# A Novel Architecture for IEEE 802.16m Subscriber Station for Joint Power Saving Class Management

Ritesh K. Kalle, Mayank Raj and Debabrata Das

International Institute of Information Technology – Bangalore (iiit-b)

# Outline

1. Introduction
2. Motivation
3. Proposed Architecture
4. Analytical and Simulation Results
5. Conclusion

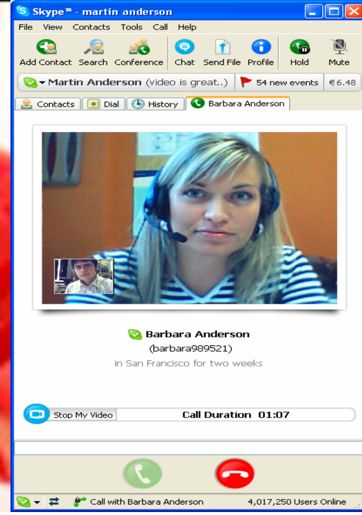
# Introduction

- IEEE 802.16m amends the IEEE 802.16 WirelessMAN-OFDMA specification to provide an advanced air interface for:
  - the requirements of IMT-Advanced next generation mobile networks
  - To Support Enhanced Power Saving Strategies [1]

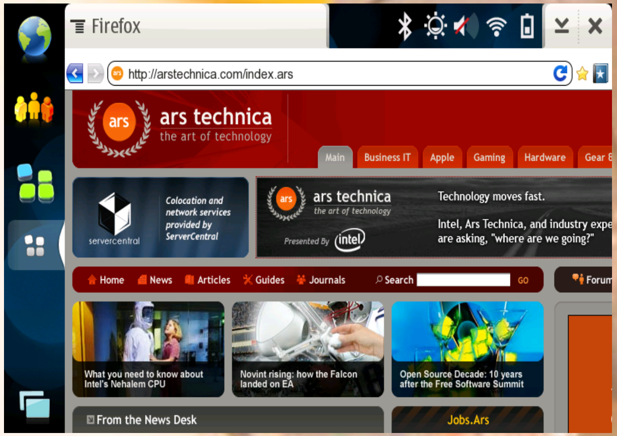
# Power Saving Mechanism in IEEE 802.16e

- Sleep mode is a state in which an MS conducts pre-negotiated periods of absence from the Serving BS air interface
- A Power Saving Class (PSC) is defined according to a group of Medium Access Control (MAC) layer connections that have common traffic demand properties and can follow a common algorithm for determining the sleep interval
- SS negotiates sleep-mode with BS per active Power Saving Class Identifier (PSC_ID) belonging to a PSC

QoS Class rtPS
Power Saving Class B
PSC_ID 1

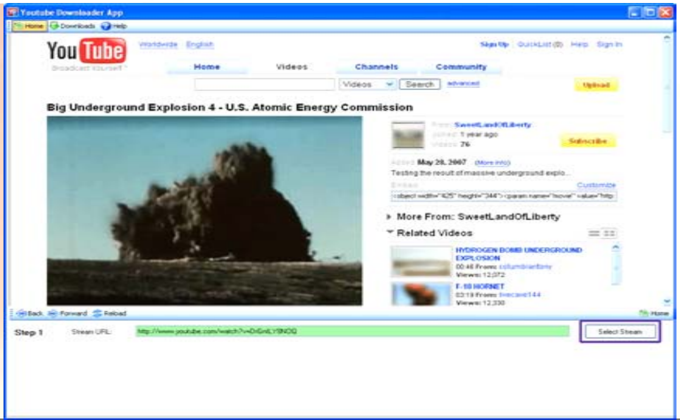



One Device Multiple Applications Simultaneously Accessing Internet over WiMAX





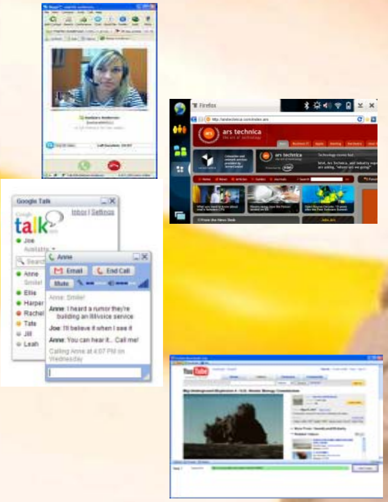

QoS Class BE
Power Saving Class A
PSC_ID 2

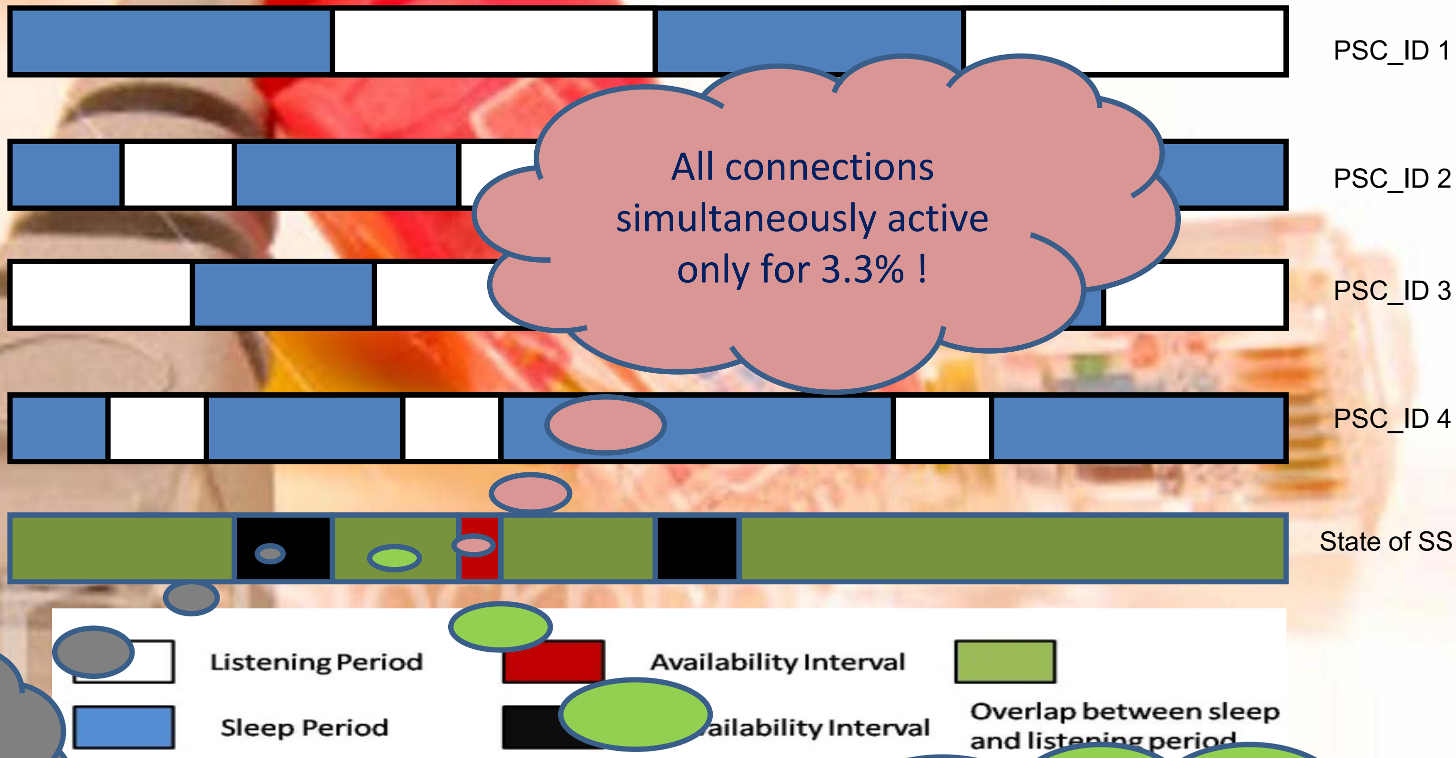



QoS Class UGS
Power Saving Class B
PSC_ID 3

QoS Class BE
Power Saving Class A
PSC_ID 4

# MOTIVATION






All connections simultaneously active only for 3.3% !

Voila!
Device is sleeping 12% of the time!

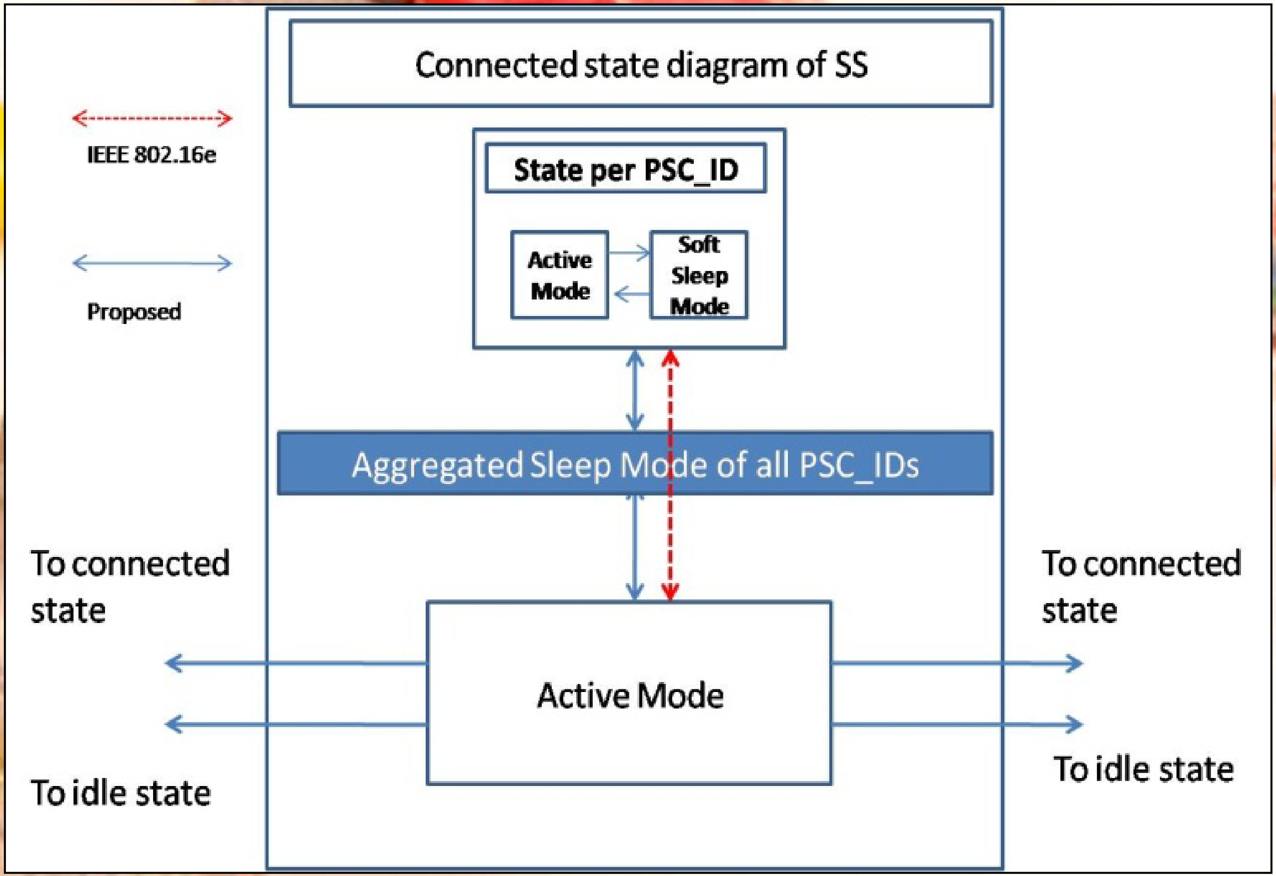
Potential power saving can be achieved, if the listening intervals could be synchronized across the PSC_IDs

Details in [5]

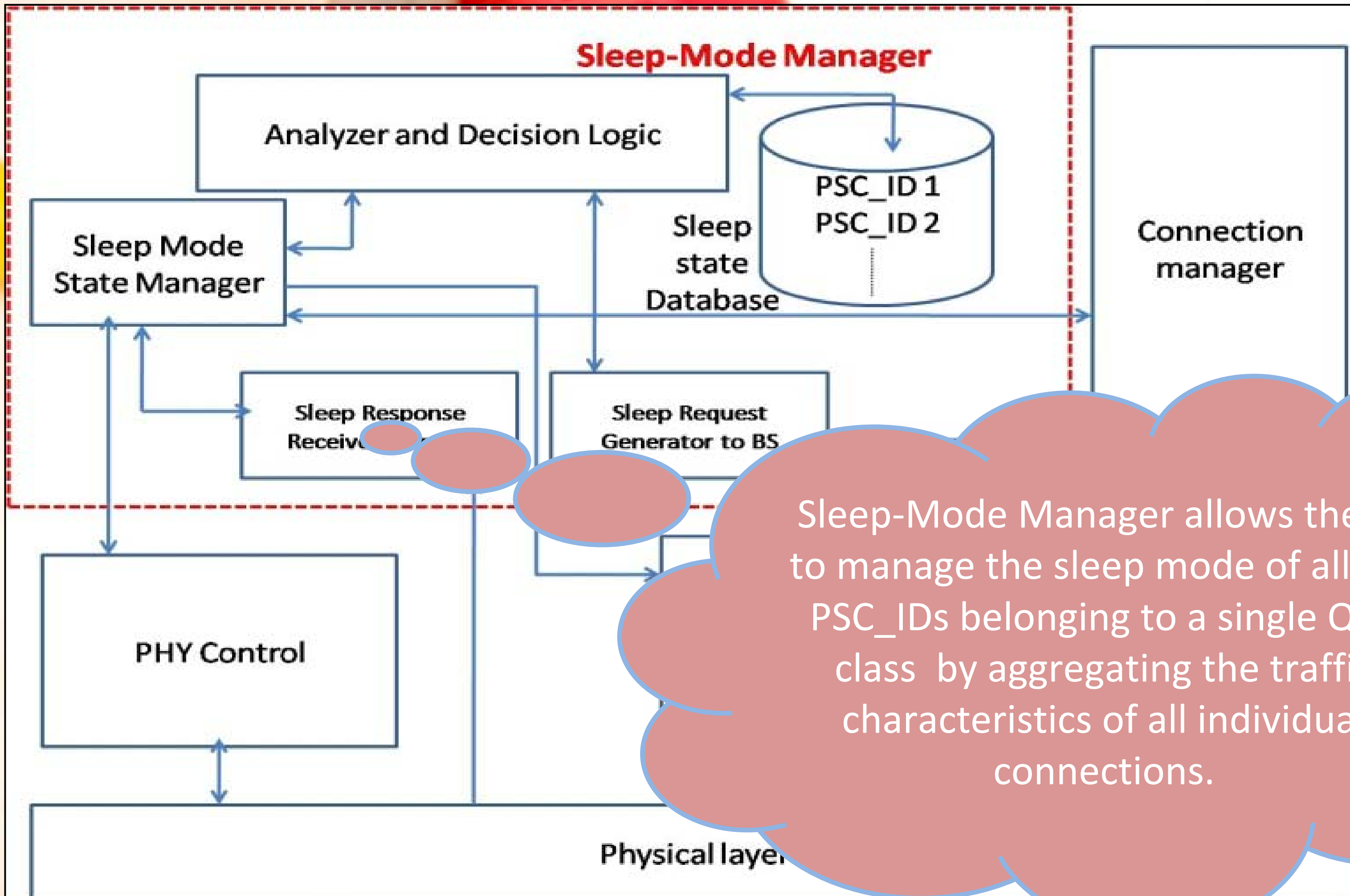
# Problem Statement

- To design an architecture and mechanism for Joint Power Saving Class Management that optimizes the sleep mode management efficiency as the number of active connections increase in IEEE 802.16m MAC

# State transitions in the proposed architecture



# Proposed Sleep-Mode Manager Architecture

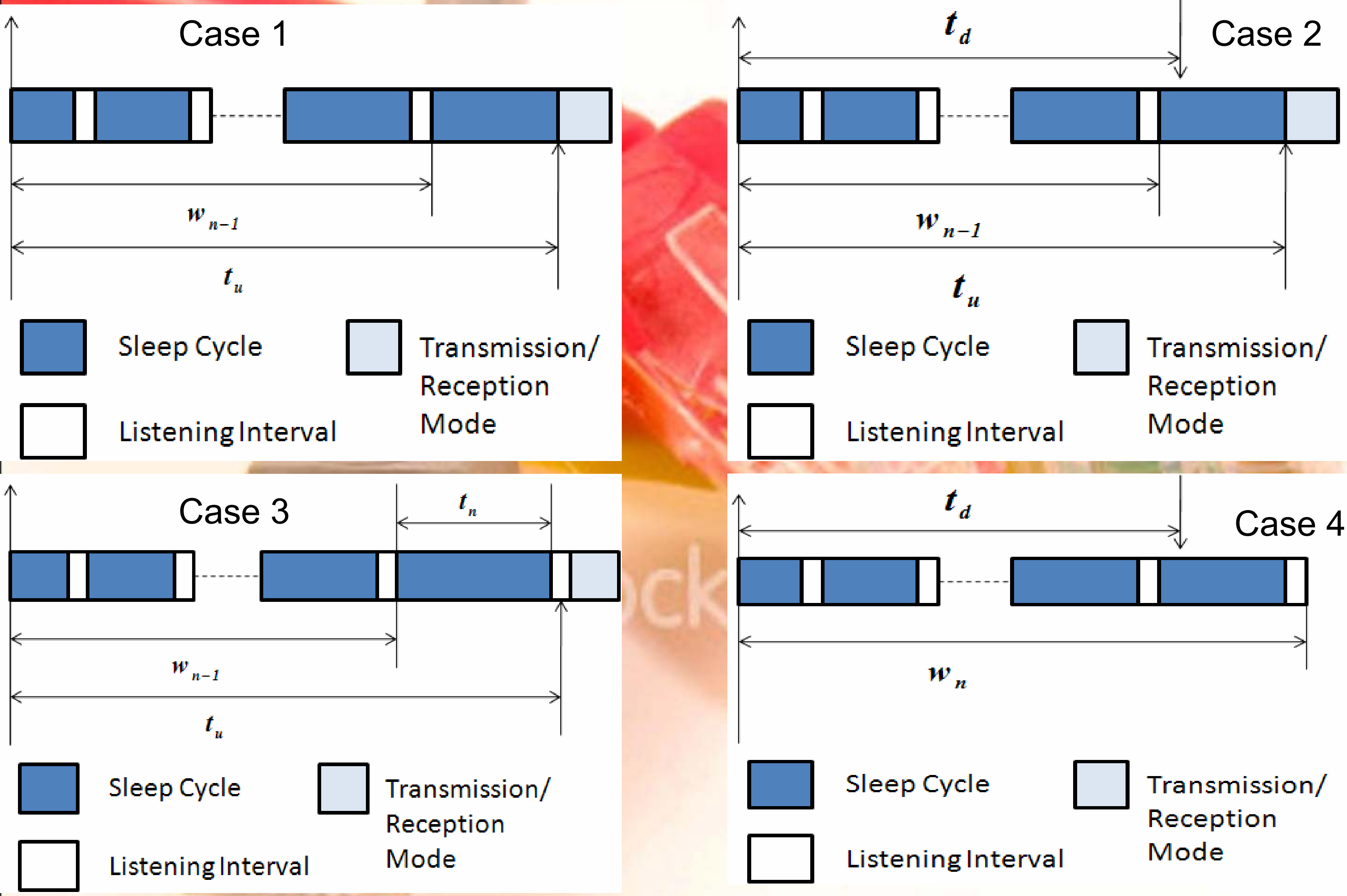



Sleep-Mode Manager allows the SS to manage the sleep mode of all the PSC_IDs belonging to a single QoS class by aggregating the traffic characteristics of all individual connections.

# Advantages of the Proposed Architecture

- The overhead of management messages is minimal as sleep is not negotiated on a PSC_ID basis.
- Changes in parameters for sleep mode do not require deactivation or activation of PSC.
- The parameters can be directly negotiated with sleep-manager.
- Robust system is available for adaptive power management according to changing traffic.

# Analytical Modeling



# Average Probability of the Unavailability Period

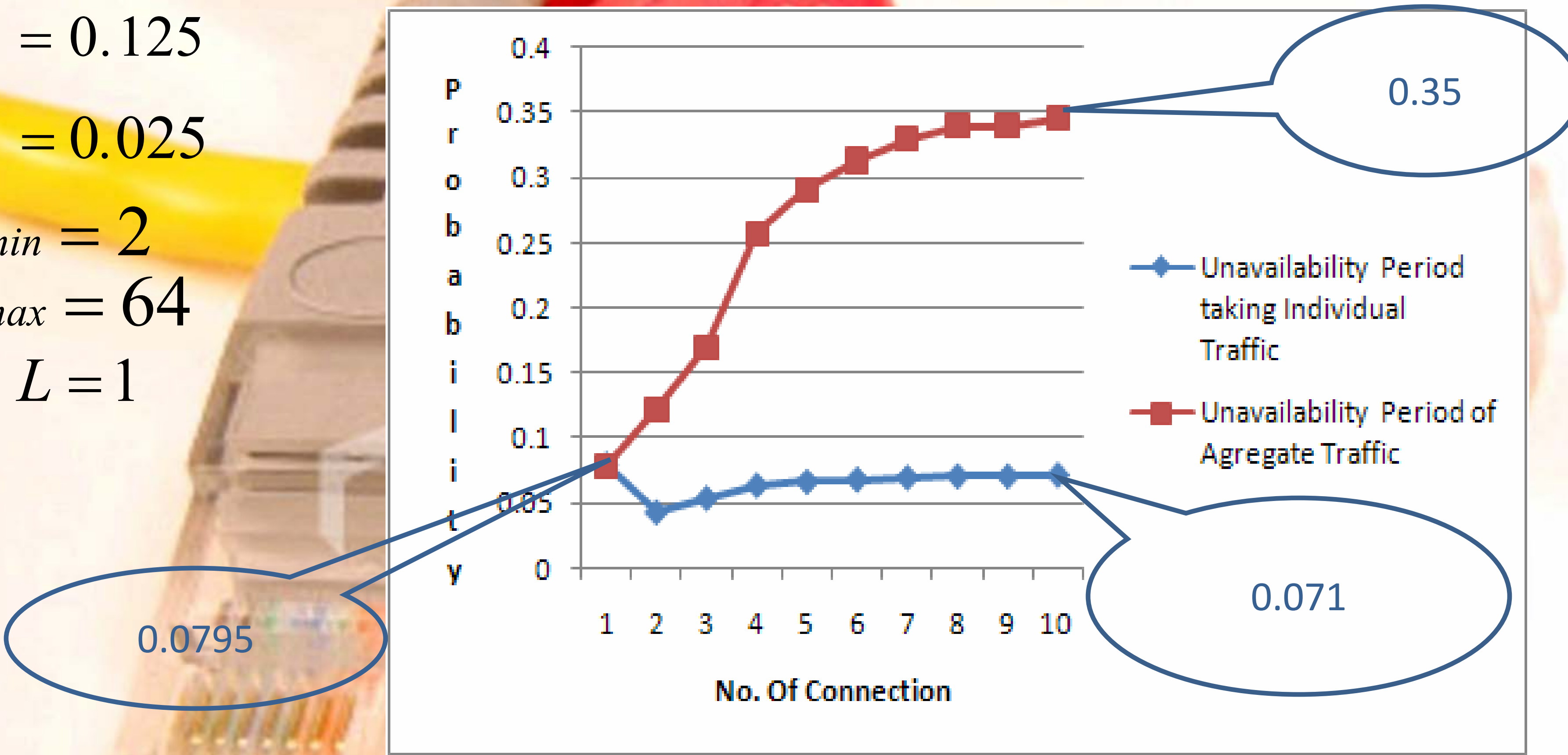
$$\lambda_u^i = 0.125$$

$$\lambda_d^i = 0.025$$

$$t_{min} = 2$$

$$t_{max} = 64$$

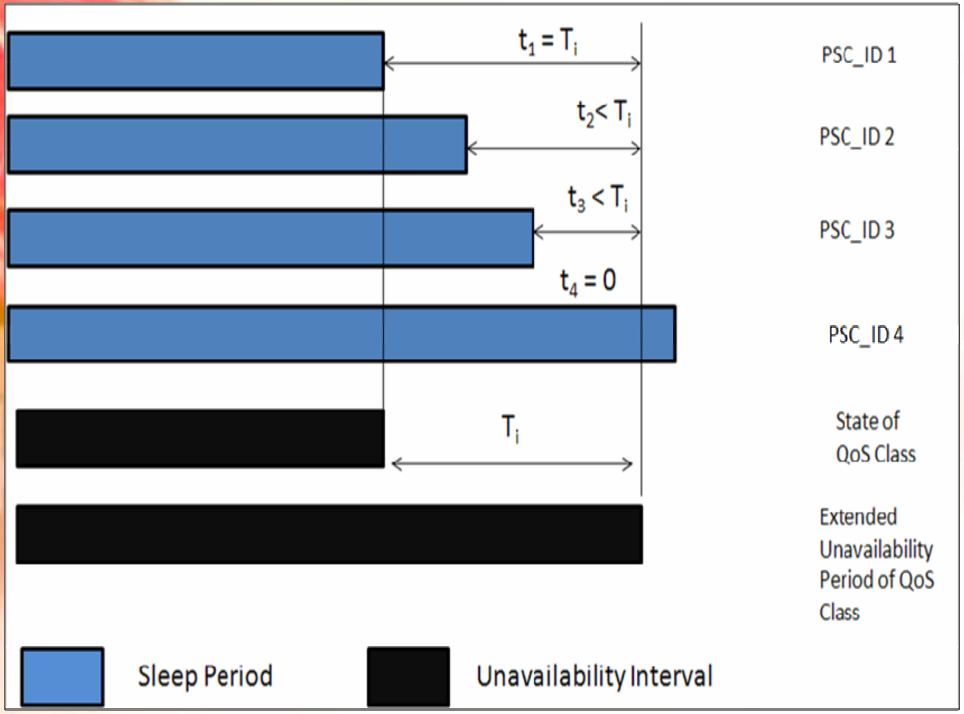
$$L = 1$$



# Extension of the unavailability period of QoS Class

- We define a Threshold Factor $T_i$, for i = 1, 2, 3, 4, 5
- Maximum frame time for which the unavailability period of the QoS Classes (UGS, ertPS, rtPS, nrtPS and BE) can be extended
- These values are selected, considering the latency and jitter requirements of the respective QoS class, such that

$$T_1 < T_2 < T_3 < T_4 < T_5$$



# Unavailability Period of SS

- The duration of extension of the unavailability period of the QoS class is then determined from a value given as $t_{ext}^{j}$ , where *j* represents each QoS Class (UGS, ertPS, rtPS, nrtPS, BE) and calculated as

$$t_{ext}^{j} = max\left(t_k \forall k, k \in n, T_j\right), j \in QoS\ Class$$

- The value by which the total unavailability can be extended is calculated as follows

$$t_{ext} = min\left(t_{ext}^{j}, \forall j, j \in QoSClasses\right)$$

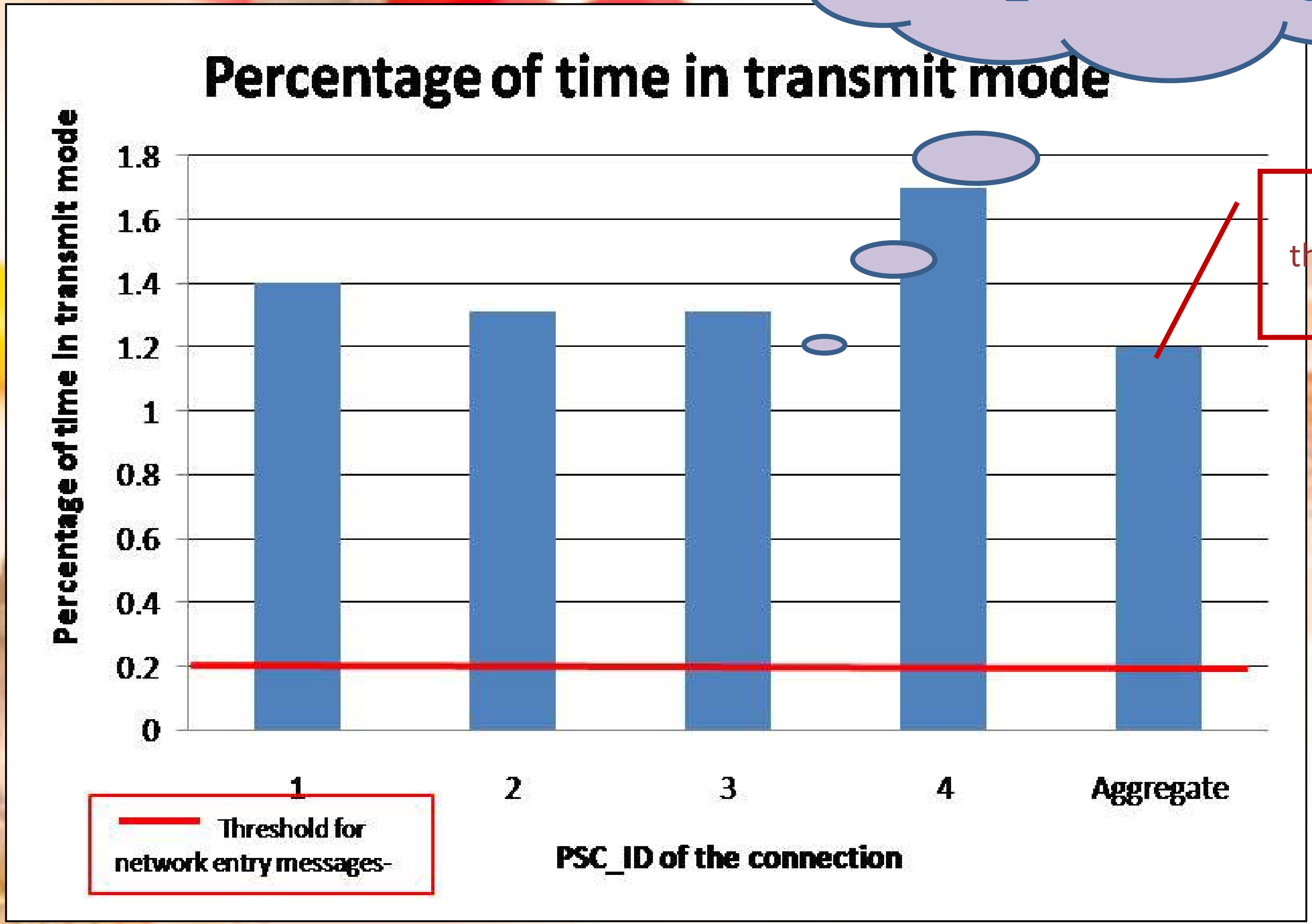
# Simulation Parameters

| Parameter | Value |
|---|---|
| Transmission Power | 15.0 dBm |
| MAC Frame Duration | 20 ms |
| TDD Downlink Duration | 10 ms |
| DCD/UCD Interval | 5 sec |
| DCD/UCD timeout interval | 25 sec |
| Simulation period | 25 sec |

DL connections with exponential traffic $\lambda = 1$ and random on-off time with on time percentage of 0.3

# Results

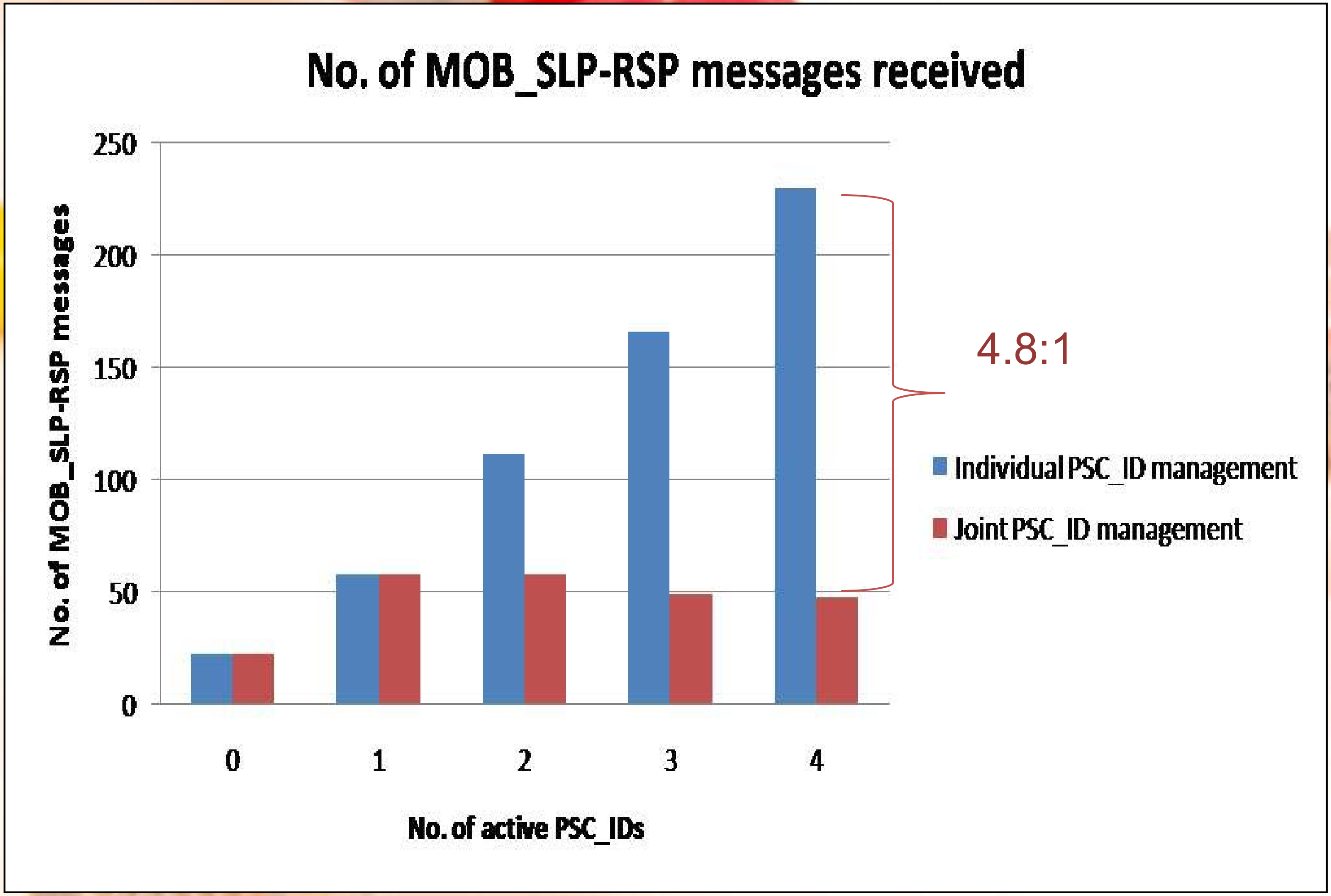
Mainly due to MOB_SLP-REQ and MOB_SLP-RSP messages




1.2 % lesser than individual PSC_IDs

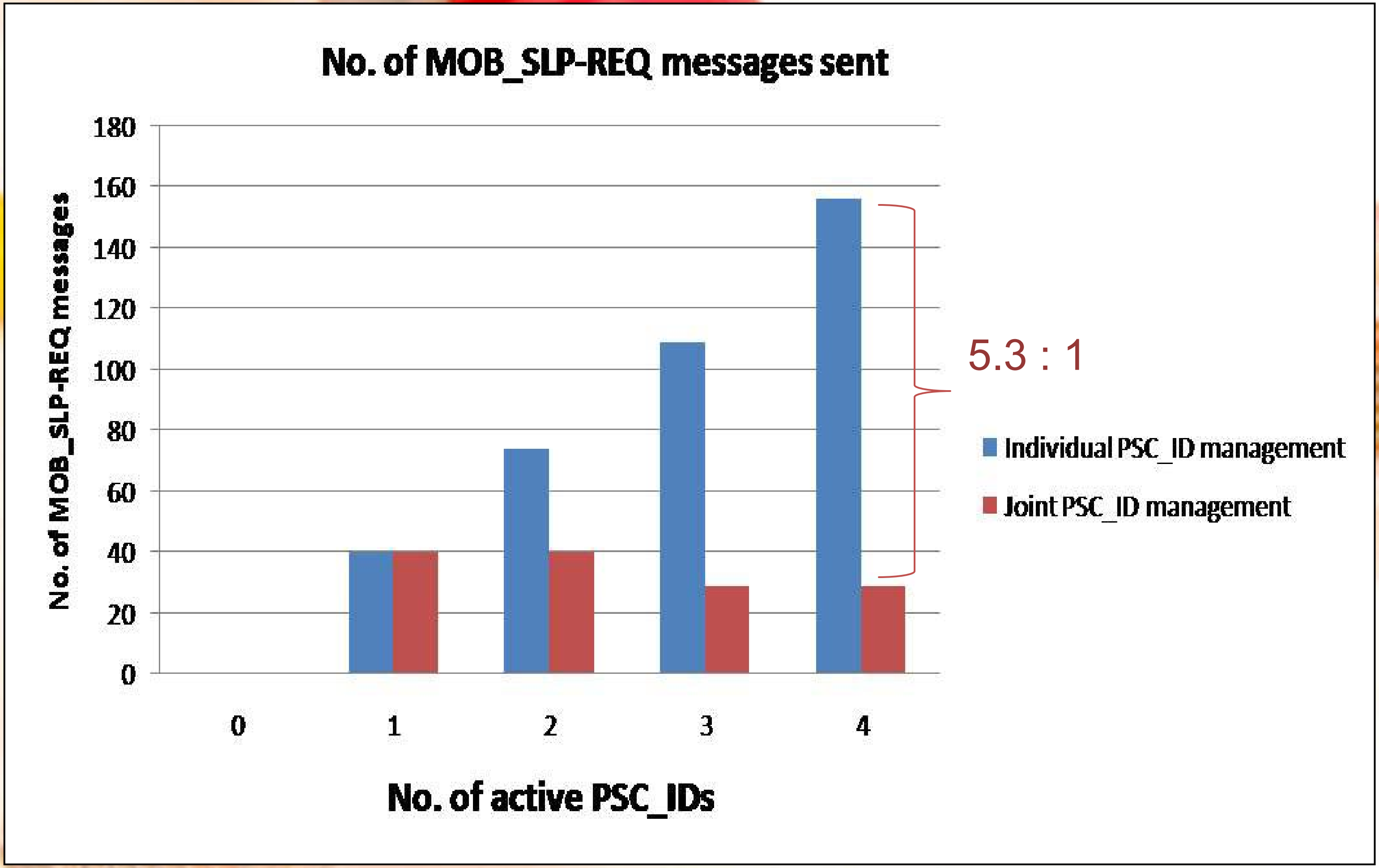
Percentage time in transmit mode of the SS for DL connection

# Results contd…




Number of MOB_SLP-RSP messages received with increasing number of active PSC_ID

# Results contd…




Number of MOB_SLP-REQ messages transmitted with increasing number of active PSC_ID

# Conclusion

- Introduction of soft-sleep mode at SS considerably reduces the management message exchanges between SS and BS
- The Joint Power Saving Class Management Architecture helps maximize the unavailability interval
- Percentage of time the SS is in transmit mode is reduced, leading to better power conservation
- The architecture enables the parameters of the sleep algorithm to be adapted to dynamic changes in traffic pattern while ensuring their QoS constraints

# References


1. IEEE 802.16m-07/002r4, “IEEE 802.16m System Requirements Document”
2. “Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000,” Recommendation ITU-R M.1645, 2003.
3. IEEE C802.16m-07/076r3, “Draft IEEE 802.16m Requirements,” March 15, 2007.
4. Vatsa, O.J.; Raj, M.; Ritesh Kumar, K.; Panigrahy, D.; Das, D., "Adaptive Power Saving Algorithm for Mobile Subscriber Station in 802.16e," *Communication Systems Software and Middleware, 2007. COMSWARE 2007. 2nd International Conference on*, vol., no., pp.1-7, 7-12 Jan. 2007.
5. Sunggeun Jin, Jaesun Cha, Sungcheol Chang, Wonik Kim, Kwangjae Lim, Hyun Lee, Chulsik Yoon, “Power Saving Strategies in IEEE 802.16m”, IEEE 802.16m Working Group, July 2008. Available online: www.wirelessman.org/tgm/contrib/C80216m-08_756r2.doc
6. Zhang, Y.; Fujise, M., "Energy management in the IEEE 802.16e MAC," *Communications Letters, IEEE*, vol.10, no.4, pp. 311-313, Apr 2006.
7. Xiao, Y., "Energy saving mechanism in the IEEE 802.16e wireless MAN," *Communications Letters, IEEE*, vol.9, no.7, pp. 595-597, July 2005.
8. Yunju Park; Gang Uk Hwang, "Performance Modelling and Analysis of the Sleep-Mode in IEEE802.16e WMAN," *Vehicular Technology Conference, 2007. VTC2007-Spring. IEEE 65th*, vol., no., pp.2801-2806, 22-25 April 2007.
9. Yan Zhang, "Performance Modeling of Energy Management Mechanism in IEEE 802.16e Mobile WiMAX," *Wireless Communications and Networking Conference, 2007.WCNC 2007. IEEE*, vol., no., pp.3205-3209, 11-15 March 2007.
10. Kwanghun Han; Sunghyun Choi, "Performance Analysis of Sleep Mode Operation in IEEE 802.16e Mobile Broadband Wireless Access Systems," *Vehicular Technology Conference, 2006. VTC 2006-Spring. IEEE 63rd*, vol.3, no., pp.1141-1145, 7-10 May 2006.
11. Jung-Ryun Lee; Dong-Ho Cho, "Performance Evaluation of Energy-Saving Mechanism Based on Probabilistic Sleep Interval Decision Algorithm in IEEE 802.16e," Vehicular Technology, IEEE Transactions on, vol.56, no.4, pp.1773-1780, July 2007.
12. Shengqing Zhu; Tianlei Wang, "Enhanced power efficient sleep mode operation for IEEE 802.16e based WiMAX," *Mobile WiMAX Symposium, 2007. IEEE*, vol., no., pp.43-47, 25-29 March 2007.
13. Seungkwon Cho; Youngil Kim, "Improving Power Savings by Using Adaptive Initial-Sleep Window in IEEE802.16e," *Vehicular Technology Conference, 2007. VTC2007-Spring. IEEE 65th*, vol., no., pp.1321-1325, 22-25 April 2007.
14. Woo Jin Jung; Hyung Joo Ki; Tae-Jin Lee; Min Young Chung, "Adaptive sleep mode algorithm in IEEE 802.16e," *Communications, 2007. APCC 2007. Asia-Pacific Conference on*, vol., no., pp.483-486, 18-20 Oct. 2007.
15. Shengqing Zhu; Xiaoyu Ma; Lujian Wang, "A Delay-aware Auto Sleep Mode Operation for Power Saving WiMAX," *Computer Communications and Networks, 2007. ICCCN 2007. Proceedings of 16th International Conference on* , vol., no., pp.997-1001, 13-16 Aug. 2007.

# THANK YOU !!

ACKNOWLEDGEMENT :

Supported by Microsoft Research India,
This work has been carried out at IIIT-Bangalore.

# Q & A