MESCAL

Management of End-to-end Quality of Service
across the Internet At Large

Agenda

- Delivering QoS-based Services across the Internet:
  "The MESCAL Project"
- The MESCAL Environment:
  Assumptions, Requirements and Business Model
- The MESCAL Approach:
  - Inter-domain Service Model
  - Functional Architecture
  - Inter-AS QoS: The MESCAL Solution

Project partners

- Industrial Partners:
  - France Telecom R&D (PM)
  - Thales Research & Technology
  - Algonet SA
- Academics:
  - University College London
  - University of Surrey

Project objectives

- Basic objective:

> ***To specify and validate scalable, incremental solutions that will enable the flexible provisioning of inter-domain QoS across the Internet***

- Project work plan includes:
  - Specification, development and validation of dynamic service management algorithms
  - Routing protocols enhancements for inter-domain traffic engineering

Collaboration

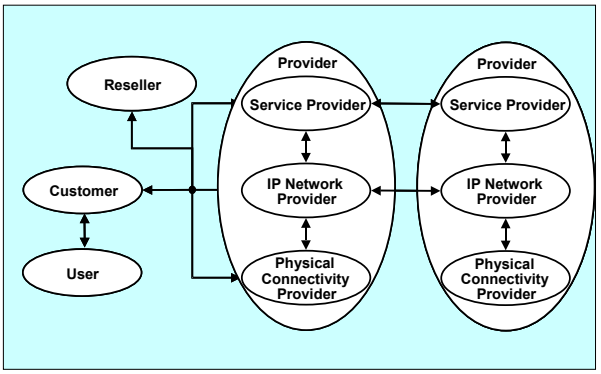
- Equipment Vendors/Solution Providers:
  - Cisco Systems
    - Specification of business models and functional architecture
    - Collaboration during specification phase
    - Cisco evaluation of MESCAL proposals
    - Joint standardisation activities
    - Equipment loan
    - Alpha and beta IOS software
  - Alcatel Bell
    - Collaboration on standardisation

The MESCAL Environment

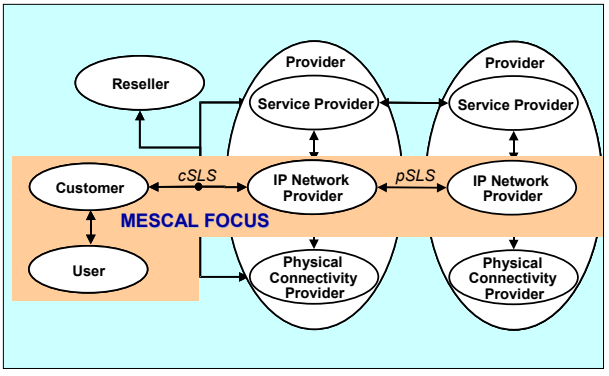
Business Model, Assumptions, and Requirements

MESCAL Business Model

- MESCAL Business Model specifies:
  - The stakeholders involved in the chain of QoS-based service delivery
  - The relationships between customers and providers & between providers.



MESCAL Focus from Business Perspectives



- MESCAL defines two types of service contracts:
  - **cSLS between customers and providers**
  - **pSLS between providers**

MESCAL Assumptions

- The project assumes:
  - DiffServ-based IP networks, with/without MPLS capabilities
  - Providers' co-operation to set-up QoS capabilities for building an end-to-end QoS delivery chain
  - QoS capabilities of each domain should be defined as a set of well-known performance characteristics
  - Providers enforce their own intra-domain traffic engineering mechanisms and routing protocols
  - No particular consideration on the applications that will use the QoS capabilities
  - If a QoS route to destinations is not available, the best effort route may be used as an alternative.

Customer & Provider Requirements

"Any proposed MESCAL solution for an end-to-end QoS delivery system must satisfy the requirements of both customers and providers."

- The customer and provider requirements are drawn from:
  - Best current business practises
  - Market needs

Customer Requirements

- The customer would like to be able to:
  - Request qualitative/quantitative QoS guarantees for value-added services
  - Dynamically subscribe/unsubscribe to QoS services
  - Invoke QoS-based services explicitly or implicitly
  - Send/receive QoS-enabled traffic to/from any/specific destinations in the Internet
  - Assess and verify the fulfilment of the requested service.

Provider Requirements (1)

- The provider requires to:
  - Extend the geographical scope its QoS-based service offering across multiple domains
  - Find quickly the appropriate providers for expanding the scope of QoS-based service offering
  - Have the means for performing pSLS negotiation with other providers
  - Have the means for configuring the network for inter-domain QoS-based service delivery
  - Verify the fulfilment of the both cSLSs and pSLSs contracts.

Provider Requirements (2)

- Any proposed solution must be:
  - Scalable in terms of its performance with regard to the size of domain span, number of QoS classes, number of required pSLSs
  - Manageable and provides automatic network configuration
  - Resilient in the case of failures in order to find alternative QoS path for the impacted destinations
  - Flexible for pSLS management (i.e., pSLS request, establishment, modification, deletion)
  - Easy to deploy
  - Compatible with Intra-domain routing process and have limited impact on the Inter-domain routing protocol.

The MESCAL Inter-domain Service Model

Introduction

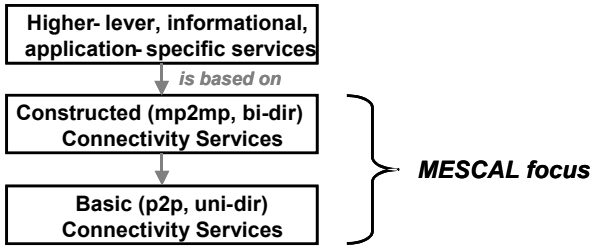
- MESCAL Inter-domain Service Model
  - defines the notions, entities and relationships pertinent to the definition and provisioning of inter-domain QoS-based services
  - presents the basic “service vocabulary” for defining & building such services
  - relies on the QoS Service Model proposed by TEQUILA

cSLSs and pSLSs

- SLS: technical part of a SLA
- Two types of SLSs:
  - *cSLSs* established between customers and providers
  - *pSLSs* established between providers
- SLS operations:
  - establishment of new SLSs
  - modification of existing SLSs
  - termination of established SLSs

MESCAL Service Focus

- Connectivity Services
  - Transport services for reaching particular destination(s) from specific source(s)
- QoS-based Connectivity Services
  - Basic (point-to-point uni-directional)
  - Constructed (multipoint-to-multipoint bi-directional)



QoS Class

- QoS-class (QC)
  - a basic *QoS transport capability* of a provider domain
  - *performance* attributes-value pairs: ordered set {delay, loss, jitter}
  - analogous to the IETF notion of Per-Domain Behaviour (PDB)
- Lexicographical ordering relationship between QoS classes
  - A >= B: A is at least as good as B
  - A > B: A is better than B

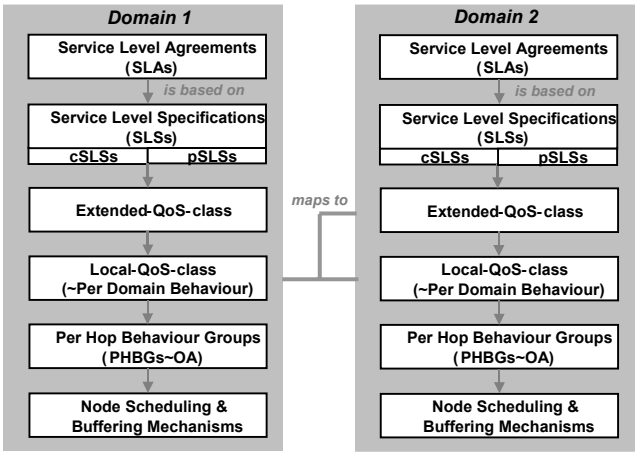
QoS Class Types

- local-QoS-class (l-QC)
  - a QC with the scope of a single provider
- extended-QoS-class (e-QC)
  - a QC which extends across the boundaries of multiple providers
- meta-QoS-class (meta-QC)
  - an abstract well-known QoS-class with standardised parameter values

QoS Class Viewpoints

- offered QC (o-QC)
  - with values as in the actual service offerings
- targeted QC (t-QC)
  - with values set as objectives for engineering the network
- engineered QC (eng-QC)
  - with values resulting from the TE functions that dimension the network
- measured QC (m-QC)
  - measured values during actual network operation
- by definition: o-QC <= t-QC <= eng-QC
  - for a well traffic-engineered network eng-QC <= m-QC

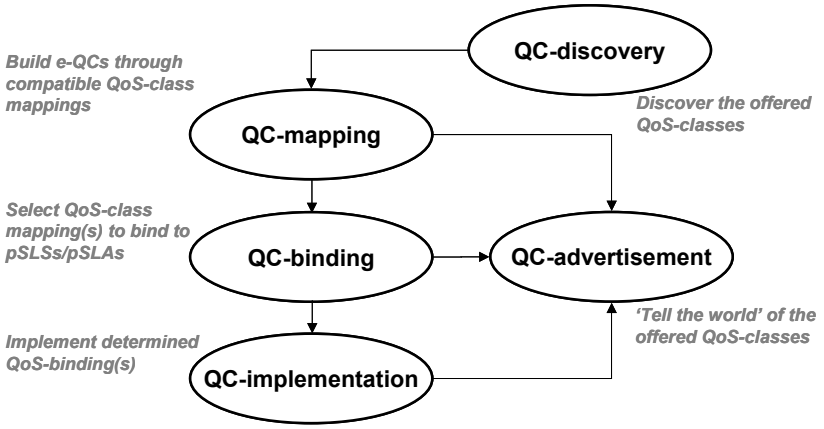
The MESCAL QoS Service Model



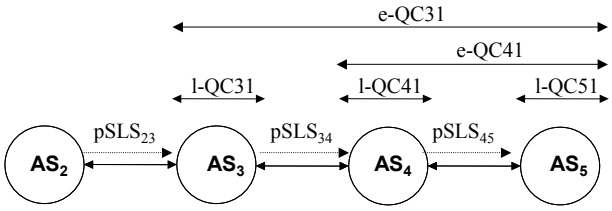
QC Operations for Building Inter-domain QoS-based Services

- QC-advertisement
  - a provider domain informs other providers of its QoS-class capabilities
- QC-discovery
  - a provider domain is able to locate and find out the QoS-classes offered by other provider domains
- QC-mapping
  - a provider domain sees how to build extended-QoS-classes that reach beyond its domain
- QC-binding
  - a provider domain decides which of the possible QoS-mappings determined for building an extended-QoS-class will be used
- QC-implementation
  - a provider domain implements a QoS-binding at the network layer

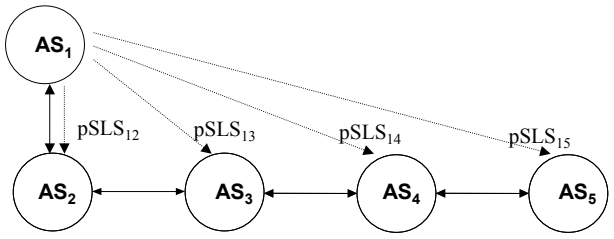
QC operations (cont'd)



Cascaded and Centralised Inter-domain Approaches

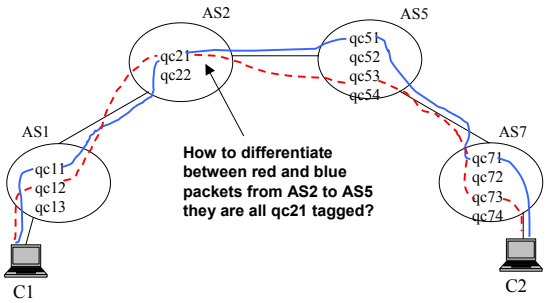


Cascaded Approach – the MESCAL choice



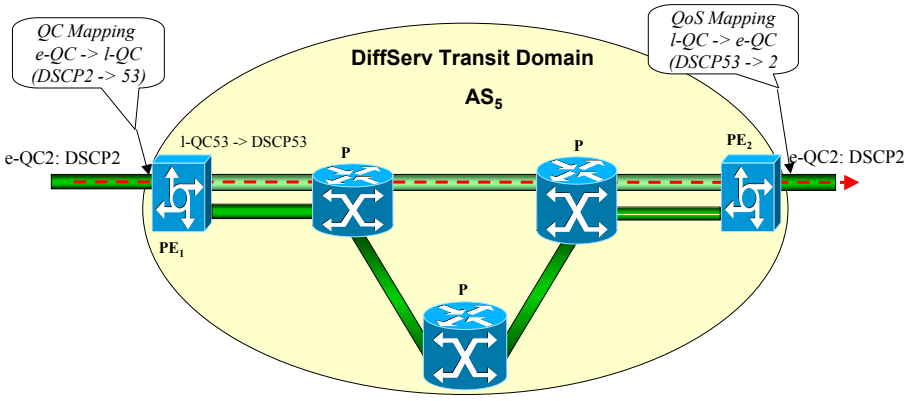
Centralised Approach

The “QC Splitting” Problem



- e-qc2: qc12->qc21->qc53->qc73
- in AS2, qc21 is used for both e-qc1 and e-qc2
- solution: virtual QCs (v-QCs) which use different DSCPs mapped onto the same PHB Group / Ordered Aggregate

Ingress-Egress QC “Signalling”

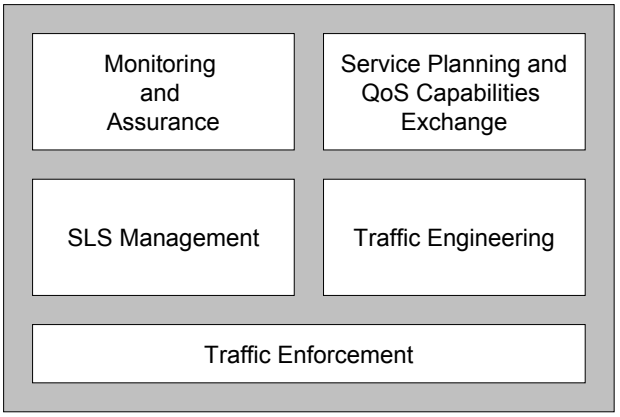


MESCAL Functional Architecture

Purpose of the Functional Architecture

- Decompose overall issue of Inter-domain QoS provision into a finer grained sets of components
  - make problem more manageable: divide and conquer
  - facilitate specification of algorithms and protocols
    - find solutions to smaller problems
    - analyse interactions between components
- Provide guidelines to engineering design task
  - functional blocks are candidate (groups of) engineering blocks
- Implementation-independent description of capabilities and processes required in each provider domain
  - does ***not*** dictate how processes are deployed: provider choice
  - some may be manual processes (at price of flexibility/ responsiveness)
- *Validated* functional architecture is a significant result by itself

Abstract view of MESCAL Functional Architecture



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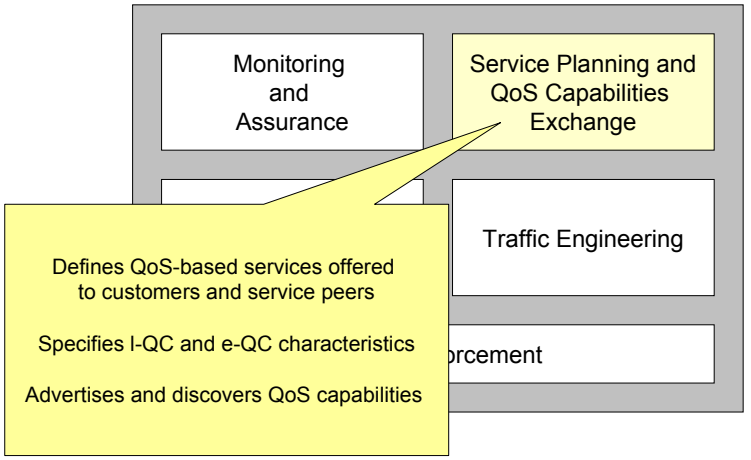

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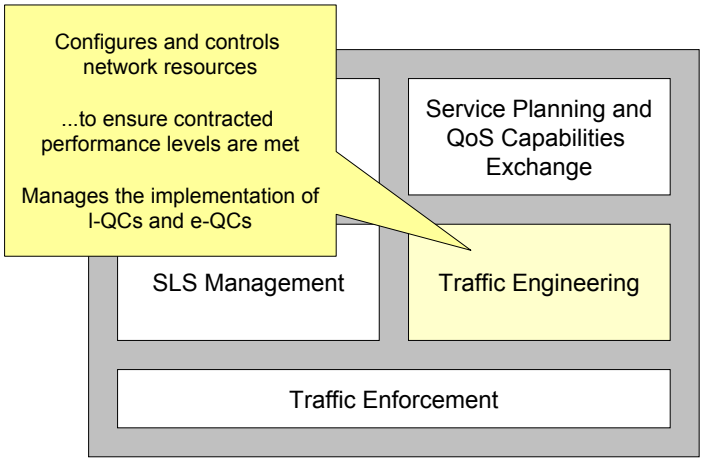

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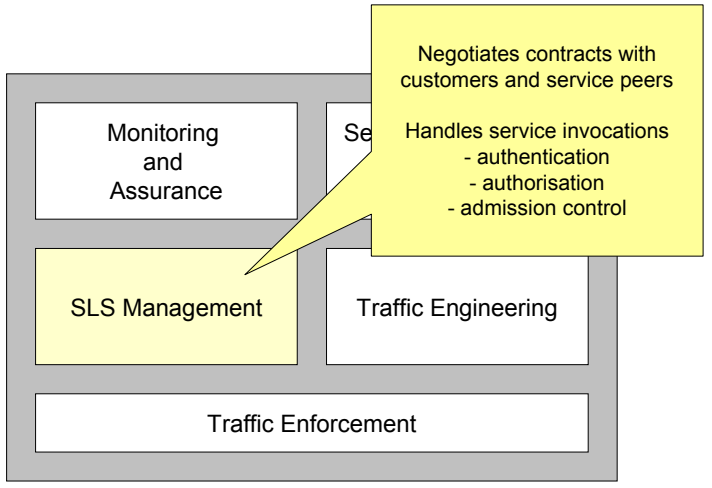

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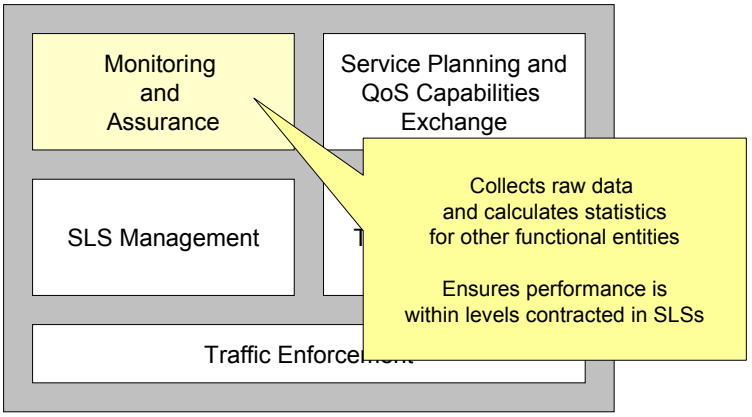

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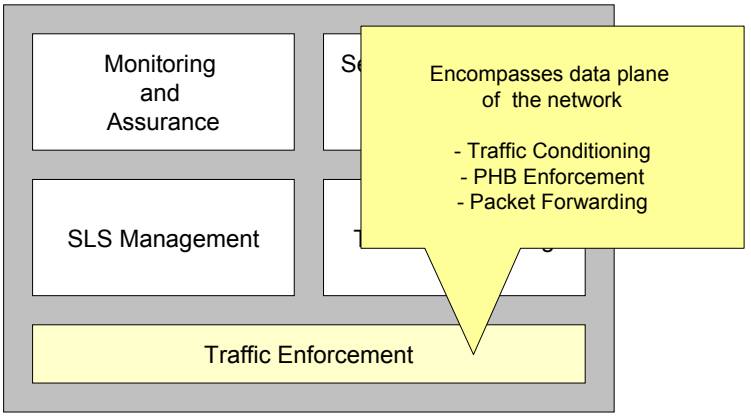
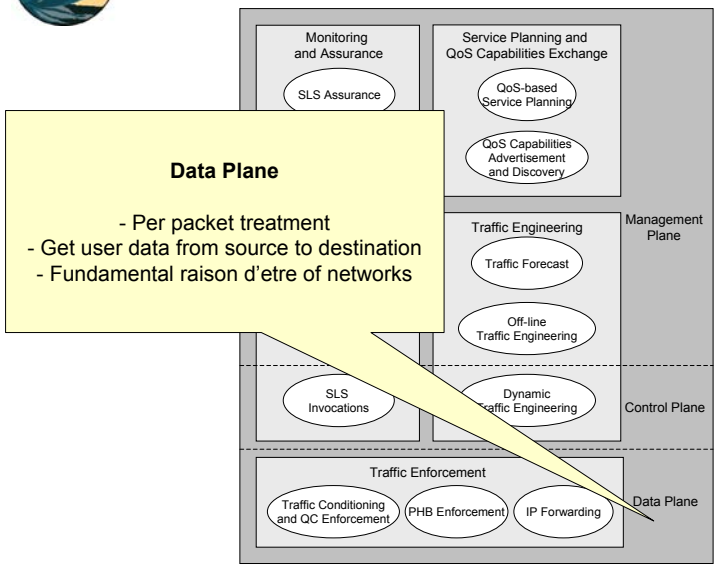


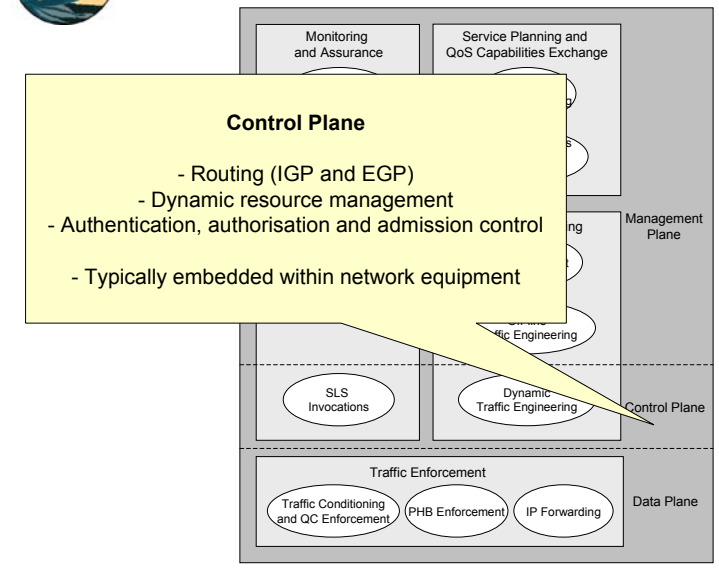
Mapping to Data, Control and Management Planes



Data Plane

- Per packet treatment
- Get user data from source to destination
- Fundamental raison d'etre of networks

Mapping to Data, Control and Management Planes

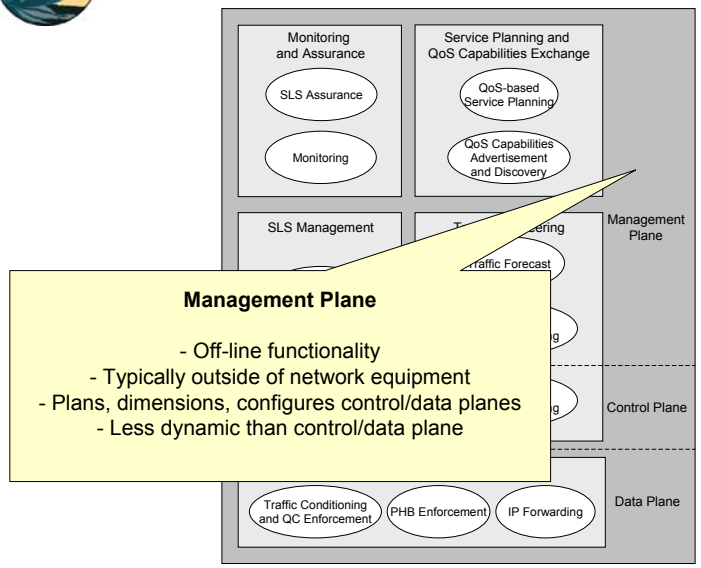


Control Plane

- Routing (IGP and EGP)
- Dynamic resource management
- Authentication, authorisation and admission control

- Typically embedded within network equipment

Mapping to Data, Control and Management Planes



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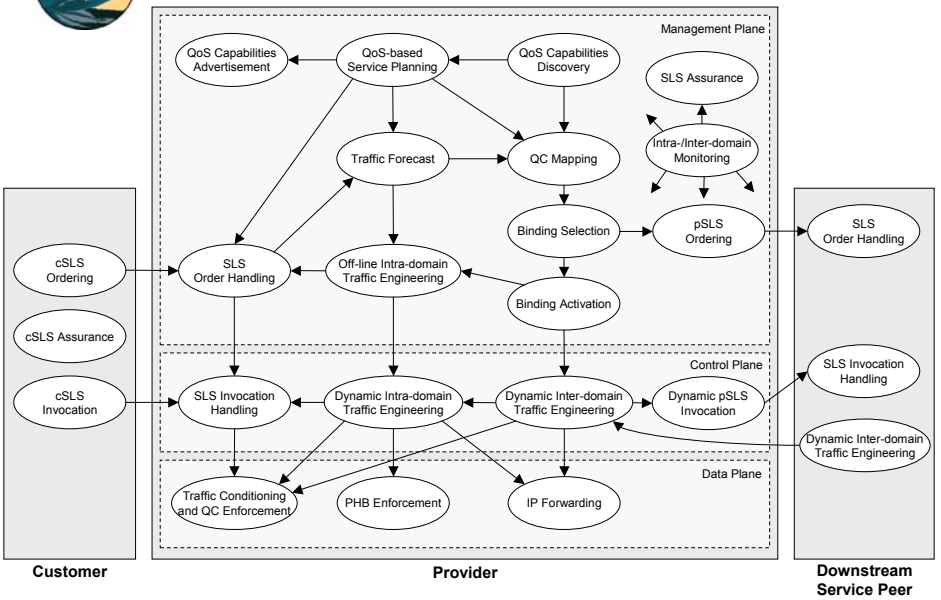

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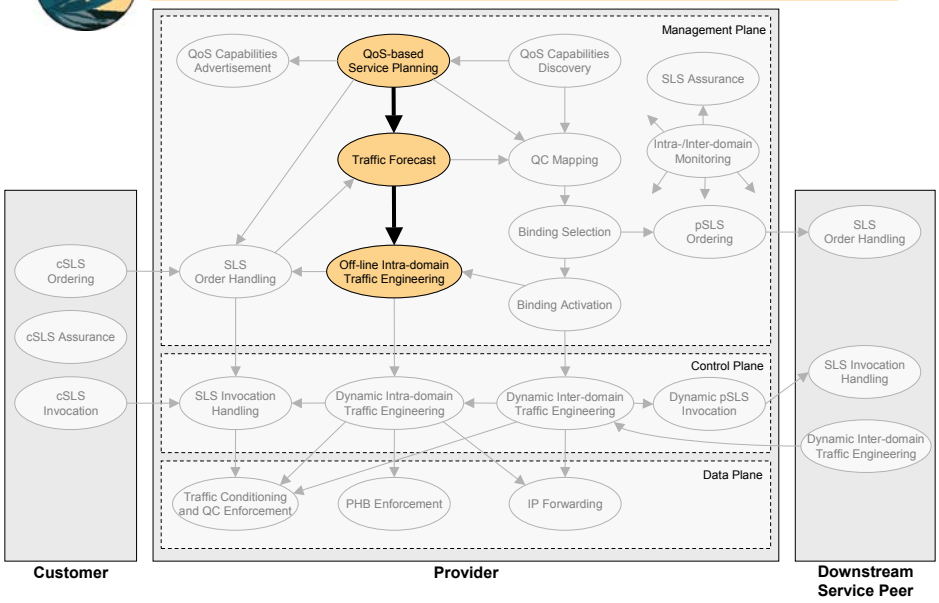

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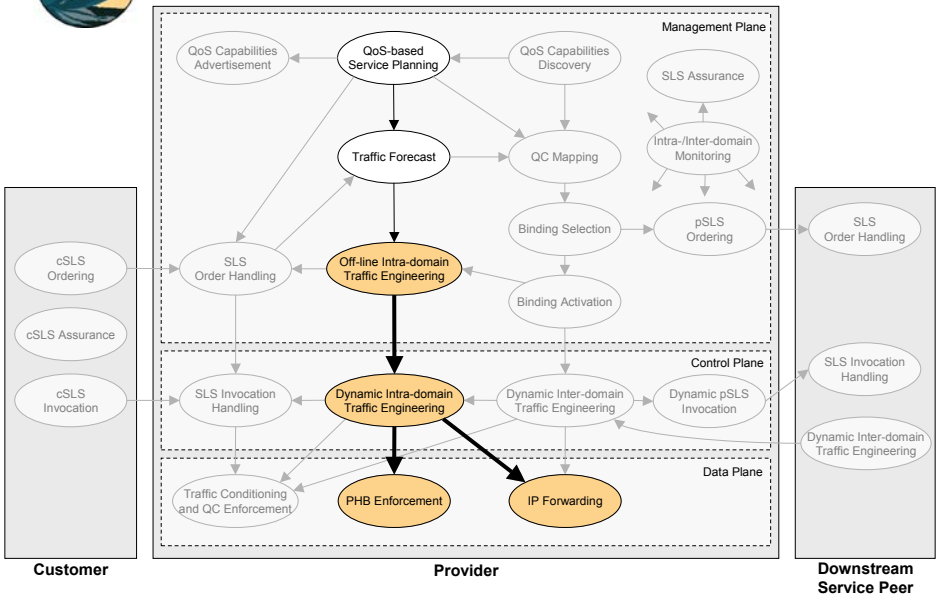

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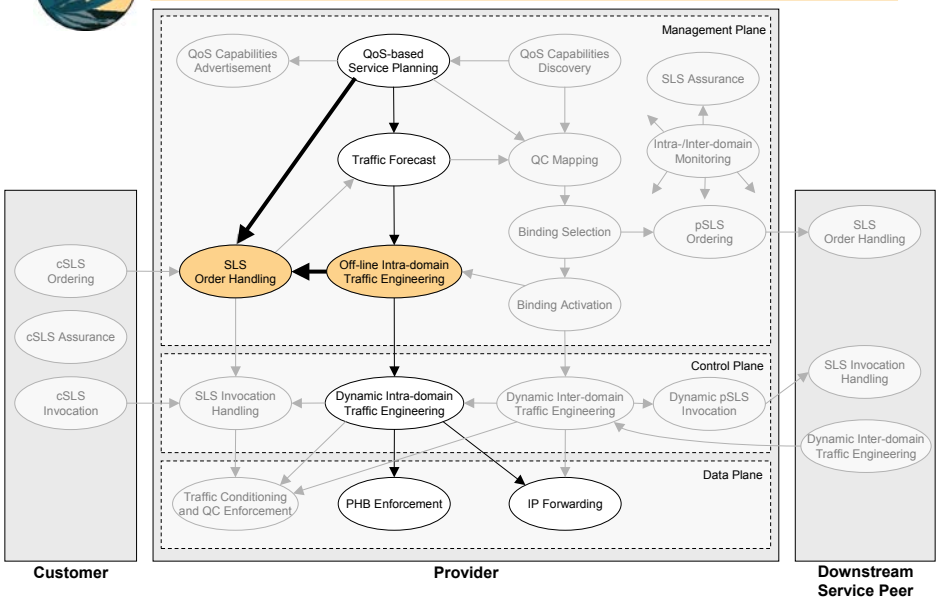

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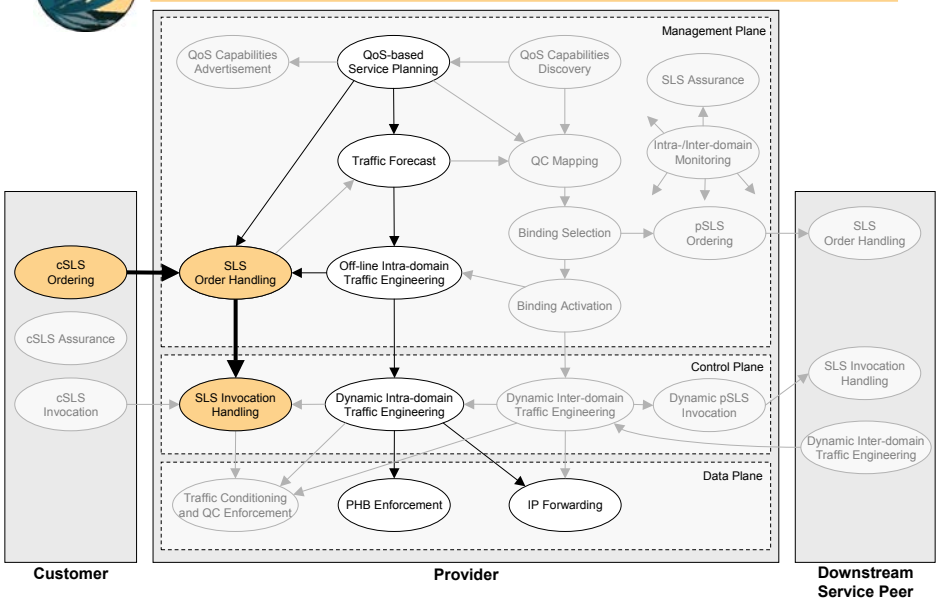

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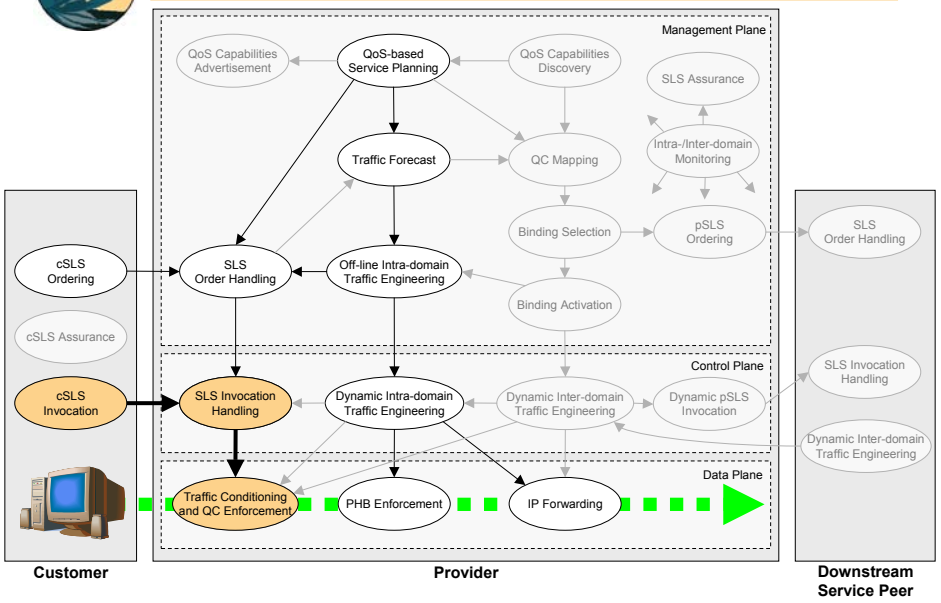

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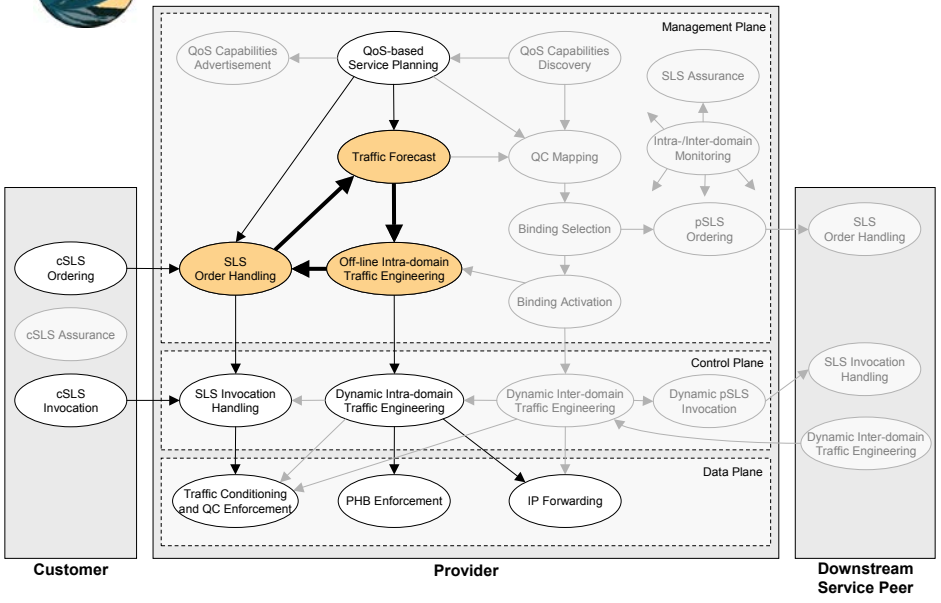

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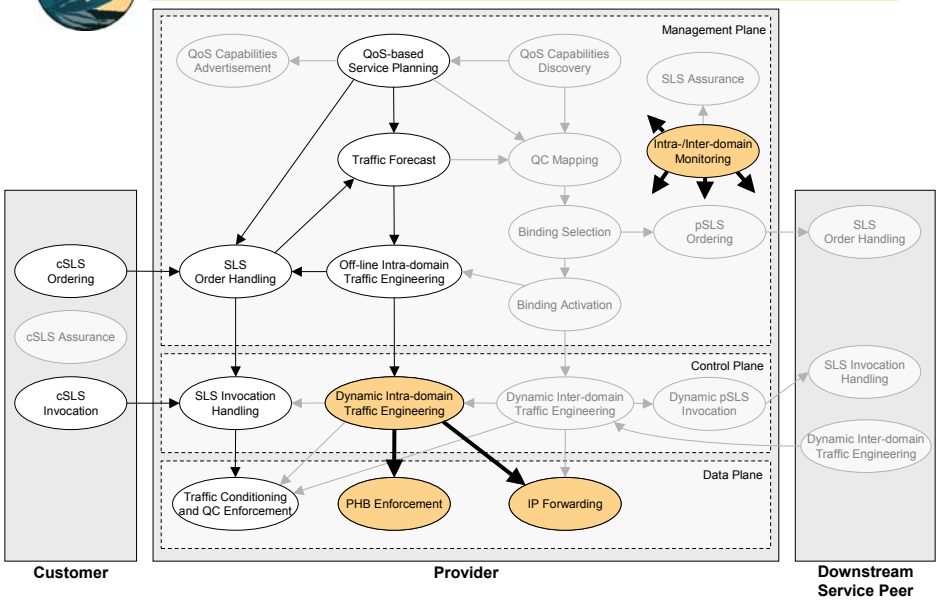

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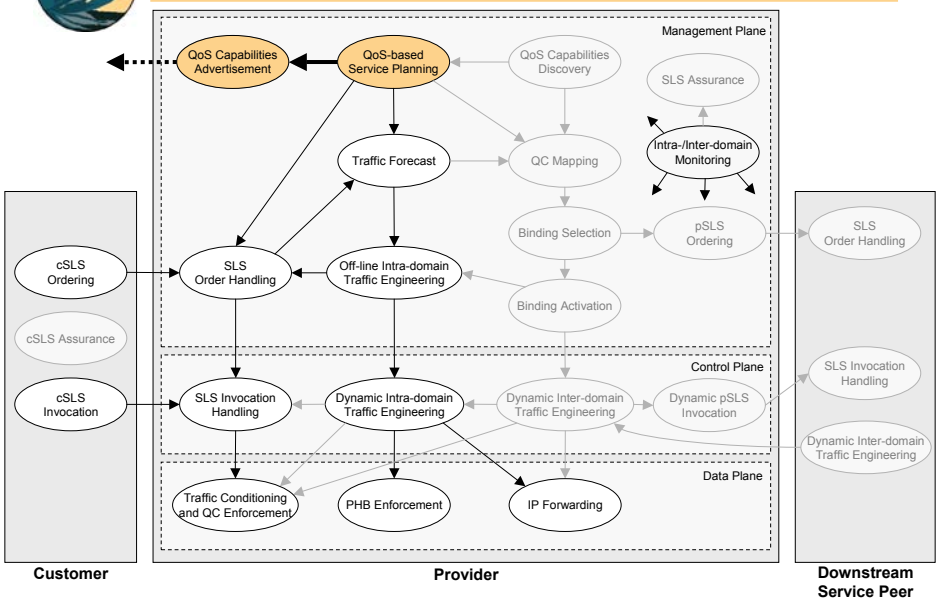

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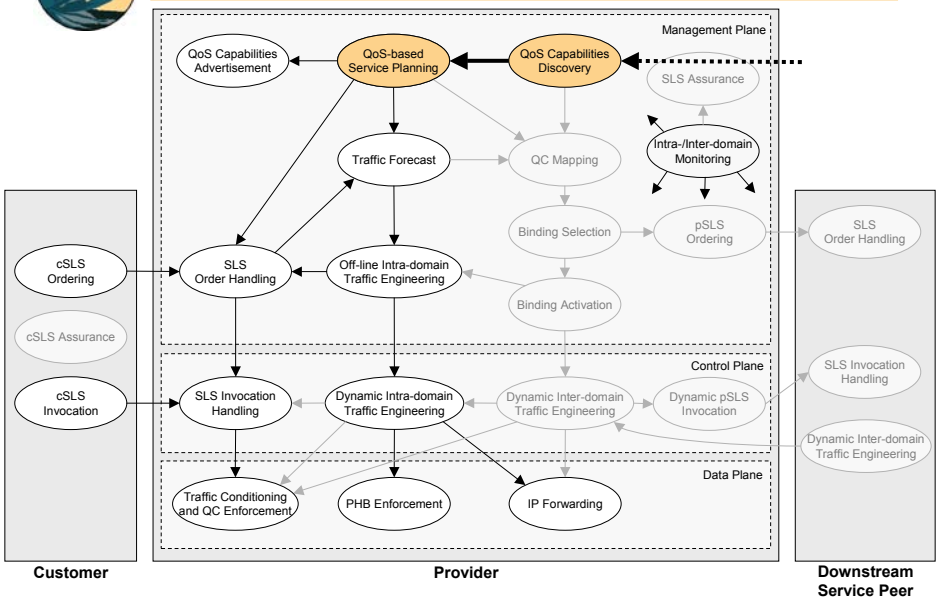

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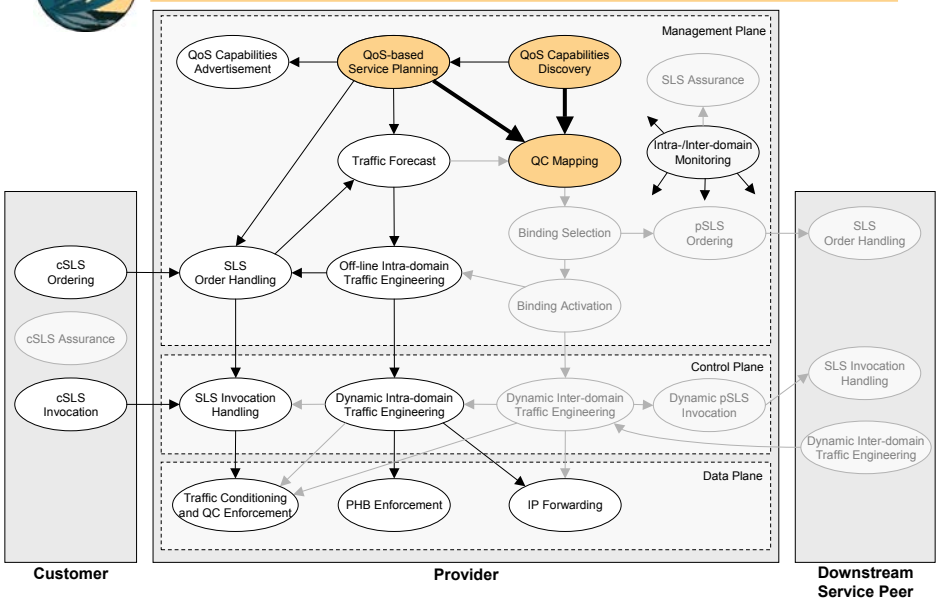

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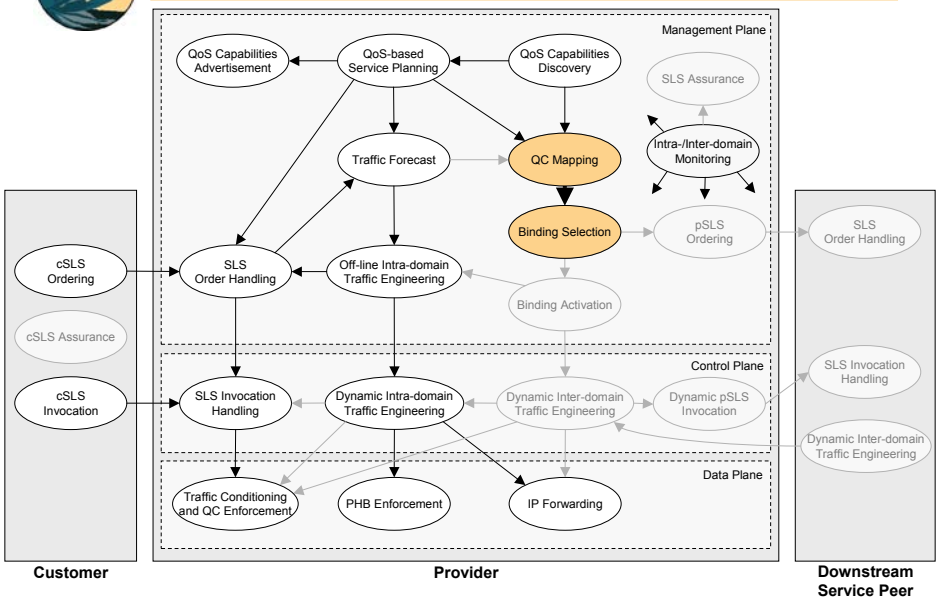

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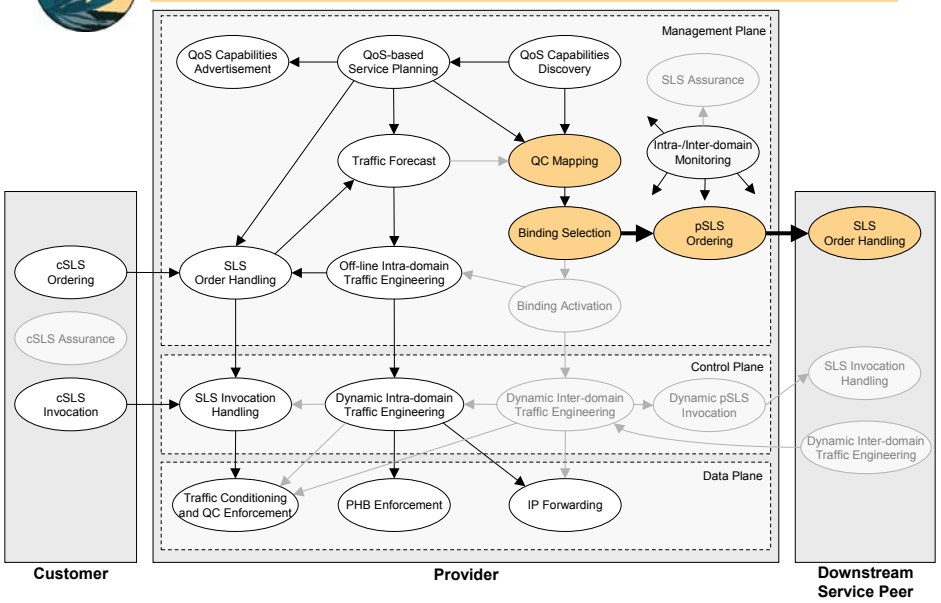

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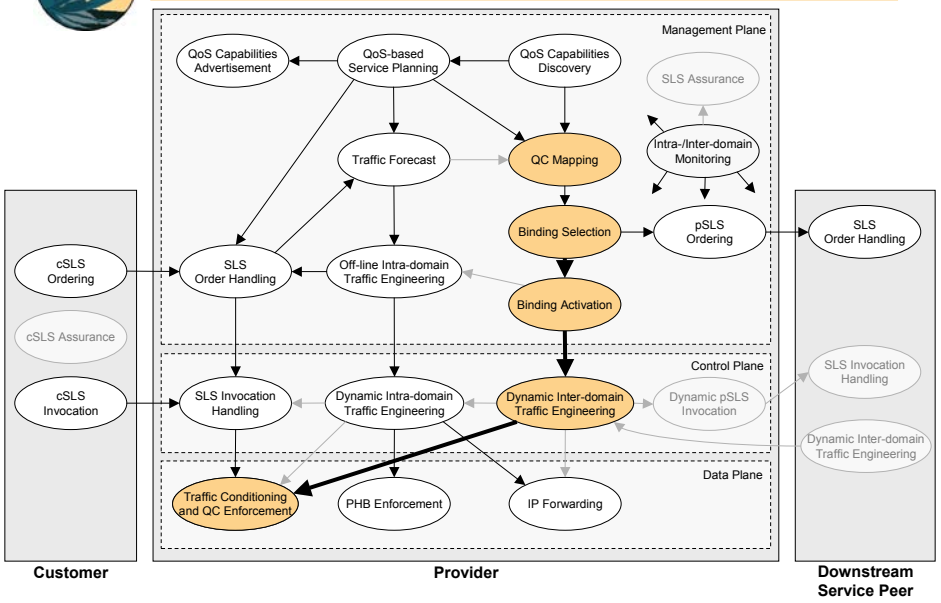

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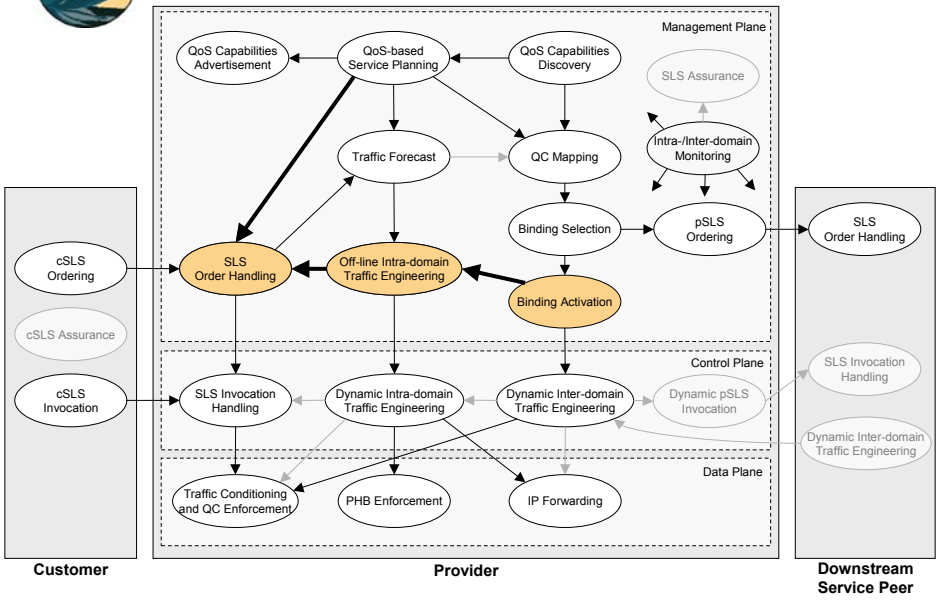

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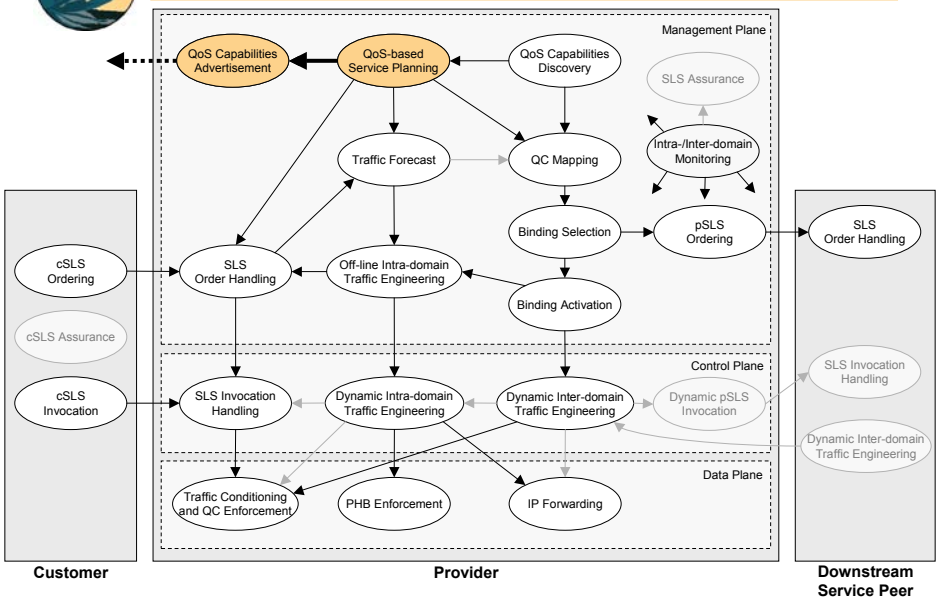

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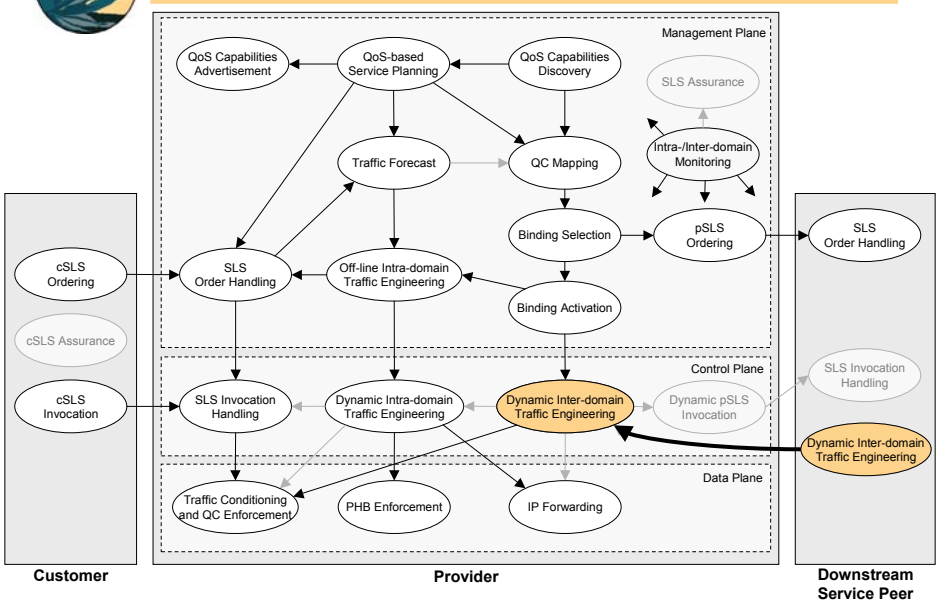

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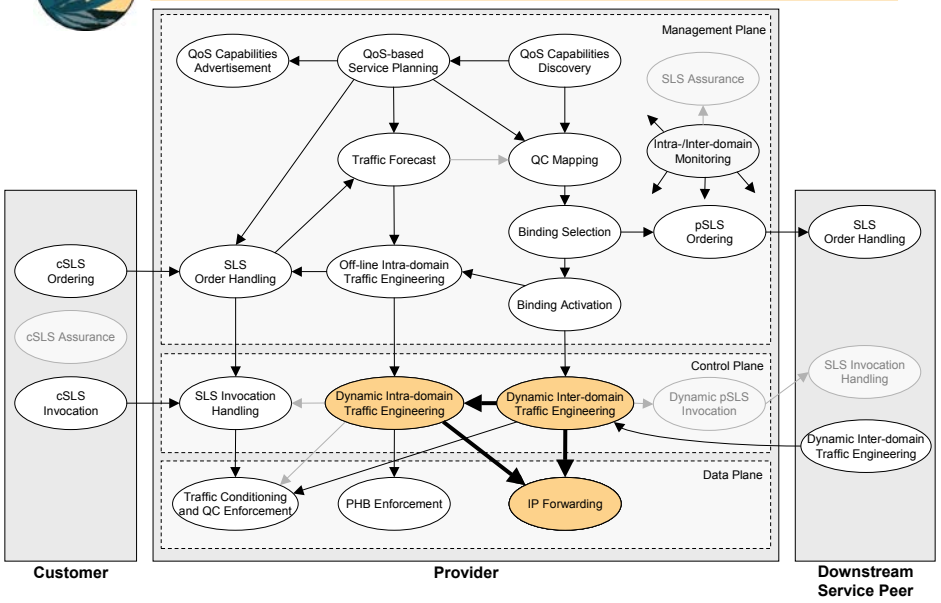

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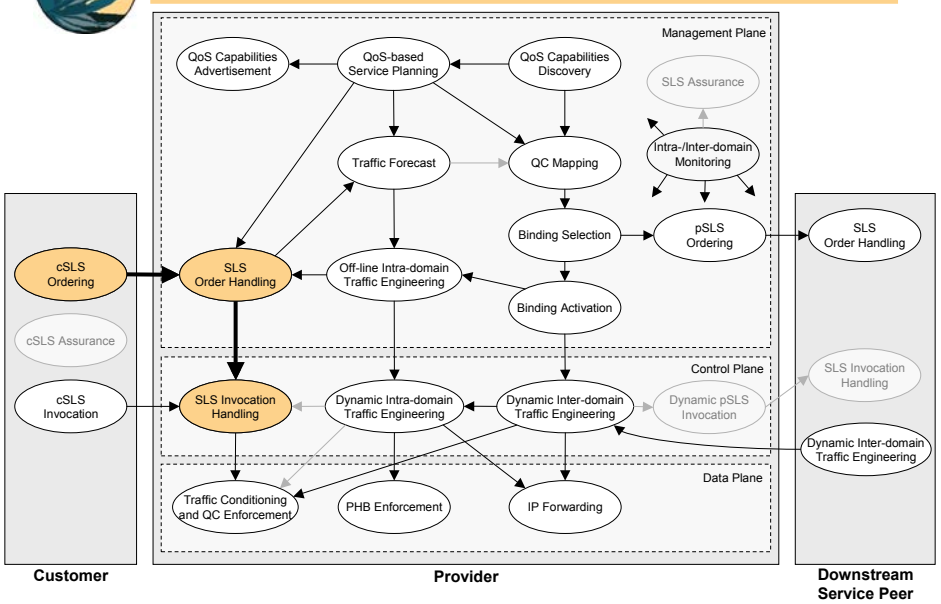

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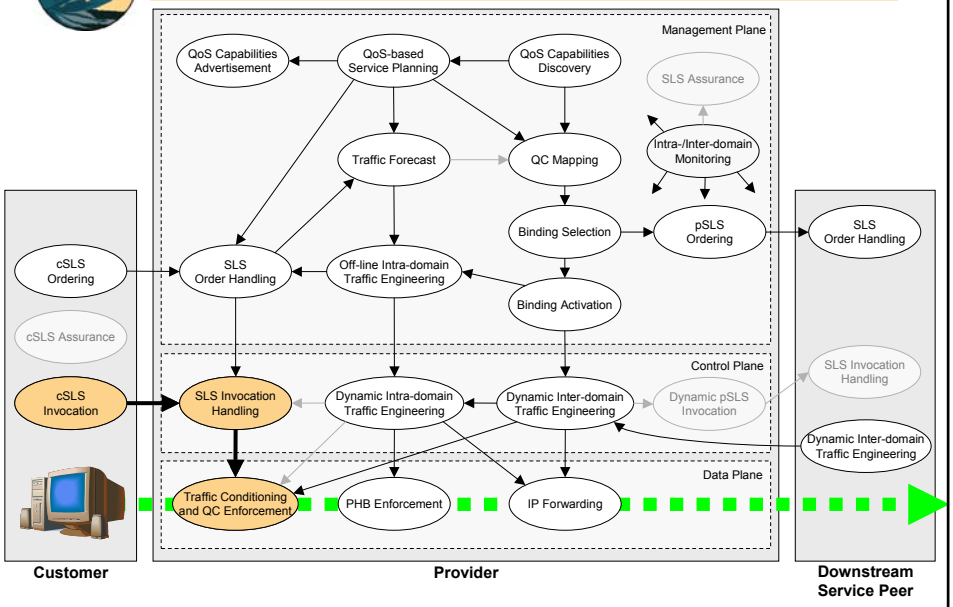

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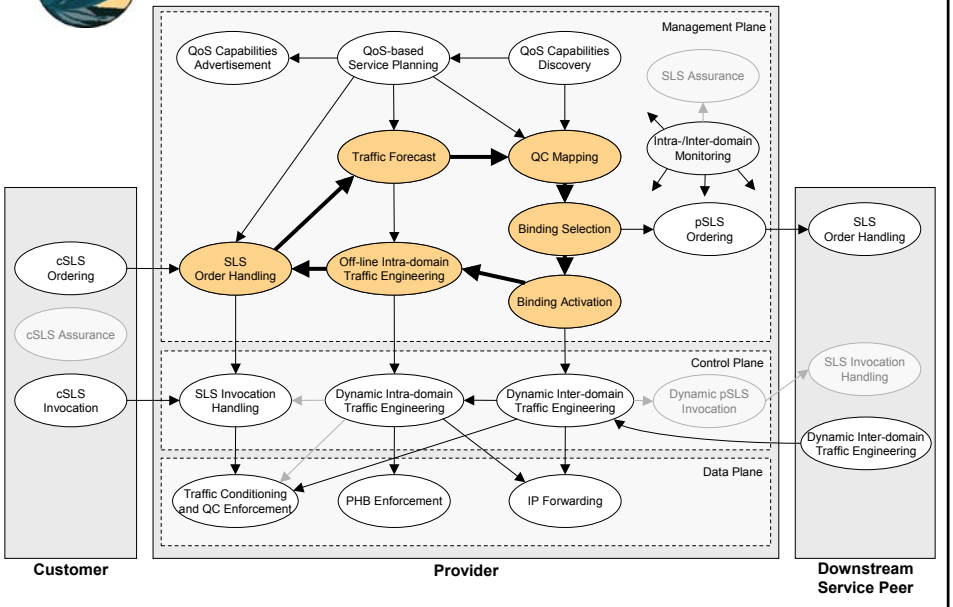

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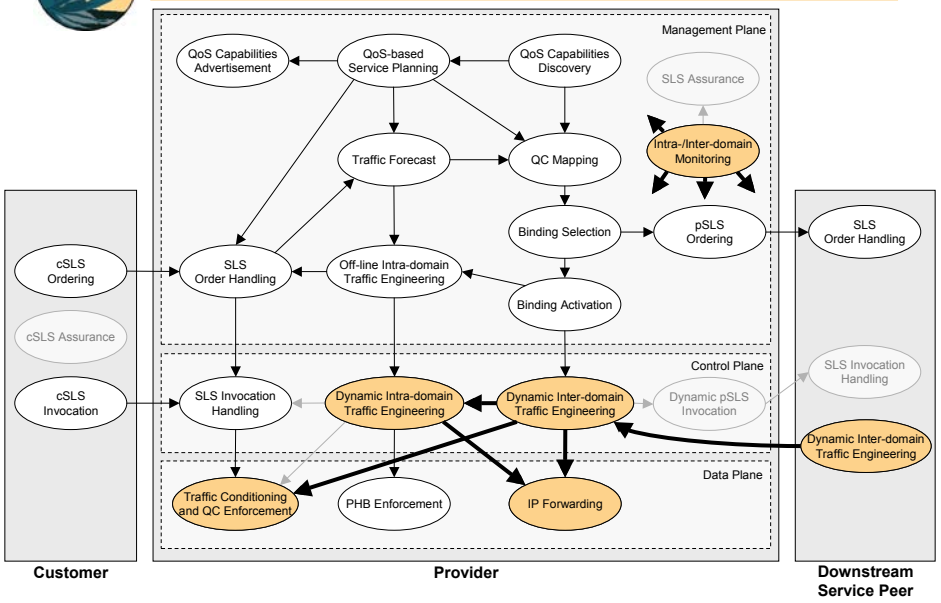

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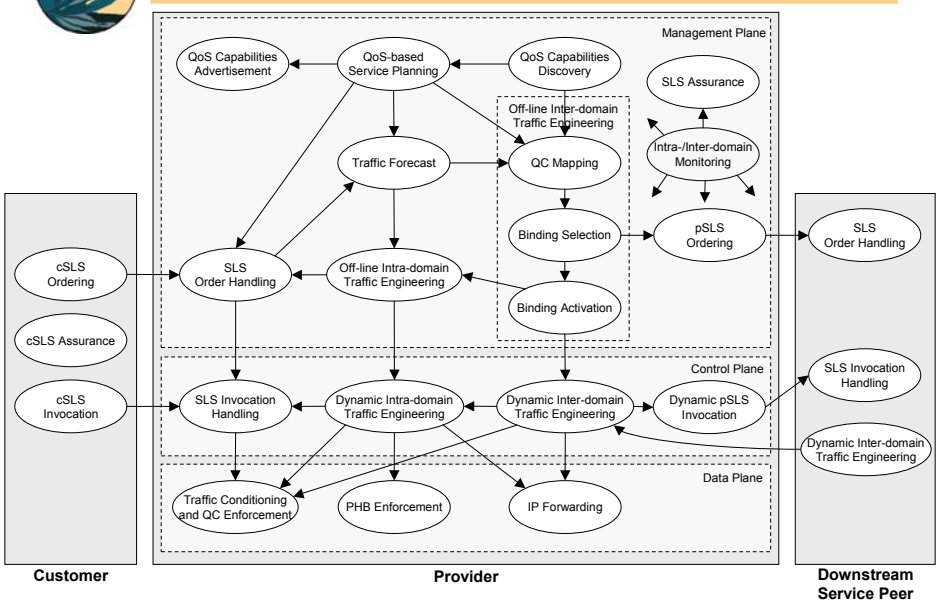


Summary

- Dimensions of the MESCAL functional architecture:
  - Functional groupings
    - Service Planning, SLS Management, Traffic Engineering, Monitoring and Assurance
  - Network plane
    - data, control and management
  - Scope
    - intra- and inter-domain
- Built on previously validated ***intra***-domain functional model
- *Validated* inter-domain functional architecture is a significant result by itself: one of the aims of MESCAL
- Applicable to a wide range of service options and service solutions (see following slides)

Inter-AS QoS: The MESCAL Solution

Solution Targets

satisfy customer service requirements

customer types: residential → corporate

service options	Loose	Statistical	Hard
service guarantees as per cSLSs: end-to-end performance (delay, loss, jitter)	QL	QN/QL	QN
bandwidth	NO	YES (not per flow)	YES (per flow)
topological scope (reachable destinations)	NO	Any/Specific	Specific

QL: qualitative guarantees e.g. gold/silver/bronze

QN: quantitative guarantees e.g. particular upper bounds

Solution Options

service options	Loose	Statistical	Hard
service guarantees as per cSLSs: end-to-end performance (delay, loss, jitter)	QL	QN/QL	QN
bandwidth	NO	YES (not per flow)	YES (per flow)
topological scope (reachable destinations)	NO	Any/Specific	Specific

solution option 1

solution option 2

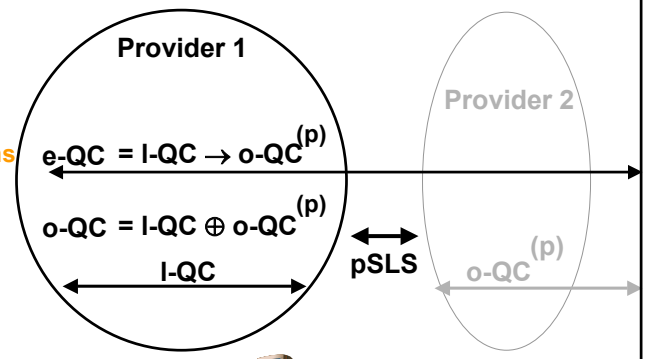
solution option 3

A Reminder of the MESCAL Approach

1 Build extended QoS capabilities

determine combinations

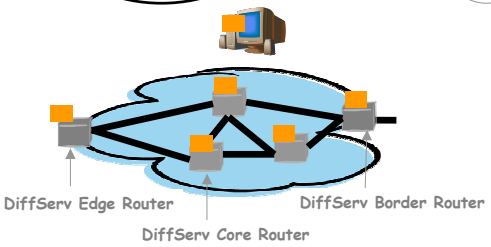
negotiate pSLSs



2 Ensure contracted cSLSs/pSLSs

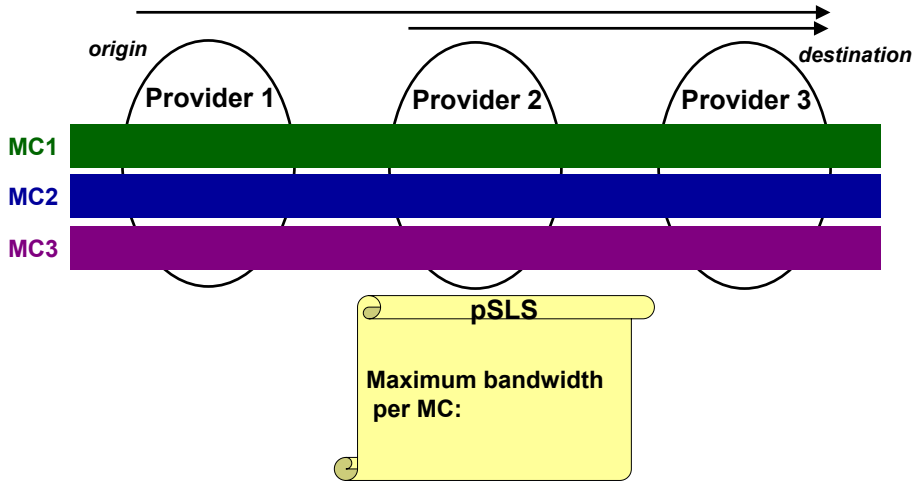
off-line and dynamic TE

admission control

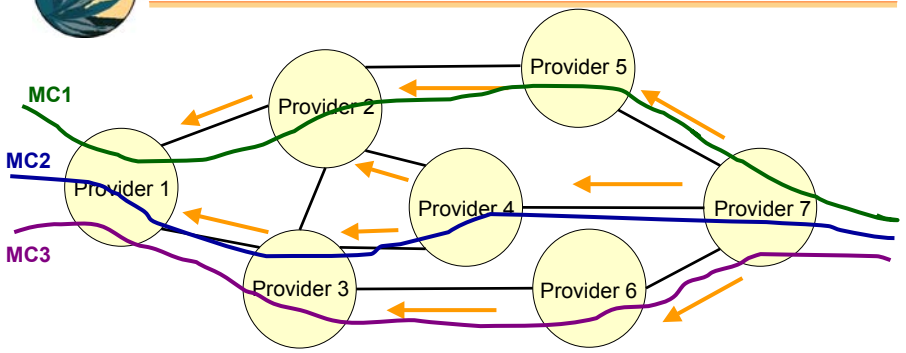


Towards 'Loose Service Guarantees' Building Extended QoS Capabilities

QoS capabilities are mapped and bound into pSLSs only in the context of meta-QoS-Classes



Towards 'Loose Service Guarantees' Deployment



qBGP BGP conveying MC information

qBGP updates after pSLSs have established

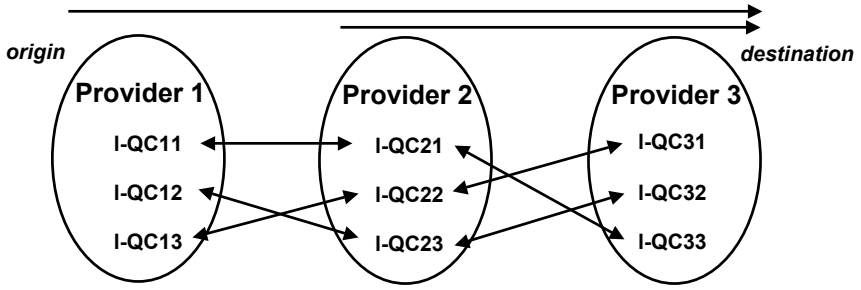
qBGP selection process selects inter-domain route(s) per MC

MC-aware intra-domain routing

Dynamic resource (PHB) management

Towards 'Statistical Service Guarantees' Building QoS Capabilities

QoS capabilities are mapped and bound into pSLSs under any suitable compatibility/conformance criteria



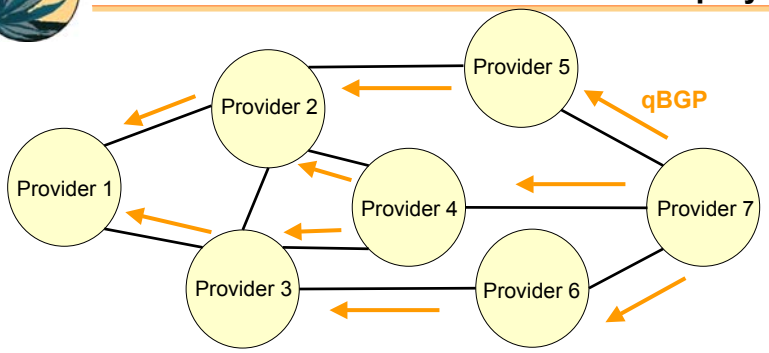
pSLS

Topological scope:

Performance guarantees (per o-QC):

Maximum bandwidth (per o-QC):

Towards 'Statistical Service Guarantees' Deployment



qBGP BGP conveying QoS-class information
could be enforced through management plane

qBGP updates after pSLSs have established

qBGP selection process selects inter-domain route(s) per o-QC

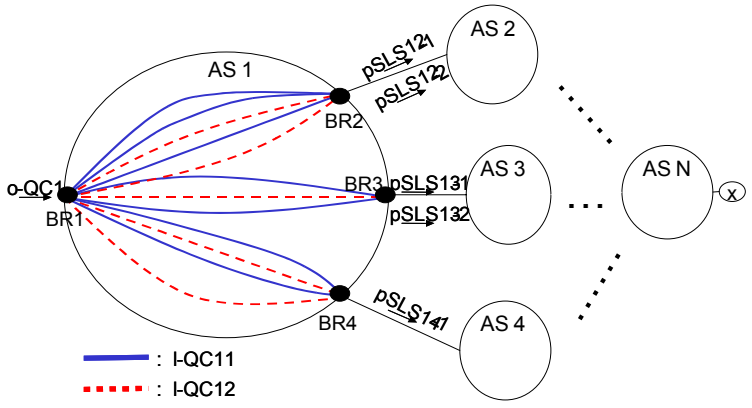
DSCP-aware intra-domain routing and/or load distribution on multi-paths

Dynamic resource (PHB) management

Intelligent off-line TE functions for deriving longer-term QoS policies

Service admission control for not overloading network resources and inter-domain resources

Towards 'Statistical Service Guarantees' Increased optimisation potential

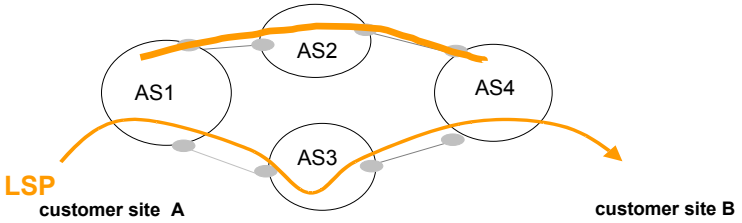


Network is engineered and dynamically managed on aggregate traffic; thus *statistical guarantees* per customer flows

Towards 'Hard Service Guarantees'

Add-on to the previous methods

Lay down inter-domain MPLS TE LSPs and reserve bandwidth



pSLS

MC, o-QC

Topological scope:

Performance guarantees (per QC):

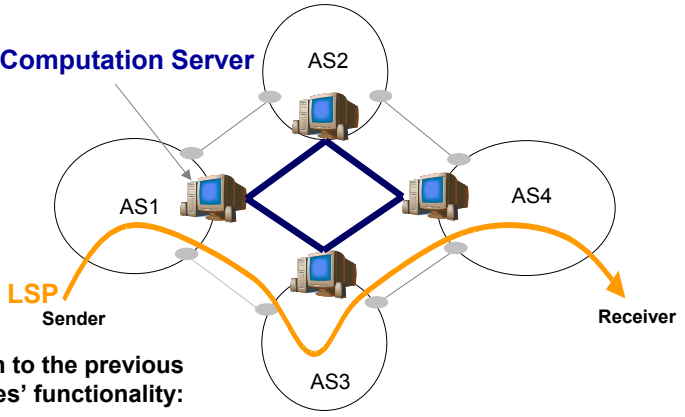
Maximum bandwidth (per QC):

Maximum reserved bandwidth (per QC):

Maximum number of LSPs:

Towards 'Hard Service Guarantees' Deployment

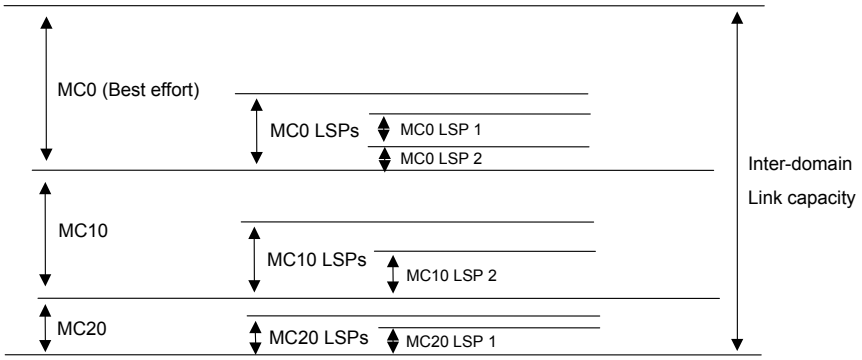
PCS: Path Computation Server



In addition to the previous cases' functionality:

- **PCS-to-PCS signalling**
- **QoS-aware path computation logic**
- **Inter-domain path establishment**
  - **commercial implementation available soon**
- **Admission control at the LSP head-end**
- **Bandwidth management**

Towards 'Hard Service Guarantees' Bandwidth Management



Summary

	service options	Loose	Statistical	Hard
	solution options	Quantum	Cool	Tunnel
pSLSs	topological scope (reachable destinations)	Any	Any/Specific	Specific
pSLSs	performance guarantees	MC	o-QC	MC/o-QC
pSLSs	bandwidth	YES	YES	YES
TE and admission control	Inter-domain routing	qBGP	qBGP/management plane	PCS-to-PCS
TE and admission control	Intra-domain routing	MC-aware	DSCP-aware, load distribution	
TE and admission control	Resource management	PHB	PHB	Link/LSP
TE and admission control	Admission control	NO	YES	YES
		QoS-aware IP layer across domains		*VPNs across domains*

All options follow the MESCAL functional model

http://www.mescal.org/

