DWDM RAM

Data@LIGHTspeed

A Platform for Data Intensive Services Enabled by Next Generation Dynamic Optical Networks

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Gesticulation by Franco Travostino

Defense Advanced Research Projects Agency

NTONC National Transparent Optical Network Consortium

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Topics

- Limitations of Packet Switched IP Networks
- Why DWDM-RAM?
- DWDM-RAM Architecture
- An Application Scenario
- Current DWDM-RAM Implementation

Limitations of Packet Switched Networks

What happens when a TeraByte file is sent over the Internet?

- If the network bandwidth is shared with millions of other users, the file transfer task will never be done (World Wide Wait syndrome)
- Inter-ISP SLAs are "as scarce as dragons"
- DoS, route flaps phenomena strike without notice

Fundamental Problems:

1) ***Limited control and isolation of Network Bandwidth***
2) ***Packet switching is not appropriate for data intensive applications => substantial overhead, delays, CapEx, OpEx***

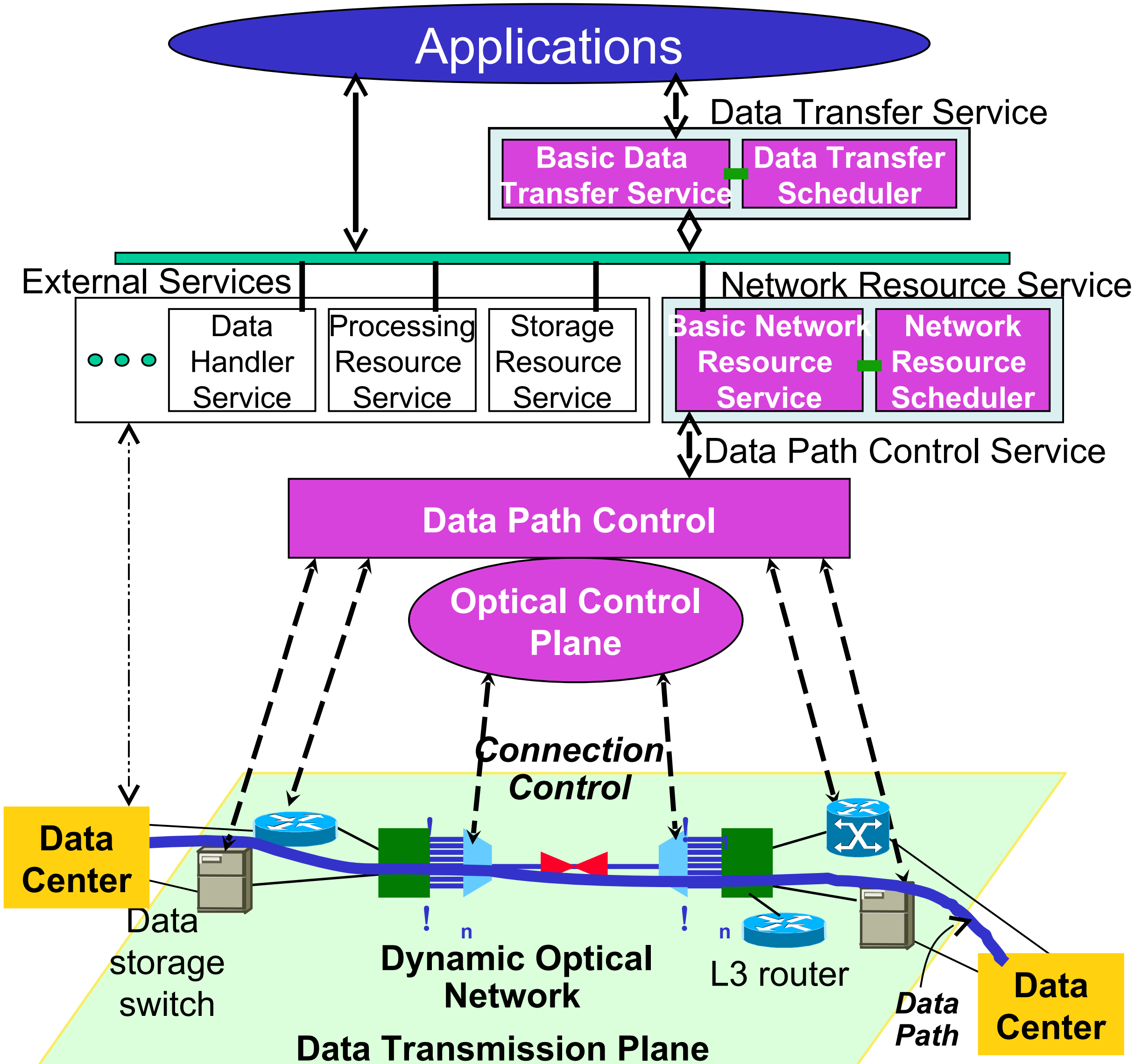
Why DWDM-RAM ?

- The new architecture is proposed for data intensive enabled by next generation dynamic optical networks
  - Encapsulates “optical network resources” into a service framework to support dynamically provisioned and advanced data-intensive transport services
  - Provides a generalized framework for high performance applications over next generation networks, not necessary optical end-to-end
  - Supports both on-demand and scheduled data retrieval
  - Supports a meshed wavelength switched network capable of establishing an end-to-end lightpath in seconds
  - Supports bulk data-transfer facilities using lambda-switched networks
  - Supports out-of-band tools for adaptive placement of data replicas
  - Offers network resources as Grid services for Grid computing

DWDM-RAM Architecture

- The middleware architecture modularizes components into services with well-defined interfaces
- The middleware architecture separates services into 3 principal service layers
  - Data Transfer Service Layer
  - Network Resource Service Layer
  - Data Path Control Service Layer over a Dynamic Optical Network

DWDM-RAM ARCHITECTURE



DWDM-RAM Service Architecture

- The Data Transfer Service (DTS):
  - Presents an interface between an application and a system – receives high-level requests, to transfer named blocks of data
  - Provides Data Transfer Scheduler Service: various models for scheduling, priorities, and event synchronization
- The Network Resource Service (NRS)
  - Provides an abstraction of "communication channels" as a network service
  - Provides an explicit representation of network resources scheduling model
  - Enables capabilities for dynamic on-demand provisioning and advance scheduling
  - Maintains schedules and provisions resources in accordance with the schedule
- Data Path Control Service Layer
  - Presents an interface between the network resource service and the network resources of the underlying network
  - Establishes, controls, and deallocates complete paths across both optical and electronic domains

An Application Scenario: Fixed Bandwidth List Scheduling

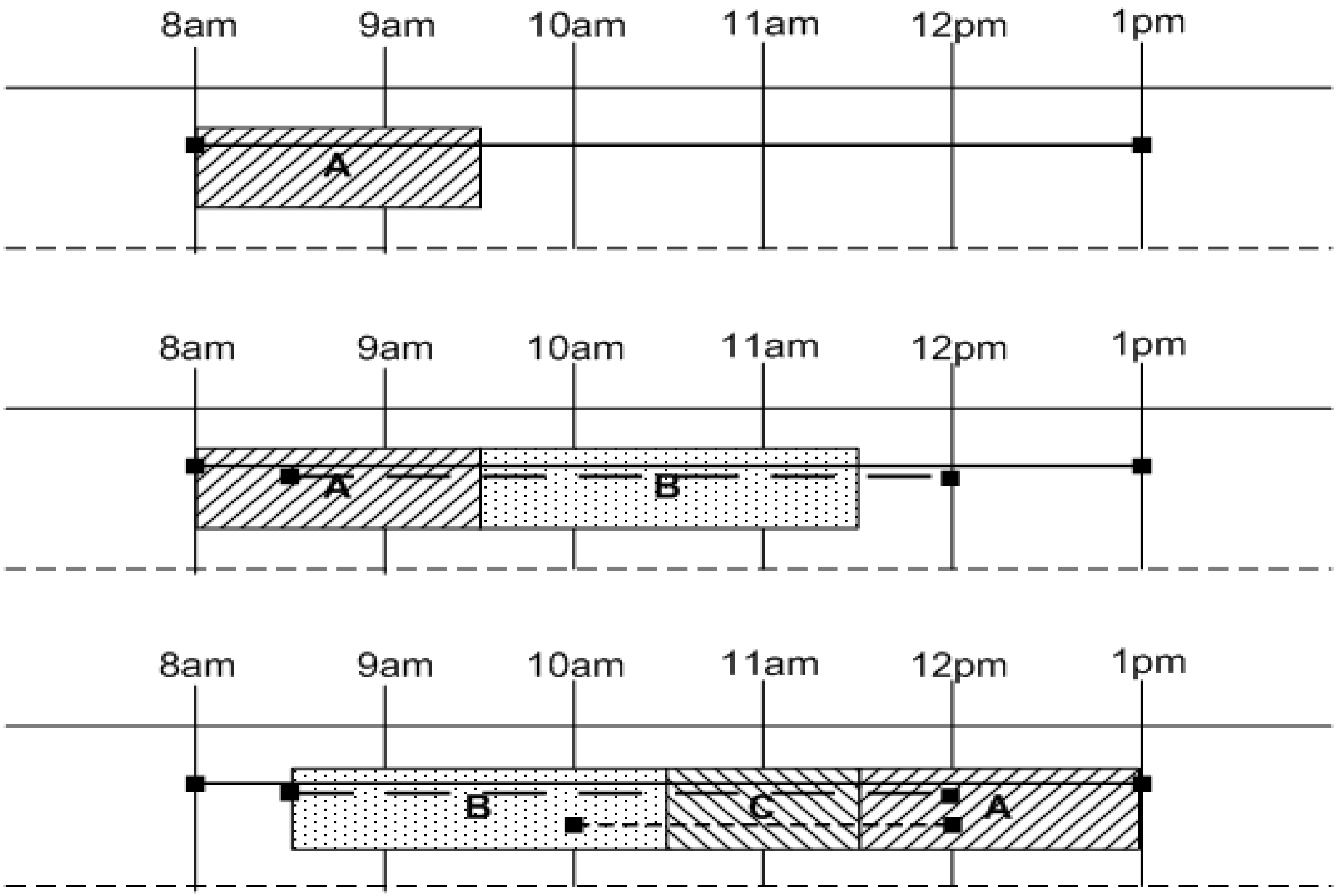
- A scheduling request is sent from the application to the NRS with the following five variables: Source host, Destination host, Duration of connection, Start time of request window, Finish time of request window
- The start and finish times of the request window are the upper and lower limits of when the connection can happen.
- The scheduler must then reserve a continuous hour slot somewhere within that time range. No bandwidth, or capacity, is referred to and the circuit designated to the connection is static.
- The message returned by the NRS is a "ticket" which informs of the success or failure of the request

Fixed Bandwidth List Scheduling

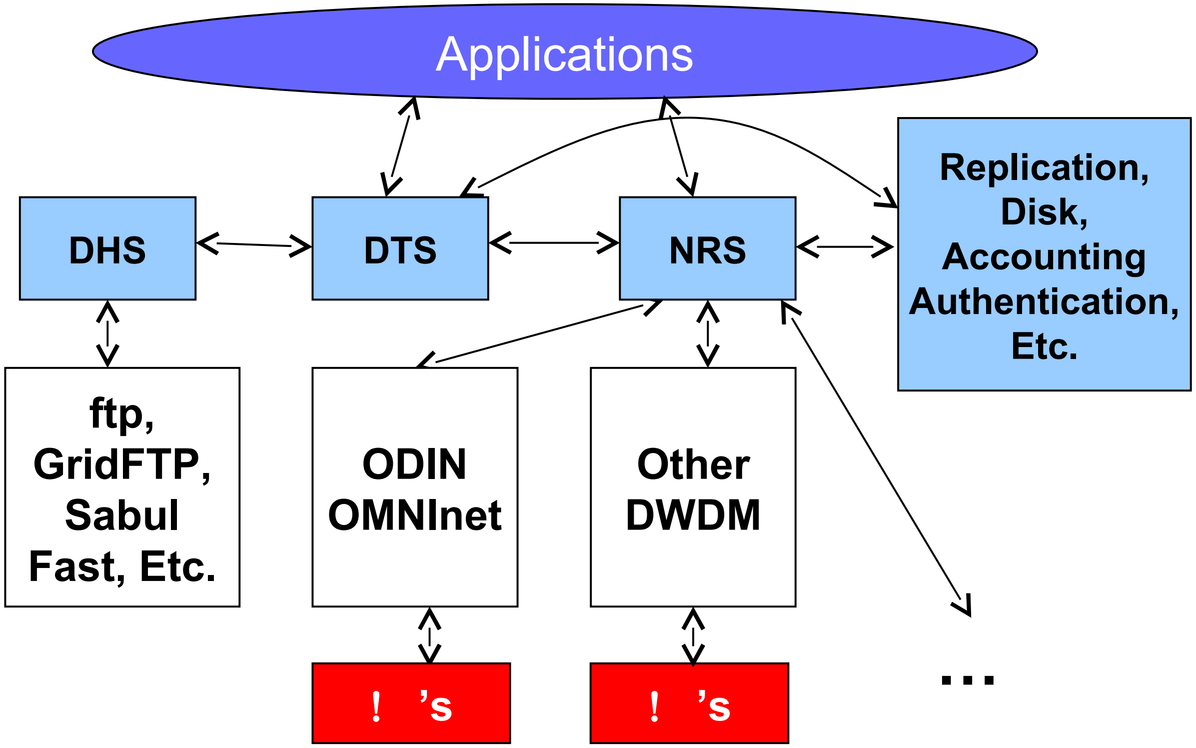
Job	Job Run-time	Window
A	1.5 hours	8am – 1pm
B	2 hours	8:30am – 12pm
C	1 hour	10am – 12pm

This scenario shows three jobs being scheduled sequentially, A, B and C. Job A is initially scheduled to start at the beginning of its under-constrained window. Job B can start after A and still satisfy its limits. Job C is more constrained with its runtime window but is a smaller job. The scheduler adapts to this conflict by intelligently rescheduling each job so all constraints are met.

Fixed Bandwidth List Scheduling



DWDM-RAM Implementation



Dynamic Optical Network

- Gives adequate and uncontested bandwidth to an application's burst
- Employs circuit-switching of large flows of data to avoid overheads in breaking flows into small packets and delays routing
- Is capable of automatic wavelength switching
- Is capable of automatic end-to-end path provisioning
- Provides a set of protocols for managing dynamically provisioned wavelengths

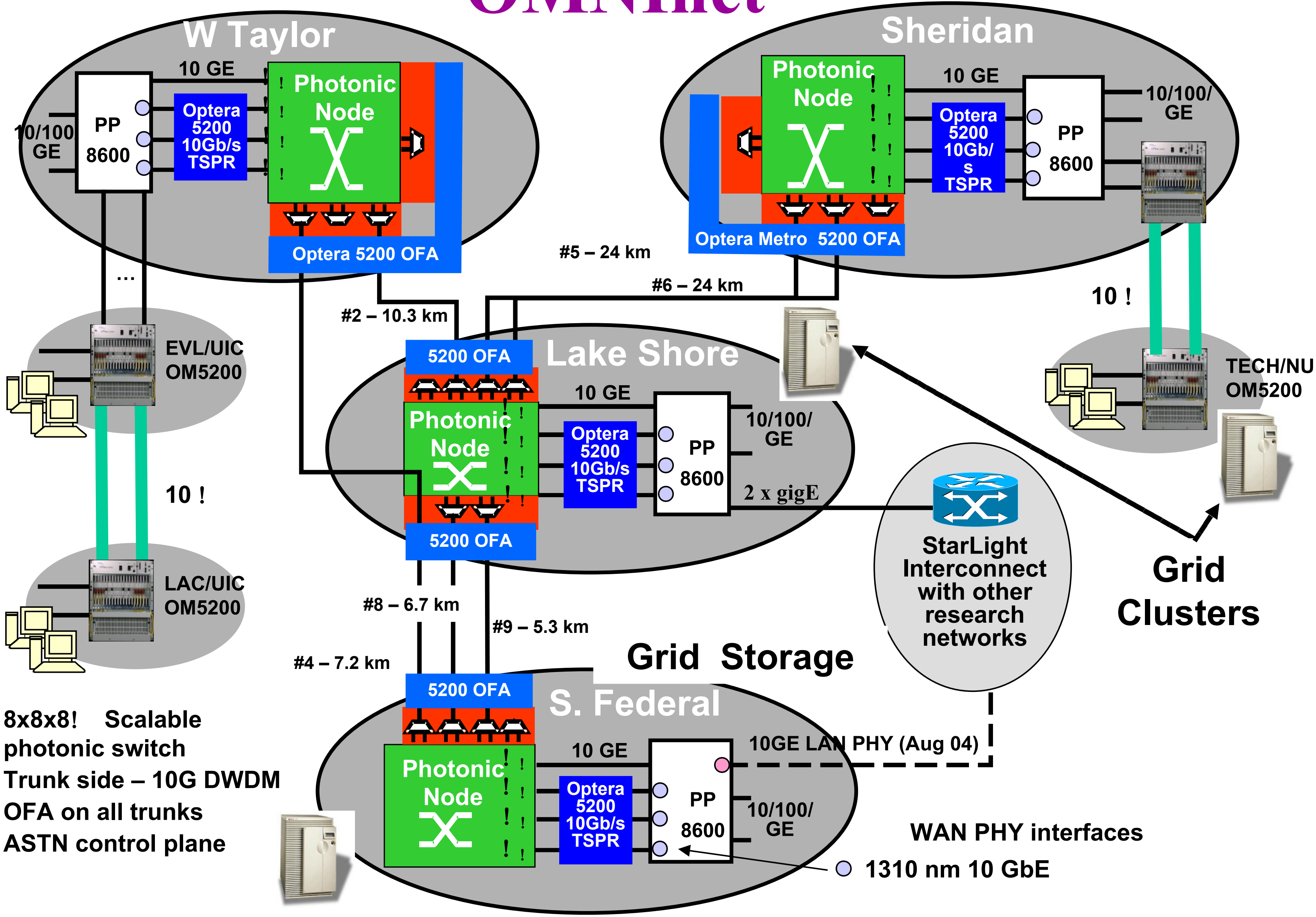
OMNInet Testbed

- Four-node multi-site optical metro testbed network in Chicago -- the first 10GigE service trial when installed in 2001
- Nodes are interconnected as a partial mesh with lightpaths provisioned with DWDM on dedicated fiber.
- Each node includes a MEMs-based WDM photonic switch, Optical Fiber Amplifier (OFA), optical transponders, and high-performance Ethernet switch.
- The switches are configured with four ports capable of supporting 10GigE.
- Application cluster and compute node access is provided by Passport 8600 L2/L3 switches, which are provisioned with 10/100/1000 Ethernet user ports, and a 10GigE LAN port.
- Partners: SBC, Nortel Networks, iCAIR/Northwestern University

Optical Dynamic Intelligent Network Services (ODIN)

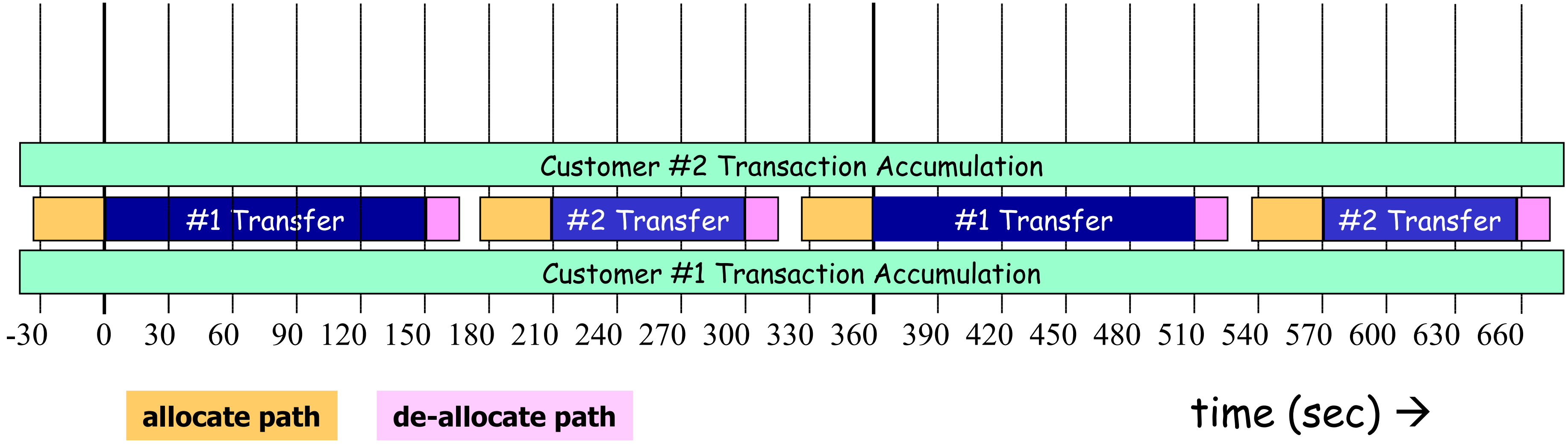
- Software suite that controls the OMNInet through lower-level API calls
- Designed for high-performance, long-term flow with flexible and fine grained control
- Stateless server, which includes an API to provide path provisioning and monitoring to the higher layers

OMNInet



- 8x8x8! Scalable photonic switch
- Trunk side – 10G DWDM
- OFA on all trunks
- ASTN control plane

Transaction Demonstration Time Line
6 minute cycle time



20GB File Transfer

Conclusion

- The DWDM-RAM architecture yields Data Intensive Services that best exploit Dynamic Optical Networks
- Network resources become actively managed, scheduled services
- This approach maximizes the satisfaction of high-capacity users while yielding good overall utilization of resources
- The service-centric approach is a foundation for new types of services

Some key folks checking us out at our CO2+Grid booth, GlobusWORLD ‘04, Jan ‘04

Ian Foster and Carl Kesselman, co-inventors of the Grid (2^{nd},5^{th} from the left)

Larry Smarr of OptIPuter fame (6^{th} and last from the left)

Franco, Tal, and Inder (1^{th}, 3^{rd}, and 4^{th} from the left)