The TEQUILA Project
Integrated IP QoS Architectures based on Bandwidth Brokerage

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Tequila consortium

- Industrial Partners
  - Alcatel, Belgium
  - Algosystems S.A., Greece
  - France Telecom-R&D, France
  - Global Crossing, UK
- Universities
  - UCL - University College London, UK
  - NTUA - National Technical University Athens, Greece
  - UniS - The University of Surrey, UK
- Research Institutes
  - IMEC, Belgium
  - TERENA, Netherlands

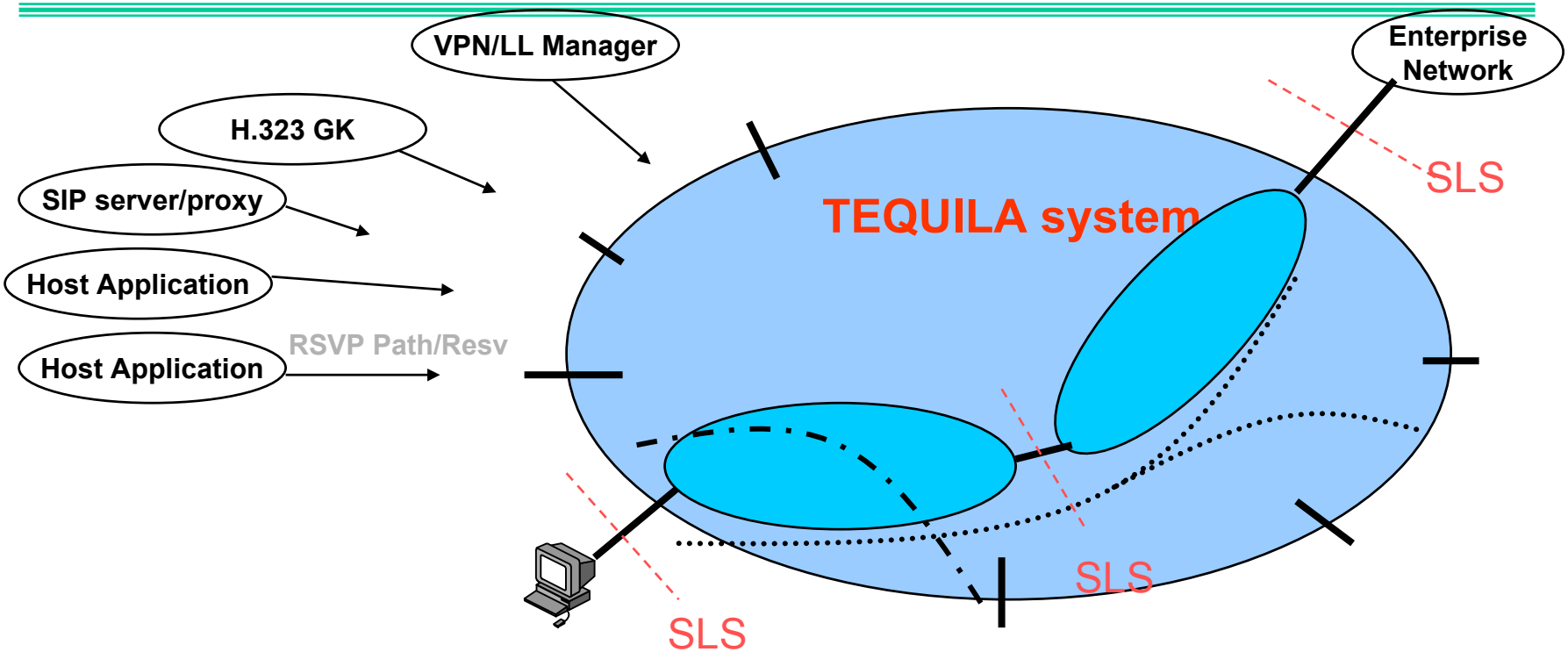
Outline

- Introduction: The TEQUILA project
- Part 1: Static IP Bandwidth Brokers
- Part 2: TEQUILA Bandwidth Brokers
- Part 3: Service Level Specifications
- Part 4: IP QoS for Next Generation Networks

Introduction: Tequila objectives

- Develop architectures, algorithms and protocols for enabling negotiation, monitoring and enforcement of Service Level Specifications (SLS) between customer/ISP and ISP/ISP
- Develop a functional model of co-operating components, algorithms and protocols offering a intra-domain traffic engineering solution for meeting the contracted SLSs
- Develop a scaleable approach for inter-domain SLS negotiation and QoS-based routing for enforcing E2E QoS across the internet"
- Validate the Models & Contribute to standardization

Introduction: Tequila assumptions



- Public IP-based, DiffServ (PHB)-enabled Network
- IPv4, Unicast
- SLS describes the *traffic characteristics* of IP services & the *QoS guarantees* offered by the network

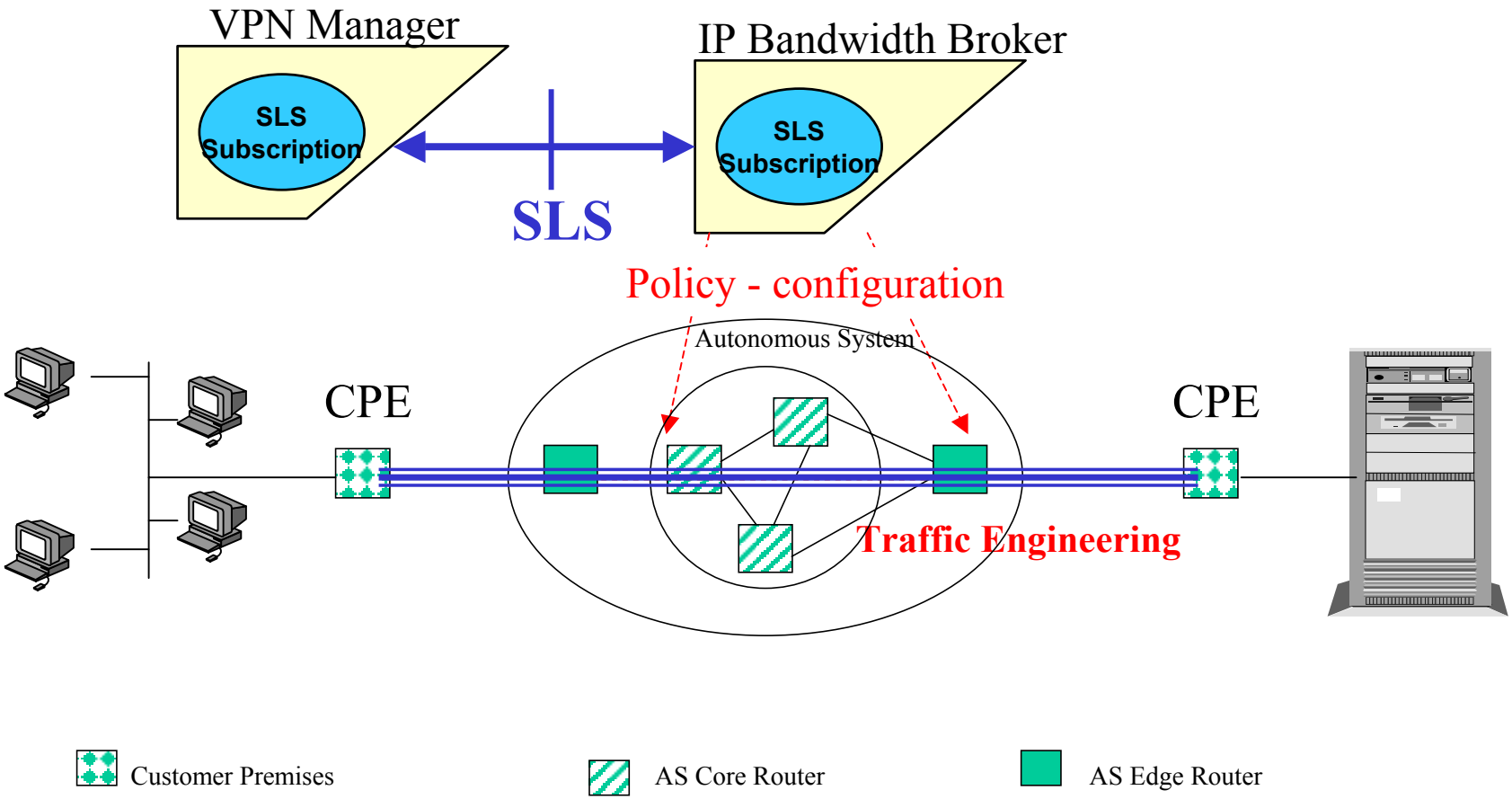
Part 1
Static IP Bandwidth Brokers

Preview: Off-line, Centralised Architectures (only)

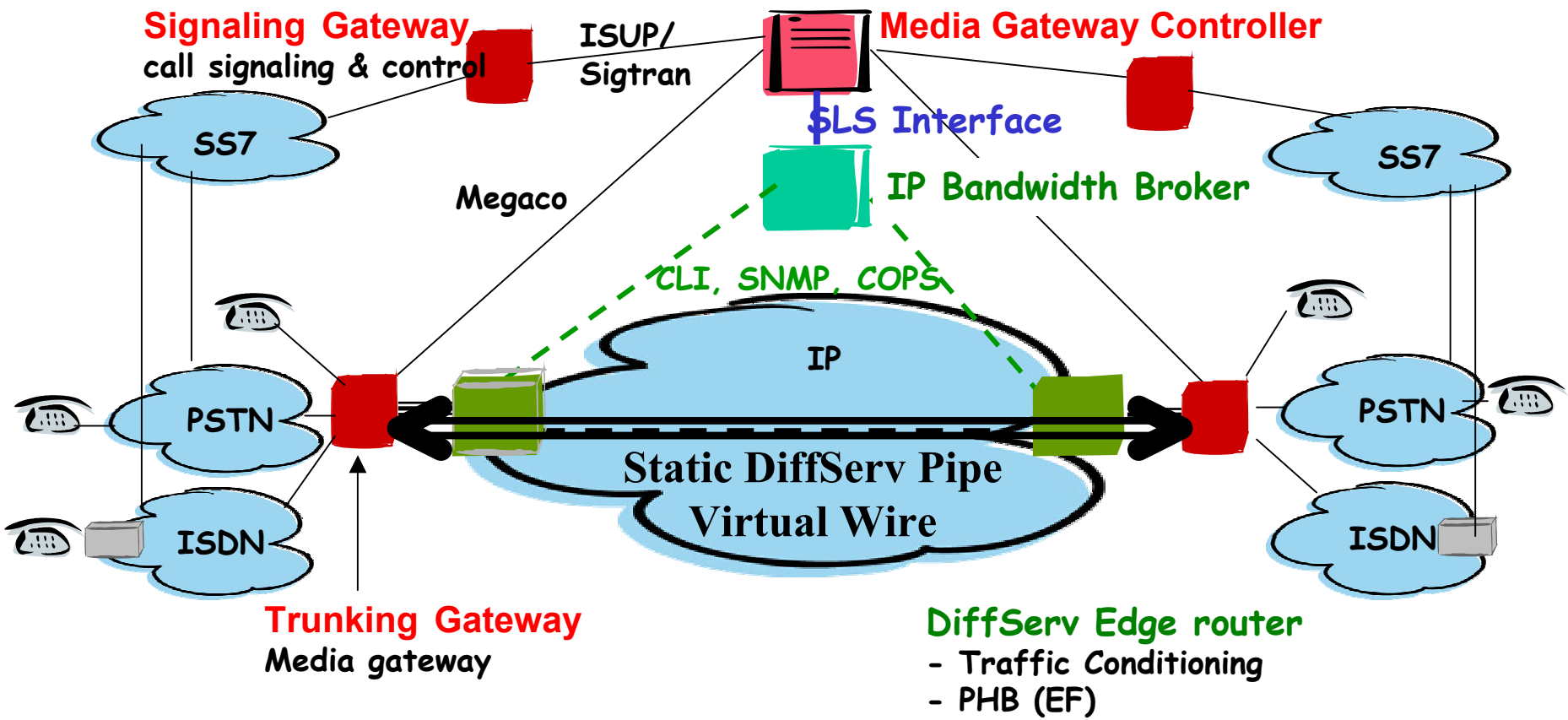
IP Bandwidth Broker

- BB-functionality
  - Service Subscription Manager
    - SLA/SLS handling
  - Resource Manager
    - reservation & admission control, traffic engineering
  - Network Configuration manager
    - enforce QoS, control QoS network building blocks
- Alcatel BB-development phase 1: Assumptions
  - Intra-domain only
  - long-lived services only: LLs, VPNs
  - Complete Centralised BB-architecture

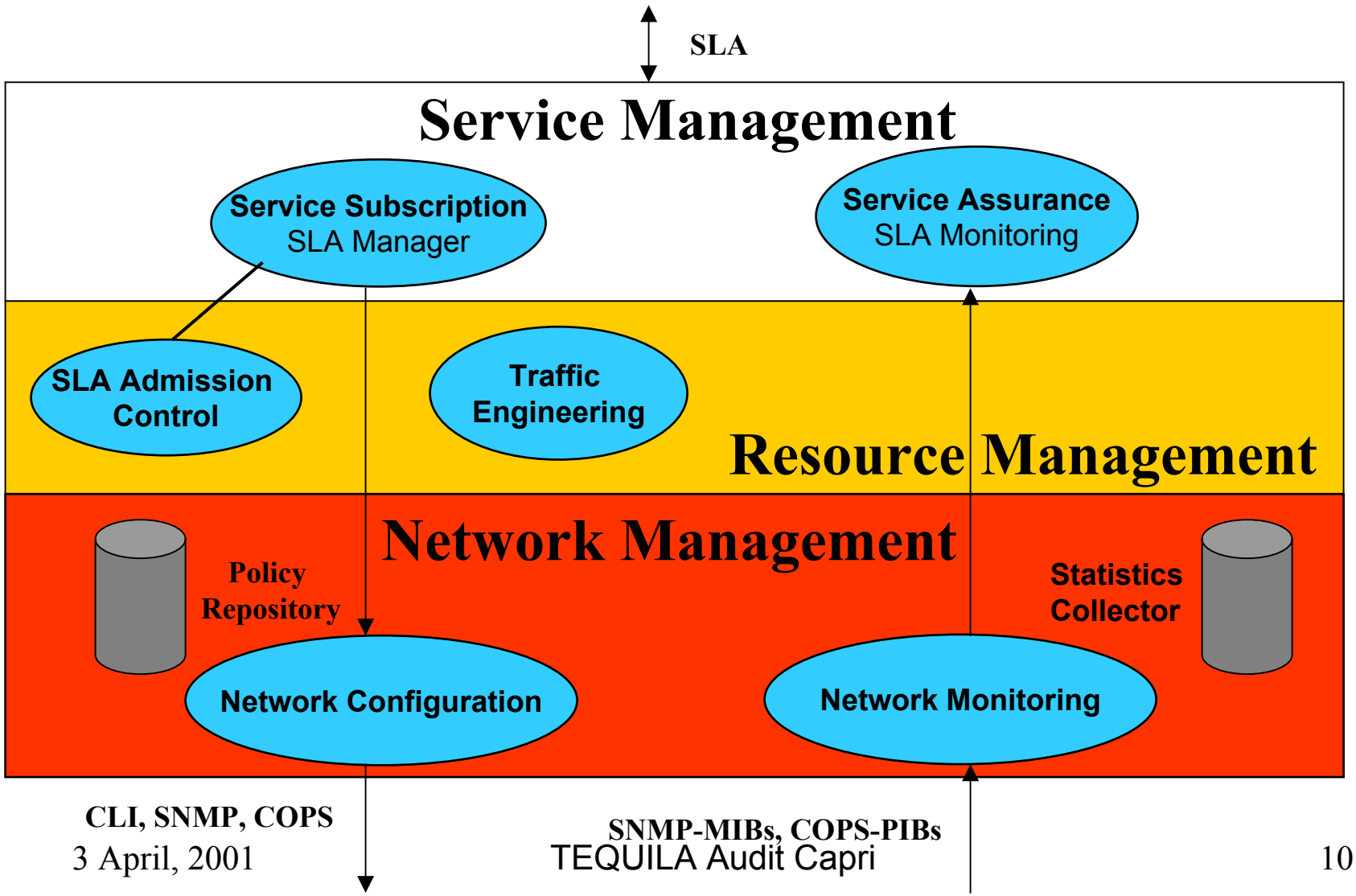
Bandwidth Brokers in action - VPNs (Preview)



Bandwidth Brokers in action - NGNs (preview)



Off-line Centralised BBs



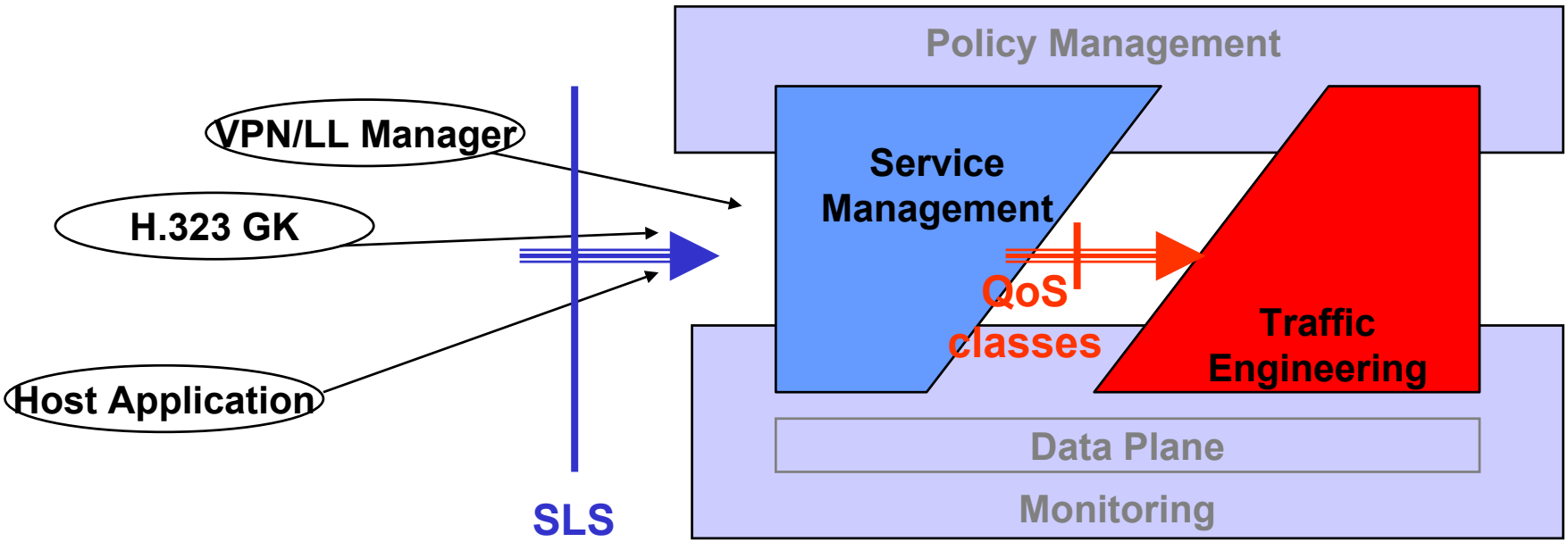
Main Issues of this BB Solution

- Static Solution Only !
  - Long-lived services
  - Traffic fluctuations & “call”-handling
- Service Interface ?
  - Service definition
  - Service Negotiation
- Service & Resource Interworking ?
  - Customer awareness
  - Class of Service & service aggregation
  - scalability

Part 2
TEQUILA Bandwidth Brokers

An integrated architecture for providing value-added IP services

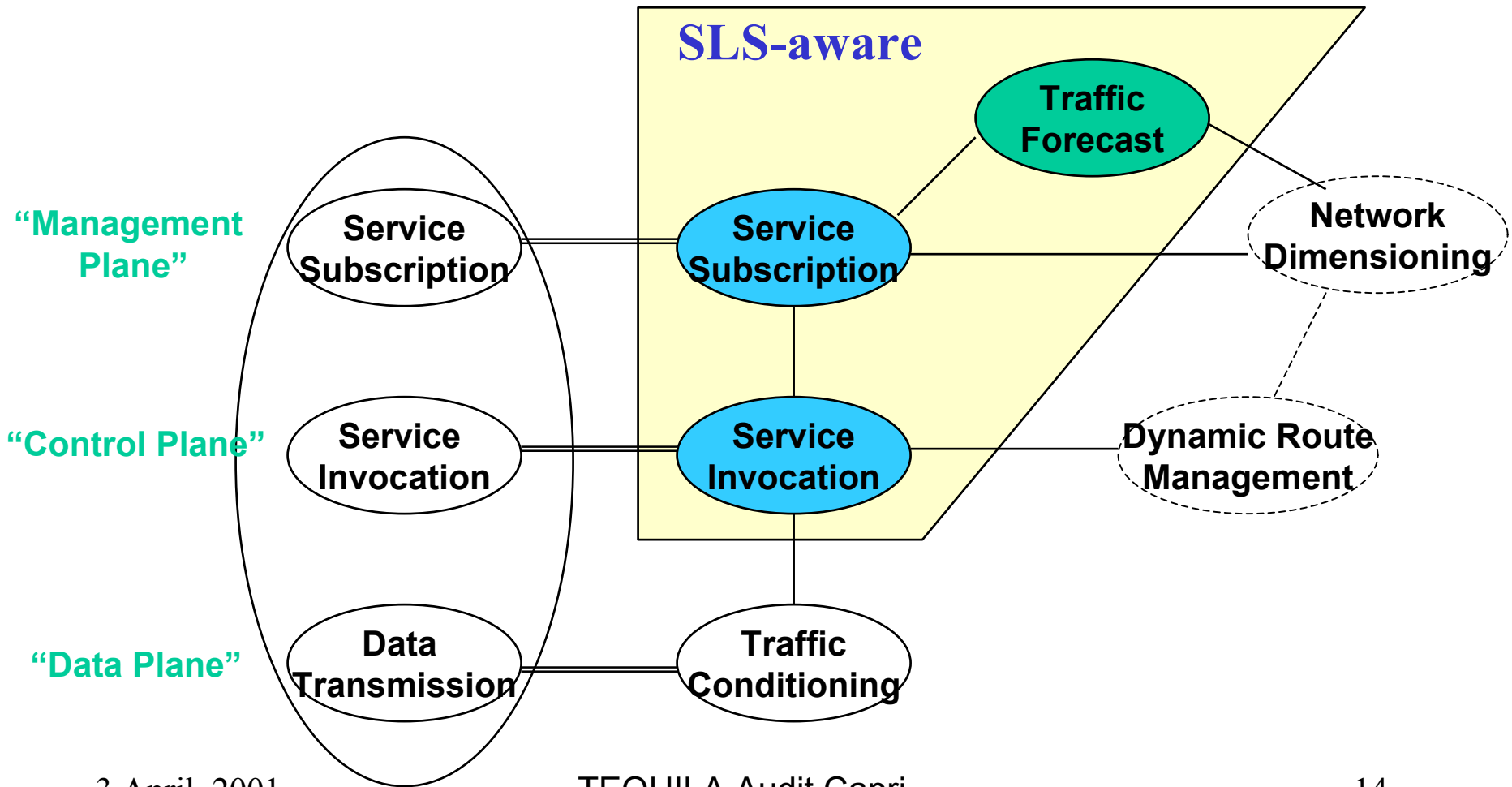
Tequila Subsystems



Service description through SLS template => *Customer* awareness

Service provisioning through Traffic Engineering => *QoS Class awareness*

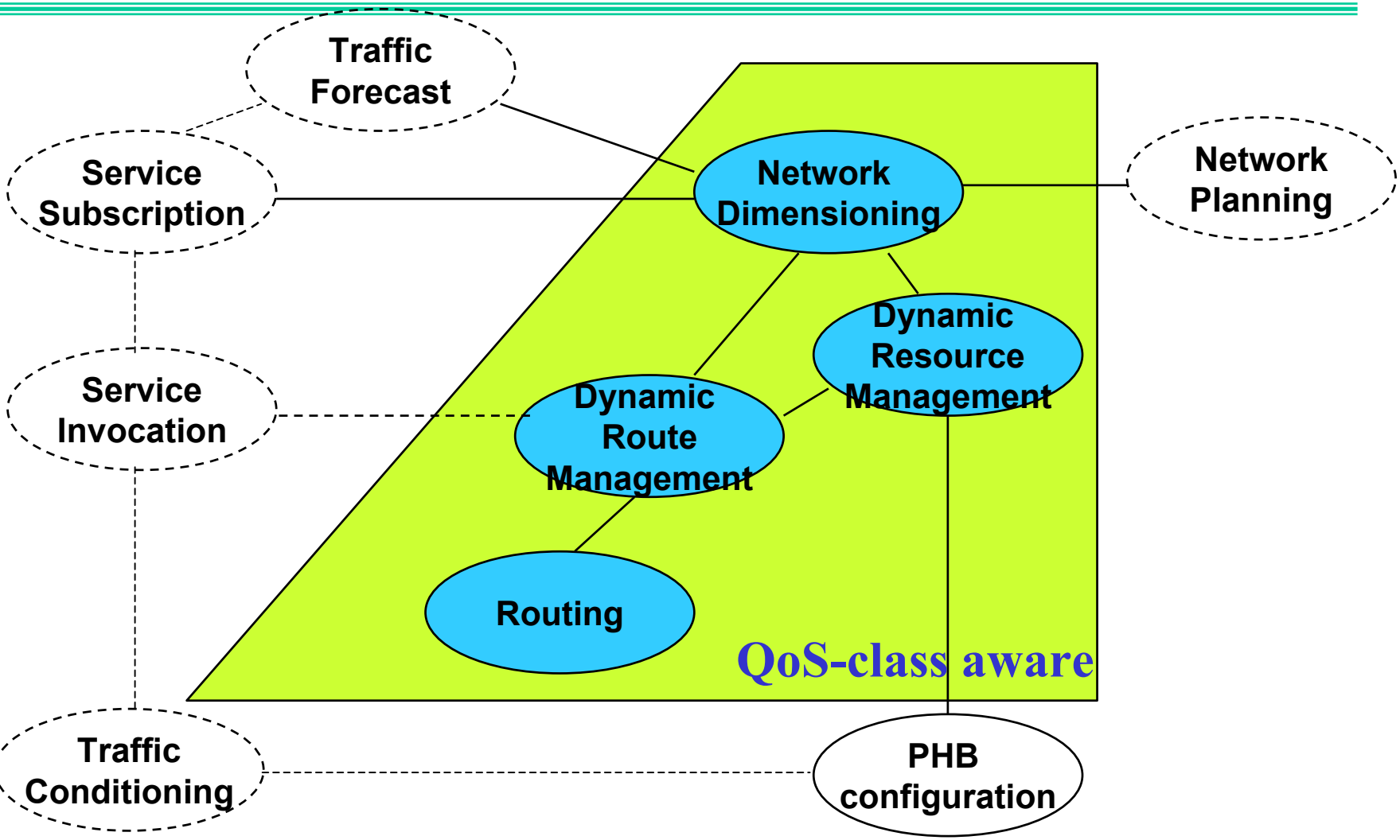
Service Management



Subscription & Invocation

- Service Subscription
  - negotiating the *right to invoke* transport (IP) services
    - ensures the customer *resource availability*
  - between ISP-Customer
    - allows the ISP to *provision* & *dimension* his network
- Service Invocation
  - actual negotiation for (allocating) *resources*
    - in-band or out-of-band
    - explicit (e.g. by RSVP) or implicit (e.g. automatic by subscription)
  - between ISP-users
    - may be *at a later time* than SLS subscription
    - may be a *N-to-1* relation with subscription
    - must be *in-range* with SLS subscription (provider policy)

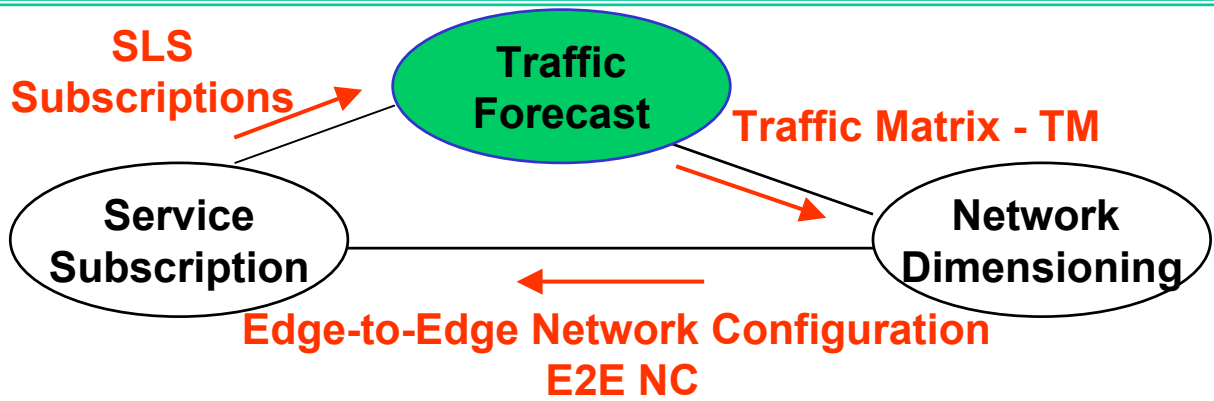
Traffic Engineering



Tequila QoS Classes

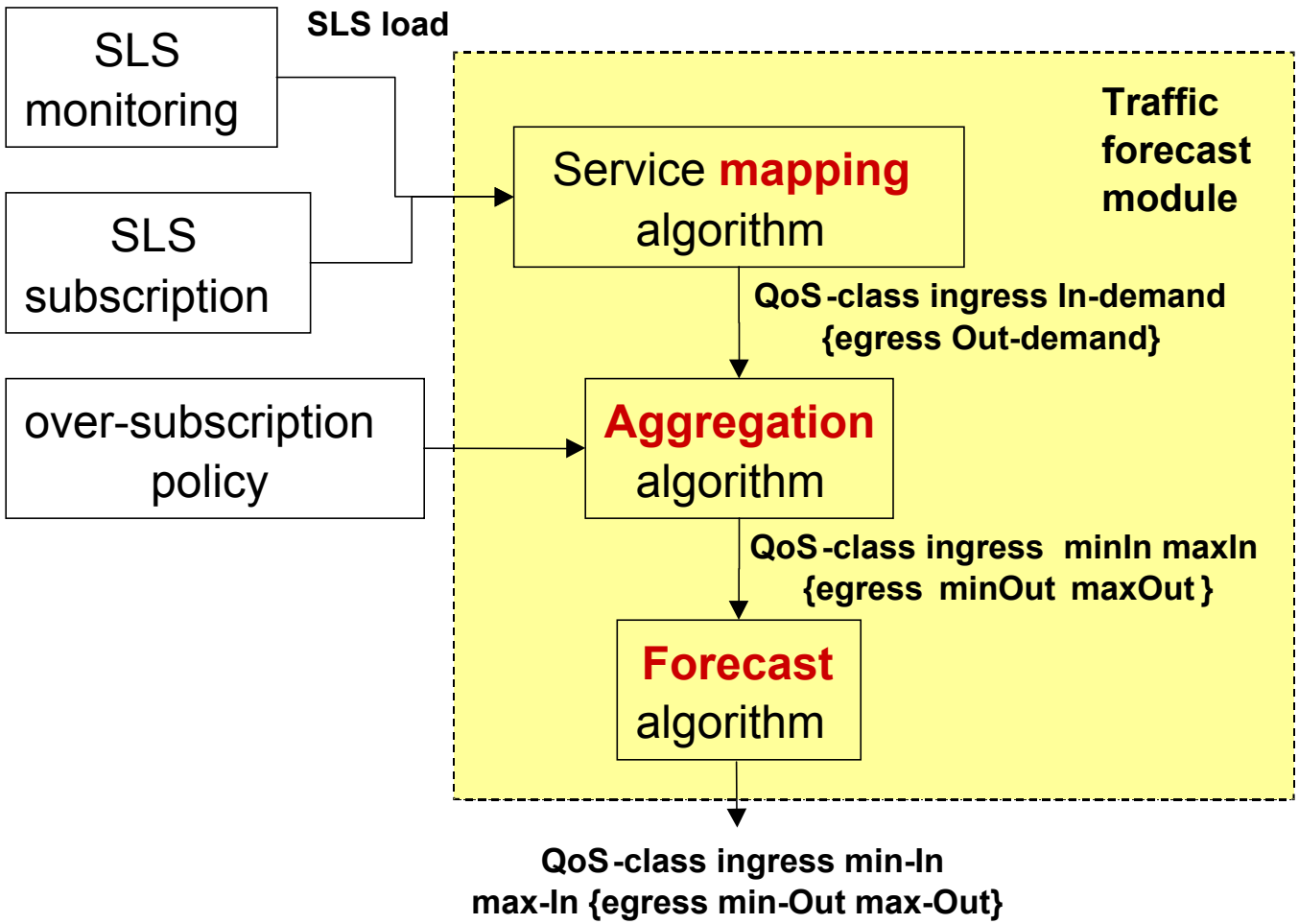
- QoS class = [OA | delay | loss]
  - Ordered Aggregate ~ PHB scheduling class
    - EF, AFx, BE
  - delay
    - edge-to-edge maximum delay
    - worst case or probabilistic (percentile)
    - delay classes (min-max intervals)
  - loss
    - edge-to-edge packet loss
    - probability

Traffic Forecast

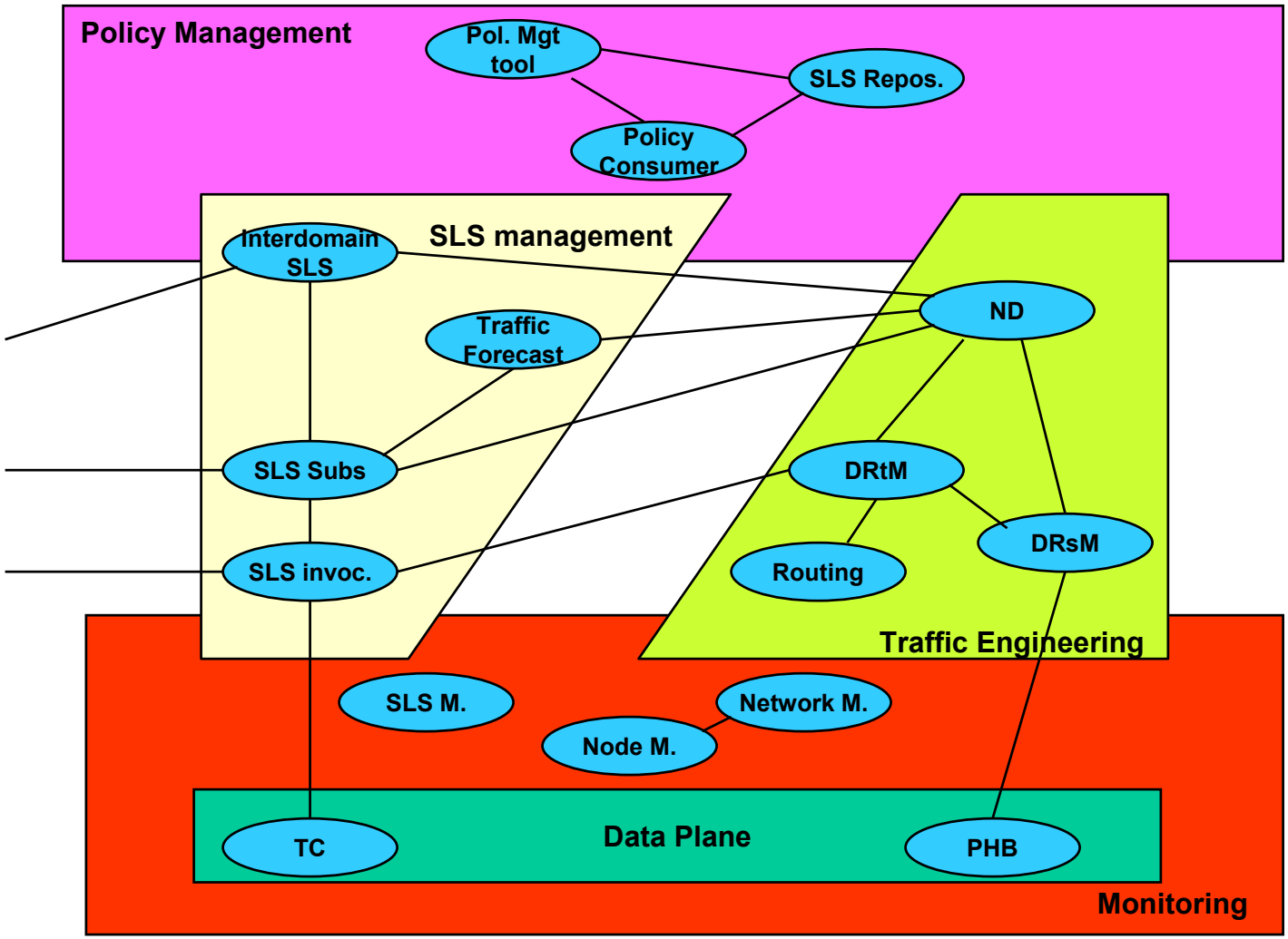


- **TM** = [pipe] [QoS class | ingr-egre | min-demand - max-demand]
  - minimum - maximum range interval
    - allows for *over-subscription* (statistical multiplexing)
    - allows for new *SLSs between two TE cycles*
- **E2E NC** = [pipe] [QoS class | ingr-egre | min-demand - sustainable load]
  - sustainable load = effective (long-term) reserved capacity
  - calculated by Traffic Engineering algorithms

Traffic Forecast



TEQUILA Functional Architecture



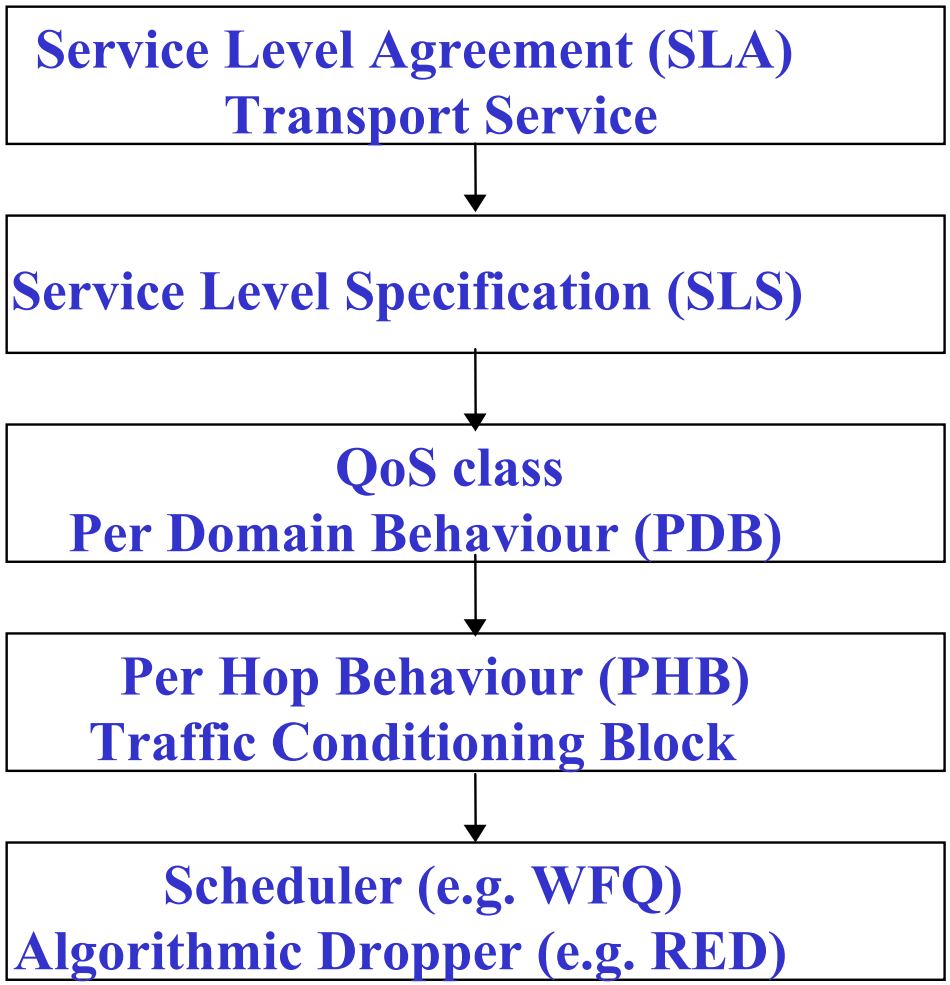
Main Issues of this BB solution

- Internet Stakeholder Roles & Business Model
  - Application Service Providers, Internet Service Providers
  - Connectivity Providers: wholesalers & access providers
- Interworking Application & Transport Plane
  - Application call/session handling
  - Transport (IP) flow/connectivity handling
- Inter-domain End-to-End QoS
  - Multiple networks
  - Multiple technologies
  - Multiple stakeholders

Part 3
Service Level Specifications

- Describing value-added IP connectivity services

Providing Transport Services
DiffServ top-down view



- Non-technical terms & conditions
- technical parameters :{SLS}-set

- IP service traffic characteristics
- offered network QoS guarantees

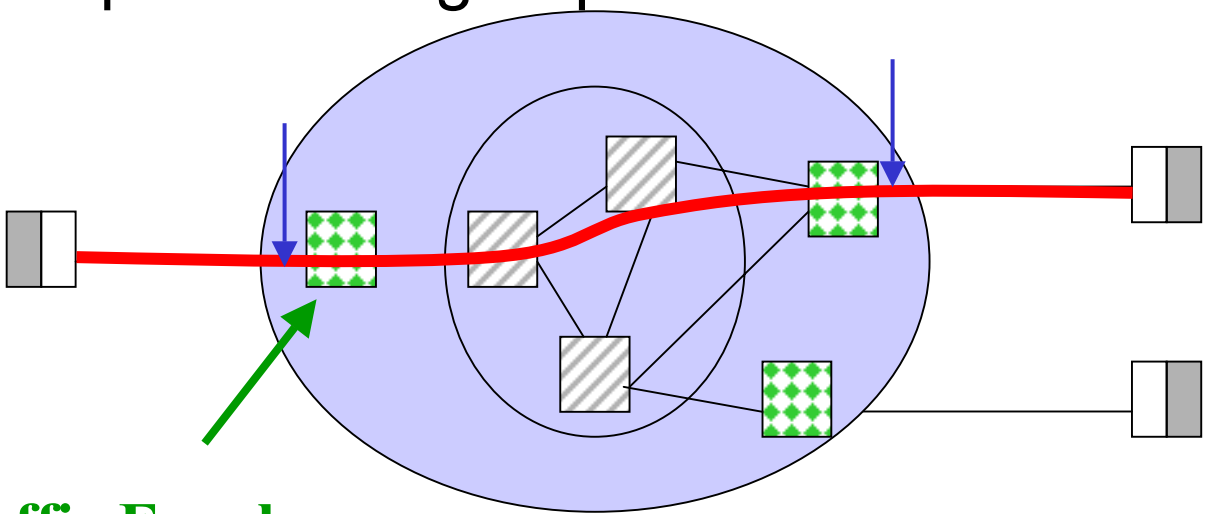
- Network QoS capabilities
- DiffServ edge-to-edge aggregates

- Router QoS capabilities
- DiffServ core & edge routers

- implementation

SLS - Parameters

- SLS = a set of parameters making up an IP flow contract
- Five basic parameter groups

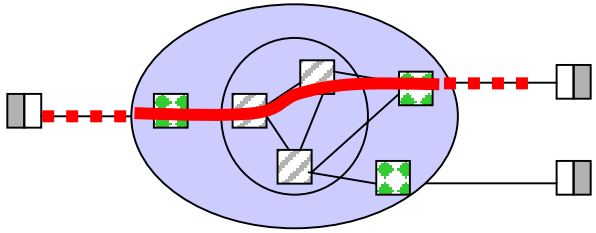


Traffic Envelope Descriptor

IP Flow Descriptor

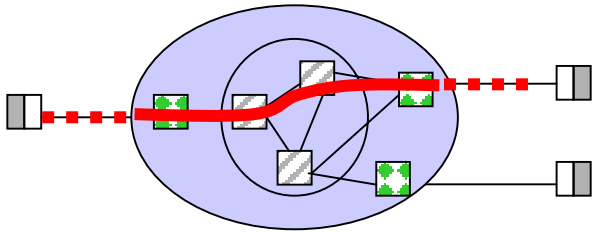
Scope = (ingress, egress)

Performance Guarantees & Excess Treatment



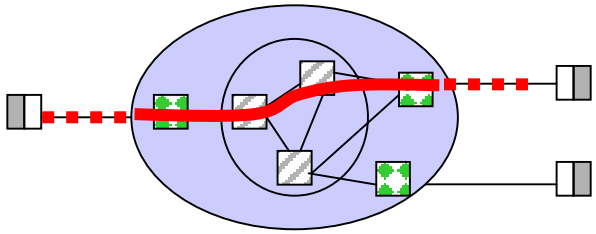
- IP Flow = stream of IP packets sharing at least one common characteristic (*WHAT*)
- Scope = the geographical region over which the QoS is to be enforced (*WHERE*)
- Traffic Envelope = set of (conformance) parameters describing *HOW* the packet stream should look like to get performance guarantees
  - => identify *in*- & *out-of-profile* packets
  - => Excess Treatment: *drop*, *shape*, *remark*
- Service Schedule: *WHEN* is the service available
- Performance guarantees describe the transport guarantees the network offers to the customer
  - => *throughput, loss, delay, jitter*

Flow Descriptor



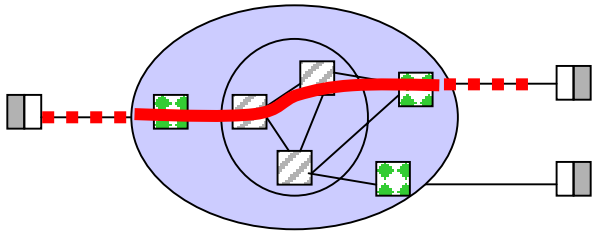
- IP Flow = stream of IP packets sharing at least one common characteristic
  - **DSCP information**
    - (set of) DSCP value(s) | any
  - **Source information**
    - (set of) source addresses | (set of) source prefixes | any
  - **Destination information**
    - (set of) destination addresses | (set of) prefixes | any
  - **Application information**
    - protocol number,...

Scope



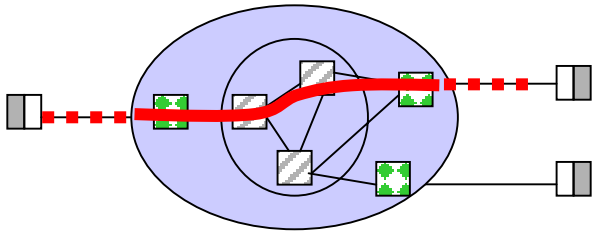
- Scope = the geographical region over which the QoS is to be enforced
- Scope = (Ingress, Egress)
  - Ingress : (set of) interface addresses | any
  - Egress : (set of) interface addresses | any
    - *IP-addresses | L2-link identifiers*
- Scope models
  - Pipe or one-to-one model : (1,1)
  - Hose or one-to-many|any model : (1, N| any)
  - Funnel or many|any-to-one model (N|any,1)

Traffic Envelope



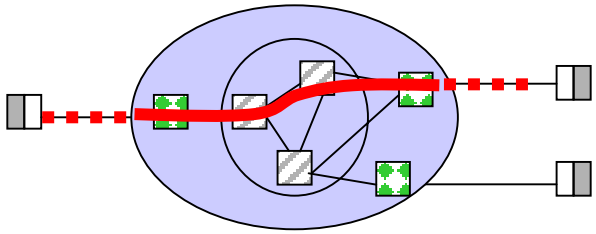
- Traffic Envelope = set of (conformance) parameters describing how the packet stream should look like to get performance guarantees
- Traffic Conformance testing is the set of actions allowing to identify in- & out-of-profile packets
  - Example: token bucket
- Excess treatment
  - drop | shape | remark

Performance Guarantees



- The performance parameters describe the transport guarantees the network offers to the customer
  - for the packet stream identified by *Flow descriptor*
  - over the geographical region defined by *Scope*
- Four (measurable) parameters
  - **delay** | optional quantile
  - **jitter** | optional quantile
  - **packet loss**
  - **throughput**

Performance Guarantees



- **Delay & jitter**
  - indicate the maximum packet transfer delay and delay variation from ingress to egress
    - can be deterministic (worst case) or probabilistic (quantile)
    - guarantee for *in-profile* packets (only)
- **Packet loss**
  - the ratio of the lost and the sent (in-profile) packets
    - *sent* packets at ingress
    - *lost* packets between (and including) ingress/egress
- **Throughput guarantee**
  - the packet rate measured at egress
    - counting all packets identified by Flow Id

Virtual Leased Line Real-time Services

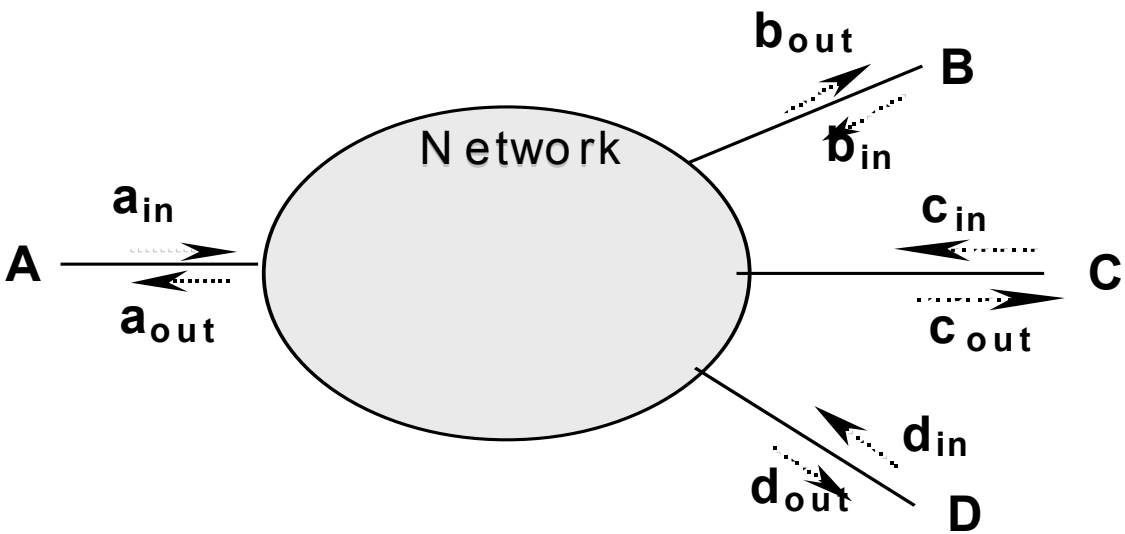
- Scope: pipe model
- Flow Id: (source IP addr| destination IP addr, DSCP = EF)
- Traffic Conditioning: token bucket (b, r)
- Excess treatment:
  - dropping
  - shaping -> shaping buffer is small, shaping rate = r
- Performance parameters:
  - packet loss p = 0
  - throughput guarantee R = (1-p) * token rate r => R = r
  - delay = 20 msec

Bandwidth Pipe

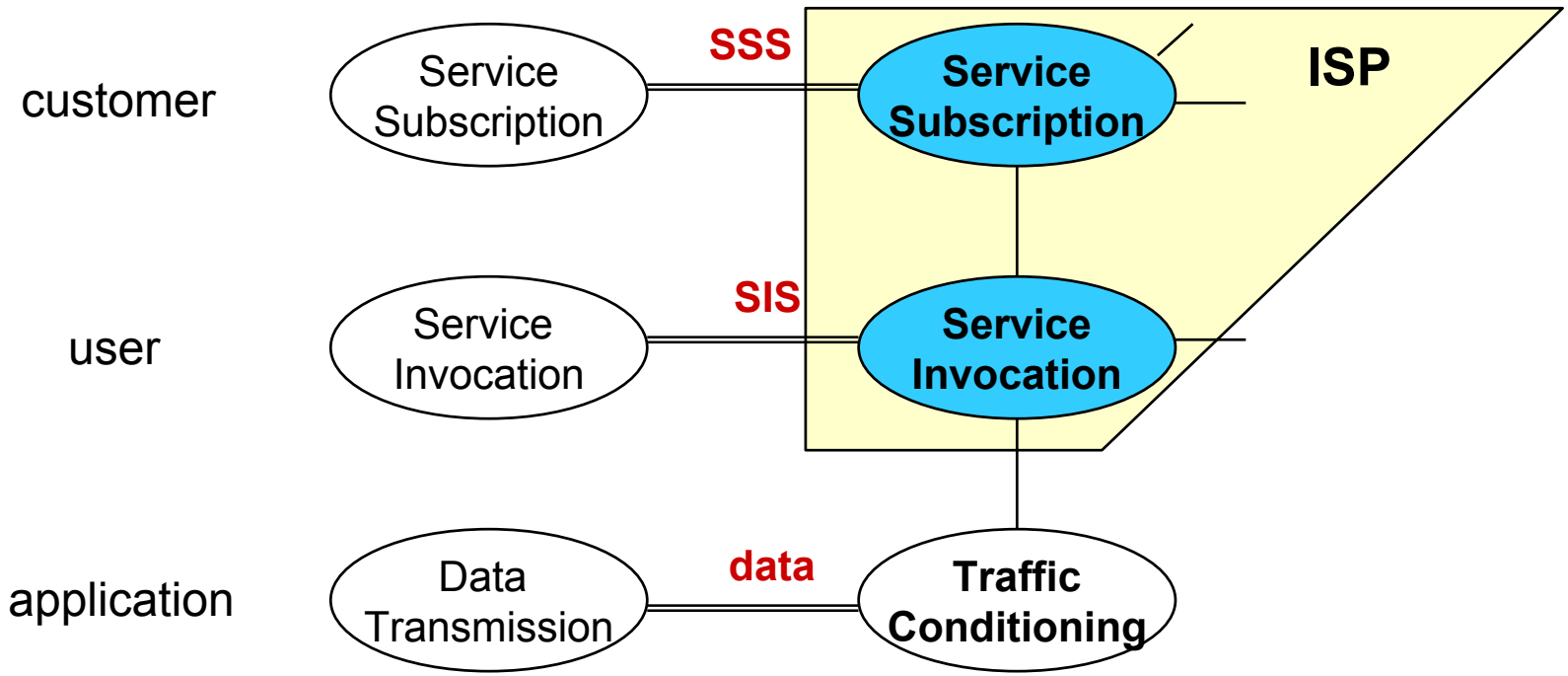
- Scope: pipe model
- Flow Id: (source IP addr| destination IP addr)
- Traffic Conditioning: token bucket (b, r)
- Excess treatment:
  - remarking (e.g. yellow/red)
- Performance parameters:
  - throughput guarantee R = 2 Mbps

SLS=building blocks for IP transport services

- Bi-directional services (e.g. VLLs)
  - bi-directional VLLs = combination of 2 SLSs
- More complex VPNs
  - combination of multiple hose & filter SLSs
  - guaranteed throughput from ingress to all egress
  - maximum allowed rate towards a customer side (e.g A_{out})



IP Transport Services Formal Description



- **SSS** = Service Subscription Structure
- **SIS** = Service Invocation Structure

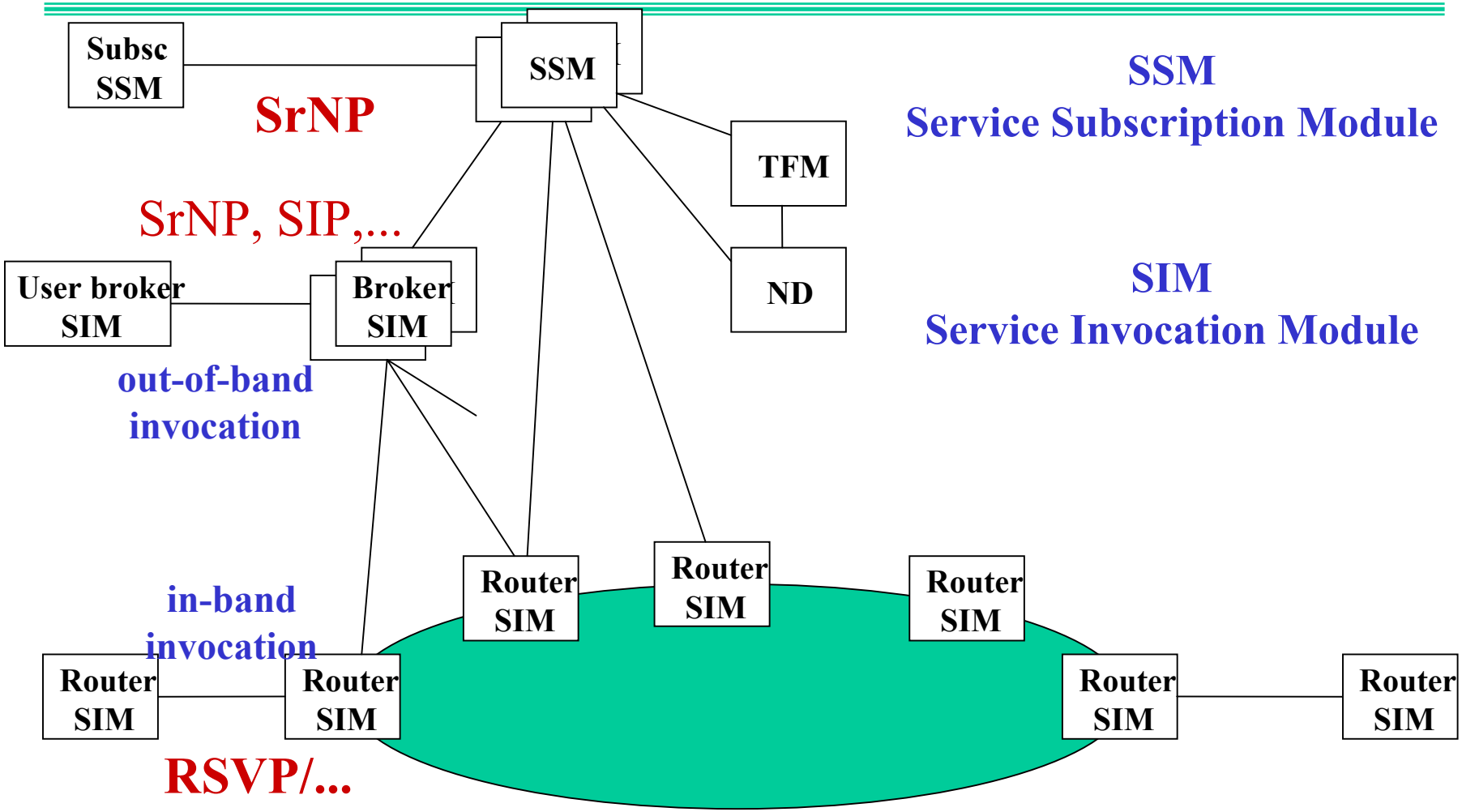
IP Transport Services Formal Description

- Service Subscription Structure
  - Subscriber id & credentials
  - Service = {SLS} set
  - Service Schedule *(Start time, End time)*
  - {user ids, credentials}
  - Invocation method *(permanent* | *on-demand - protocol-id)*
  - Grade of Service *(blocking probability of invocations)*
- Service Invocation Structure
  - SSS_reference handle
  - {user id, credential}
  - Service = {SLS-set}
  - Atomic Invocation *(yes/no)*

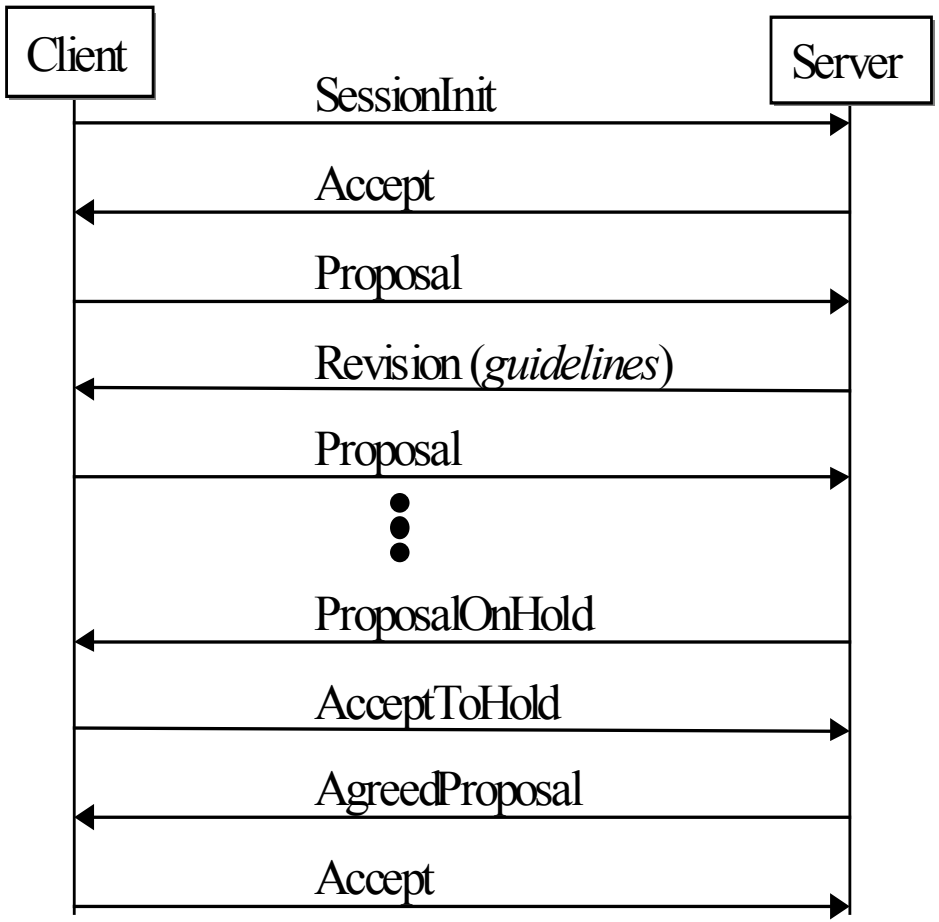
Addendum
Service Negotiation Protocol (SrNP)

Negotiating value-added IP services

Tequila Service Management Engineering Model & Protocols



Service Negotiation Protocol - SrNP



- Client-server based
- Form-fill oriented
- Messaging is content-independent
- Protocol stacks

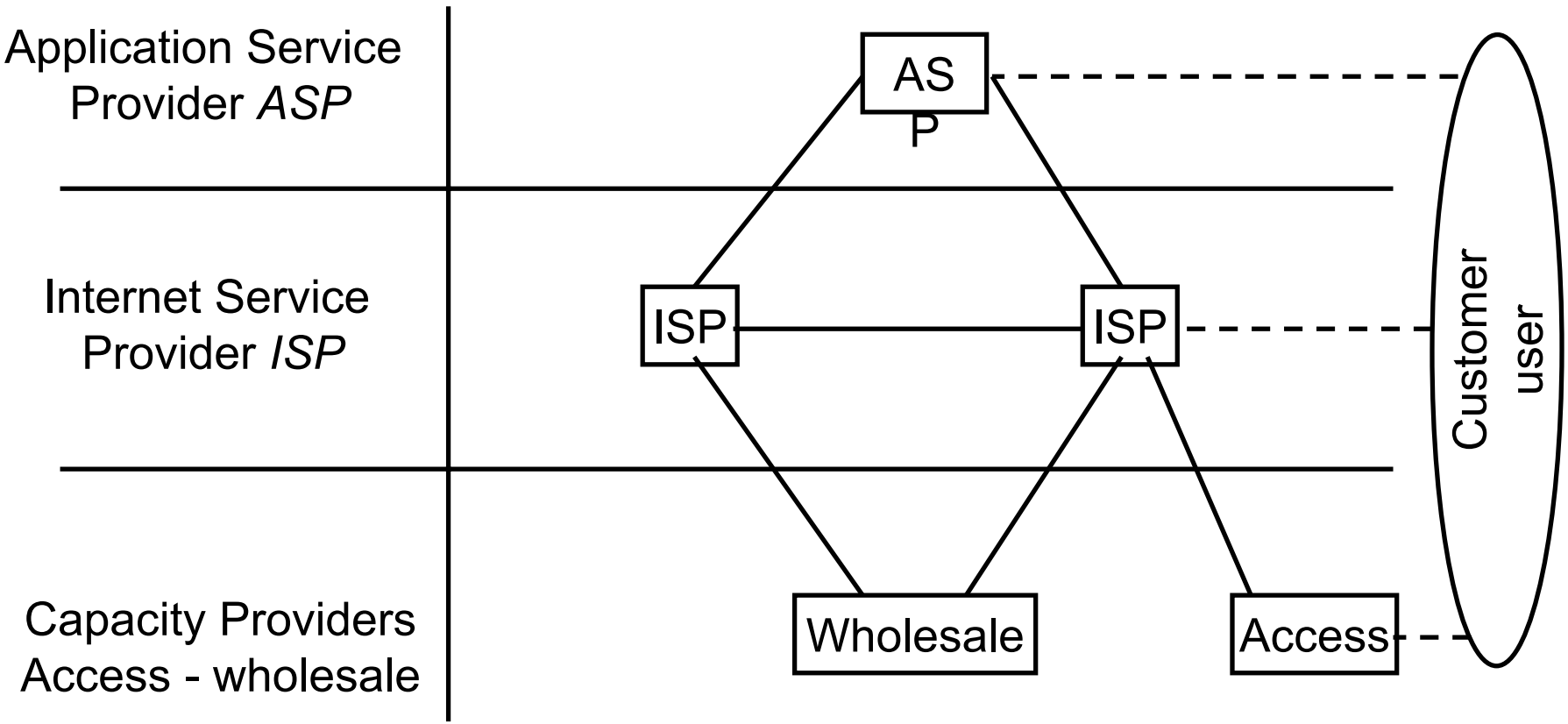
SrNP
ebXML
HTTP,SMTP,IIOP
TCP/IP

SrNP
TCP/IP

Part 4
IP QoS for Next Generation networks

Towards an Integrated Solution for
Multimedia over IP

Internet Stakeholder Roles



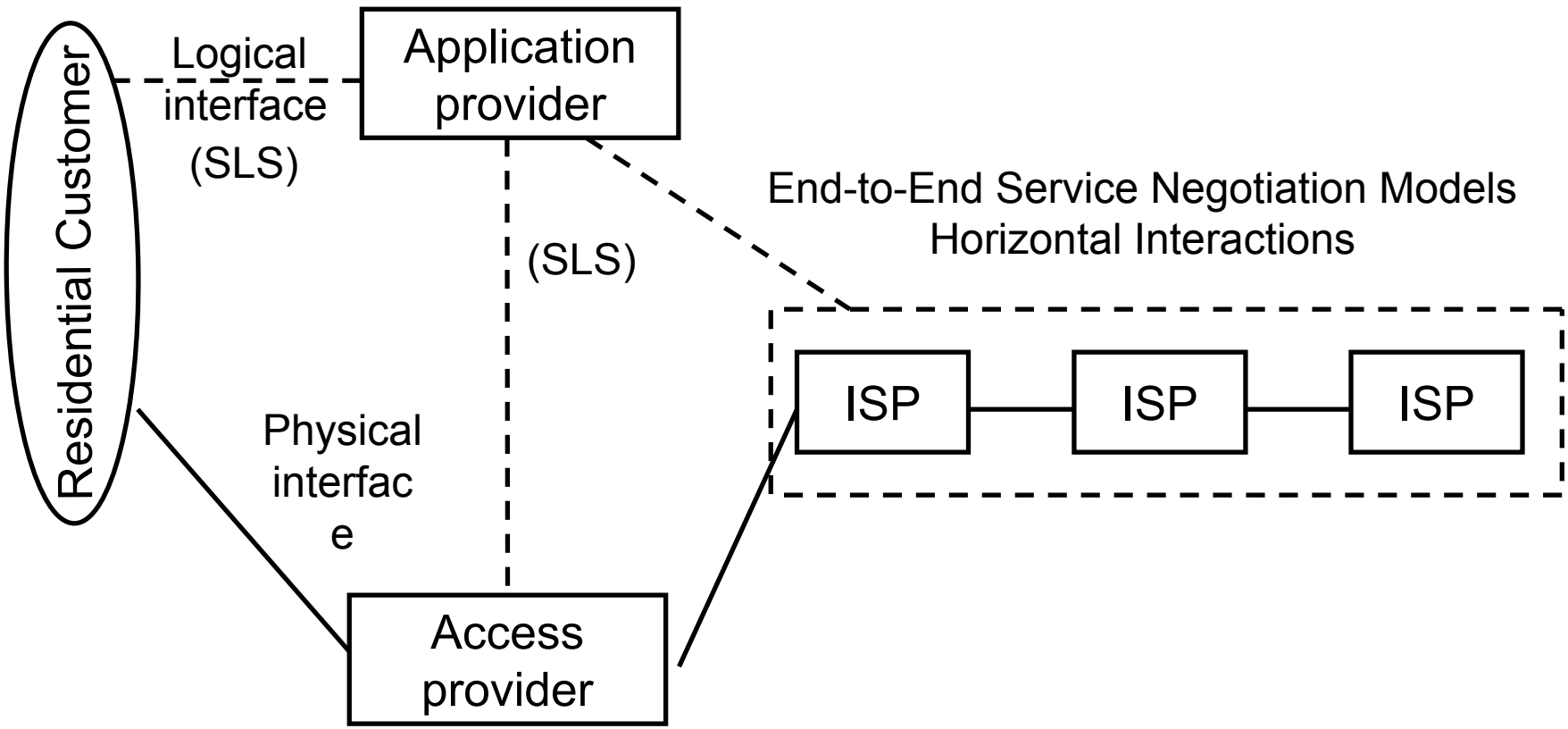

Residential Customer
Logical interface (SLS)
Application provider
(SLS)
End-to-End Service Negotiation Models
Horizontal Interactions
ISP
ISP
ISP
Physical interfac e
Access provider

Figure 4

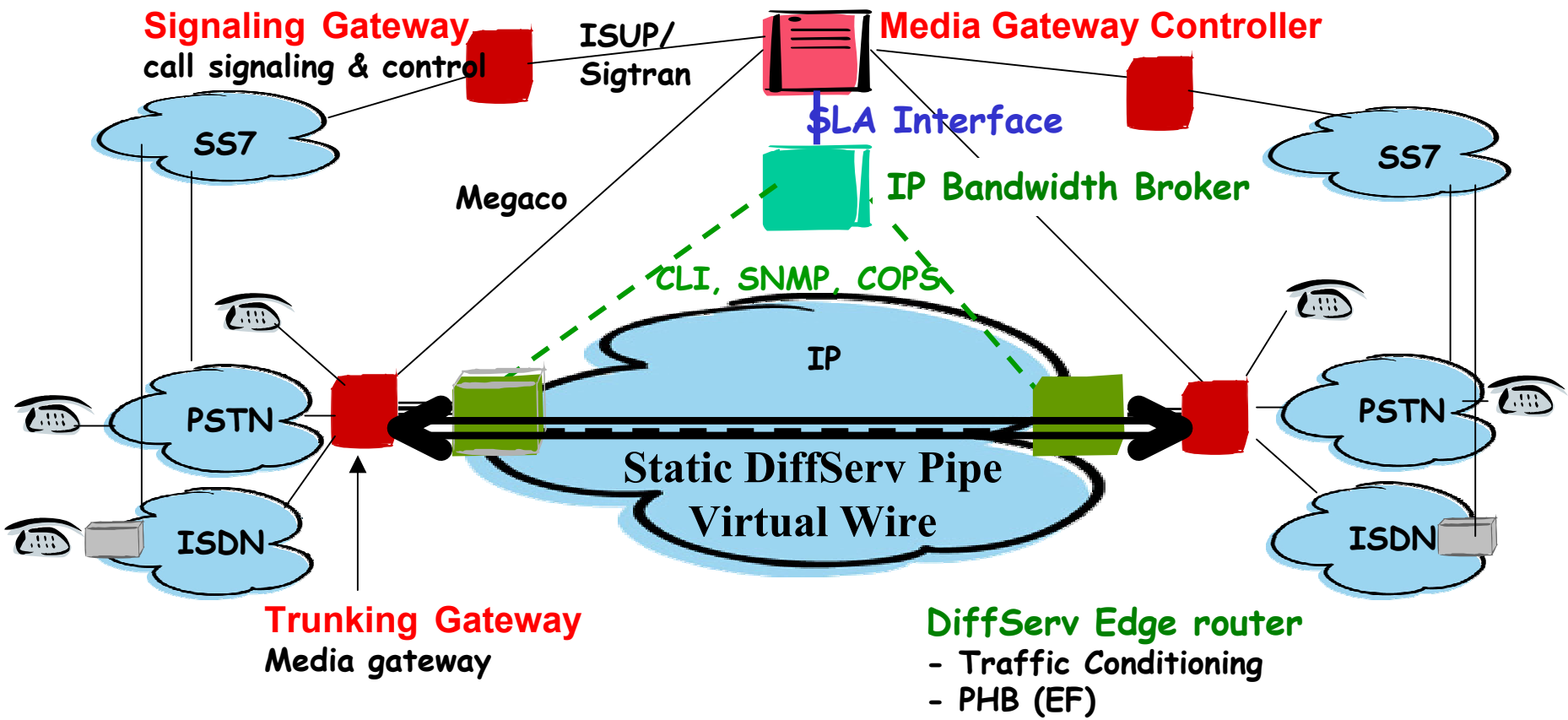

Signaling Gateway
call signaling & control
ISUP/
Sigtran
Media Gateway Controller
SLA Interface
IP Bandwidth Broker
SS7
SS7
Megaco
CLI, SNMP, COPS
IP
PSTN
PSTN
ISDN
ISDN
Static DiffServ Pipe
Virtual Wire
Trunking Gateway
Media gateway
DiffServ Edge router
- Traffic Conditioning
- PHB (EF)

Figure 5

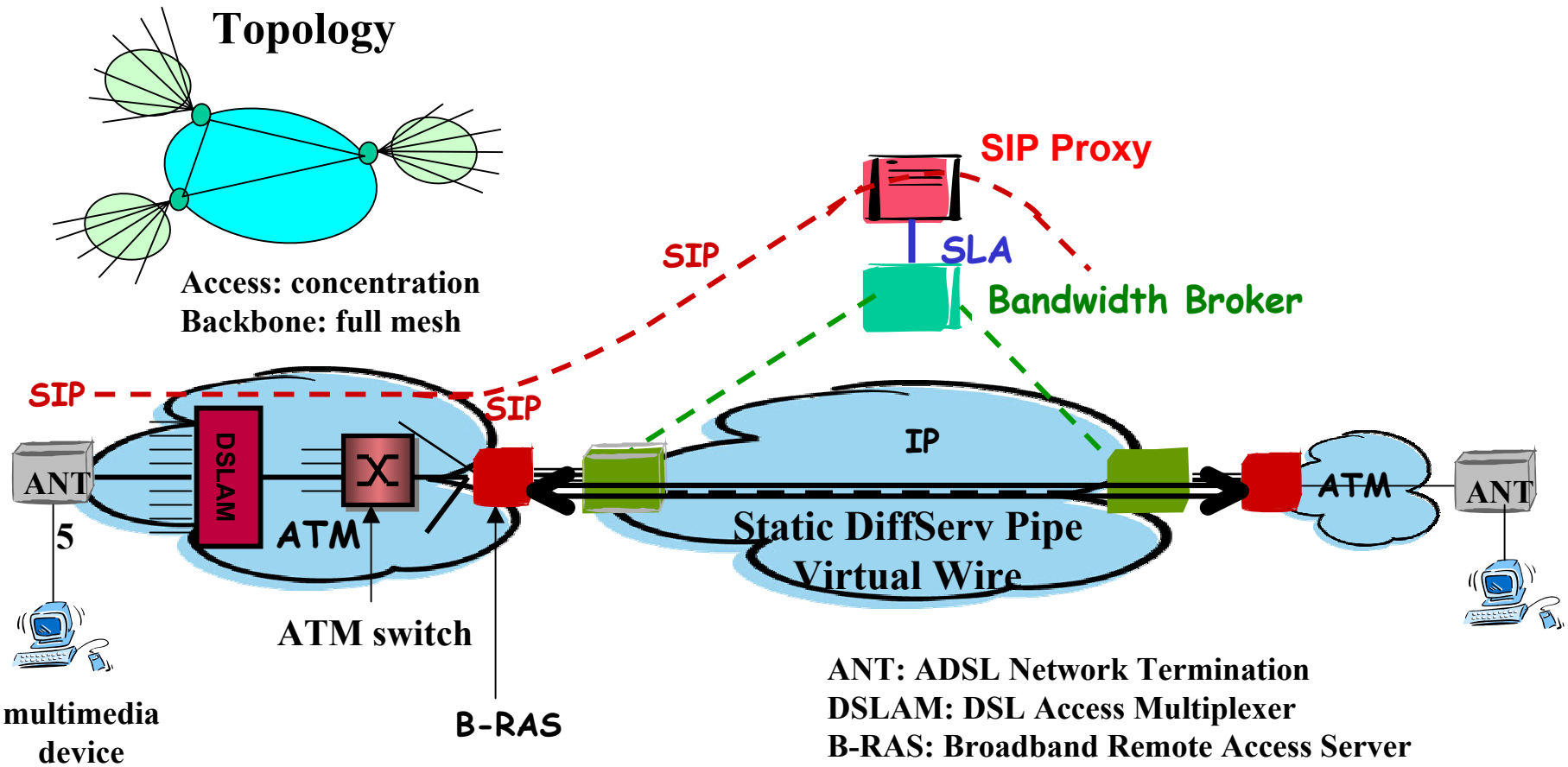
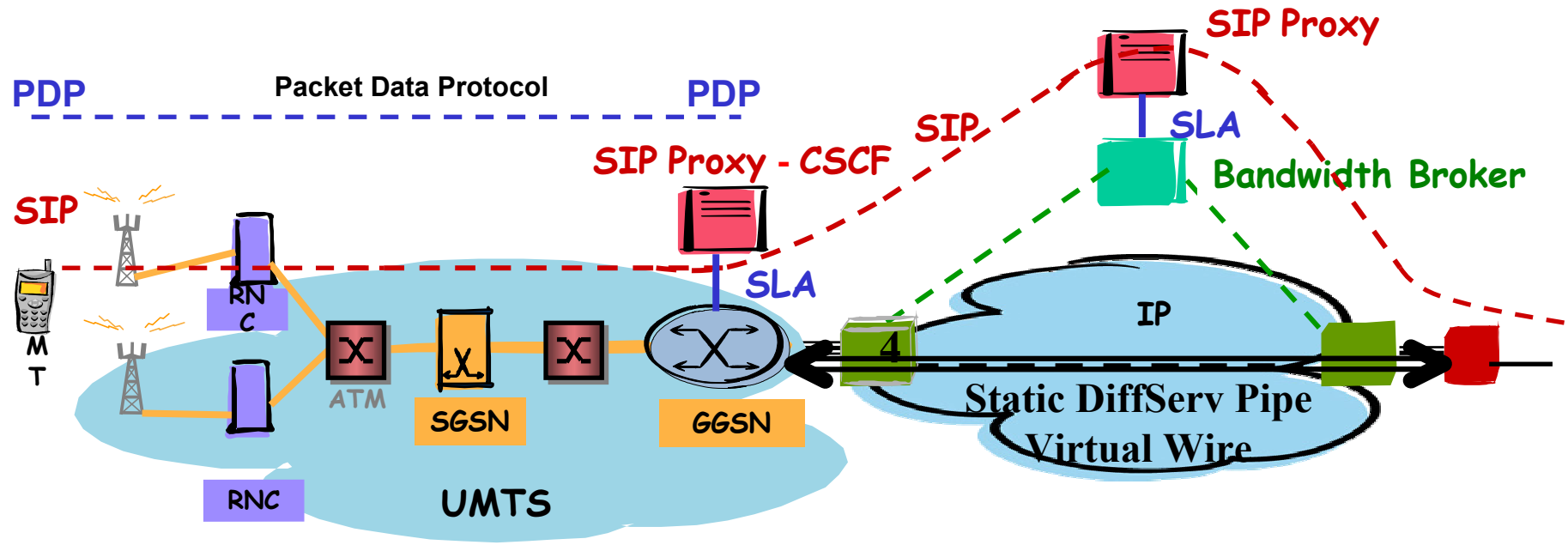
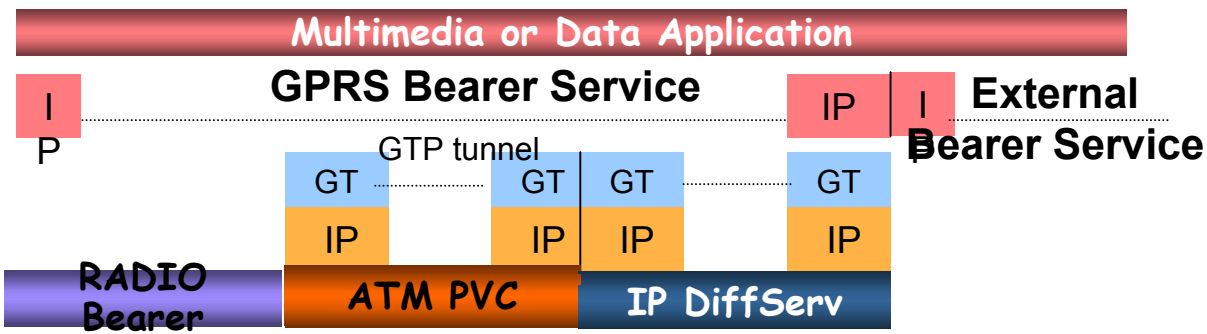

Topology
Access: concentration
Backbone: full mesh
SIP Proxy
SIP
SLA
Bandwidth Broker
SIP
SIP
ANT
DSLAM
ATM
IP
ATM
ANT
5
Static DiffServ Pipe
Virtual Wire
ATM switch
B-RAS
multimedia
device
ANT: ADSL Network Termination
DSLAM: DSL Access Multiplexer
B-RAS: Broadband Remote Access Server

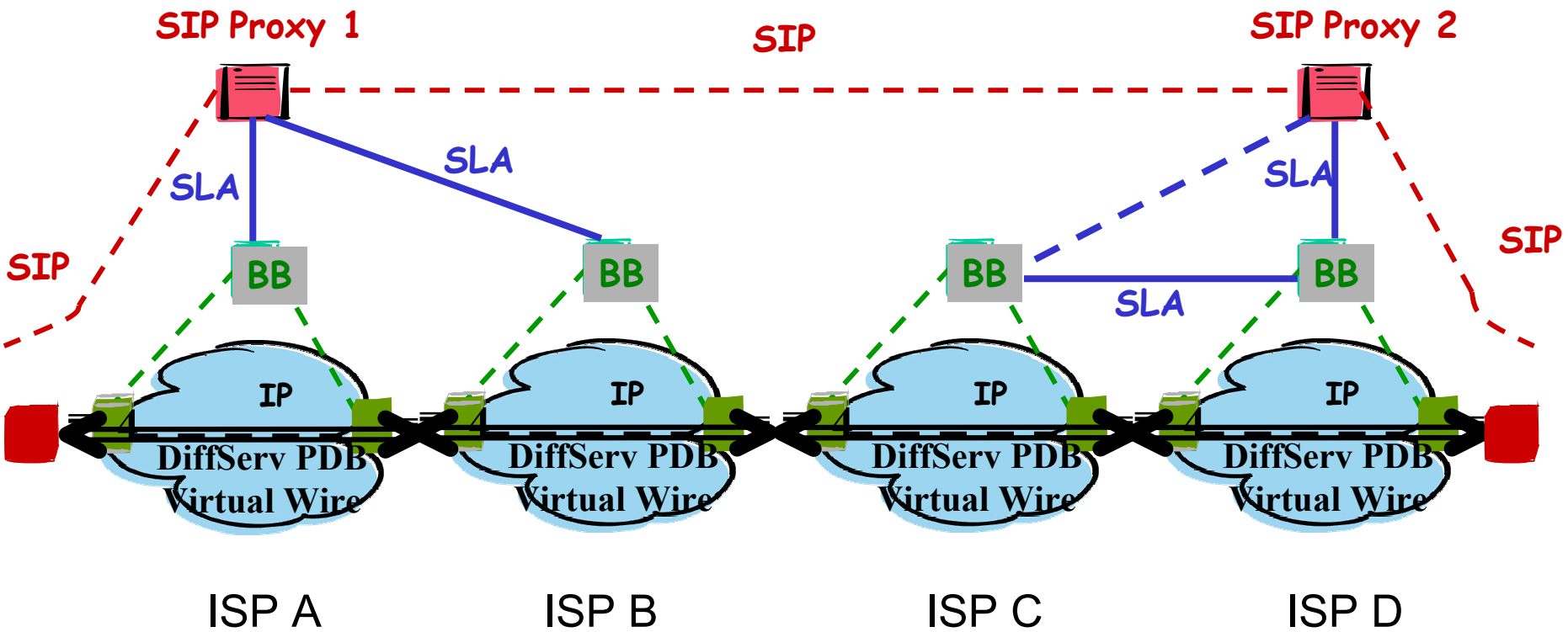
Figure 6





CSCF: Call State Control Function
GPRS: General Packet Radio Service
GGSN: Gateway GPRS Support Node
SGSN: Serving GPRS Support Node
RNC: Radio Network Controller
MT: Mobile Terminal

Figure 9


SIP Proxy 1
SIP
SIP Proxy 2
SLA
SLA
SLA
SIP
SIP
BB
BB
BB
BB
SLA
IP
IP
IP
IP
DiffServ PDB
Virtual Wire
DiffServ PDB
Virtual Wire
DiffServ PDB
Virtual Wire
DiffServ PDB
Virtual Wire
ISP A
ISP B
ISP C
ISP D