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An Architectural Framework for Providing QoS in IP Differentiated Services Networks

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Presentation Outline

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- Introduction and Objectives
- Service Level Specifications (SLSs)
  - Contents and Semantics
- Functional Architecture
- SLS Management
- Traffic Engineering
- Policy Management
- Summary

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Introduction

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- The Internet evolves towards the global multi-service network of the future
  - Support for end-to-end (e2e) QoS guarantees
- Need for scalable QoS solutions
- Differentiated Services (DiffServ)
  - Classify, mark and police at the edges
  - Limited per-hop behaviours (PHBs)
    - Scheduling disciplines, buffer management
  - Per-aggregate state information
- Traffic Engineering
  - Control the manner traffic is treated
  - User and network-oriented objectives

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Objectives

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- Current proposals focus on control and data plane mechanisms. Management plane?
  - Bandwidth Broker (BB)
- Specify the contents and semantics of SLSs
  - Reflect the elemental QoS-based services
- Develop an architecture for enabling negotiation, monitoring and enforcement of SLSs between customer/ISP and ISP/ISP
- Develop a model of co-operating components, algorithms and protocols offering a BB solution for fulfilling the contracted SLSs, while continuously optimizing use of network resources

SLS Contents and Semantics

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- **IP Flow** - stream of IP packets sharing at least one common characteristic (*WHAT*)
  - Source, Destination, Application, DSCP info
- **Scope** - the geographical limits over which the SLS is to be enforced (*WHERE*)
  - Support for pipe, hose and funnel models
- **Traffic Envelope** - set of (conformance) parameters describing *HOW* the packet stream should look like to get performance guarantees
- **Traffic Conformance testing** - set of actions for identifying in- and out-of-profile packets

SLS Contents and Semantics (cont'd)

- **Excess Treatment** - how the out-of-profile traffic is treated
  - drop, shape, remark
- **Performance guarantees** - describe the transport guarantees the network offers to the customer
  - throughput, loss, delay, jitter
- **Service Schedule** - indicates *WHEN* the SLS is active
  - Start and end time
- **Reliability** - indicates the level of SLS assurance
  - mean downtime per year, maximum time to repair

Defining IP Transport Services

- The proposed SLSs constitute the elemental blocks for defining services
  - Unidirectional
  - Not necessary to quantify all the parameters
  - Also quantification using relative values (e.g. for defining Olympic services)
- Providers can choose to offer only certain predefined SLSs
  - By using limited pre-defined (ranges of) values
- More complex services can be defined, e.g.
  - Bi-directional Virtual leased lines (2 pipe SLSs)
  - Virtual Private Networks (combination of multiple hose and funnel SLSs)

Functional Architecture for Supporting QoS

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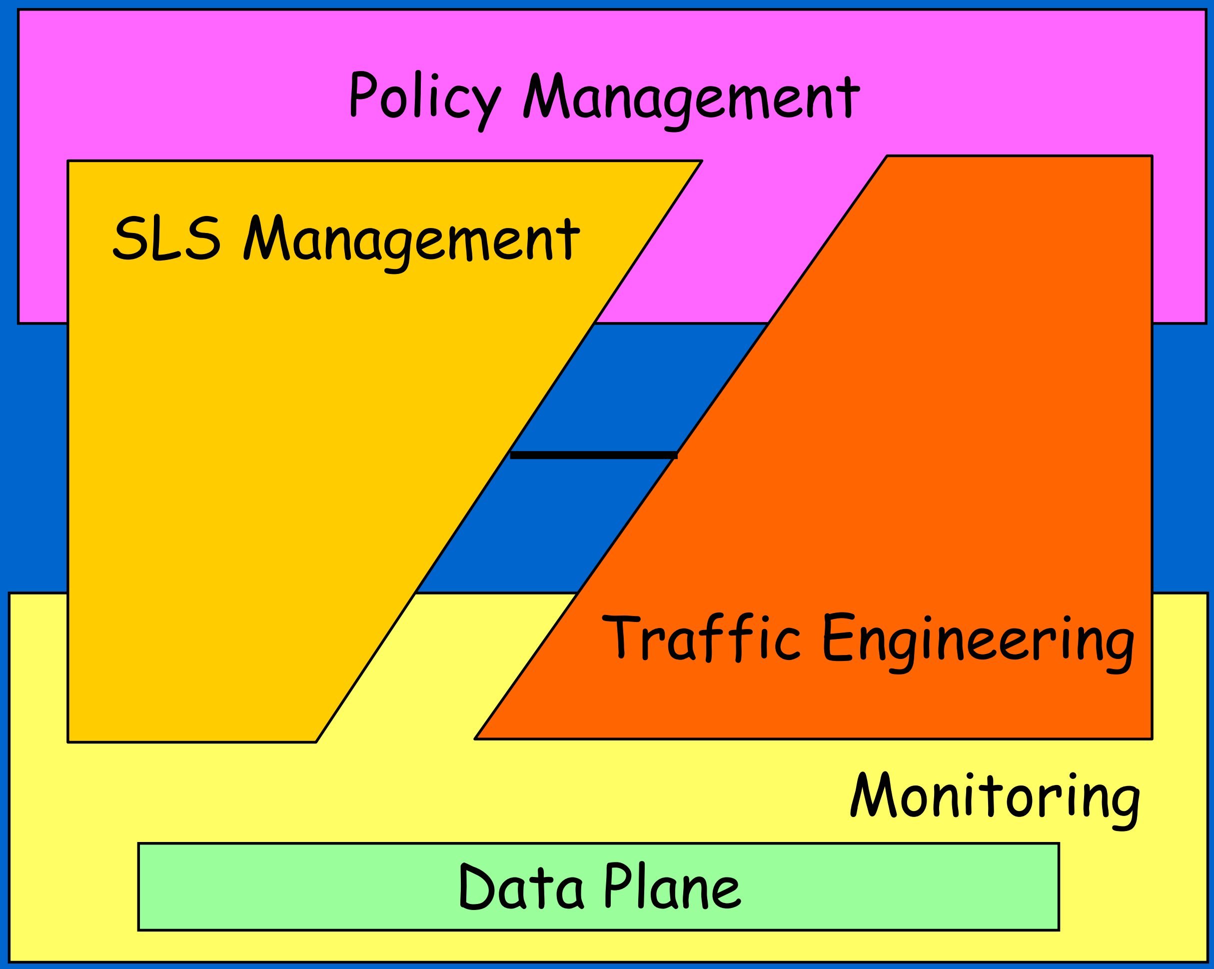

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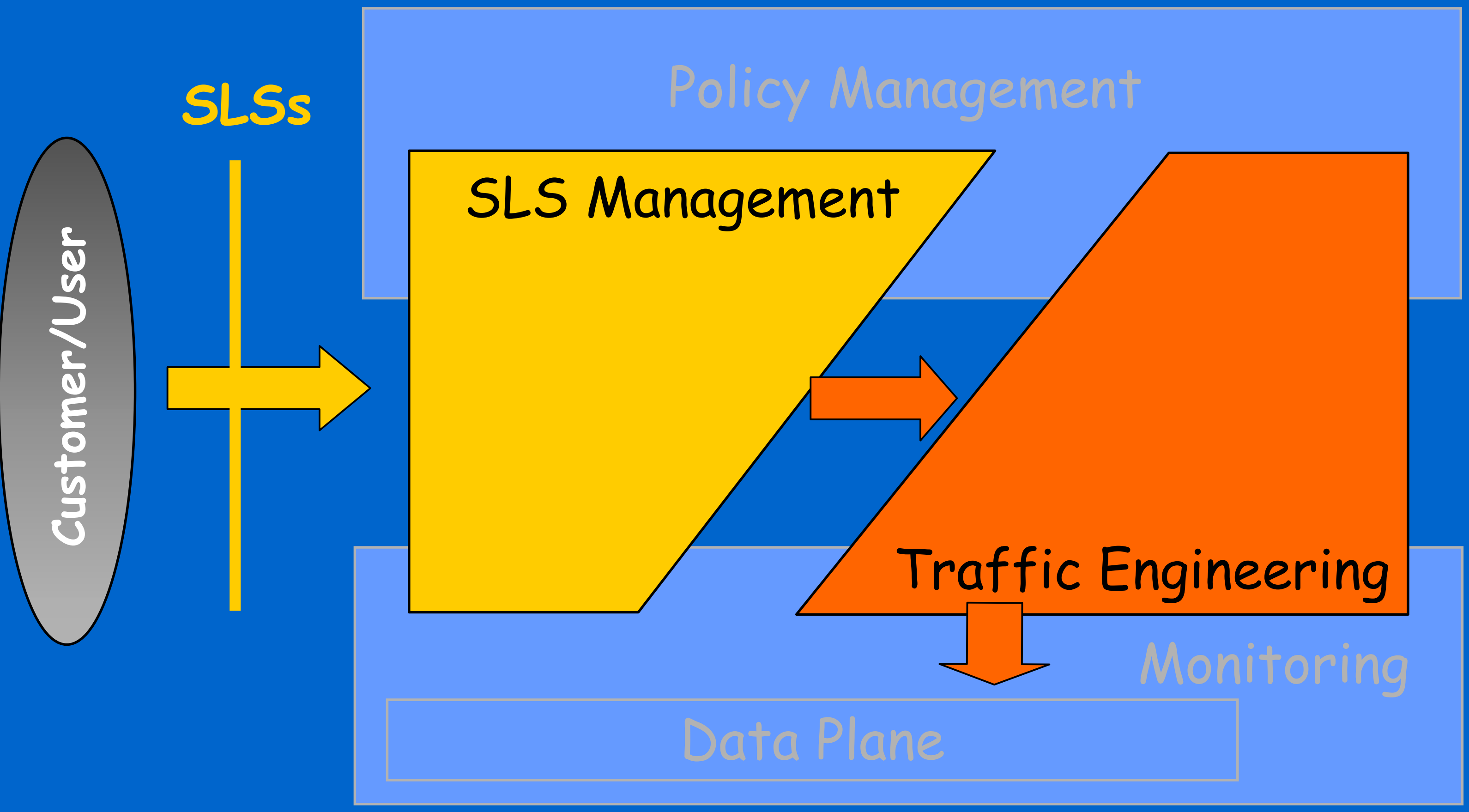
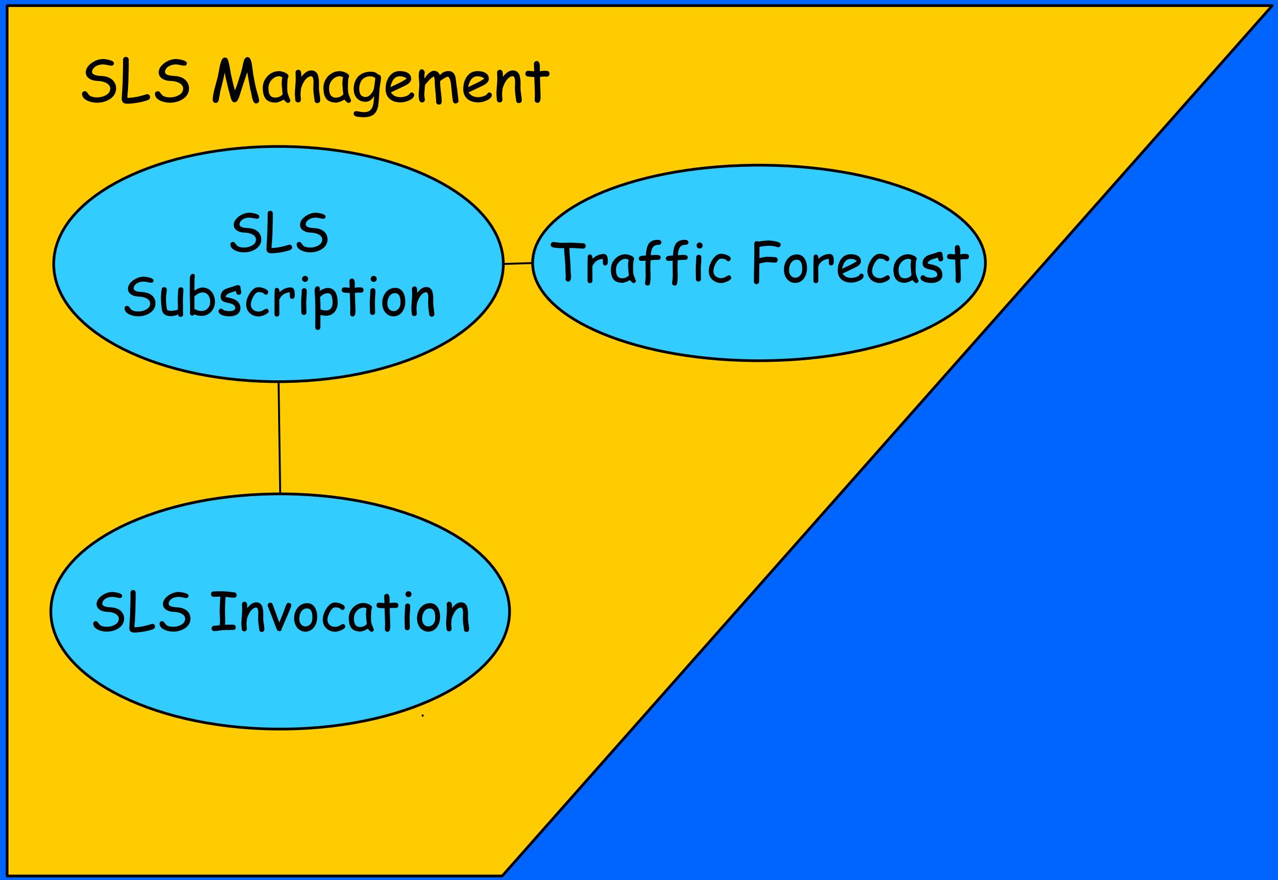
Functional Architecture: Fulfilling the SLSs



Service description and
negotiation through SLSs
(per-)Customer awareness

Service provisioning
through Traffic Engineering
(per-)Class awareness

SLS Management



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SLS Management (cont'd)

- SLS Subscription between Customer-Provider
  - Customer registration and long-term policy-based admission control
  - Negotiating the right to later invoke SLSs
  - Allows the provider to *provision* the network
- SLS Invocation between User-Provider
  - Dynamic (per-flow) admission control based on:
    - the subscribed/provisioned SLSs
    - traffic measurements
- Traffic Forecast provides the estimated traffic matrix
  - Based on subscribed SLSs, measurements and (over-subscription/business) policies
  - Ties the customer- and resource-oriented parts

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Traffic Engineering

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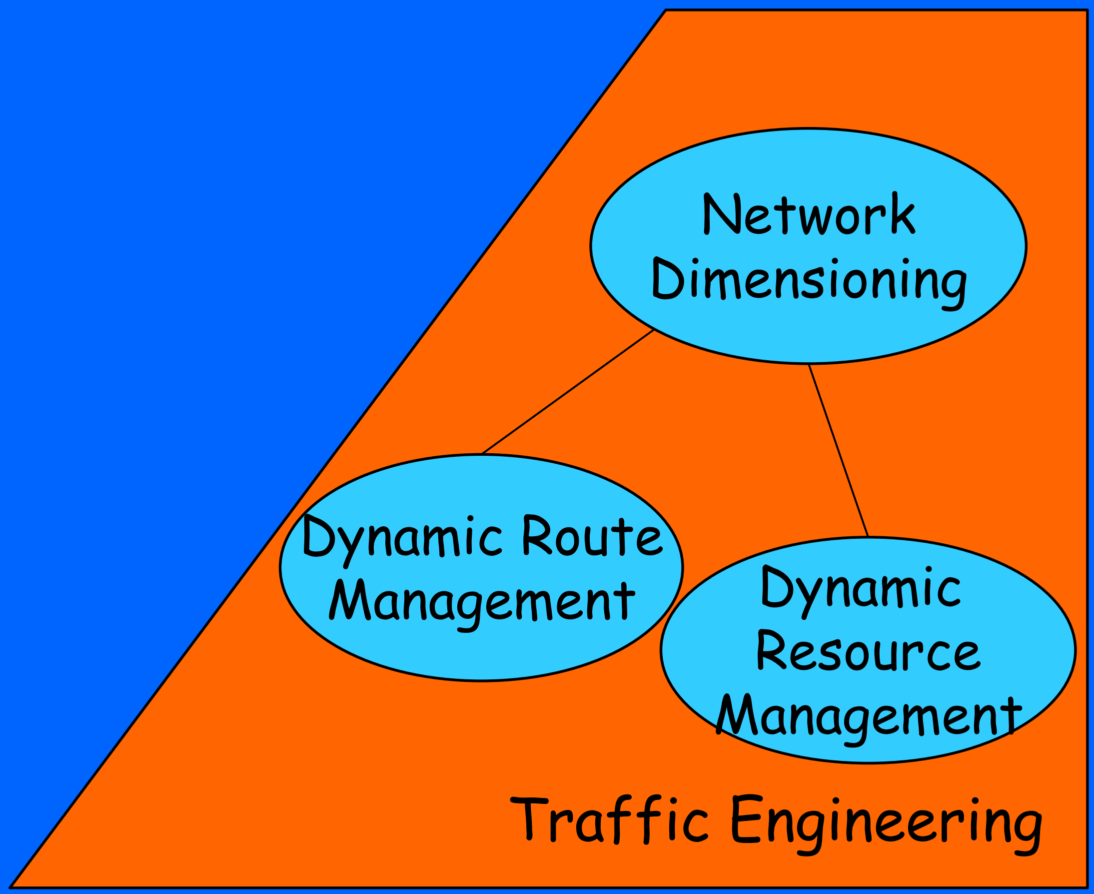

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Traffic Engineering (cont'd)

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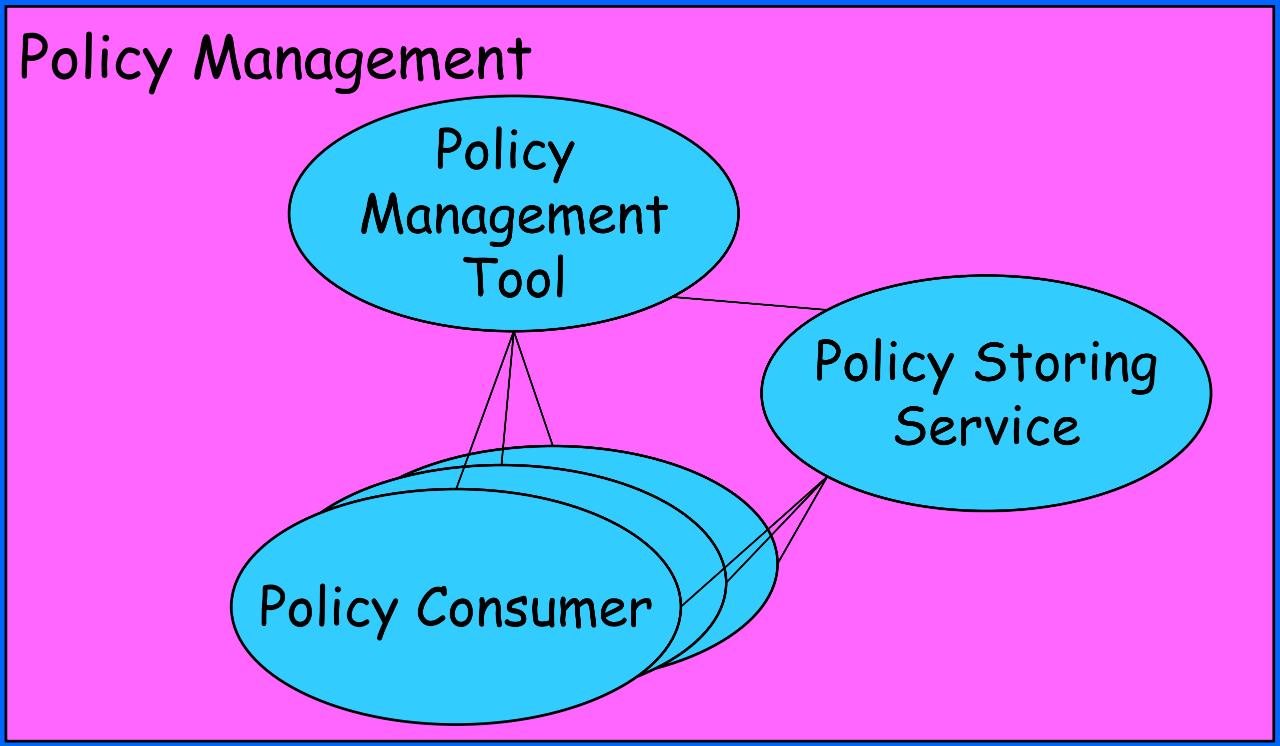
- Two Traffic Engineering approaches:
  - Explicit routed path based
    - Multi-Protocol Label Switching (MPLS)
  - Node-by-node based
    - Open Shortest Path First (OSPF)

- Operation timescales
  - Long-term (days)
    - Network Dimensioning
  - Short-term (minutes)
    - Dynamic Route and Resource Management

Traffic Engineering (cont'd)

- **Network Dimensioning**
  - **Input: network topology, traffic forecast, policies**
  - **Objective: optimisation problem**
    - Maintain low link cost while satisfying QoS objectives
  - **Output in the form of configuration directives:**
    - Explicitly routed paths (MPLS-based)
    - Values for the link cost metrics (IP-based)
    - Per-queue range of requirements
- **Dynamic Route Management (DRtM)**
  - **Multi-path load distribution**
- **Dynamic Resource Management (DRsM)**
  - **Configures PHBs**
  - **Performs dynamic link partitioning**

Policy Management



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Policy Management (cont'd)

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- **Policy Consumer**
  - **Policy interpretation and enforcement**
  - **Many instances, collocated with:**
    - SLS Subscription, SLS Invocation, Traffic Forecast, Network Dimensioning, DRtM, DRsM
- **Policy refinement and hierarchical decomposition**
  - **High-level policies refined to reflect the hierarchical management architecture**
  - **Targets: managed objects of the associated component or one level below**
  - **The administrator defines of classes of policies and refinement logic/rules**
  - **Automated decomposition of instances of policy classes**

Functional Architecture: Detailed View

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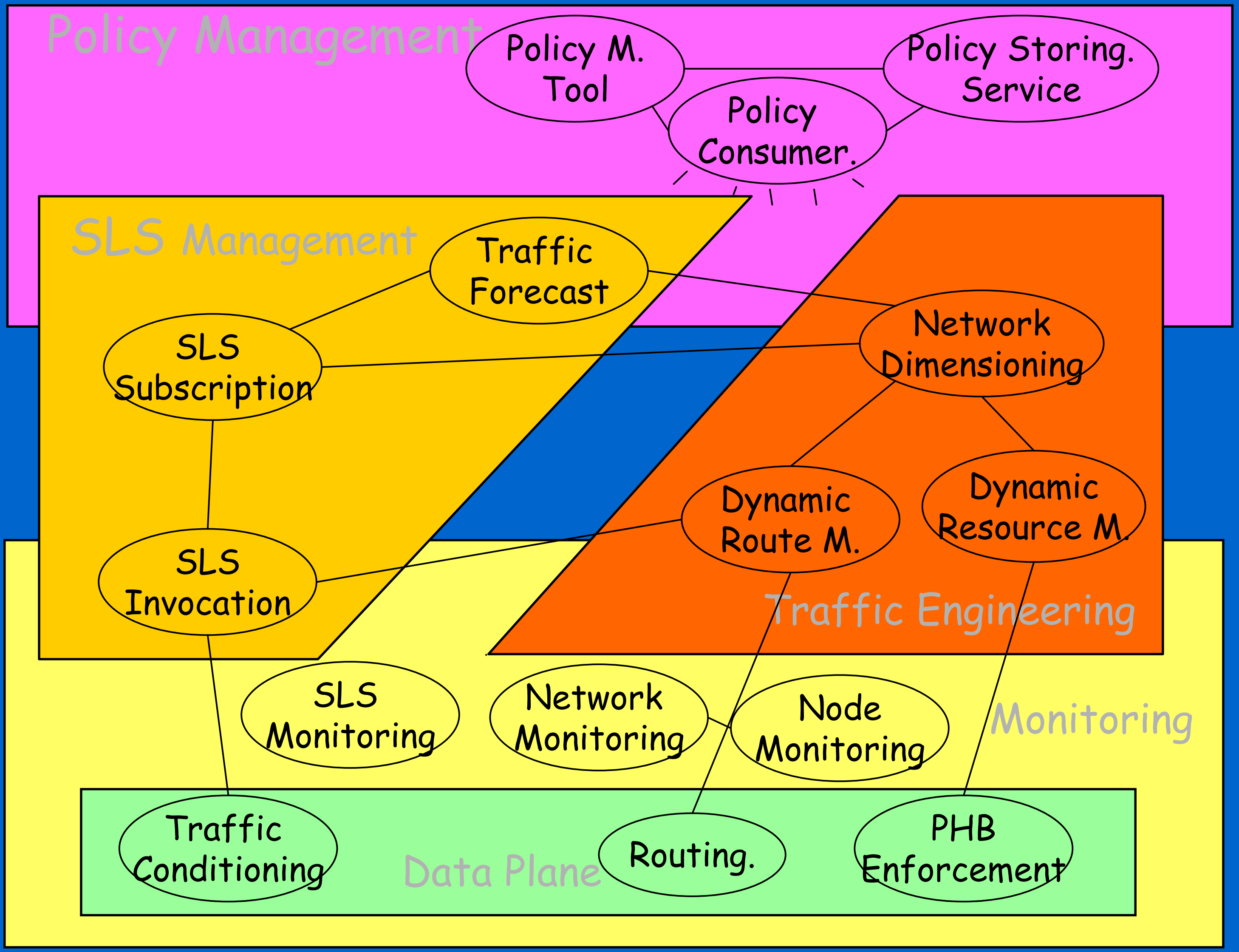

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Summary

- Definition of an architecture for DiffServ-based IP QoS
- Proposed SLS content and semantics
  - IETF drafts
- Policy-driven SLS Management and Traffic Engineering
- Detailed design of algorithms and protocols
- System currently being realised
- Validation both through simulation and testbed experimentation
- Work done in the European project TEQUILA

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TEQUILA: Traffic Engineering for QUality of service in the Internet at LArge scale

Partners:

Alcatel, France Telecom, Algonet, Global Crossing, University of Surrey, University College London, University of Ghent, National Technical University of Athens

For more information visit:

http://www.ist-tequila.org

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<table>
<tr><th></th><th>Virtual Leased Line Service</th><th>Bandwidth Pipe for Data Services</th><th>Minimum Rate Guaranteed Service</th><th colspan="2">Qualitative Olympic Services</th><th>The Funnel Service</th></tr>
<tr><td rowspan="2">Comments</td><td rowspan="2">Example of a uni-directional VLL, with quantitative guarantees</td><td rowspan="2">Service with only strict throughput guarantee. TC and ET are not defined but the operator might define one to use for protection.</td><td rowspan="2">It could be used for a bulk of ftp traffic, or adaptive video with min throughput requirements</td><td colspan="2">They are meant to qualitatively differentiate between applications such as:</td><td rowspan="2">It is primarily a protection service; it restricts the amount of traffic entering a customer’s network</td></tr>
<tr><td>on-line web-browsing</td><td>e-mail traffic</td></tr>
<tr><td>Scope</td><td>(1|1)</td><td>(1|1)</td><td>(1|1)</td><td colspan="2">(1|1) or (1|N)</td><td>(N|1) or (all|1)</td></tr>
<tr><td>Flow Descriptor</td><td>EF, S-D IP-A</td><td>S-D IP-A</td><td>AF1x</td><td colspan="2">MBI</td><td>AF1x</td></tr>
<tr><td>Traffic Descriptor</td><td>(b, r) e.g. r=1</td><td>NA</td><td>(b, r)</td><td colspan="2">(b, r), r indicates a minimum committed Olympic rate</td><td>(b, r)</td></tr>
<tr><td>Excess Treatment</td><td>Dropping</td><td>NA</td><td>Remarking</td><td colspan="2">Remarking</td><td>Dropping</td></tr>
<tr><td>Performance Parameters</td><td>D=20 (t=5, q=10e-3), L=0 (i.e. R=r)</td><td>R=1</td><td>R=r</td><td>D=low L=low (gold/green)</td><td>D=med L=low (silver/green)</td><td>NA</td></tr>
<tr><td>Service Schedule</td><td>MBI, e.g. daily 9:00-17:00</td><td>MBI</td><td>MBI</td><td>MBI</td><td>MBI</td><td>MBI</td></tr>
<tr><td>Reliability</td><td>MBI, e.g. MDT=2 days</td><td>MBI</td><td>MBI</td><td>MBI</td><td>MBI</td><td>MBI</td></tr>
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