Hierarchical Inter-Domain Management for Networks with Condo-Switches

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Customer Owned Fibre & Wavelengths

- Many institutions are purchasing fibre and wavelengths through condominium arrangements
- Condo fibre means that separate organizations own individual strands of fibre in a fibre cable
  - Each strand owner is responsible for lighting up the strand
  - Collectively responsible for sharing costs of maintenance on fibre cable, relocation, etc
- Condo wavelengths
  - A number of parties share in the cost of a single strand and then light it up with an agreed upon number of wavelengths
  - Wavelengths are portioned based on percentage of ownership
- Condo-Switch : a switch where different ports belong to different owners

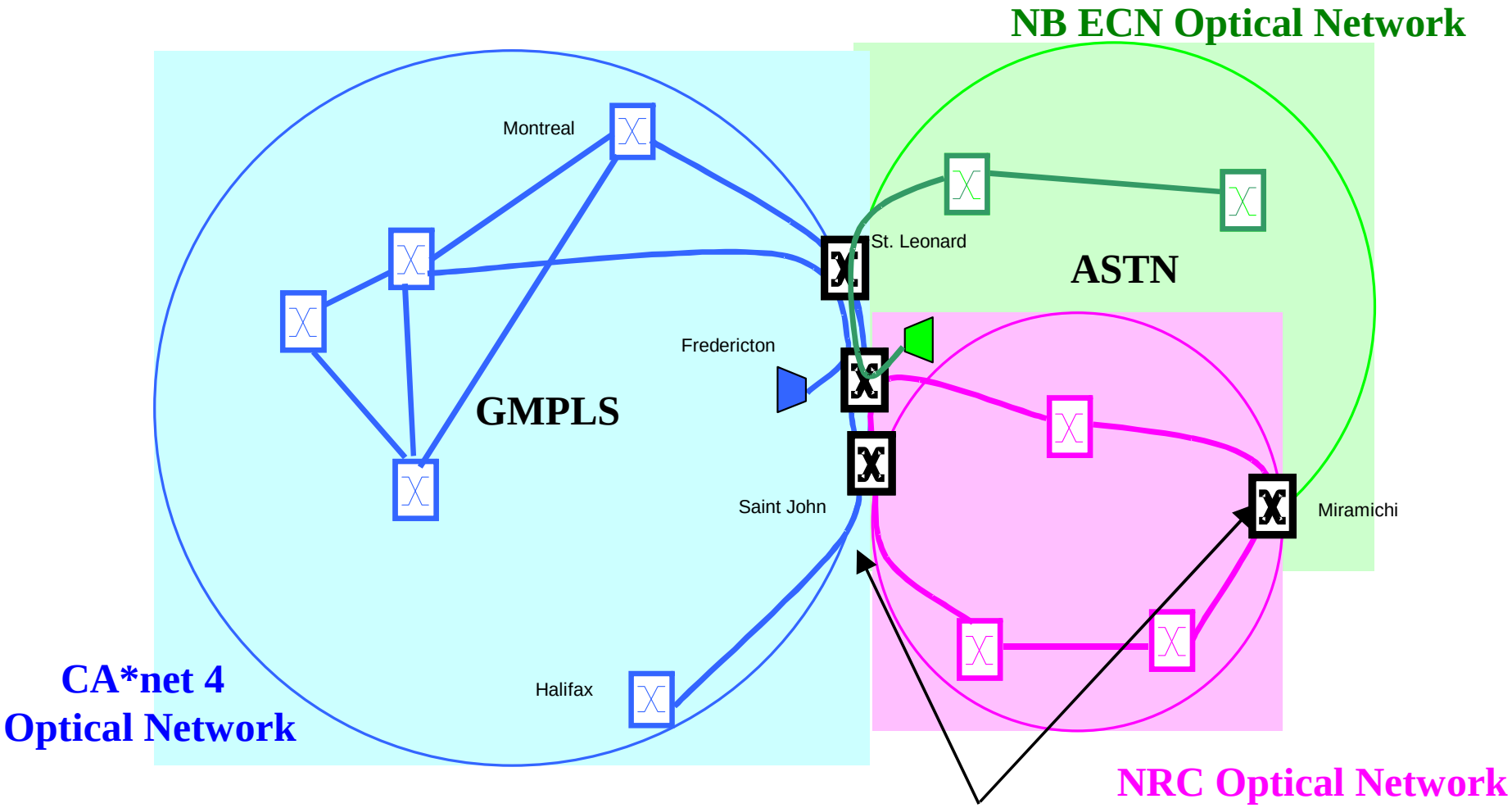
Why User-Controlled Lightpaths

- Customers can independently manage their own add/drops and cross connects
- With condo fibre and condo wavelengths, institutions can treat network as an asset just like purchasing a computer, rather than a service as today
- More flexibility in network planning and deployment
  - Can purchase dark fibre/wavelengths from many different independent suppliers

Major Application Areas

- eLearning systems and repositories
- eResearch and computationally based science
- eScience for participation of educators and public in scientific research
- eHealth records and information systems
- eStorage archival systems and indestructible data for telephone systems, etc
- eContent and digital rights management systems
- eManufacturing process control and manufacturing systems
- eSmallBusiness systems
- eCommunity for self organizing community broadband networks
- eStrategy for integration of workflow and information systems
- eUniversity student registration systems and admin systems
- eGovernment for integrating and delivering government services

Condominium Network Example



Condominium OXC and OADM

Advertising Network Resources

- Resources that are available for peering or leasing should be publicly advertised using service registries
  - Web Service Directories, i.e. UDDI, WSIL
  - Jini Lookup Service
  - other data bases
- Potential users can query the service registries for available resources or services
- Resources are advertised as objects with attributes allowing meaning full queries to be made to the registries

Inter-domain architecture for BGP routing

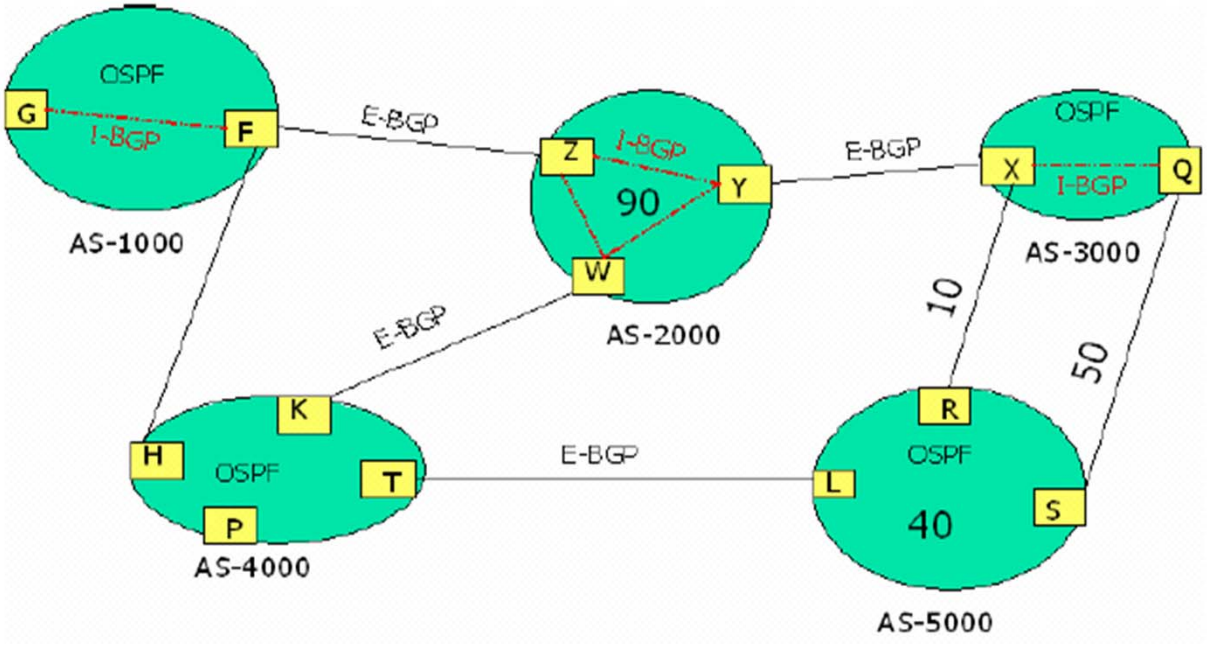


Figure 3. 8: A network scenario consisting of five ASs

Hierarchical routing with OSPF

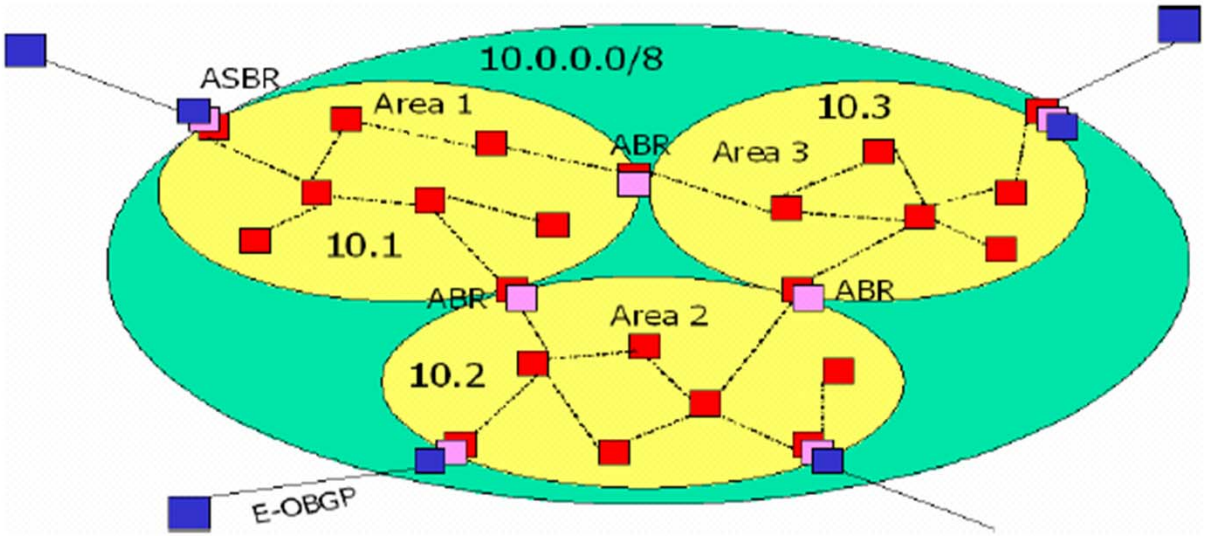
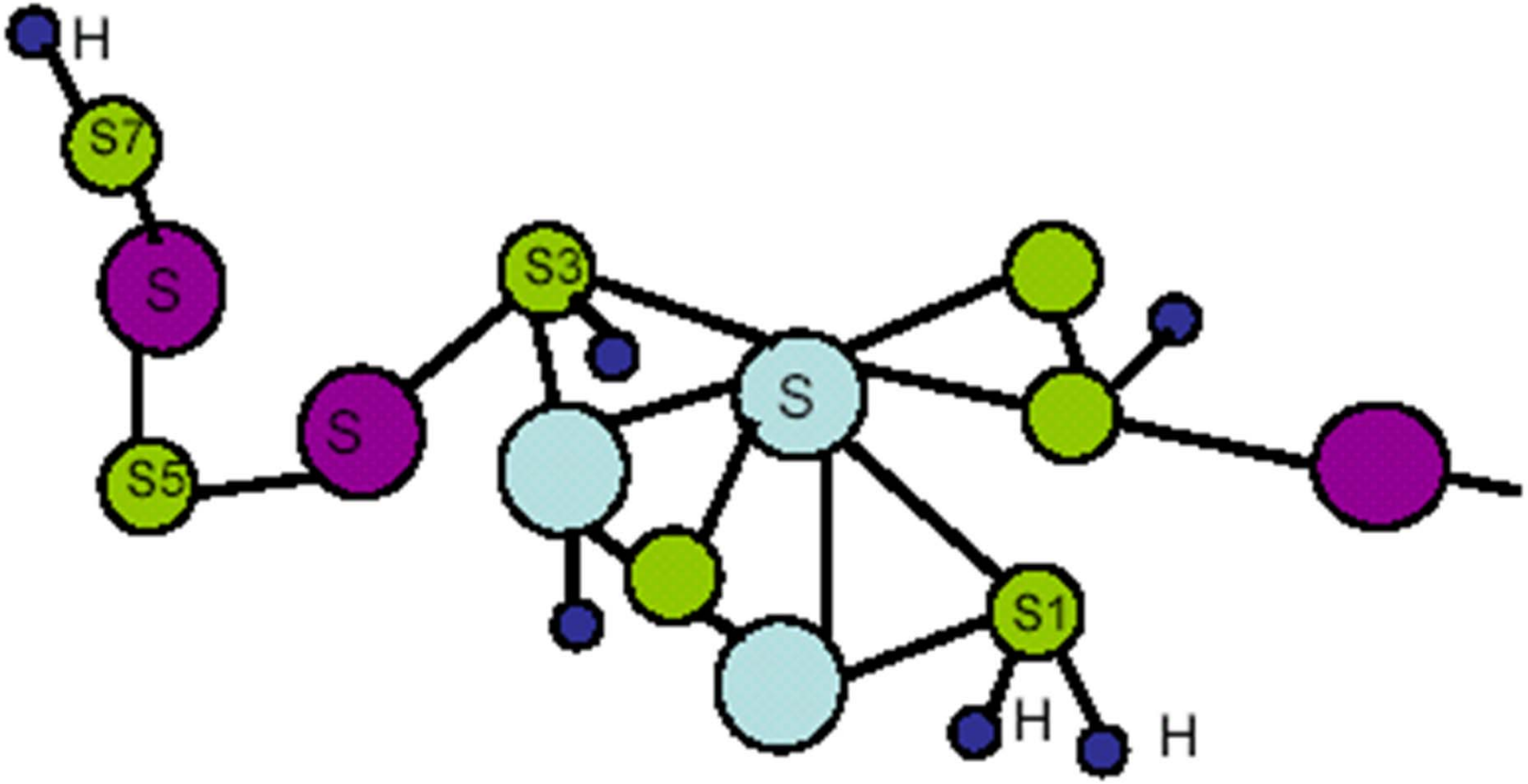
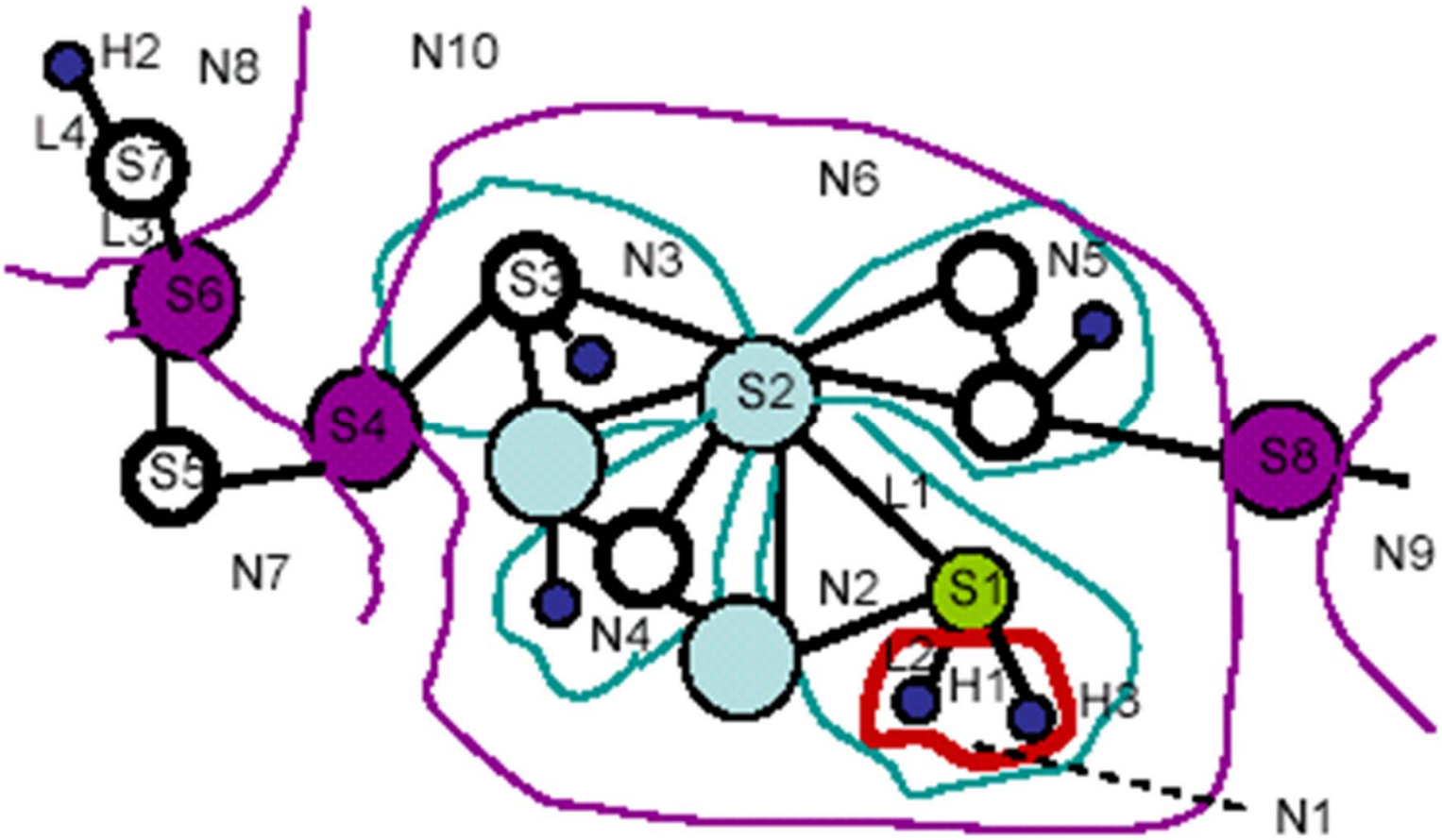


Figure 3. 4: AS-2 using OSPF as IGP

Example Network



Example network with hierarchical structure



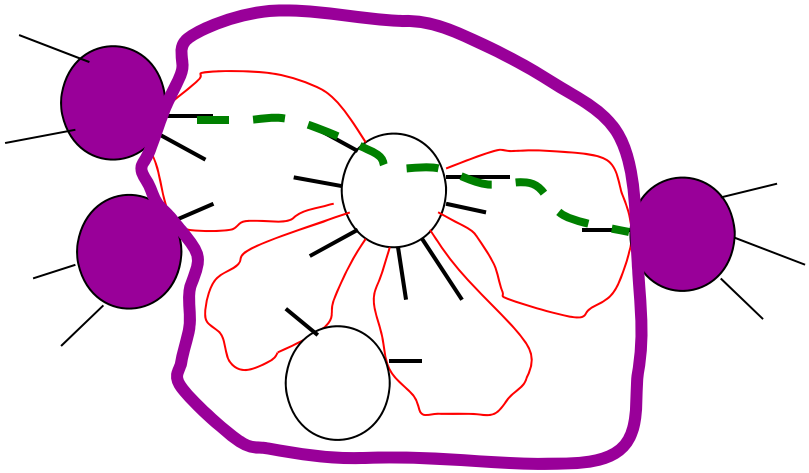
New conceptual definitions

- **Switch**
  - Has several **ports** (input, output, or both ways)
  - Can establish several **cross-connections** between ports. A non-blocking switch can establish any permutation between all input and output ports
  - Has an interface by which one can request the establishment or tear-down of a cross-connection
- **Network**
  - Has several **external switches** of which it uses certain ports (the **external network ports**)
  - Has several **internal switches**
  - Is composed of several **sub-networks**; the external switches of each sub-network belong to the external and/or the internal switches of the network; each external network port of the network is used by one and only one internal network.
  - Can establish several **external connections** between external network ports using a sequence of sub-network connections and cross-connections of internal (and possibly intermediate external) switches
  - Can establish several **internal connections** between external ports of subnetworks or between an external network port and an external port of a subnetwork
  - Has some routing information for finding suitable paths for the establishment of such network connections
  - Has an interface by which one can request the establishment or tear-down of a network connection and has a directory where one can find available connections

Special cases

- Switch
  - Normal cross-connect
  - Add-drop switch
  - **Terminal device** (usually has only one port, no switching function)
  - **Distributed switch**: Implemented by a set of (distributed) switches and a network having these switches as external switches. The ports not used by the network are the ports of the implemented (virtual) switch.
- Network
  - Normal network (consisting of sub-networks)
  - “primitive” network
    - A communication **link** connecting two entities. These entities are either two external switches, or one switch and a terminal device. There are no internal switches
    - A **broadcast network** connecting several devices (switches and/or terminal devices)

Network vs. Switch

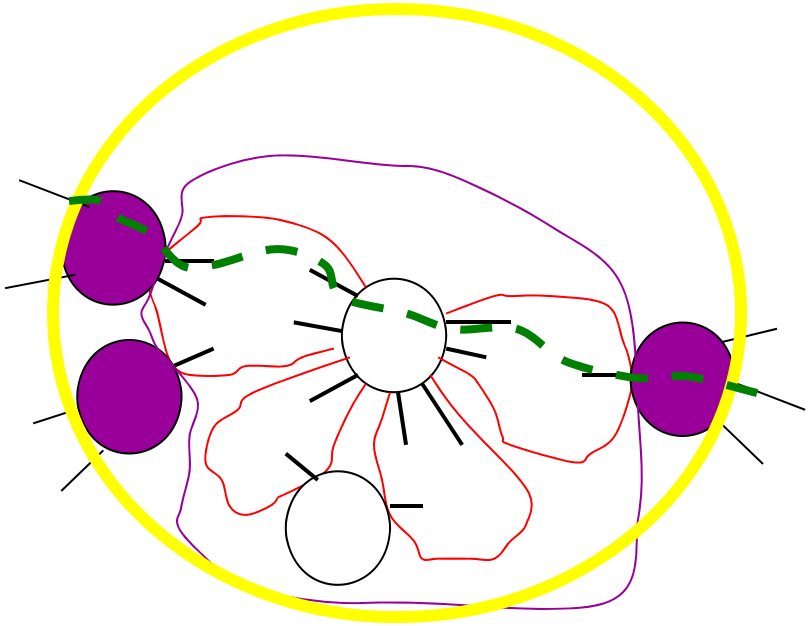


A **network**

with three external switches

(which have altogether seven unused ports)

Note: a **connection** is between two "internal" ports of external network switches (as indicated in green)



A **switch**

with seven ports

Note: a **cross-connection** is between two "external" ports of external network switches (as indicated in green)

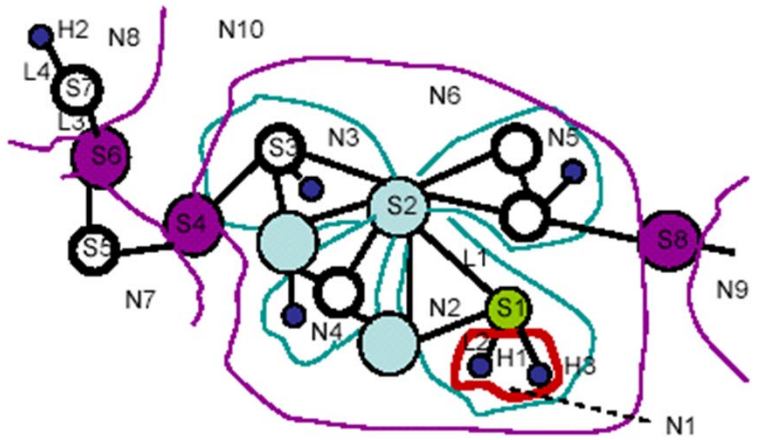
Network service interface

- The following functions are provided at the service access point (SAP) of a (sub-) network
  - Find route:
    - Between two sub-networks of the network
    - Between two external switches of the network
    - Between an external switch and a subnetwork
  - Find available lightpath along a given route
  - Advertize a lightpath as available
  - Lease a lightpath to another party

Connection establishment procedure

Use of hierarchical addresses: e.g. the host H1 has the global address « root/N10/N6/N2/N1/H1 »

1. Determine highest network involved in route (common prefix of the two end-point addresses)
2. Find route in highest-level network (route between subnetworks)
3. Extend the route in each of the subnetworks (recursively) (route from external switch of subnetwork to sub-subnetwork)



Finding the SAP of networks

Additional functions for exploring the global network hierarchy (provided by each network):

- Global network identification: global address and URL of SAP
- Subnetworks: list of subnetworks (name and SAP URL)
- Switches: list of external and internal switches (name and SAP URL)

Conclusions

- We proposed a simple network-subnetwork hierarchy which accomodates condo-switches.
- We defined an inter-domain connection establishment protocol based on a few routing and lightpath reservation functions provided by each (sub-) network.
- In collaboration with CRC and I2cat (Barcelona, Spain) we are implementing an inter-domain UCLP system based on Web Services technology.
- We plan to extend that system to provide support for the hierarchical inter-domain routing described in this paper.