Inter-Provider QoS Peering for IP Service Offering, Scalability, and Bi-directionality of Services

Hamid Asgari

Thales Research & Technology (TRT) UK Limited

Hamid.Asgari@thalesgroup.com

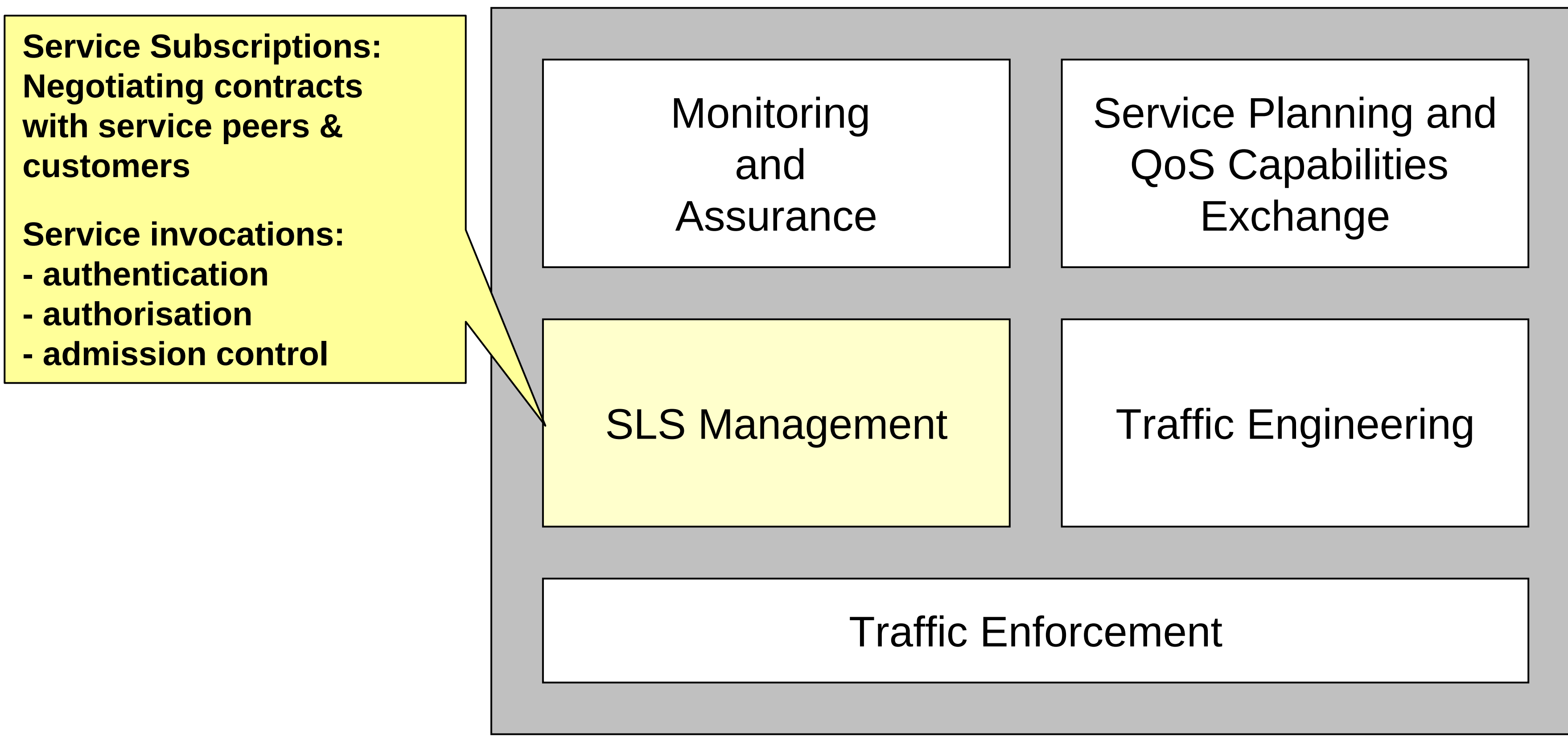
Presentation Overview

- **Abstract View of Functional Architecture**
- **Inter-domain QoS Peering Models (Source-based, Cascaded, & Bilateral)**
- **Scalability of QoS Peering Models**
- **Bi-directionality support in QoS Peering Models**
- **Target Services**
- **Conclusion**

Abstract view of MESCAL Functional Architecture

QoS offering across multiple domains necessitates co-operation among IP Network Providers (INP)

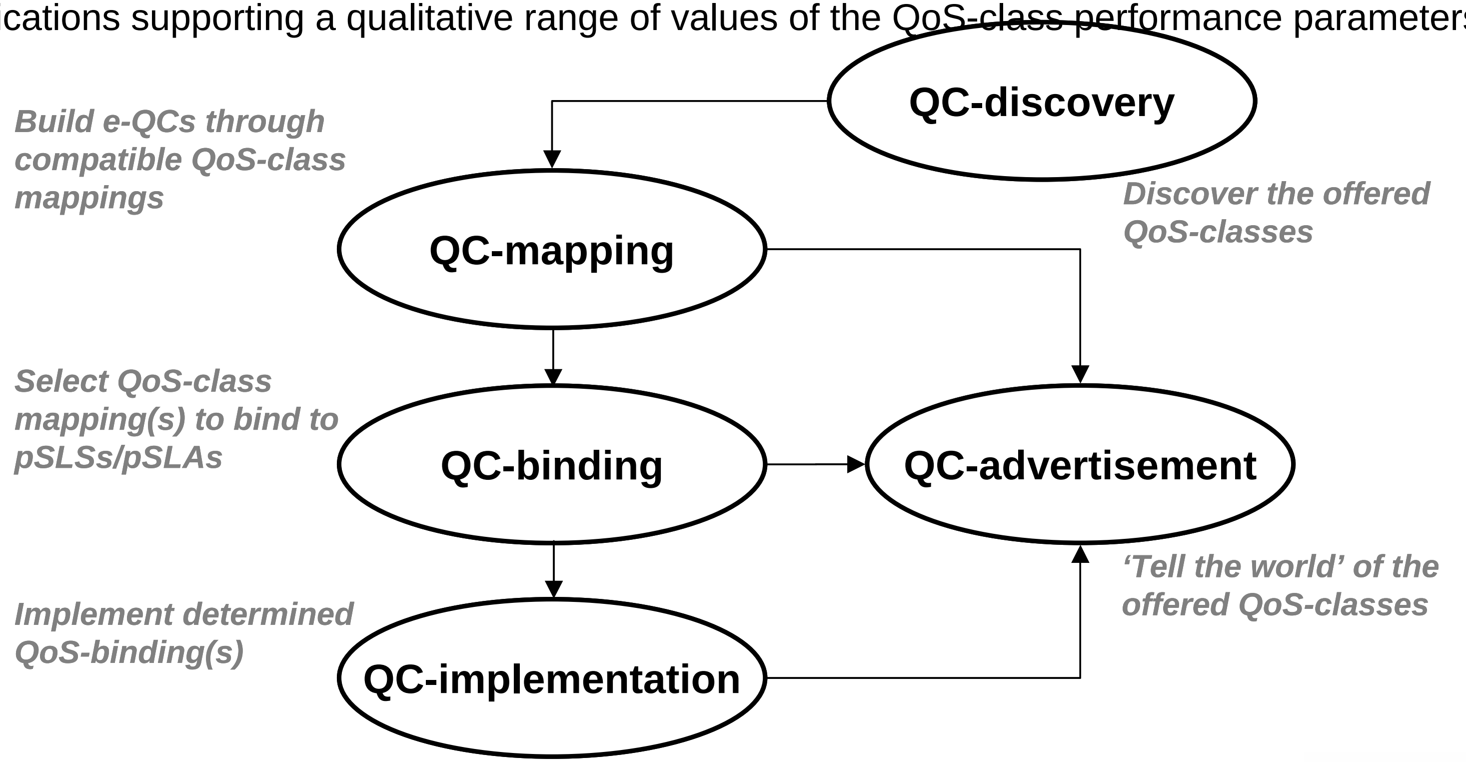
– INP interactions occur at both *service layer* and *network layer*.



THALES

QoS Classes and their operations

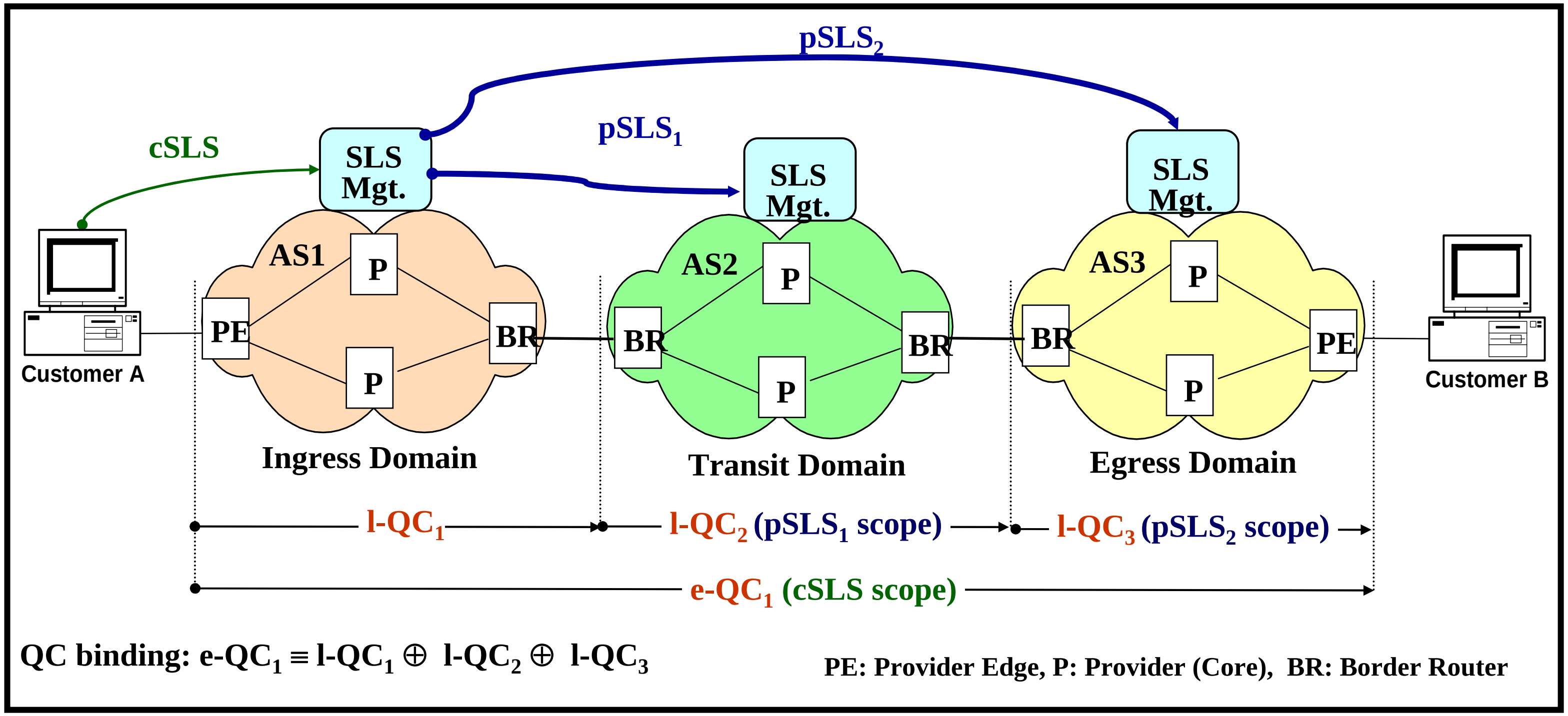
- A '***QoS-class (QC)***' denotes a basic network-wide *QoS transfer capability* of one/more domains.
- A QoS transfer capability is a set of attribute-value pairs expressing packet transfer performance parameters such as OWD, OPL & IPDV.
- ***l-QC****:* QoS transfer capability provided by means employed in the provider domain itself.
- ***e-QC****:* multi-network-wide QoS transfer capability provided by means employed in the provider domain and other peering domains.
- ***m-QC****:* an abstract concept which relies on global understanding of QoS requirements of well-known applications supporting a qualitative range of values of the QoS-class performance parameters.



THALES

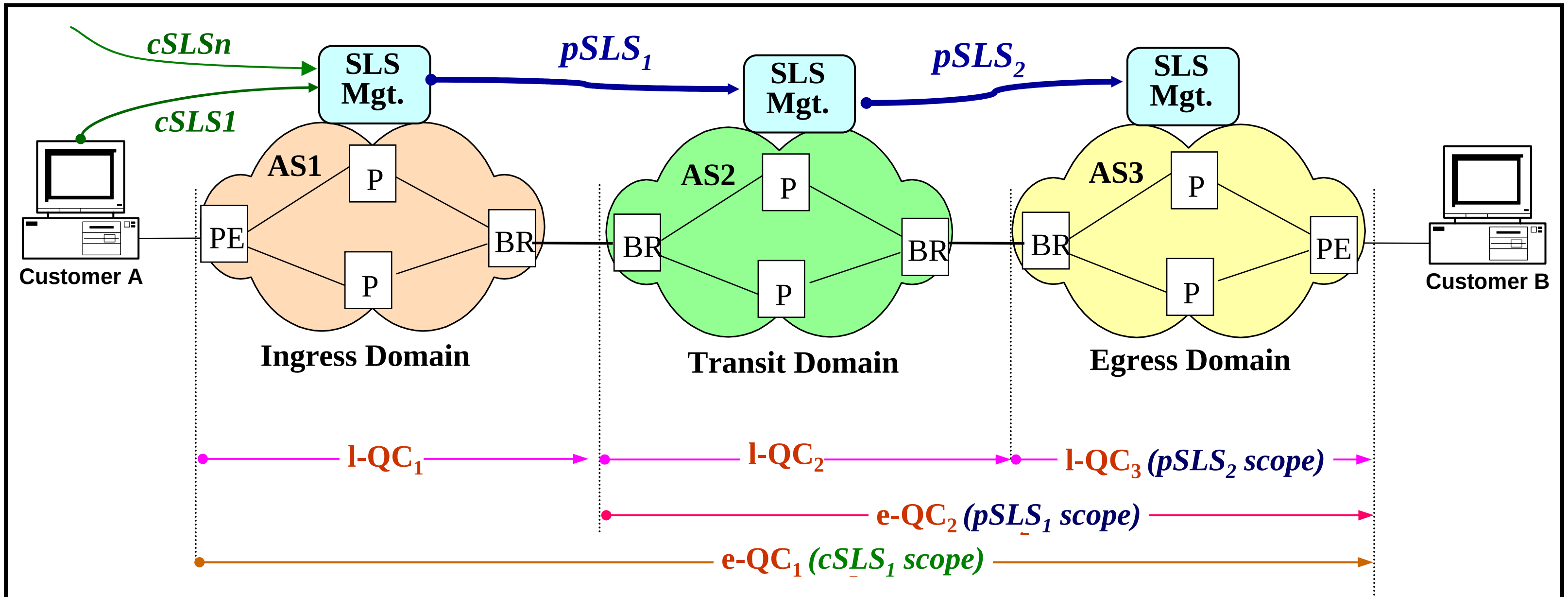
Inter-domain QoS Peering: Source-based Model

- An INP negotiates pSLSs directly with a number of providers.
- Source INP requires topology of Internet for finding domains to negotiate with.



Inter-domain QoS Peering: Cascaded Model

- Domains’ capabilities are discovered via different means.
- An INP negotiates pSLSs with its adjacent providers to implement e-QCs.
- pSLSs are set-up between adjacent providers, but not between providers more than "one AS hop away".
- pSLSs are set-up with defined scope and distinct performance characteristics.

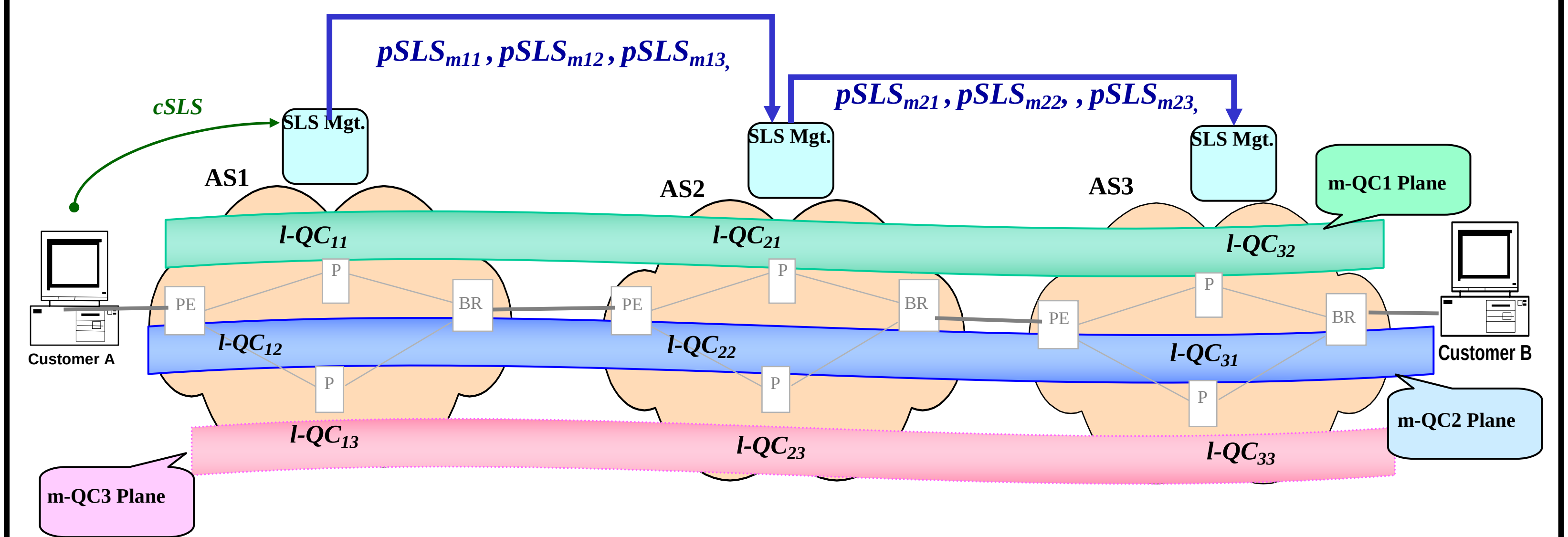


QC bindings: $e\text{-}QC_2 \equiv l\text{-}QC_2 \oplus l\text{-}QC_3$

$e\text{-}QC_1 \equiv l\text{-}QC_1 \oplus e\text{-}QC_2$

Inter-domain QoS Peering: Bilateral Model

- **pSLSs are set-up between adjacent domains with open scope. pSLSs are not tied to certain destinations.**
- **pSLSs are set-up with no distinct performance characteristics but simple compliance with well-known QCs defined globally.**
- **An INP advertise m-QCs it supports for other INPs to make use of offered m-QCs.**
- **Each domain finds reachability information in an m-QC plane via qBGP updates.**



$pSLS_{m11}$ & $pSLS_{m21}$: Set-up for m-QC1 - $pSLS_{m12}$ & $pSLS_{m22}$: Set-up for m-QC2 - $pSLS_{m13}$ & $pSLS_{m23}$: Set-up for m-QC3

Scalability

- Definition
- Ability for the system to function effectively and keep its performance in desired levels, as the size of parameters influencing its behavior increase.

- Expected results
- A “no more than linear” dependency to the arrival rate of requests/messages indicates the system is prone to scale.

- Parameters to consider
- Number of pSLS to be managed per INP for offering inter-domain services

- Message flow during the pSLS negotiation
  - The extent of messages passing/processing involved in a new pSLS set-up.
- Number and granularity of classes of service (QCs) offered

- Number of customer requests (cSLS) can be managed per INP
- Number of routing announcements, size of routing tables, etc.

Pro, Cons and Scalability of Source-based Model

- Source INP requires topology of Internet for finding domains to negotiate with.
- Source INP needs to know l-QCs offered in each domain for binding them to form e-QCs.
- pSLS agreements are tailored to the source INP requirements.
- It is possible to set-up optimal routes to destinations.
- Source-based model is feasible for a small number of domains.
- The source INP as the central point may end up with many *pSLSs* to manage.

N_{lqc} = Nr. of well-known l-QCs (N_{lqc}) used across all domains (constant).

N_s = Nr. of *pSLSs* required from source to reach an AS for an e-QC.

i = Nr. of transit hops (ASs) plus the egress hop for constructing an e-QC from S to D path

N_d = Nr. of AS domains in the Internet. N_p = Nr. of *pSLSs* from a central point to reach all ASs for all e-QCs.

N_{pt} = Nr. of total *pSLSs* required to offer QoS-based services across Internet.

$$N_s = i, \qquad N_{pt} = N_d * N_p$$

$$\text{Worst case}: N_p = N_{lqc} * \sum_{j=1}^{N_d - 1} (N_d - j) = N_{lqc} * \left[\frac{N_d * (N_d - 1)}{2} \right], \text{ Best case}: N_p = N_{lqc} * (N_d - 1)$$

Worst case: INP is the furthest away from destination. Best case: INP is located close to the centre of net.

Thus Nr. of *pSLSs* may need to be established by the source INP is $O(N_d^{\ 2})$.

Making the scalability of source-based model a cause for concern

THALES

Scalability of Cascaded/Bilateral Models

- No need for complete topology related information except routing information.
- Each INP may only have a limited number of *pSLSs* to manage:

N_{eqc} = Nr. of e-QCs offered to each destination (constant).

N_s = Nr. of *pSLSs* required between two adjacent domains to reach an AS for an e-QC.

N_{req} = Nr. of *pSLSs* required to reach from a S to D for a single e-QC.

N_p = Nr. of *pSLSs* from an AS to reach all destination ASs for all e-QCs.

N_{pt} = Nr. of total *pSLSs* required to offer QoS-based services across Internet.

$$N_s = 1 \quad \& \quad N_{req} = i$$

$$N_p = N_{eqc} * (N_d - 1), N_{pt} = N_p * N_d$$

Thus, Nr. of of *pSLSs* needs to be established by an INP is $O(N_d)$.

Making the cascaded model more scalable than source-based model.

- In bilateral model, only a very limited number of well-known m-QCs are globally used.
- While in cascaded model, the QC binding is done arbitrary increasing the number of offered QCs, increasing the number of pSLSs to set-up.

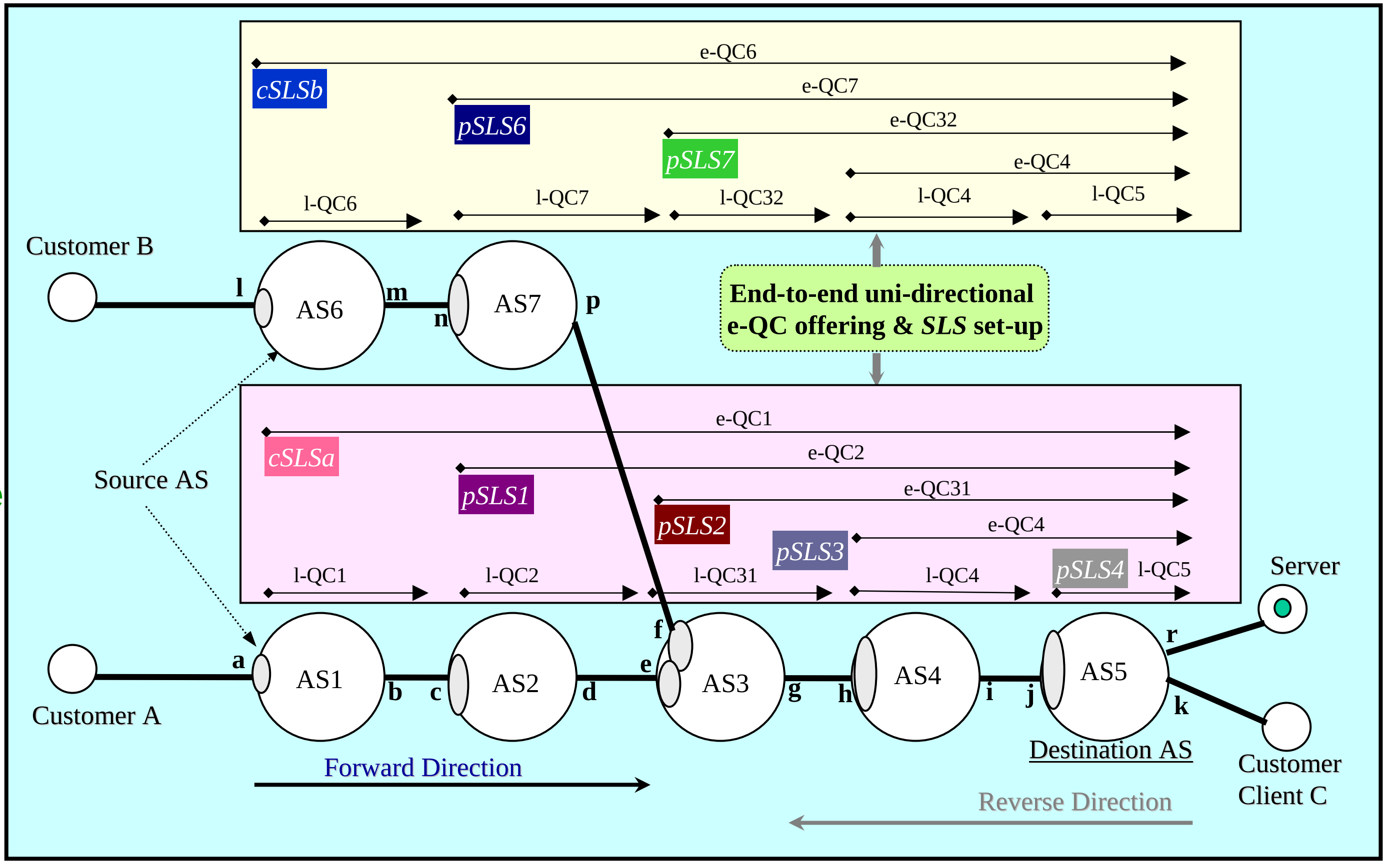
Bi-directionality in Cascaded Model (1)

1 ***cSLSa*** **is between Customer** ***A & AS1*** **for the scope of (*****A@AS1*** **to** ***C@AS5*****). How does any Destination AS (e.g.,** ***AS5*** **in forward direction) figure out the scope for the reverse direction (sink for return traffic, i.e.,** ***A@AS1*****)?**

2 **Every time an upstream AS forms an e-QC, the scope for the return paths extends.**

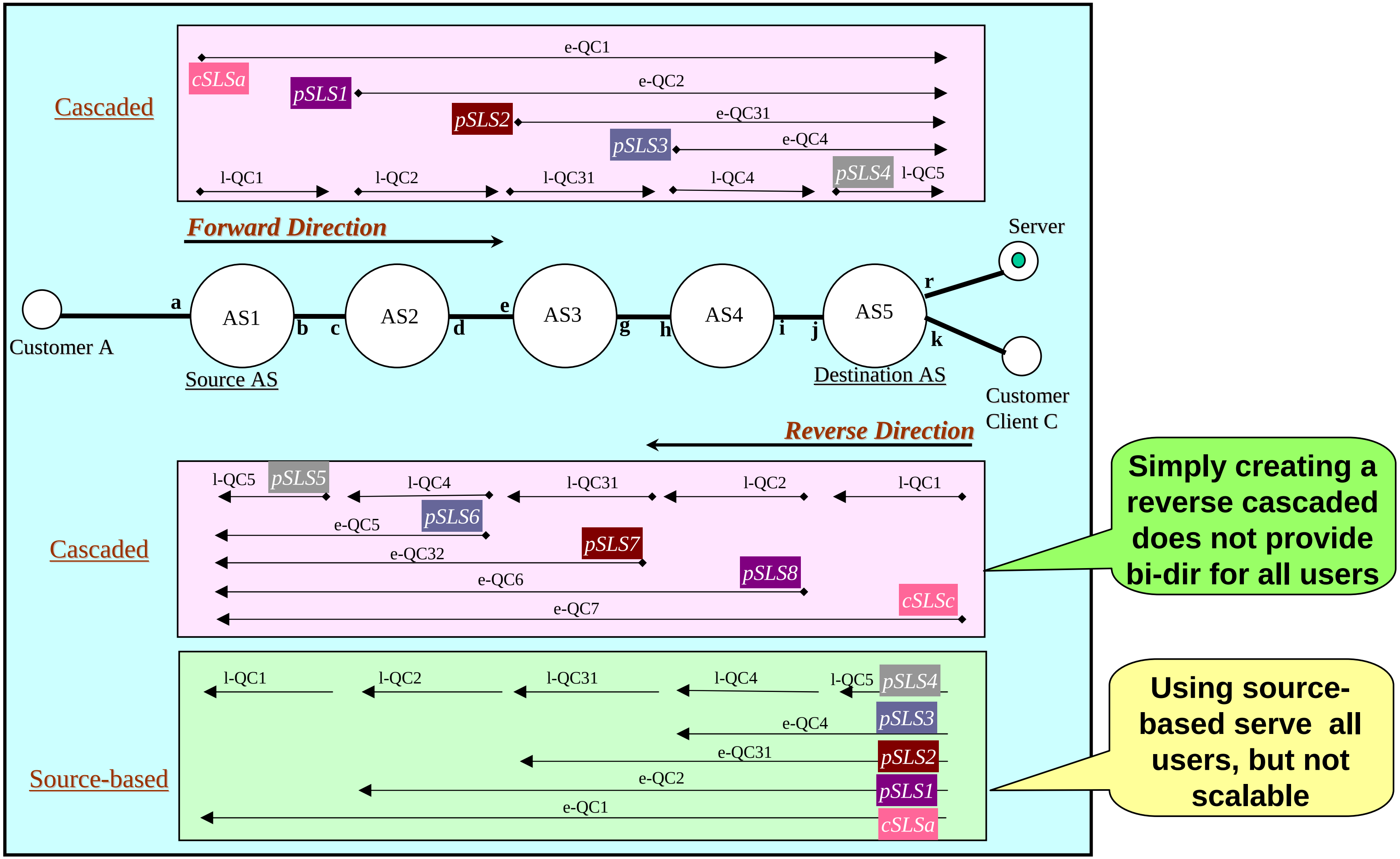
3 **Which l-QC at each AS (e.g., AS5) should be used for return traffic?**

4 **How should this l-QC be mapped to an e-QC (if any) offered by the upstream AS?**



Bi-directionality in Cascaded Model (2)

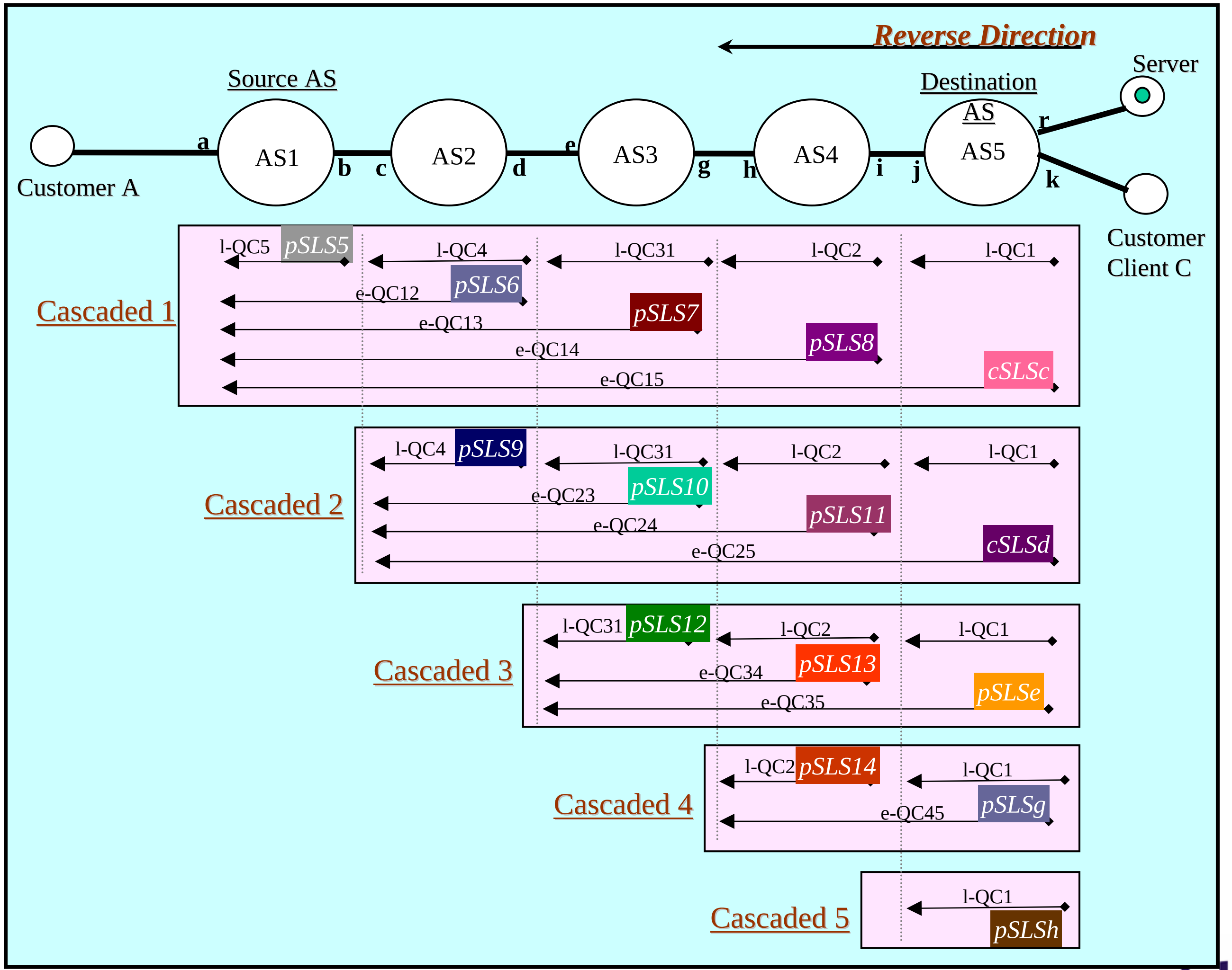
– Can there be a reverse path e-QC for every forward path e-QC?



THALES

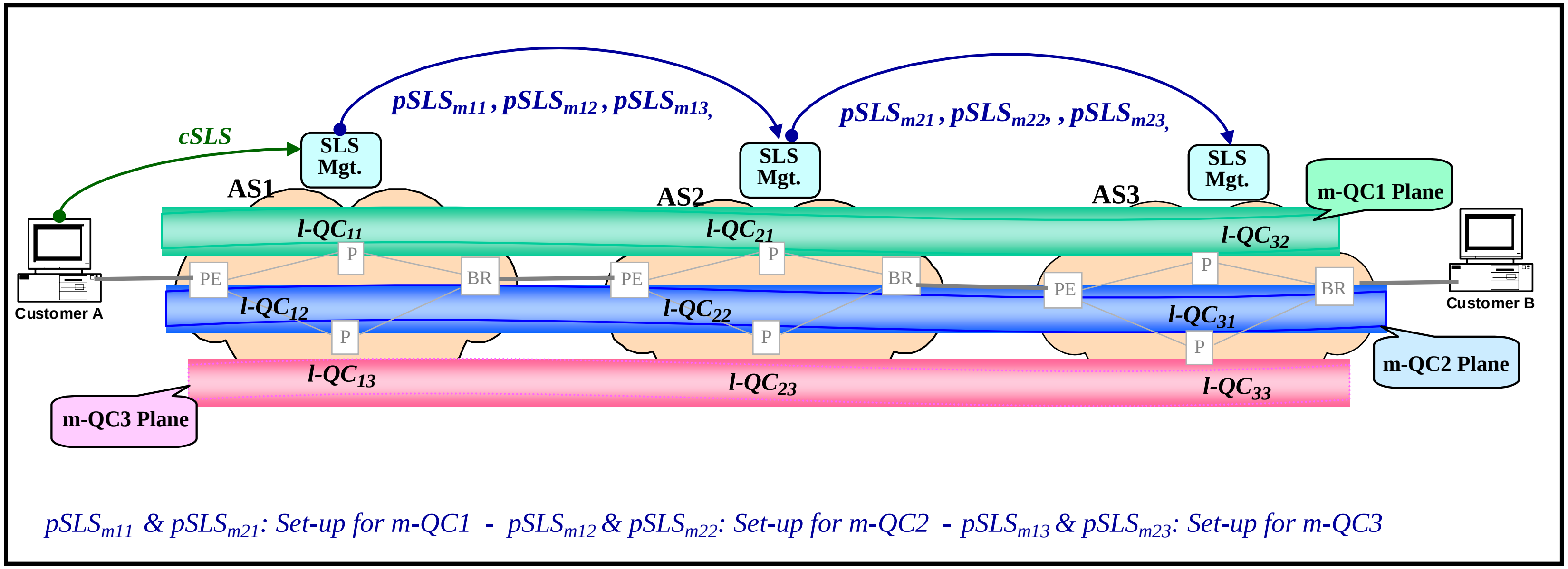
Implementing Multiple Cascades for Reverse Directions

- **Multiple cascade are built in reverse direction in order to cover the sources and destinations serve by the single cascade in forward direction to allow transporting return traffic.**
- **The way these multiple cascades are built serve more downstream customers in reverse direction.**



Bi-directionality in Bilateral Model

- **The pSLSs between all involved ASs are put in place in both directions irrespective of the paths traffic may take in either directions.**
- **The scope for these pSLSs are within the domain (m-QCs).**
- **Path for forward & return traffic may be different depending on q-BGP updates.**



In this approach, q-BGP can provide:

- ***QoS service capabilities***
- ***QoS Class (QC) identifier* to distinguish various m-QC planes**
- ***QoS performance characteristics***

Target Services

- Residential and corporate customers differ both at the level of the performance and traffic guarantees and geographical scope of the services they require.
  - Residential customers need to reach any available destination at any time with better-than-best-effort service levels.
  - Corporate customers need strong QoS guarantees and constant bandwidth for supporting particular services such as IP VPNs in order to reach a limited set of destinations.
- The ‘CM’ can be used for services that require QoS performance guarantees for reaching specific destinations allowing E2E bandwidth guarantee within statistical bounds.
- The ‘BM’ can used to offer better Internet connectivity services with some QoS levels, but no strong guarantees. It enables a provider to offer differentiated services, where each service is related to an *m-QC*.
  - It is envisaged that providers throughout the Internet will implement a small number of well-known *m-QC*s.
  - In effect, a set of parallel “internets” can be deployed, each offering service levels associated with a specific *m-QC*.

Conclusion

- QoS offering across multiple domains requires co-operation among INPs.
- Source-based QoS peering does not scale.
- CM is a more scalable but requires fine tuning.
- BM follows the loosely coupled structure of Internet and easier to deploy.
- Providing bi-directionality in ‘BM’ causes far less complication.
- BM provides the means for deploying a set of parallel “internets” offering qualitative differentiated services.
- We have also evaluated in a testbed how pSLSs can be established and how q-BGP can be implemented across multiple domains to support QoS delivery using BM.