ITU-T Kaleidoscope 2009
Innovations for Digital Inclusion

DYNAMIC RESOURCE MANAGEMENT FOR DOWNLINK MULTIMEDIA TRAFFIC IN OFDMA CELLULAR NETWORKS

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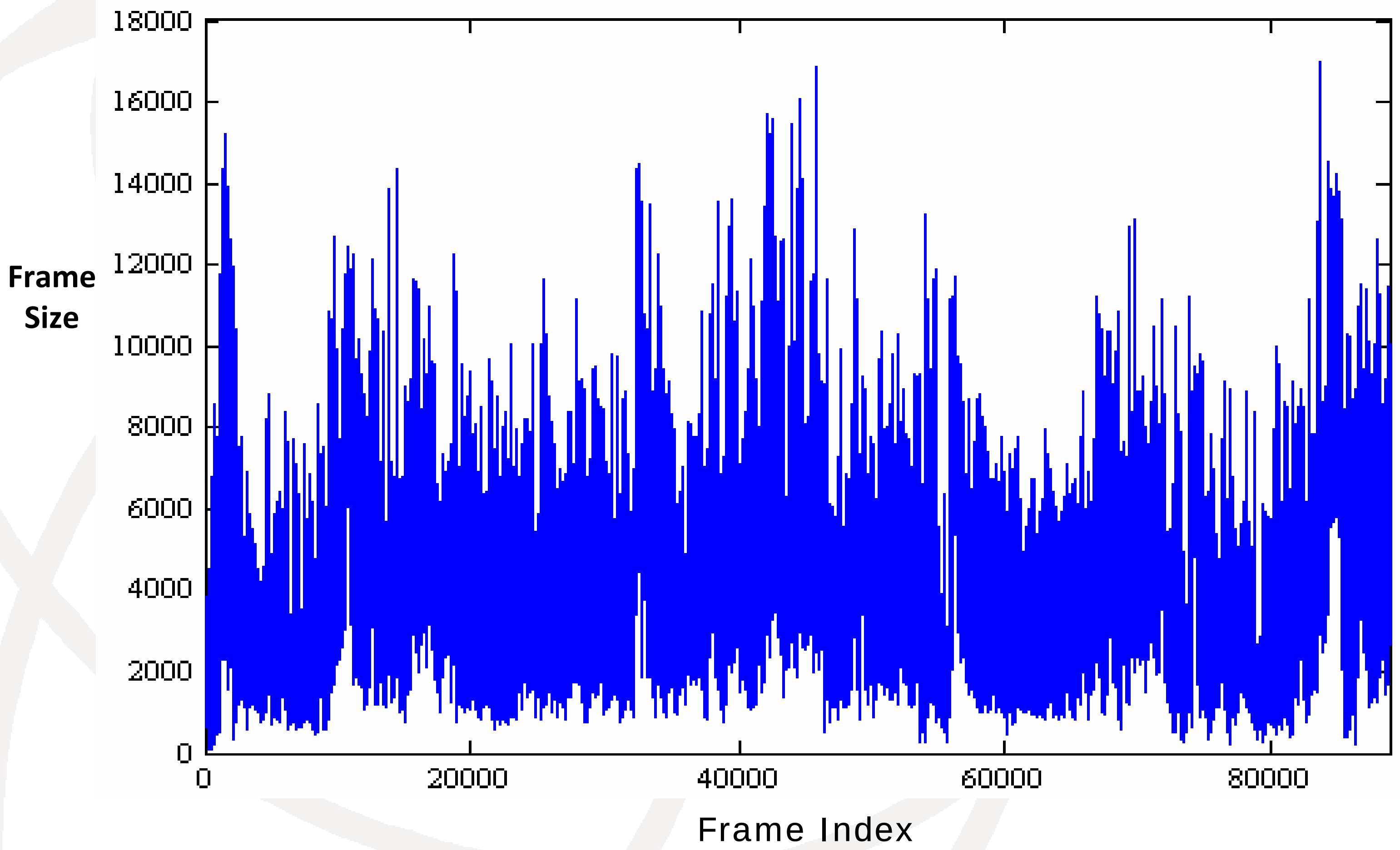
Presentation Outlines

- Multimedia Services
- Multi Carrier Systems
- OFDMA System Model
- Problem Formulation
- Two Stage Rate Adaptive (TSRA) Algorithm
  - Bandwidth Adaptive (BWA) algorithm
- Results & Discussions

Mobile Multimedia Services

- Multimedia over Mobile Network
  - Text
  - Images
  - Video
  - Audio
- QoS Support
- Dynamic & Efficient Resource Requirements

MPEG-4 video trace (Die Hard III)



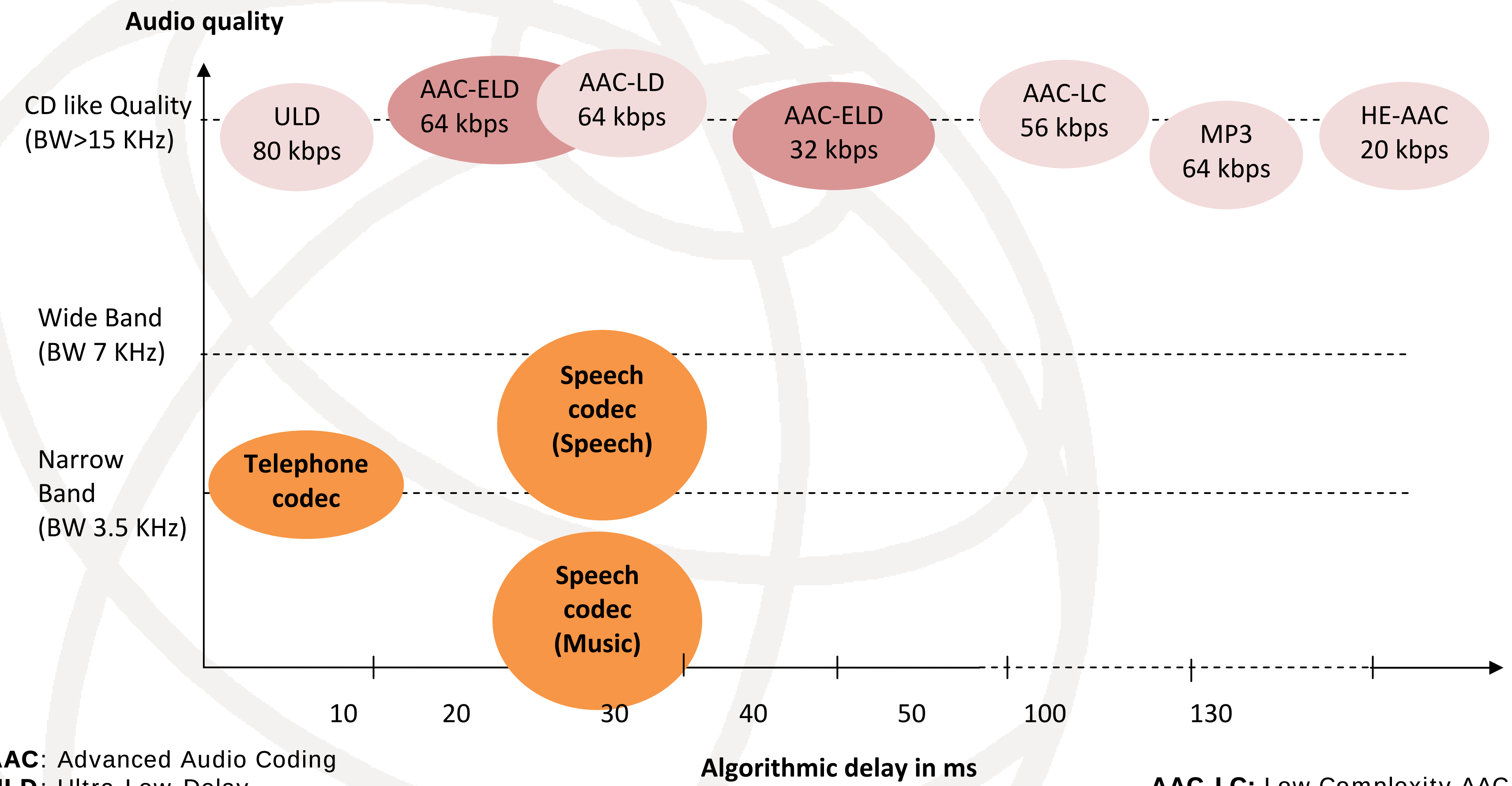
Courtesy: Technical University, Berlin : http://www.tkn.tu-berlin.de/research/trace/ltvt.html

Trace File of Some Hollywood Movie

Quality	Trace	Compression Ratio YUV:MP4	Frame Size			Bit Rate	
			Mean X [kbyte]	Cov σ^2/X	Peak/ Mean X_{max}/X^	Mean X/t[Mbps]	Peak X_{max}/t[Mbps]
High	Jurassic Park I	9.92	3.8	0.59	4.37	0.77	3.3
	Silence of the Lambs	13.22	2.9	0.80	7.73	0.58	4.4
	Star Wars IV	27.62	1.4	0.66	6.81	0.28	1.9
Medium	Jurassic Park I	28.4	1.3	0.84	6.36	0.27	1.7
	Silence of the Lambs	43.43	0.88	1.21	13.6	0.18	2.4
	Star Wars IV	97.83	0.39	1.17	12.1	0.08	0.94
Low	Jurassic Park I	49.46	0.77	1.39	10.61	0.15	1.6
	Silence of the Lambs	72.01	0.53	1.66	21.39	0.11	2.3
	Star Wars IV	142.52	0.27	1.68	17.57	0.053	0.94

Courtesy: Technical University, Berlin : http://www.tkn.tu-berlin.de/research/trace/pub.html

MPEG-4 Advanced Audio Coding



AAC: Advanced Audio Coding
ULD: Ultra-Low-Delay
AAC-ELD: Enhanced Low Delay AAC
AAC-LD: Low Delay AAC

AAC-LC: Low Complexity AAC
HE-AAC: High-Efficiency AAC

Courtsey: Fraunhofer IIS

Service classification and service parameters

Guidelines for evaluation of radio interface technologies for IMT-Advanced

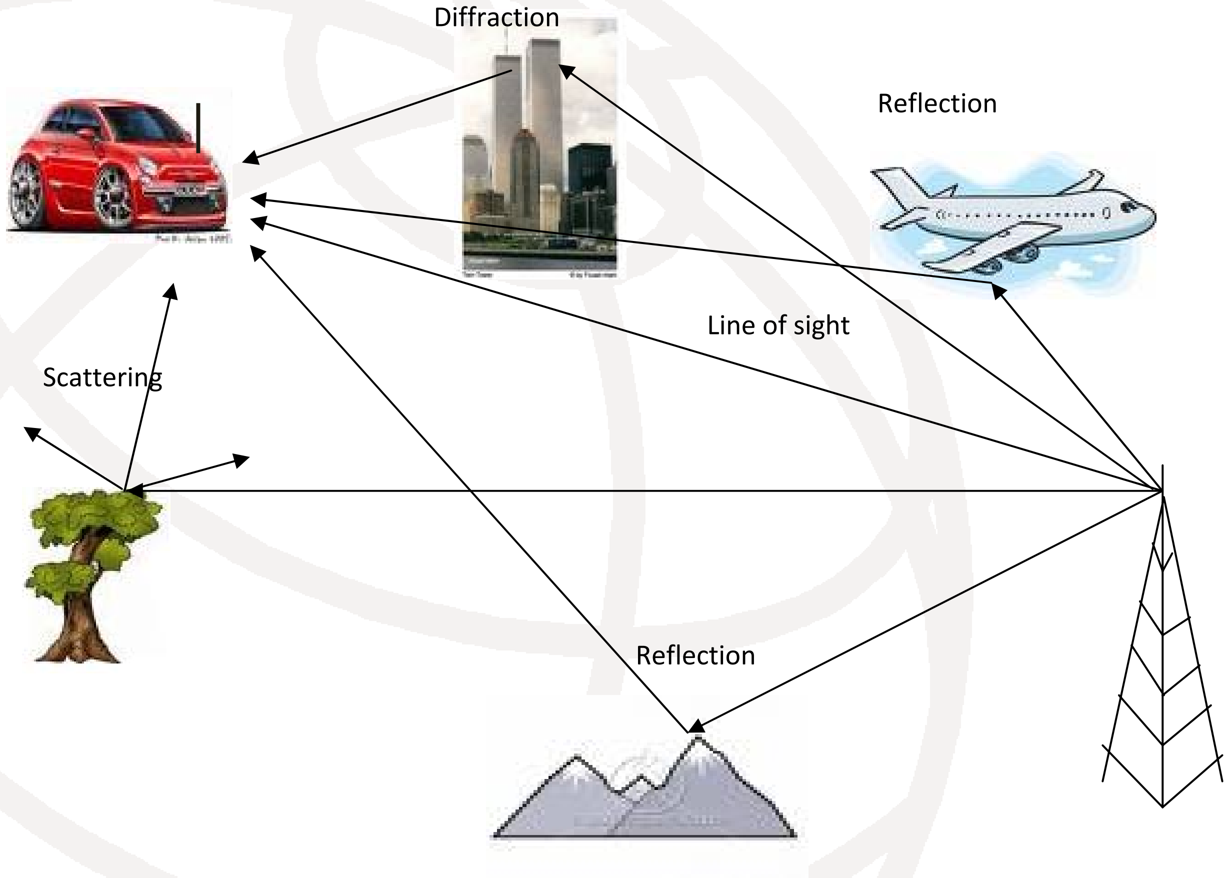
User Experience Class	Service Class	Service Parameters (Numerical Values)	
Conversational	Basic conversational service	Throughput:	20 kbit/s
		Delay:	50 ms
	Rich conversational service	Throughput:	5 Mbit/s
		Delay:	20 ms
	Conversational low delay	Throughput:	150 kbit/s
		Delay:	10 ms
Streaming	Streaming Live	Throughput:	2 – 50 Mbit/s
		Delay:	100 ms
	Streaming Non-Live	Throughput:	2 – 50 Mbit/s
		Delay:	1 s
Interactive	Interactive high delay	Throughput:	500 kbit/s
		Delay:	200 ms
	Interactive low delay	Throughput	500 kbit/s
		Delay	20 ms
Background	Background	Throughput:	5 – 50 Mbit/s
		Delay:	< 2s

Source: Document 8F/TEMP/568

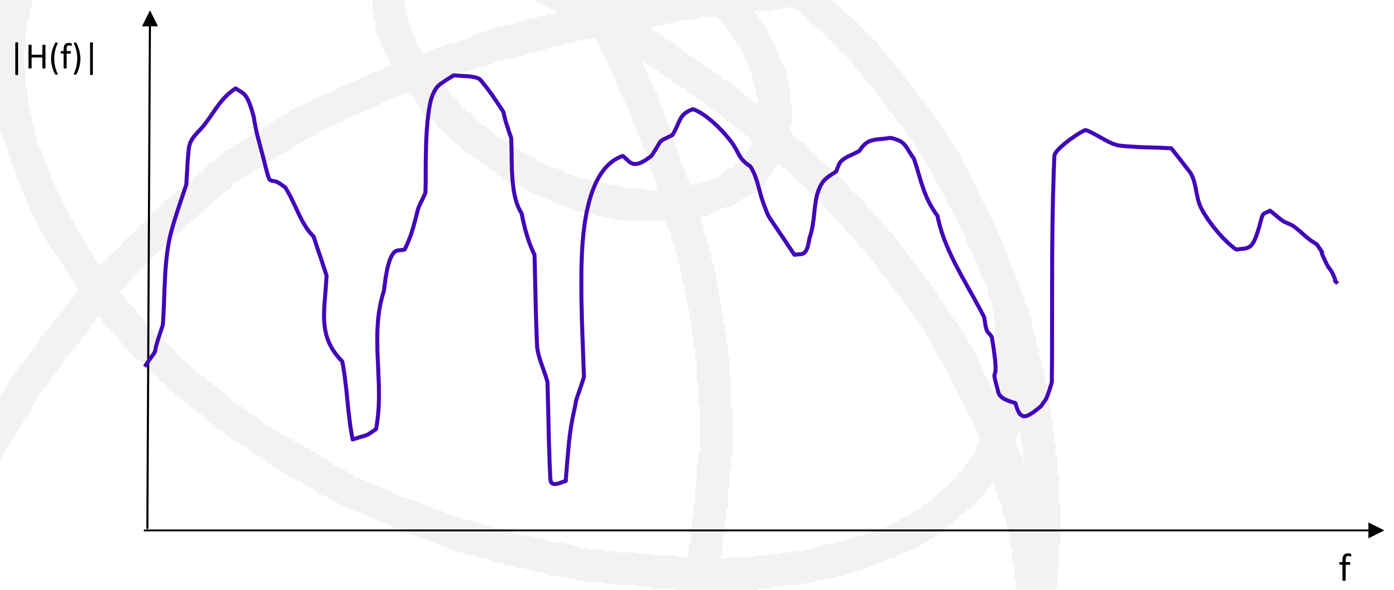
Multi-Carrier Communication in Next Generation Networks

- Higher Capacity
  - Can approach theoretical limit
- Easy support for adaptive resource Allocation
  - The Concept of Sub Channel/Carrier
- Ability to combat inherent problems in wireless

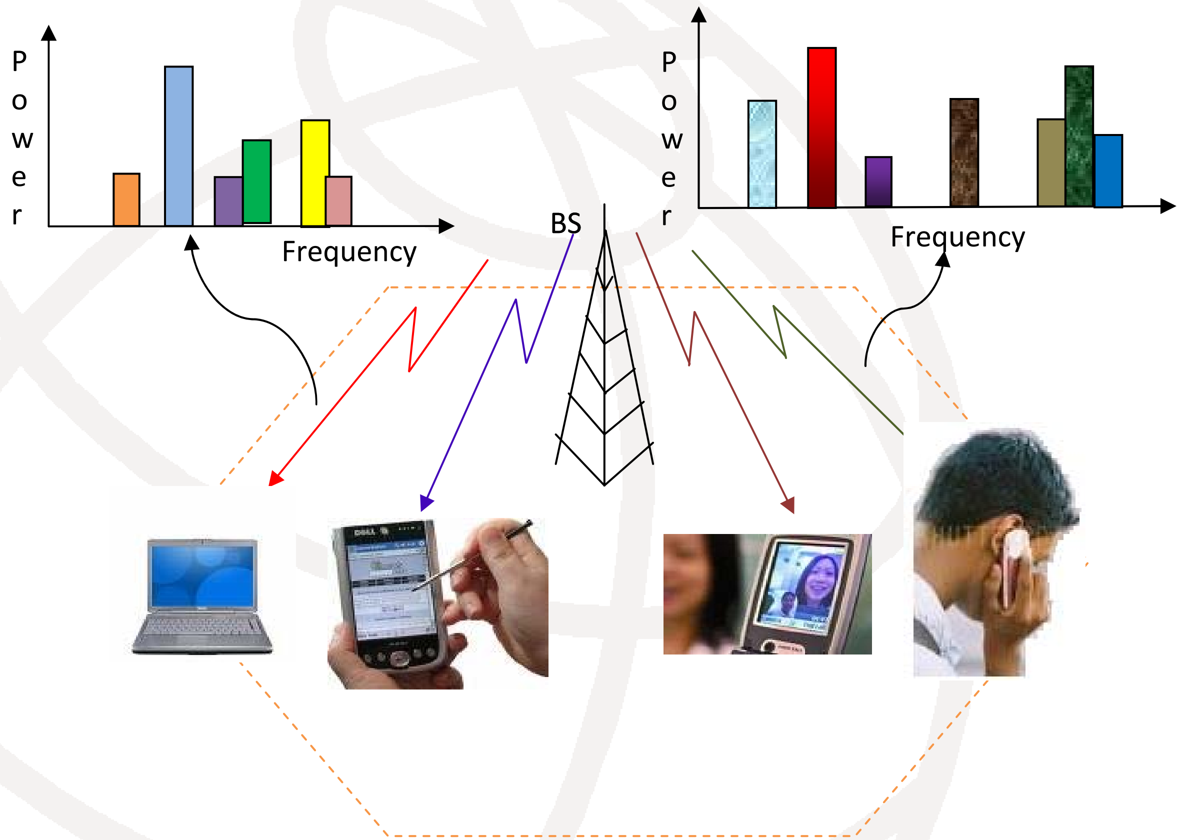
Multi Path Propagation



Channel Response in Freq. Domain



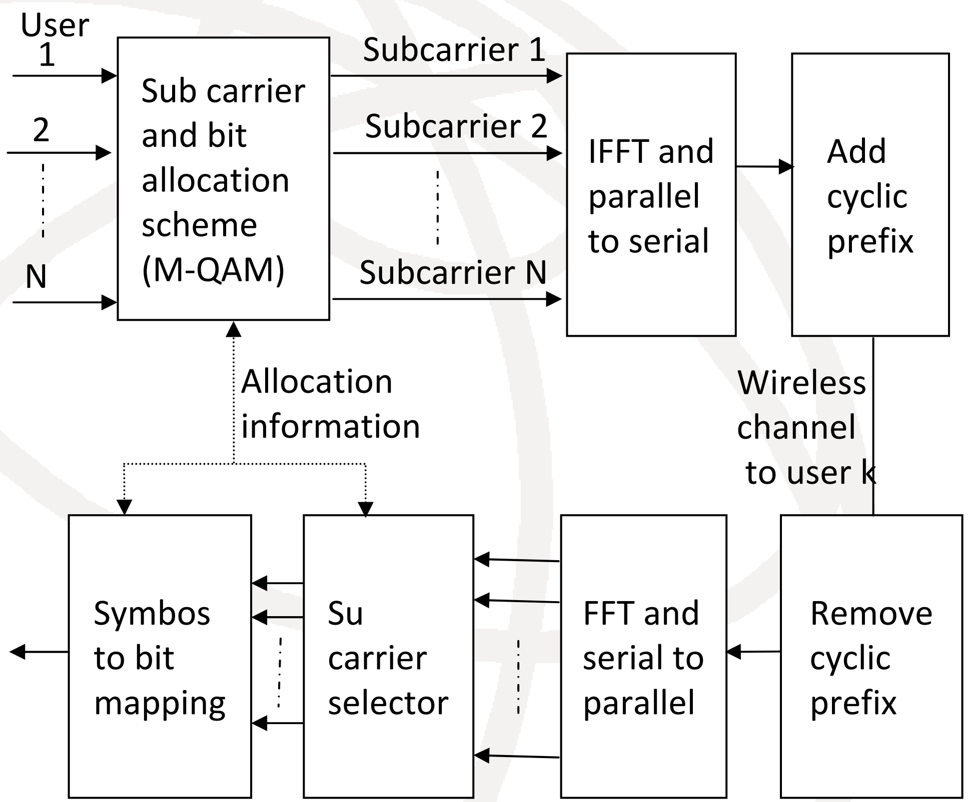
The Concept of Multi-carrier



Multi-Carrier Communication Systems

- MC-CDMA
  - Suitable for indoor wireless environment
  - Fading resistance using frequency diversity
  - Need for rake receivers
- OFDMA
  - Handling of multipath fading (ISI)
  - Spectral efficiency
  - No intra-cell interference (No Cell breathing)

OFDMA System Model



Problem Formulation

Initial subcarrier allocation:

$$N_{in}^{k} = \Phi(N_{\min}^{k}, \alpha_k)$$

α_k is chosen such that $0 \leq \alpha_k < 1$ while satisfying the condition

$$\sum_{k} \alpha_k = 1, \forall k$$

To calculate N_{min} , we first compute BER of the sub channel. The BER of i^{th} subcarrier using M-QAM can be approximated by.

$$BER^{i} = \frac{1}{5}\exp\left(-\frac{1.5SINR^{i}}{M-1}\right)$$

Problem Formulation cont.

The order of modulation M for the i^{th} sub carrier is chosen such that the BER $\leq 10^{-3}$.
In M-QAM the maximum capacity could be approximated by

$$R_{sb}^{i} = \frac{B}{N}\log_2 M$$

If R_k is the minimum bit rate needed to support an application k, and R^i_{sb} is the bit rate supported on the i^{th} sub carrier, then the minimum no of required sub carrier is given by

$$N_{\min}^{k} = \left\lceil \frac{R_k}{\sum_{i=1}^{N_k} R_{sb}^{i}} \right\rceil$$

Problem Formulation cont.

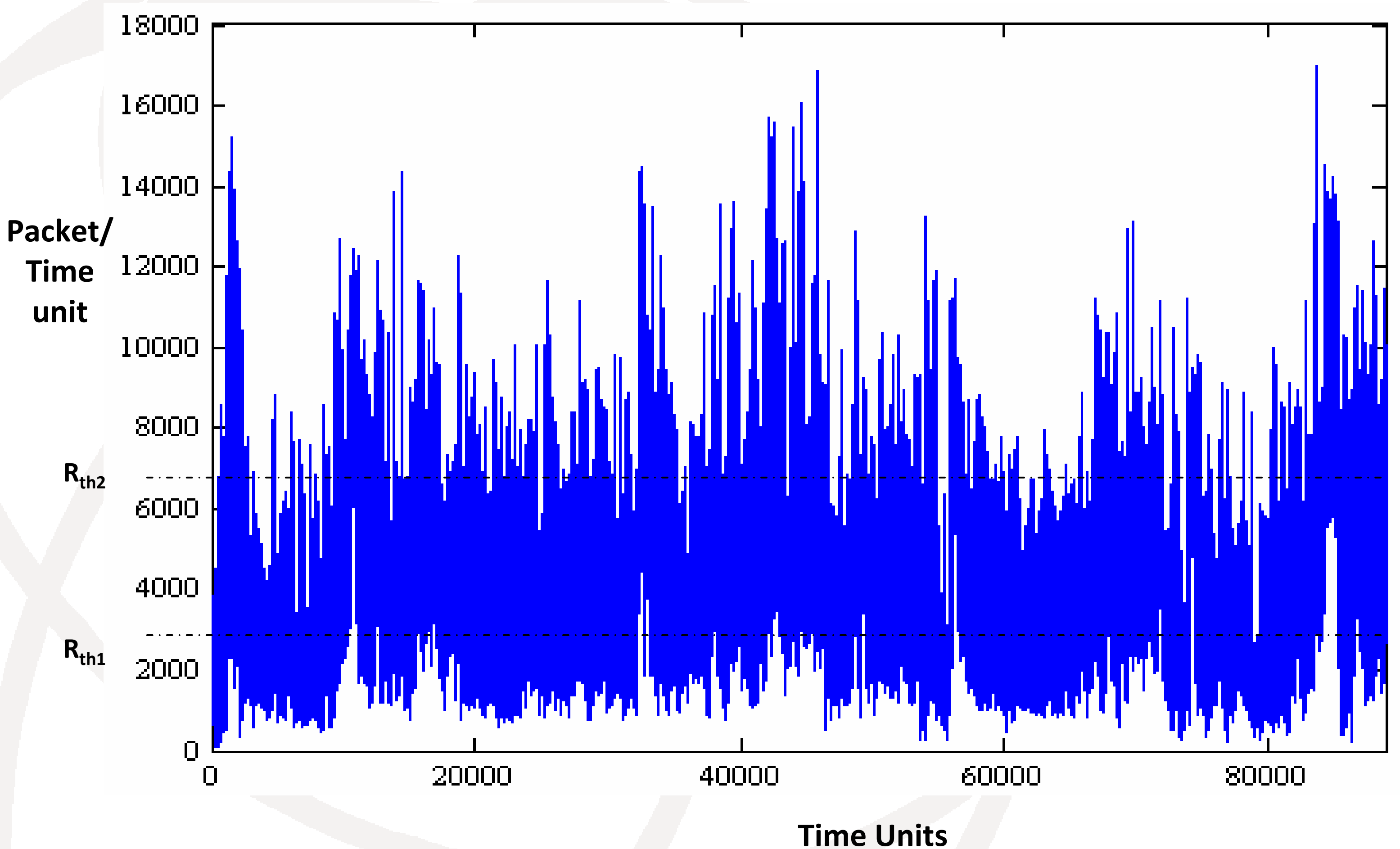
Considering L types of applications, the sub carrier selection can be defined as optimization of

$$\sum_{l=1}^{L}\sum_{k=1}^{K_l}\sum_{i=1}^{N_k}\alpha_{l,k}^{i}\, p_{l,k}^{i}\,(CINR)_{l,k}^{i}$$

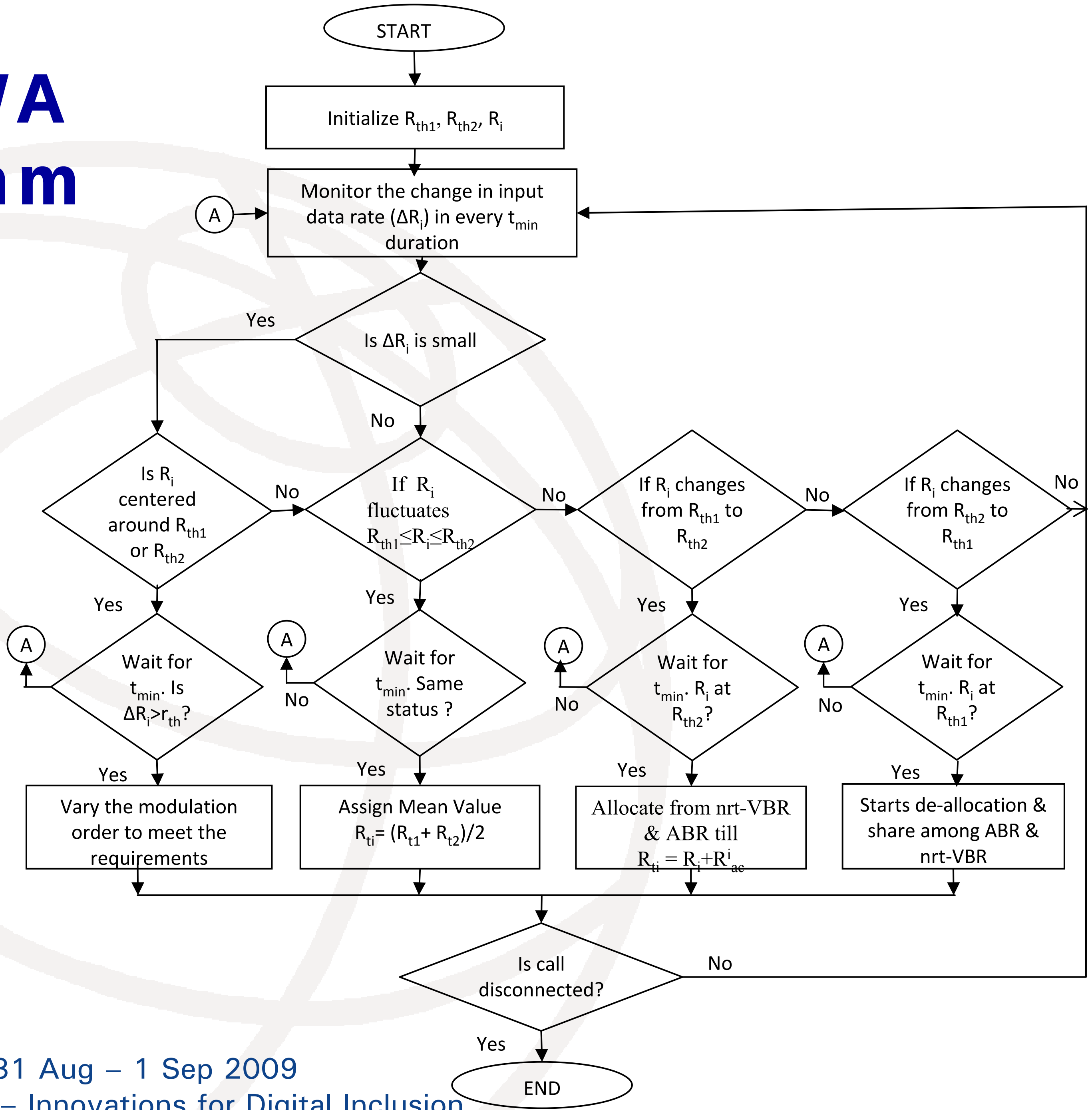
such that average capacity (bits/second per Hz), C_{av} represented below is maximum.

$$C_{av} = \sum_{l=1}^{L}\sum_{k=1}^{K_l}\sum_{i=1}^{N_k}\frac{R_{l,k}^{i}}{N_k\,(BW)_{sb}}$$

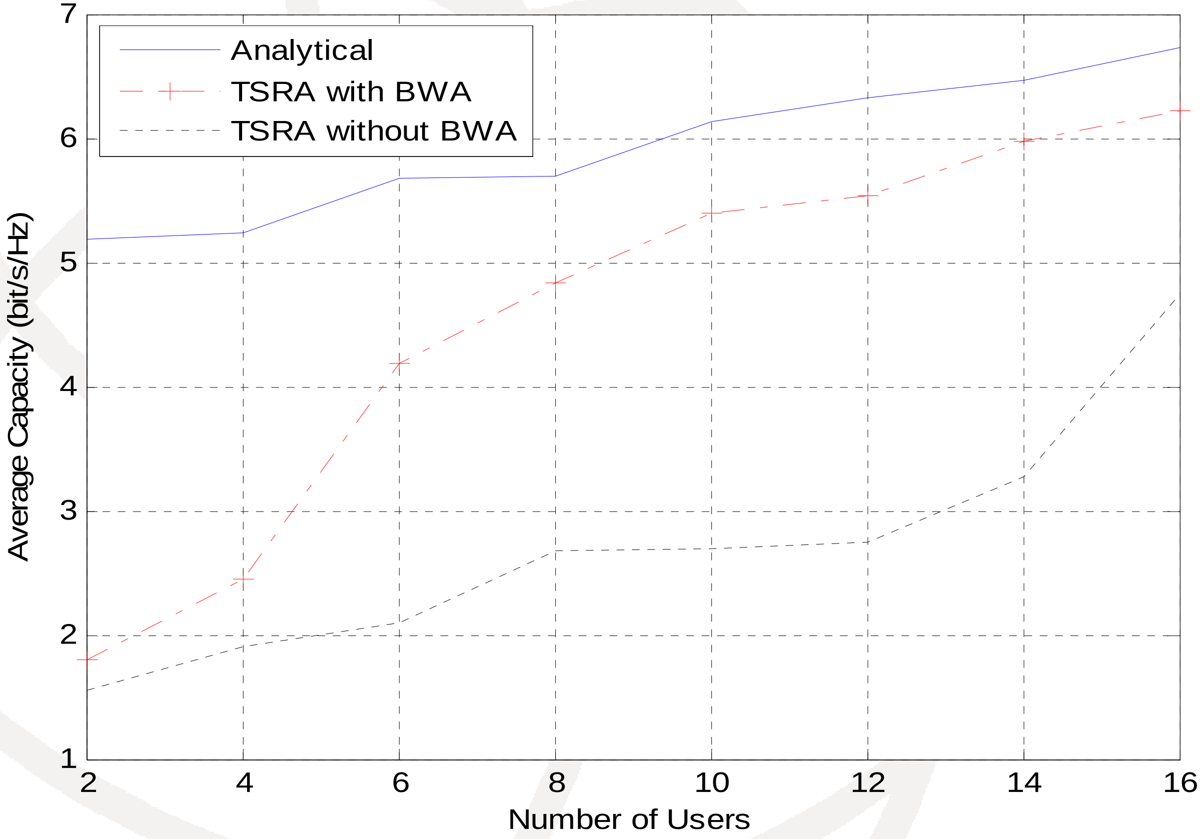
Development of TSRA Protocol



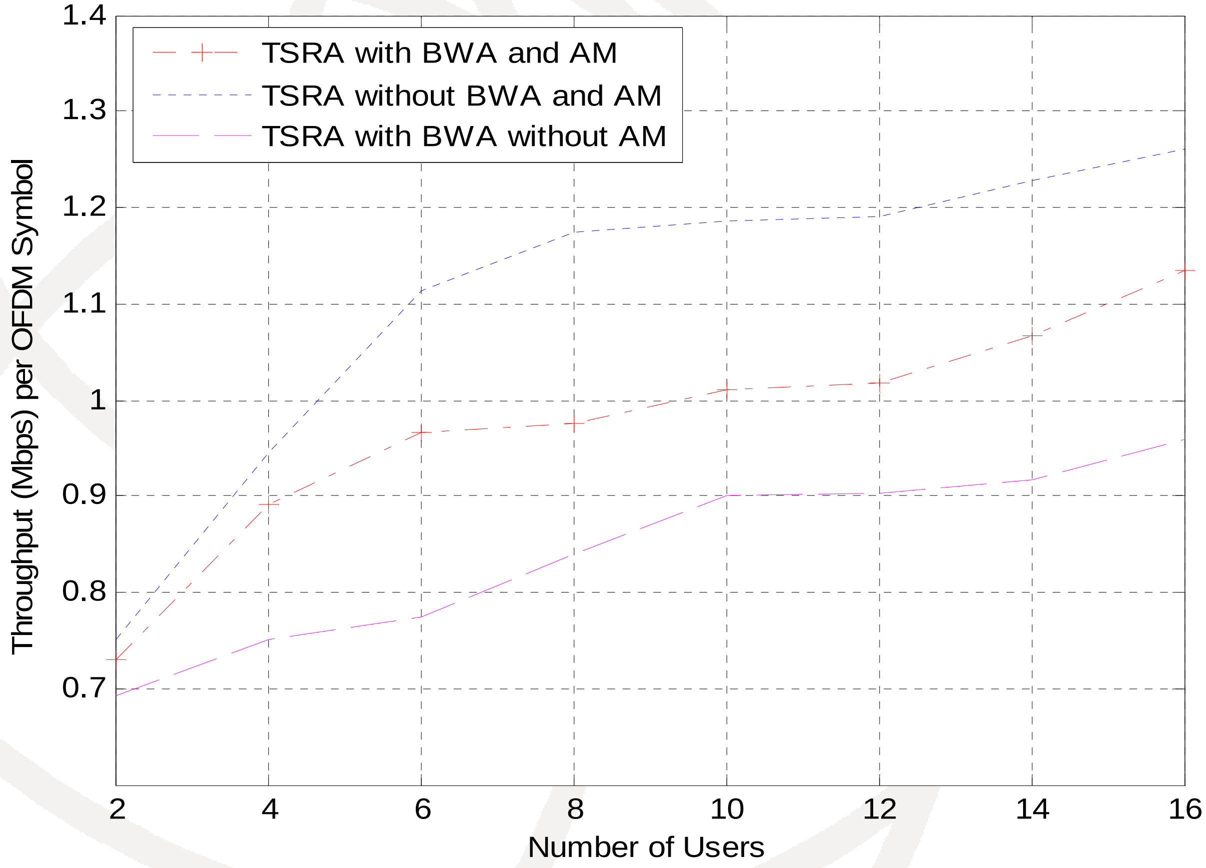
The BWA Algorithm



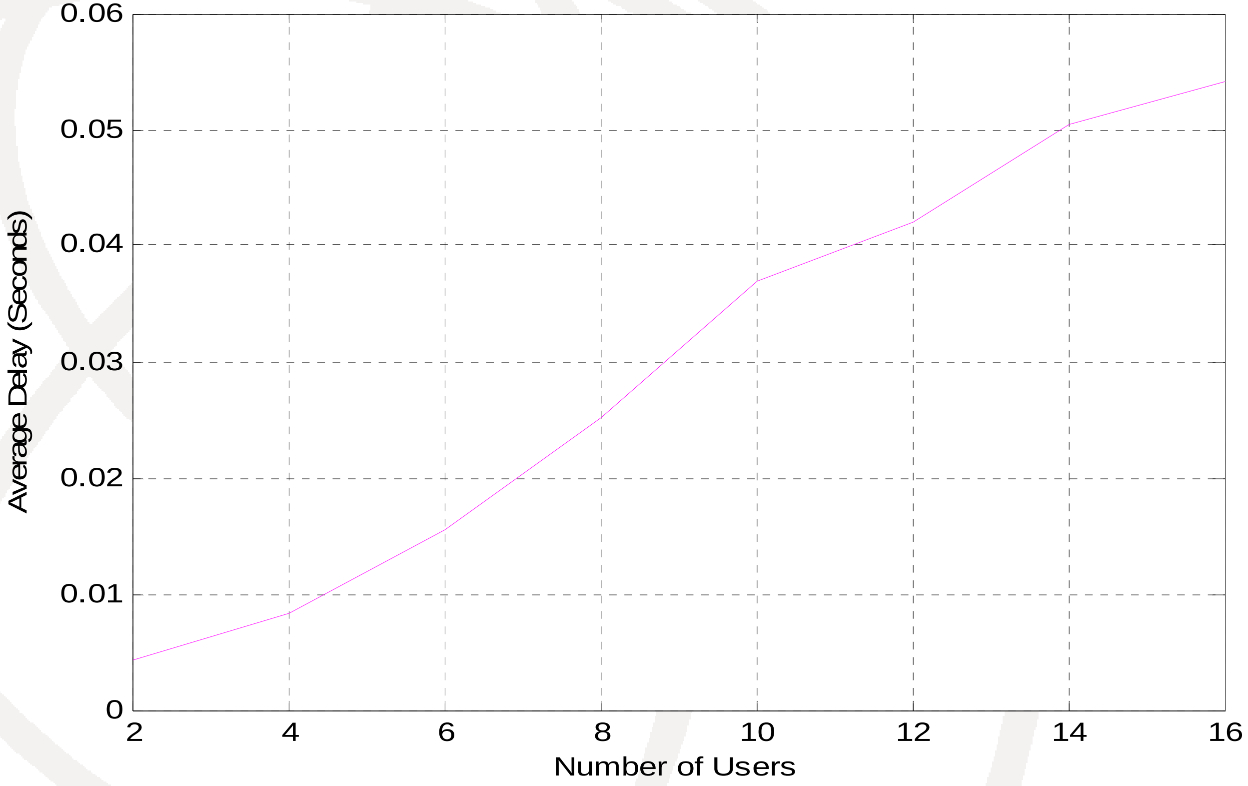
Average Capacity



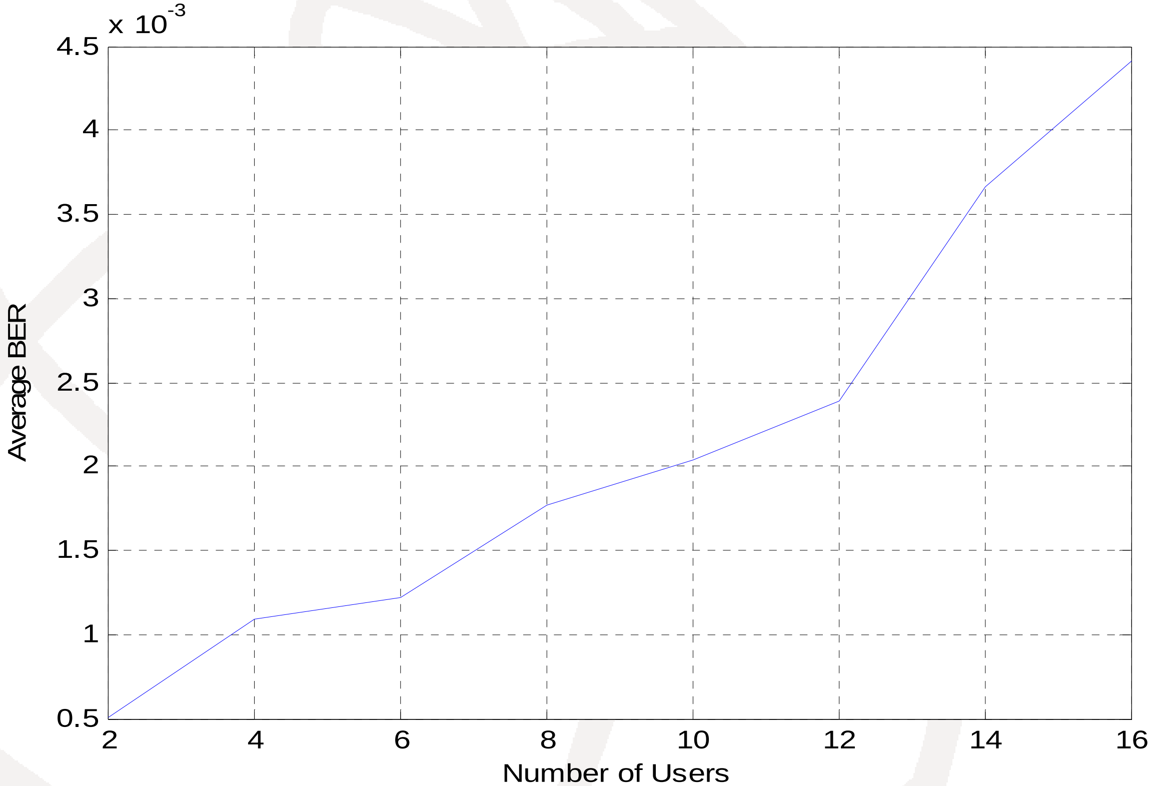
Throughput per OFDM Symbol



Average delay for rt-VBR traffic



Average BER



x 10^-3
4.5
4
3.5
3
2.5
2
1.5
1
0.5
Average BER
2
4
6
8
10
12
14
16
Number of Users

CONCLUSION

- Multi-carrier can support future multimedia services
- The OFDMA based system offers high capacity / efficiency
- The TSRA algorithm can meet the QoS requirement of high quality multimedia applications while approaching theoretical limit (more than 6b/s/Hz for 128-QAM)

Thank You Very Much