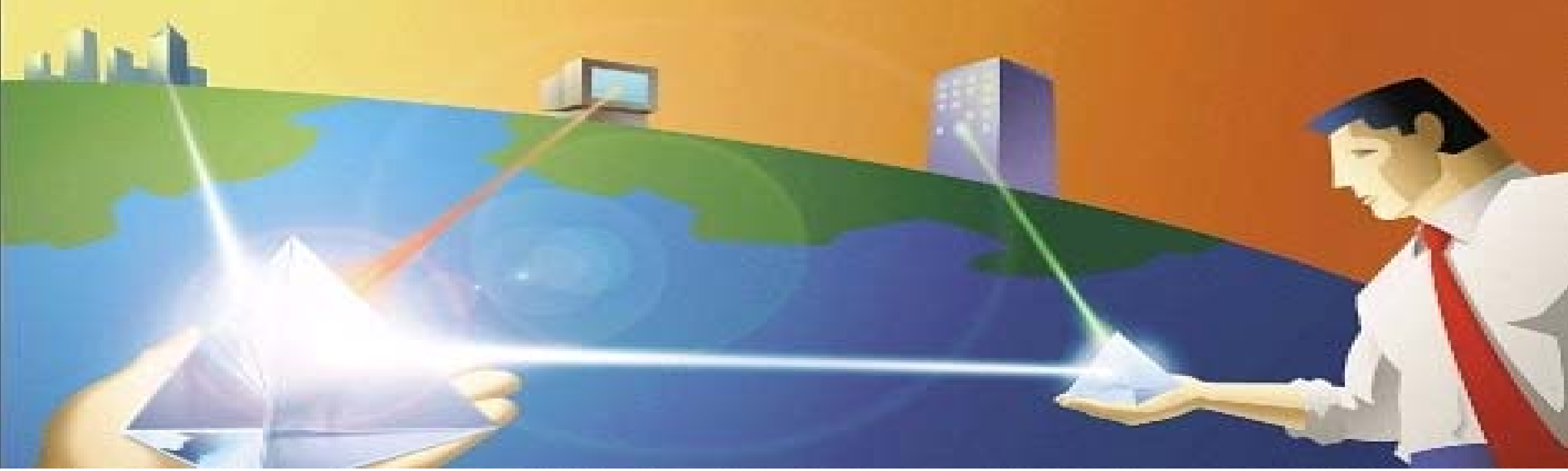

Optical Networking for Grid Computing

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Optical Networks are emerging power driver for the Grid

- Grid applications generate terabytes of data
- Performance of Grid depends on network fabric
- Optical bandwidth grows faster than CPU processing capability predicted by Moore's Law.

Country	GRID NETWORK	PROJECT
USA	Abilene/vBNS *U.S. University Corporation for Advanced Internet Development (10Gbps)*	NCSA National Technology Grid
CANADA	CA*net4 *An advanced network of the Canadian Network of the Advancement of Research, Industry and Education* (22.5Gbps)	CFD Grid
EU	EU DataTAG *European Union Data-Intensive TransAtlantic Grid* (2.5Gbps)	Euro Grid

- The cost of adding lambda on fiber between processors is less than procuring the processors.
- To enable applications to configure lambdas dynamically requires advanced network control and signaling protocols in network infrastructure.

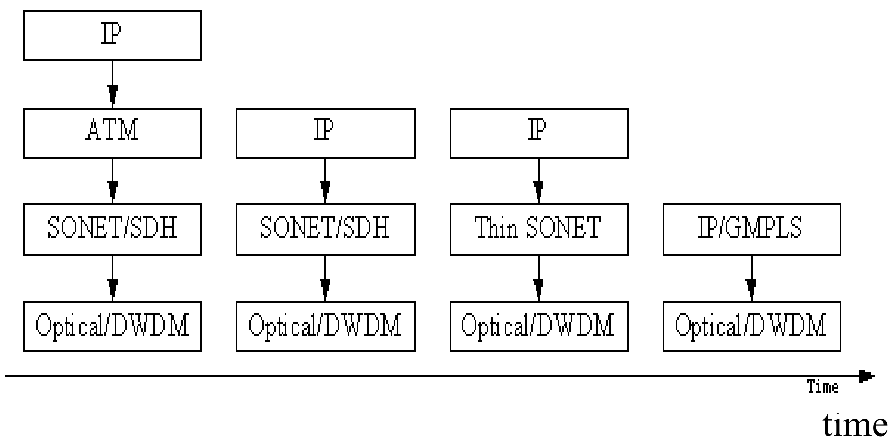
http://www.startap.net/starlight/NETWORKS/

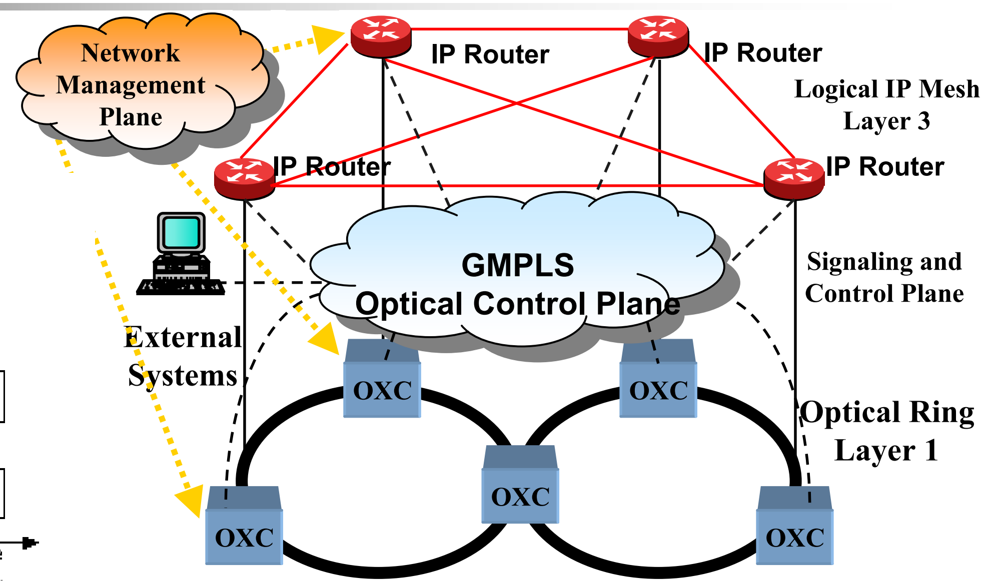
Current efforts in Singapore

- **ONFIG Project:**
  - A*STAR project on optical testbed with GMPLS development
  - I2R, NUS, NTU, IME, IMRE, DSI
- **MPλS Project:**
  - SingAREN project
  - NTU NTRC optical laboratory
- **Optical VPN and Optical Multicast:**
  - NTU EEE
- **QoS scheduling study:**
  - NTU ICIS

Optical Internet: IP/GMPLS/WDM

Evolution of Network



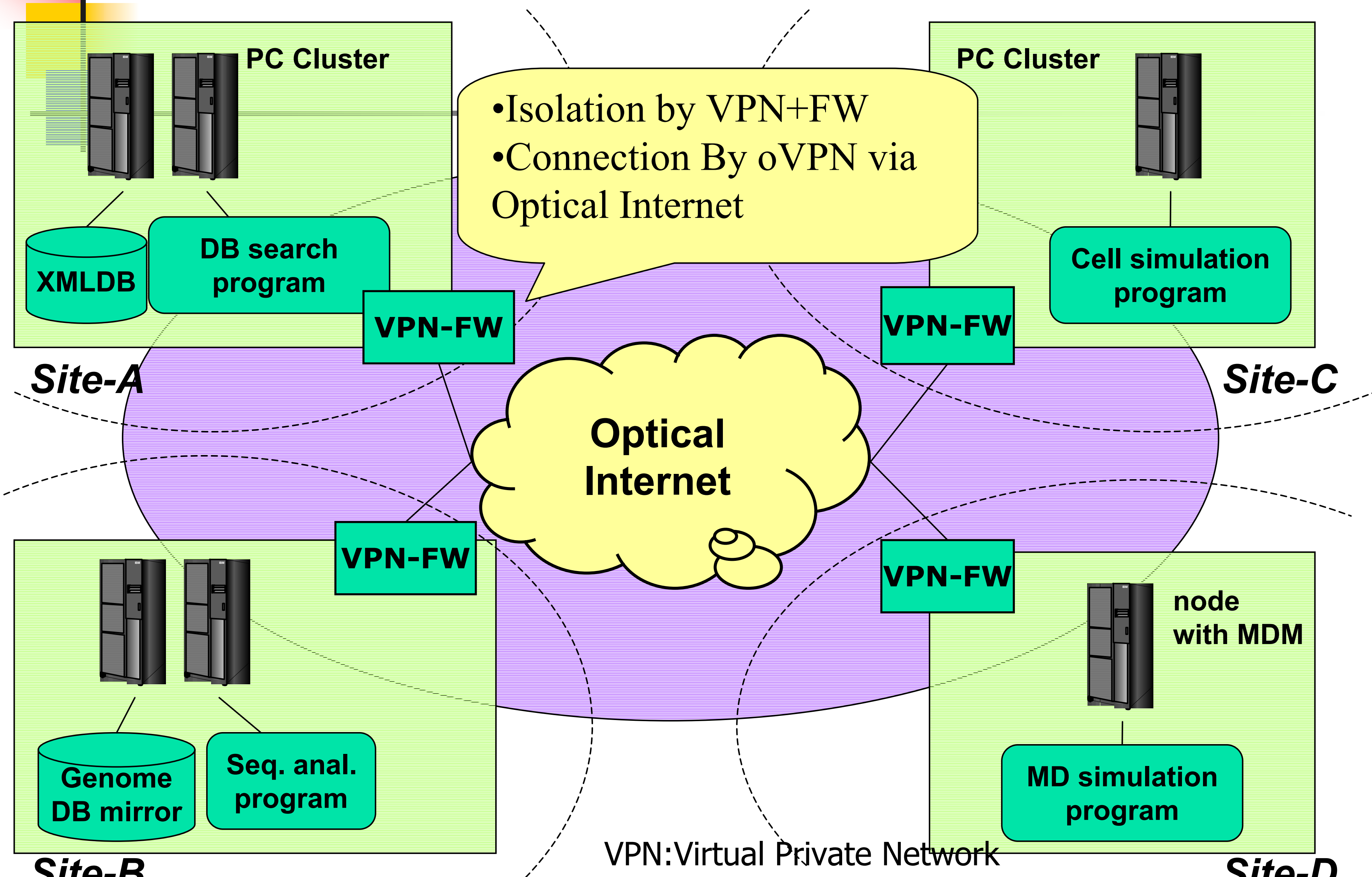


*GMPLS provides resource discovery, lightpath provisioning, traffic engineering, circuit routing, channel signaling, path protection and recovery.

•Three research focuses:

- **•Optical Virtual Private Network (oVPN)**
- **•Optical Multicast**
- **•Optical Burst Scheduling**

VPN for Grid applications



VPN:Virtual Private Network
FW: FireWall

Problems of conventional IP VPN in Grid environment

- Mainly limited to electronic speed;
- No control over lower layer implementations;
- Limited support for End-to-End QoS guarantee.
  - IP-based L3/L2 VPNs only provide QoS for the PE-to-PE tunnel;
- Weak policy-based management on resource allocation, peering agreement, end-to-end SLAs when spanning across multiple Service Providers
- No integrated approach for reliability/fault-tolerance support

Optical Virtual Private Networks (oVPN) to support Grid Computing

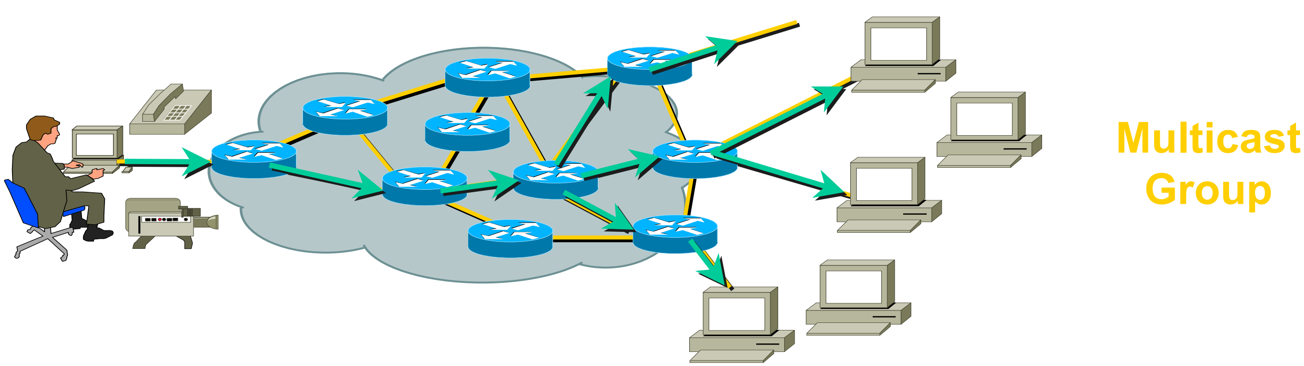
- Research on providing oVPN service on future IP/GMPLS/WDM network to support Grid computing
- Research on building up LambdaGrid infrastruture
- To enable future Grid applications
  - To directly signal their own resources
  - To directly manipulate optical networking functions
  - To dynamically provision & control their own lightpaths
  - To create optical VPNs
  - To extend lightpath to edge resources

Research issues

- **High performance optical resource regulator for oVPN**
  - To manage optical control plane and resource provisioning
  - To dynamic create and delete lightpaths
  - To extend GMPLS to support oVPN
- **Policy based Management for oVPN**
  - A policy based management scheme for VPN providers;
- **Optimal topology design and dynamic topology reconfiguration**
  - Traffic adaptable, network adaptable and membership adaptable
- **Protection and Restoration of oVPN**
  - Differentiated protection scheme(1+1,1:1,m:n etc);
  - Restoration for static and dynamic traffic.

The need of multicast for Grid Applications

- **Video and Audio conferencing**
- **Multimedia distribution**
- **Access Grid**
  - multimedia display, presentation and interaction environments,
  - interface to grid middleware,
  - interface to visualization environments,
  - support group to group communication over Internet.
- Need **IP multicast**: one copy for all recipients.



Problems of conventional IP multicast in Grid environment

- Limited to electronic speed;
- Depend on lower layer support;
- No control over lower layer implementation;
- Not capable to support true QoS:
  - Possibly high error rate;
  - Unexpected delay and jitter;

Optical Multicast for Grid Applications

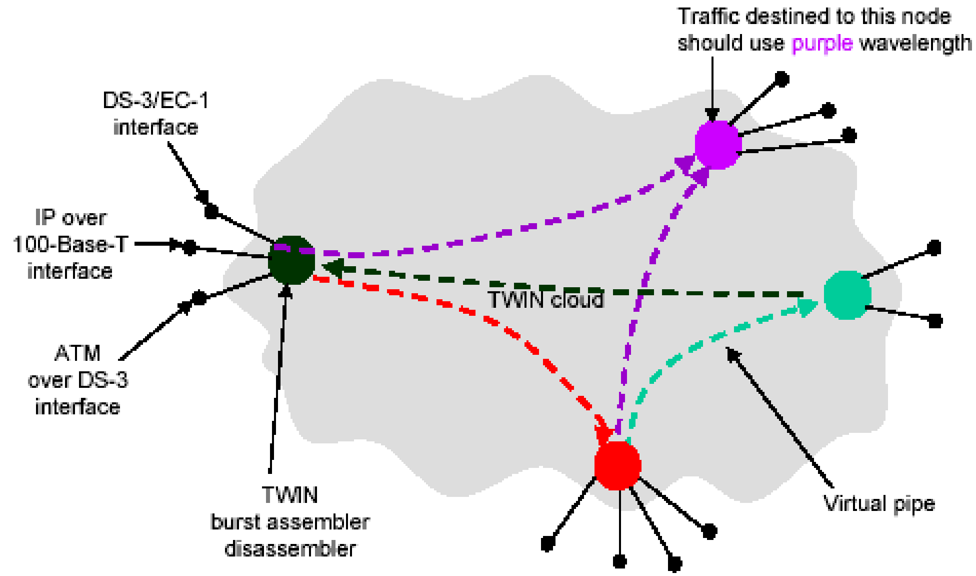
- To research on a new Multicast technology based on WDM optical network to support future Grid applications:
  - Based on **Light Splitters** and **Wavelength Converters** to form **Light Tree**
  - Support QoS multicast;
  - Reliable, Scalable, Survivable;
- Capable of **light speed** delivery of multicast data

Research Issues

- **Multicast Routing and Wavelength Assignment (MC-RWA)**
  - To research for suitable MC-RWA algorithms eg. multicast capable virtual source-rooted RWA for optical multicast;
- **GMPLS extension for Optical Multicast**
  - To extend the routing and signaling functions of GMPLS in order to support optical multicast;
- **Scalable Core Migration Protocol for Dynamic Multicast Tree**
  - To research for scalable distributed protocols to relocate and optimize the multicast tree to cater for dynamic membership/topology/traffic change;
- **Multicast Traffic Grooming based on dynamic traffic granularity**
  - Multicast on packet, time-slot, wavelength, waveband, fibre;
- **Protection and Restoration for optical multicast**
  - How to make optical multicast survivable?

Time-Domain Wavelength Interleaved Networks (TWIN)

•**Destination-based multipoint-to-point architecture using dedicated lambda**
•**cost-effective optical transport architecture**



- **Advantages of TWIN for Grid**
  - Provide a flexible, cost-effective, multiservice solution to the problem of QoS provisioning for applications in Grid
  - Capable of handling both asynchronous and synchronous traffic.
  - Reduce layering by eliminating packet and TDM switching and keep the core light and the edge intelligent.

Problems of Conventional QoS Provisioning Architecture in Grid Environment

- Current transport networks are **not cost-effective** in handling synchronous traffic and asynchronous traffic.
- Current transport **cannot handle** different **bandwidth granularities** and **dynamic traffic demands**.
- Current definition and specifications of QoS for packet-switched networks are **not applicable** to the grid-computing environment
- Need to **re-define the QoS request specification** and management for end-users in the grid-computing environment

QoS provisioning using Optical Burst Scheduling in TWIN networks for Grid environment

- A **new network QoS provisioning mechanism** for the high-end network applications and highly bursty demands in Grid computing environment
  - based on the new network transport architecture using **optical burst scheduling**.
  - new architecture has a **light core** and **intelligent edge** and is **flexible, thin-layered and cost-effective**.

Research Issues and Approach

- **Redefine QoS definition and specification** to encompass the dependability of Grid services
- **QoS provisioning architecture** based on OBScH transport architecture
  - **resource scheduling**
  - **dynamic requests from end-users**
  - **micro-management of QoS at edge sites**
  - **QoS management under local administrative controls**
- **Traffic control and resource management**
- **Framing & encapsulation**
- **Protection scheme**

THANK YOU

THE

END