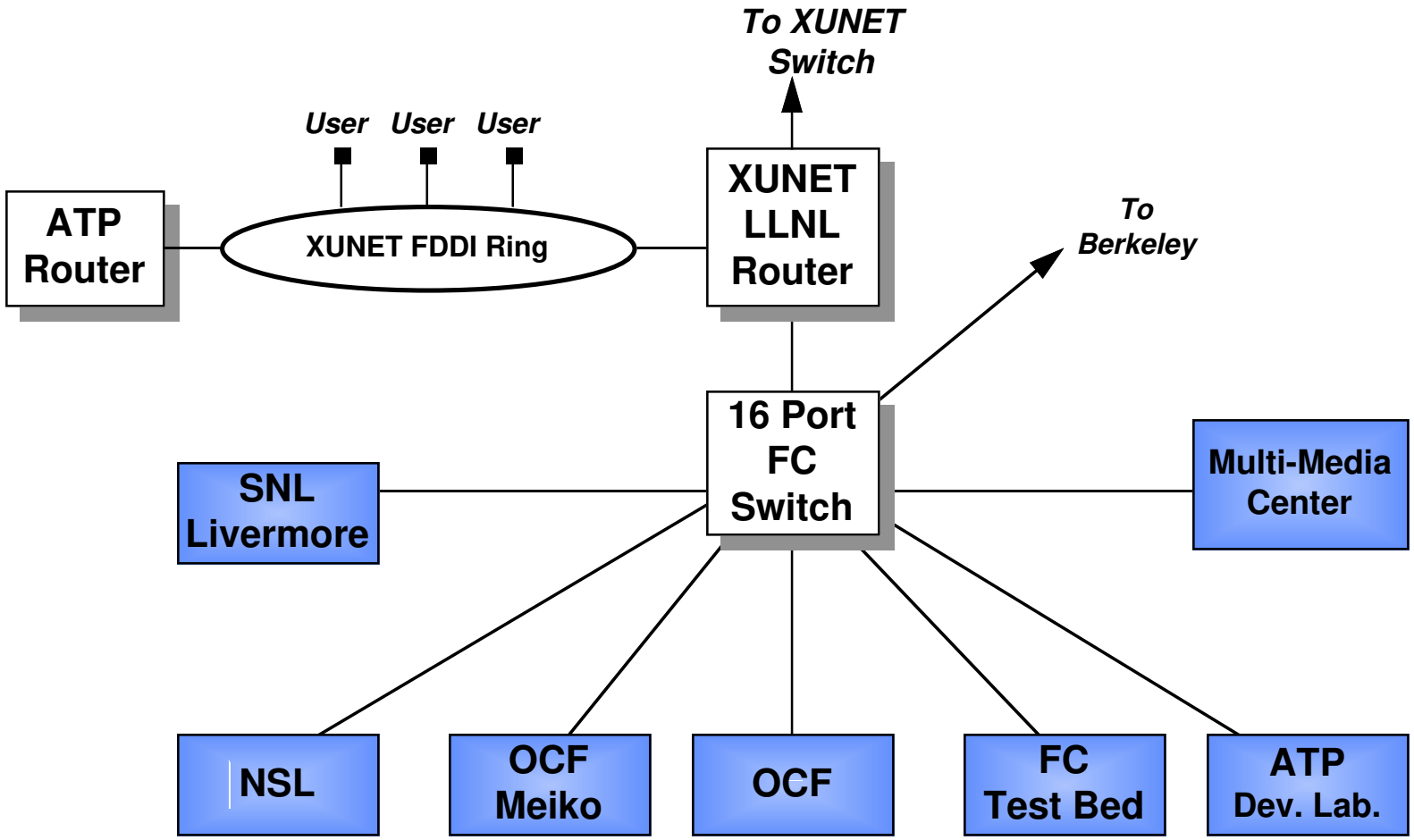
- **Collaborations**
  - **Test & evaluate LAN inter-connections and inter-networking issues.**

Accomplishments to date:

- **Installation of the XUNET ATM switch.**
- **V. P. Gore demonstration.**
- **Implementation of the XUNET routing policy in GateD.**
- **Design and implementation activities to support the OART 100 Km optical WDM experiment between LLNL and U.C. Berkeley.**
- **Livermore and Berkeley XUNET switches will soon be interconnected with a new 622 Mb/s link carried on one of the OART WDM channels.**
- **Demonstrated the operation of a 16 port fibre channel switch.**
- **Expanded our XUNET FDDI LAN.**
- **Connected two LLNL scientist to the XUNET to support WAN. collaborations with UCB and AT&T.**

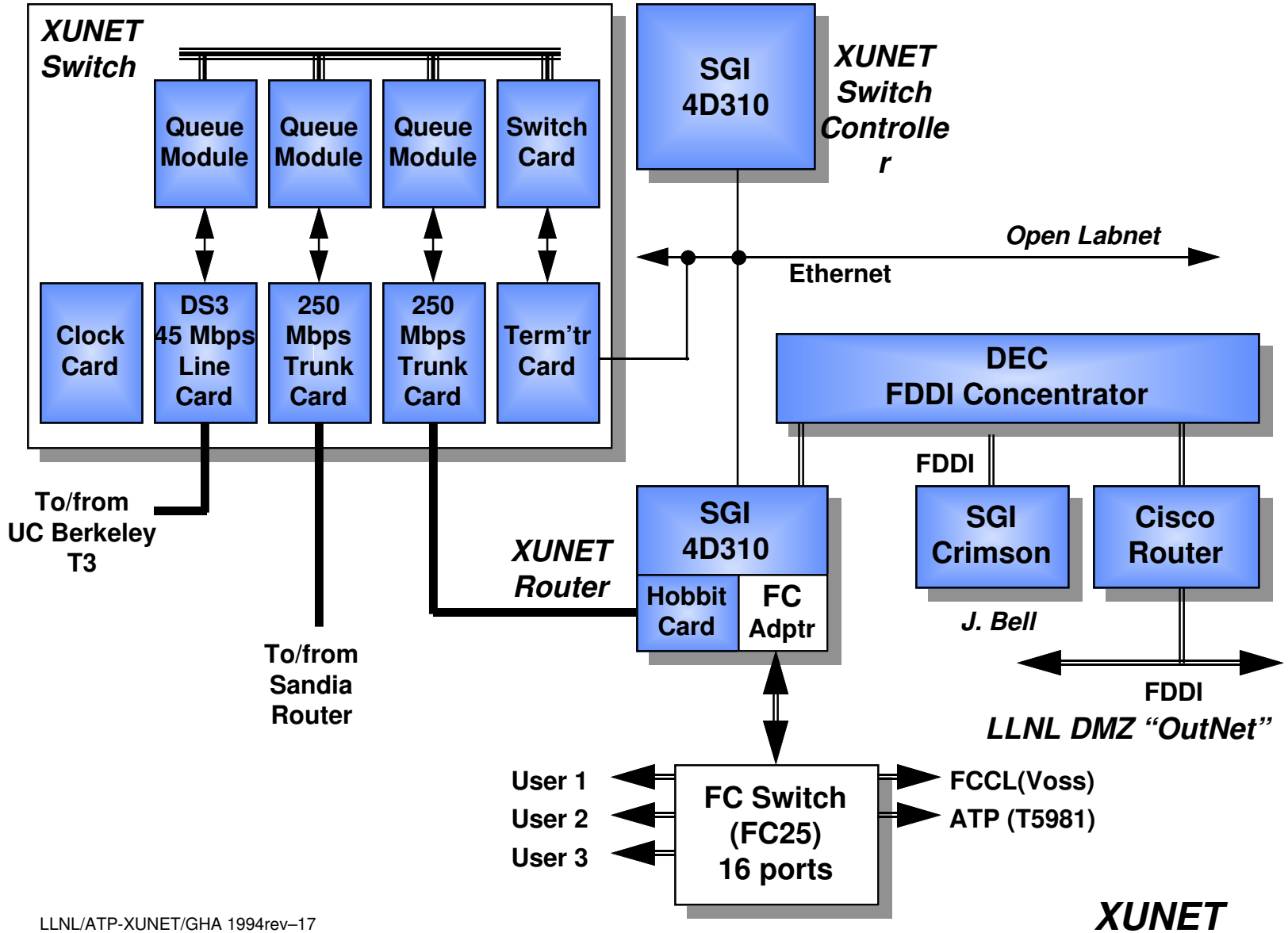
Planned Activities

- **Install a small FC LAN and interconnect it to the XUNET.**
  - **First FC switch connection is to the XUNET SGI router.**
  - **Second connection will be to a somewhat faster workstation based router**
- **Implement a workstation based IP router with FC and ATM/ Forum interfaces.**
- **Design and build a fibre channel to OC12c SONET/ATM interface.**
- **Pre-liminary designs for other variants of FC to SONET/ATM interfaces.**
- **Collaborations & Applications:**
  - **SNLL R6000 connections to LLNLFC LAN.**
  - **Add new scientific collaborations over the FC/ATM network.**
  - **BAGnet interactions with XUNET.**
  - **Multi-Media Application Tests.**



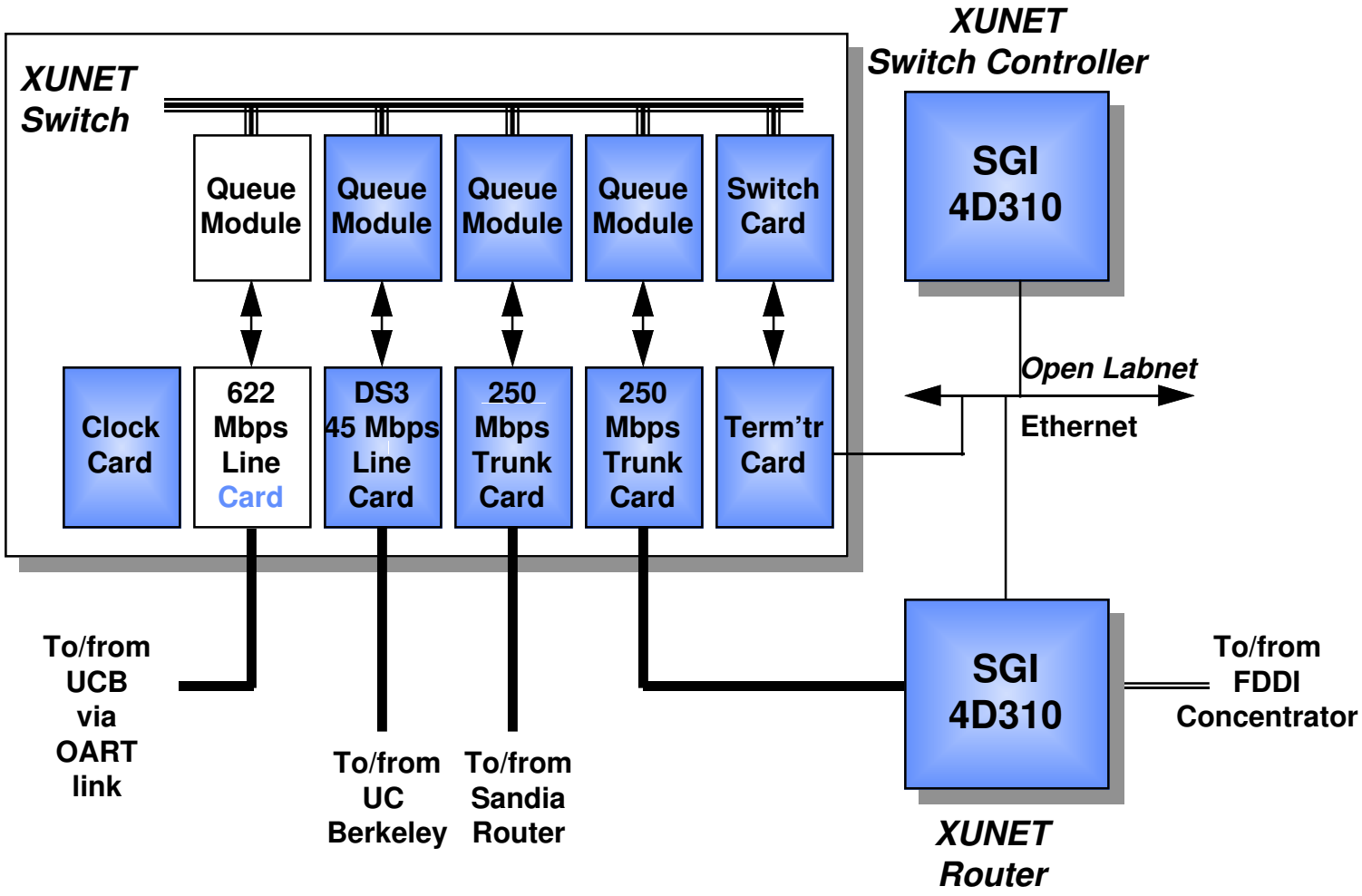
Installation Target :4/1/94

LLNL XUNET Configuration —First Fibre Channel Connect

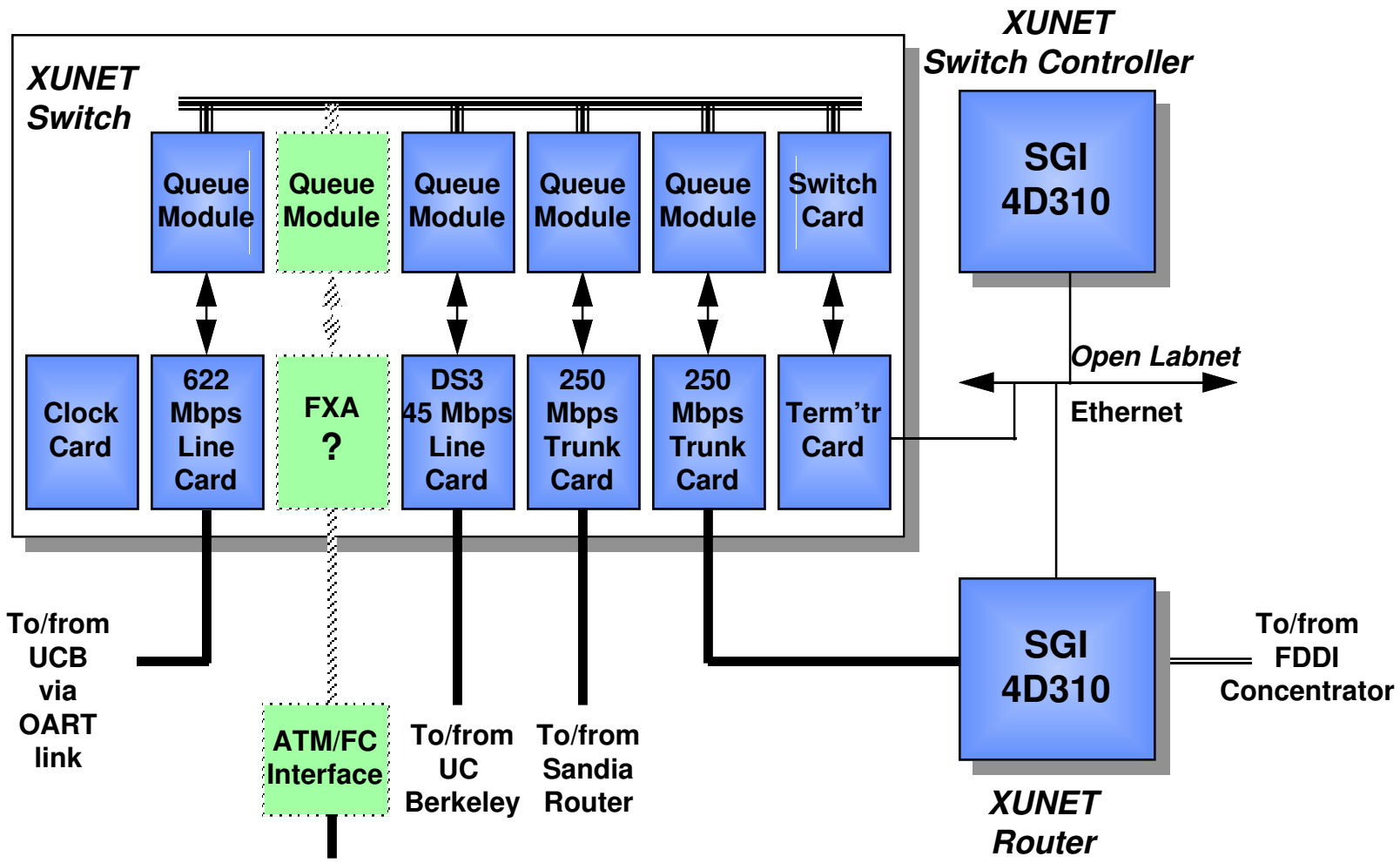


XUNET

LLNL XUNET Configuration — Proposed 622 Upgrade



LLNL XUNET Configuration — Possible FC Upgrade

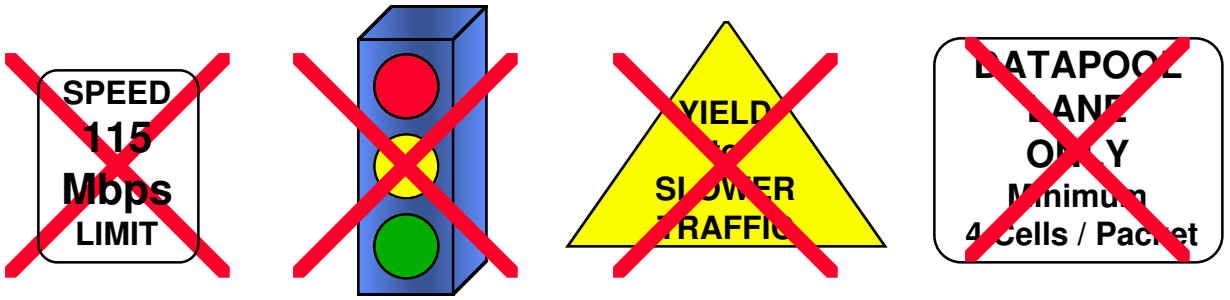
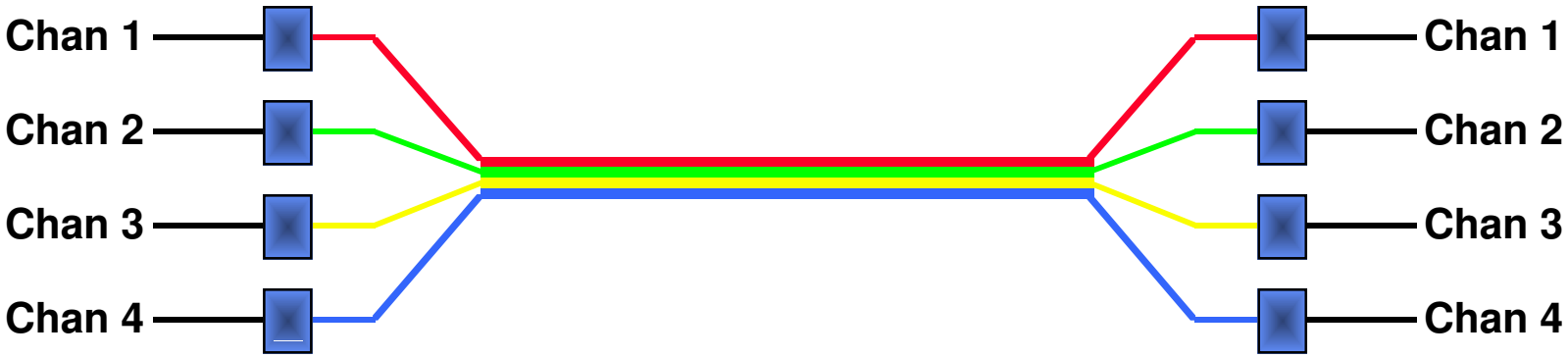


An open invitation ...

The OART link offers tremendous possibilities for testing and proving gigabit WAN concepts.

We have planned several experiments for this link. However, we would like this to be an open testbed.

We are interested in proposals and suggestions which can exploit the OART testbed.

Project OART provides a transparent 100 km path for four independent data channels

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