Performance Evaluation over GPRS Networks

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Outline

- Introduction
- Overview of GPRS Technology
- Brief about VoIP
- Description of Experiments
- Result of Experiments
- Discussion and Conclusion

Introduction

- Mobile network
  - GSM → GPRS(2.5G) → UMTS(3G)
- GPRS - A half point toward 3G
- Carry real-time applications in packet-switching network ?
  - Delay, Packet loss, Jitter
- Real-time applications : VoIP, VoD, etc.
- The performance of real-time application over GPRS network.

All-IP Network

- Network Convergence
  - Circuit-Switching : Real-time application – phone calls.
  - Packet-Switching : Data Network
  - All-IP Network.
- Benefits
  - Reduce complexity of networks
  - Lower management cost

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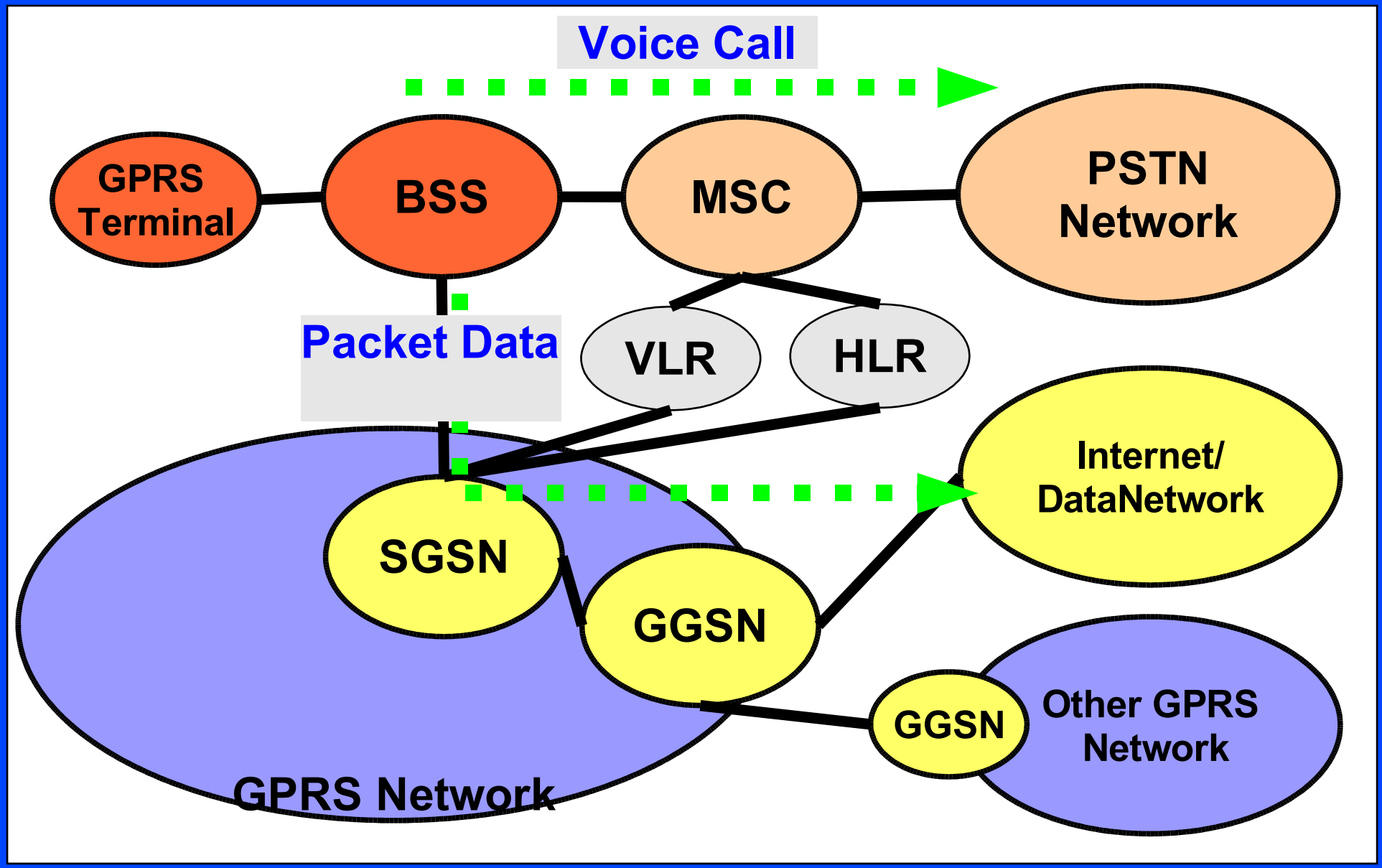
GPRS Features

- Packet-switching capability over GSM
- Low migration cost – just need to upgrade some components in GSM network
- Charge by packets
- Similar infrastructure to UMTS

GPRS Architecture



GPRS Components

- Core Network
  - Serving GPRS Support Node (SGSN)
    - Gateway of BSSs.
  - Gateway GSN Support Node (GGSN)
    - Gateway to external network.
- Base Station System(BSS)
  - Packet Data Unit
- HLR & VLR – need some softwares upgrade to support GPRS.

GPRS Components

- Terminal Equipment(TE)
  - Class A,B,C – duplex, half duplex, simplex of voice and data
  - Speed – one time slot : 13.4 kbps
    - Class 8 – 4 down 1 up
    - Class 10 – 4 down 2 up
- The same channel allocation method as GSM network

Mobile Sets with GPRS Capability

GPRS Protocol Stacks

- GPRS Tunnel Protocol(GTP)
  - Tunneling the packet through GPRS networks.
- MAC Protocol
  - To coordinate the usage of time slot between BSSs.
- Radio Link Control(RLC)
  - Protocol between BSSs and SGSN

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VoIP overview

- Protocols
  - Signaling : H.323, SIP
  - Media encoding
    - Voice : G.723, G.723a, G.729
    - Video : H.261, H.263
  - Gateway : MGCP, MEGACO

VoIP encode technologies

Standard	Algorithm	Bit Rate (Kbit/s)	Typical end-to-end delay (ms) (excluding channel delay)	Resultant Voice Quality
G.711	PCM	48, 56, 64	<<1	Excellent
G.723.1	MPE/ACELP	5.3, 6.3	67-97	Good(6.3), Fair (5.3)
H.728	LD-CELP	16	<<2	Good
G.729	CS-ACELP	8	25-35	Good
G.729a	CS-ACELP	8	25-35	Good
G.722	Sub-band ADPCM	48, 56, 64	<<2	Good
G.726	ADPCM	16,24,32,40	60	Good(40), Fair (24)
G.727	AEDPCM	16, 24, 32, 40	60	Good(40), Fair (24)

From www.protocols.com

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Motivation of Experiment

- To evaluate the performance of GPRS network.
- Real-time application : simulated VoIP packet.
- Performance metrics
  - Delay time
  - Packet loss ratio
  - Jitter

Experiment Environment

- Two different operators(A,B), all of them claim that they can provide full features of GPRS.
- Several mobile sets have been tested in experiment.
- Show only one mobile set with GPRS capability 2d1u.

Experiment Design

- Sensitivite to
  - Data rate
  - Operator
  - Movement Speed
- One test set on three different environment.

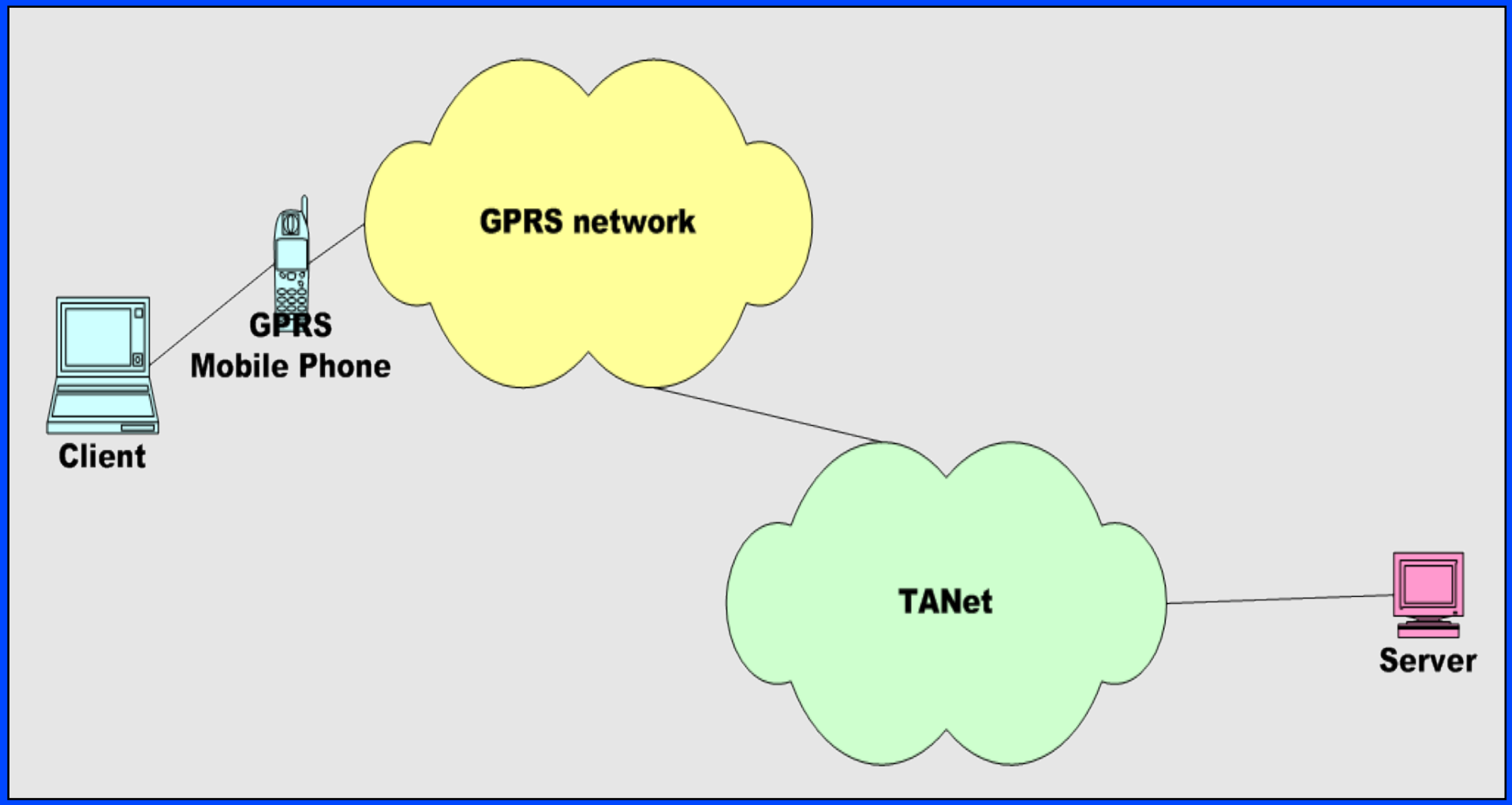
	Packet Size (byte)	*Transmit Interval(ms)*	*Move Speed*
Experiment I	36-1024	100-600	0
Experiment II (Operator A)	36-1024	100-600	MRT
Experiment III (Operator B)	36-1024	100-600	MRT

Experiment Design (cont')

- Each experiment has 20 test instances.
- Test Instances : (system can not perform when transmission interval is below 100ms.)
- Transmit 100 packets in each test instance, and take average delay, packet loss ratio and jitter.

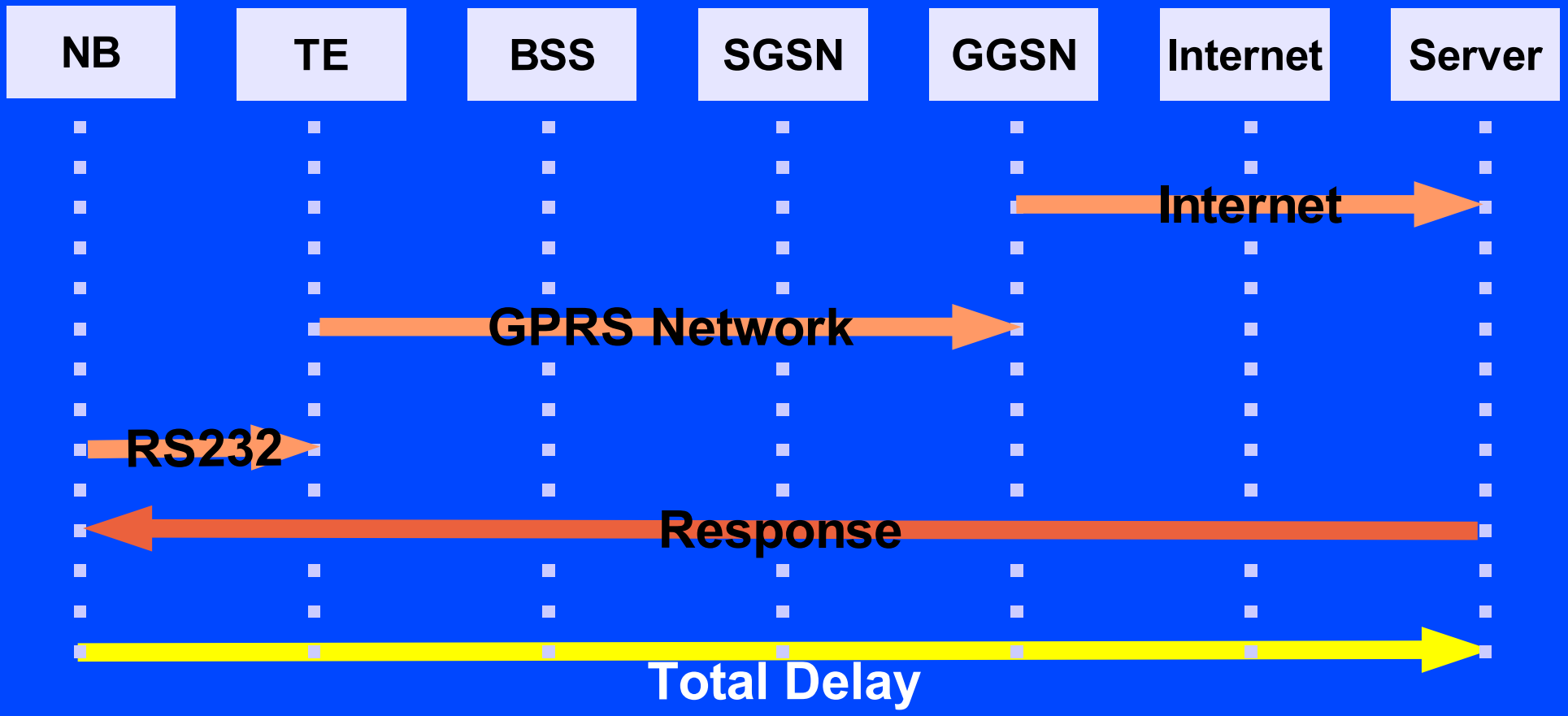
interval\packet size	36bytes	64bytes	128bytes	256bytes
100ms	#1	#6	#11	#16
200ms	#2	#7	#12	#17
300ms	#3	#8	#13	#18
400ms	#4	#9	#14	#19
500ms	#5	#10	#15	#20

Packet Travel Path



Process time on server is very small(<=1ms), so it has been omitted.

One Way Delay



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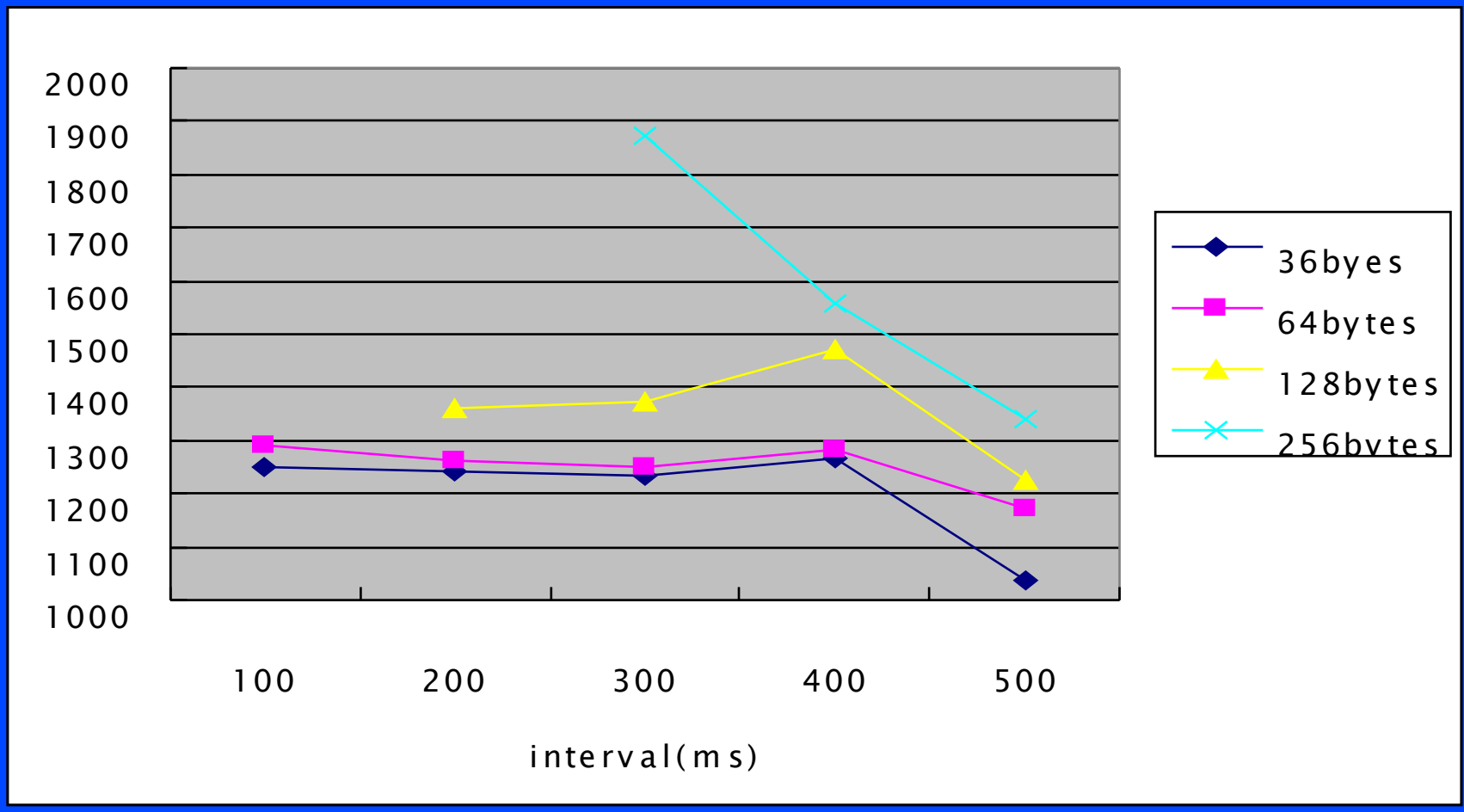
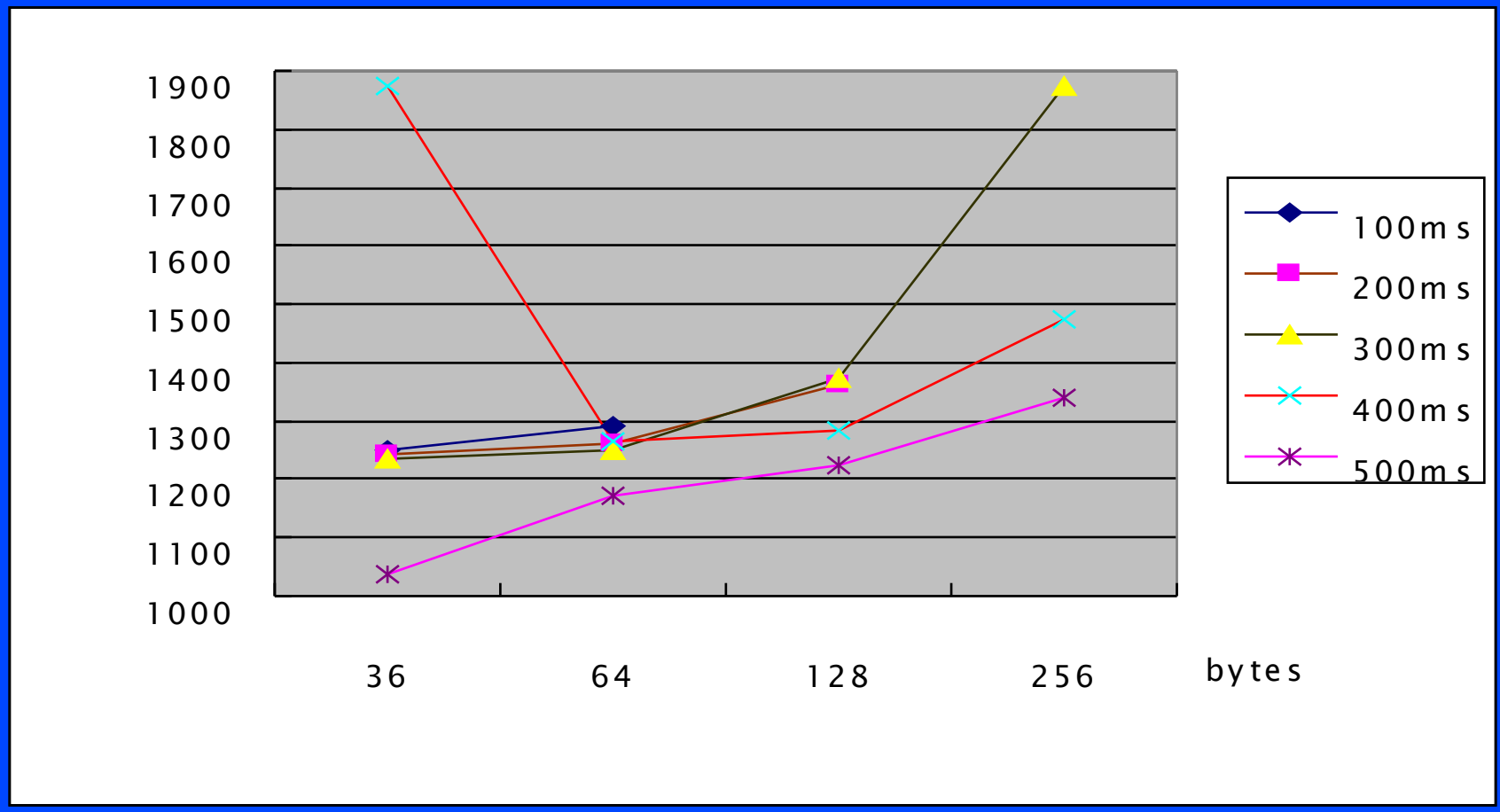
Experiment I :
Fixed Location

Transmission Interval and Delay



When transmission interval increase, delay decrease.

Packet Size and Delay



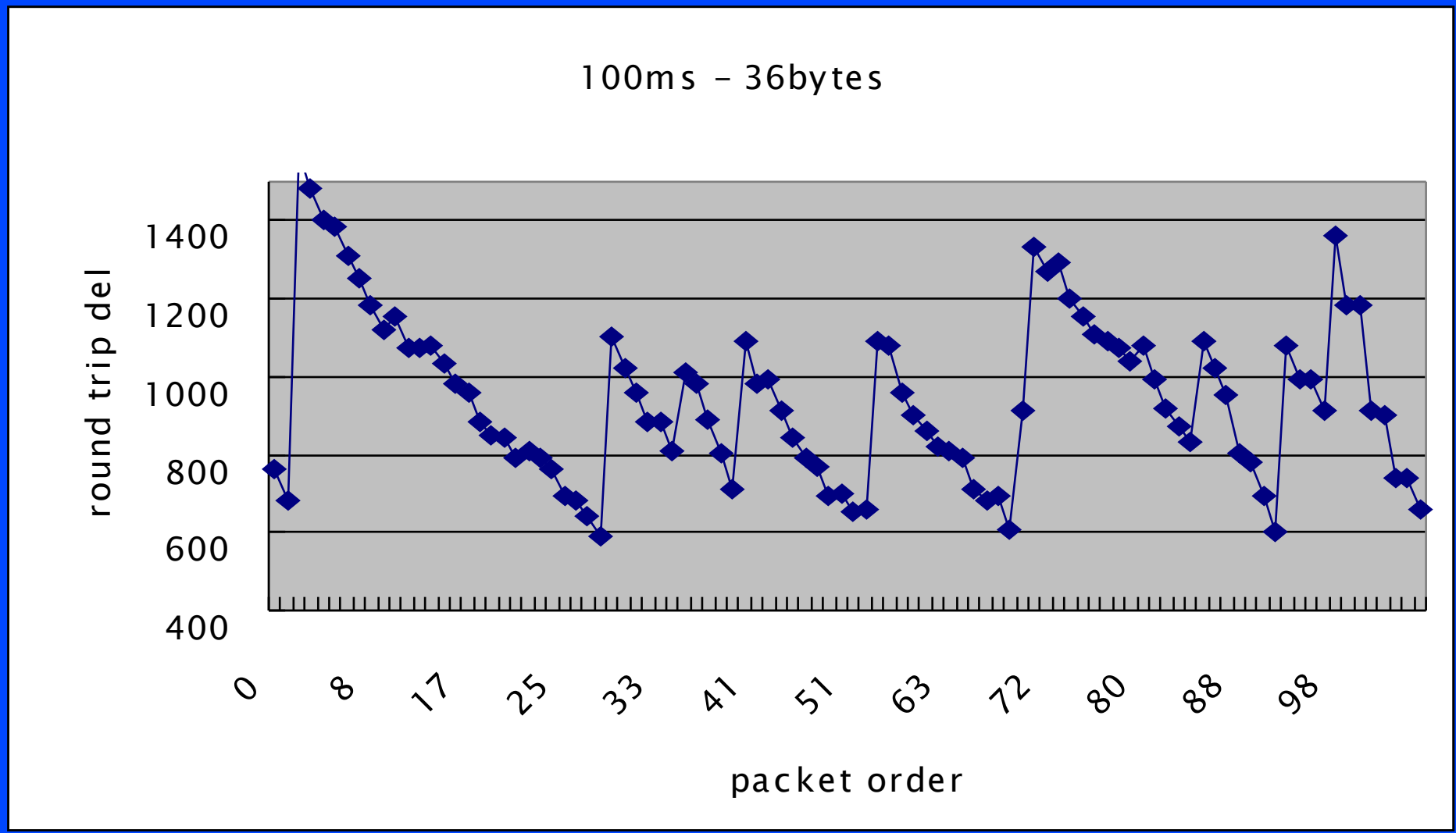
When packet size increase, the delay decrease.

Discussion

- In all time interval, transmission delay will be low when packet size is less than 128 bytes.
- When packet size is larger than 256 bytes, the limit of system transmission speed, the delay will increase very quickly.

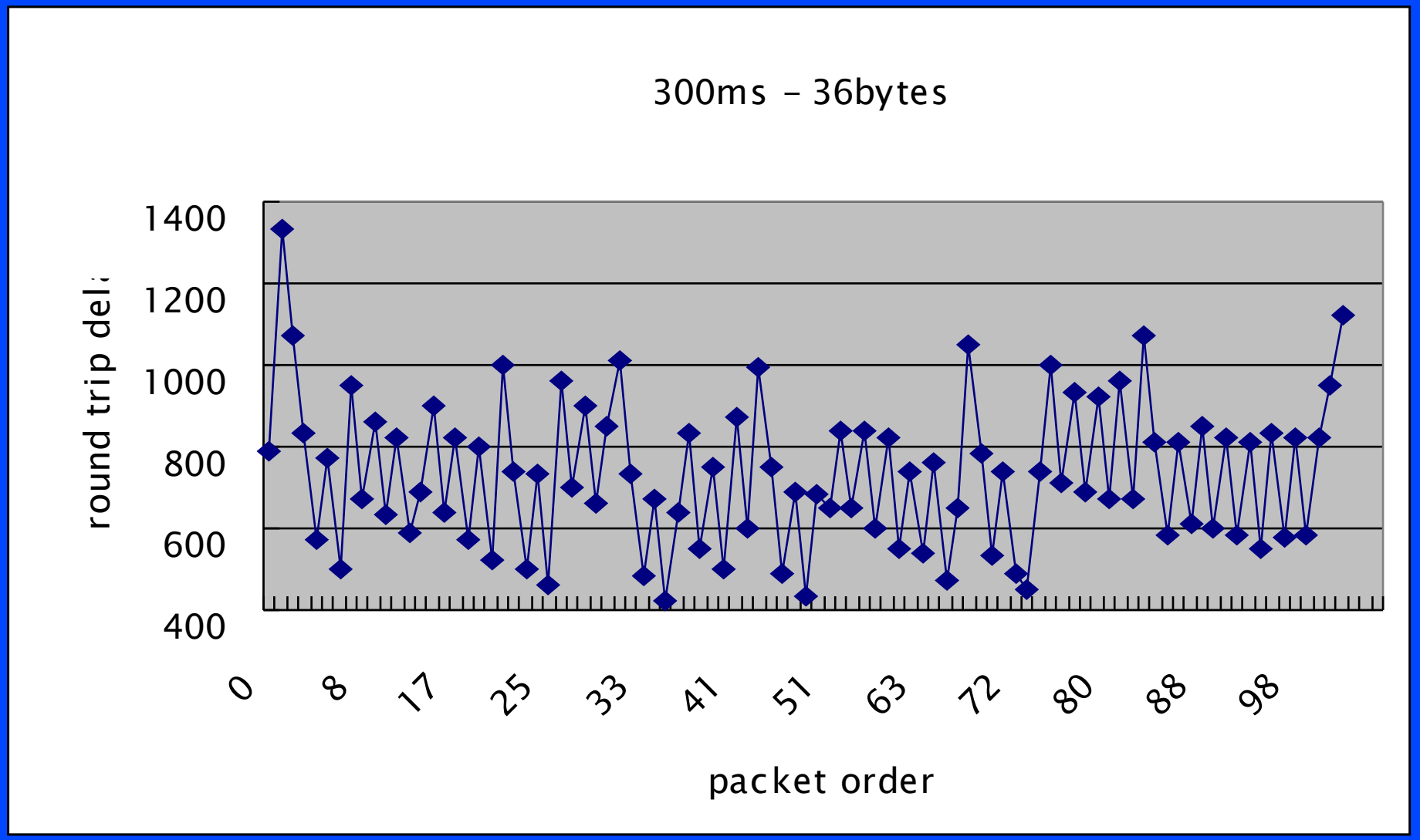
Sawtooth Phenomenon (Rayman Phenomenon)

transmission interval : 100ms



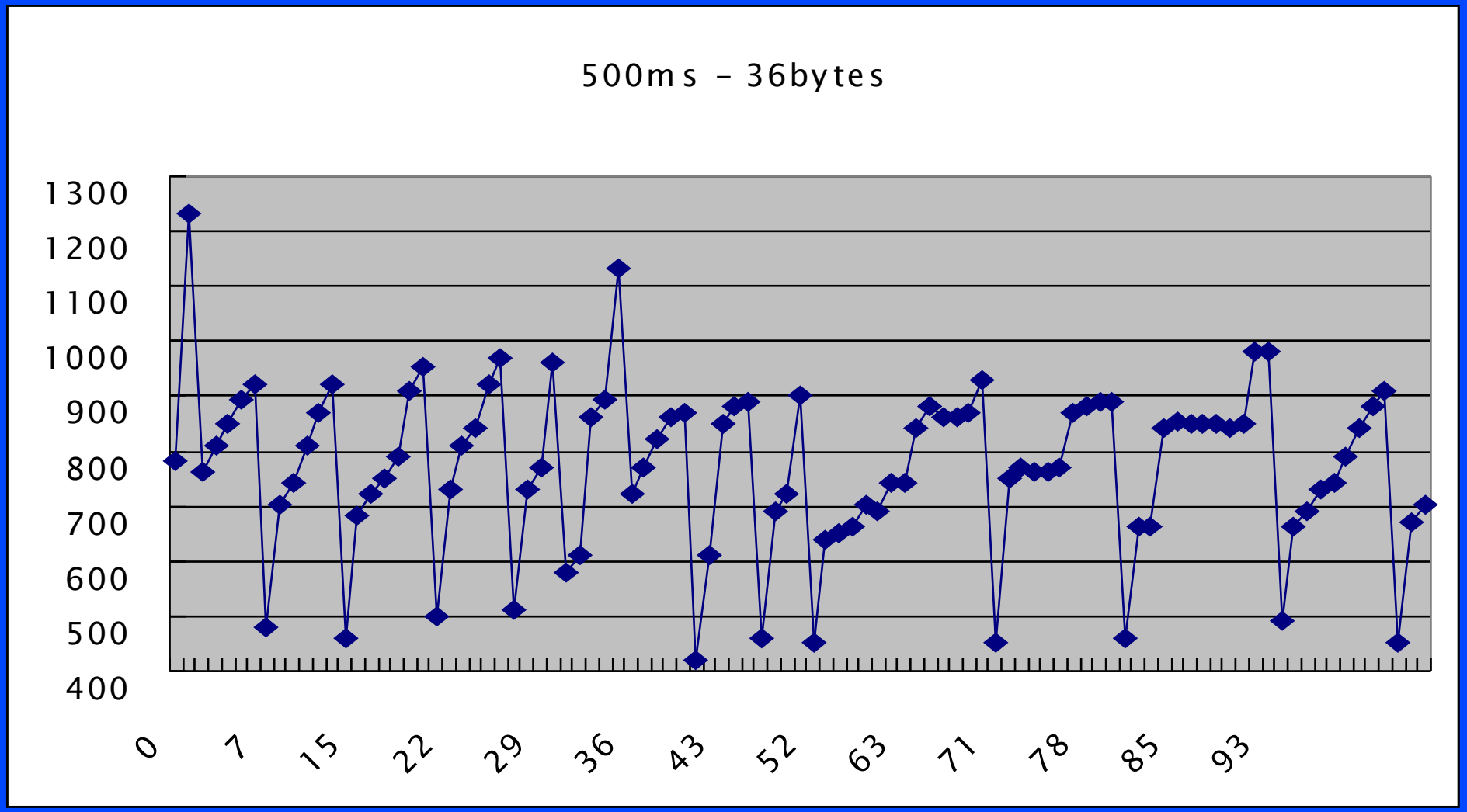
Sawtooth Phenomenon (Rayman Phenomenon)

transmission interval : 300ms



Sawtooth Phenomenon (Rayman Phenomenon)

transmission interval : 500ms



Discussion of Sawtooth Phenomenon

- The results are similiar in different times of days.
- The phenomenon is independent to system load.
- The phenomenon might be caused by batch operation of GPRS networks.

Jitter

Transmission interval	□□□	Average
100ms	213.84	1024.96ms
200ms	171.57	1143.52ms
300ms	178.78	1017.34ms
400ms	173.13	1193.41ms
500ms	152.11	993.44ms

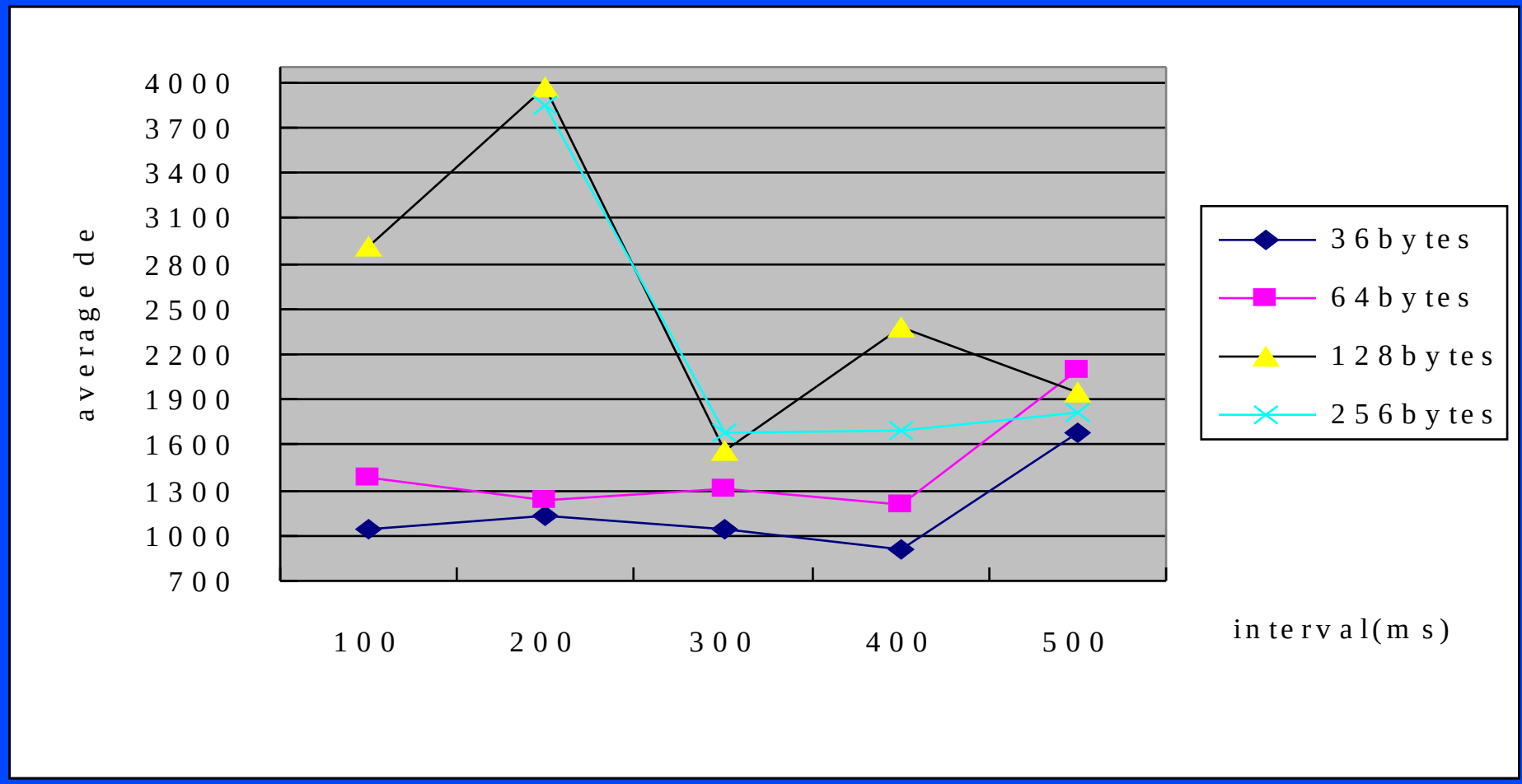
Note : Packet Size -36bytes

Remark about Jitter

- Jitter seems very large.
- GPRS networks may not adaguate to carry jitter sensitive services.

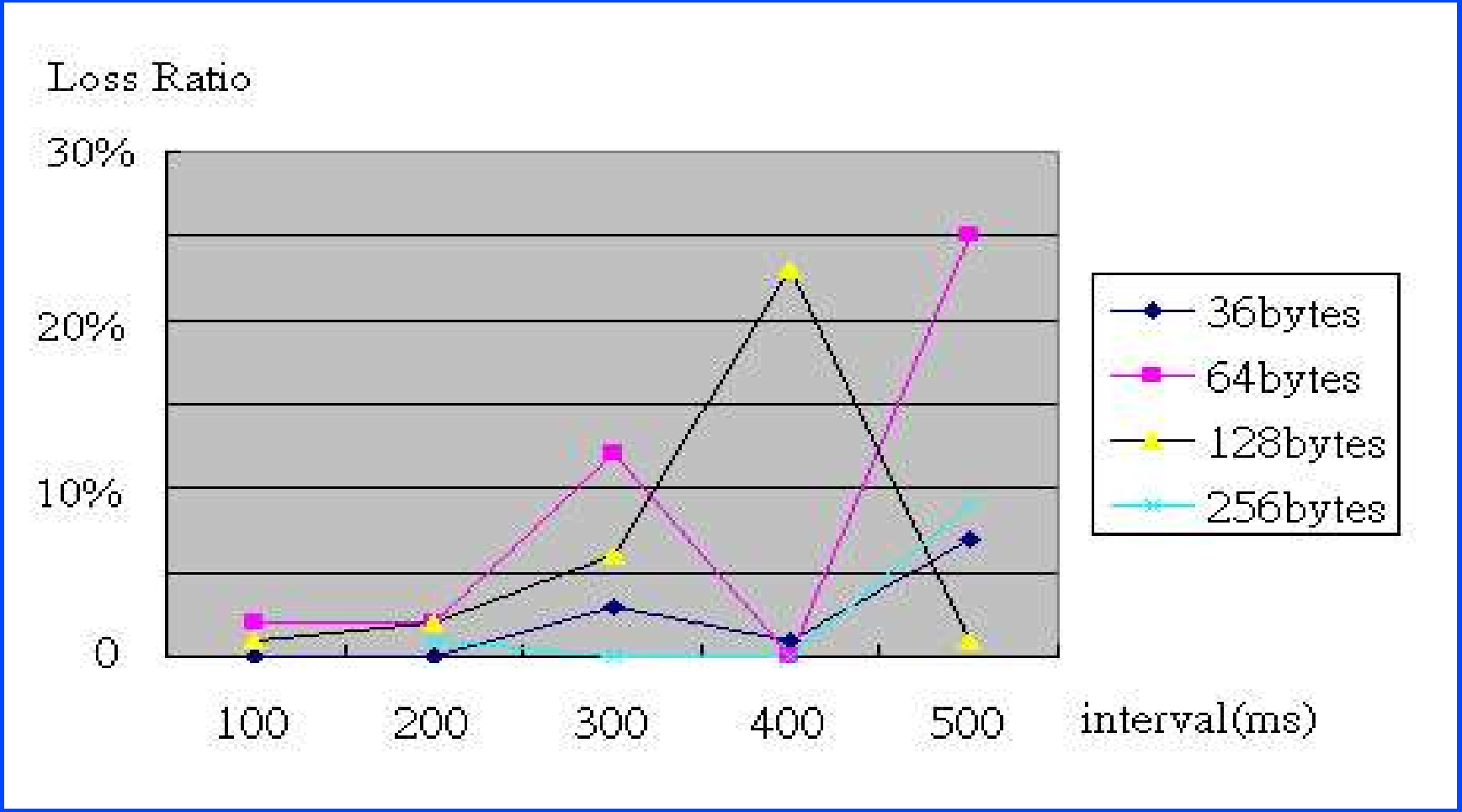
Experiment II:
Test in movment over
GPRS Network of Operator A

Transmission interval and delay



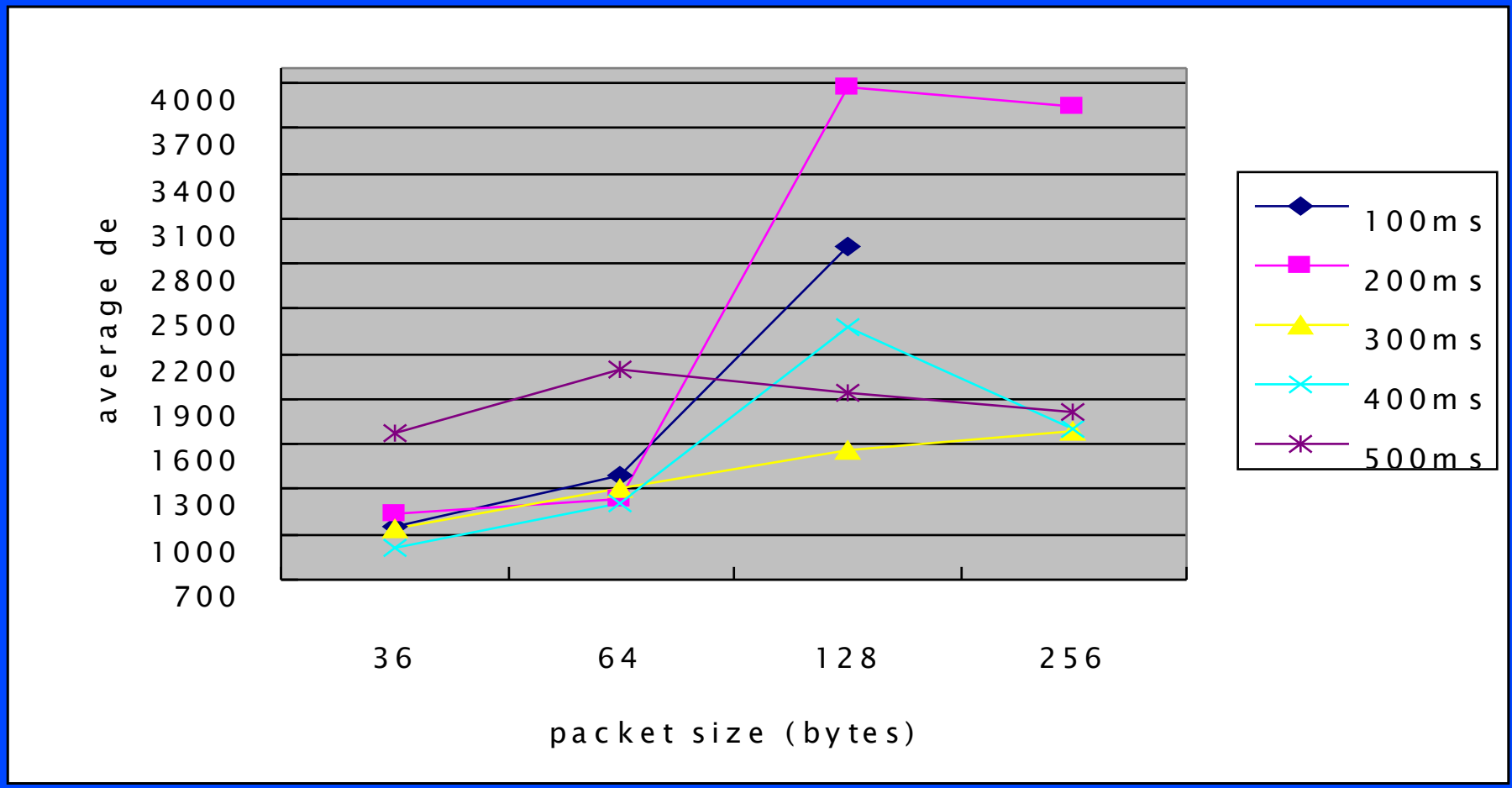
When transmission interval increase, delay decrease.

Transmission interval and packet loss ratio



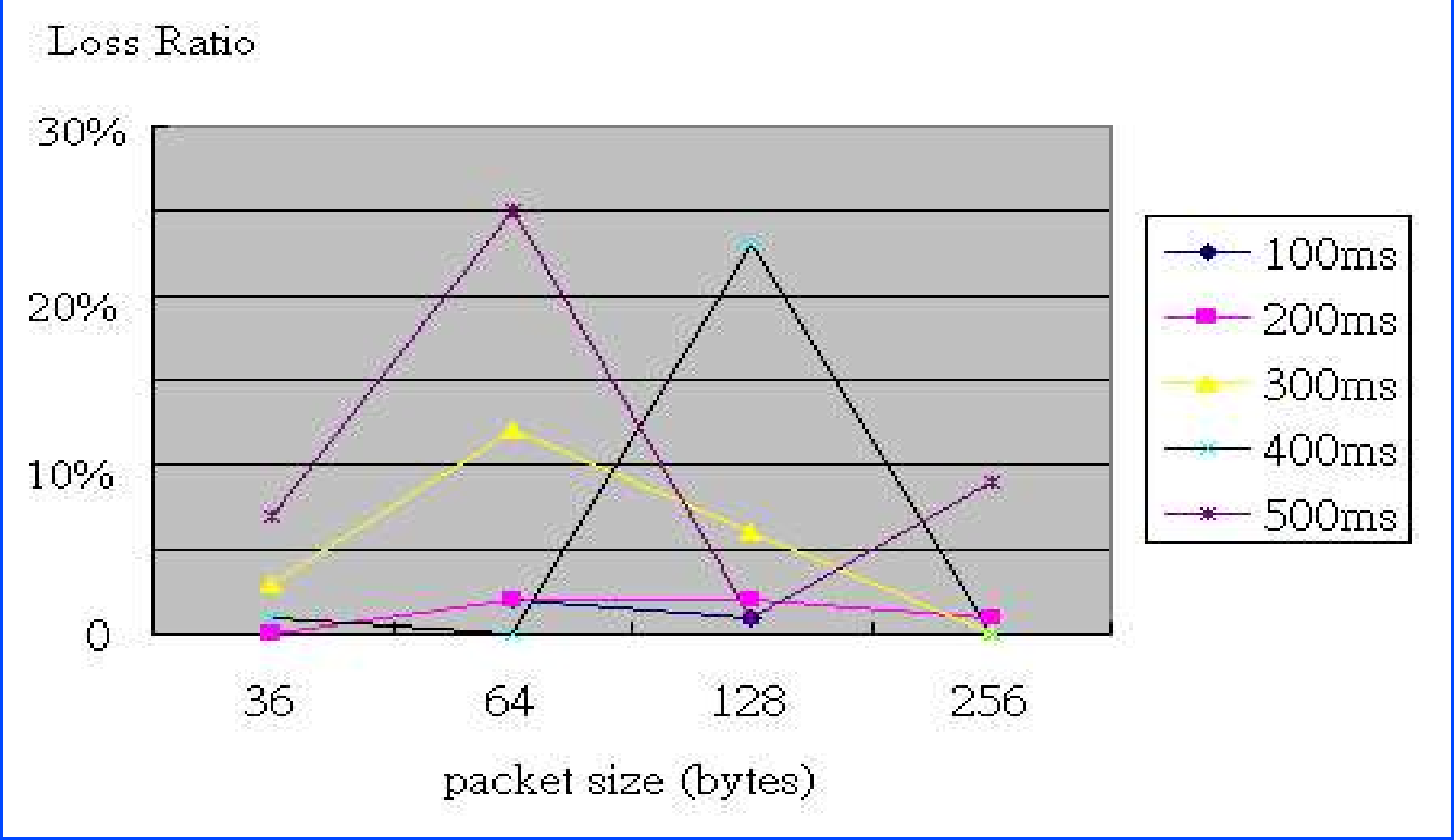
When transmission interval increase, packet loss ratio also increase.

Packet Size and Delay



When packet size increase, delay also increase.

Packet Size and Packet Loss Ratio



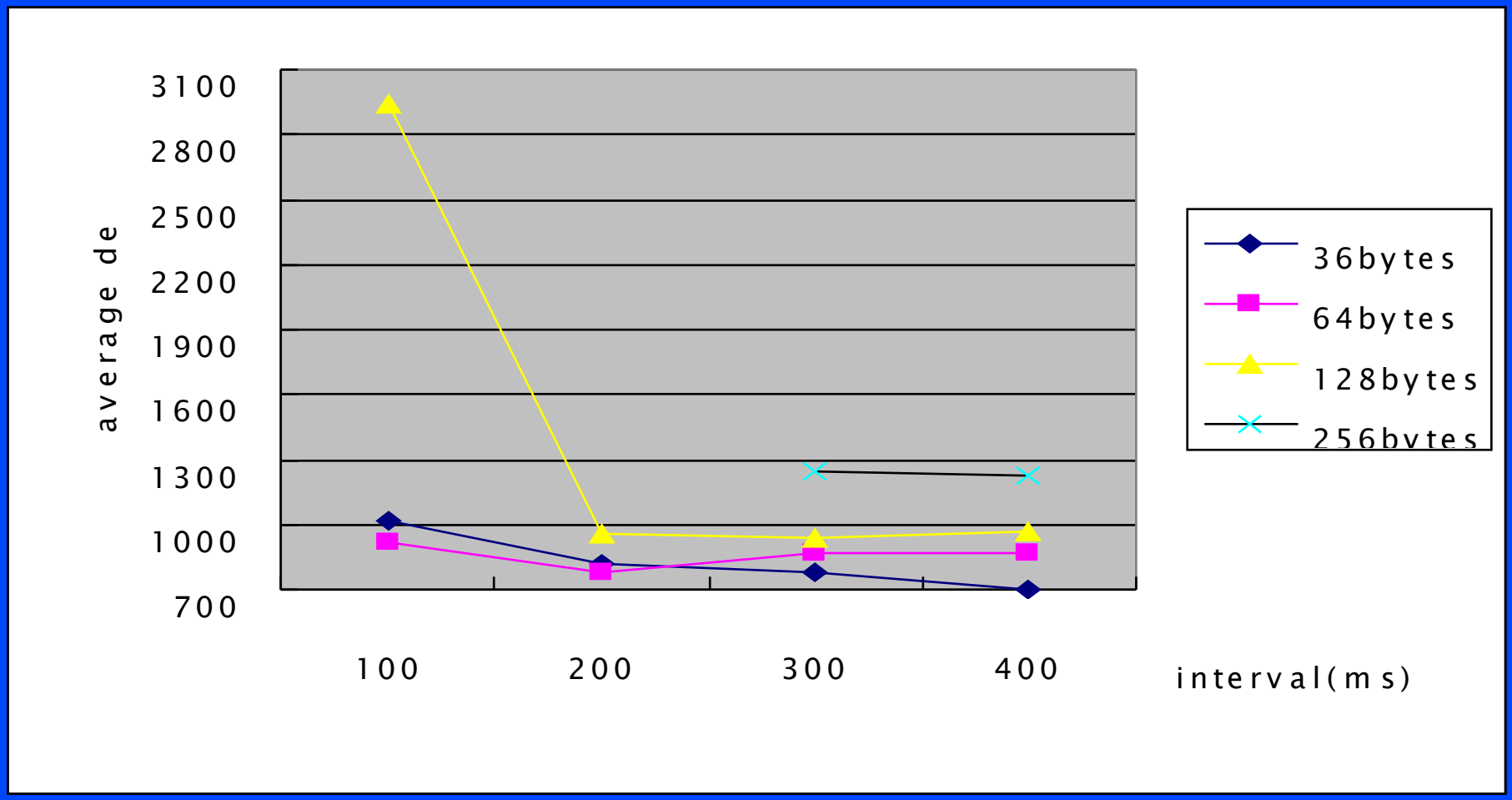
packet loss ratio is independent of packet size.

Observation on Experiment II

- Packet loss ratio is unstable when packet size is over 36byte.
- When transmission interval is over 500ms, the delay will also increase.

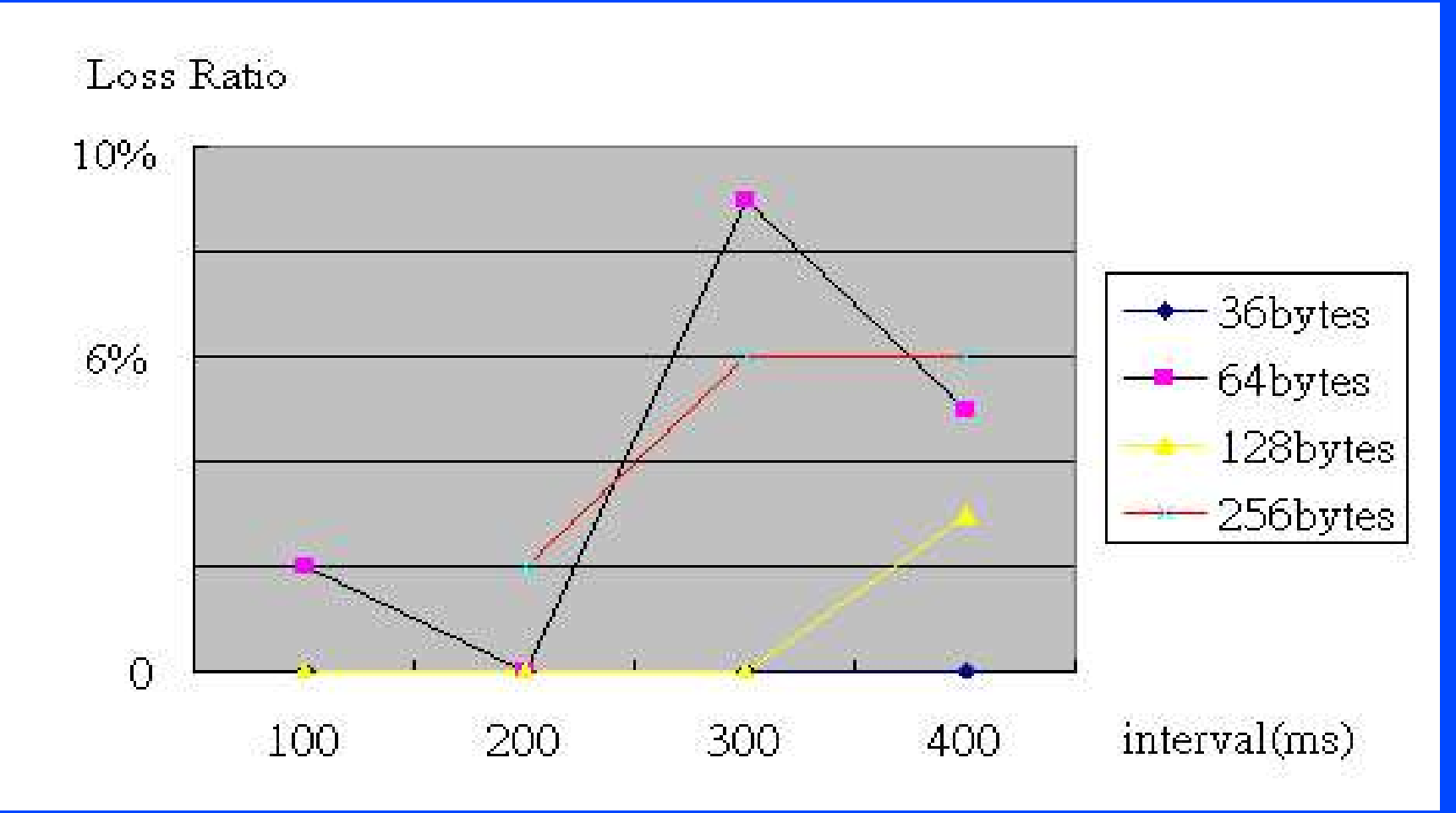
Experiment III:
Test in movment over
GPRS Network of Operator B

Transmission Interval and Delay



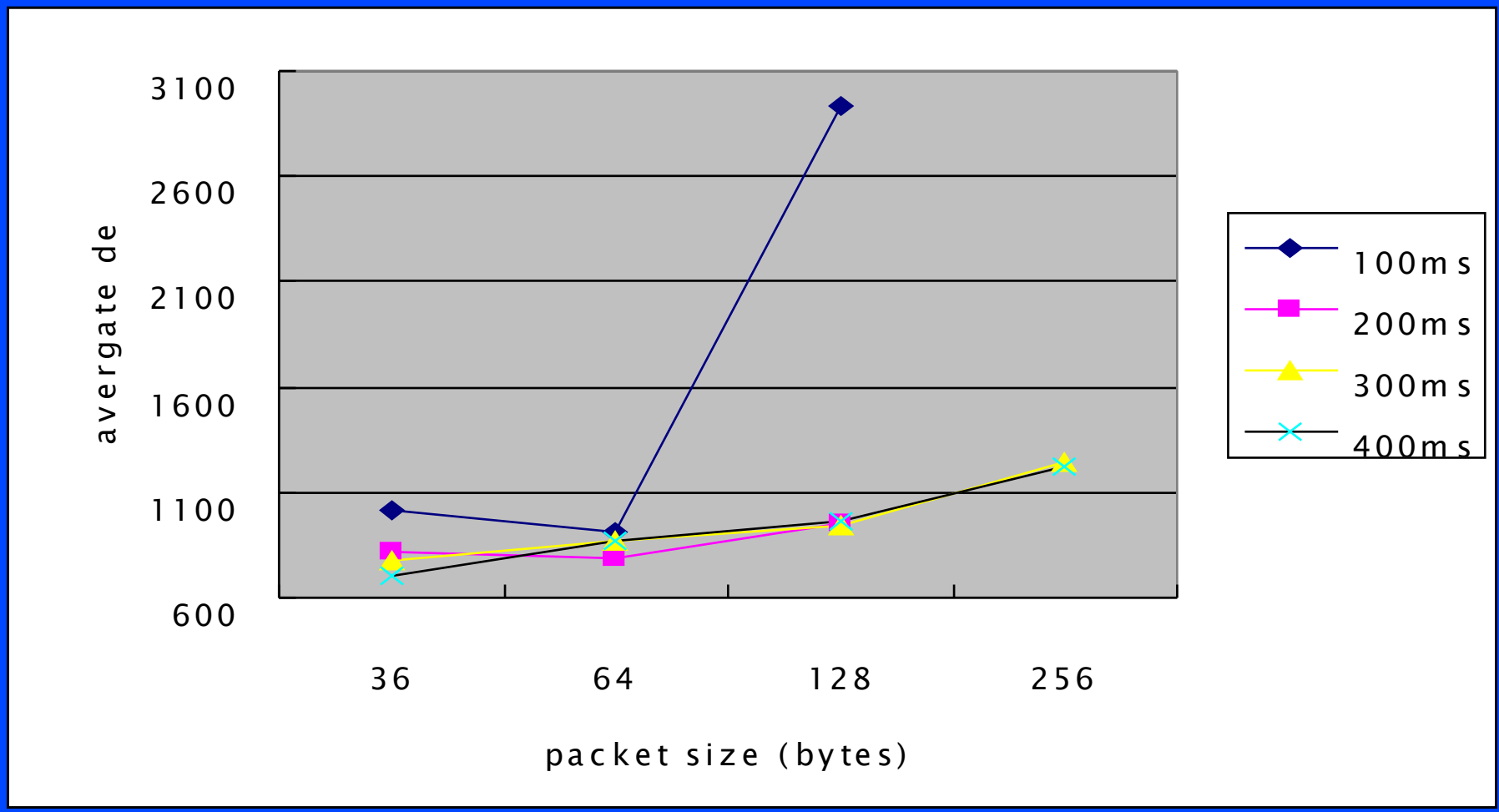
When transmission interval increase, delay decrease.

Transmission Interval and Packet Loss Ratio



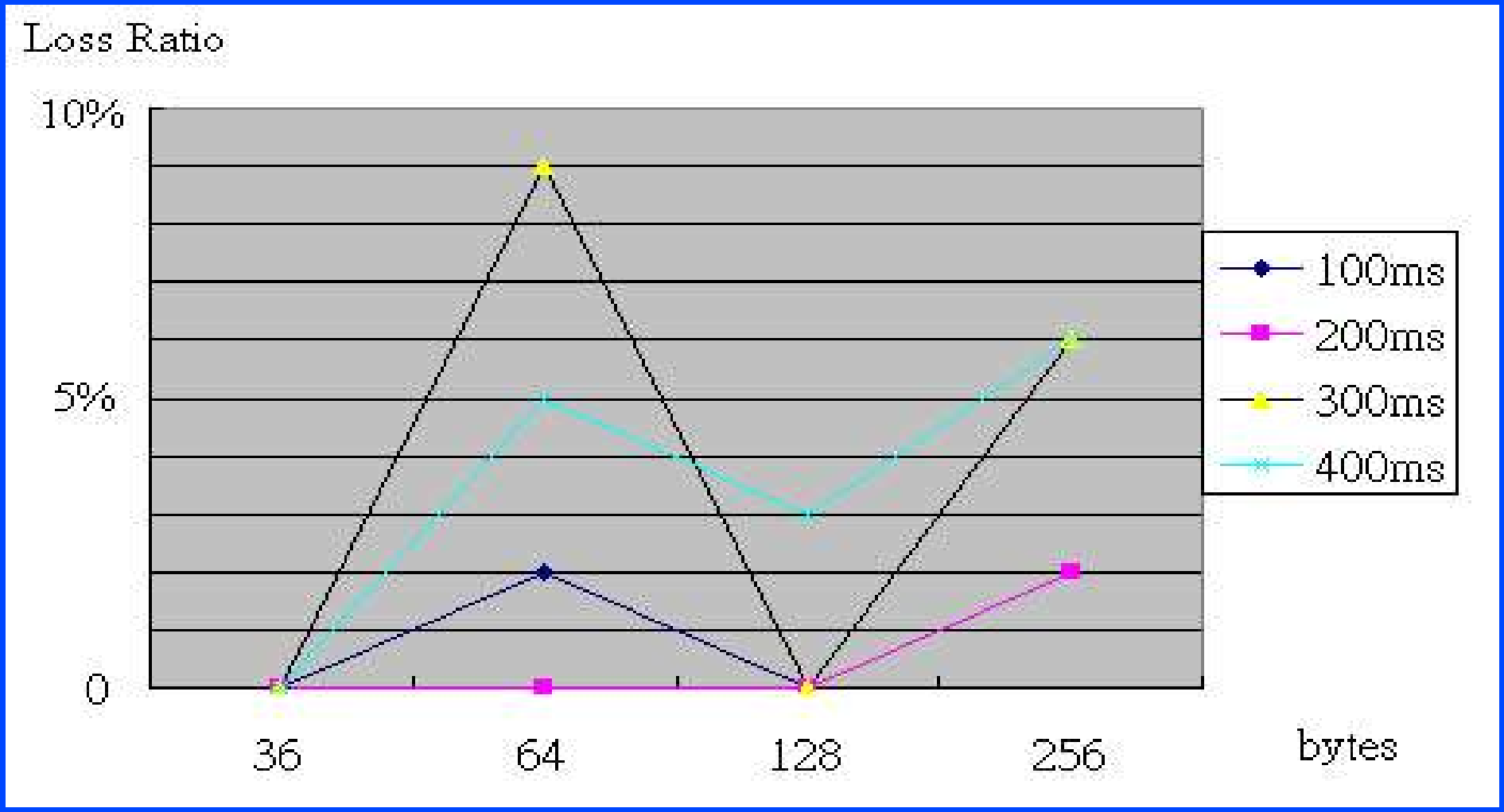
When transmission interval increase, packet loss ratio is unstable.

Packet Size and Delay



When packet size increase, delay also increase.

Packet Size and Packet Loss Ratio



packet loss ratio is independent to packet size.

Observation of Experiment III

- Most of chareristics are the same as Operator A.
- The performance is better than Operator A, when transmission interval is between 200ms and 400ms.
- In average, operator B has better performance than operator A.

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Quality of Transmission

- 無論是縱貫鐵路或中山高，在山區裡通訊品質較差
- 行車速度在80-90以上時，loss rate 增加，也常會斷訊
- 受到網路擁擠的影響，在通訊尖峰時段內，封包遺失率較多

User Experiences

- 撥接程序非常耗時，網路經常斷線需要重撥，將對使用者造成極大困擾
- Connection Oriented Services（例如 telnet 或 vi）在品質不穩定的情況下使用非常不方便，工作容易半途而廢
- 封包遺失可能由 TCP 等協定負責處理（重傳），使用者所感覺到的是資料之延遲
- 電池消耗問題 — 手機電力不足，無法在上網這類Idle時間較長的行為中，讓使用者完成所需的工作。

Conclusion

- 綜合以上網路品質與行動使用者的經驗，在封包延遲時間，封包遺失率以及斷訊三種品質因素中，斷訊導致斷線對GPRS 上網使用者所造成的困擾最為嚴重。
- 封包傳送時間呈現鋸齒狀的現象，將對具時效性的應用造成傷害性的影響。
- 從以上在GPRS網路上的實驗看來，具時效性應用在的現行GPRS網路上，仍不可行，有待大幅改進。