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Performance Evaluation of MIMO Downlink WiMAX for Different Schedulers

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Introduction

- WiMAX performance evaluation for single antenna and multiple antenna techniques in particular at different scheduling techniques has received considerable attention by WiMAX researches and operators.
- Due to the antenna technologies and different scheduling policies approached, these have significant impact to the system performance.
- This paper evaluates the maximum total goodput for Single Input Single Output (SISO) and MIMO (both STBC and SM) in WiMAX, including the scheduling performance.

PHY DL Data Rates and After Overhead

Modulation and Encoding Rate	SISO and STBC (Mbps)		SM (Mbps)	
	PHY Data Rates	*After IP and MAC Overheads*	*PHY Data Rates*	*After IP and MAC Overheads*
QPSK ½	3.571	3.393	7.142	6.786
QPSK ¾	5.357	5.089	10.714	10.178
16QAM ½	7.143	6.786	14.286	13.572
16QAM ¾	10.714	10.179	21.428	20.358
64QAM ½	10.714	10.176	21.428	20.358
64QAM 2/3	14.286	13.571	28.572	27.142
64QAM ¾	16.071	15.268	32.142	30.536

WiMAX DL PHY DATA RATES and THEIR DATA RATES AFTER CONSIDERING THE IP AND MAC OVERHEADS FOR SISO, STBC 2x2, SM 2x2 (PUSC, DL:UL[99:99])

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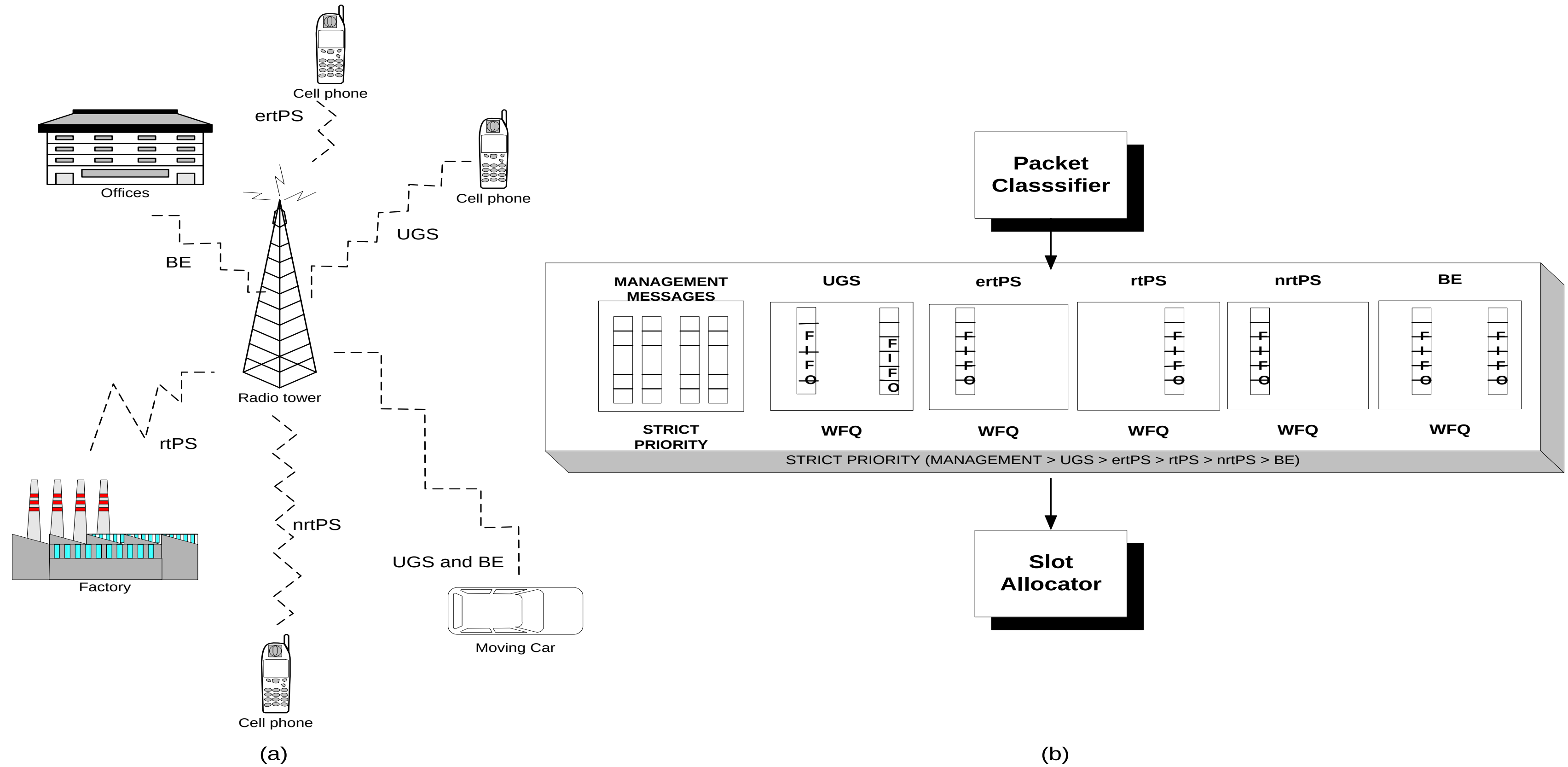
QoS Downlink Architecture



(a) Seven different QoS service flows in a WiMAX cell, (b) The corresponding packet downlink schedulers employing WFQ for the intra-schedulers and Strict Priority for the inter-scheduler

Intra-Scheduler Algorithm: Qos Class Scheduler

- **Weighted Fair Queuing (WFQ)**

  Selects the user who has the smallest *finish number,* an estimation of time for a Head-of-line (HOL) packet in the queue to be served and considers minimum reserved traffic rate (MRTR) and packet size

- **Proportional Fair (PF)**

  Selects the user who has the highest ratio of current data rate to last average goodput at different observation window to observe the trade off between capacity and fairness

- **Greedy or Max-SNR**

  Selects the user who has the maximum instantaneous SNR in order to achieve the highest capacity by exploiting multi-user diversity

Link Level Simulation (1)

- We perform SISO, SM 2x2, STBC 2x2 at link level to produce BER curves
- The parameters used are:
  - Spatial Channel Model Extension (SCME) and an urban micro 3GPP tapped delay line (TDL)
  - A correlation factor of 0.4
  - STBC Alamouti
  - A minimum mean square error (MMSE) receiver for SM-MIMO
- We set exit and entry thresholds at BER between 10^{-4} and 10^{-5} for the link adaptation

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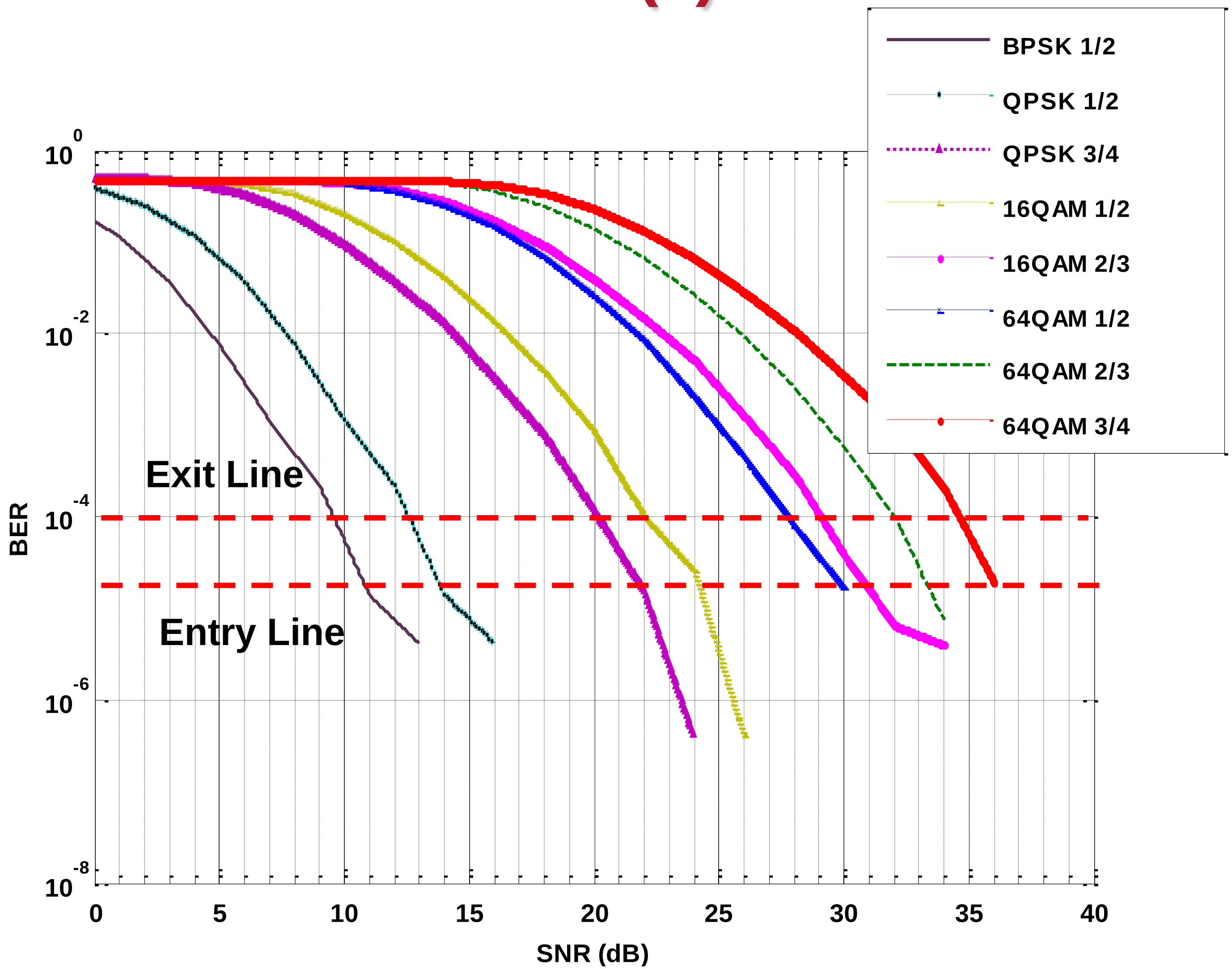
Link Level Simulation (2)



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System Level Simulation (1)

Scenario 1

- A BS communicates to a stationary SS with fixed-size data packets of 1024 bytes at Constant-Bit-Rate (CBR) which is performed across QPSK, 16QAM and 64QAM.
- The load is increased to saturation by increasing the packet rate; packet size is constant..
- The traffic load is calculated as

$$Traffic\ Load\,(bps) = \frac{Packet\ Size\,(bytes)\,x\,8\,bits}{Packet\ Interval\,(s)}$$

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System Level Simulation (2)

Scenario 2

- We employ WFQ and PF as well as Greedy for the QoS class type scheduler independently, and
- 3, 6, 10 and 50 users in a cell at the range supporting 64QAM ¾ STBC are assumed

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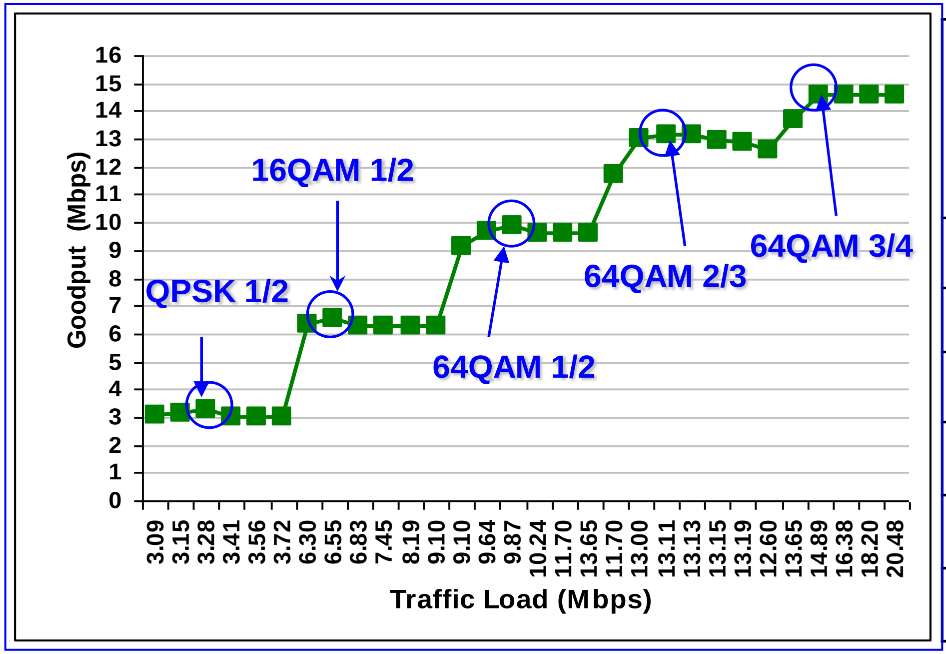
Simulation Results: SISO (1)



UGS goodput vs traffic load for SISO

Traffic Load (kbps)	UGS Goodput (Mbps)	Packet Loss (%)	Average End-2-End Delay (ms)
9102.22	9.11	0.01	20.30
9637.65	9.64	0.01	20.60
9869.88	9.88	0.01	21.26
10240.00	9.58	6.59	81.85
11702.86	9.58	18.26	100.67
13653.33	9.58	29.24	103.92

64 QAM ½ SISO

- The BS does not adopt all modulation and coding scheme due to some modes never provide the highest throughput in these channel conditions

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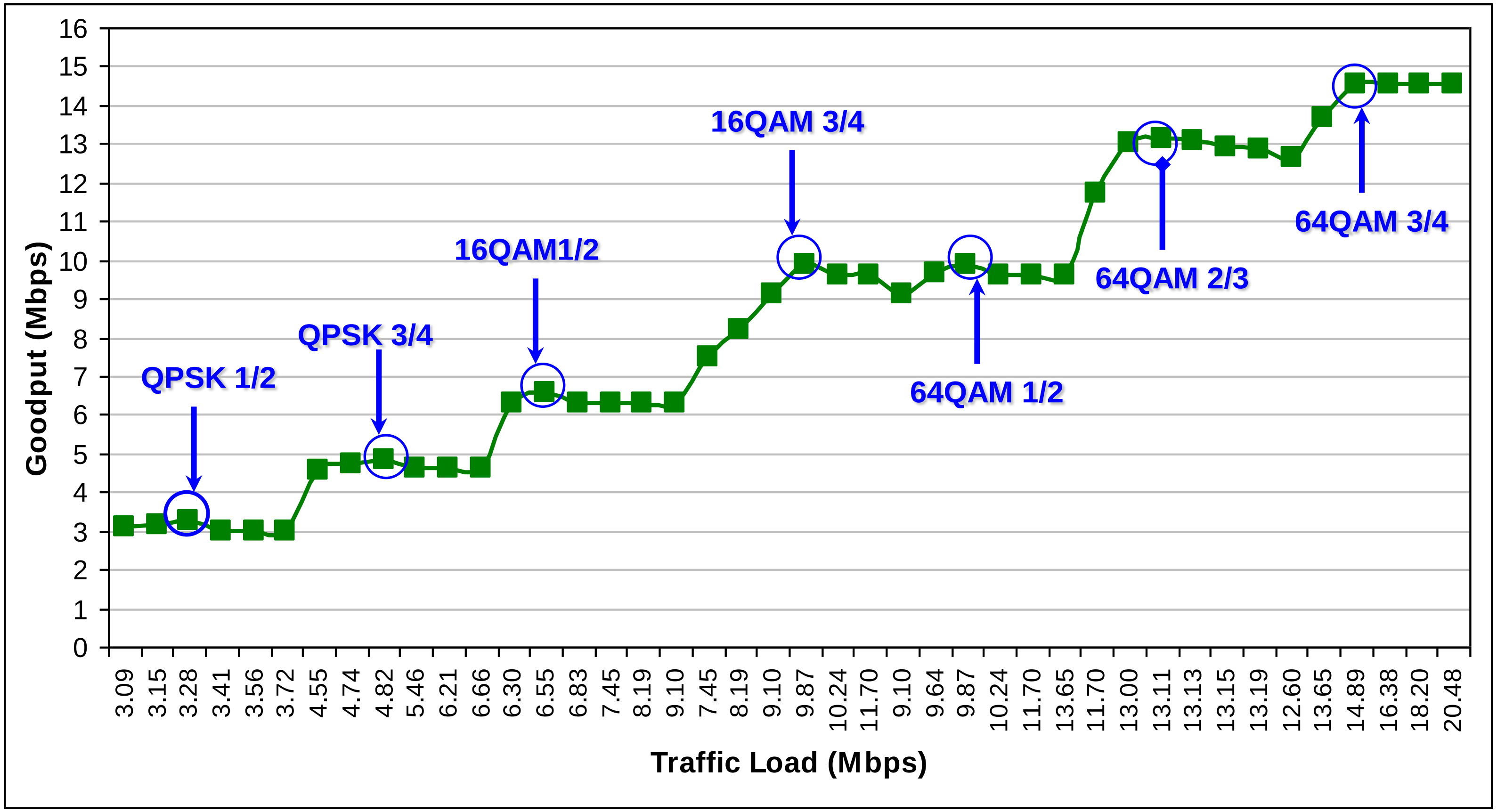
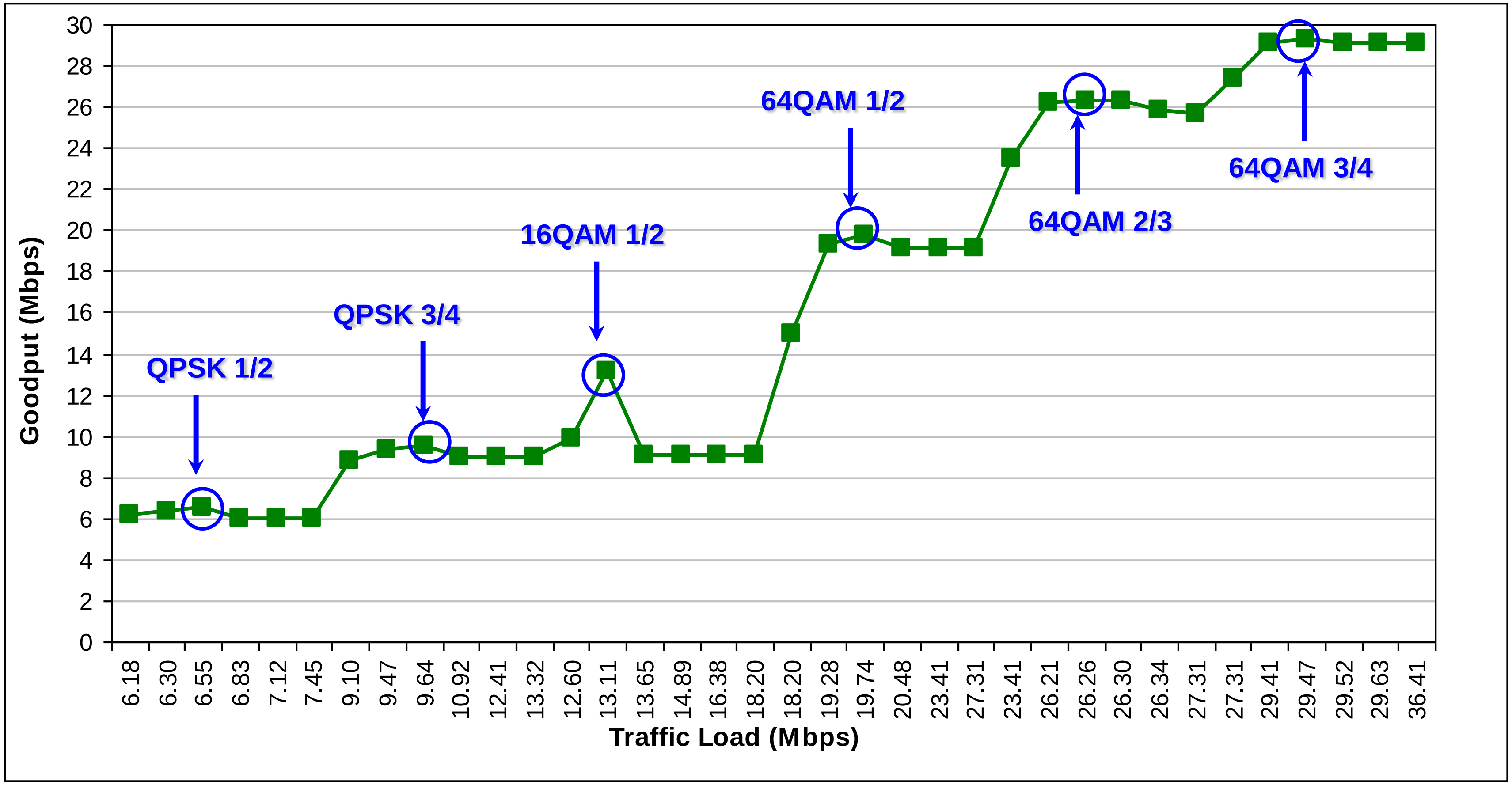
Simulation Results: STBC 2x2 (2)



UGS goodput vs traffic load for STBC 2x2

Simulation Results: SM 2 x2 (3)



UGS goodput vs traffic load for SM 2x2

Simulation Results: Maximum Goodputs (4)

Modulation Coding Scheme	Antenna Technology	SNR (dB)	Maximum Traffic Load (Mbps)	Maximum User Goodput (Mbps)
QPSK ½	**SISO**	**19.40**	**3.3092**	**3.2934**
	STBC	**6.25**	**3.2768**	**3.2701**
	SM	**20.54**	**6.5536**	**6.5504**
QPSK ¾	**SISO**			
	STBC	**8.41**	**4.8188**	**4.8138**
	SM	**23.93**	**9.6376**	**9.5591**
16QAM ½	**SISO**	**23.16**	**6.5536**	**6.5504**
	STBC	**12.49**	**6.5536**	**6.5504**
	SM	**24.93**	**13.1070**	**13.1010**
16QAM ¾	**SISO**			
	STBC	**14.7**	**9.8698**	**9.8671**
	SM			
64QAM ½	**SISO**	**30.10**	**9.8698**	**9.8601**
	STBC	**16.07**	**9.8698**	**9.8601**
	SM	**32.15**	**19.7390**	**19.7300**
64QAM 2/3	**SISO**	**32.16**	**13.1281**	**13.1276**
	STBC	**17.22**	**13.1072**	**13.1038**
	SM	**34.75**	**26.2986**	**26.2752**
64QAM ¾	**SISO**	**41.23**	**14.7603**	**14.7324**
	STBC	**30.12**	**14.8945**	**14.5392**
	SM	**42.75**	**29.4676**	**29.2873**

Max. goodputs in the range of 94.5% to 97.0% of the theoretical data rates due to packet losses during transmission

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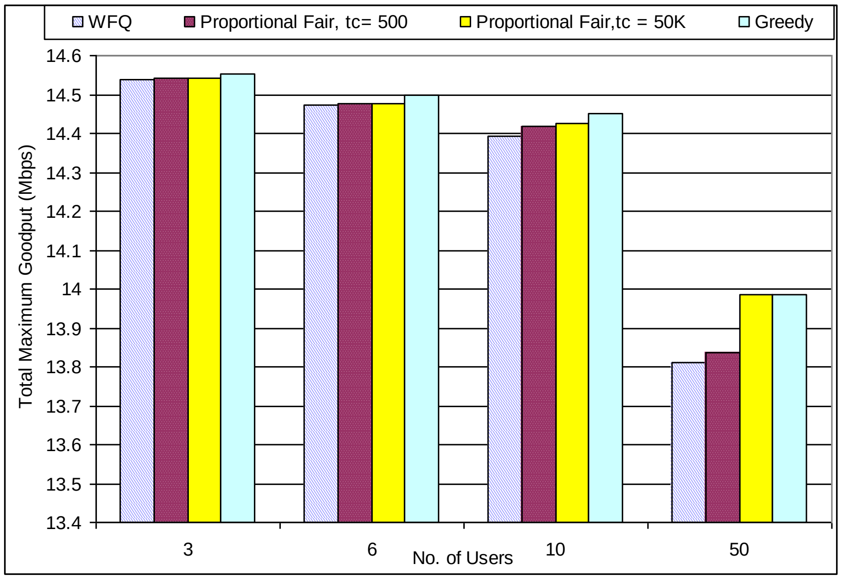
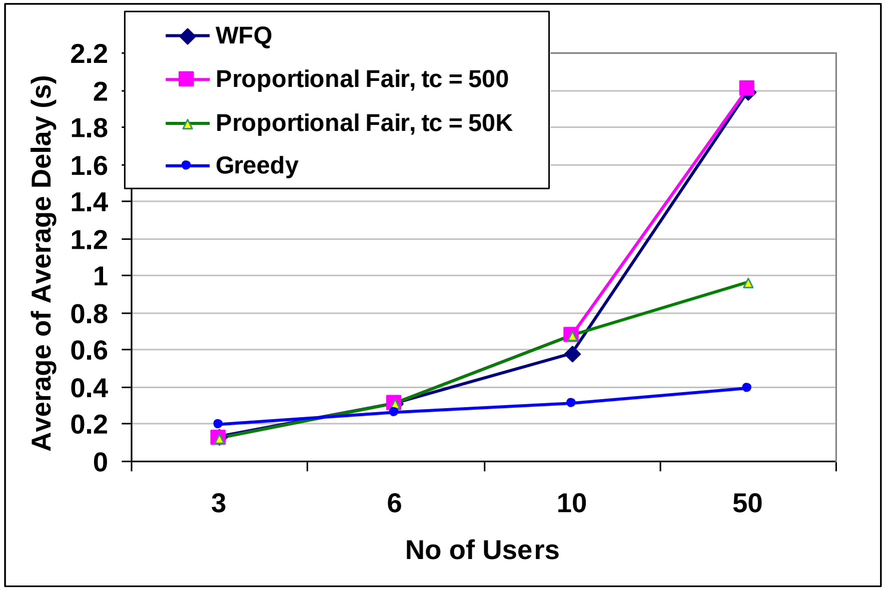
Multiple SSs and Downlink Scheduling



Max. Achievable Goodput for multiple Users for 64QAM ¾ STBC



Average delay for multiple users for 64QAM3/4 STBC

The PF with a window size, *tc* = 50K achieves higher goodput than *tc* = 500 since the high *tc* results in a greedy like performance

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Conclusion

1. The achievable maximum goodput for a single user with CBR traffic is found to be between 94.5% and 97.0% of the theoretical data rates.
2. The PF behavior is highly dependent from observation window *tc* values:
   - For higher *tc* (e.g. *tc* = 50K), PF behaves more as a greedy scheduler, outperforming PF with a smaller *tc* = 500 and also WFQ
   - For low *tc* values (e.g. *tc*=500) PF achieves similar performance as WFQ for a specific scenario
3. The channel-aware scheduler achieves better capacity as well as average delay against the pure queue-scheduler since it exploits multi-user diversity.

Any Questions?