# *The Return of Circuit Switching*

# *A Review of the Proposed CA*net$^4$ Implementation of User-Controlled Lightpaths*

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# *Outline*

- Background/Motivation – Grid Computing
- What is CA*net$^4$?
- User-Controlled Lightpaths
- Physical Layer: Optical BGP
- Next Steps?

# *Motivation – High Energy Physics*

- Who needs user-controlled lightpaths?
- One application: high-energy physics
- ATLAS Project at CERN particle accelerator in Switzerland:
  - Trying to find the fundamental source of mass (Higg's Boson)
  - Exceeds in complexity and scale all other computational challenges in history
  - Will produce over a petabyte (1000000 gigabytes) of data per year

# *The Solution – Grid Computing*

- Problems:
  - Data cannot be stored or analyzed at a single computational facility
  - Static network cannot handle large bandwidth requirement
- The solution – Grid Computing
  - Allow the sharing of computational resources across administrative domains
  - Includes sharing compute, storage, and network resources (possibility for user provisioning of network resources)

# *Example Storage Resource*

- Dr. Randy Sobie recently acquired $6 Million in funding to build a mass storage facility at UVic
- IBM won the contract, and a few months ago the system was installed
- Includes 10TB of disk and 120TB tape
- 100 processor linux cluster for free!!
- Plan to double capacity every year for 4 years
- Network is saturated to fill this disk and send results out

# *Enter CA*net$^4$*

- CA*net$^4$ is the national data research network, connecting Universities and research institutions
- Began replacing CA*net$^3$ in Fall 2002
- Multiple OC192 ( 10 Gbps) connections between GigaPOPs

# CA*net$^4$ Map


CA*net 4
Edmonton
Vancouver
Victoria
Calgary
Saskatoon
Seattle
Regina
Winnipeg
Charlottetown
Fredericton
Halifax
St. John's
Montréal
Ottawa
Toronto
New York
Chicago
Legend
CA*net 4 Access Point

# *Why Upgrade from CA*net$^3$*

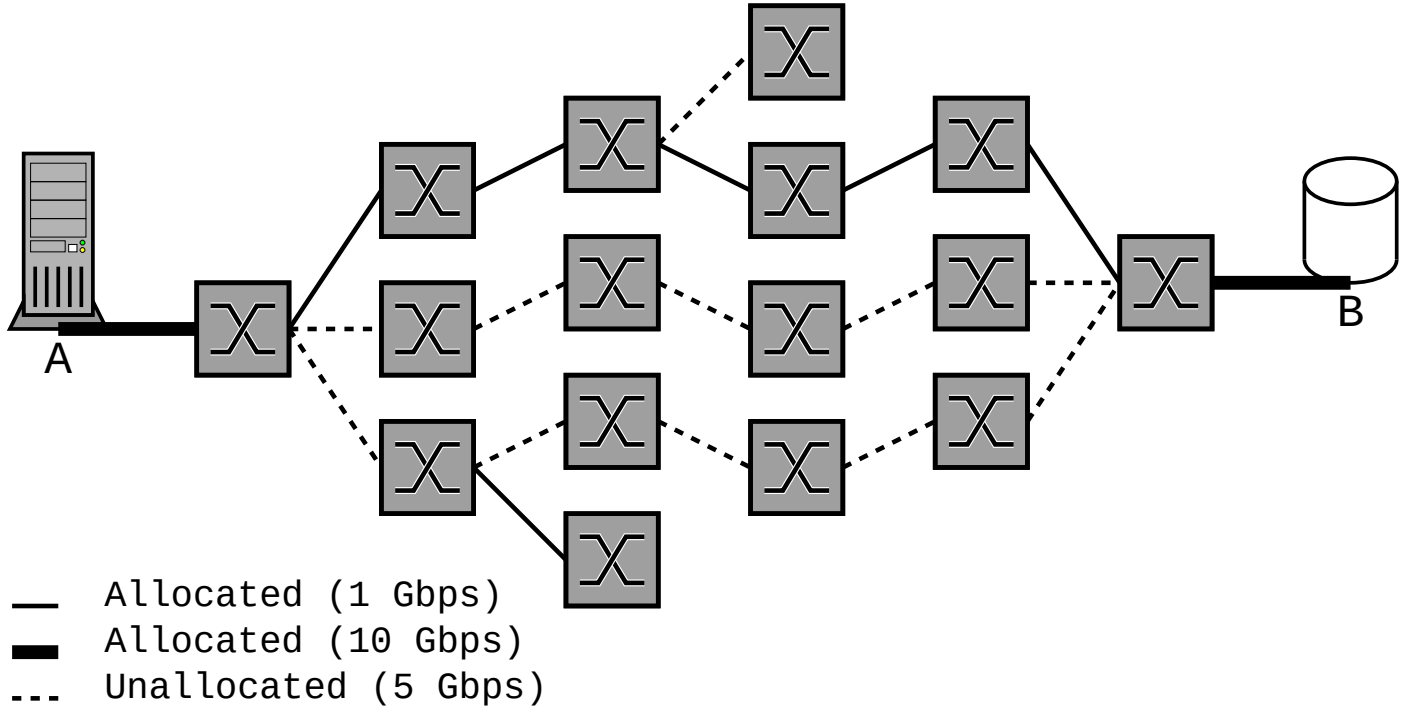
- How to get government funding? .. not just higher throughput
- Goals for CA*net$^4$ [1]:
  - End users to provision, manage and control the routing of their own light paths
  - Management in a P2P manner (no need to signal or request service from any central authority or server)

# *User-Controlled Lightpaths*

- Allow users to allocate and deallocate available fibres in a dynamic fashion
- No centralized network management authority or server
- Each light path can be considered as a VPN but with the added ability of the user being able to add/drop bandwidth at any node

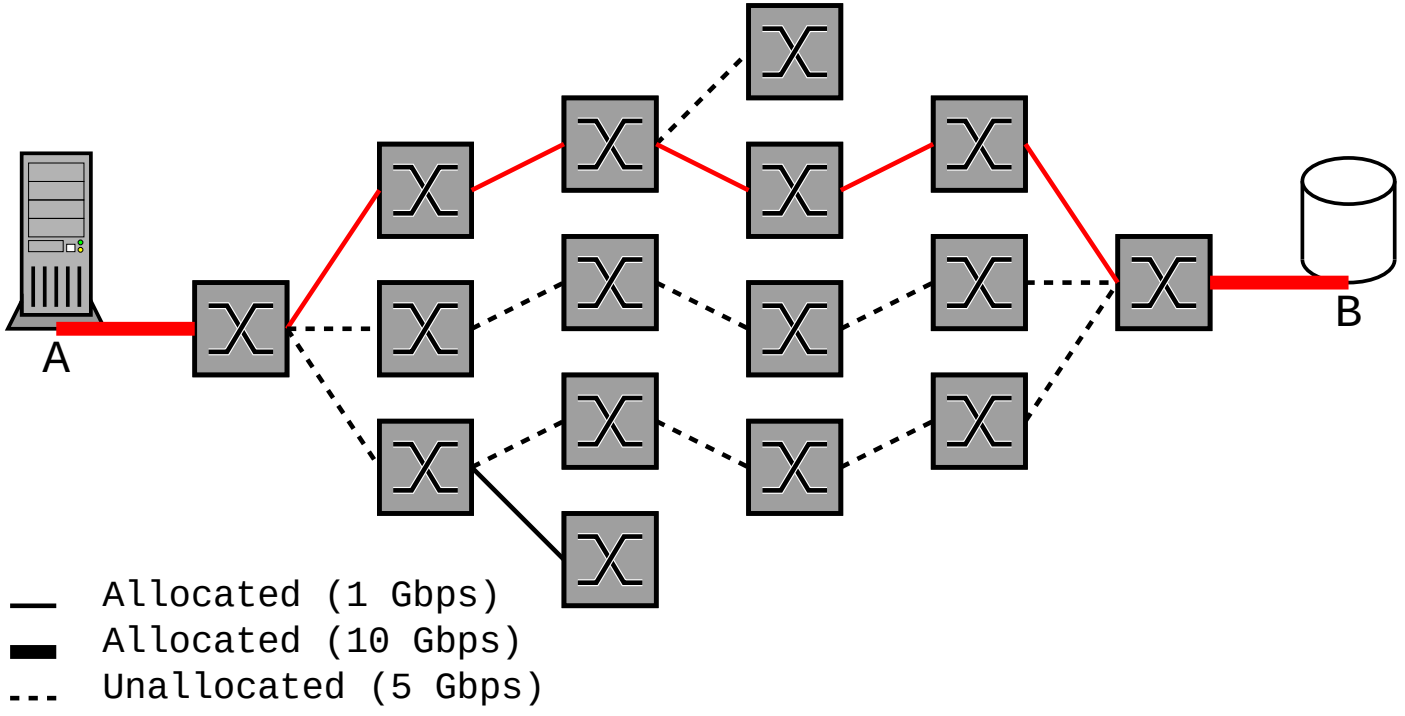
# Example Situation

- User A needs to transfer 5TB of data to disk B (in separate AS's)



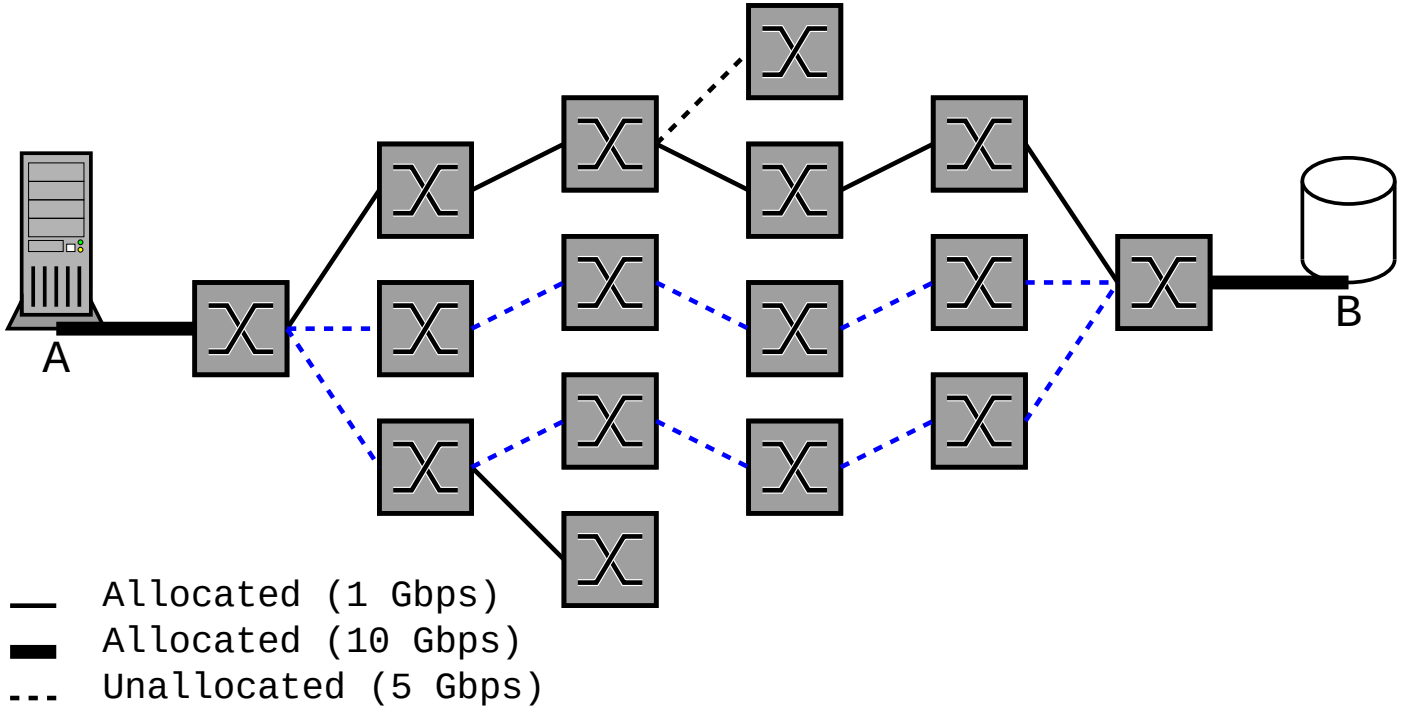
# Example Situation

- Current connection between A and B is a mere 1Gbps



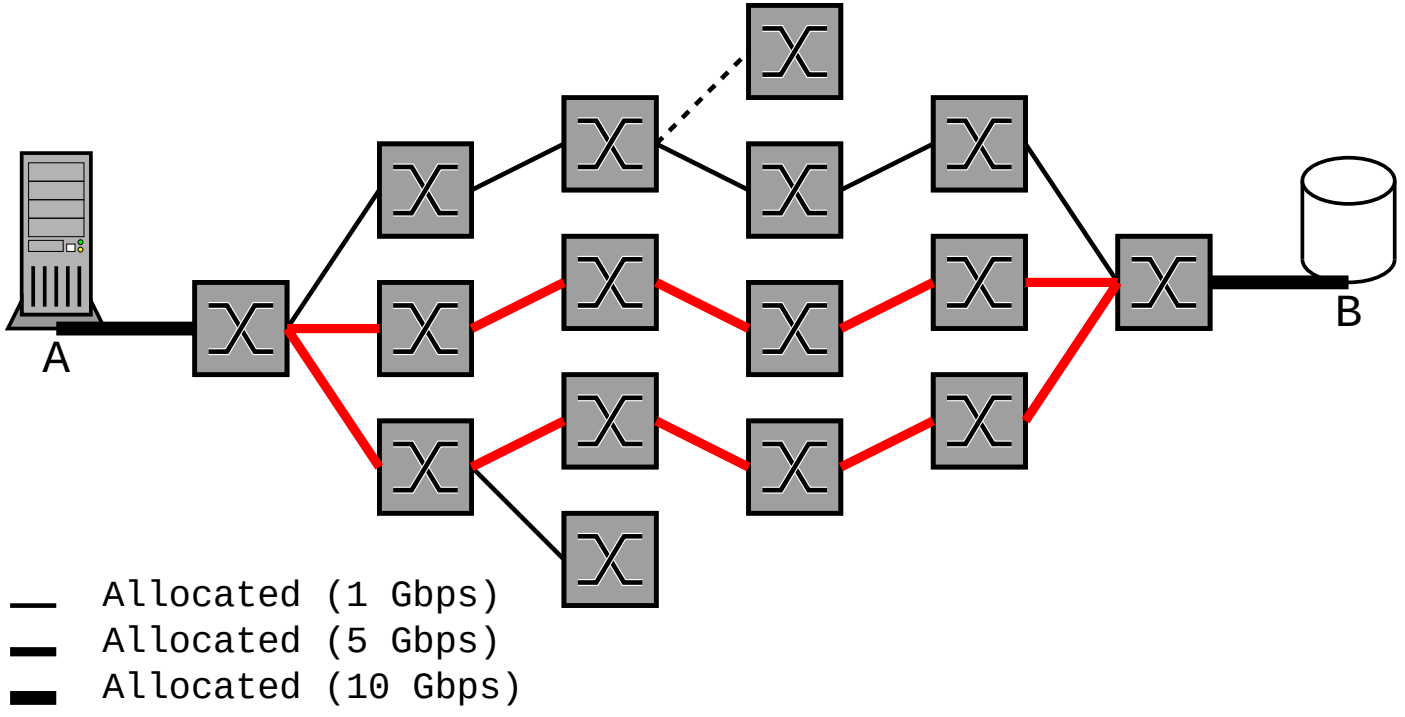
# *Example Situation*

- The network can allocate 10Gbps from X to Y



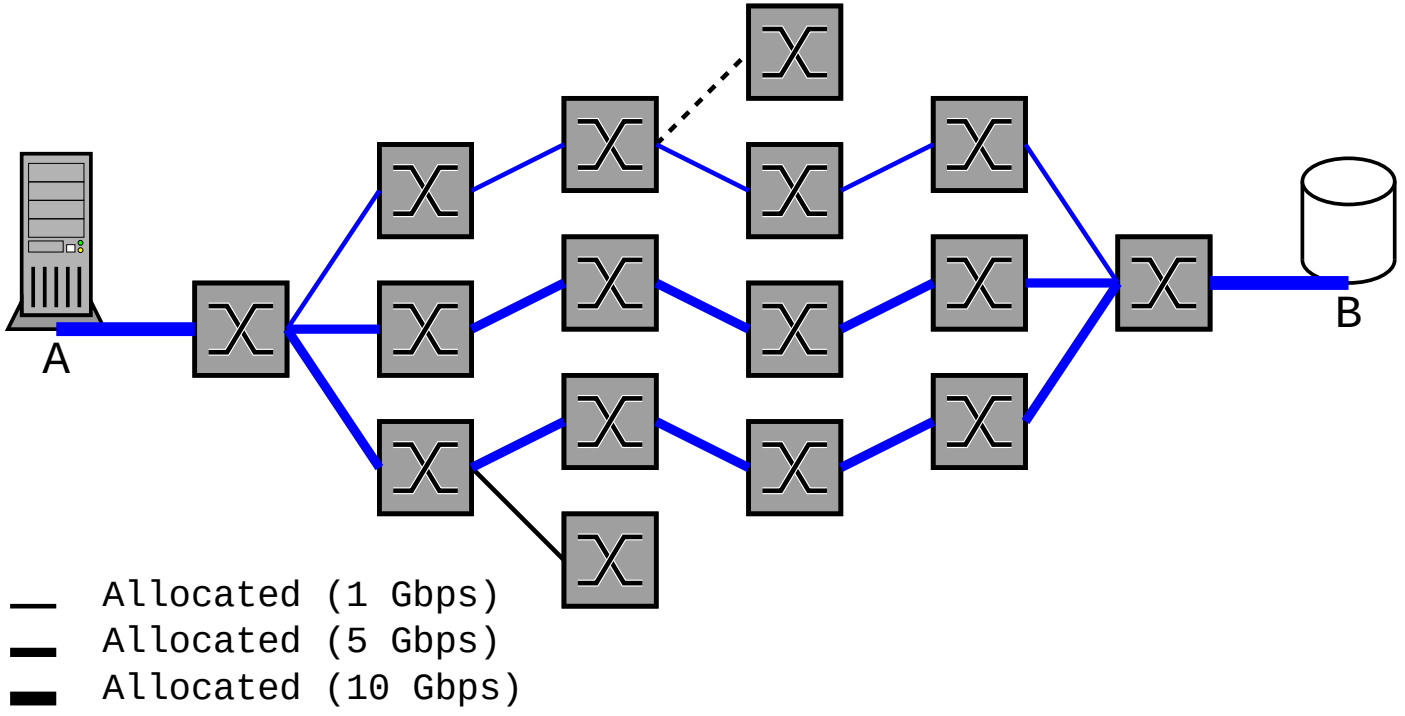
# Example Situation

- User A requests access to the lightpaths



# Example Situation

- Lightpaths are allocated and data is transferred



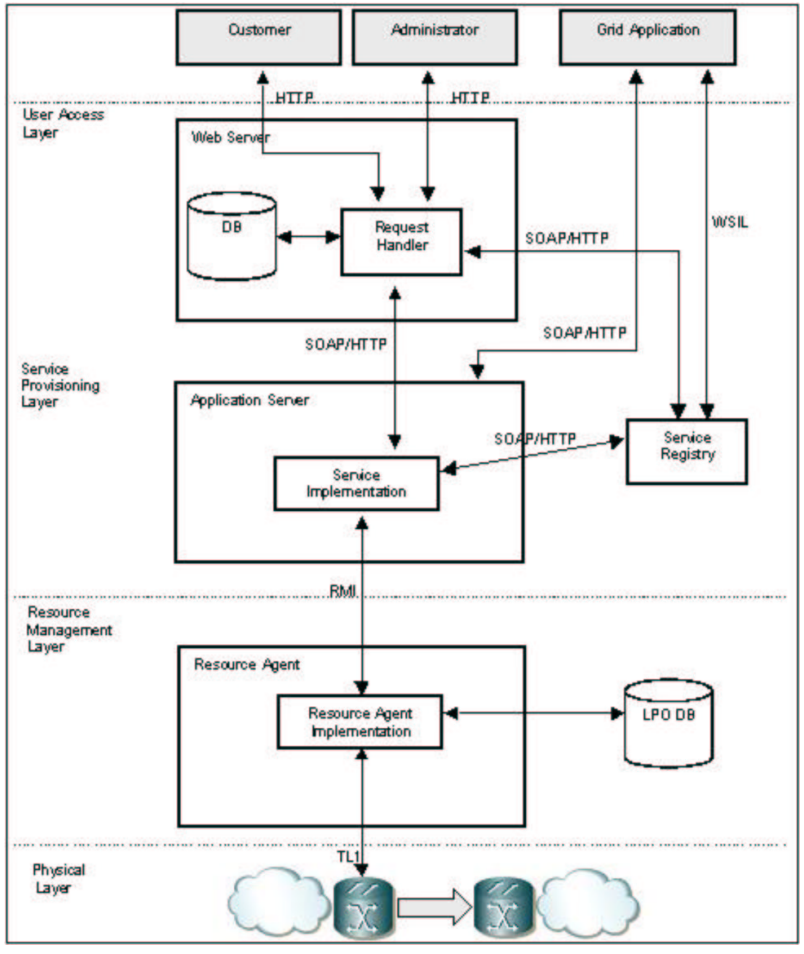
# *The Return of Circuit Switching?*

- The Internet hinted at the end of circuit switched networks
- Packet switching advantages: end-to-end principle (packets without permission), peer-to-peer applications, statistical multiplexing.
- However most communication is connection-based (i.e. TCP).
- Circuit switching advantages: circuits can be setup on demand, QoS is very easy

# *How to Implement?*

- System design broken into 4 layers
  1. User Access: Web and Grid Services Interfaces
  2. Service Provisioning: Application Server with SOAP/HTTP
  3. Resource Management: Resource Agent w/ LPO database
  4. Physical Layer: ??

# How to Implement?



# *The Physical Layer*

- Need to provision lightpaths across autonomous systems (AS)
  - Also called inter-AS lightpath provisioning
- Open shortest path first (OSPF) operates within an AS
- Border gateway protocol allows AS's to share routing information
- CANARIE decided to extend BGP to the optical layer, thus Optical BGP

# *Optical BGP (OBGP)*

- Protocol proposes two phases:
  1. Lightpath Reachability: sites advertise through BGP the availability of a lightpath to their site.
     - Each site builds up a list of feasible lightpaths to neighboring optical cross-connects (OXC).
  2. Lightpath Establishment: send a BGP update message to communicate lightpath establishment.

# *OBGP: Lightpath Reachability*

- Extend the NLRI attribute to carry necessary optical and routing information:
  - IP address of site OXC
  - Reachable IP address prefixes
  - A lightpath identifier
- Communicated through BGP Update message of type 0xA101
- Local table maps destination network to available lightpaths.

# *OBGP: Lightpath Establishment*

- Lookup destination network in lightpath table. Lookup intermediate networks as well.
- Send an Update message (0xA102) to an AS with desired lightpath ID.
- Destination and intermediate AS's send advertisements that lightpaths are no longer available.
- Upon lightpath establishment, the normal BGP routing tables are updated.

# *Prototype Implementations*

- A few University's are working on prototype implementations:
  - U of Carleton
  - U of Waterloo
  - U of Quebec in Montreal
- Status: still in development, not production quality

# *Next Steps?*

- Some prototypes are working, but not production quality.
- Efforts need to be unified – standard implementation agreed upon.
- Possible future: Fibre to the Home (FTTH)

# *Is FTTH Possible?*

- Quite pricey:
  - Cost to connect a home: $500-$2500
  - Cost to pass by a home: $500-$2000
  - Assuming 5% take up rate (like Cable/DSL): $11,000-$42,000 [1]
- Not quite yet!!

# *References*


1. CANARIE, “Proposed CA*net 4 Network Design and Research Program”, Revision 9, March 2001.
2. Network Working Group (CANARIE), “Optical BGP (OBGP): InterAS lightpath provisioning”, IETF, March 2001.
3. Simeonidou, D. “Optical Network Infrastructure for GRID”, Global Grid Forum, July 2003.
4. UWaterloo Lightpaths Project, *http://bbcr.uwaterloo.ca/˜canarie/*