Helsinki University of Technology

Communication Laboratory

Diploma Thesis

LINK ADAPTATION IN GENERAL PACKET RADIO SERVICES (GPRS)

Juan Li

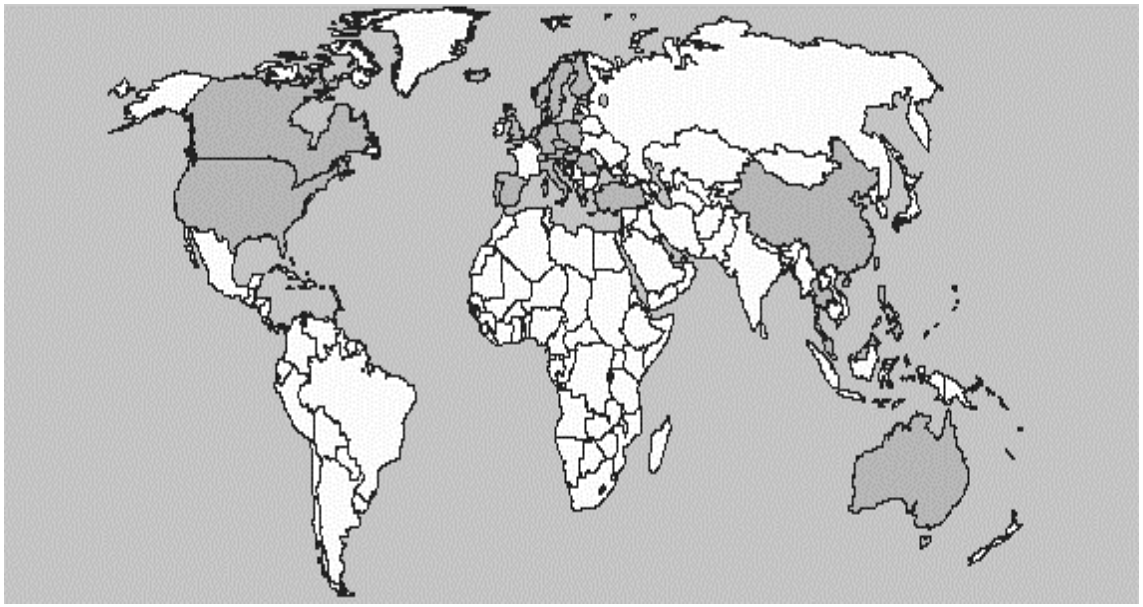
Instructor: Boris Makarevitch

Supervisor: Sven-Gustav Häggman

Communication Laboratory, HUT

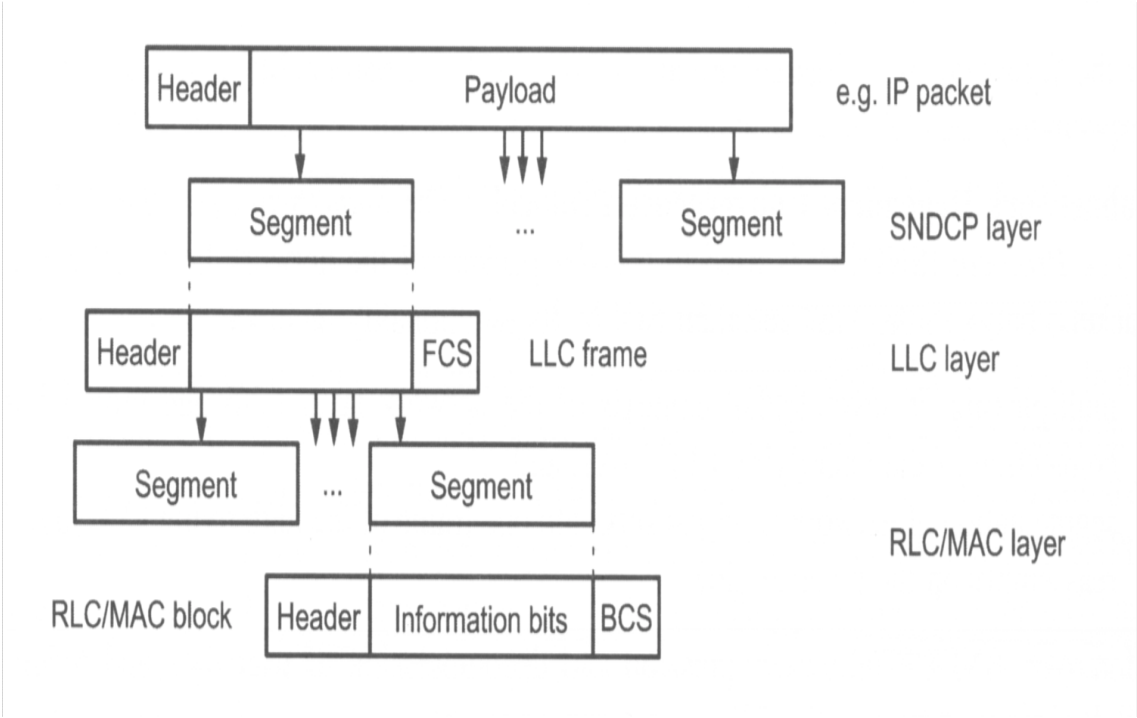
Important Role of GPRS

GPRS is being rolled out by operators around the world as the first vital step toward 3G.



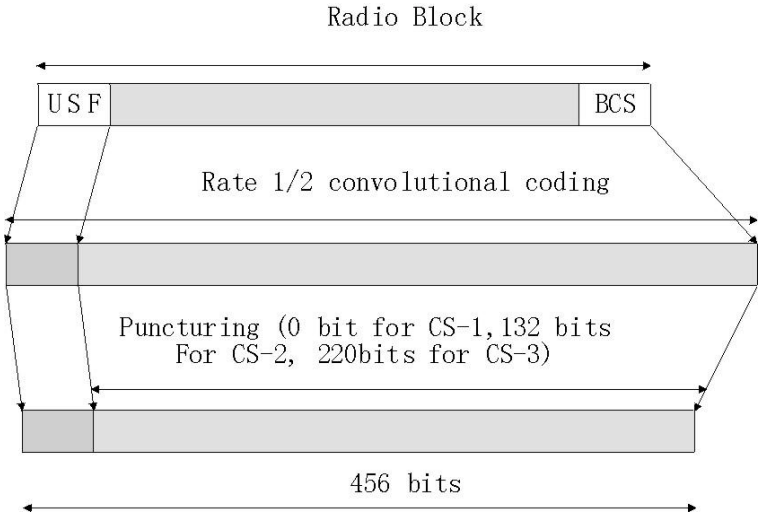
Communicated GPRS launches 2000- December 2001

Data Flow in GPRS

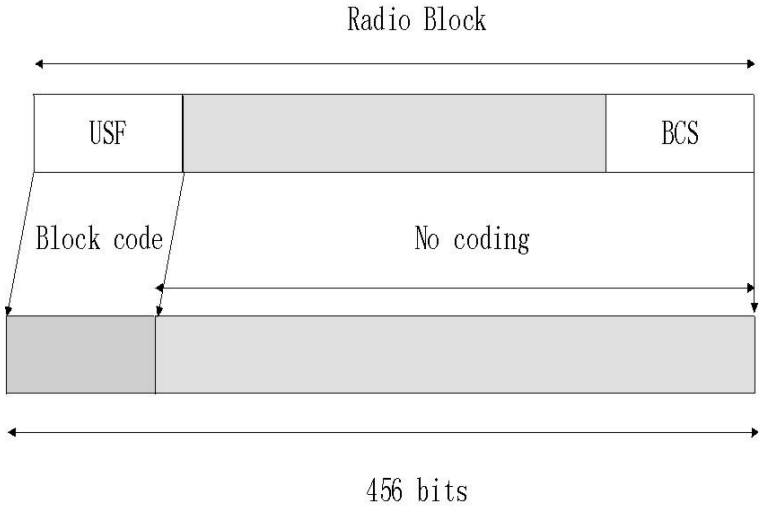


Data flow and Segmentation Between the Protocol Layers in the MS

Four Coding Schemes of GPRS



Radio Block Structure for CS1 to CS3



Radio Block Structure for CS4

Why link adaptation?

During the evolution to 3G, Link Adaptation (LA) has been identified as a key technology for evolved GSM systems, such as, AMR, GPRS, EDGE.

What is link adaptation?

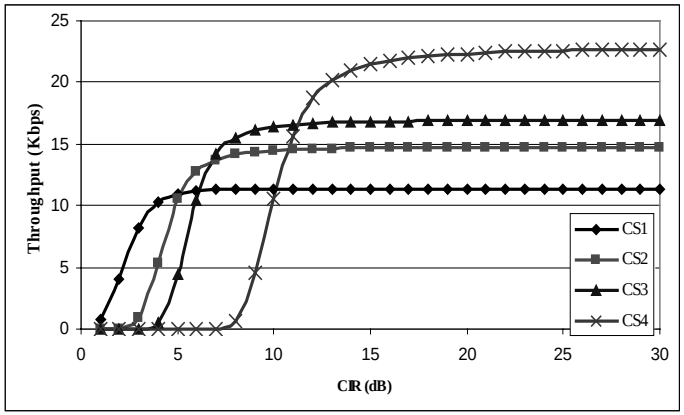
Select the most suitable coding scheme accroding to the current channel quality.

Objective:

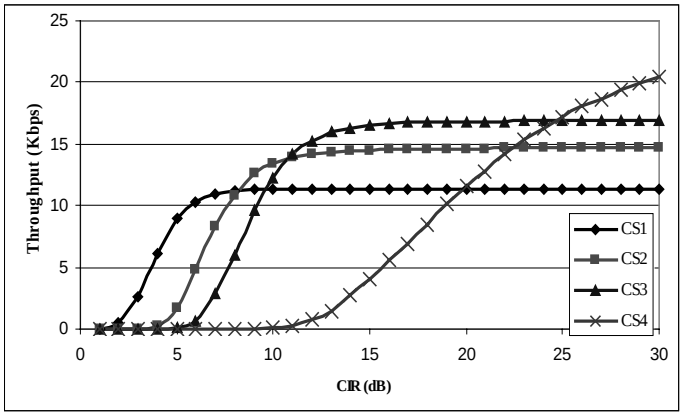
The objective of link adaptation is to achieve maximum throughput by selecting a suitable coding scheme instantaneously

Performance of Four Coding Schemes

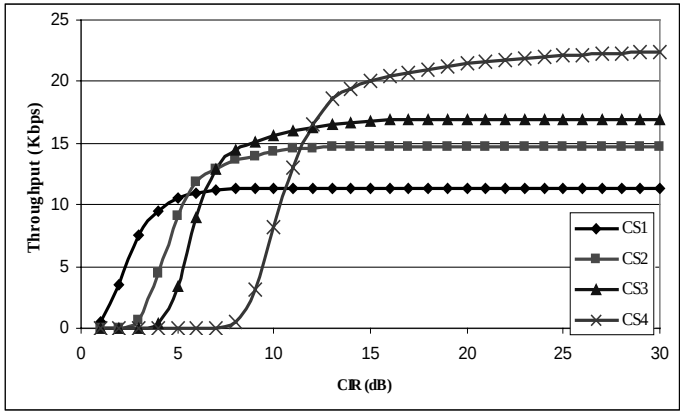
Throughput vs. CIR



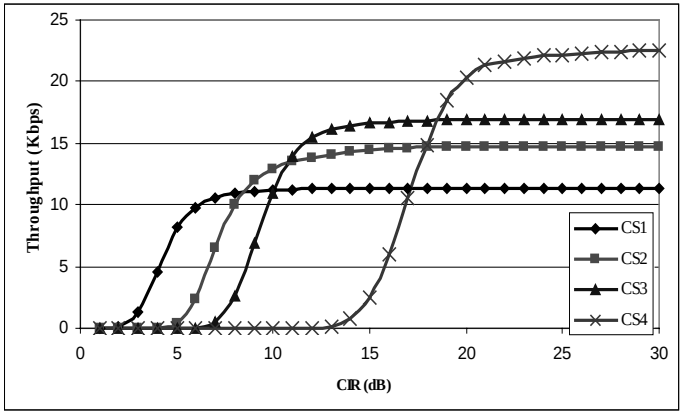
without frequency hopping, user speed = 1m/s



without frequency hopping, user speed = 15m/s



with frequency hopping, user speed = 1m/s



with frequency hopping, user speed = 15m/s

Link Adaptation Algorithms (1)

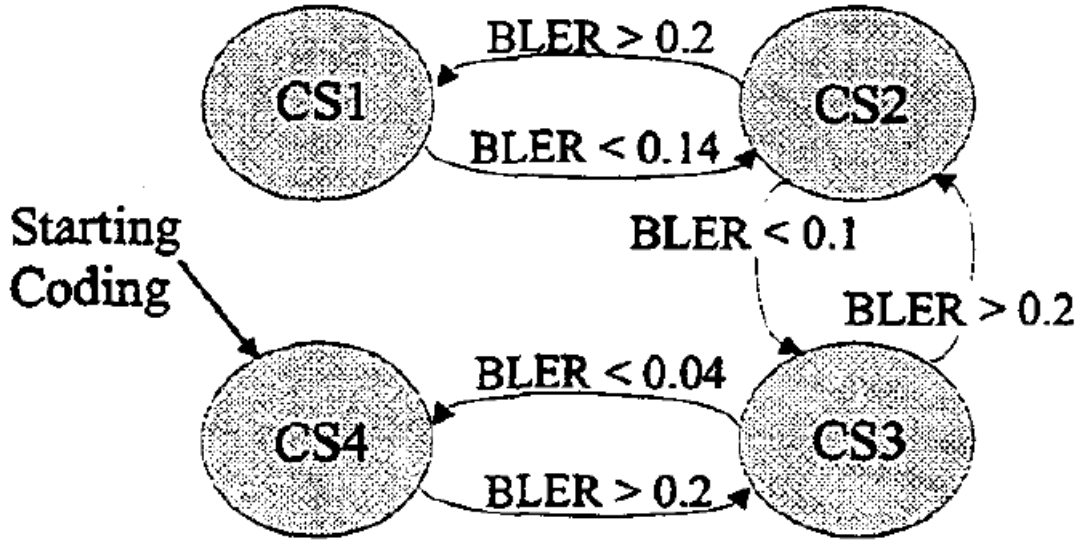
Two algorithms have been discussed in this thesis:

--BLER-based algorithm: the parameter used to estimate the channel quality is the Block Error Rate (BLER). The BLER at intersections are taken as the thresholds and they are calculated as:

$$BLER = \left(1 - \frac{Thr}{Thr_{\max}}\right)$$

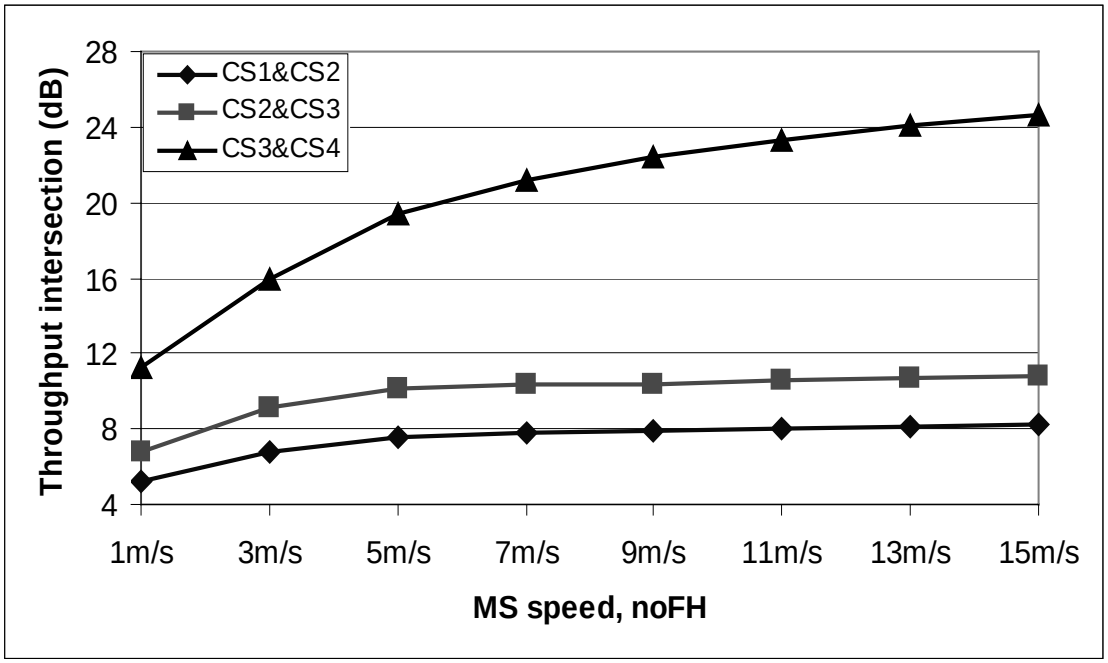
--CIR-based algorithm: the parameter used to estimate the channel quality is the Carrier-to-Interference (CIR) instead. The thresholds can be directly taken from above figures based on the intersections.

Link Adaptation Algorithms (2)



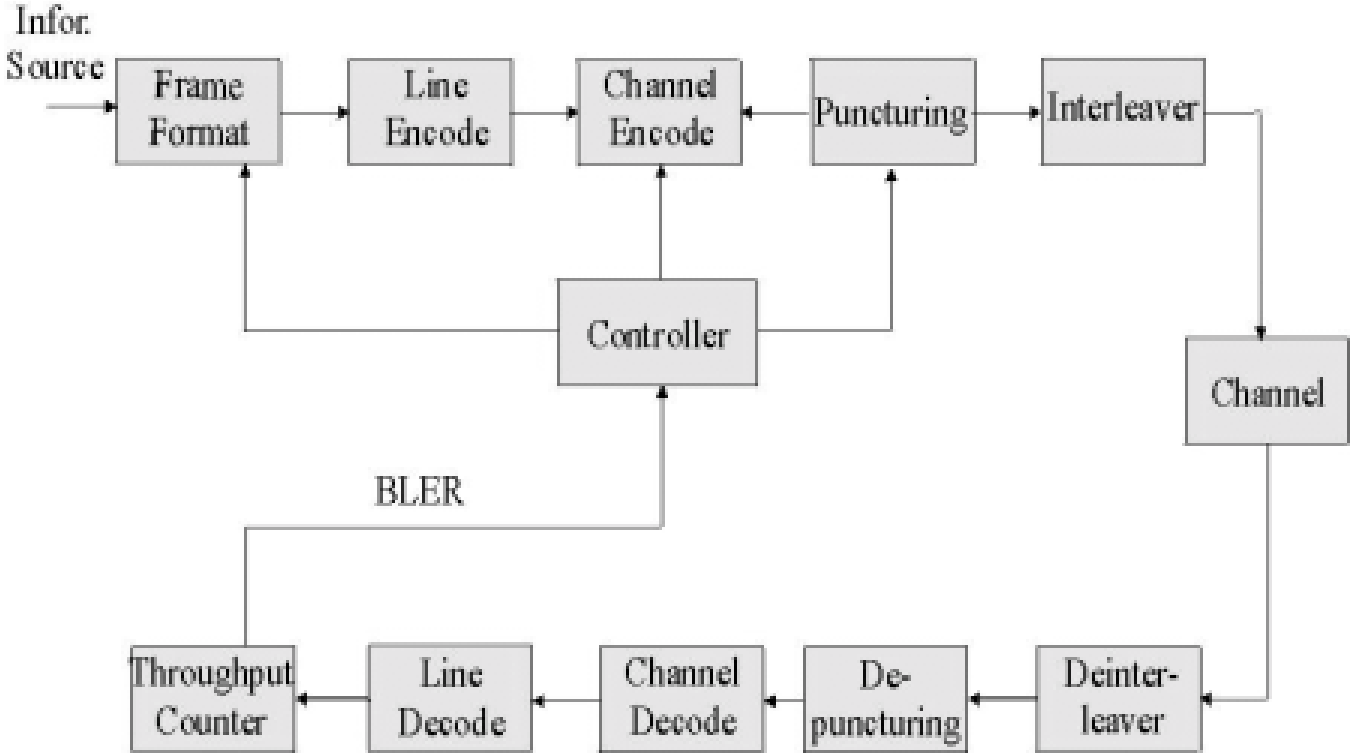
An Example of Coding Scheme Updating for BLER-Based algorithm

Throughput Intersections vs. User Speed



without frequency hopping

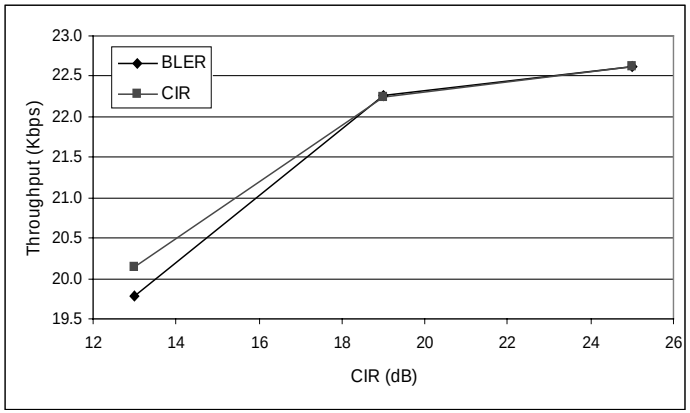
Simulation Model



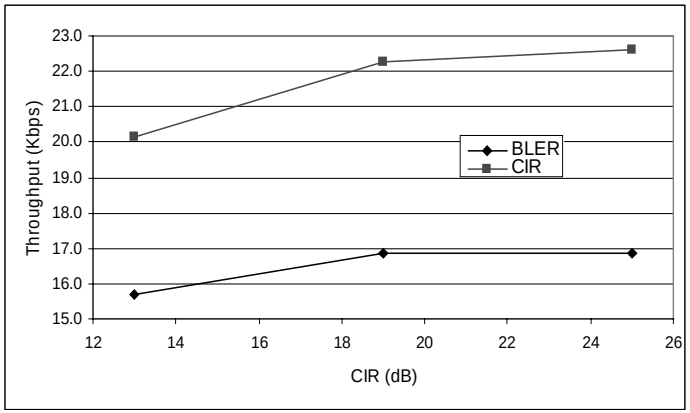
Link level model for link adaptation in GPRS

Comparsion Under Ideal Situation

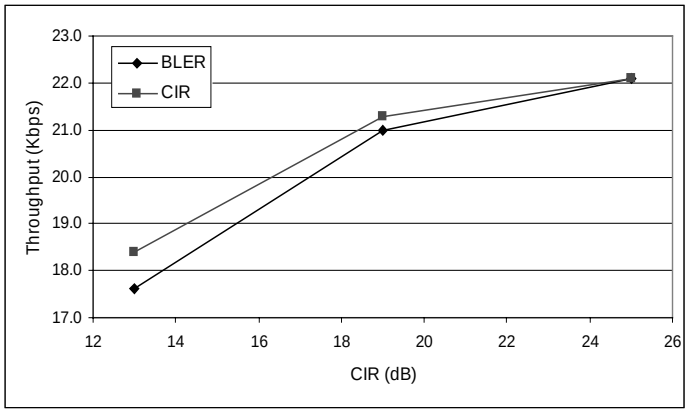
Throughput vs. CIR



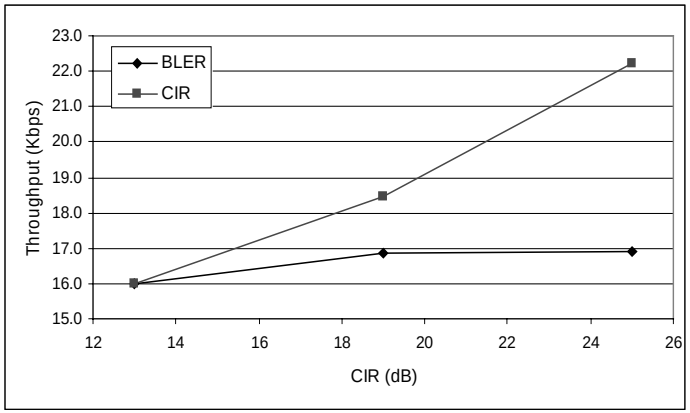
without frequency hopping, MS speed = 1m/s



without frequency hopping, MS speed = 15m/s



with frequency hopping, MS speed = 1m/s



with frequency hopping, MS speed = 15m/s

Comparsion Under Practical Situation (1)

without frequency hopping

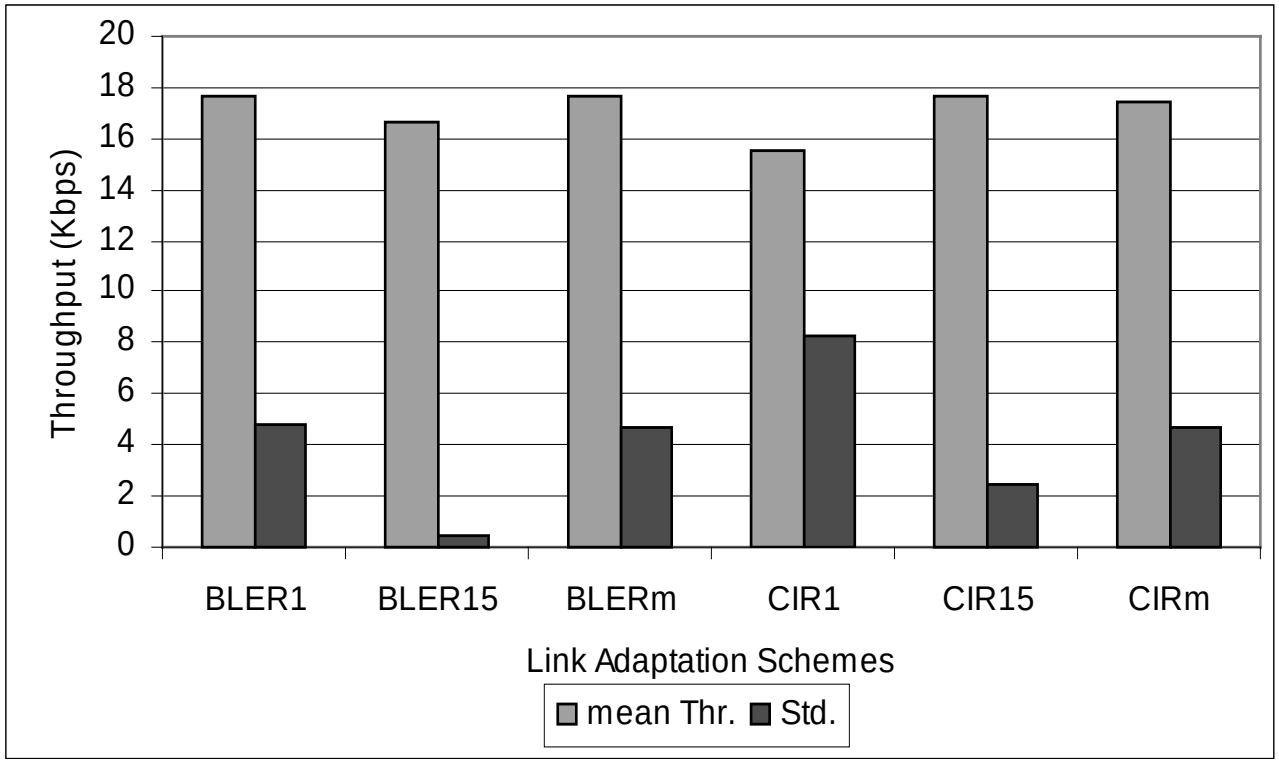
	BLER1	BLER15	BLERm	CIR1	CIR15	CIRm	fixedCS1	fixedCS4
13dB_1m/s	19.78	16.79	19.78	20.14	16.80	16.80	11.39	20.21
19dB_1m/s	22.26	16.88	22.26	22.25	16.88	22.22	11.39	22.26
25dB_1m/s	22.61	16.88	22.61	22.61	22.61	22.63	11.39	22.59
13dB_15m/s	10.95	15.70	11.03	1.54	15.74	15.74	11.38	1.48
19dB_15m/s	13.30	16.84	13.39	9.93	16.82	9.98	11.39	10.10
25dB_15m/s	17.12	16.88	17.07	16.93	17.00	17.04	11.39	17.23
	BLER1	BLER15	BLERm	CIR1	CIR15	CIRm	fixededCS1	fixededCS4
mean_Thr.	17.67	16.66	17.69	15.57	17.64	17.40	11.39	15.65
Std.	4.79	0.47	4.75	8.31	2.48	4.67	0.00	8.33

with frequency hopping

	BLER1	BLER15	BLERm	CIR1	CIR15	CIRm	fixedCS1	fixedCS4
13dB_1m/s	17.61	16.60	17.61	18.38	16.58	16.58	11.39	18.57
19dB_1m/s	20.98	16.88	20.98	21.28	21.21	21.21	11.39	21.26
25dB_1m/s	22.09	16.88	22.09	22.09	22.08	22.08	11.39	22.08
13dB_15m/s	10.04	15.98	10.04	0.14	15.97	15.97	11.35	0.12
19dB_15m/s	17.96	16.86	17.96	18.44	18.46	18.46	11.39	18.50
25dB_15m/s	22.12	16.88	22.12	22.17	22.22	22.22	11.39	22.14
	BLER1	BLER15	BLERm	CIR1	CIR15	CIRm	fixedCS1	fixedCS4
mean_Thr.	18.47	16.68	18.47	17.08	19.42	19.42	11.38	17.11
Std.	4.58	0.36	4.58	8.48	2.79	2.79	0.02	8.48

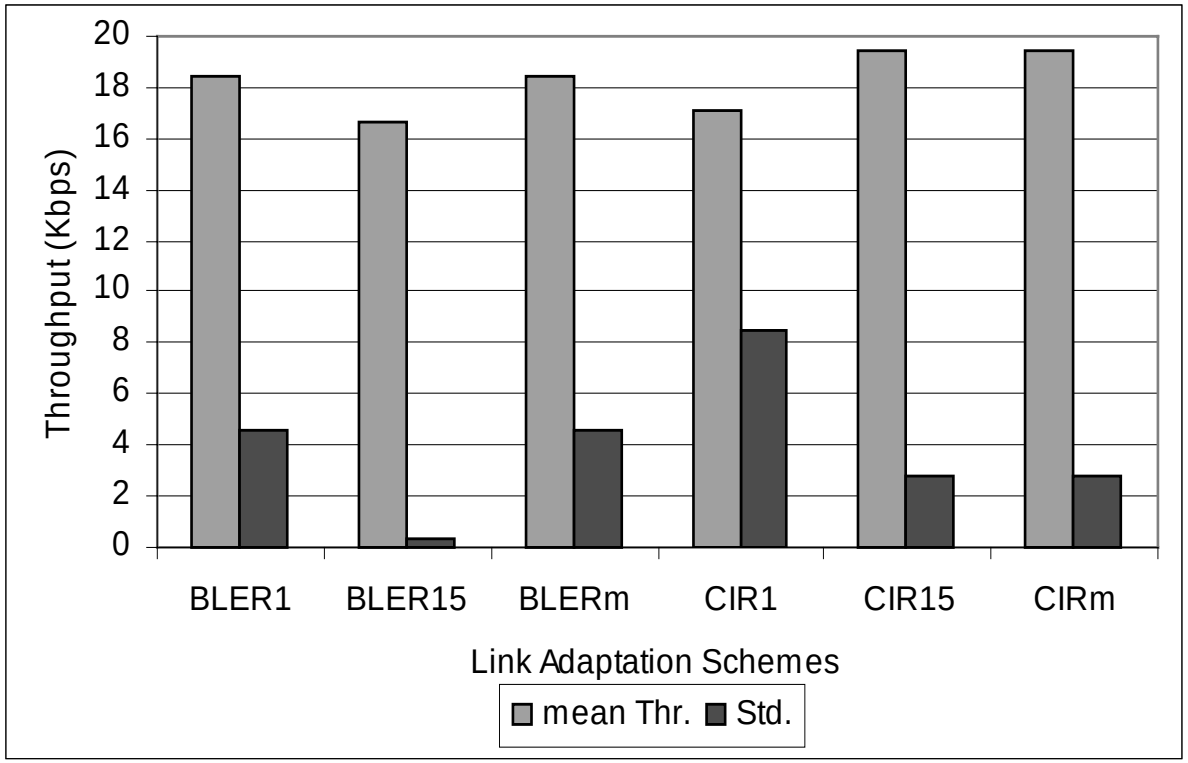
Comparsion Under Practical Situation (2)

without frequency hopping

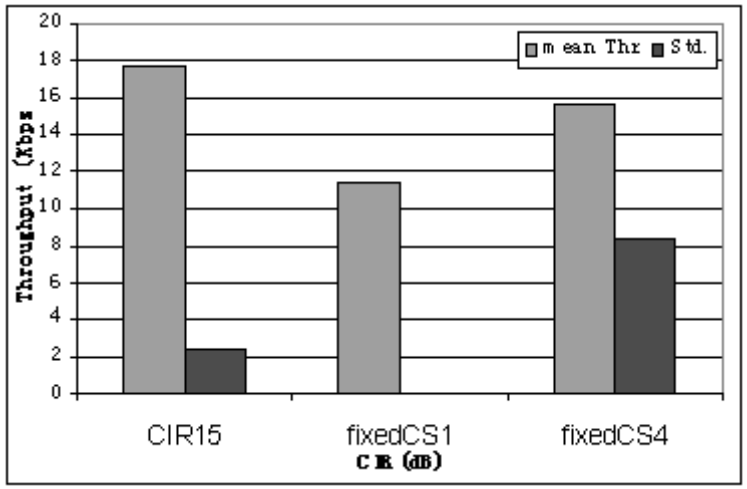


Comparsion Under Practical Situation (3)

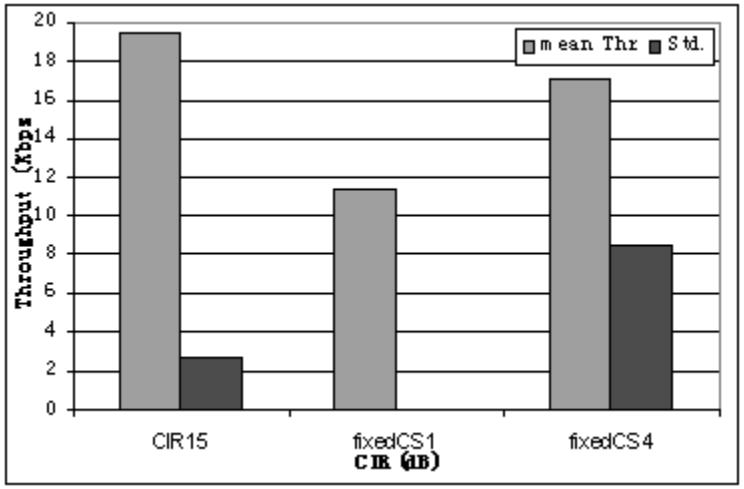
with frequency hopping



Comparsion of Link Adaptation and Fixed Coding Scheme



without frequency hopping

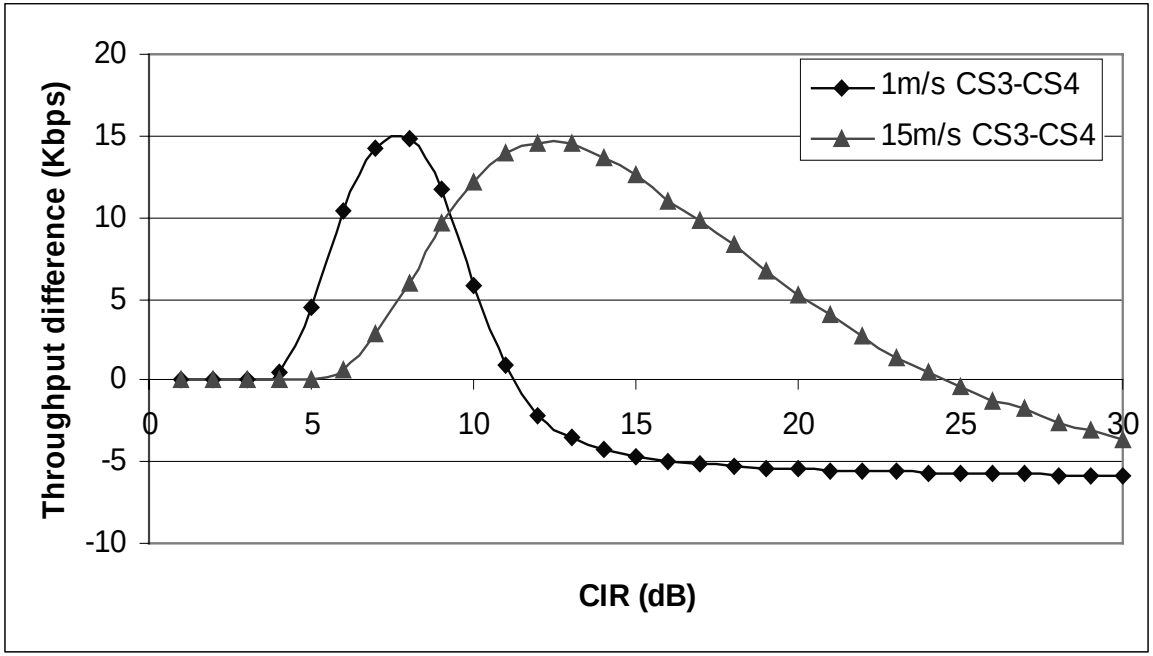


with frequency hopping

Remarks on Statistic-Based Method

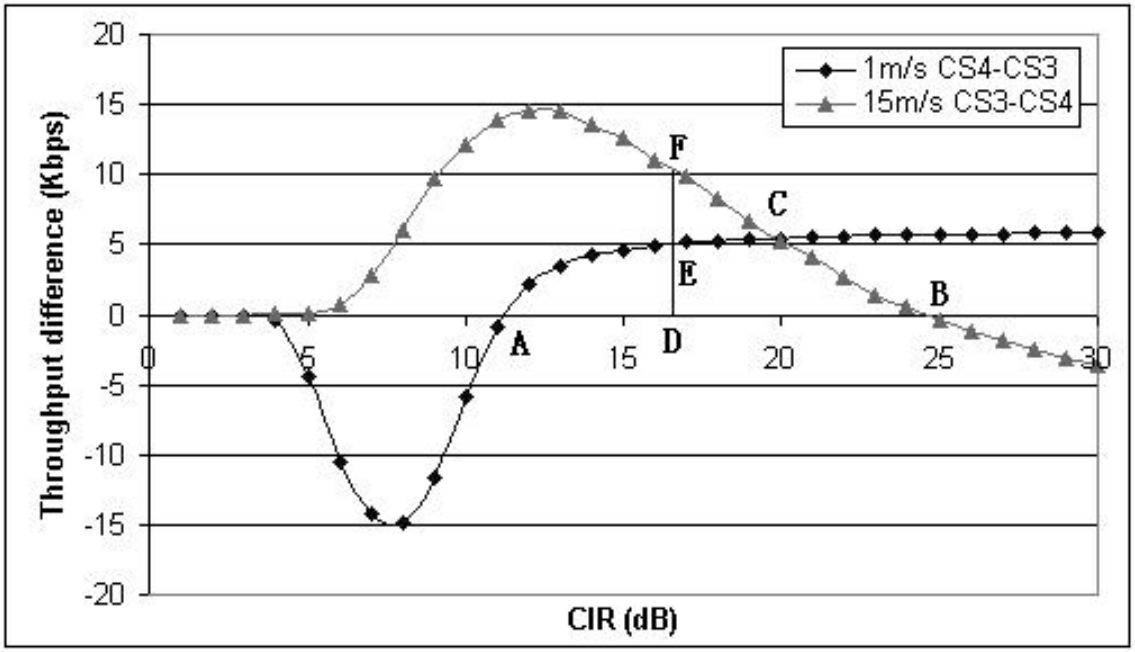
- The above discussions proved that the proposed statistic-based method offered a powerful tool in evaluating and optimizing link adptation scheme. It is interesting to note that the method is flexible. More accurate model can be obtained by increasing the number of typical circumstances if necessary. The method is also open to other link adaptation schemes of interest.

Preliminary Explanation of Superior Performance of CIR15 (1)



Throughput difference between CS3 and CS4 without frequency hopping, MS speed = 1m/s.

Preliminary Explanation of Superior Performance of CIR15 (2)



Throughput loss resulted by misjudgement

Conclusion

- The simulation suggested that CIR-based algorithm was superior to BLER-based algorithm under ideal situation.
- A method based on statistical analysis was proposed to evaluate the performances of different link adaptation schemes for the first time. According to the comparison, CIR-based link adaptation scheme owns the best performance when thresholds are selected by assuming high user speed (15m/s). The method was proved helpful and powerful in evaluating and optimising link adaptation schemes.
- A go-without-saying performance comparison for system either with link adaptation or with fixed coding scheme was also done. System with fixed coding scheme would have low throughput and possible high throughput variation. Therefore link adaptation was proved to be necessary.
- A preliminary study was done to reveal why CIR15 was superior to other schemes by considering the throughput difference between different schemes.
- The discussion suggested an new topic for link adaptation study on how to the find the optimized threshold to improve the performance, which had been proved to be interesting and important.

Question?