An Architectural Framework for Providing QoS in IP Differentiated Services Networks


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Introduction and Objectives

Service Level Specifications (SLSs)
  • Contents and Semantics

Functional Architecture

SLS Management

Traffic Engineering

Policy Management

Summary
Introduction

- 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
Objectives

- 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

- **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
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
Functional Architecture: Fulfilling the SLSs

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

- **Policy Management**
  - SLS Management

- **Traffic Engineering**
  - Service provisioning through Traffic Engineering
  - (per-)Class awareness

- **Monitoring**

- **Data Plane**
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
Traffic Engineering

- Network Dimensioning
- Dynamic Route Management
- Dynamic Resource Management

Traffic Engineering
Traffic Engineering (cont'd)

- 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

Policy Management

Policy Management Tool

Policy Storing Service

Policy Consumer

Policy Consumer

Policy Consumer
Policy Management (cont’d)

- **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 classes of policies and refinement logic/rules
  - Automated decomposition of instances of policy classes
Functional Architecture: Detailed View

- Policy Management
  - Policy M. Tool
  - Policy Storing. Service
  - Policy Consumer.
- SLS Management
  - SLS Subscription
  - SLS Invocation
- Traffic Forecast
- Traffic Engineering
  - Network Dimensioning
  - Dynamic Route M.
  - Dynamic Resource M.
- Monitoring
  - Network Monitoring
  - Node Monitoring
- Data Plane
  - Traffic Conditioning
  - Routing.
  - PHB Enforcement
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
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
<table>
<thead>
<tr>
<th><strong>Comments</strong></th>
<th>Virtual Leased Line Service</th>
<th>Bandwidth Pipe for Data Services</th>
<th>Minimum Rate Guaranteed Service</th>
<th>Qualitative Olympic Services</th>
<th>The Funnel Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example of a uni-directional VLL, with quantitative guarantees</td>
<td>Service with only strict throughput guarantee. TC and ET are not defined but the operator might define one to use for protection.</td>
<td>It could be used for a bulk of ftp traffic, or adaptive video with min throughput requirements.</td>
<td>They are meant to qualitatively differentiate between applications such as:</td>
<td>It is primarily a protection service; it restricts the amount of traffic entering a customer’s network.</td>
<td></td>
</tr>
</tbody>
</table>

| **Scope** | (1|1) | (1|1) | (1|1) | (1|1) or (1|N) | (N|1) or (all|1) |
|----------|-------|-------|-------|-------------|---------------|

<table>
<thead>
<tr>
<th><strong>Flow Descriptor</strong></th>
<th>EF, S-D IP-A</th>
<th>S-D IP-A</th>
<th>AFIx</th>
<th>MBI</th>
<th>AFIx</th>
</tr>
</thead>
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<tr>
<th><strong>Traffic Descriptor</strong></th>
<th>(b, r) e.g. r=1</th>
<th>NA</th>
<th>(b, r)</th>
<th>(b, r), r indicates a minimum committed Olympic rate</th>
<th>(b, r)</th>
</tr>
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<tr>
<th><strong>Excess Treatment</strong></th>
<th>Dropping</th>
<th>NA</th>
<th>Remarking</th>
<th>Remarking</th>
<th>Dropping</th>
</tr>
</thead>
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<tr>
<th><strong>Performance Parameters</strong></th>
<th>D=20 (t=5, q=10e-3), L=0 (i.e. R=r)</th>
<th>R = 1</th>
<th>R = r</th>
<th>D=low L=low (gold/green)</th>
<th>D=med L=low (silver/green)</th>
<th>NA</th>
</tr>
</thead>
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<tr>
<th><strong>Service Schedule</strong></th>
<th>MBI, e.g. daily 9:00-17:00</th>
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<th>MBI</th>
<th>MBI</th>
<th>MBI</th>
</tr>
</thead>
</table>

| **Reliability** | MBI, e.g. MDT=2 days | MBI | MBI | MBI | MBI | MBI |