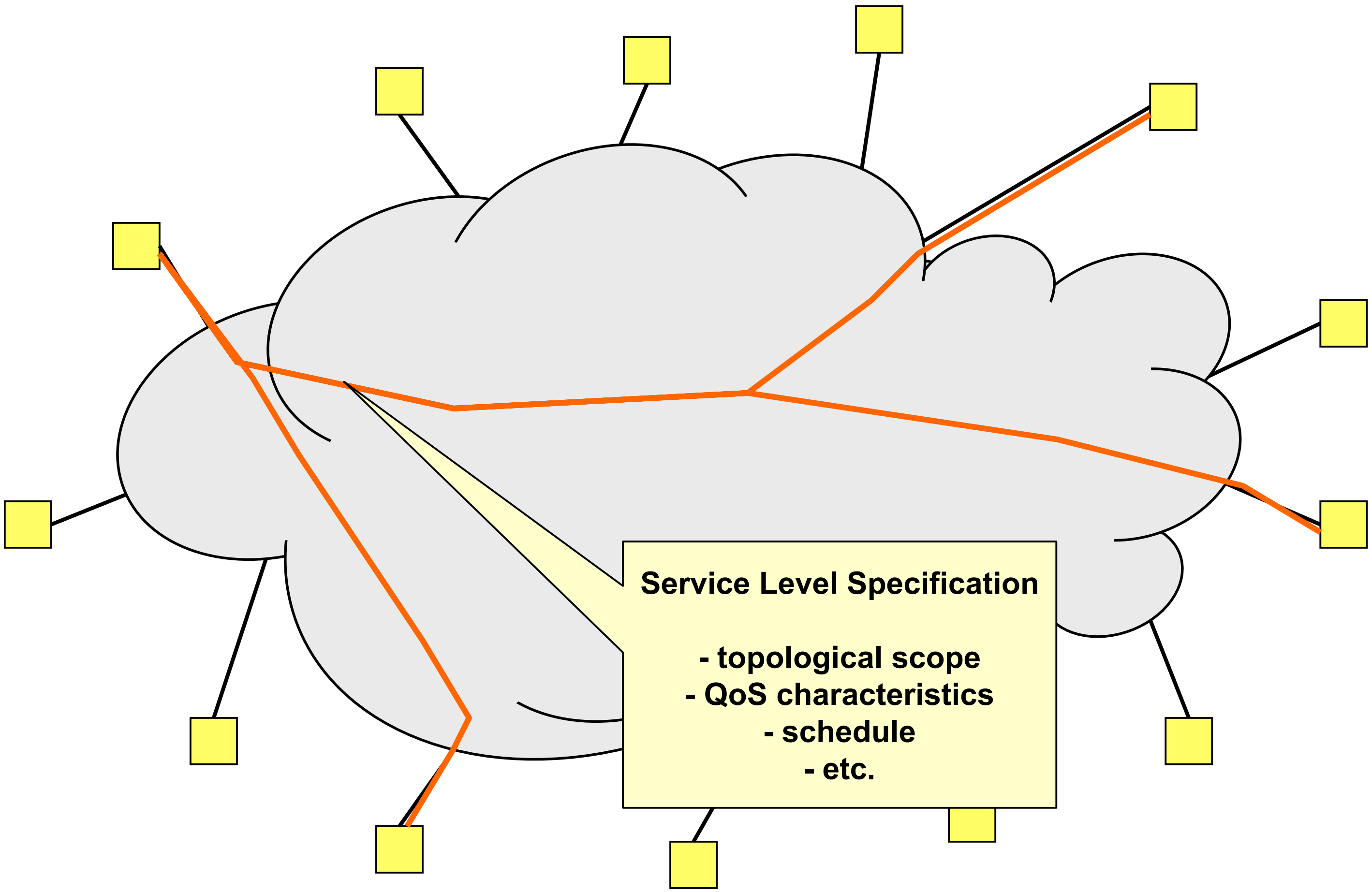
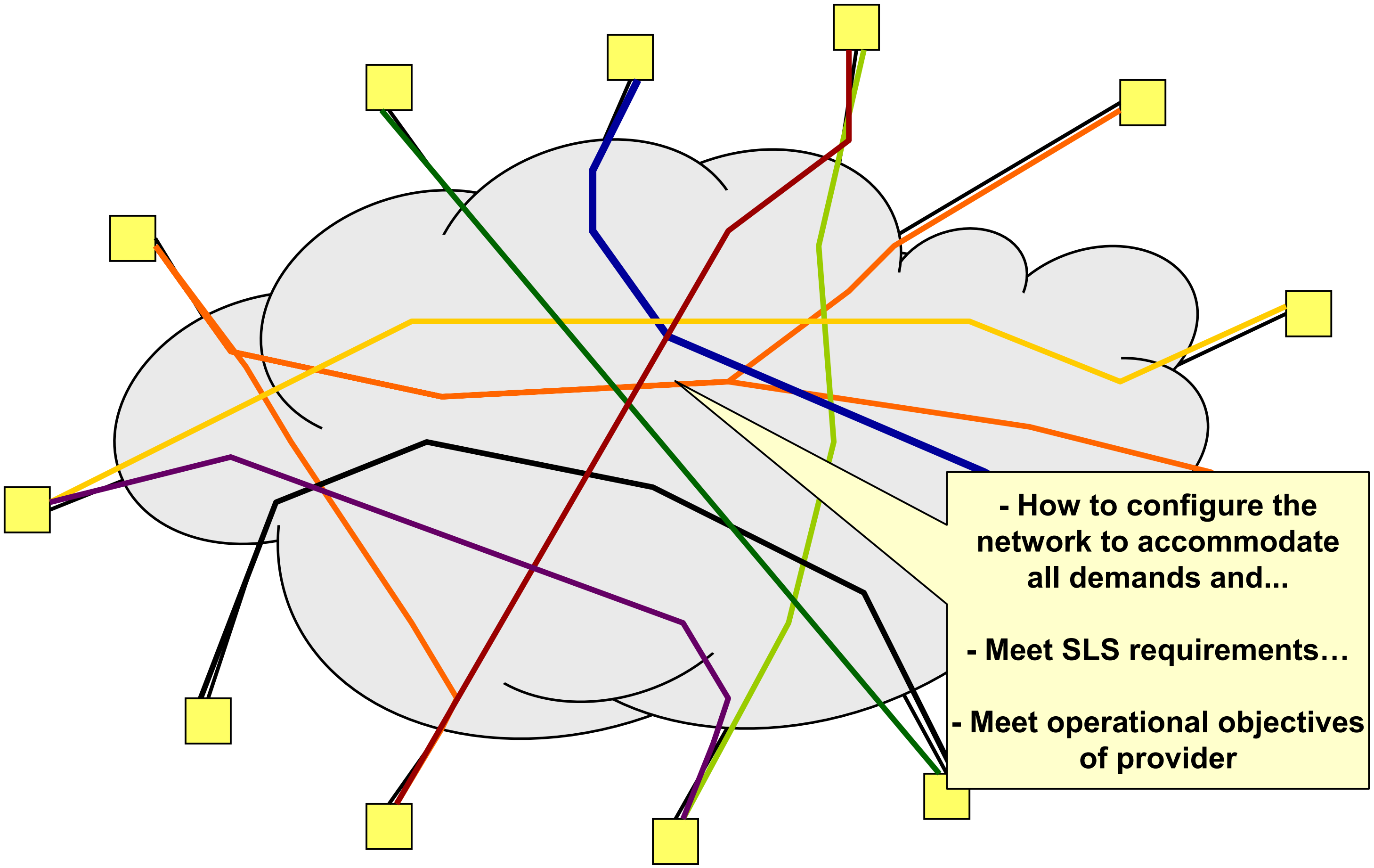
TEQUILA presentations/demonstrations

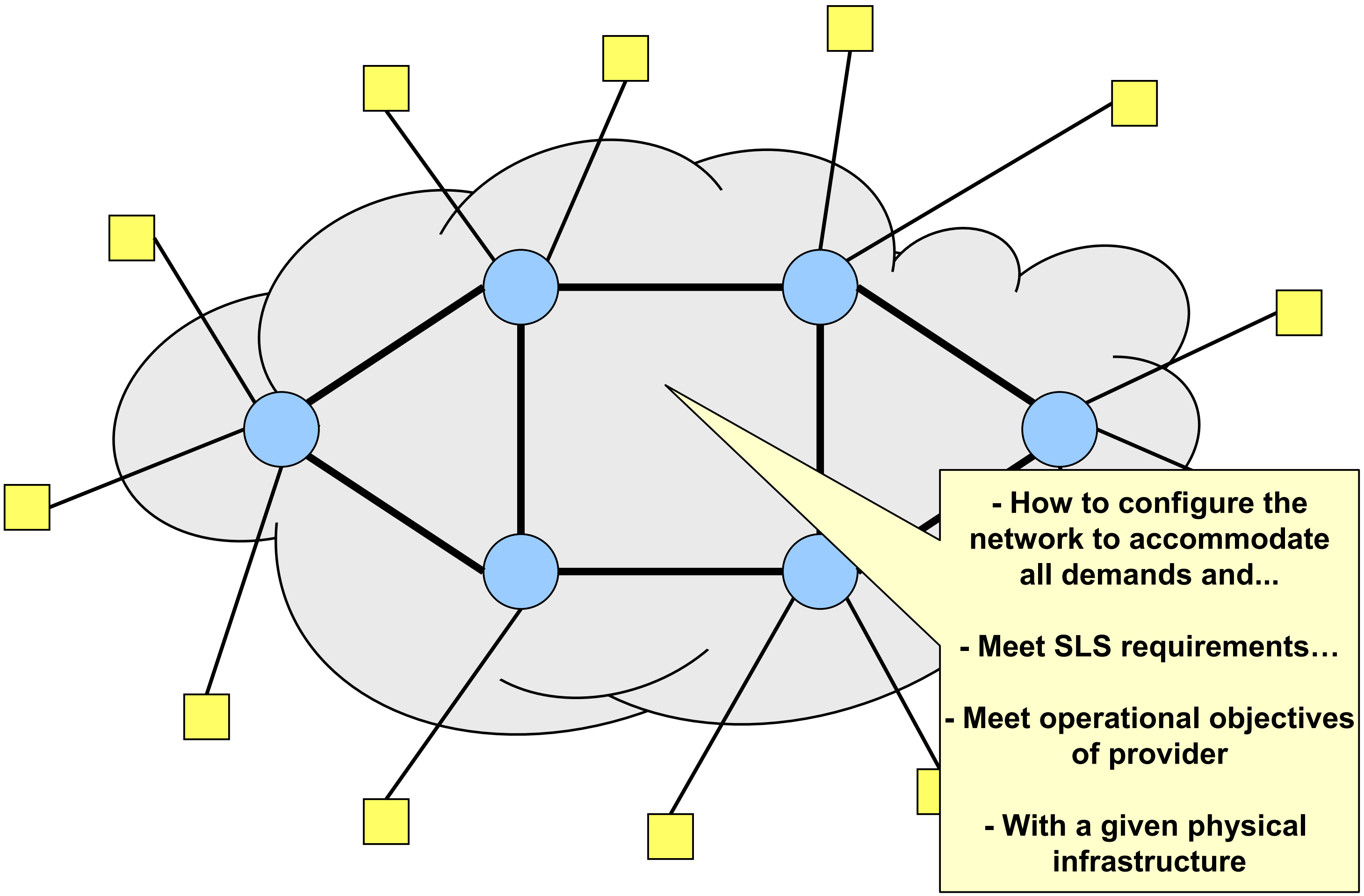
- Overview of the TEQUILA System
  - David Griffin, UCL
- Demo 1: Traffic Engineering
  - Panos Trimintzios, Paris Flegkas, UniS
- Demo 2: Resource Provisioning Cycle, Network Configuration, Service Negotiation and Monitoring
  - Steven Van den Berghe, IMEC
  - Takis Damilatis, Algonet
  - Charalampos Charalampous, NTUA
- UK Testbed: Monitoring Results
  - Richard Egan, Global Crossing

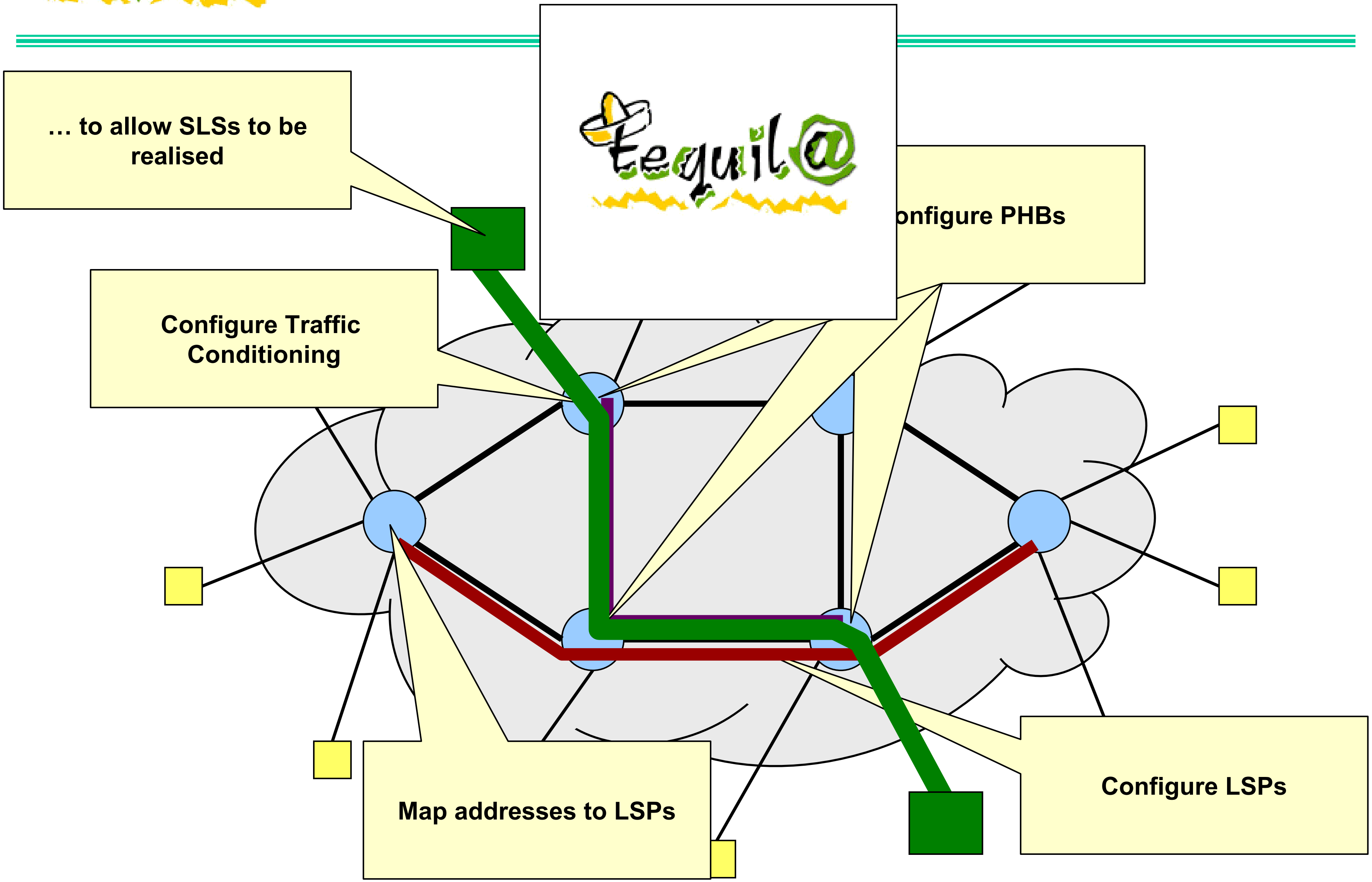
- Overview of the TEQUILA System
  - David Griffin, UCL
  - Panos Trimintzios, Paris Flegkas, UniS
- Demo 2: Resource Provisioning Cycle, Network Configuration, Service Negotiation and Monitoring
  - Steven Van den Berghe, IMEC
  - Takis Damilatis, Algonet
  - Charalampos Charalampous, NTUA
- UK Testbed: Monitoring Results
  - Richard Egan, Global Crossing

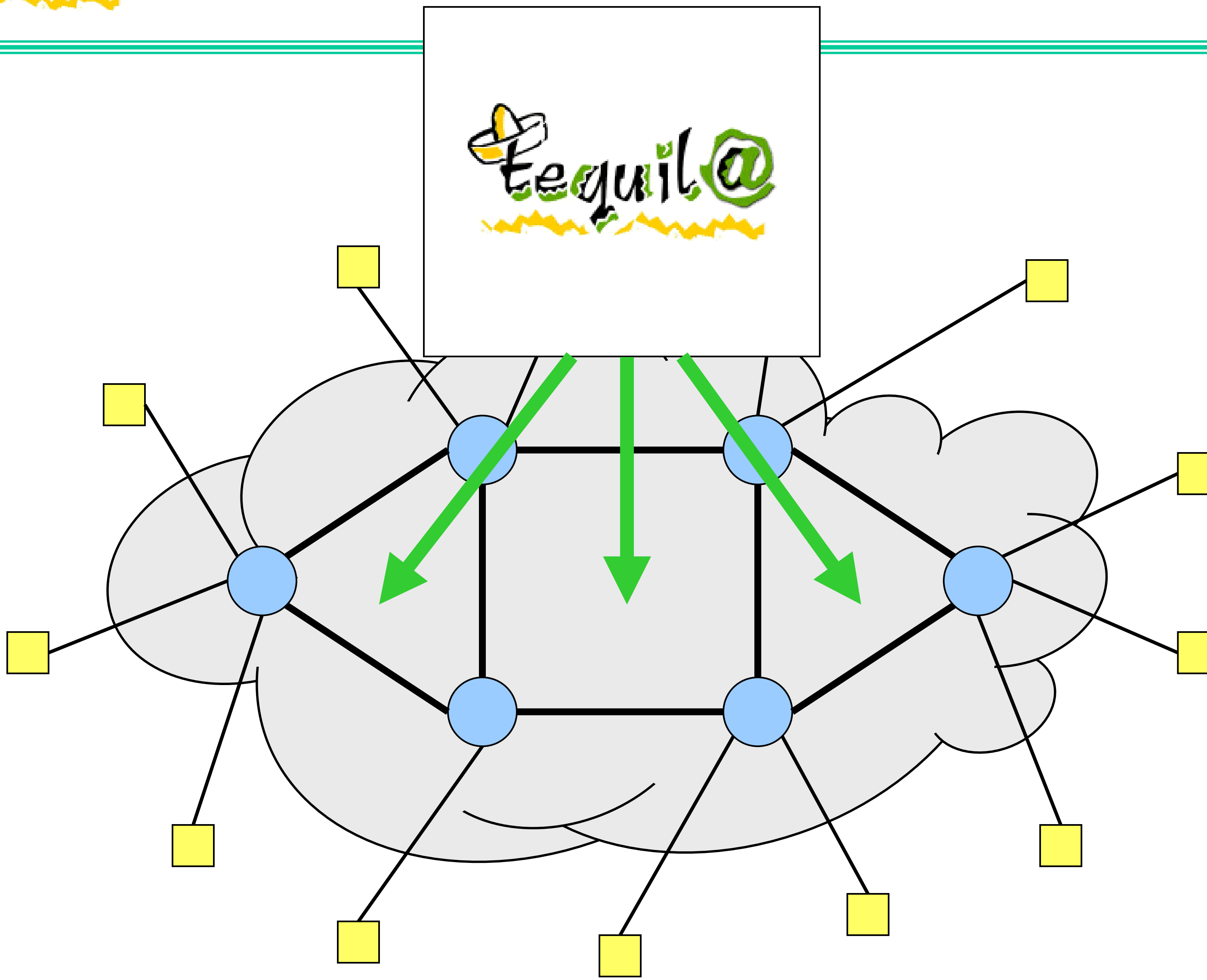

Service Level Specification
- topological scope
- QoS characteristics
- schedule
- etc.

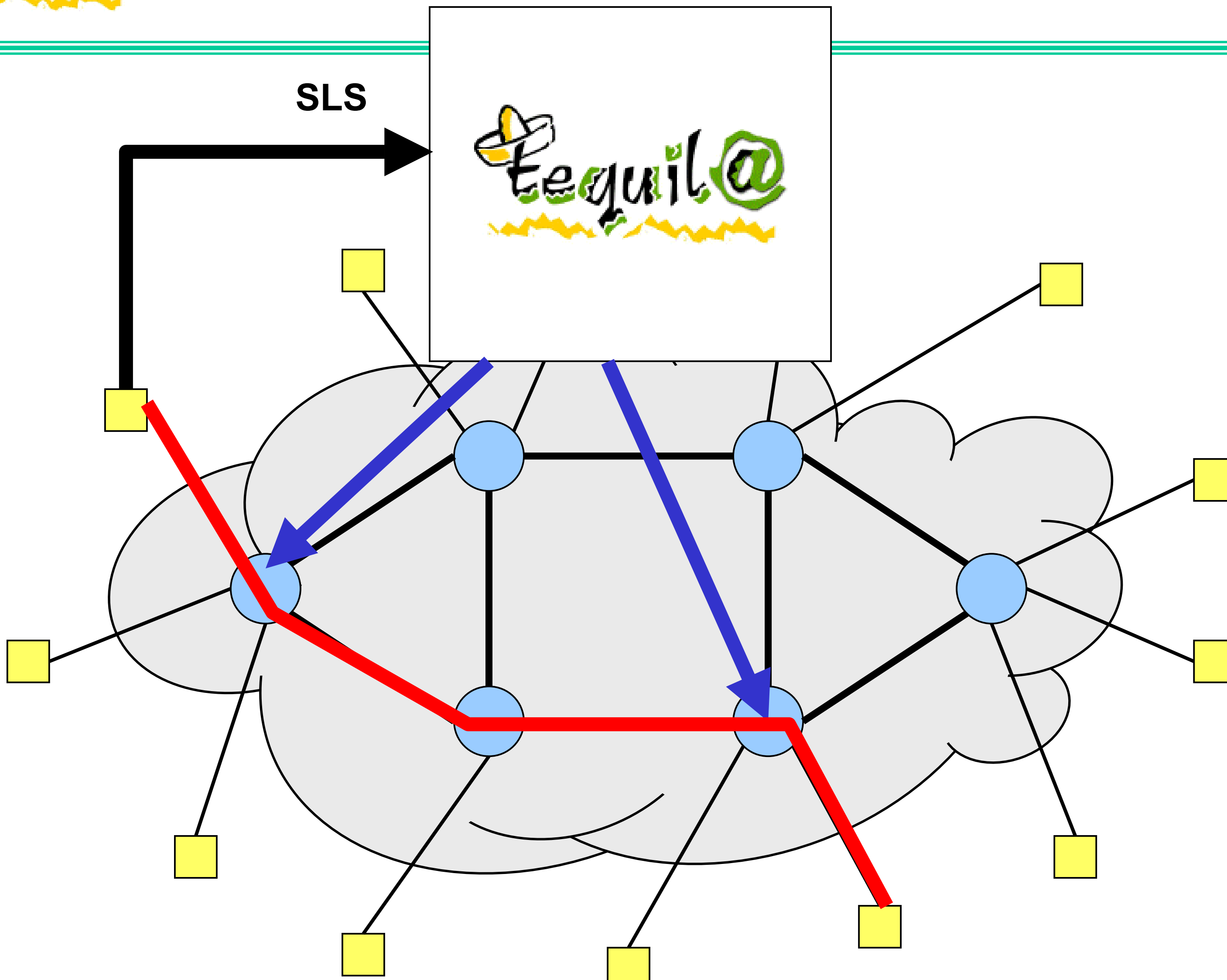


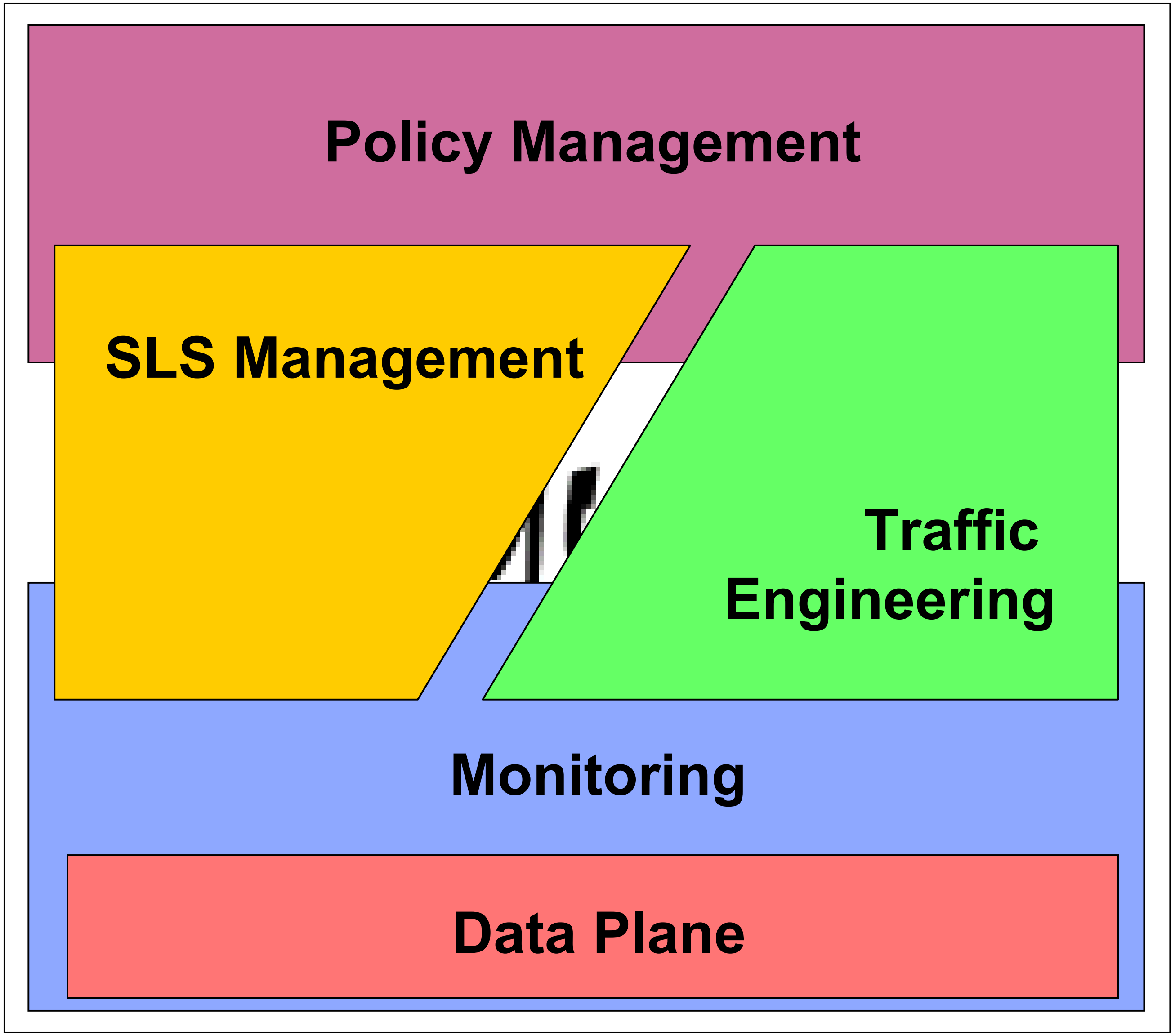
- How to configure the network to accommodate all demands and...
- Meet SLS requirements…
- Meet operational objectives of provider


- How to configure the network to accommodate all demands and...
- Meet SLS requirements…
- Meet operational objectives of provider
- With a given physical infrastructure


… to allow SLSs to be realised
onfigure PHBs
Configure Traffic Conditioning
Map addresses to LSPs
Configure LSPs

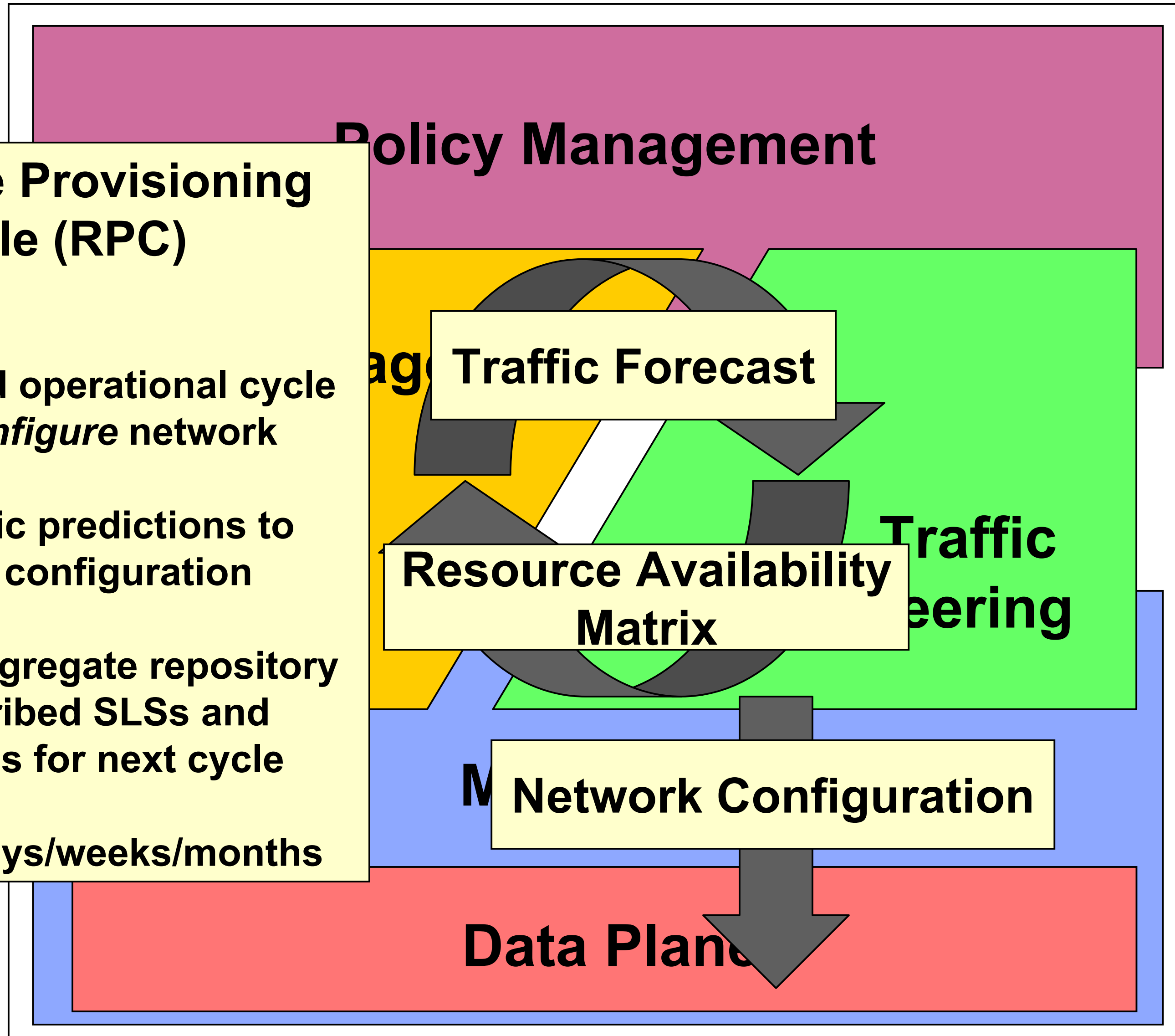



SLS


Policy Management
SLS Management
Traffic Engineering
Monitoring
Data Plane

Resource Provisioning Cycle (RPC)

- background operational cycle to *pre-configure* network
- map traffic predictions to network configuration
- based on aggregate repository of subscribed SLSs and predictions for next cycle
- order of days/weeks/months



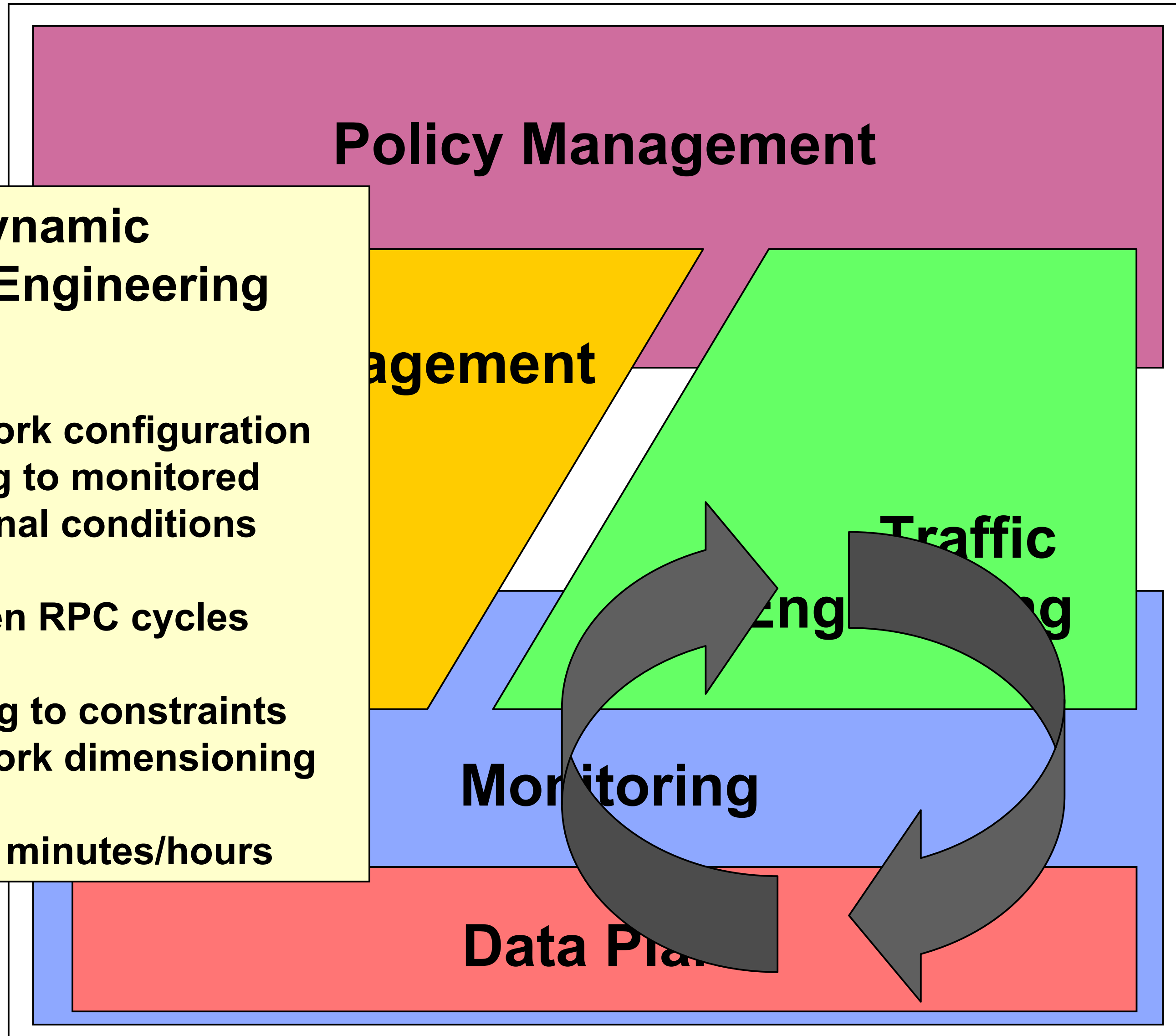
Dynamic
Traffic Engineering

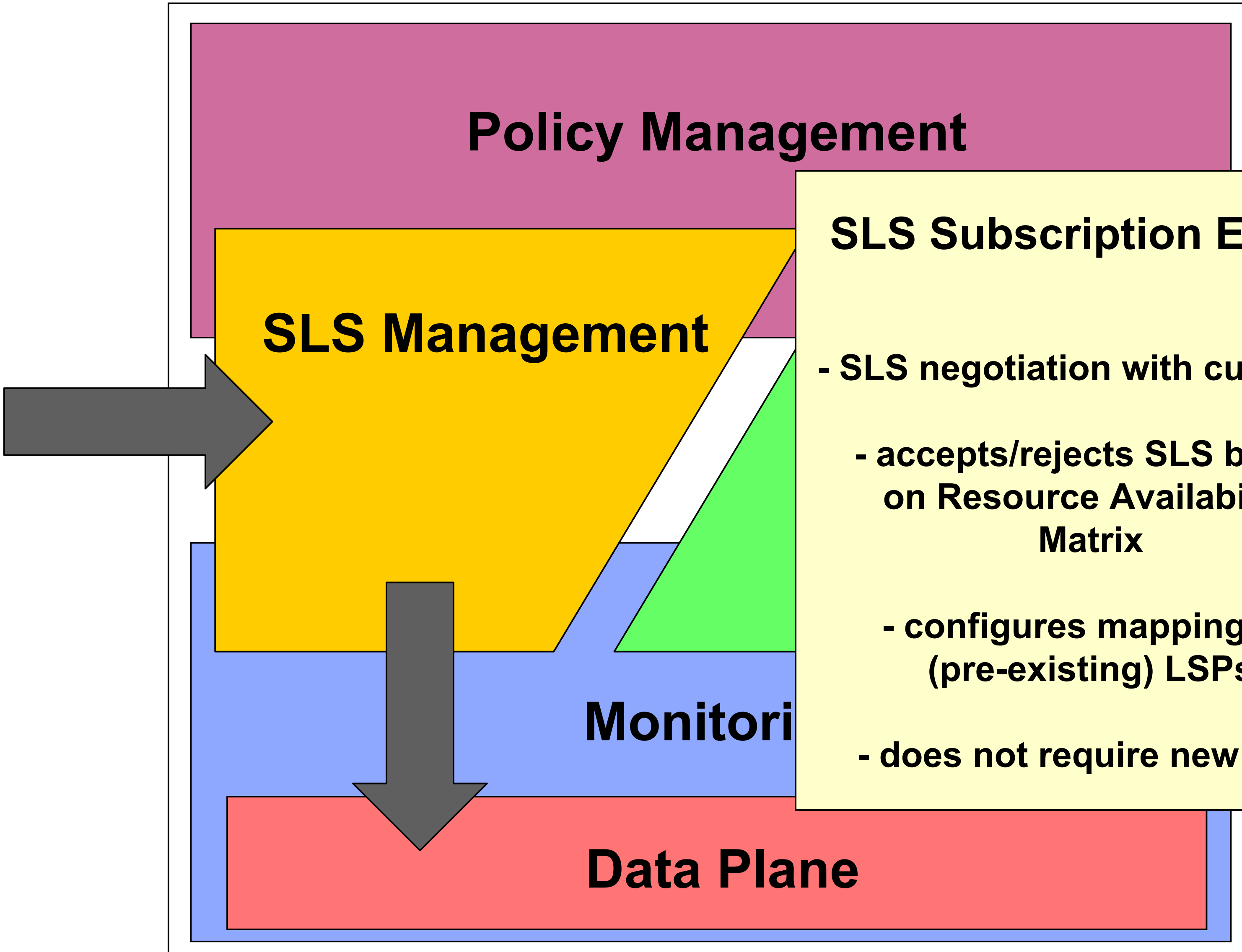
- tune network configuration according to monitored operational conditions

- between RPC cycles

- according to constraints set by network dimensioning

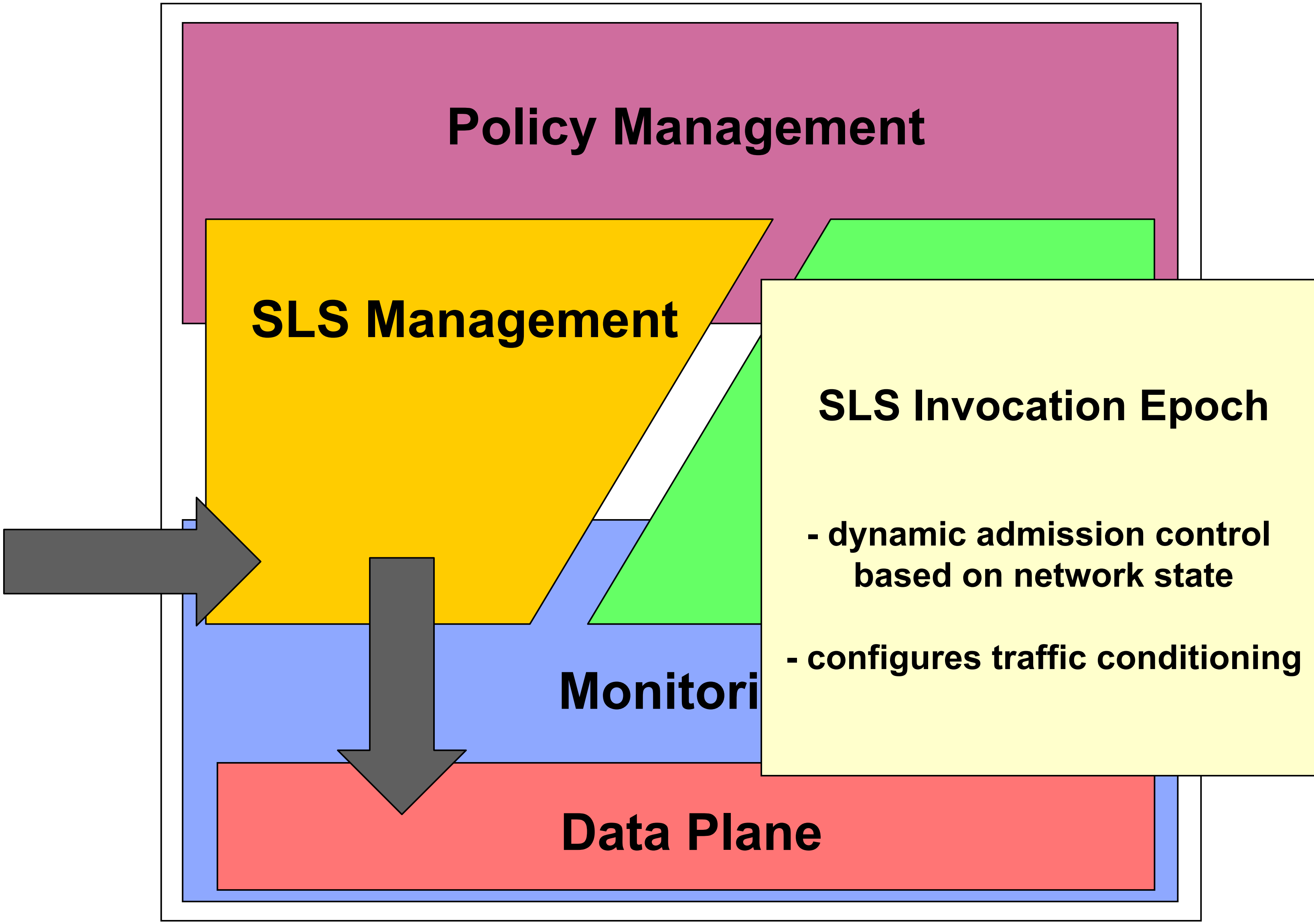
- order of minutes/hours



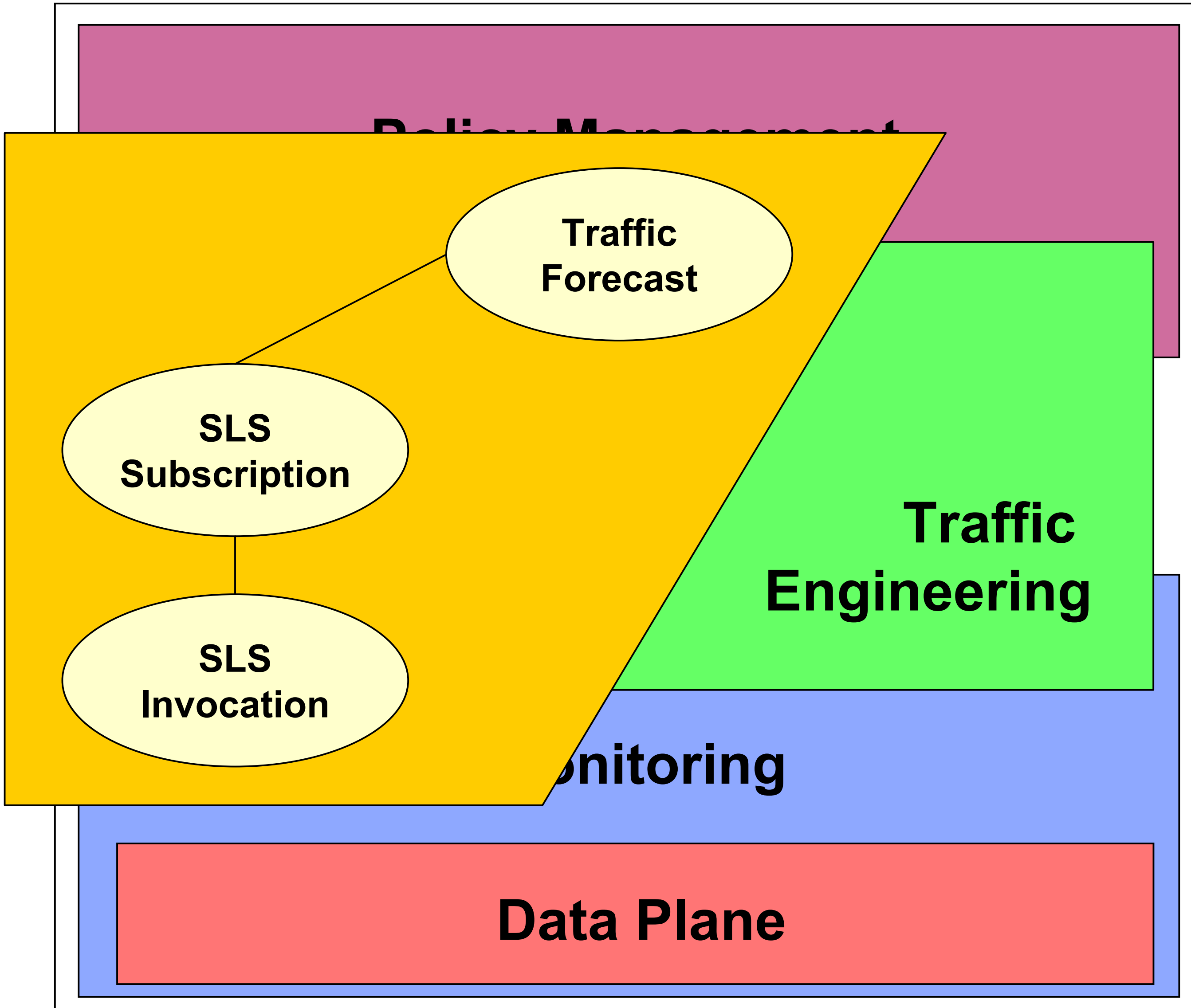


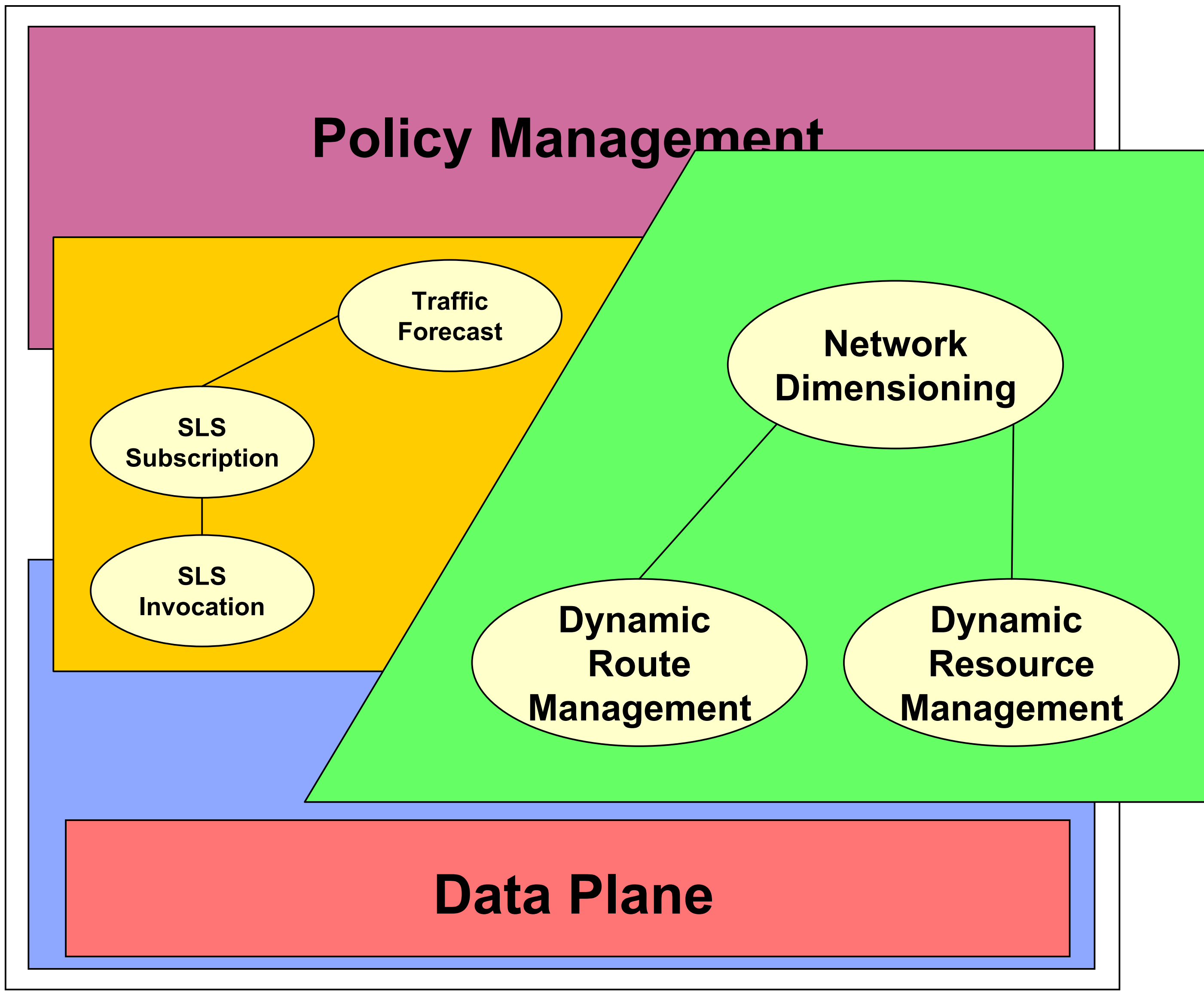
SLS Subscription Epoch

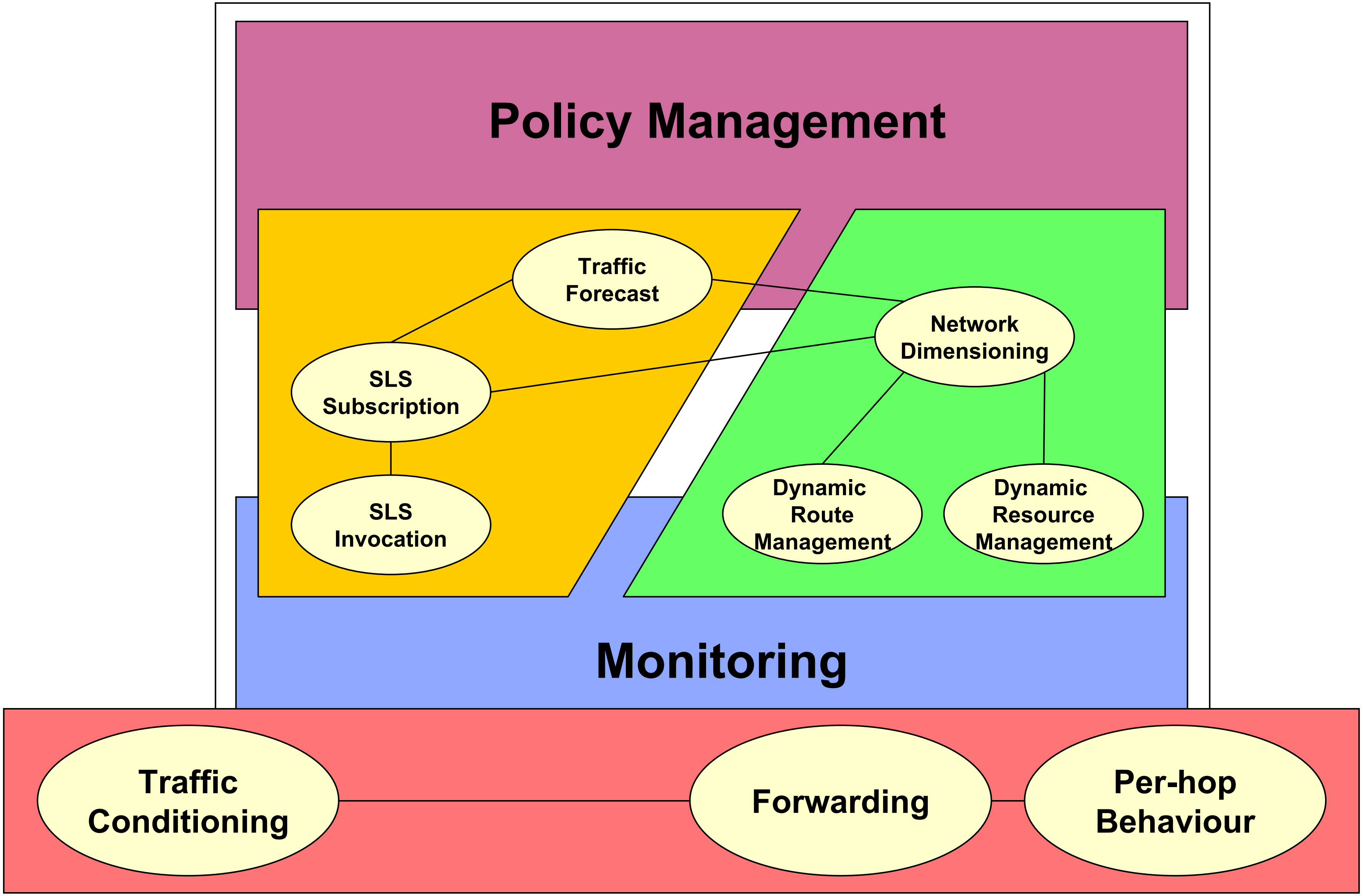
- SLS negotiation with customer
- accepts/rejects SLS based on Resource Availability Matrix
- configures mapping to (pre-existing) LSPs
- does not require new RPC

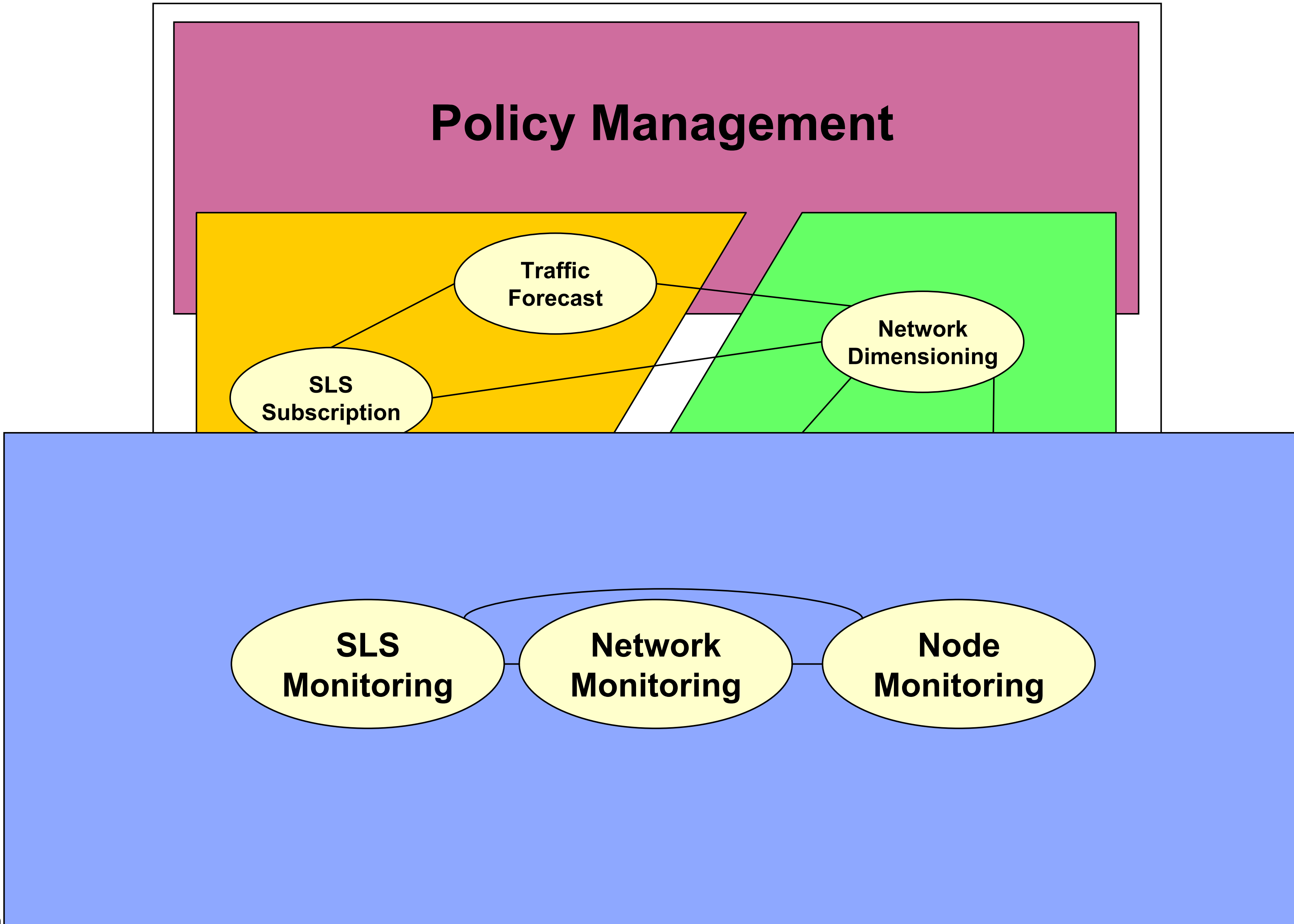


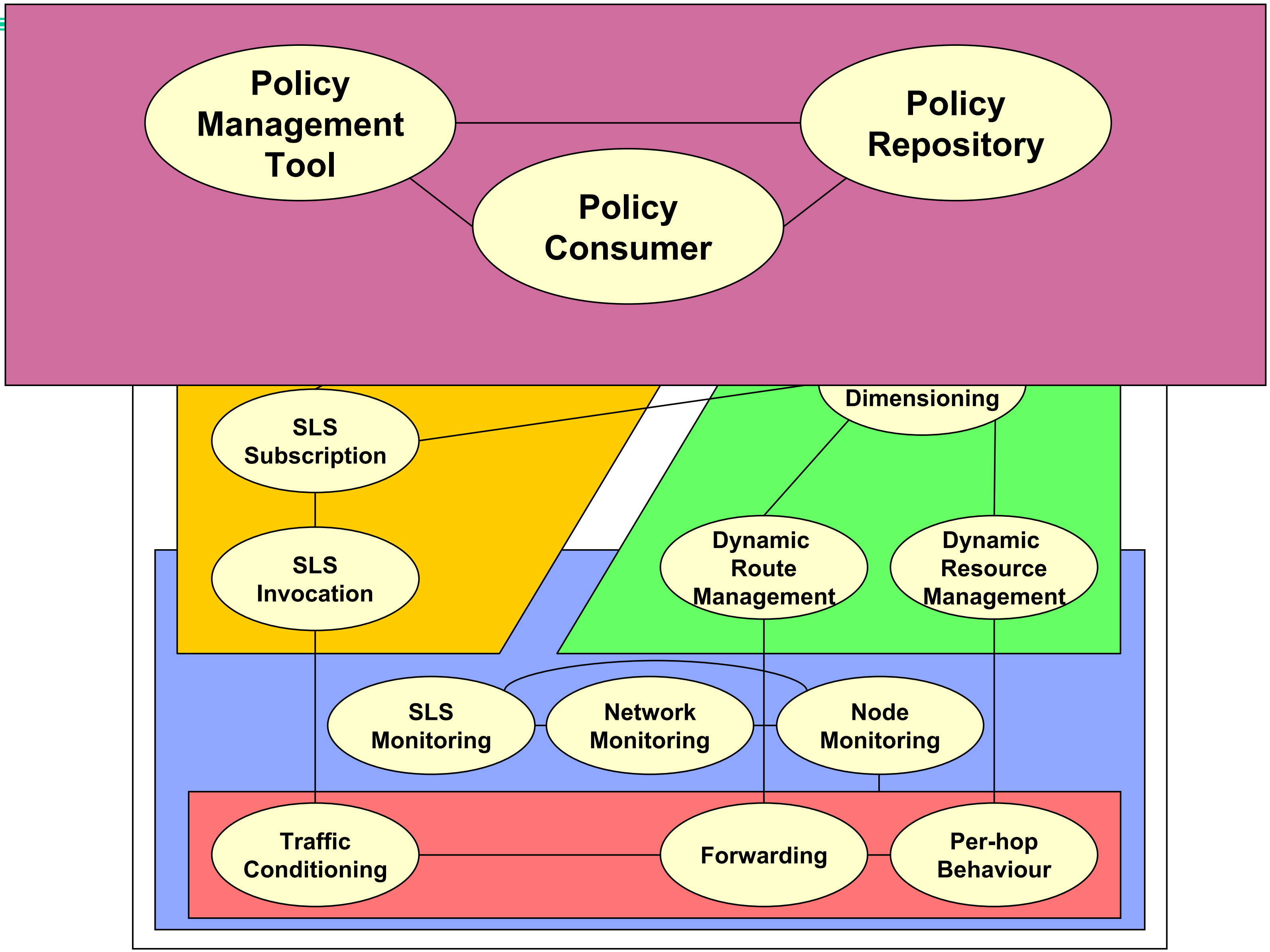
Policy Management
SLS Management
SLS Invocation Epoch
- dynamic admission control based on network state
- configures traffic conditioning
Monitori
Data Plane


Traffic
Forecast
SLS
Subscription
SLS
Invocation
Traffic
Engineering
Data Plane

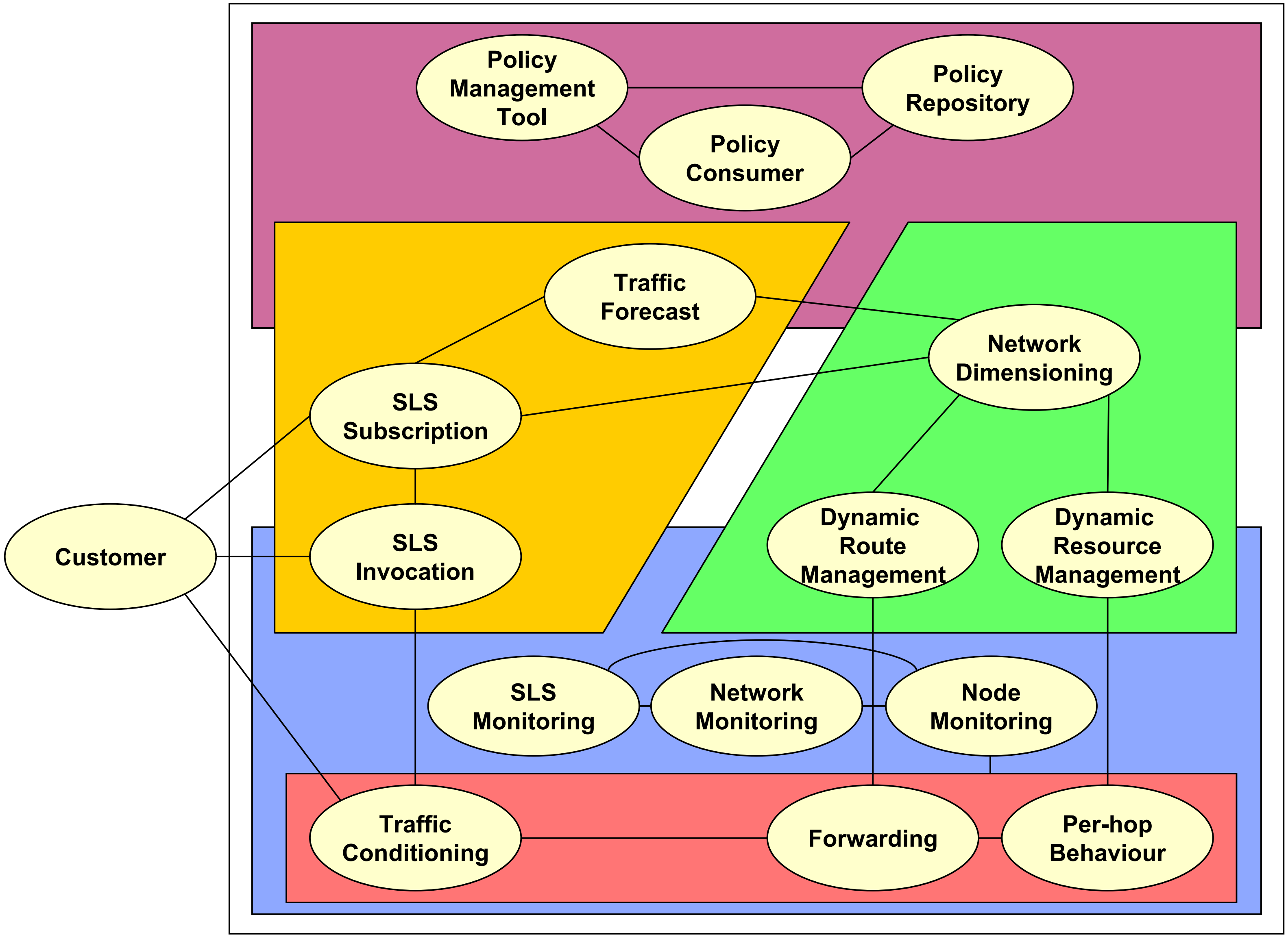

Policy Management
Traffic Forecast
SLS Subscription
SLS Invocation
Network Dimensioning
Dynamic Route Management
Dynamic Resource Management
Data Plane

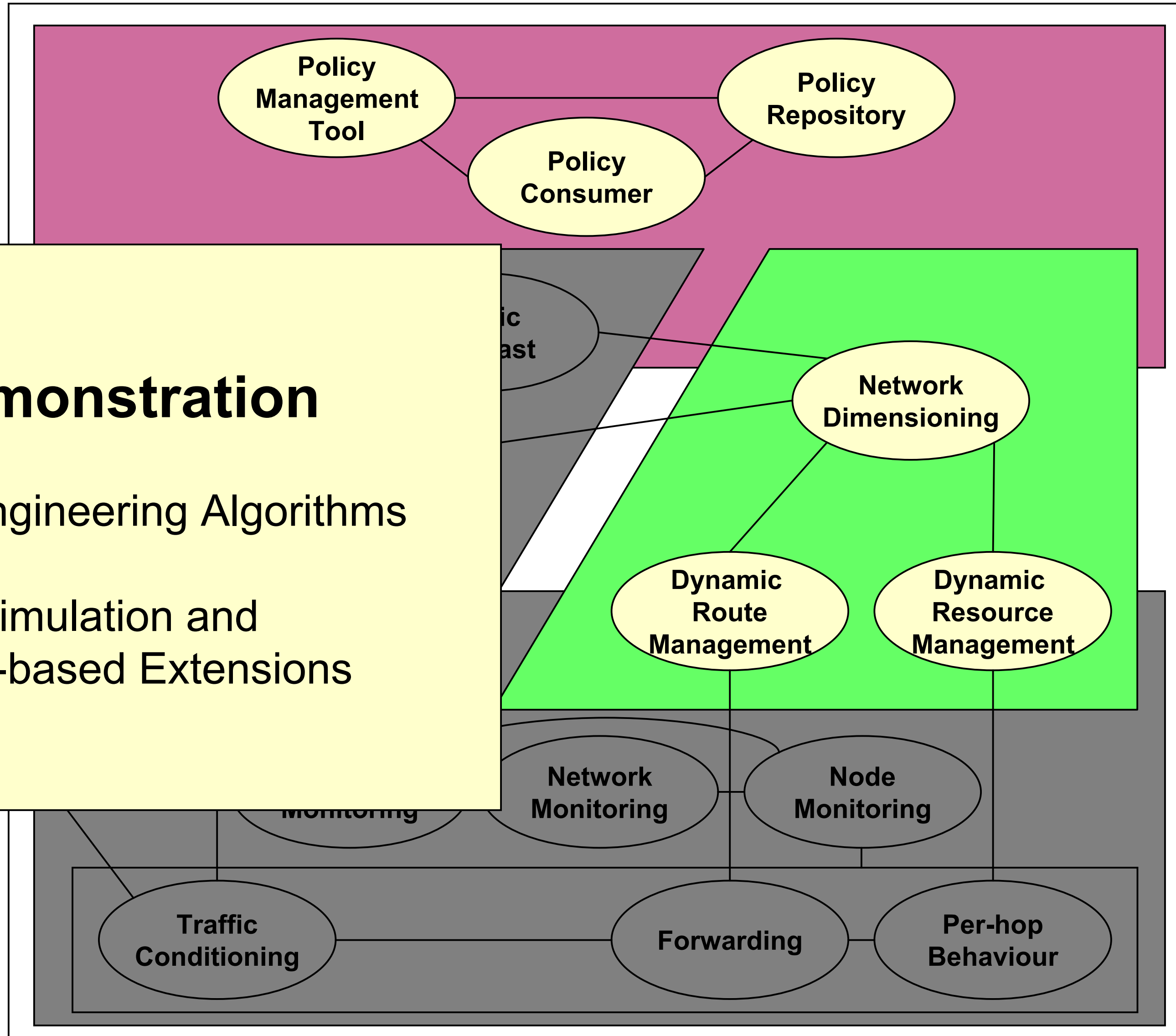

Policy Management
Traffic Forecast
SLS Subscription
SLS Invocation
Network Dimensioning
Dynamic Route Management
Dynamic Resource Management
Monitoring
Traffic Conditioning
Forwarding
Per-hop Behaviour


Policy Management
Traffic Forecast
Network Dimensioning
SLS Subscription
SLS Monitoring
Network Monitoring
Node Monitoring



Policy Management Tool
Policy Repository
Policy Consumer
Dimensioning
SLS Subscription
SLS Invocation
Dynamic Route Management
Dynamic Resource Management
SLS Monitoring
Network Monitoring
Node Monitoring
Traffic Conditioning
Forwarding
Per-hop Behaviour


Policy Management Tool
Policy Repository
Policy Consumer
Traffic Forecast
Network Dimensioning
SLS Subscription
Customer
SLS Invocation
Dynamic Route Management
Dynamic Resource Management
SLS Monitoring
Network Monitoring
Node Monitoring
Traffic Conditioning
Forwarding
Per-hop Behaviour



Demonstration

Traffic Engineering Algorithms

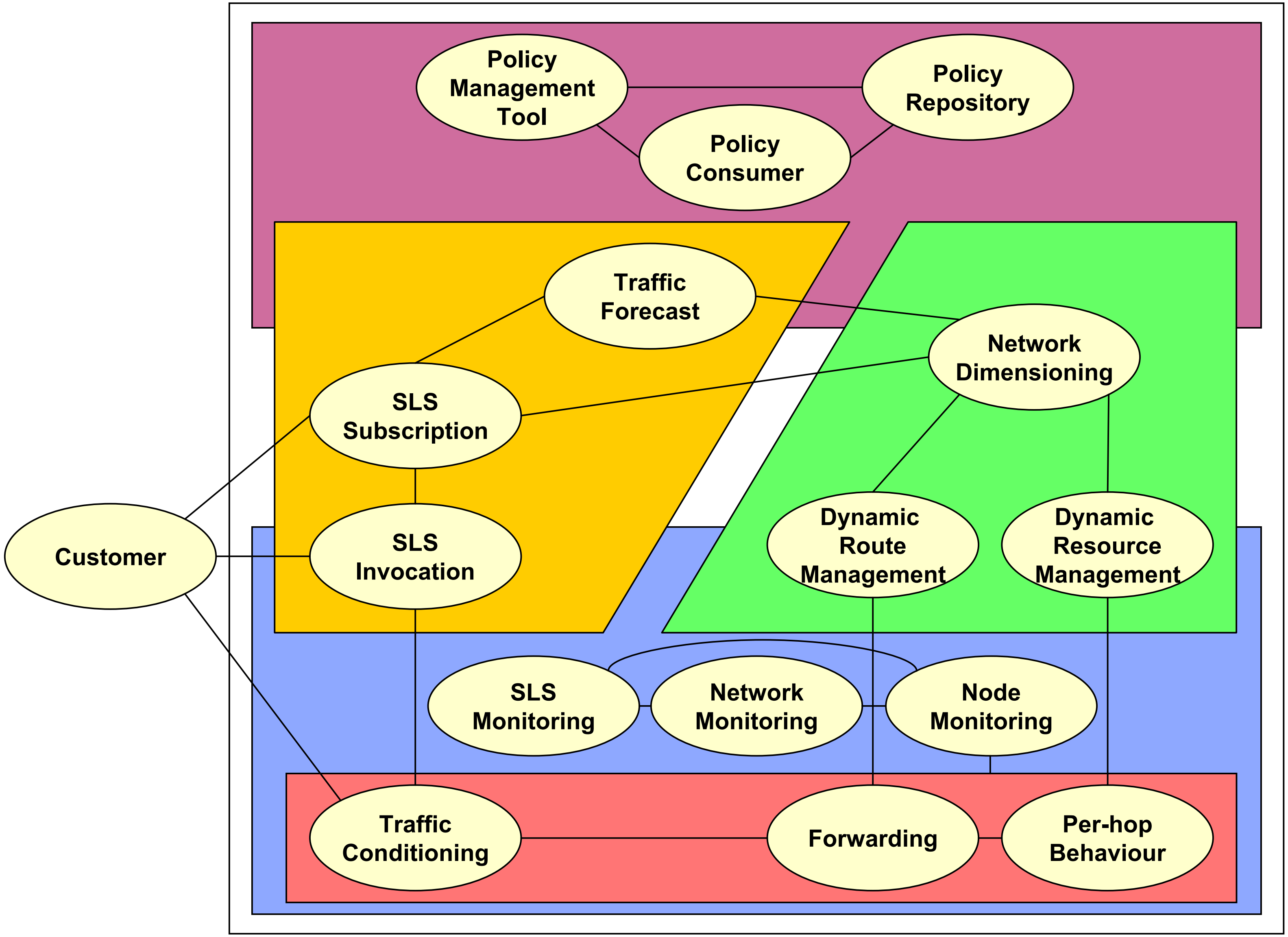
Simulation and
Policy-based Extensions

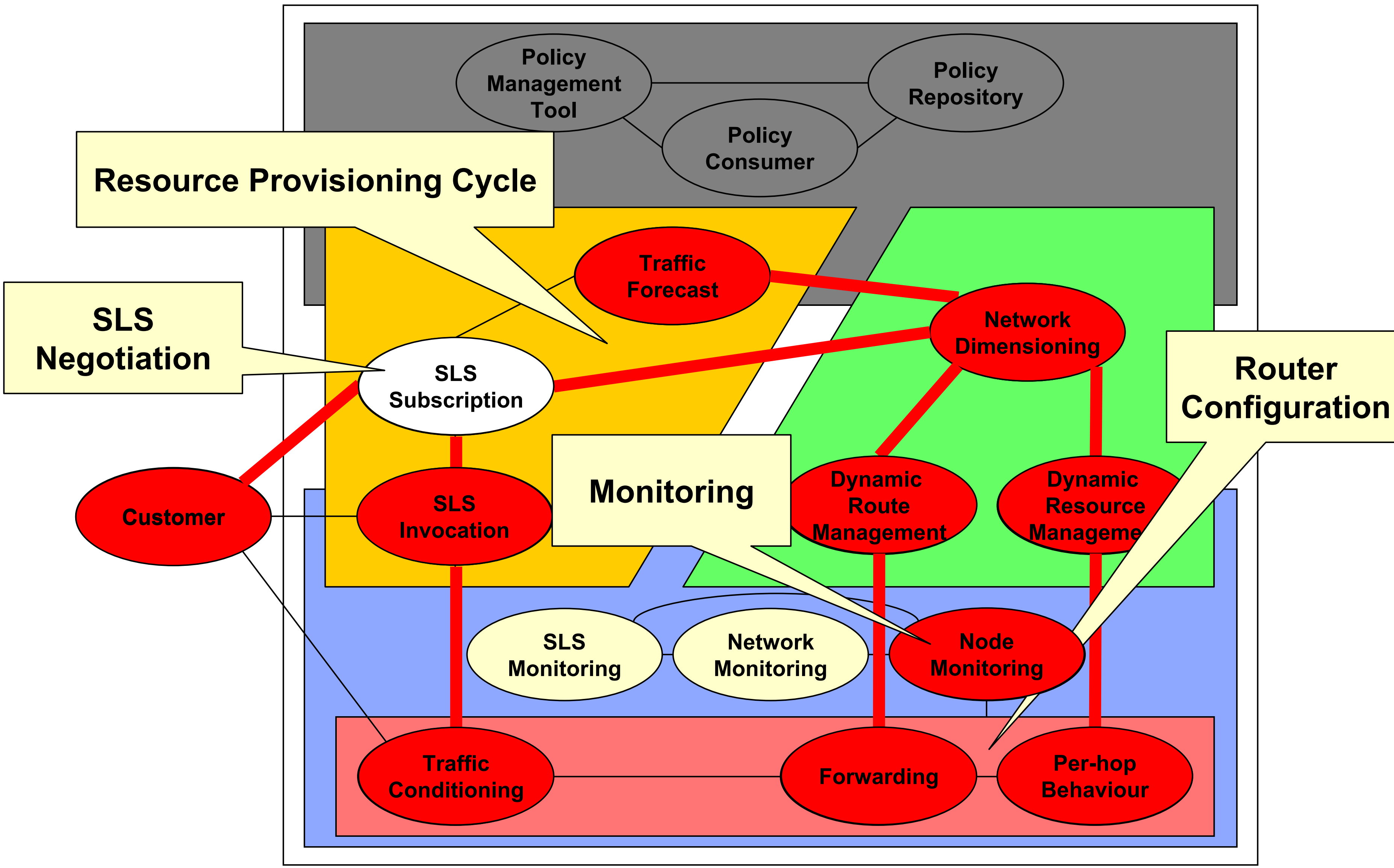
TEQUILA presentations/demonstrations

- Overview of the TEQUILA System

- Demo 1: Traffic Engineering
  - Panos Trimintzios, Paris Flegkas, UniS

Configuration, Service Negotiation and Monitoring
  - Steven Van den Berghe, IMEC
  - Takis Damilatis, Algonet
  - Charalampos Charalampous, NTUA
- UK Testbed: Monitoring Results
  - Richard Egan, Global Crossing


Policy Management Tool
Policy Repository
Policy Consumer
Traffic Forecast
Network Dimensioning
SLS Subscription
Customer
SLS Invocation
Dynamic Route Management
Dynamic Resource Management
SLS Monitoring
Network Monitoring
Node Monitoring
Traffic Conditioning
Forwarding
Per-hop Behaviour



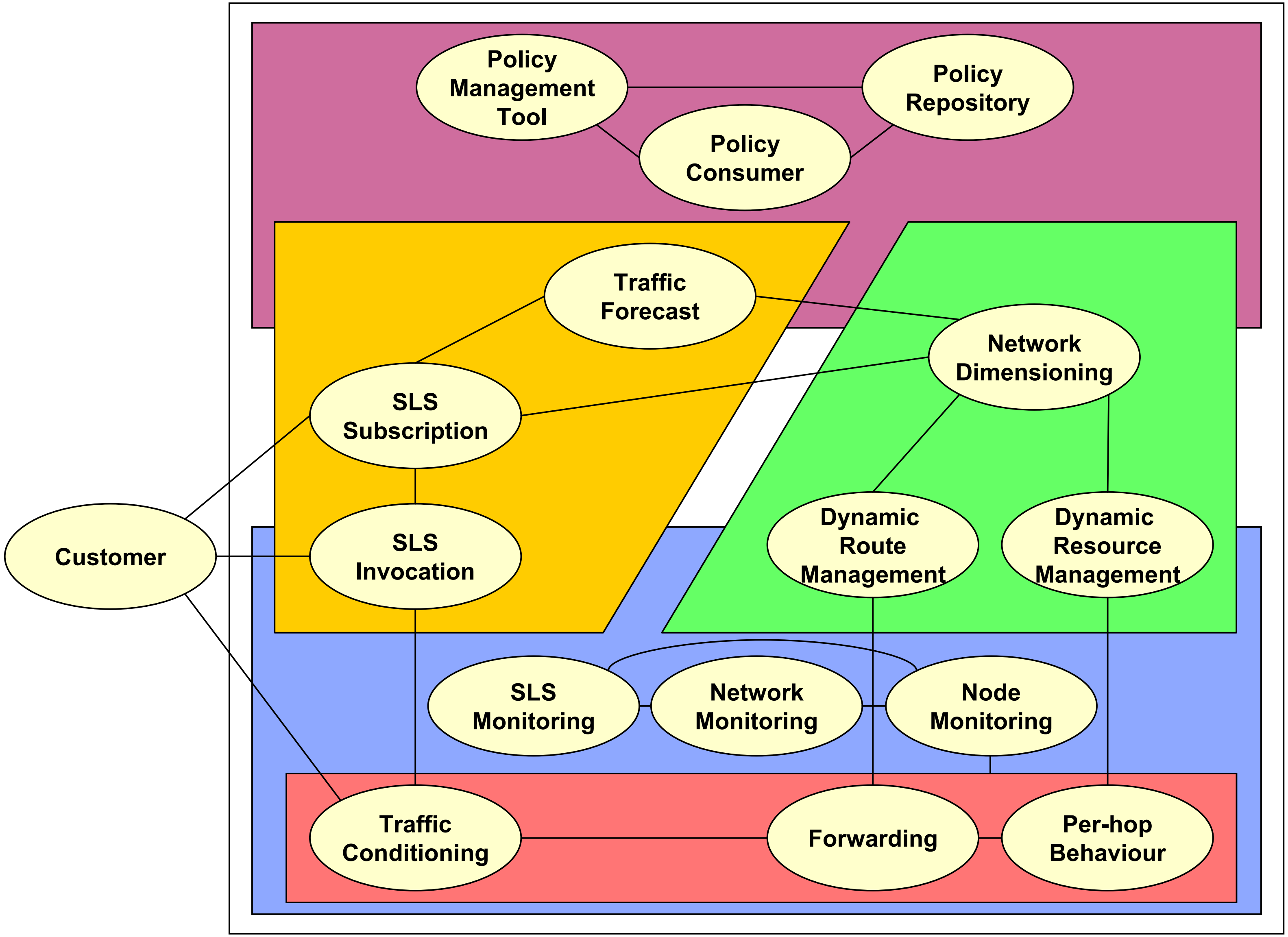
Policy Management Tool
Policy Repository
Policy Consumer
Resource Provisioning Cycle
Traffic Forecast
SLS Negotiation
Network Dimensioning
SLS Subscription
Router Configuration
Monitoring
Dynamic Route Management
Dynamic Resource Manageme
Customer
SLS Invocation
SLS Monitoring
Network Monitoring
Node Monitoring
Traffic Conditioning
Forwarding
Per-hop Behaviour

TEQUILA presentations/demonstrations

- Overview of the TEQUILA System
  - David Griffin, UCL
- Demo 1: Traffic Engineering

- Demo 2: Resource Provisioning Cycle, Network Configuration, Service Negotiation and Monitoring
  - Steven Van den Berghe, IMEC
  - Takis Damilatis, Algonet
  - Charalampos Charalampous, NTUA

  - Richard Egan, Global Crossing


Policy Management Tool
Policy Repository
Policy Consumer
Traffic Forecast
Network Dimensioning
SLS Subscription
Customer
SLS Invocation
Dynamic Route Management
Dynamic Resource Management
SLS Monitoring
Network Monitoring
Node Monitoring
Traffic Conditioning
Forwarding
Per-hop Behaviour

TEQUILA presentations/demonstrations

- Overview of the TEQUILA System
  - David Griffin, UCL
- Demo 1: Traffic Engineering
  - Panos Trimintzios, Paris Flegkas, UniS
- Demo 2: Resource Provisioning Cycle, Network Configuration, Service Negotiation and Monitoring
  - Steven Van den Berghe, IMEC
  - Takis Damilatis, Algonet
- UK Testbed: Monitoring Results
  - Richard Egan, Global Crossing

UK Testbed: Monitoring

Steven Van den Berghe

imec

Richard Egan
Hamid Asgari
Mark Irons

Global Crossing

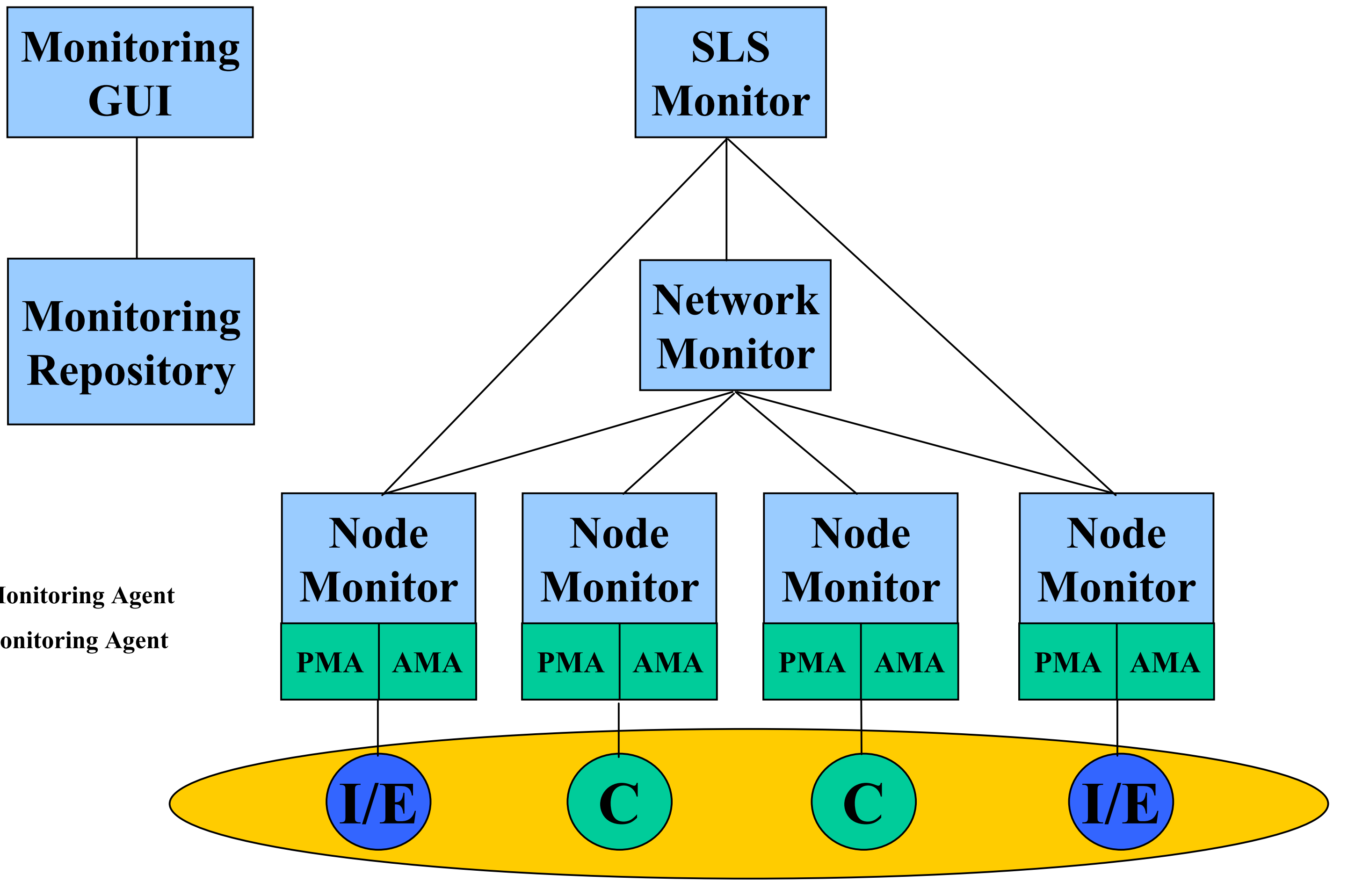
Presentation Outline

- Monitoring Architecture & Design
- Monitoring Scalability
- Overview of UK Testbed
- Results of Monitoring Tests
- Conclusions

Network Monitoring

- **Purpose:**
  - to provide in-service verification of customer services
  - to assist Dynamic TE (MPLS & IP) to adapt to congestion / under-utilisation
- **Two primary components**
  - Node Monitor
    - contains the distributed active/passive measurement agents
  - Network Monitor
    - centralised component builds a physical & logical network view
- **Relevant Metrics**
  - Active - OneWayDelay, OneWayLoss
  - Passive - PHB BW Usage, PHB Packet Discard, Throughput

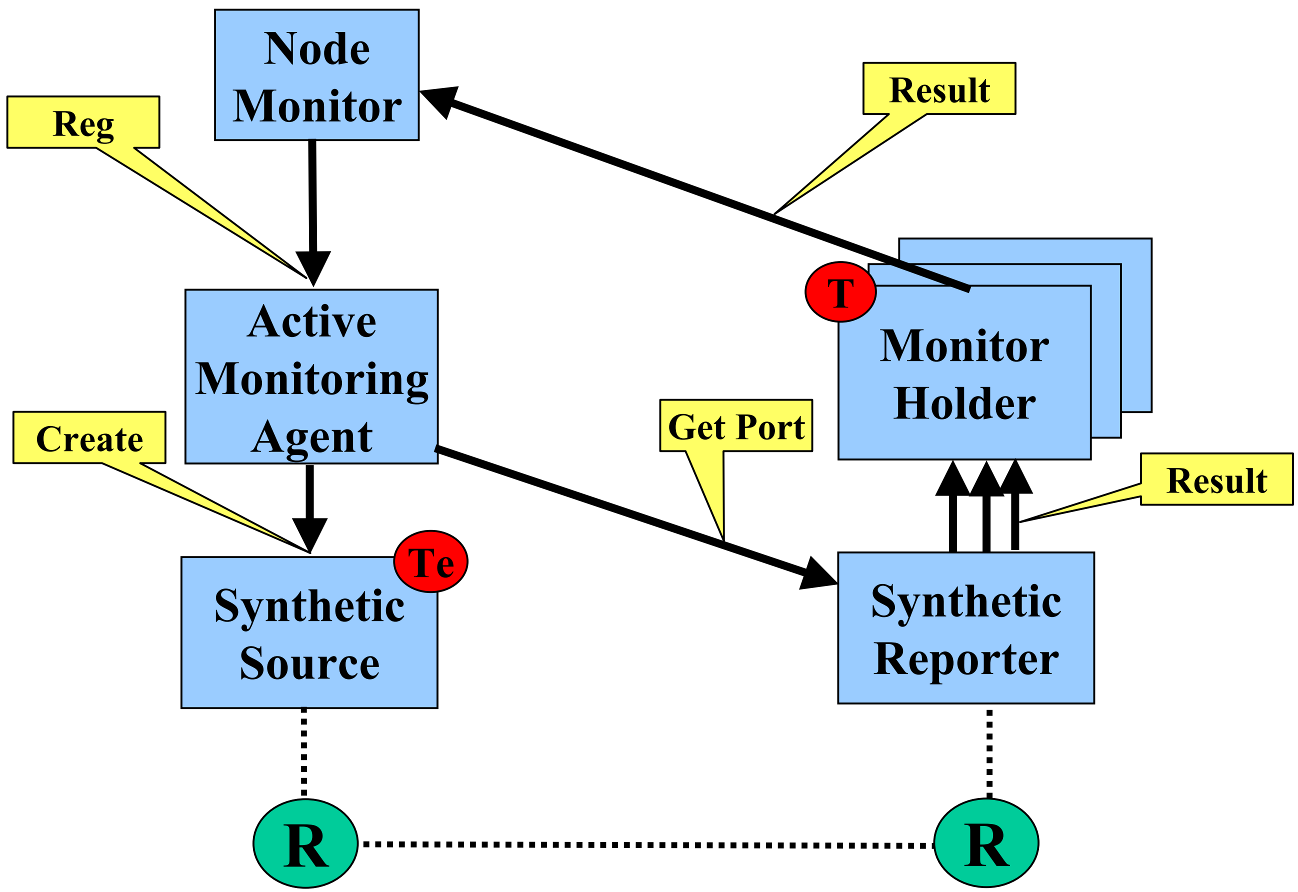
Monitoring Architecture



PMA Passive Monitoring Agent

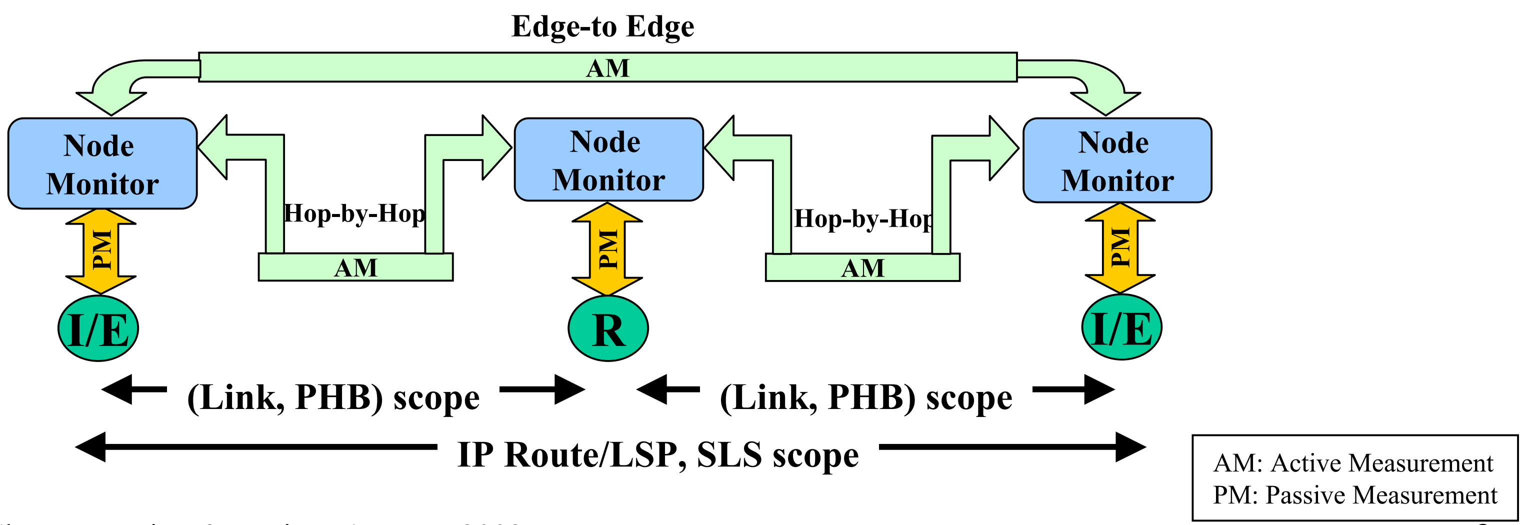
AMA Active Monitoring Agent

Creating an Active Monitor

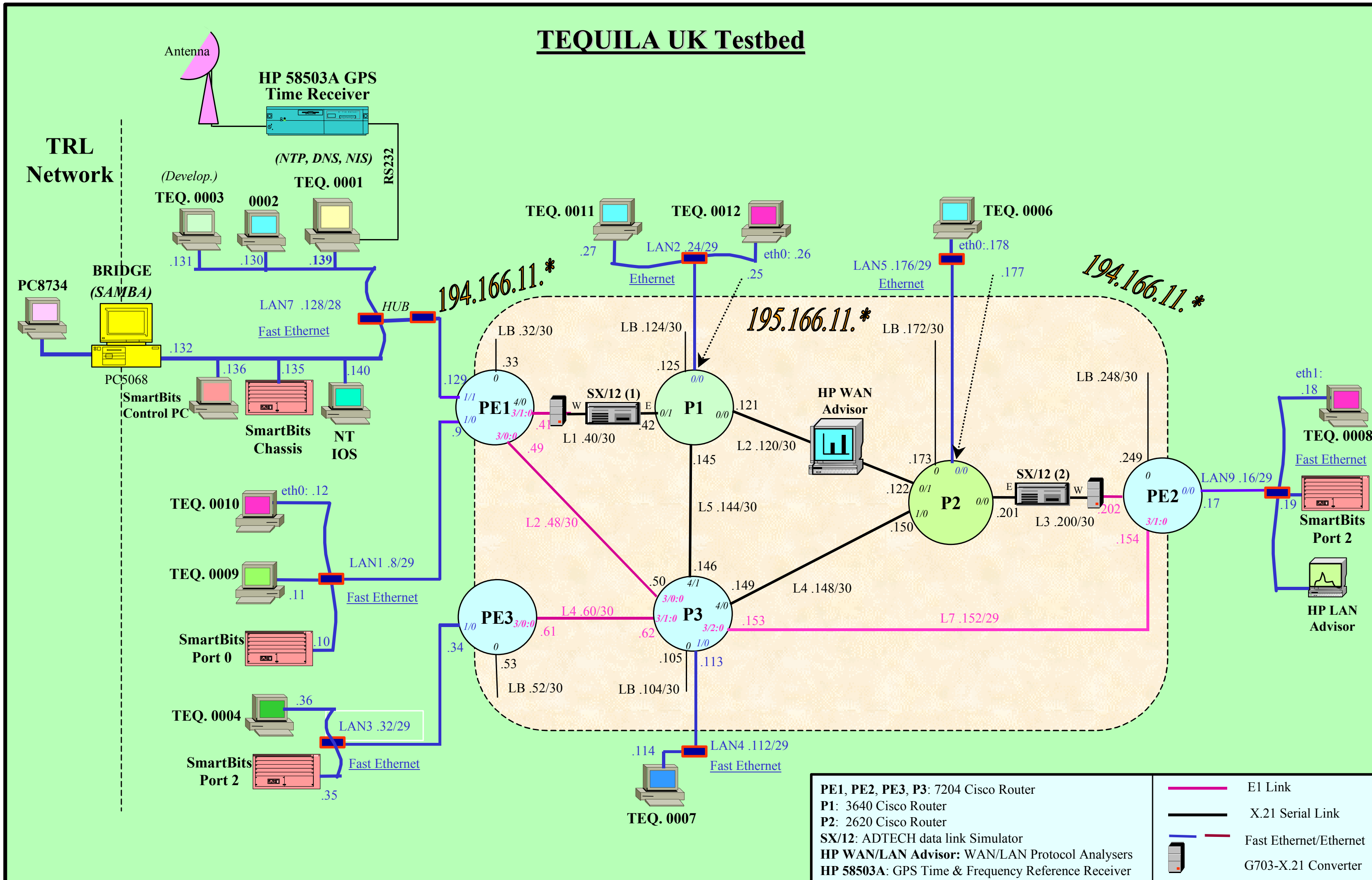


Scalability

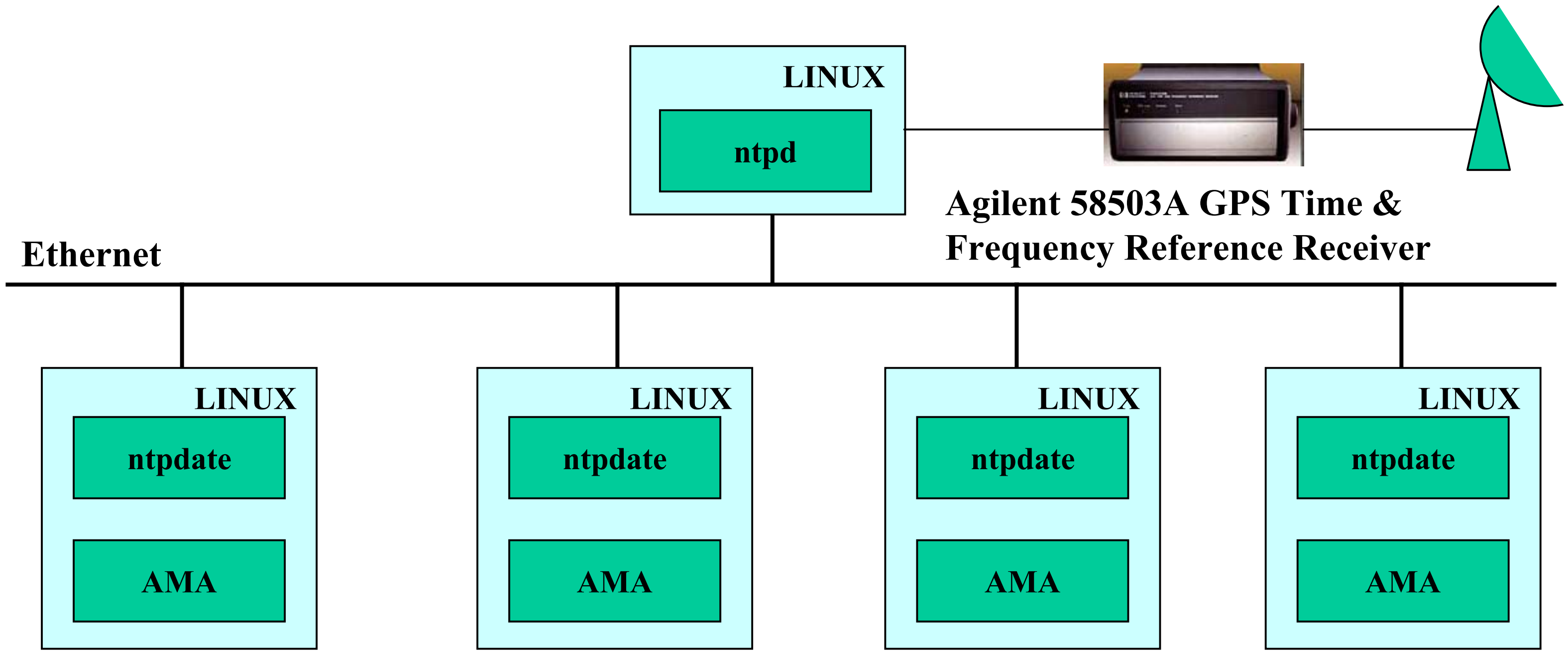
- **SLS Monitor uses Network Aggregate Measurements**
  - Per LSP monitoring is more scalable than per SLS
  - Combine with per-SLS Ingress/Egress measurements
    - throughput / offered load
- **Use Hop by Hop Measurements**
  - Reduce volume of synthetic traffic
  - Aggregate hop measurements to get E2E measurement



UK Testbed


TEQUILA UK Testbed
Antenna
HP 58503A GPS Time Receiver
(NTP, DNS, NIS)
RS232
TRL Network
(Develop.)
TEQ. 0003
0002
TEQ. 0001
.131
.130
.139
PC8734
BRIDGE (SAMBA)
PC5068
.132
LAN7 .128/28
Fast Ethernet
HUB
.136
.135
.140
SmartBits Control PC
SmartBits Chassis
NT IOS
194.166.11.*
195.166.11.*
194.166.11.*
TEQ. 0011
TEQ. 0012
.27
LAN2 .24/29
eth0: .26
Ethernet
.25
TEQ. 0006
eth0:.178
LAN5 .176/29
Ethernet
.177
LB .32/30
.33
LB .124/30
.125
LB .172/30
LB .248/30
.129
PE1
SX/12 (1)
P1
L1 .40/30
.41
.42
.121
HP WAN Advisor
L2 .120/30
.145
.9
.49
L2 .48/30
L5 .144/30
.173
.122
P2
SX/12 (2)
L3 .200/30
.201
.202
.150
.249
PE2
LAN9 .16/29
.17
.19
.154
eth1: .18
TEQ. 0008
Fast Ethernet
SmartBits Port 2
HP LAN Advisor
TEQ. 0010
eth0: .12
LAN1 .8/29
TEQ. 0009
.11
Fast Ethernet
SmartBits Port 0
.10
.146
.50
.149
L4 .148/30
PE3
L4 .60/30
.61
.62
P3
.153
L7 .152/29
.34
.53
LB .52/30
.105
.113
LB .104/30
TEQ. 0004
.36
LAN3 .32/29
Fast Ethernet
SmartBits Port 2
.35
.114
LAN4 .112/29
Fast Ethernet
TEQ. 0007
PE1, PE2, PE3, P3: 7204 Cisco Router
P1: 3640 Cisco Router
P2: 2620 Cisco Router
SX/12: ADTECH data link Simulator
HP WAN/LAN Advisor: WAN/LAN Protocol Analysers
HP 58503A: GPS Time & Frequency Reference Receiver
E1 Link
X.21 Serial Link
Fast Ethernet/Ethernet
G703-X.21 Converter

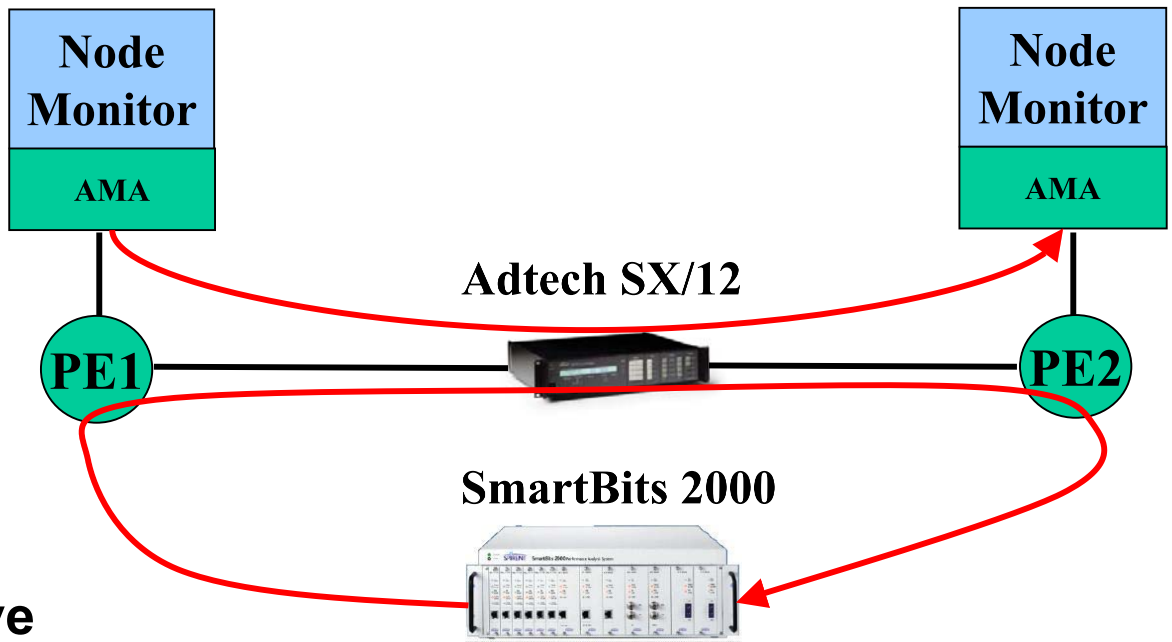
Synchronisation



- **Achieves client synchronisation accuracy of < 1ms**

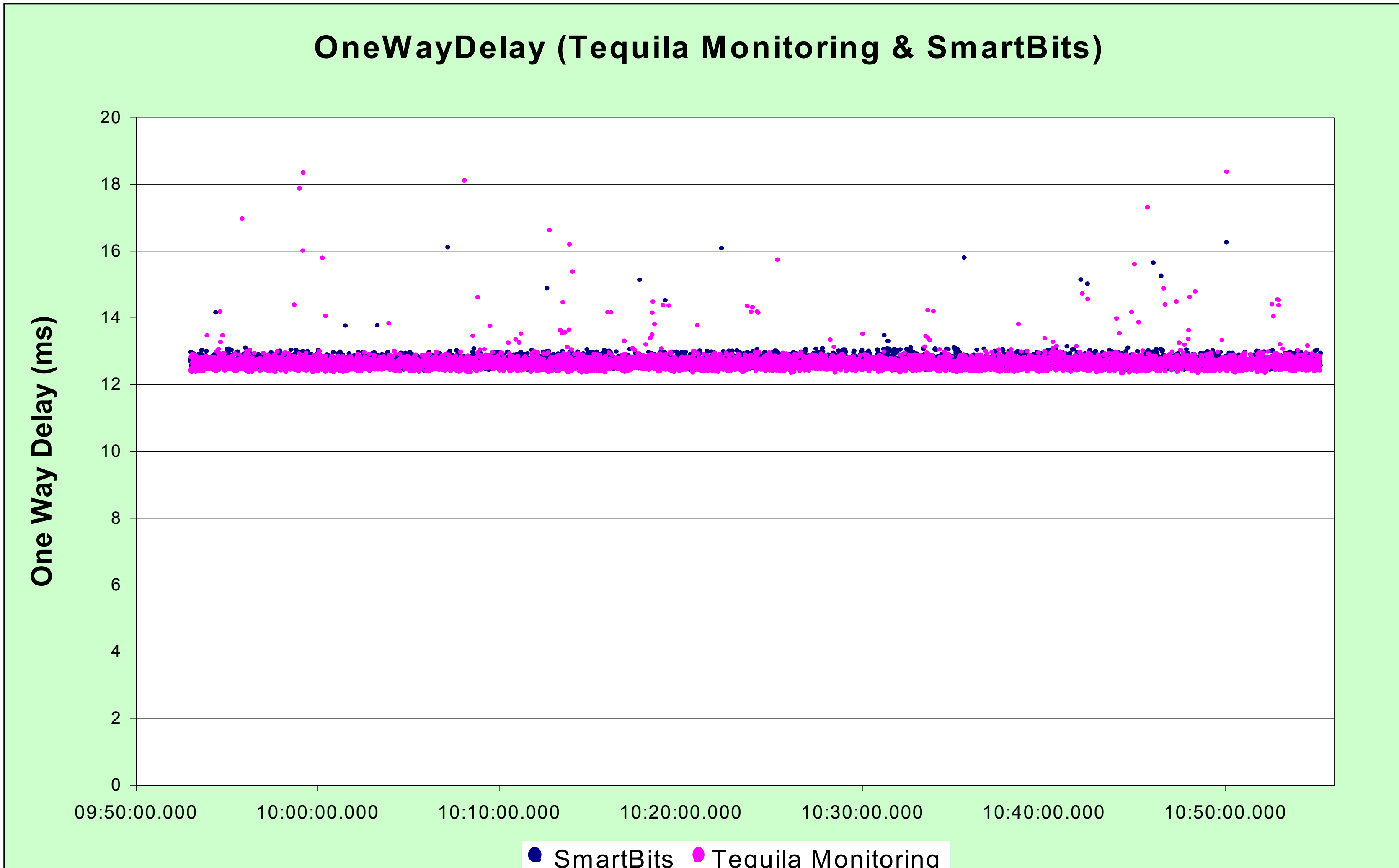
Accuracy Test Set-up

Suite 3_2/GC/Mon/BC/1

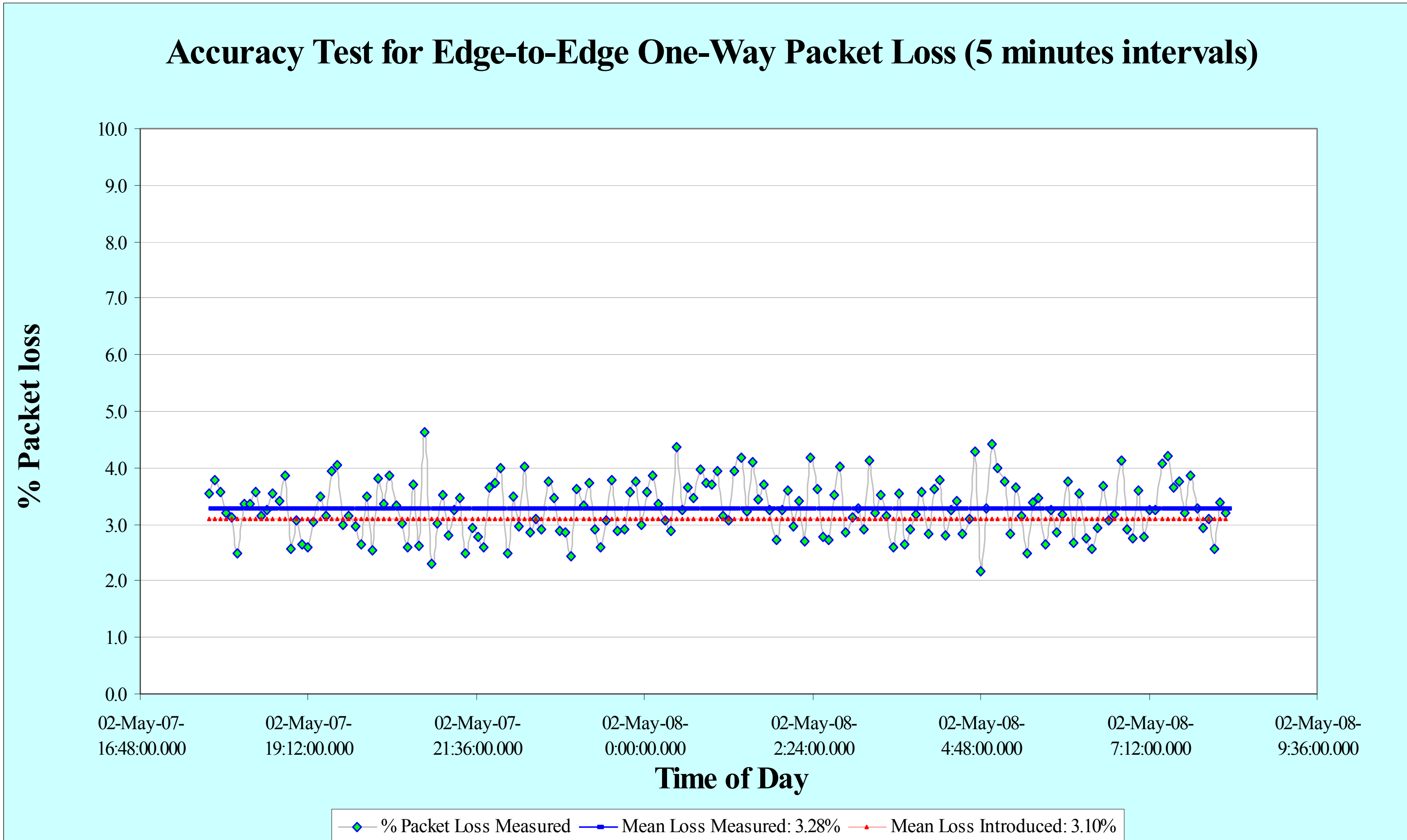


- **Objective**
  - **verify accuracy of active delay and loss measurements**
- **Method**
  - **compare Node Monitor result with SmartBits result (delay)**
  - **compare Node Monitor result with SX/12 (loss)**

One Way Delay



One Way Packet Loss

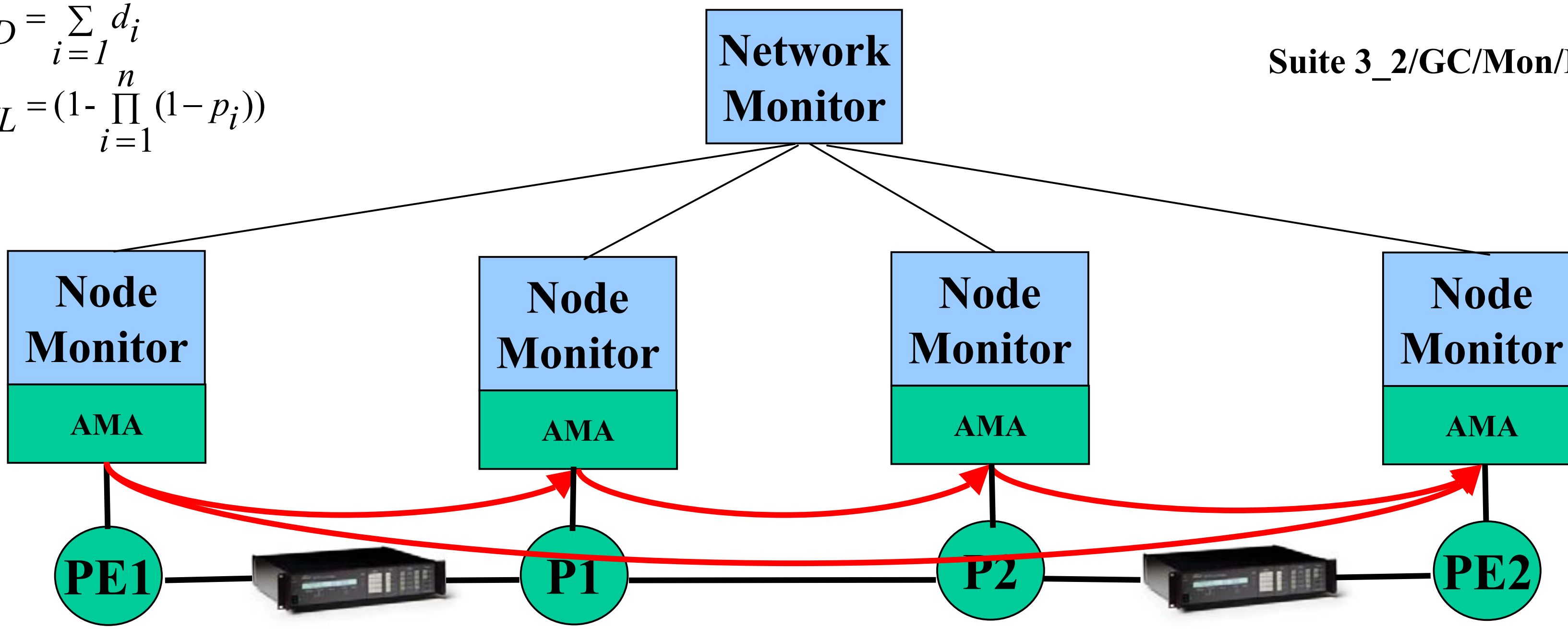


Test Set-up

$$EE_{OWD} = \sum_{i=1}^{n} d_i$$

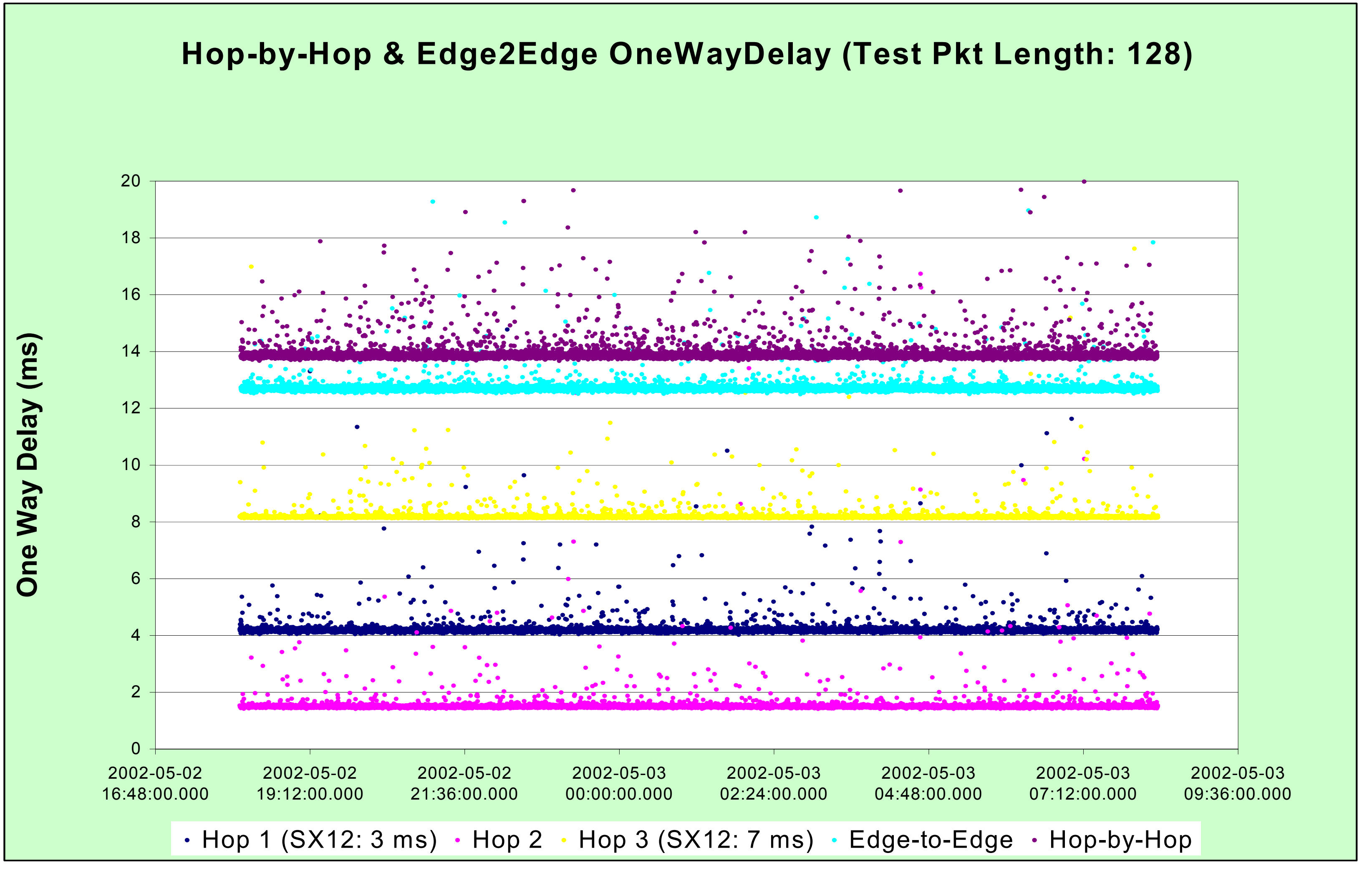
$$EE_{OWL} = (1 - \prod_{i=1}^{n} (1 - p_i))$$

Suite 3_2/GC/Mon/BC/2

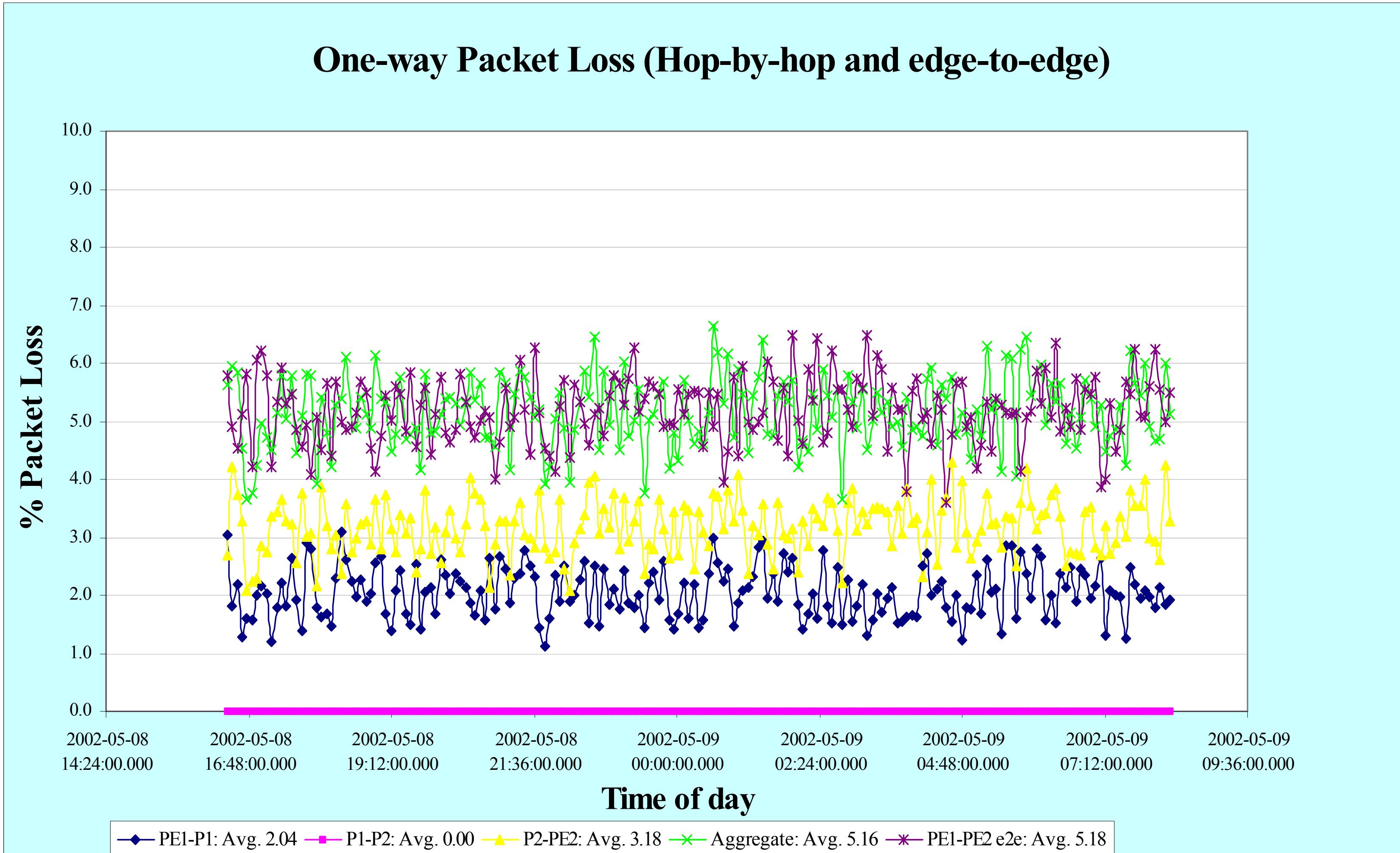


- **Objective**
  - **Compare accuracy of edge2edge with hop by hop measurement**
- **Method**
  - **compare Node Monitor result with SX/12 (delay & loss)**

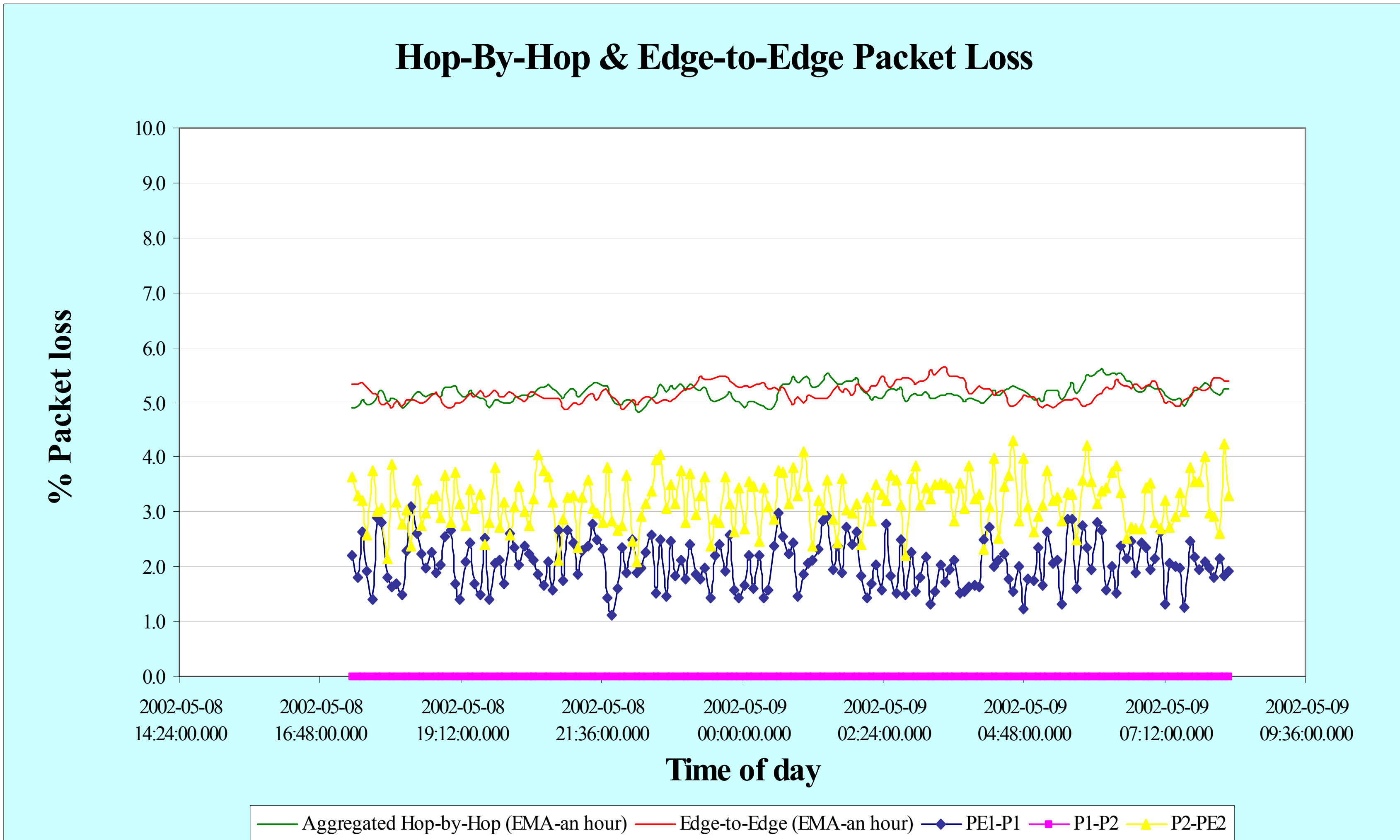
One Way Delay



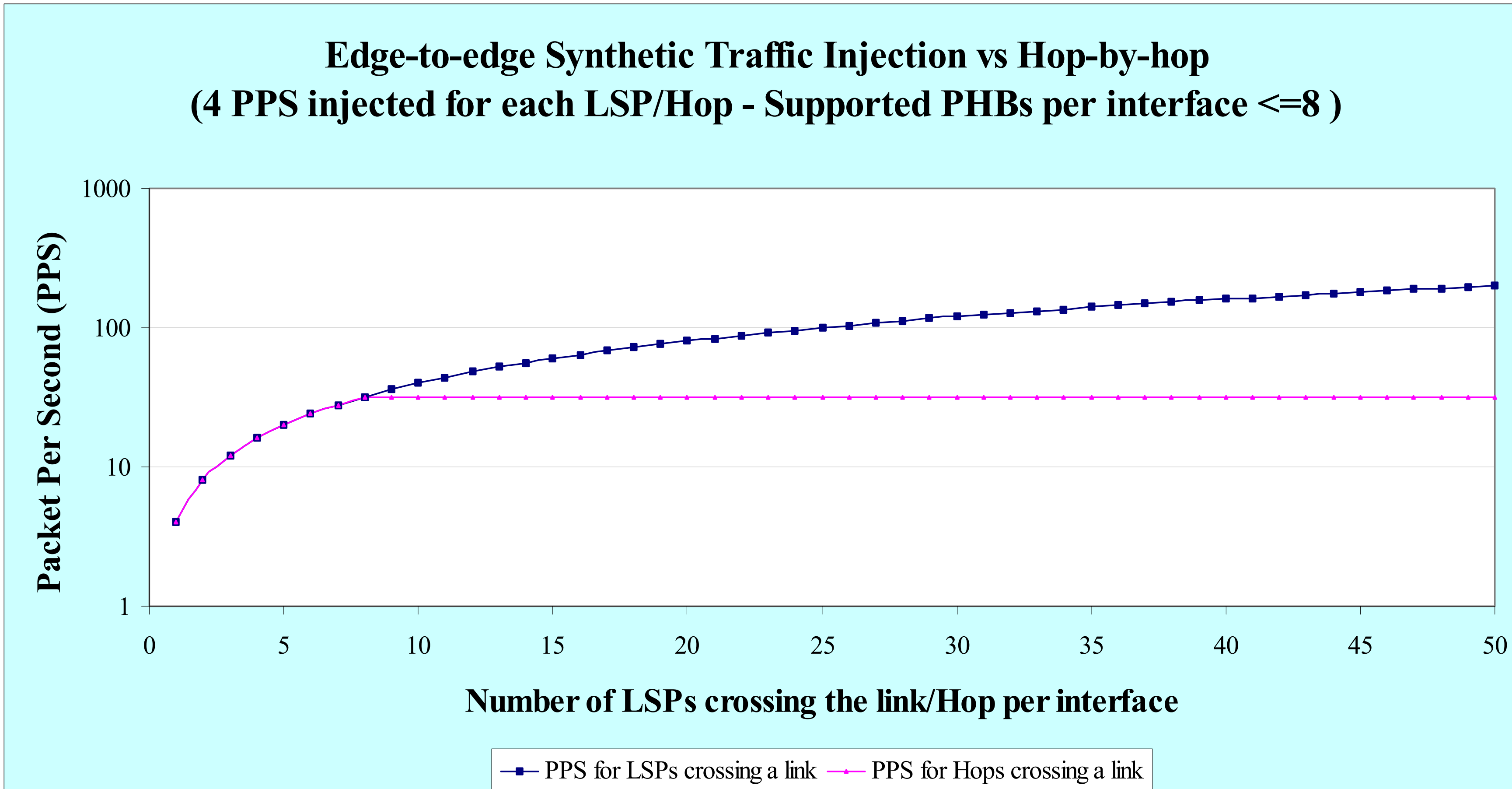
One Way Packet Loss



One Way Packet Loss (EMA)



Scalability



Conclusions

- **Good accuracy for both OWD and OWL**
  - even with agents outside the routers
  - comparable E2E and hop by hop results
- **Scalability claims for hop by hop are justified**
- **OWD results suitable for dynamic operation & SLS Monitoring**
- **OWL results suitable for SLS Monitoring**
  - use passive monitoring of packet discards for dynamic mgt
- **Need for accurate synchronisation of agents**
  - higher cost for hop by hop approach

Enforcing an IP TE policy

Christian JACQUENET
christian.jacquenet@rd.francetelecom.com

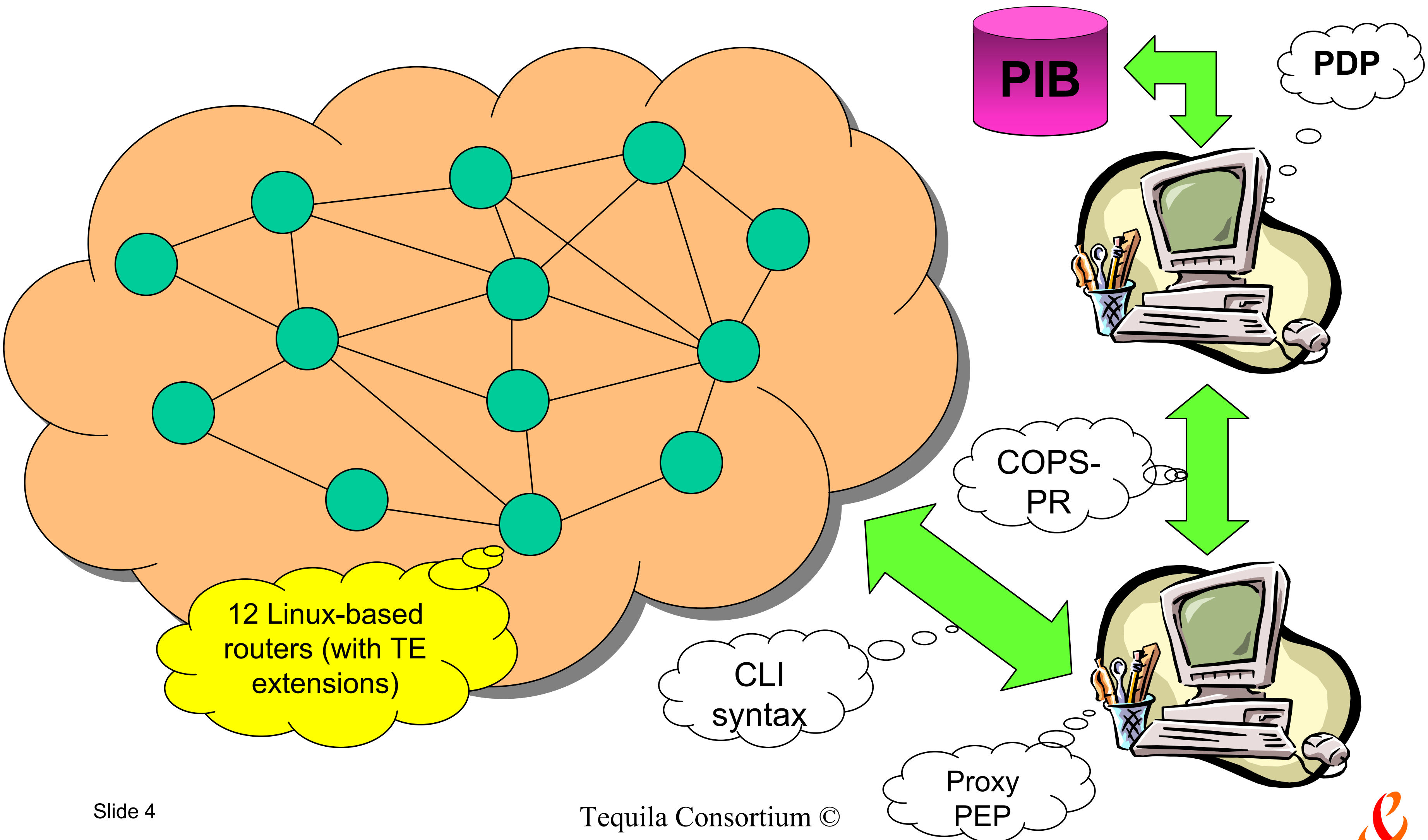
Enforcing an IP TE policy

- Outline:
  - Configuration and testing environment
  - Enforcing an IP TE policy: an example
    - PRC instantiation
    - COPS-PR provisioning of the configuration information
    - Reporting the actions
    - Validation aspects
  - Current restrictions
  - Preliminary performance results

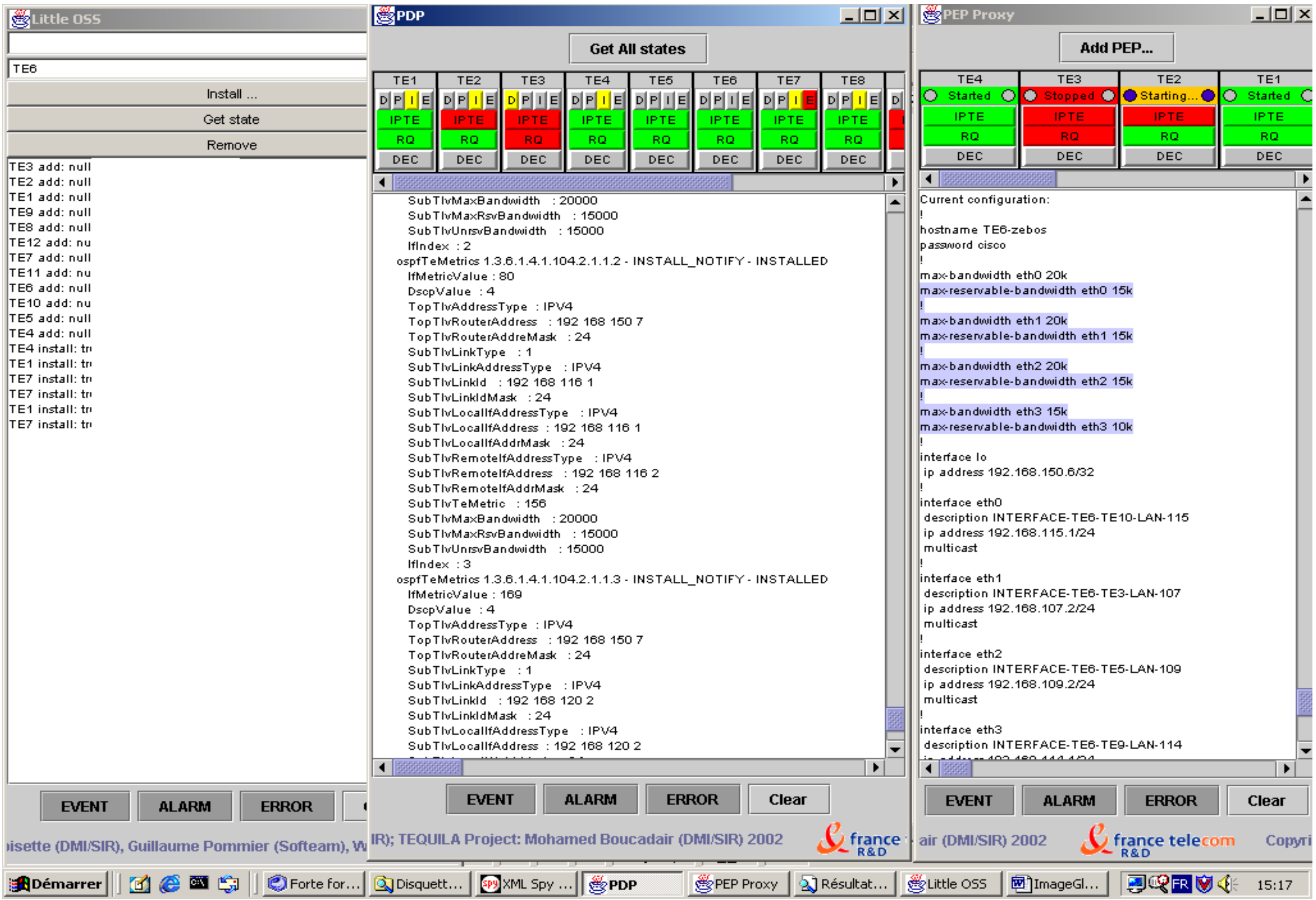
Configuration and testing environment

- Basic components:
  - An XML-based “OSS”
    - For populating the IP TE PIB, based on the manipulation of XML files
  - A PDP for making the decisions
    - *E.g.* modify a TE metric value on a given router interface
  - PEPs for applying the decisions
    - The PEP capability is currently outsourced from the routers
  - OSPF-TE-capable routers
    - Embed a CSPF computation algorithm

Development and testing resources

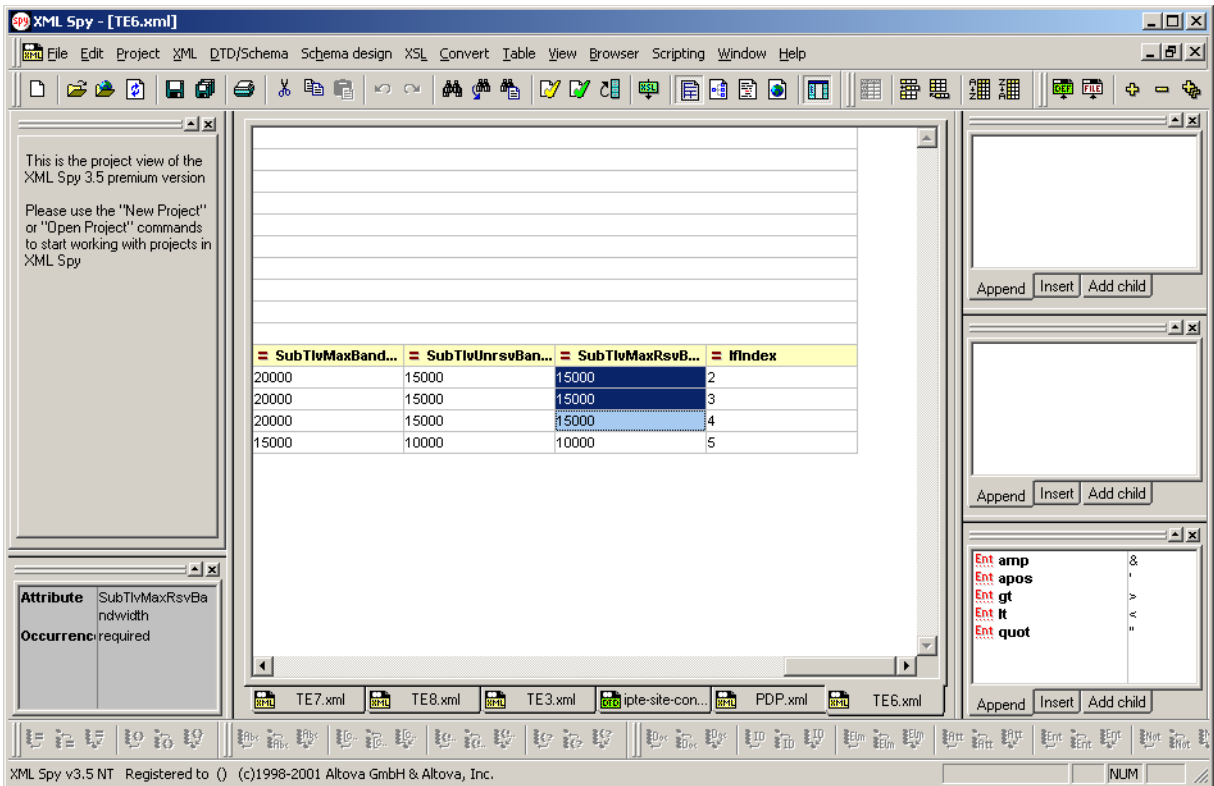


Access interfaces



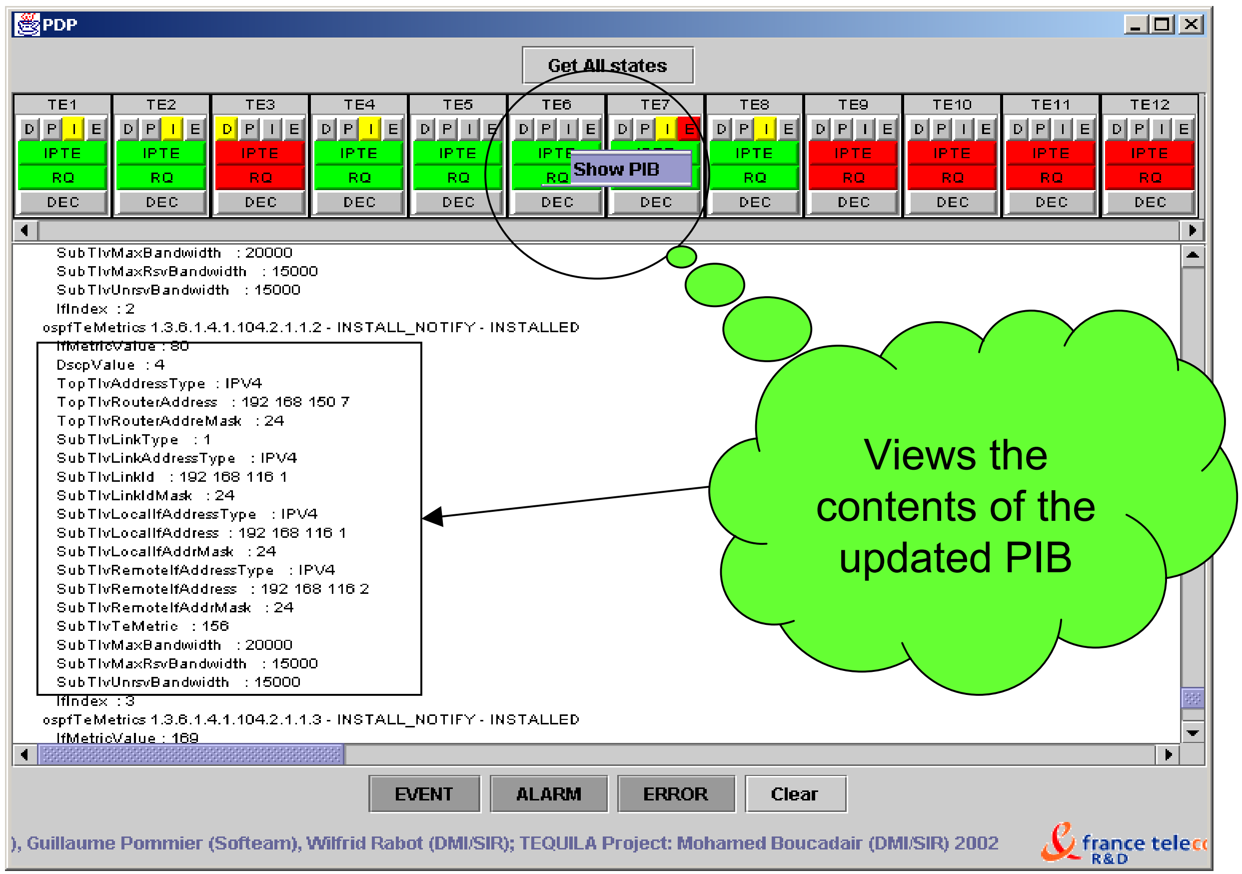
Instantiating a PRC

- According to the IP TE PIB structure
  - *E.g.* modification of the **`ospfTeMetricSubTlvMaxRsvBandwidth`** value



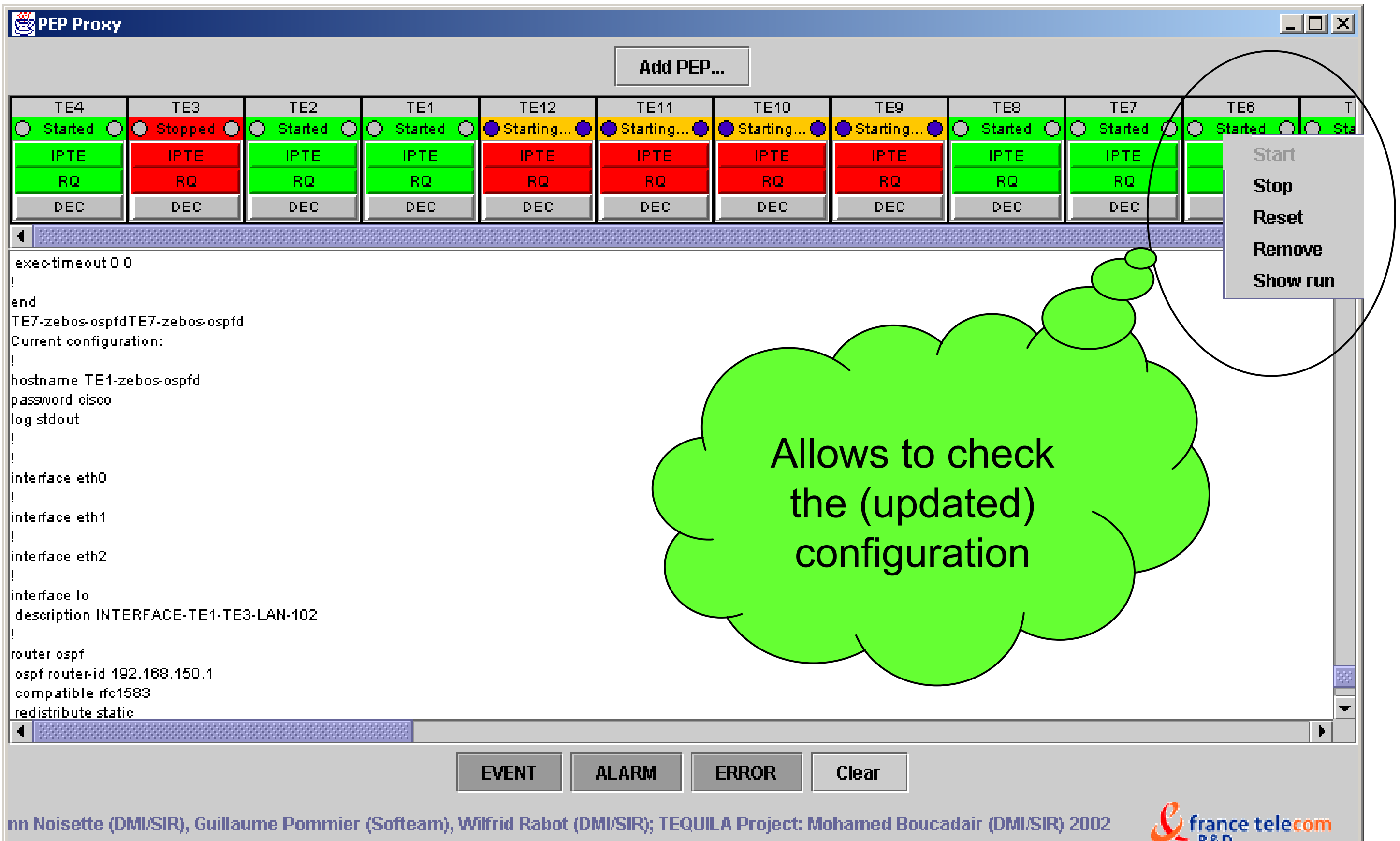
COPS-PR provisioning of the configuration information

- By sending (unsolicited) DEC messages:



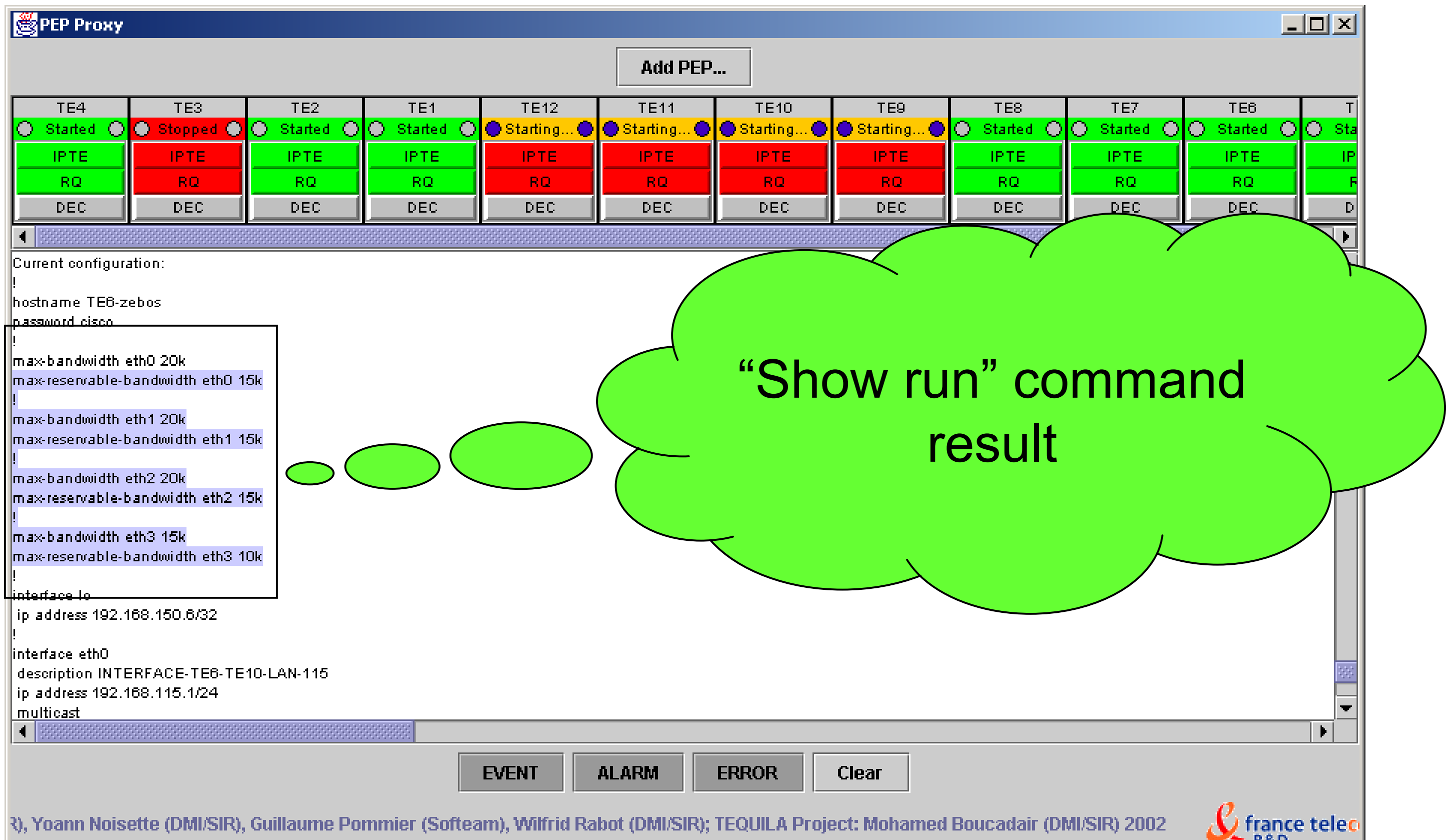
Reporting the actions

- By sending RPT messages towards the PDP:



Validation aspects

- Checking the router's configuration:



Current restrictions

- Syntax correctness is not checked by the current PIB parser
  - Some syntax errors have been detected
- The PEP capability is external
  - Native PEP support available in June

Preliminary performance results

- On the benefits of the COPS-PR approach:
  - Manual configuration of the 12-router platform takes about 1 hour
  - COPS-PR configuration procedure takes less than 5 minutes
- On the support of the TE extensions to OSPF:
  - Negligible impact on the switching performances of the routers
    - Less than 5% on PC-based routers