Systematic QoS Class Mapping Framework for Application Requirement over Heterogeneous Networks

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Introduction

- The trend of recent development in a network
  - NGN, a packet-based network providing the differentiated QoS over heterogeneous networks
  - New applications

Our goal is to propose a scalable framework to support end-to-end QoS for fine-granular applications over heterogeneous networks

QoS over heterogeneous networks

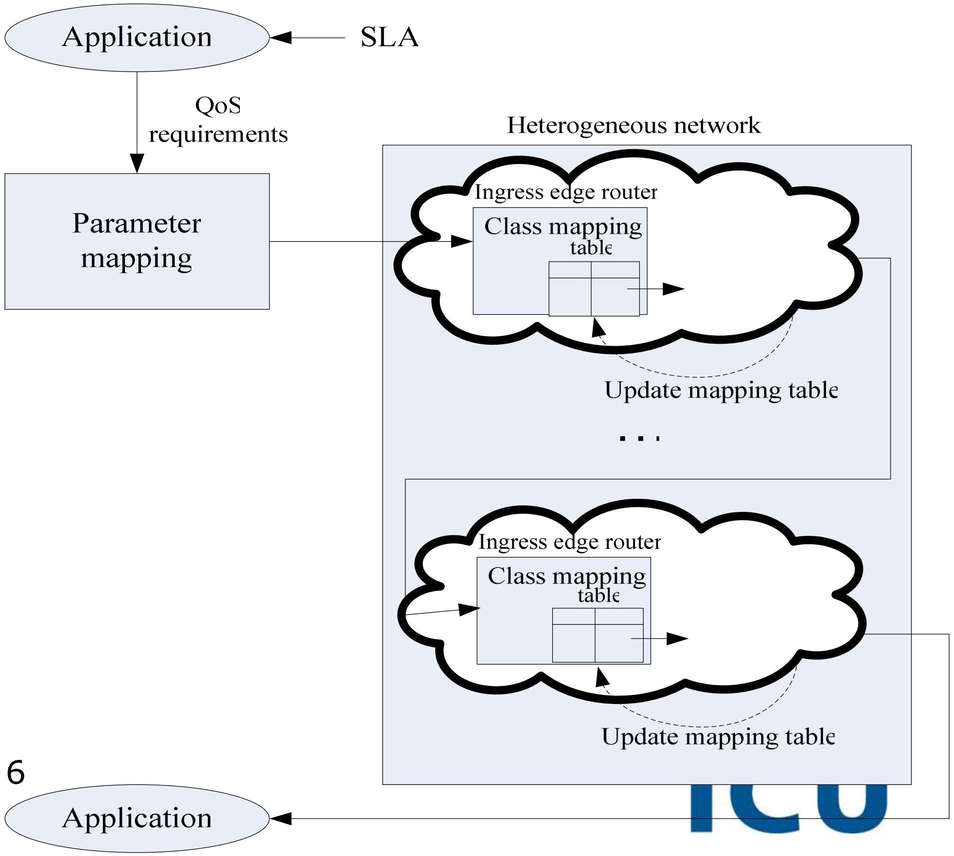
- Many studies on ways for the delivery of end-to-end QoS to applications over heterogeneous networks
  - Central approach
    - To efficiently manage network resources across several different QoS domains such as QoS apportionment, QoS control signaling
    - It causes scalability problem
  - Distributed approach
    - Through QoS class interworking between different QoS domains, it can support end-to-end QoS
    - Appropriate QoS class mapping can provide not absolute but differentiated QoS

New applications

- In the future, new applications will emerge and need more fine-granular QoS
  - A variety of applications may require fine-granular QoS

QCM(QoS Class Mapping) Framework

- In this paper we do not deal with how to provide QoS mechanism in each network. We assume that each network operates its own QoS mechanism and provides QoS based on class
- The two key blocks
  - parameter mapping : determine the best suitable QoS class at the entrance
  - class mapping : interwork at the Ingress Edge Router (IER) of each network



QCM Framework

- IER (Ingress Edge Router)
  - Generates, manages its own class mapping table
  - Executes packet transformation and QoS class conversion
  - We do not deal with packet transformation and only focus on QoS class conversion

Parameters mapping

- Need to find the most suitable QoS class for the offered application service requirements in any network.
  - determine QoS class having minimum difference value between service requirement and QoS class bound.
  - best suitable QoS class can lead to prevent resource waste through effectively distributing resource and to provide end-to-end QoS.
- Must have Scalability: the number of service requirement parameters is not a single one. It consists of several parameters

Parameters mapping formulation

- Method: select a class which has the least difference b/w demanding transport requirements and parameter information that can be guaranteed

$$y = \mathrm{F}_{\alpha}(\mathbf{X})$$

$$c_i = \mathbf{W} \cdot (\|\mathbf{X} - \mathbf{P}^{\alpha}{}_i\|) = \sum_{j=0}^{N-1} w_j \left| x_j - p^{\alpha}{}_{ij} \right| \quad \forall i = 0,1,\ldots M_{\alpha} - 1$$

$$y = \left\{ k \mid c_k = \min_i \{c_i\} \right\} \quad \forall i = 0,1,\ldots M_{\alpha} - 1$$

$$\mathbf{X} = \begin{bmatrix} x_0 & x_1 & x_2 & \ldots & x_{N-1} \end{bmatrix}^T$$

$$\mathbf{W} = \begin{bmatrix} w_0 & w_1 & w_2 & \ldots & w_{N-1} \end{bmatrix}$$

$$\mathbf{P}^{\alpha} = \begin{bmatrix} \mathbf{P_0}^{\alpha} & \mathbf{P_1}^{\alpha} & \mathbf{P_2}^{\alpha} & \ldots & \mathbf{P}_{\mathbf{M}_{\alpha}\mathbf{-1}}{}^{\alpha} \end{bmatrix}$$

$$\mathbf{P_i}^{\alpha} = \begin{bmatrix} p_{i0}{}^{\alpha} & p_{i1}{}^{\alpha} & p_{i2}{}^{\alpha} & \ldots & p_{iN-1}{}^{\alpha} \end{bmatrix}^T$$

$$\mathbf{C} = \begin{bmatrix} c_0 & c_1 & c_2 & \ldots & c_{M_{\alpha}-1} \end{bmatrix}$$

M_{α}: the number of QoS class in α

N: the number of performance requirement

y: the output value that shows the closest QoS class

X: a matrix that shows requirement with N-1 parameters in a packet

$\mathbf{P}^{\alpha}$: is a matrix that shows requirement of parameter in * network

$\mathbf{P}_i^{\alpha}$:a matrix that shows bound values of i-th QoS class parameter in * network

W: a matrix that shows weight factor of parameters

C: a matrix that shows difference between a input requirement and requirement according to class

Class mapping table

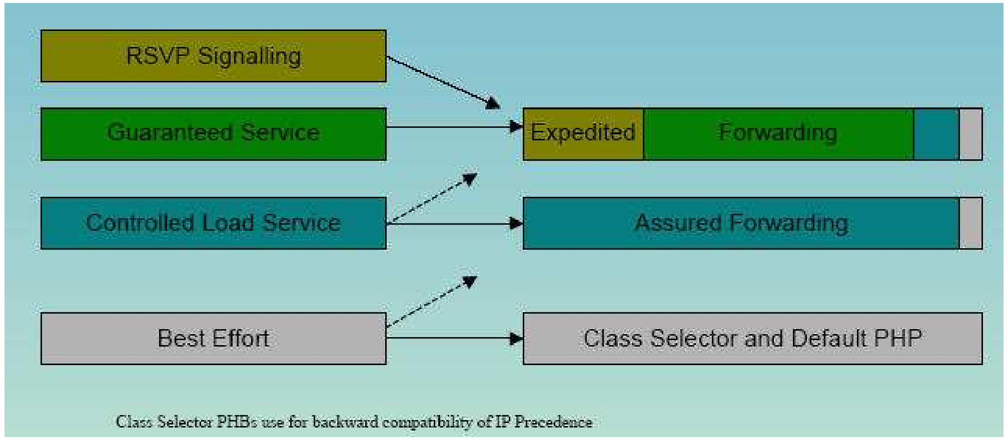
- There are approaches to make class-to-class mapping table
  - Using Standard documents and Papers
    - 3GPP TS 23.107, ITU-T SG13 FGNGN output documents "FGNGN-OD-00206" Y.1541 3GPP TS 29.207-640…

- This simple QoS class concatenation is applied to support end-to-end QoS
  - Accurate QoS class mapping table makes applications achieve end-to-end QoS over heterogeneous network
  - However, it does not guarantee absolute QoS

Related works – QoS Class mapping

IntServ	ATM
Guaranteed Service	CBR or rtVBR
Controlled Load	NrtVBR or ABR
Best Effort	UBR or ABR

IntServ	DiffServ
Guaranteed Service	EF
Controlled Load	Assured (High priority)
Best Effort	Assured (low priority)



UMTS	DiffServ
Network management	Network control
Conversational	EF
Streaming	AF11, AF12, AF13
Interactive	AF22,AF22,AF23
Background	BE

Related works – QoS Class mapping

TCID	Access Category	Traffic Type
1	0	Best effort
2	0	Best effort
0	0	Best effort
3	1	Video probe
4	2	Video
5	2	Video
6	3	Voice
7	4	Voice

User priority	Acronym	Traffic Type
1	BK	Background
2	-	Spare
0 (Default)	BE	Best effort
3	EE	Excellent effort
4	CL	Controlled Load
5	VI	Video<100ms latency and jitter
6	VO	Voice<10ms latency and jitter
7	NC	Network Control

Traffic class(AC)	Example	DSCP	TCIP
Class 1	VoIP	(101)xxx for EF	7
Class 2	Video Streaming	(100)xxx for AF4x	5
Class 3	Signaling bearer	(010)xxx for AF2x	3
Class 4	Normal Data (e-mail, Web)	(000)000 Default best effort	1

QCM-IP Framework(1)

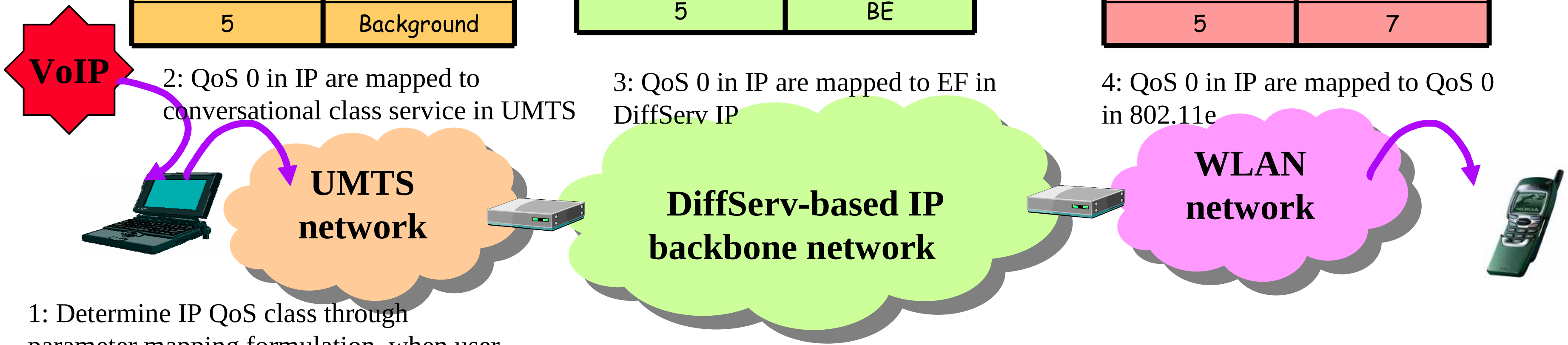
- IP QoS class may be reasonable for mapping among various networks
  - NGN is a packet-based network
  - QoS class translation between IP and other networks has been studied in many papers and related standardization exists.
- This framework is based on a concatenation based on IP QoS class to support end-to-end QoS.
- IP class-to-class mapping table can be built off-line
  - Using Standard documents and Papers
    - 3GPP TS 23.107, ITU-T SG13 FGNGN output documents “FGNGN-OD-00206” Y.1541 3GPP TS 29.207-640…

QCM-IP Framework(2)

IP QoS	UMTS QoS Class
0	Conversational
1	Streaming
2	Interactive
3	Interactive
4	Interactive
5	Background

IP QoS	DiffServ
0	EF
1	EF
2	AF
3	AF
4	AF
5	BE

IP QoS	WLAN QoS
0	0
1	2
2	2-4
3	5
4	6
5	7



2: QoS 0 in IP are mapped to conversational class service in UMTS

3: QoS 0 in IP are mapped to EF in DiffServ IP

4: QoS 0 in IP are mapped to QoS 0 in 802.11e

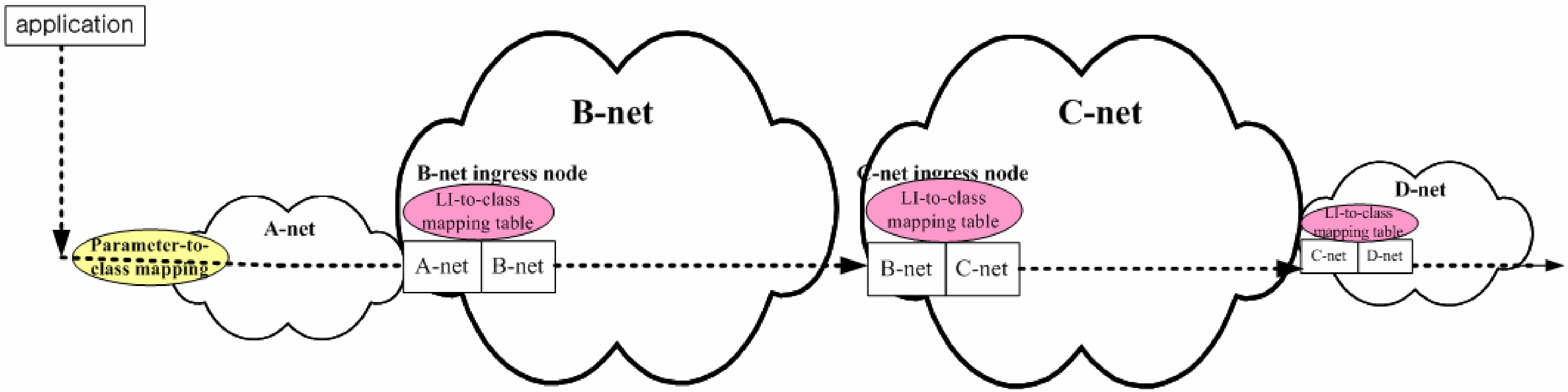
1: Determine IP QoS class through parameter mapping formulation when user demands VoIP(delay 100ms, loss 3%..)

QCM-IP Framework(3)

- It can be easily implemented because of the established studies.
- IP-based class mapping is not effective
  - coarse granularity to support for NGN service (multimedia service, telephony, text)
  - It is hard to match QoS class between IP and other networks perfectly
  - If QoS class of IP has coarse granularity, the class information can be lost through multiple mapping process
- So we propose QoS Class Mapping Framework using **Application Service Map**

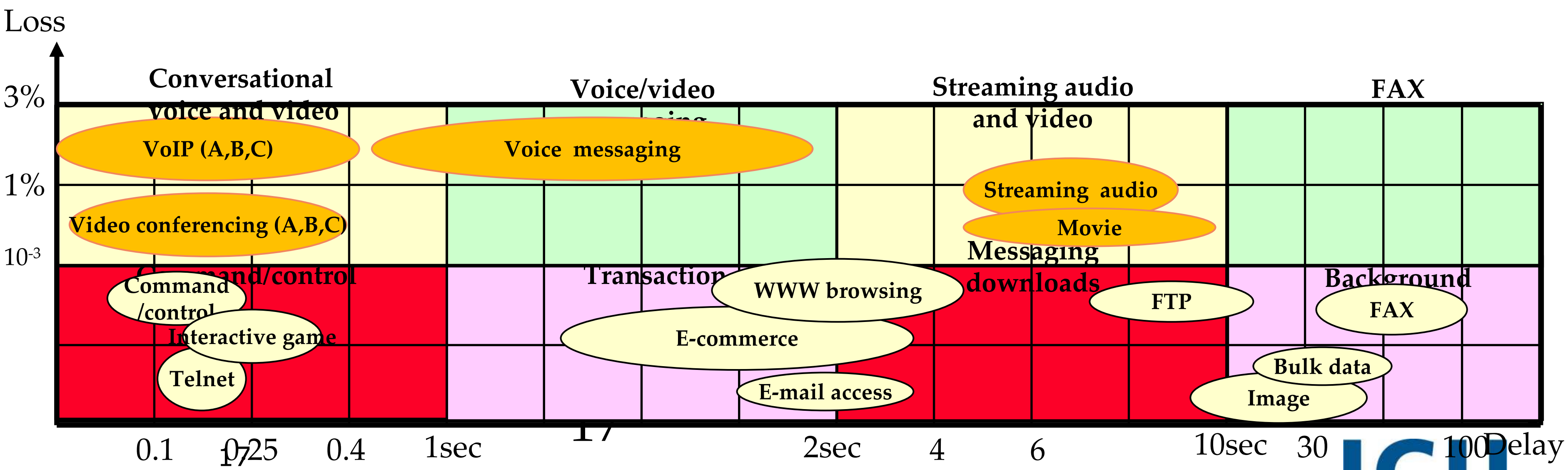
QCM-ASM Framework(1)

- We define Application Service Map (ASM)
  - to support fine granular application
- LI (location information) in ASM is delivered through networks
  - LI-to-class mapping at intermediate nodes
- By monitoring QoS class performance in each network, update the mapping table



Application Service Map

- Determine location of application’s demand using map information
  - Find a suitable QoS class using network delay and error requirements
  - Mapping considering related service and QoS class rather than exact parameters
- LI (Location Information) is inserted in the TOS field of a packet header. This LI can be used globally.



LI-to-class mapping

$$z = \max(y_{\min}, y_{\max}) = \max(F_\alpha(\mathbf{X}_{\min}), F_\alpha(\mathbf{X}_{\max}))$$

$$c_{i,\max} = \mathbf{W} \cdot (\left\|\mathbf{X}_{\max} - \mathbf{P}_i^{\alpha}\right\|) = \sum_{j=0}^{N-1} w_j \left| x_{j,\max} - p_{ij}^{\alpha} \right| \quad c_{i,\min} = \mathbf{W} \cdot (\left\|\mathbf{X}_{\min} - \mathbf{P}_i^{\alpha}\right\|) = \sum_{j=0}^{N-1} w_j \left| x_{j,\min} - p_{ij}^{\alpha} \right|$$

$$y_{\max} = \left\{ k \mid c_k = \min_i \left\{ c_{i,\max} \right\} \right\} \quad \forall i = 0,1,\ldots M_\alpha - 1 \quad y_{\min} = \left\{ k \mid c_k = \min_i \left\{ c_{i,\min} \right\} \right\} \quad \forall i = 0,1,\ldots M_\alpha - 1$$

$$if \;\; y_{\min} = y_{\max},\; y^* = y_{\min} = y_{\max}$$
$$if \;\; y_{\min} \neq y_{\max},\; y^* = \min(y_{\min}, y_{\max})$$

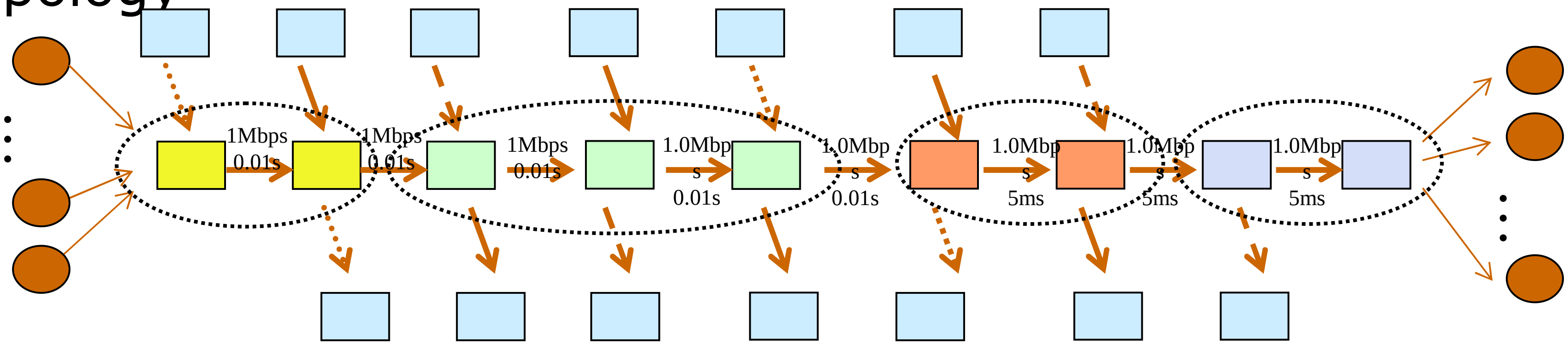
- LI of ASM has the upper and lower bounds for requirements.
- Prevent violation of service requirement by class mis-mapping

QCM-ASM Framework(2)

- It can support fine granular applications
- Mapping table based on ASM can perfectly translate LI such as (3,2) into QoS class information in any networks without distortion of application requirements
  - Distortion of application requirements causes resource to be waste or performance to be degraded

Simulation conditions

- In this paper, we apply PQ scheduler to all nodes for providing a differentiated service based on class
- Topology

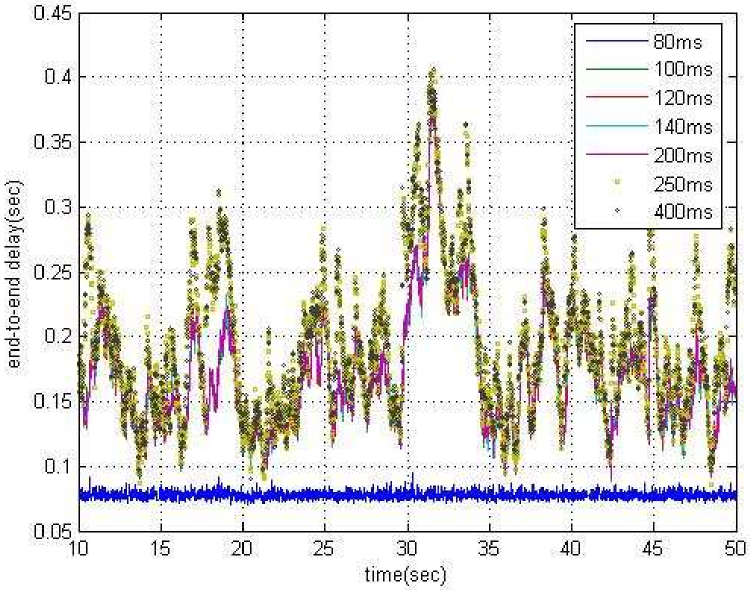


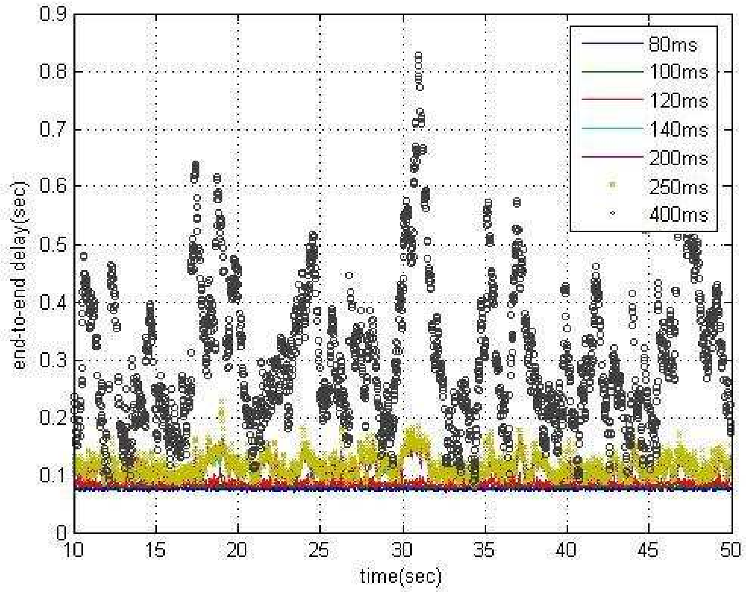
- Traffic conditions
  - source -> destination (0.56) and cross traffic (0.39)

Delay Requirement	traffic	Rate *offered load	number	size
80msec	exp	0.001Mbps*0.56	100	64
100msec	exp	0.001Mbps*0.56	100	128
120msec	exp	0.0012Mbps*0.56	100	128
140msec	exp	0.13Mbps*0.56	1	210
200msec	exp	0.15Mbps*0.56	1	210
250msec	exp	0.2Mbps*0.56	1	210
400msec	exp	0.2Mbps*0.56	1	210

Experimental Results

- **End-to-end delay**
  - QCM-IP
  - QCM-ASM





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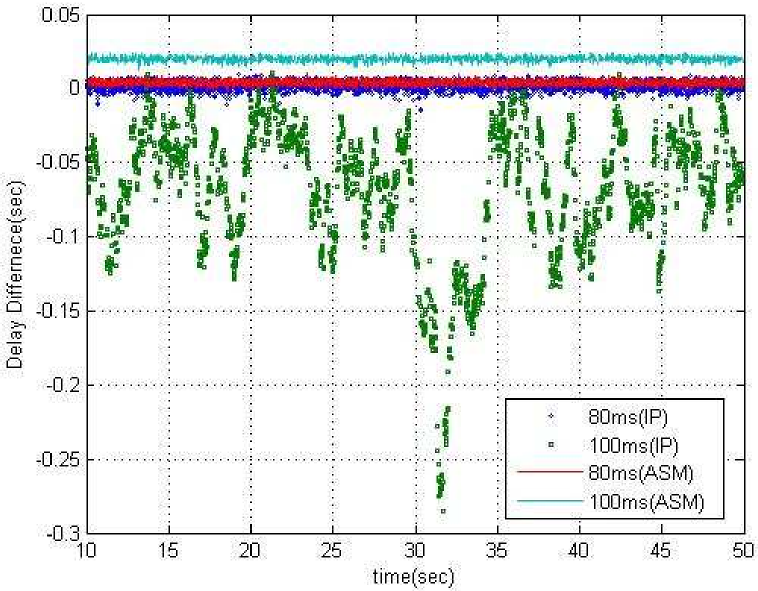
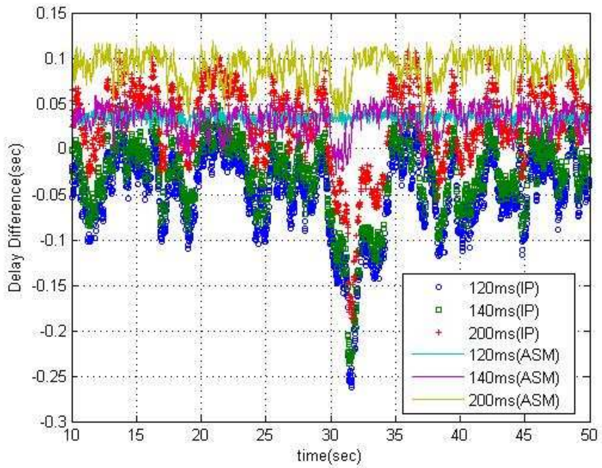
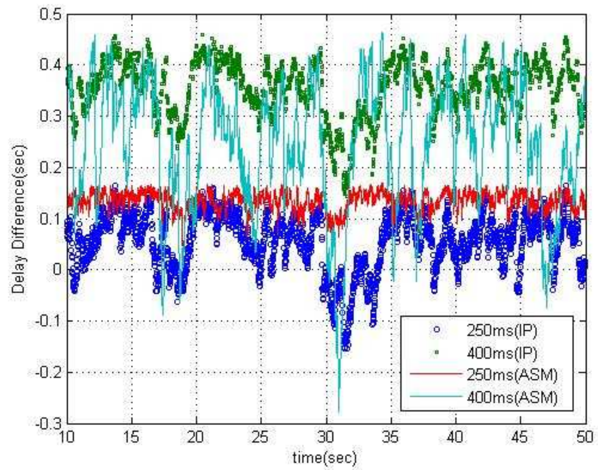
Experimental Results(2)

- **Delay difference**

= delay requirement - experienced delay







Conclusions

- This paper recognizes the interoperability of QoS class over heterogeneous networks
- We proposed two QCM frameworks
  - The QCM-IP can be easily implemented because of the established studies. However, it has a limitation to provide end-to-end QoS for each fine-granular application because class mapping has many flaws
  - A QCM-ASM framework can support finer applications that emerge in the future and a specific network's QoS class change can have no effect on the framework