An Efficient Call Admission Control for IEEE 802.16 Networks

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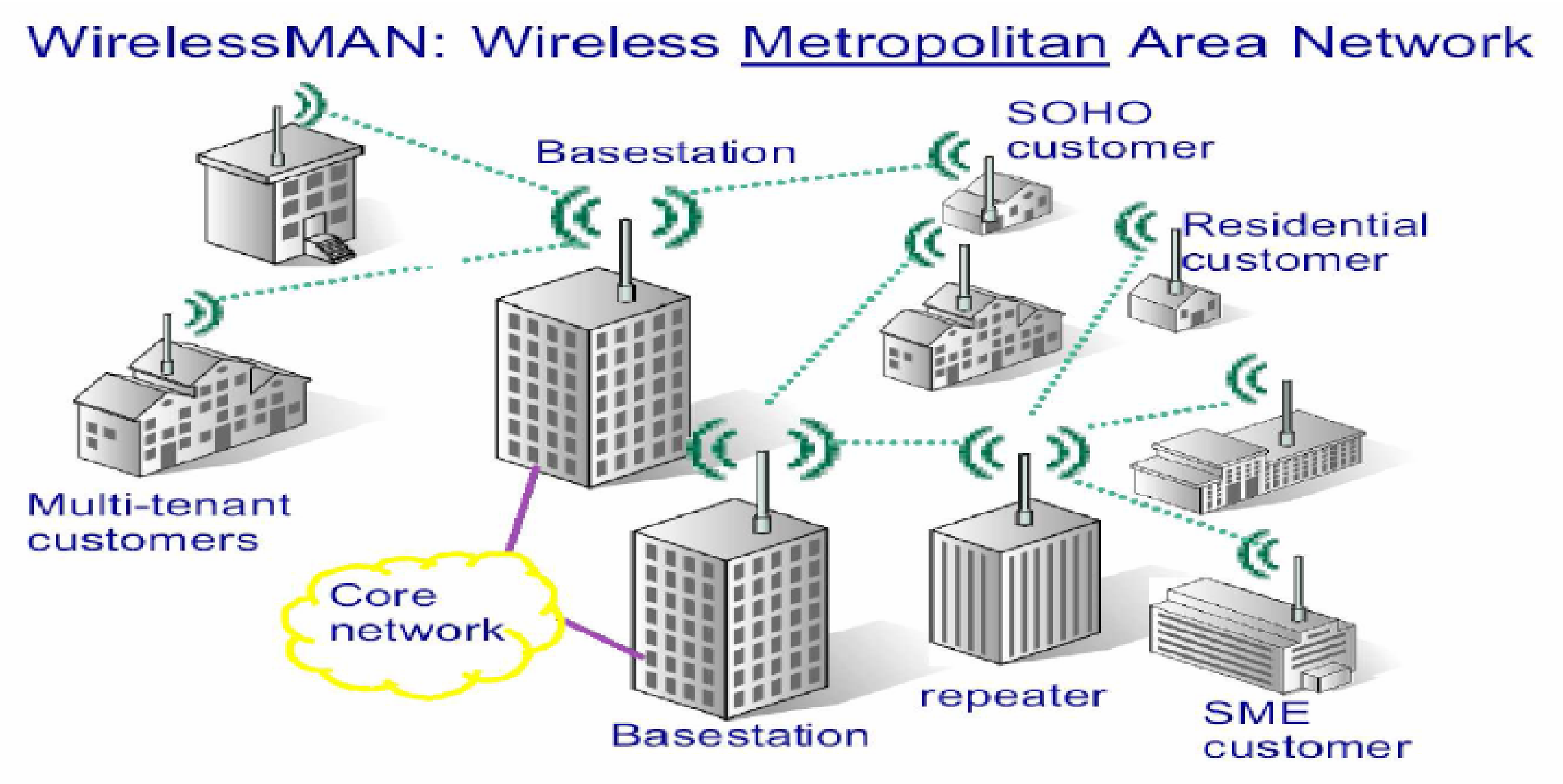
Introduction

- IEEE 802.16 is a PHY and MAC layer specification for broadband wireless access in LAN and MAN
- High Bandwidth and long range deployment
- Native support for Quality of Service for voice, video and data

Motivation

- 802.16 MAC supports different services such as UGS, RTPS, NRTPS, BE, which require various levels of QoS guarantees.
- 802.16 standard does not specify any scheduling or admission control
  - But Call Admission Control (CAC) is a very important part of the 802.16 network which can determine the correctness of the QoS Provisioning and efficiency of the network
  - In this paper, we propose an efficient CAC for 802.16 network

Typical Deployment Topology

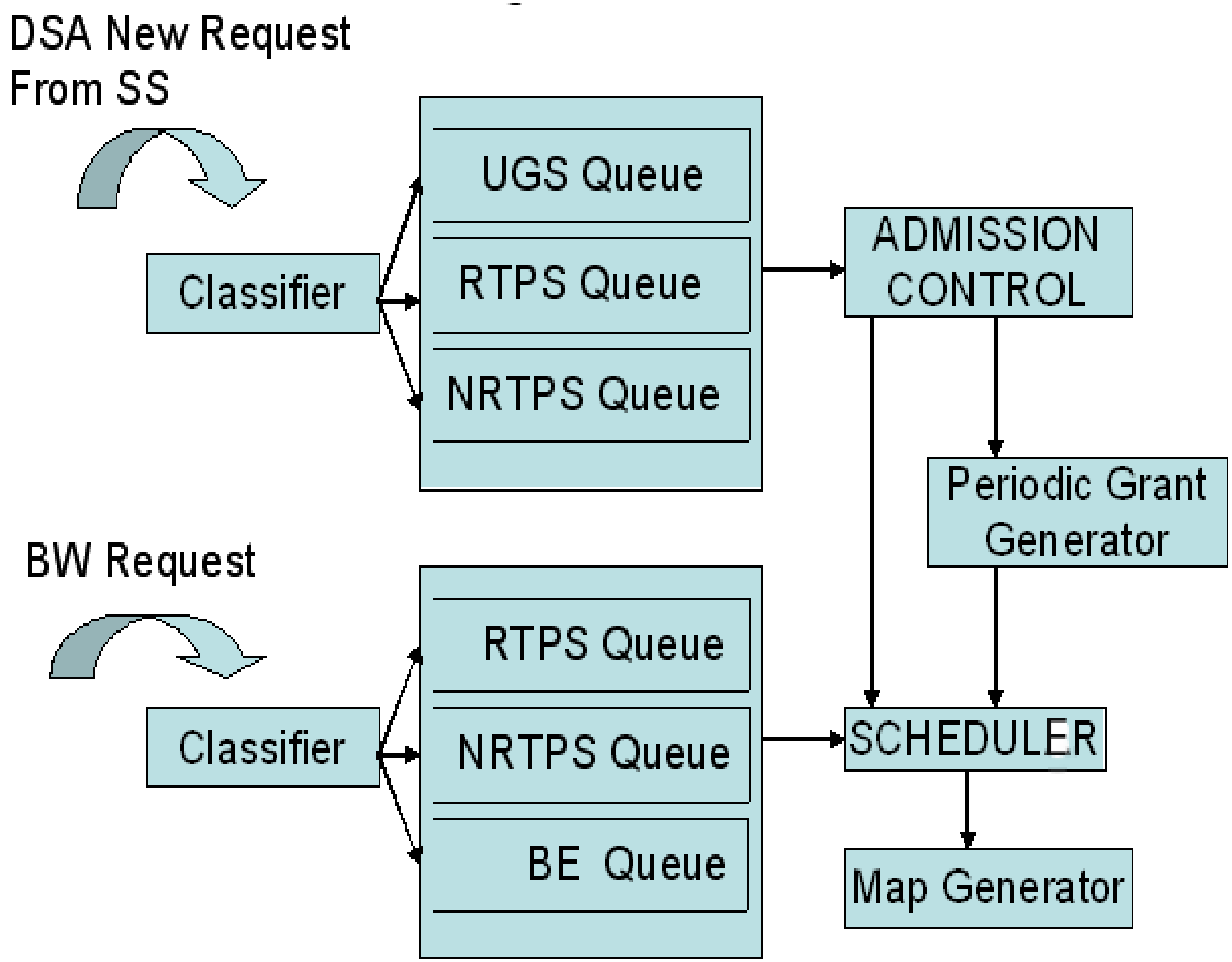


Source: Nokia

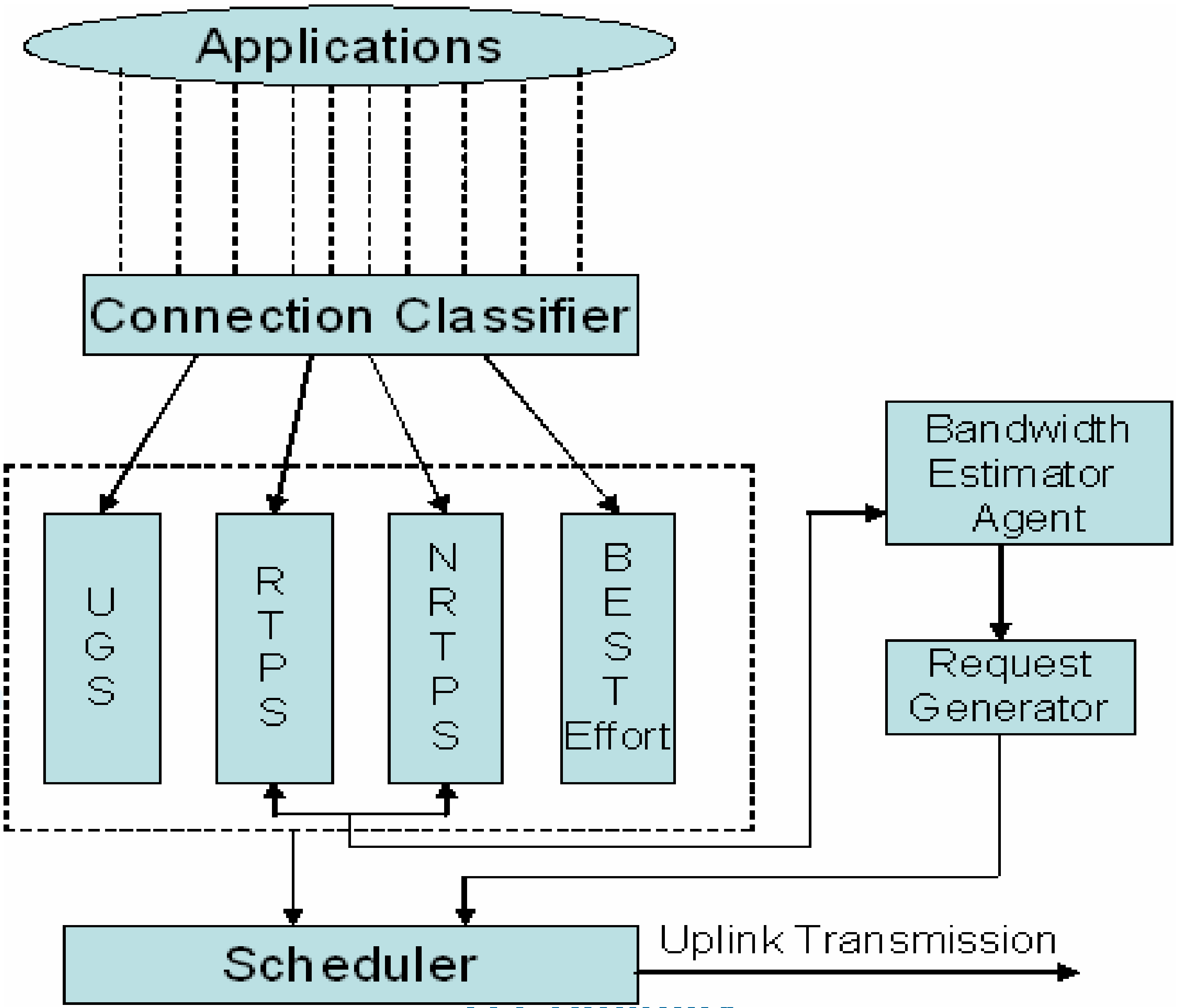
Uplink Scheduling Services

- **Four services are supported in IEEE 802.16 networks**
  - **Unsolicited Grant Service**
    - **Fixed size data packets on a Periodic basis.**
    - **Example :- Voice over IP**
  - **Real time polling Service**
    - **Variable sized data packets on a Periodic basis**
    - **Example :- MPEG**
  - **Non-Real time polling Service**
    - **Variable sized data packets on a Periodic basis but not real time**
    - **Example :- High Bandwidth FTP**
  - **Best-Effort Service**
    - **Example :- Internet traffic**

Proposed BS Architecture



Proposed SS Architecture



Connection Request Parameters

UGS	**Nominal grant interval C_i^{UGS}[*ngi*]**	**Tolerated grant jitter C_i^{UGS}[*tpj*]**	**-**	**Maximum traffic rate C_i^{UGS}[maxrate]**	**-**
RTPS	**Nominal polling interval C_i^{RTPS}[*npi*]**	**Tolerated poll jitter C_i^{RTPS}[*tpj*]**	**Minimum traffic rate C_i^{RTPS}[*minrate*]**	**Maximum traffic rate C_i^{RTPS}[*maxrate*]**	**-**
NRTPS	**Nominal polling interval C_i^{NRTPS}[*npi*]**	**Tolerated poll jitter C_i^{NRTPS}[*tpj*]**	**Minimum traffic rate C_i^{NRTPS}[*minrate*]**	**Maximum traffic rate C_i^{NRTPS}[*maxrate*]**	**Traffic priority C_i^{RTPS}[*priority*]**
BE	**-**	**-**	**-**	**Maximum traffic rate C_i^{BE}[maxrate]**	**Traffic priority C_i^{BE}[*priority*]**

Admissibility Test

- **Hyper Interval (*HI*):** Since connections come with different parameters, ***HI*** is used for testing admissibility of requests. This makes sure that QoS requirements are met at every periodic interval of the corresponding service class type. ***HI*** of different service classes are defined as follows.

$$HI^{UGS}(N) = \forall_I \ LCM\,(C_i^{UGS}[ngi]), \quad 1 \le i \le N^{UGS}$$

$$HI^{RTPS}(N) = \forall_I \ LCM\,(C_i^{RTPS}[npi]), \quad 1 \le i \le N^{RTPS}$$

$$HI^{NRTPS}(N) = \forall_I \ LCM\,(C_i^{NRTPS}[npi]), \quad 1 \le i \le N^{NRTPS}$$

The ***HI*** of all the connections across the three service classes are calculated as follows:

$$HI\,(N) = LCM\,(HI^{UGS}, HI^{RTPS}, HI^{NRTPS})$$

BW-based CAC

The available Bandwidth is given by

$$BW_{avail} = BW - \sum_{s \in \{UGS, RTPS, NRTPS\}} \sum_{i=1}^{N^s} C_i^s[rate]$$

where $C_i^s[rate] = C_i^s[maxrate]$ when $s \in UGS$, $C_i^s[rate] = C_i^s[minrate]$ otherwise and BW is the total link bandwidth.

Our QoS-CAC

- Overview
  - Our algorithm admits connections only if it can provide QoS guarantees to all the previously admitted connections along with the newly arrived connection request.
  - A new connection request is classified into a particular queue depending on the associated Service Class type.
  - Service Class Queue Priority Order (highest to lowest)
    - UGS, RTPS, NRTPS, BE

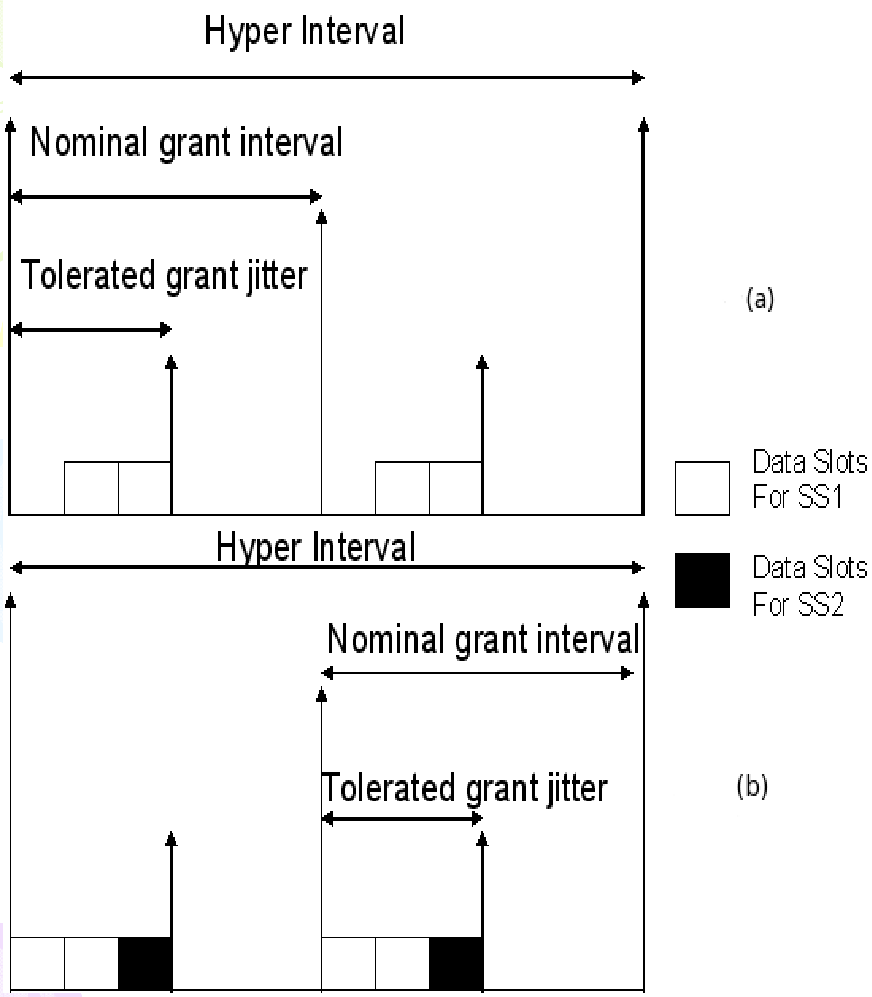
QoS-CAC: Admission Decision of various connection requests

- **UGS Connection :**
  - **If the request is of type UGS then it should satisfy the necessary condition:** ***the requested slots based on its maxrate within its ngi should be less than or equal to the total number of slots that can actually be accommodated within the tgj based on BW*** **i.e.**

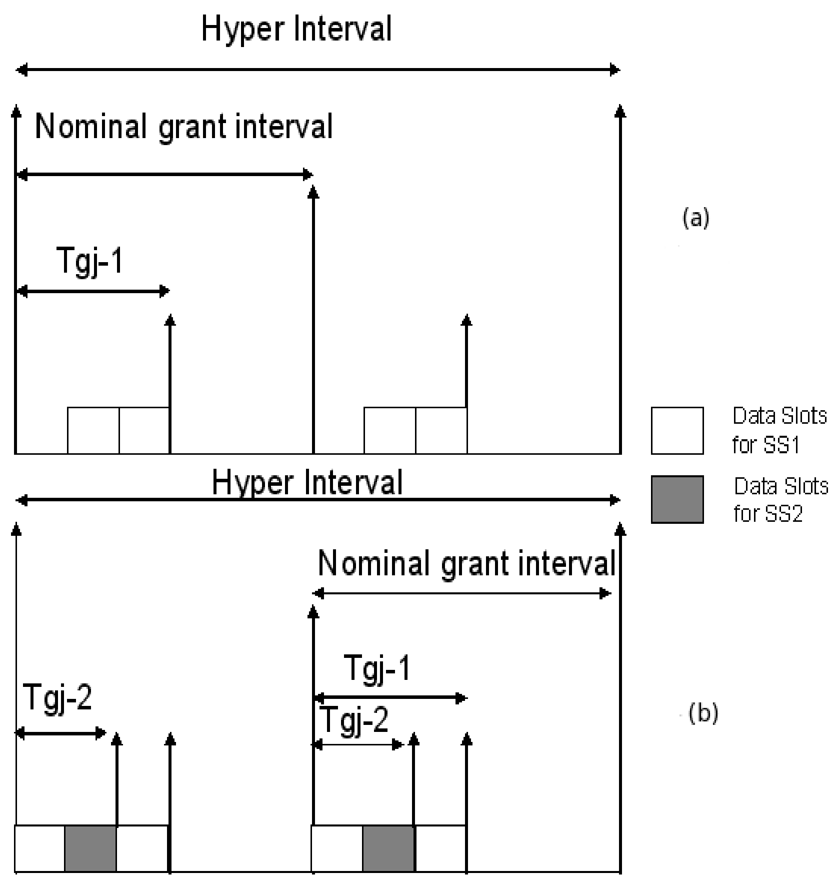
$$\lceil (C_i^{UGS}[ngi] * C_i^{UGS}[maxrate])/slot\_size \rceil \leq \lfloor (C_i^{UGS}[tgj] * BW)/slot\_size \rfloor$$

  - **Then it assigns required number of slots starting from** ***tgj***

UGS CAC Illustrated



Contiguous Allocation



Non-Contiguous Allocation

RTPS Connection

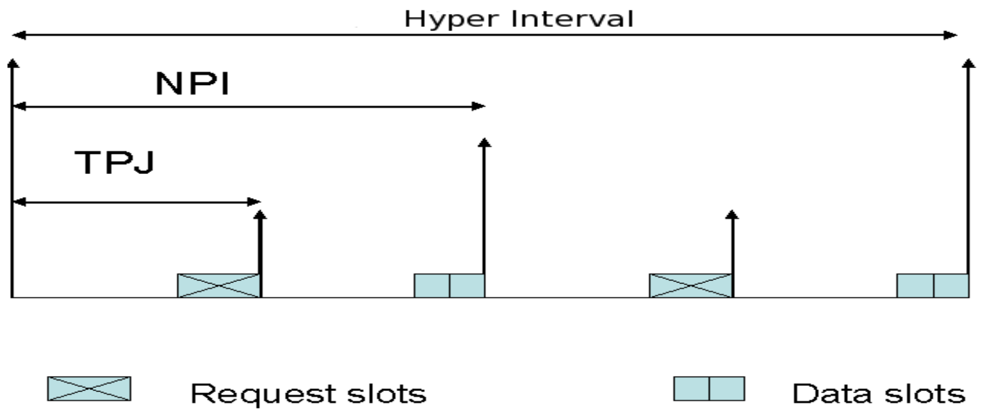
- If the request is of type RTPS then it should satisfy the necessary condition: *the number of required slots within the npi as per its minrate should be less than or equal to the total number of slots that can actually be accommodated within the npi as per the total bandwidth. i.e.*

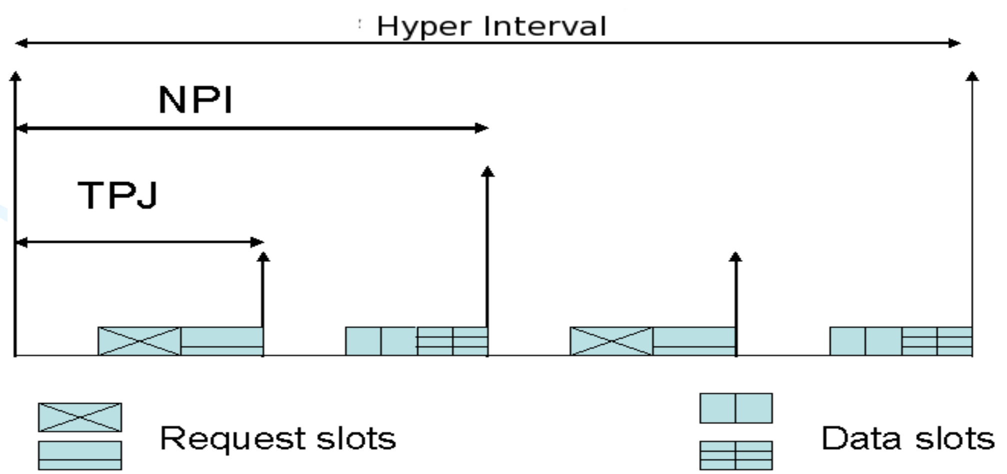
$$\left\lceil (C_i^{RTPS}[npi] * C_i^{RTPS}[\min rate]) / slot\_size \right\rceil \leq \left\lfloor (C_i^{RTPS}[npi] * BW) / slot\_size \right\rfloor$$

RTPS Connection

- Then it checks that enough number of slots are available for bandwidth request: enough number of bw request slots should be available within *tpj*

RTPS CAC Illustrated





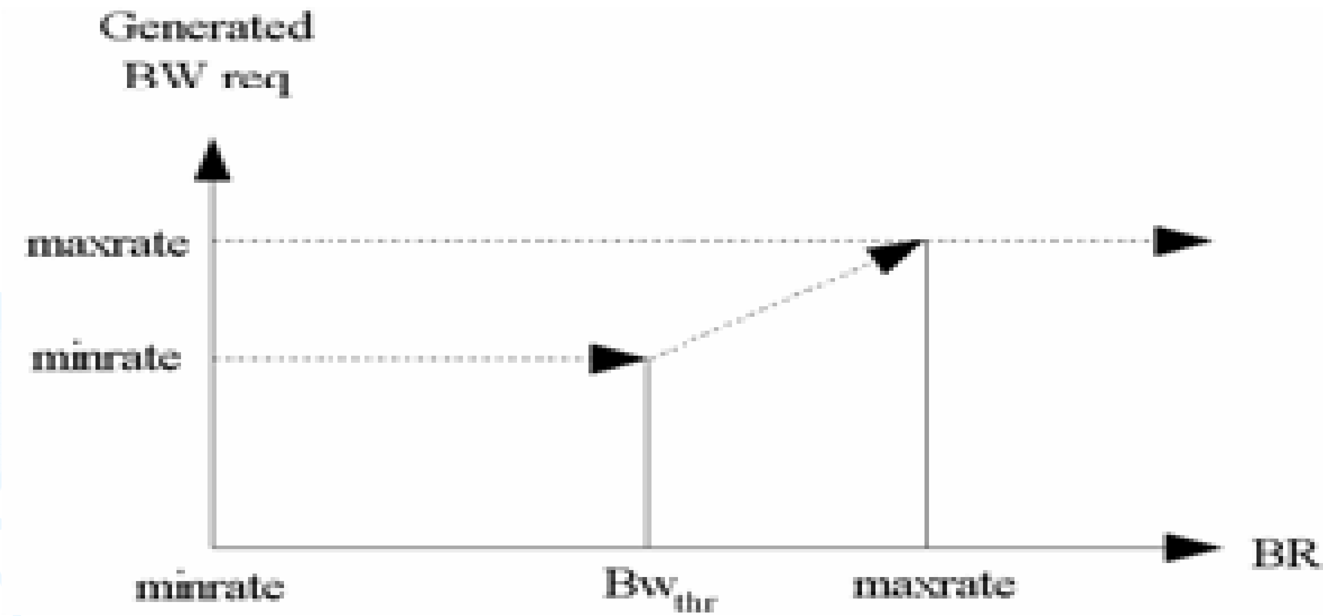
NRTPS Connection

- Similar is the case with NRTPS except that the values taken by the parameters are large when compared to the RTPS connections.

Need for BW Estimator

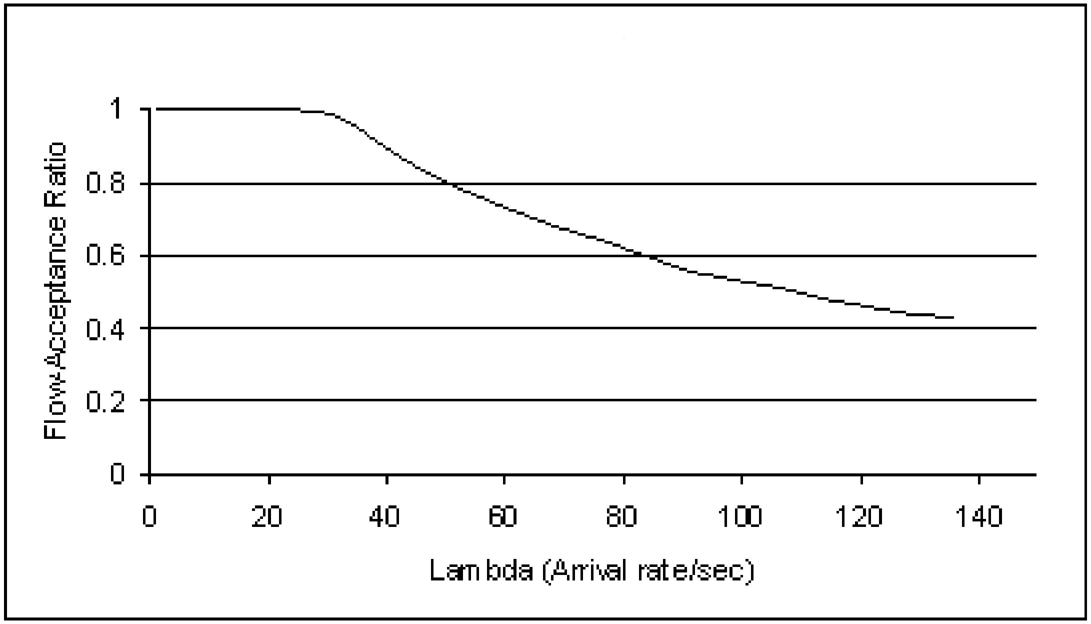
- In RTPS and NRTPS connection, admission of a connection is based on its minrate.
- But they have a variable bandwidth requirement
  - Always allocating minrate will have performance impact on nrtps application
  - Always allocating maxrate will result in low utilization of resources of 802.16 system
  - Thus, a bw estimator at the SS which monitors the queue length and changes the bw requirement accordingly
  - BR : ratio of change of queue length between two successive observation to the monitoring interval.

Bandwidth Estimator Agent (BEA) for RTPS and NRTPS connections



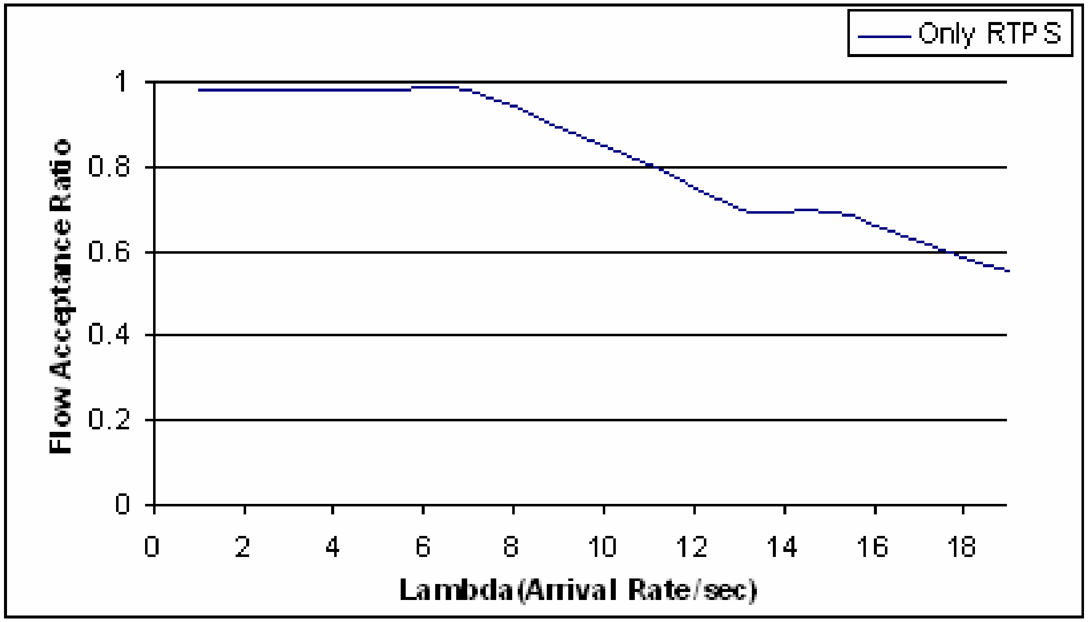
- $minrate \leq BR \leq BW_{thr}$: BEA sends a bandwidth request for $minrate$
- $BW_{thr} < BR \leq maxrate$: BEA sends a bandwidth request for BR
- $maxrate < BR$: BEA sends a bandwidth request for $maxrate$

Only UGS connections



Codec chosen is G.711
Acceptance Ratio is 100% until arrival rate is 38/sec

Only RTPS connections



Minrate = 128kbps, maxrate=256kbps, npi=1sec, tpj=0.5sec
Acceptance ratio falls much quicker than UGS because of high Bw requirement

Mixed Traffic Classes

Parameter	Value
Channel Capacity	32 Mbps (QPSK)
Symbol Rate (MBd)	16
Frame Duration	1 ms
Physical slots per frame	4000
Slot size	1 byte

System Parameters used in Simulation

Codec	G.711	G.721	G.728
Bit rate (Kbps)	64	32	16
ngi (ms)	20	20	20
tpj (ms)	10	10	10
Duration (sec)	180	180	180

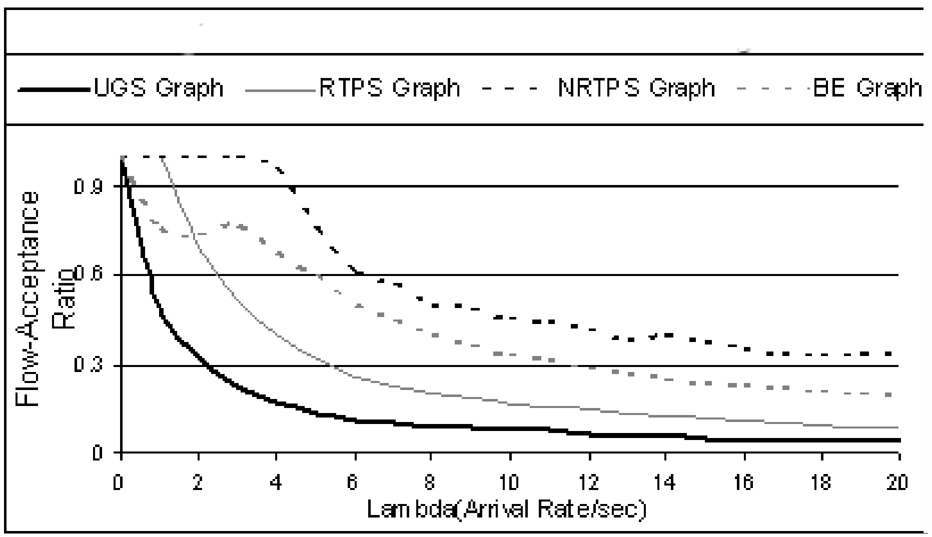
UGS Traffic Parameters

RTPS, NRTPS, BE parameters

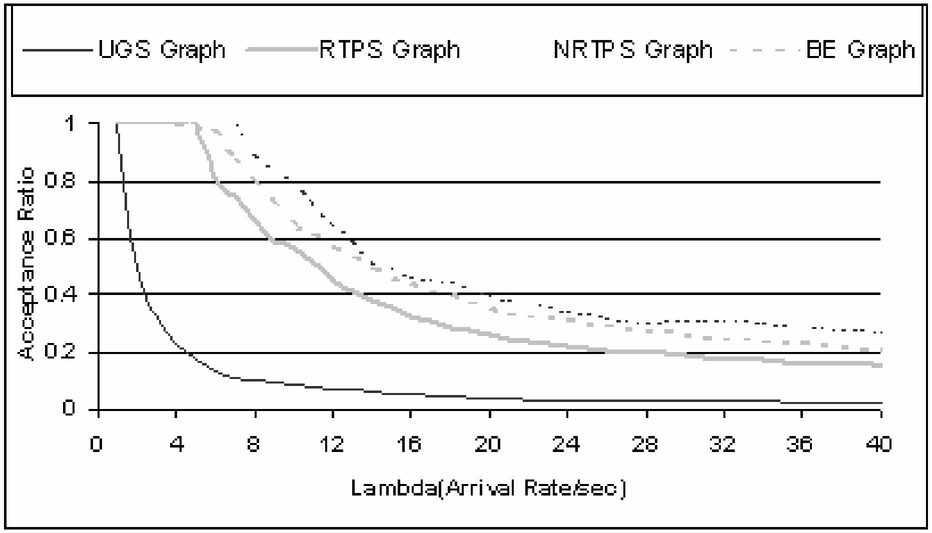
Service type	maxrate (kbps)	minrate (kbps)	npi (sec)	tpj (sec)
RTPS	128	64	0.5	0.5
RTPS	256	128	0.5	0.5
RTPS	512	256	0.5	0.5
NRTPS	128	64	1	1
NRTPS	256	128	1	1
NRTPS	512	256	1	1
BE	32	-	-	-
BE	64	-	-	-
BE	128	-	-	-

Experimental Results

All classes of Traffic allocated Maxrate

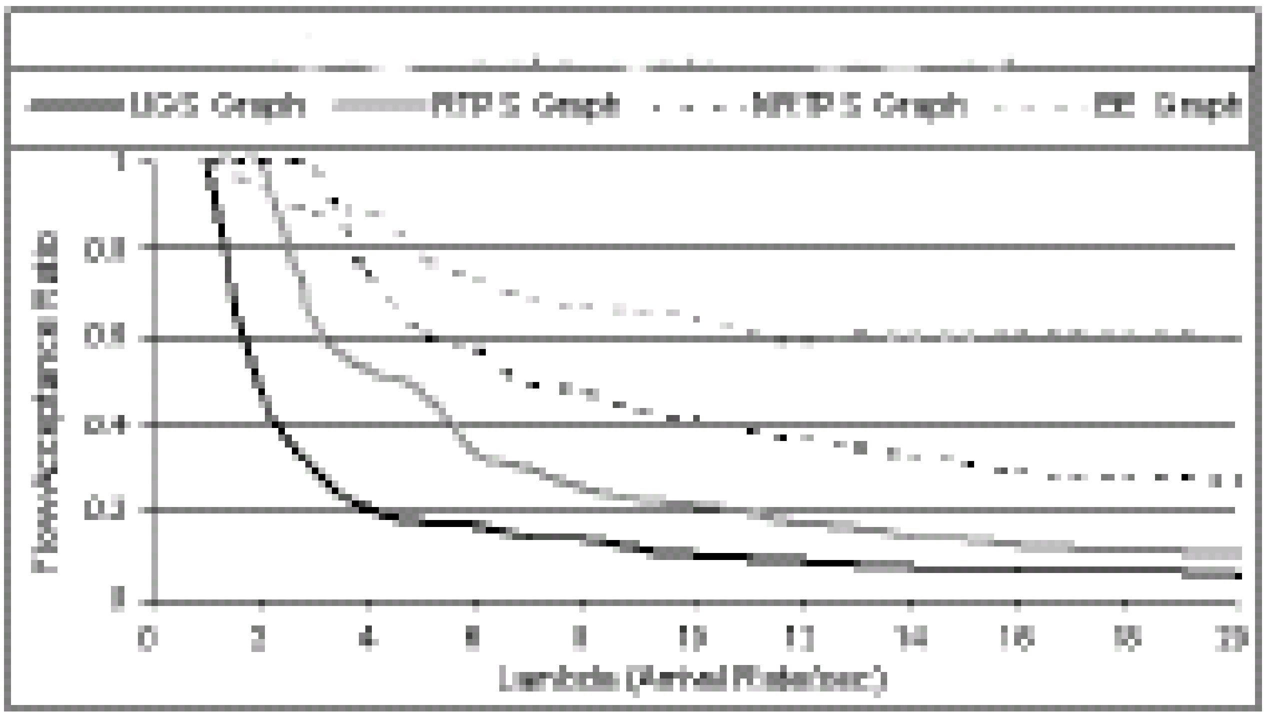


All classes of Traffic allocated Minrate



Experimental Results

All classes of Traffic with Bandwidth Estimator



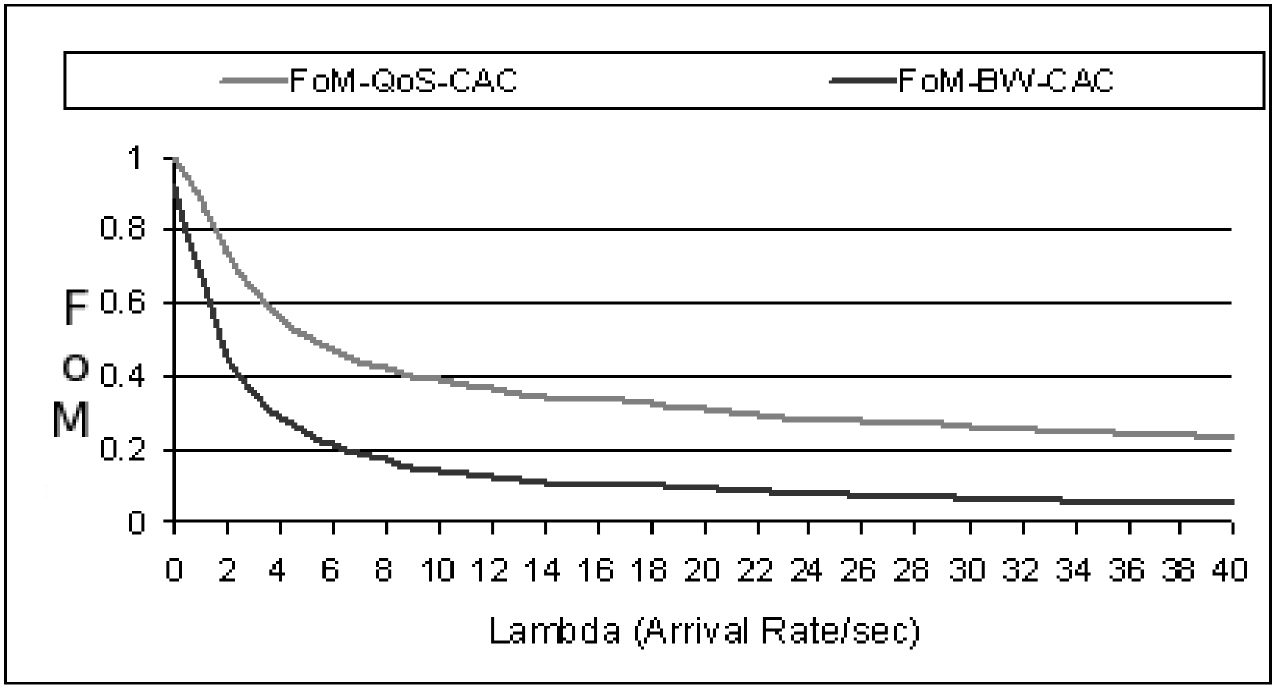
BW_thr midway between min and max
Acceptance Ratio of all classes increase except for NRTPS (compared to maxrate case)

Comparison with BW-CAC

- BW-CAC admits connections only based on available bandwidth
  - Can admit more connections than QoS-CAC
  - But connections might miss deadlines
- Hence we define a Figure of Merit (FOM) to compare the two CACs:

$$FoM = \frac{Utilization * (No\_of\_conn\_admitted - No\_of\_conn\_miss\_deadlines)}{Total\_no\_of\_conn\_requests}$$

Experimental Results



Conclusion

- Presented an architecture for BS and SS of 802.16 system
- Presented the Call Admission Control algorithm for UGS, RTPS and NRTPS connections
- Proposed a method for estimating BW to increase system utilization
- Proposed a composite Figure of Merit for comparing QoS-CAC with BW-CAC
- QoS-CAC is more suitable for 802.16 network which provide bandwidth, delay and jitter guarantee to different connections.

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Thank you

Questions??