DWDM-RAM: DARPA-Sponsored Research for Data Intensive Service-on-Demand Advanced Optical Networks

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The Data Intensive App Challenge:
Emerging data intensive applications in the field of HEP, astro-physics, astronomy, bioinformatics, computational chemistry, etc., require extremely high performance and long term data flows, scalability for huge data volume, global reach, adjustability to unpredictable traffic behavior, and integration with multiple Grid resources.

**Response: DWDM-RAM**
An architecture for data intensive Grids enabled by next generation dynamic optical networks, incorporating new methods for lightpath provisioning. DWDM-RAM is designed to meet the networking challenges of extremely large scale Grid applications. Traditional network infrastructure cannot meet these demands, especially, requirements for intensive data flows.

Optical Abundant Bandwidth Meets Grid

PBs Storage

Data-Intensive Applications

DWDM-RAM

Abundant Optical Bandwidth

Tbs on single fiber strand
DWDM-RAM Architecture

The DWDM-RAM architecture identifies two distinct planes over the dynamic underlying optical network:

1) the **Data Grid Plane** that speaks for the diverse requirements of a data-intensive application by providing generic data-intensive interfaces and services and

2) the **Network Grid Plane** that marshals the raw bandwidth of the underlying optical network into network services, within the OGSI framework, and that matches the complex requirements specified by the Data Grid Plane.

At the application middleware layer, the **Data Transfer Service (DTS)** presents an interface between the system and an application. It receives high-level client requests, policy-and-access filtered, to transfer specific named blocks of data with specific advance scheduling constraints.

The network resource middleware layer consists of three services: the **Data Handler Service (DHS)**, the **Network Resource Service (NRS)** and the **Dynamic Lambda Grid Service (DLGS)**. Services of this layer initiate and control sharing of resources.
**Application**

**Fabric**

“Controlling things locally”: Access to, & control of, resources

**Connectivity**

“Talking to things”: communication (Internet protocols) & security

**Resource**

“Sharing single resources”: negotiating access, controlling use

**Collective**

“Coordinating multiple resources”: ubiquitous infrastructure services, app-specific distributed services

### DWDM-RAM vs. Layered Grid Architecture

- **Layered DWDM-RAM**
  - Application
  - Data Transfer Service
  - Network Resource Service
  - Data Path Control Service
  - Optical Control Plane

- **Layered Grid**
  - Application
  - Collective
  - Resource
  - Connectivity
  - Fabric

- **APIs**
  - DTS API
  - NRS Grid Service API
  - OGSI-ification API
Optical Control Network

Network Service Request

Data Transmission Plane

OmniNet Control Plane

Connection Control

L2 switch

Data Center

Service Control

DATA GRID SERVICE PLANE

GRID Service Request

NETWORK SERVICE PLANE

ODIN

UNI-N

DATA GRID SERVICE PLANE

Service Control

NETWORK SERVICE PLANE

ODIN

UNI-N

DATA GRID SERVICE PLANE

Service Control

NETWORK SERVICE PLANE

ODIN

UNI-N

Data Path Control

Data Center

Data storage switch

L2 switch

L3 router

Data Center

Data Path
OMNIInet Core Nodes

• A four-node multi-site optical metro testbed network in Chicago -- the first 10GE service trial!
• A test bed for all-optical switching and advanced high-speed services
• OMNIInet testbed Partners: SBC, Nortel, iCAIR at Northwestern, EVL, CANARIE, ANL
DWDM-RAM Components

Data Management Services
OGSA/OGSI compliant, capable of receiving and understanding application requests, have complete knowledge of network resources, transmit signals to intelligent middleware, understand communications from Grid infrastructure, adjust to changing requirements, understands edge resources, on-demand or scheduled processing, support various models for scheduling, priority setting, event synchronization

Intelligent Middleware for Adaptive Optical Networking
OGSA/OGSI compliant, integrated with Globus, receives requests from data services and applications, knowledgeable about Grid resources, has complete understanding of dynamic lightpath provisioning, communicates to optical network services layer, can be integrated with GRAM for co-management, architecture is flexible and extensible

Dynamic Lightpath Provisioning Services
Optical Dynamic Intelligent Networking (ODIN), OGSA/OGSI compliant, receives requests from middleware services, knowledgeable about optical network resources, provides dynamic lightpath provisioning, communicates to optical network protocol layer, precise wavelength control, intradomain as well as interdomain, contains mechanisms for extending lightpaths through E-Paths - electronic paths, incorporates specialized signaling, utilizes IETF – GMPLS for provisioning, new photonic protocols
Design for Scheduling

Network and Data Transfers scheduled
• Data Management schedule coordinates network, retrieval, and sourcing services (using their schedulers)
• Scheduled data resource reservation service (“Provide 2 TB storage between 14:00 and 18:00 tomorrow”)

Network Management has own schedule
• Variety of request models:
  • Fixed – at a specific time, for specific duration
  • Under-constrained – e.g. ASAP, or within a window

Auto-rescheduling for optimization
• Facilitated by under-constrained requests
• Data Management reschedules for its own requests or on request of Network Management
Example: Lightpath Scheduling

- Request for 1/2 hour between 4:00 and 5:30 on Segment D granted to User W at 4:00
- New request from User X for same segment for 1 hour between 3:30 and 5:00
- Reschedule user W to 4:30; user X to 3:30. Everyone is happy.

Route allocated for a time slot; new request comes in; 1st route can be rescheduled for a later slot within window to accommodate new request.
End-to-end Transfer Time

20GB File Transfer
Set up: 29.7s
Transfer: 174s
Tear down: 11.3s

File
Transfer
requests
arrive
Path
Allocation
request
ODIN
Server
Process
Path
Return
Network
reconfig
Transport
Setup
time
Data
Transfer
20 GB
Path
Deallocation
request
Server
Processing
done,
Path
release
20GB File Transfer