



DRAGON

# Policy-Based Resource Management and Service Provisioning in GMPLS Networks

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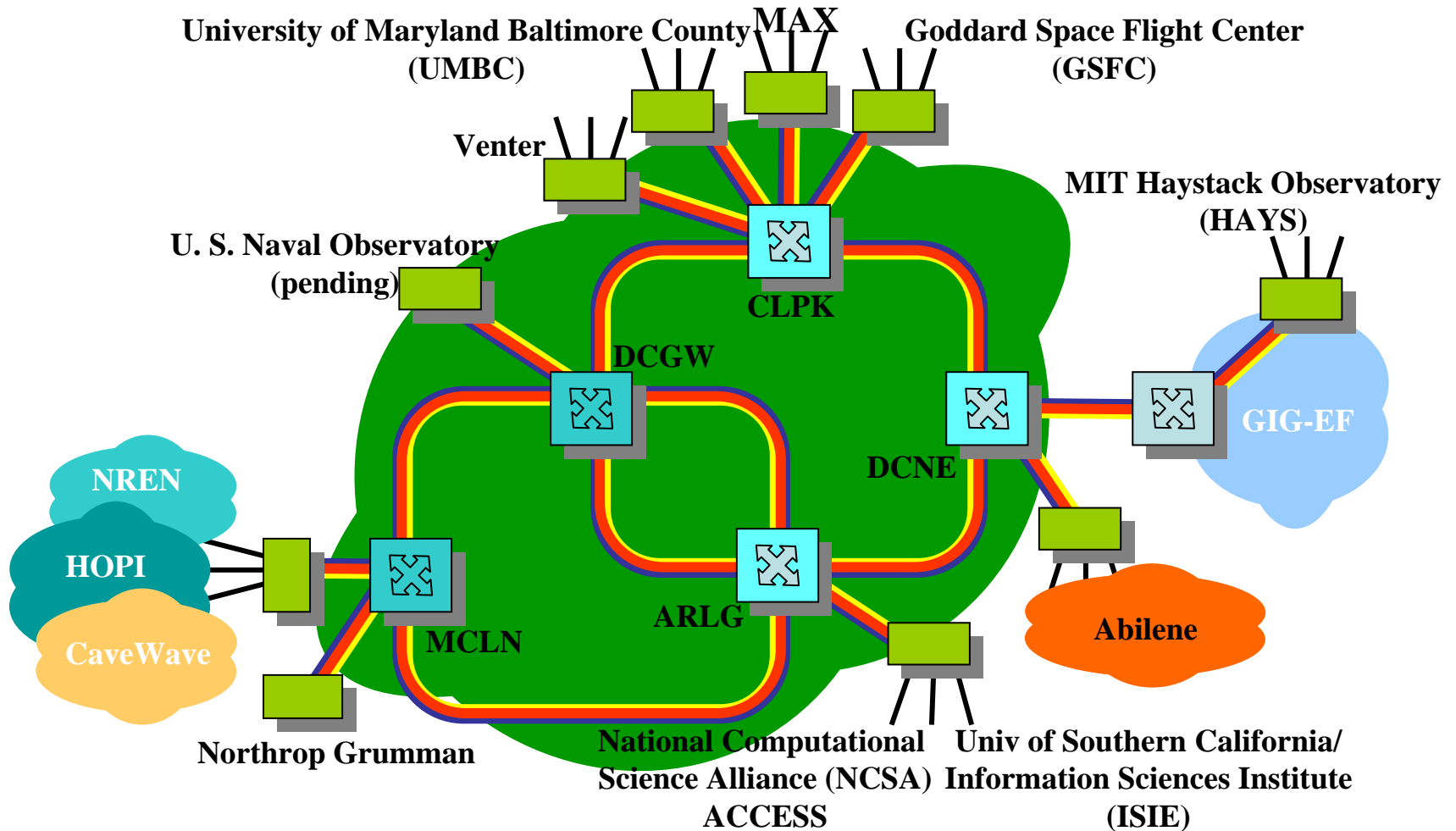
# Outline

- DRAGON Network
- DRAGON GMPLS Control Plane Architecture
- 3D Resource Computation Model
- Interdomain Path Computation
- Policy Based Provisioning with Scheduling and AAA
- Summary

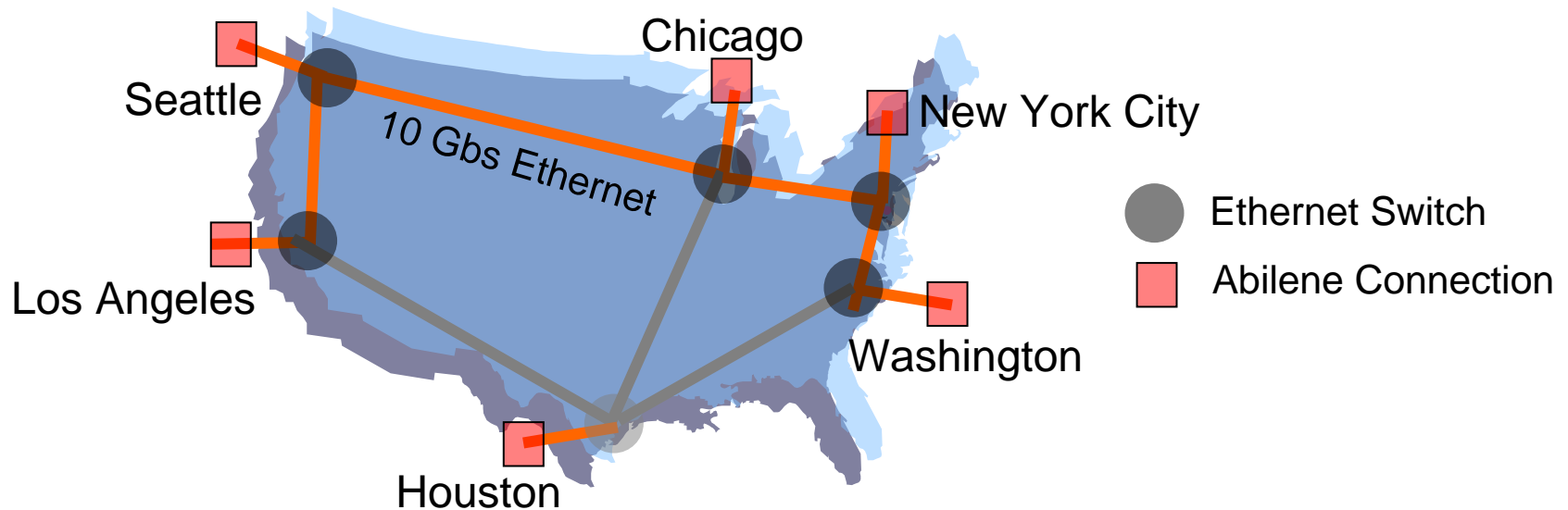


# The DRAGON Testbed

## Washington, DC, USA metro region



# Internet 2's Hybrid Optical Packet Infrastructure (HOPI)

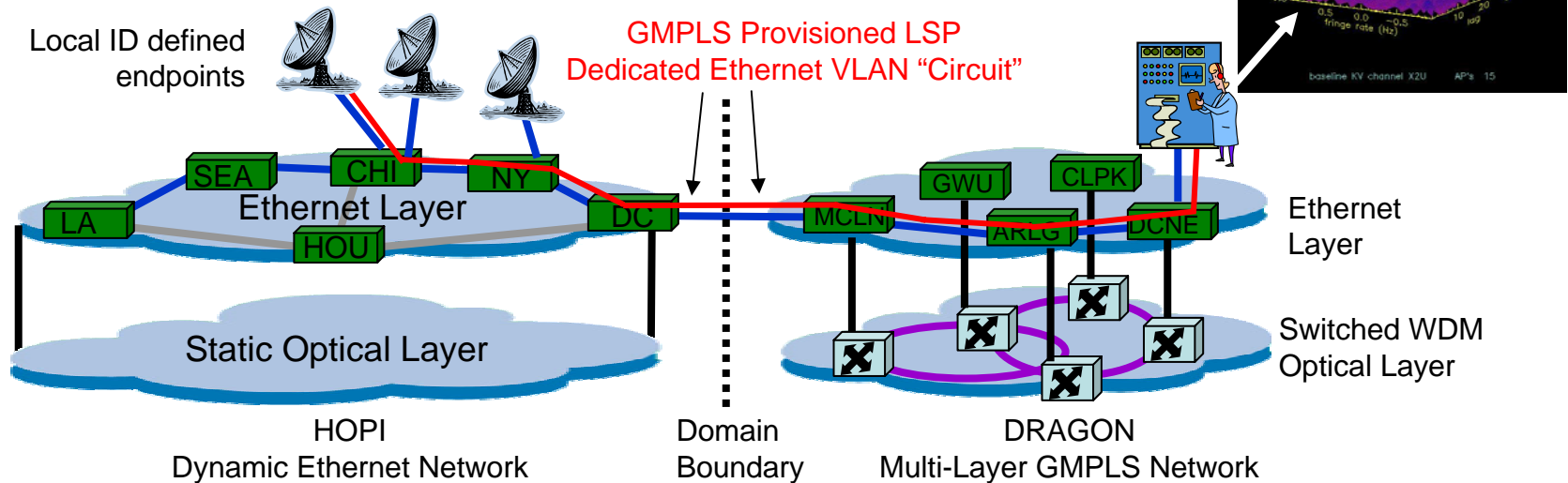


- Footprint across United States
- Ethernet Switches on top of National Lambda Rail (NLR) infrastructure
- Ten Gigabit/s backbone
- Multiple One and Ten Gigabit connections at sites for users, regional networks, and Abilene connection
- [networks.internet2.edu/hopi](http://networks.internet2.edu/hopi)



# DRAGON/HOPI Control Plane Provisioning Environment

- GMPLS Multi-layer, Multi-Domain
- Ethernet Service Provisioning
- Dynamic dedicated VLAN based connections





# DRAGON Control Plane

## Key Components

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- Network Aware Resource Broker – **NARB**
  - Intradomain listener, Path Computation, Interdomain Routing
- Virtual Label Swapping Router – **VLSR**
  - Open source protocols running on PC act as GMPLS network element (OSPF-TE, RSVP-TE)
  - Control PCs participate in protocol exchanges and provisions covered switch according to protocol events (PATH setup, PATH tear down, state query, etc)
- End System Agent – **ESA**
  - End system or client software for signaling into network (UNI or peer mode)
- Application Specific Topology Builder – **ASTB**
  - User Interface and processing which build topologies on behalf of users
  - Topologies are a user specific configuration of multiple LSPs



# NARB

## (Network Aware Resource Broker)

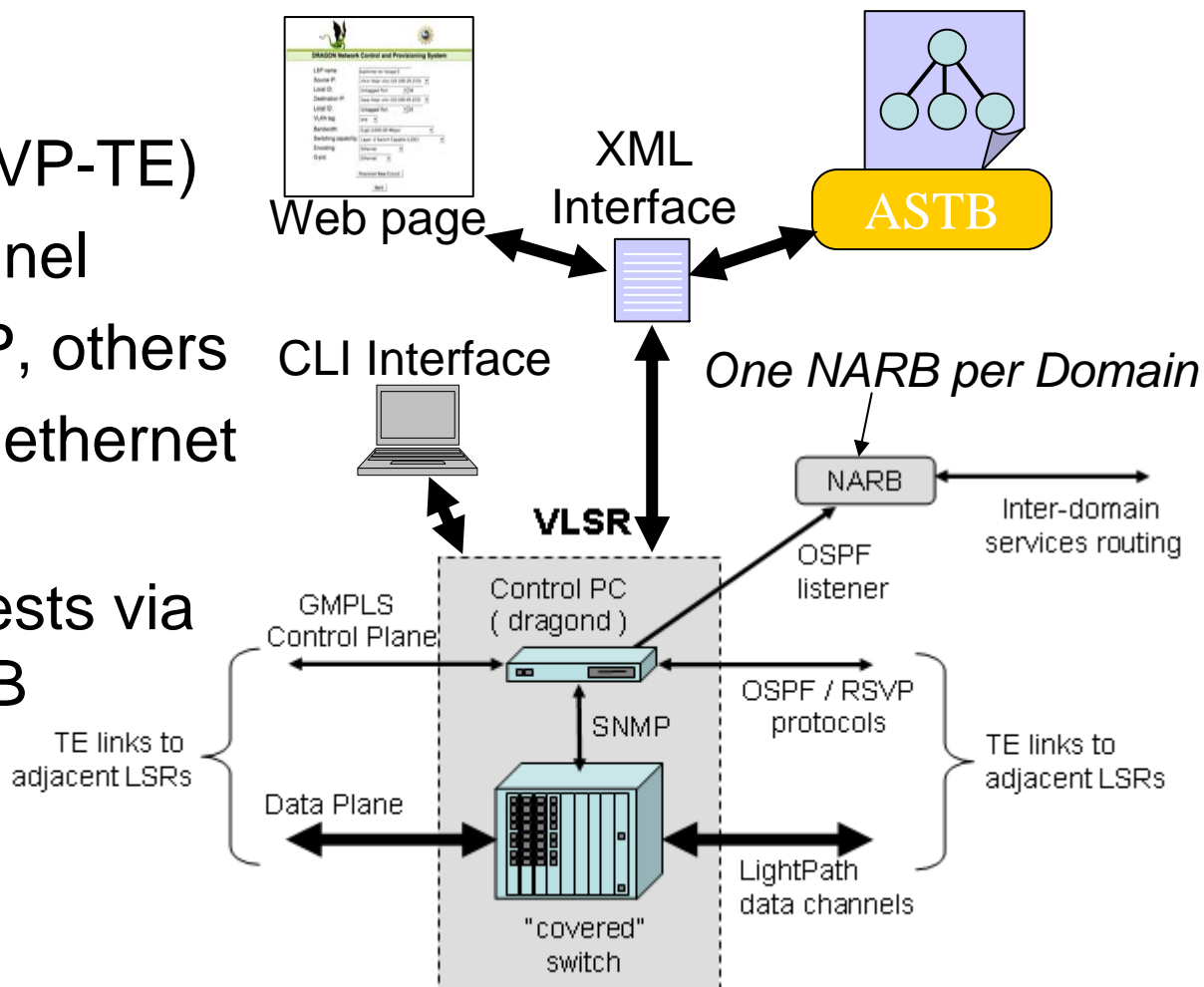
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- NARB is an agent that represents a domain
- Intra-domain Listener
  - Listens to OSPF-TE to acquire intra-domain topology
  - Builds an abstracted view of internal domain topology
- Inter-domain routing
  - Peers with NARBs in adjacent domains
  - Exchanges (abstracted) topology information
  - Maintains an inter-domain link state database
- Path Computation
  - Performs intra-domain (strict hop) TE path computation
  - Performs inter-domain (loose hop) TE path computation
  - Expands loose hop specified paths as requested by domain boundary (V)LSRs.
- Hooks for incorporation of AAA and scheduling into path computation via a “3 Dimensional Resource Computation Engine (3D RCE)”
  - The Traffic Engineering DataBase (TEDB) and Constrained Shortest Path Computation (CSPF) are extended to include dimensions of GMPLS TE parameters, AAA constraints, and Scheduling constraints.
  - 3D RCE is the combination of 3D TEDB and 3D CSPF



# VLSR (Virtual Label Switching Router)

- GMPLS Proxy
  - (OSPF-TE, RSVP-TE)
- Local control channel
  - CLI, TL1, SNMP, others
- Used primarily for ethernet switches
- Provisioning requests via CLI, XML, or ASTB





# VLSR

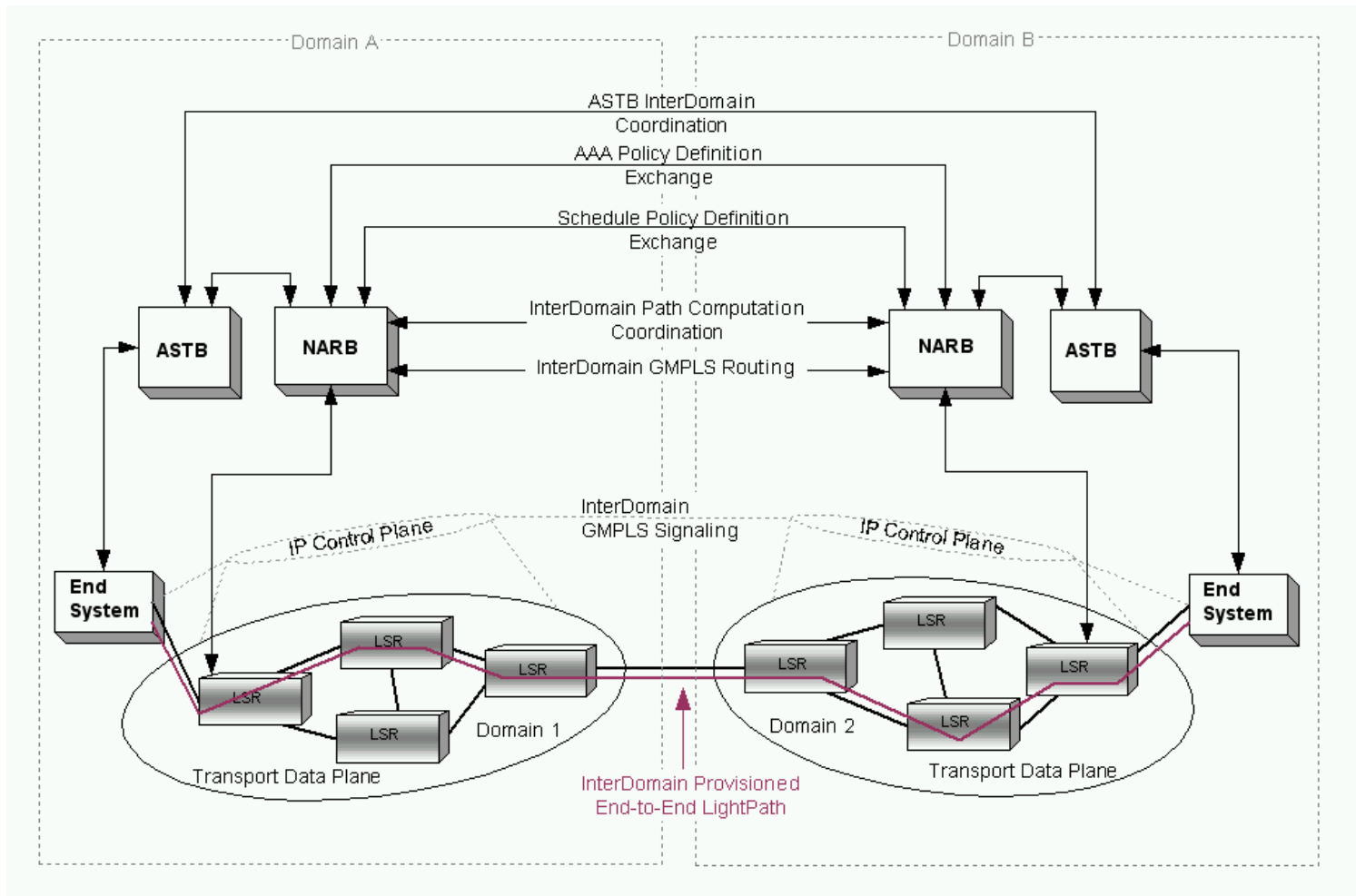
## (Virtual Label Switching Router)

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- RSVP Signaling module
  - Originated from Martin Karsten's C++ KOM-RSVP
  - Extended to support RSVP-TE (RFC 3209)
  - Extended to support GMPLS (RFC 3473)
  - Extended to support Q-Bridge MIB (RFC 2674)
  - For manipulation of VLANs via SNMP (cross-connect)
  - Extended to support VLAN control through CLI
- OSPF Routing module
  - Originated from GNU Zebra
  - Extended to support OSPF-TE (RFC 3630)
  - Extended to support GMPLS (RFC 4203)
- Ethernet switches tested to date
  - Dell PowerConnect, Extreme, Intel, Raptor, Force10

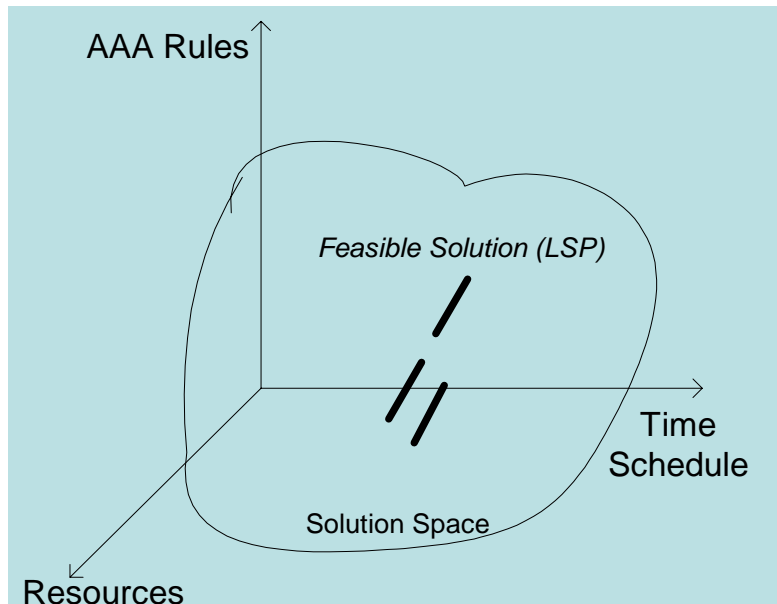


# DRAGON Control Plane



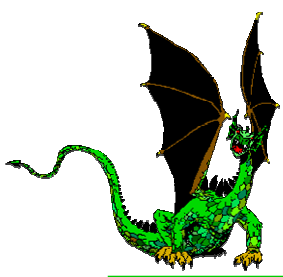


# Three Policy Dimensions in GMPLS Service Provisioning



- Resource dimension
  - Link availability, bandwidth capability & resource interdependence
  - TE constraints, e.g. switching cap.
- AAA policy dimension
  - User privileges
  - App. specific requirements (SLA)
  - Administration policies
- Time schedule dimension

- Integrate and translate network resource states and policies into shared control plane intelligence.
- Synergize AAA policy decision with TE based provisioning decision, resulting in fast, precise and simplified control process.



# 3 Dimensional (3D) Resource Computation Model

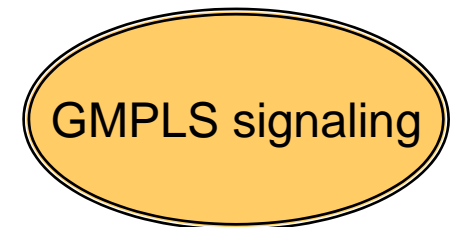
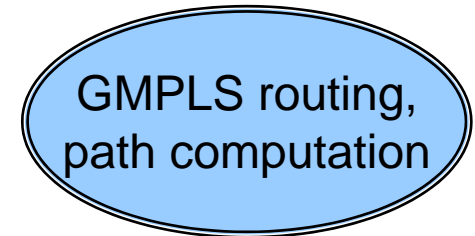
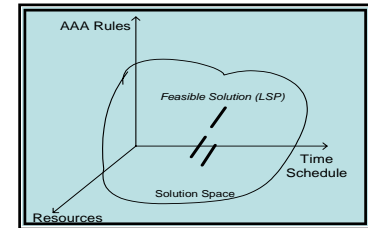
Resource states, time schedule and AAA policies are exchanged among control-plane entities in both intradomain and interdomain scopes.

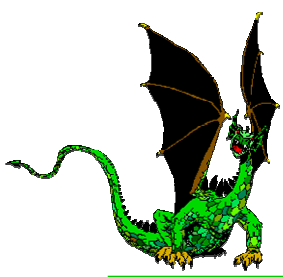


Three dimensions of constraints are used in joint to compute which resource to allocate and generate policy decisions.

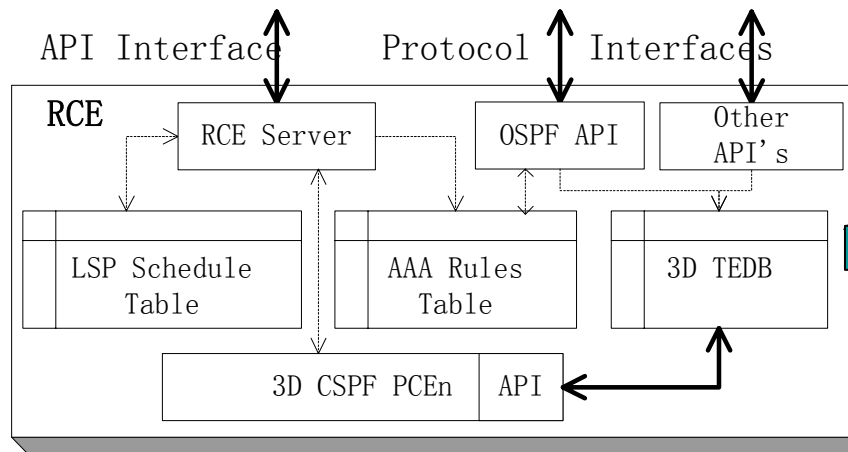


Actual service provisioning:  
resource allocation and policy enforcement.





# DRAGON Resource Computation Engine (RCE)



Support

Interdomain E2E path computation

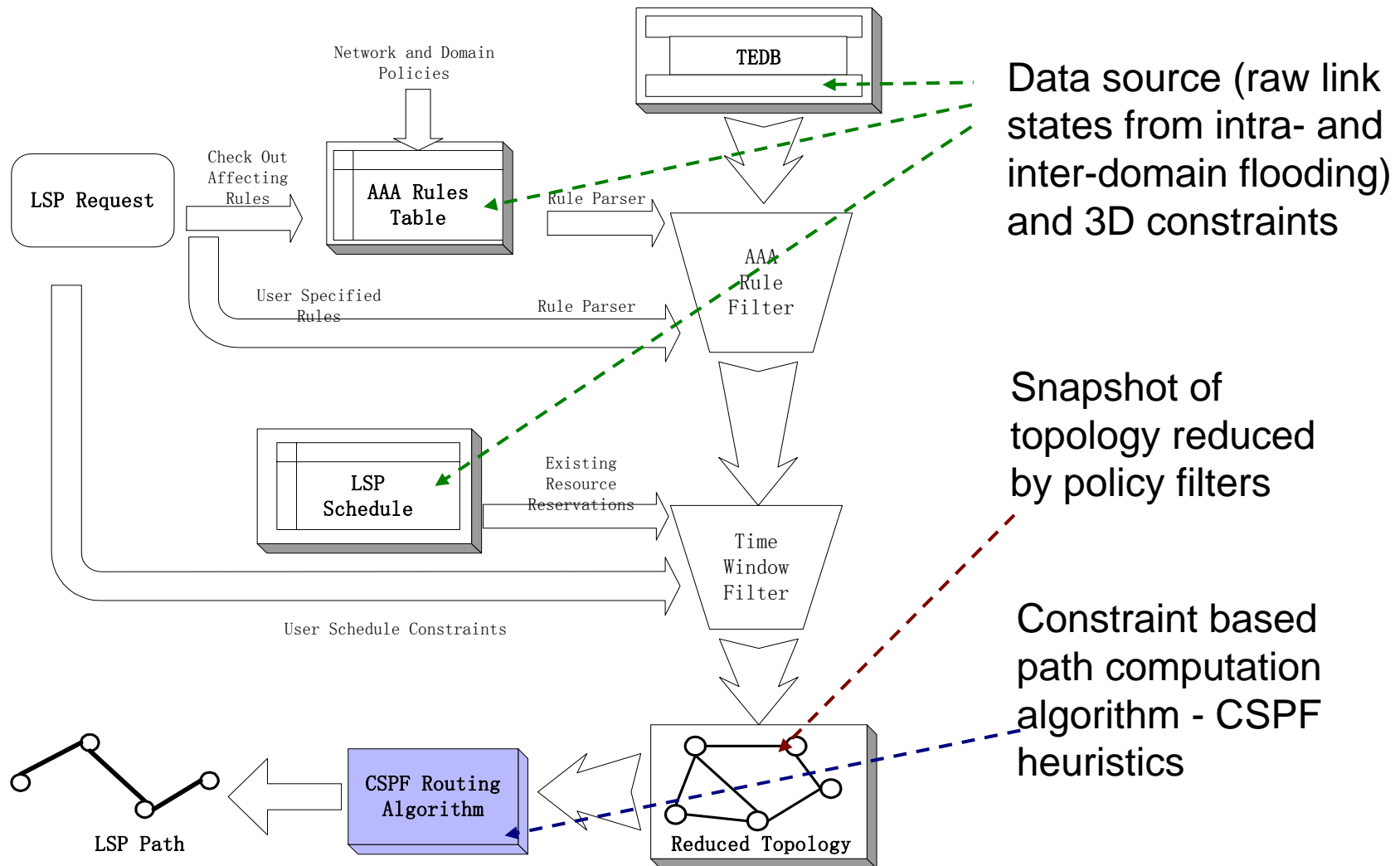
Advance scheduled service provisioning

AAA based provisioning and admission control

- RCE is the power horse in GMPLS control-plane to perform the computation intensive resource management & policy decision tasks.
- RCE can be used as a standalone server or as an integrated NARB module.



# 3D Constraint Based Path Computation





# DRAGON CSPF Path Computation Heuristics

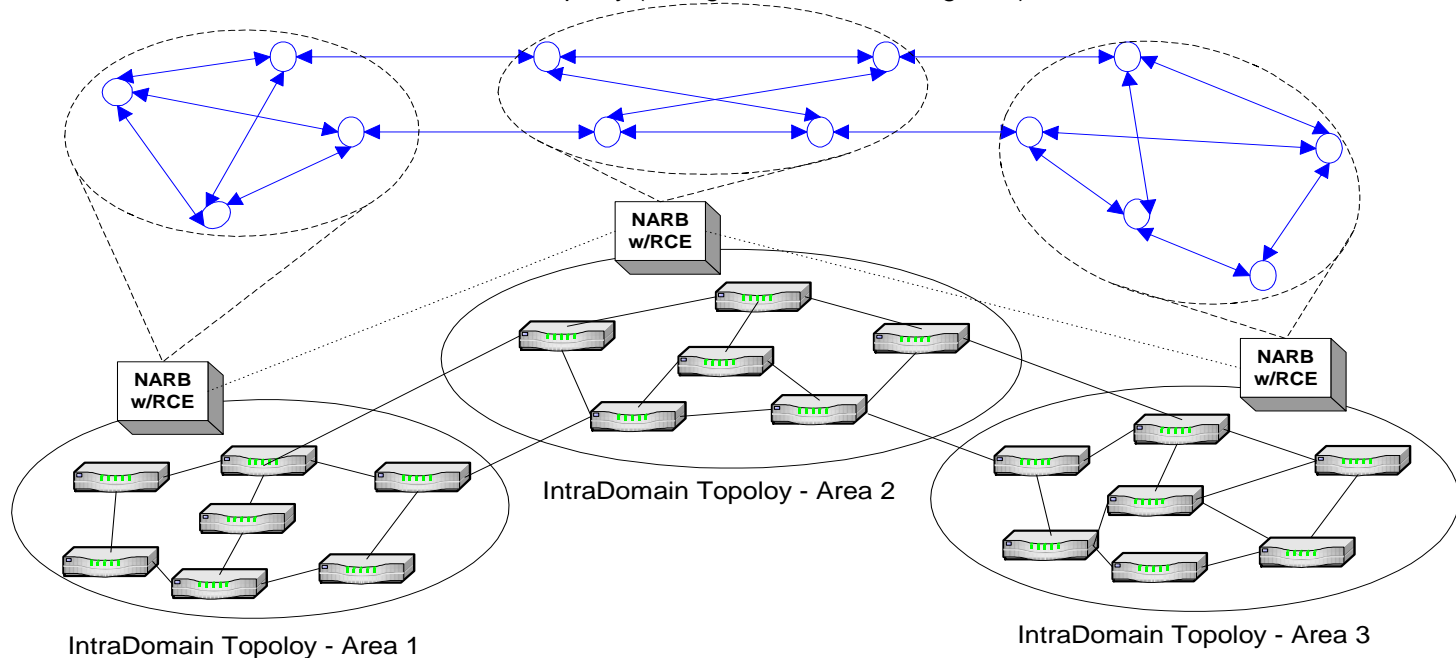
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- A breadth first search based CSPF heuristic in deployment
  - Takes flexible combination of various constraints, such as bandwidth, switch cap., wavelength, VLAN tag and add-on policy constraints.
  - Supports multi-region networks using configurable region-crossing criteria
  - Reliable results; probably time-consuming in large networks (~30ms in the 12-node HOPI+DRAGON network)
- Other heuristics under research; one is based on a channel-graph model in combination with K-shortest path routing.



# Interdomain Path Computation – A Hierarchical Architecture

Summarized/Abstract InterDomain Topology (A single link state flooding area)

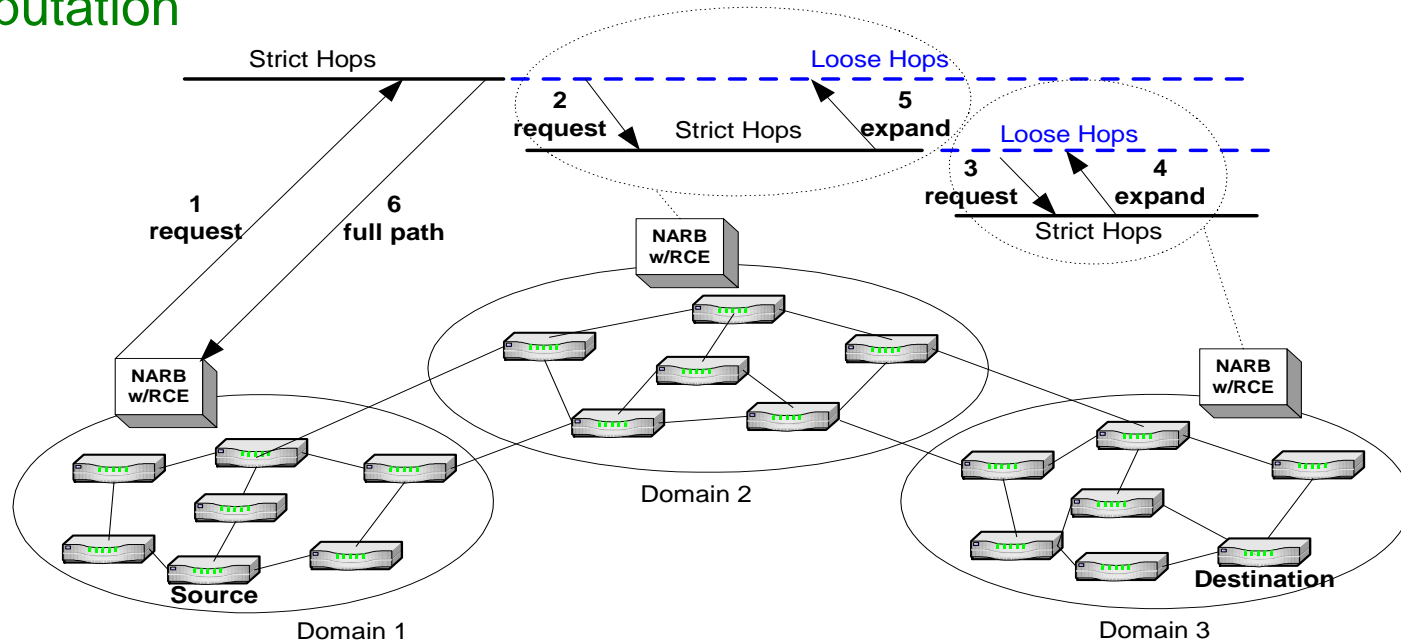


- NARB summarizes individual domain topology and advertises it globally using link-state routing protocol, generating an abstract topology.
- RCE computes partial paths by combining the abstract global topology and detailed local topology.
- NARB's assemble the partial paths into a full path by speaking to one another across domains.



# E2E Multi-Domain Path Computation Scheme

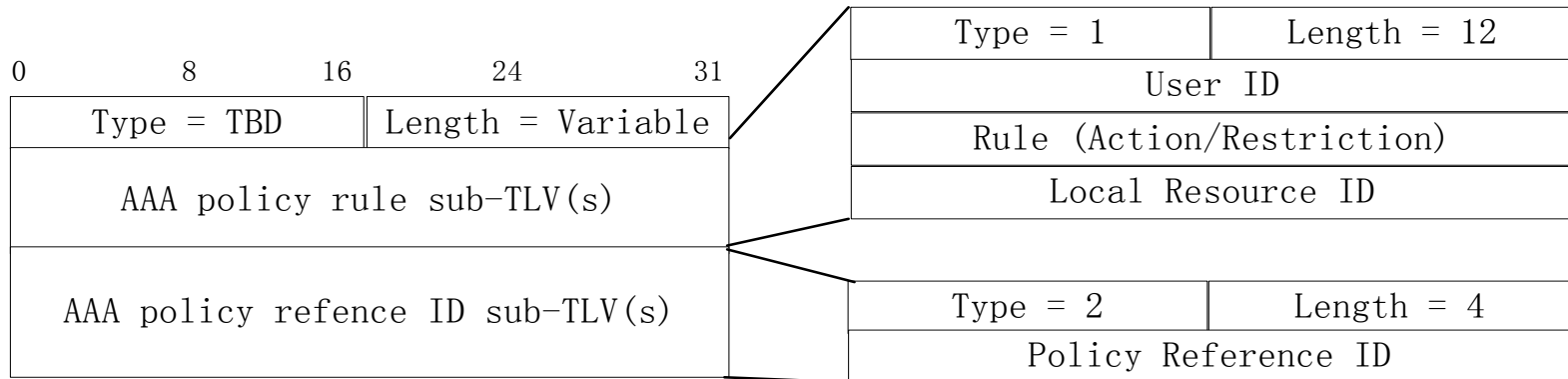
DRAGON mainly uses Recursive Per-Domain (RPD) interdomain path computation



- Full explicit path is obtained before signaling.
- Other supported schemes include Centralized path computation and Forward Per-Domain (FPD) path computation.



# AAA Based Provisioning



- AAA Policy TE Link TLV
- Allows a AAA information to be included as part of path computation
- Path Computation understanding/interpretation of rules very simple
- Much work needed in this area



# Time Based Provisioning

0	8	16	24	31
Type = TBD		Length = N*5		
Resv 1 – Start time		Resv 1 -		
Duration	Resv 2 – Start time			
Resv 2 - Duration		Resv 3 ...		
Repeated N times ( $N \leq 40$ )				

- Schedule TE Link TLV
- Allows a time constraint to be included as part of path computation



# Summary

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- We have a need today for a GMPLS control plane which can operate in a multi-domain, multi-level environment with features for AAA and scheduling
- Current implementation is being utilized to provide services to science users on multiple experimental testbeds
- Major challenges in the areas of higher fidelity incorporation of AAA and scheduling information, interoperation with other control planes, robust multi-level, multi-vendor operation



# Additional Information

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- Dynamic Resource Allocation via GMPLS Optical Networks (DRAGON) Project
  - <http://dragon.maxgigapop.net/>
- Tom Lehman, tlehman@isi.edu