

Appeared in ACM NOSSDAV 2005 (15th International Workshop on Network and Operating System Support for Digital Audio and Video)



Game Traffic Analysis: An MMORPG Perspective

(MMORPG: Massive Multiplayer Online Role Playing Game)

*Kuan-Ta Chen, Polly Huang,
Chun-Ying Huang, Chin-Laung Lei*

*Department of Electrical Engineering
National Taiwan University*



Apr. 29, 2005

Talk Outline

- Overview
 - network game research
 - current status of MMORPG
- Trace collection
- Traffic characterization & their physical explanations
- Conclusion
- Future work

Network Game Research

- Traffic analysis and modeling
 - packet size/arrival process
 - connection time/arrival process
- User behavior analysis and modeling
 - session time, session arrival process
 - session membership
- The effects of network QoS
 - affect player duration?
 - affect arrival / departure rate?
 - affect overall score or running speed?

Network Game Research (cont.)

- Dead reckoning (client-side prediction)
- Interest management (preference clustering)
- Server discovery mechanism
(select a best game server)
- Network infrastructure
 - multicast - group management
 - multi-tier (proxied)
 - p2p / overlay networks

Motivation

- Network games contribute 3% -- 4% Internet traffic at backbones in 2000
- MMORPG
 - the dominate network game genre in Asia
 - exhibit distinct features, such as
 - no explicit game rounds
 - no restrict on player number

The Increasing Popularity of MMOG

Total MMOG Active Subscriptions (Excluding Lineage, Lineage II, and Ragnarok Online)

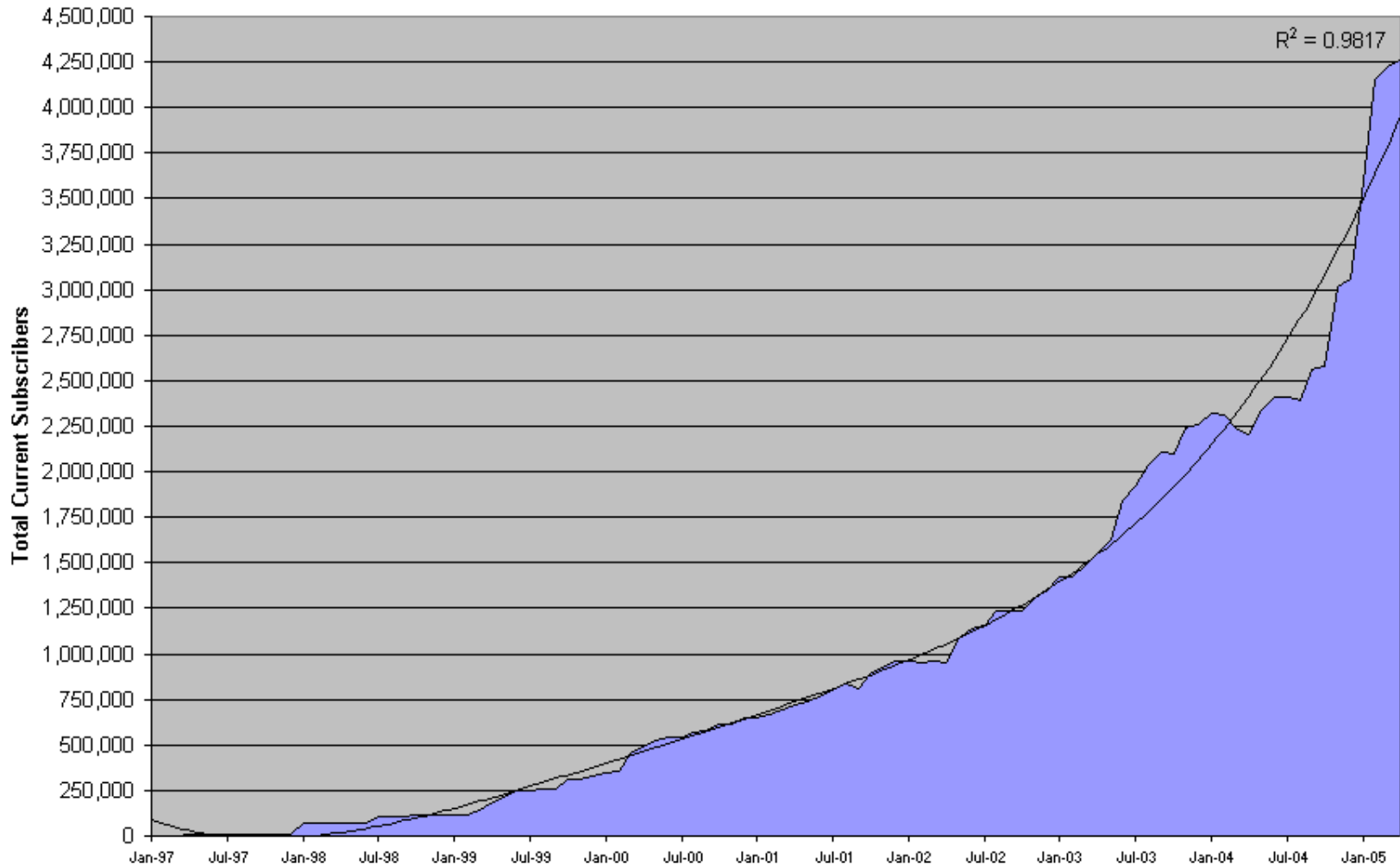


Figure courtesy of <http://www.mmogchart.com/>

Popular Genres in MMORPG

Market Share By Genre (Excluding Lineage, Lineage II, and Ragnarok Online) - Feb 2005

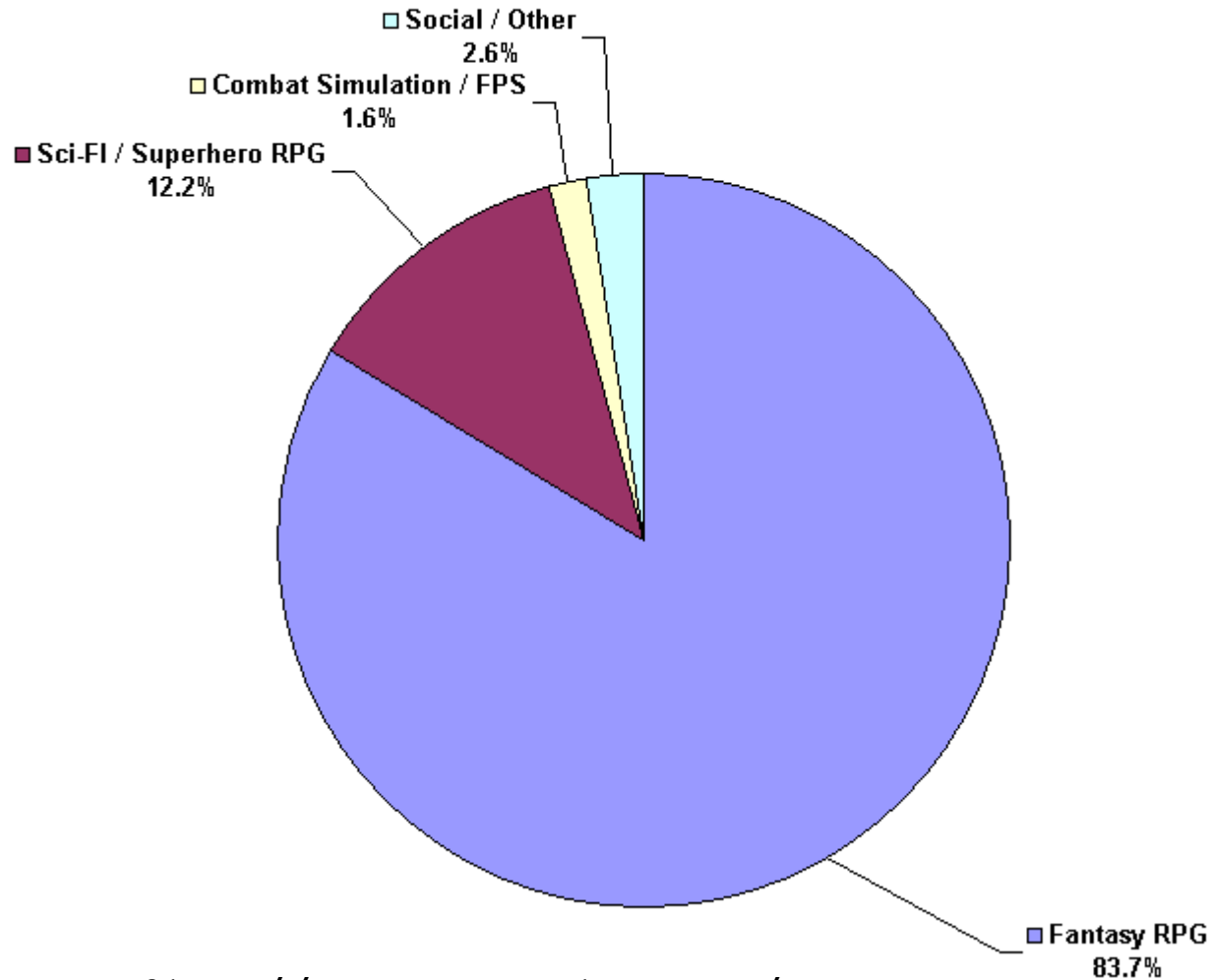


Figure courtesy of <http://www.mmogchart.com/>

Network Games in Taiwan

- 120 network games in 1st quarter, 2003
- market value of 6,800 million NT dollars in 2003 \Rightarrow 80% share of the whole PC game industry
- Gamania (Lineage) owns $>$ 4,000 Mbps links
- R. O. has a record of 370,000 players online, equivalent to 1.5% of the population

神州 Online

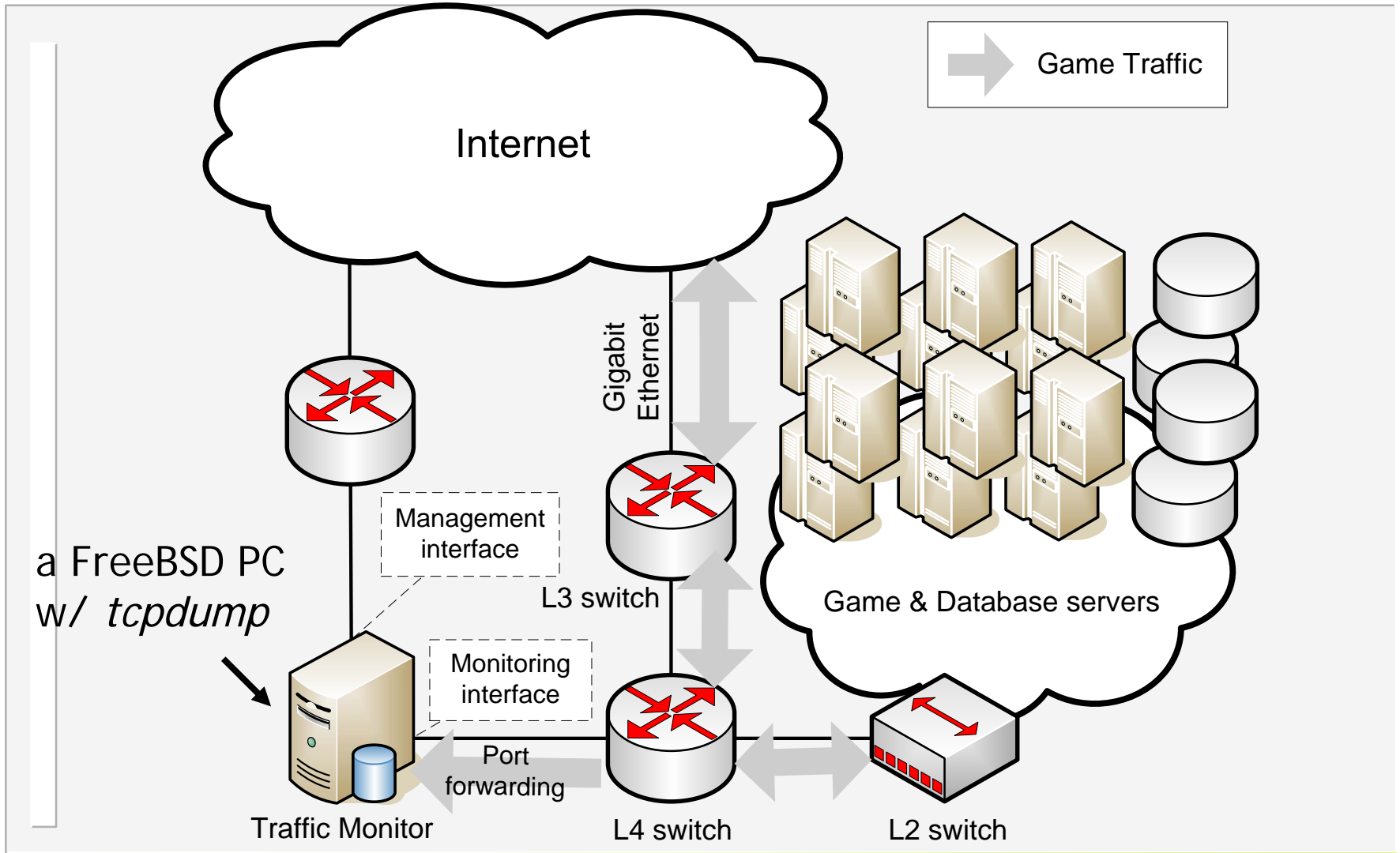
- a mid-scale, commercial MMORPG in Taiwan
- a typical Asia MMORPG ---
 - Microsoft Windows platform (Windows 2000, MS SQL Server)
 - data communication based on TCP
- (By the way) Issues on network protocols
 - UDP: Ultima Online (EA), Everquest series (SOE)
 - TCP: World of Warcraft (Blizzard)
 - no general agreement on the use of base protocol



It's me

| | | | | | |
|-----|------------|------------------------|---------|---------|--|
| 神州城 | | 241 / 241 | 93 / 93 | [Icons] | |
| | 姓名 小寬 | 抓圖成功(cap\cap0059.jpg)° | | | |
| | 職業 劍俠 | 冰心雪>今天打蛇才賺為70萬 | | | |
| | 名聲 無名小卒 | 抓圖成功(cap\cap0060.jpg)° | | | |
| | 生日 水曜日 | 冰心雪>白鹿還死為一次 | | | |
| | 負重 27 / 75 | 冰心雪>忘為看血 故看電視 QQ" | | | |
| | | 抓圖成功(cap\cap0061.jpg)° | | | |
| 6 級 | 760 | [Icons] | | | |

Trace Collection - Setup



Trace Collection - Summary

| Trace | Sets | Date | Time | Period | Drops |
|-------|------|----------------|-------|--------|--------|
| N1 | 3 | 8/29/04 (Sun.) | 15:00 | 8 hr. | 0.003% |
| N2 | 2 | 8/30/04 (Mon.) | 13:00 | 12 hr. | ? |

| Trace | TCP Conn. | Packets (in/out/both) | Bytes (in/out/both) |
|-------|-----------|-----------------------|-------------------------|
| N1 | 57,945 | 342M / 353M / 695M | 4.7TB / 27.3TB / 32.0TB |
| N2 | 54,424 | 325M / 336M / 661M | 4.7TB / 21.7TB / 26.5TB |

1,356 million packets in total

Term definition

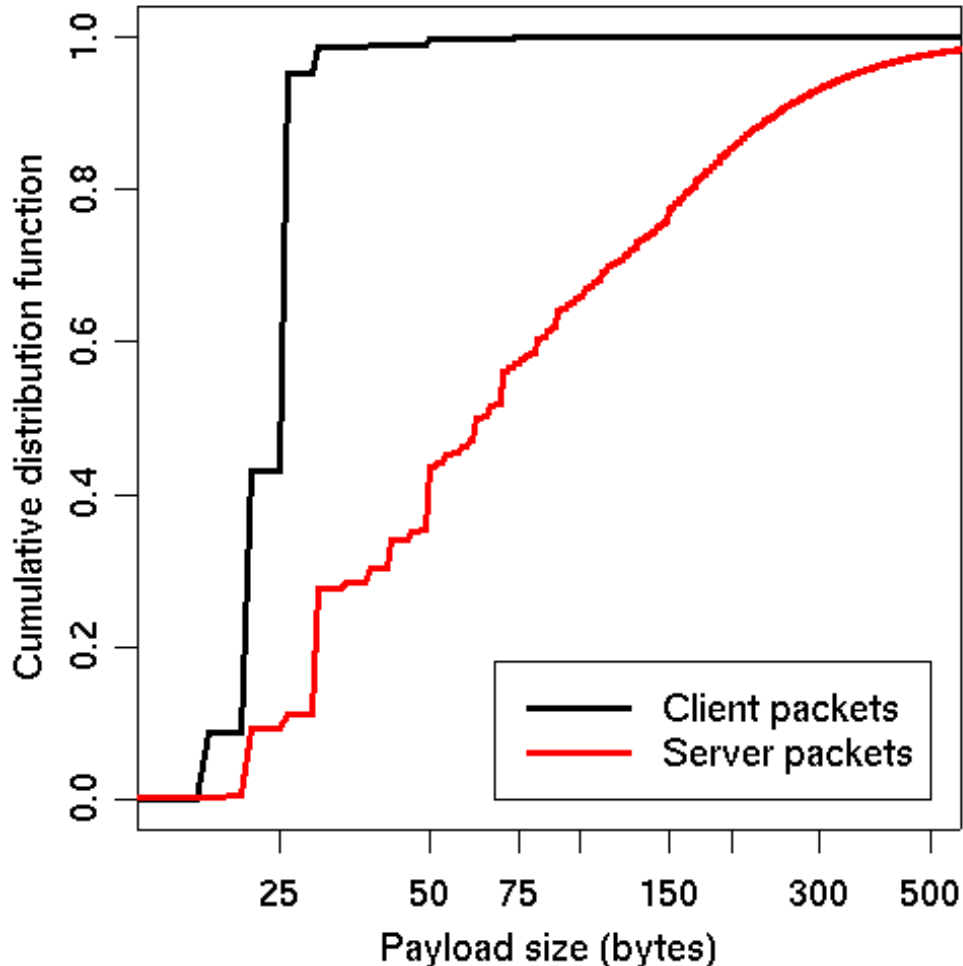
| | |
|----------------------------|---|
| <i>Client traffic</i> | all traffic sent from clients |
| <i>Client packets</i> | all packets sent from clients |
| <i>Client data packets</i> | all packets excluding “pure TCP ack packets” (40 bytes) sent from clients |

- The same rules apply to *server traffic*, *server packets*, and *server data packets*

Traffic Characterization

- Tiny packets
- Low bandwidth requirement
- Temporal dependency in both
 - within-connection traffic
 - aggregate traffic
- Periodicity and synchronization

Payload size distribution - CDF

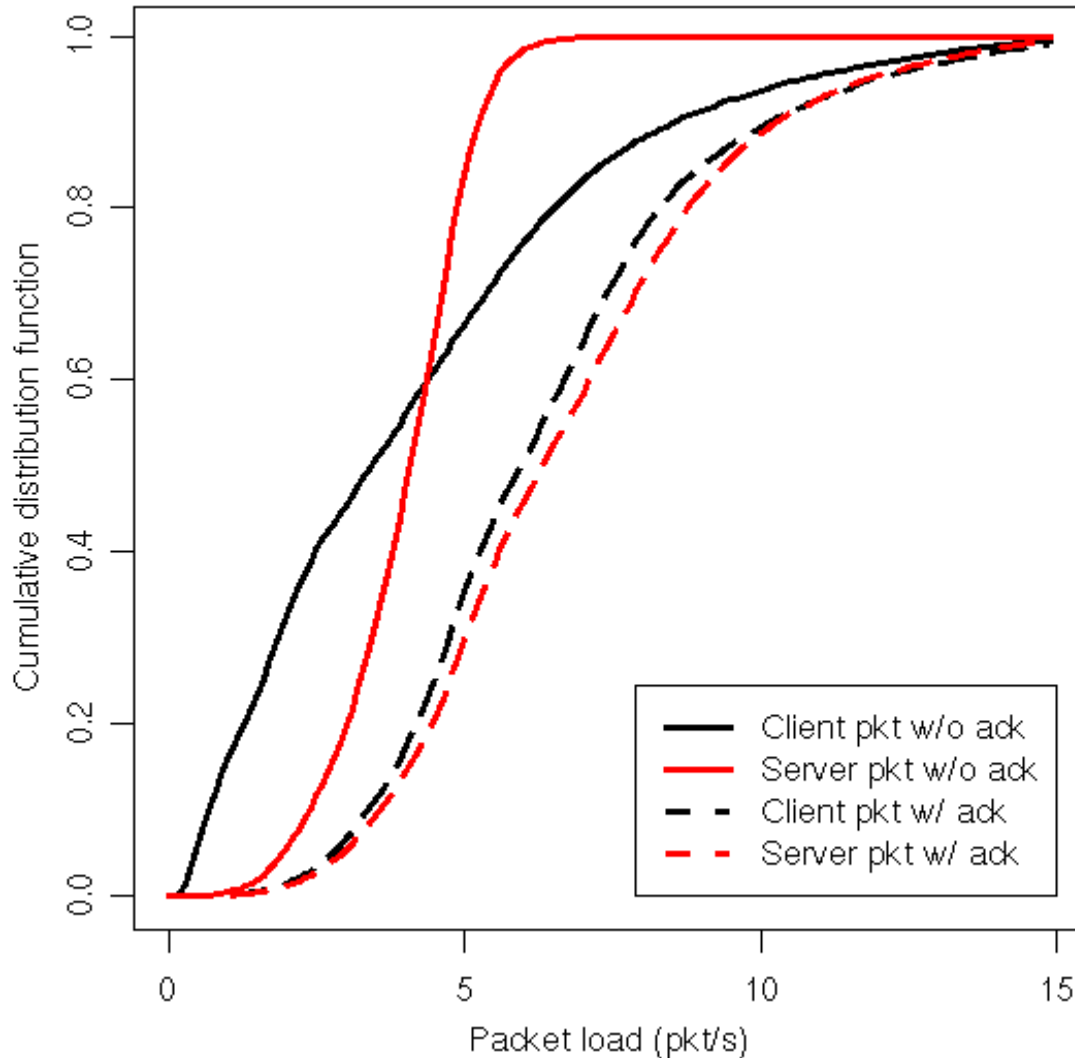


- client packets
 - 98% pkts' payload \leq 31 bytes
 - the most two modes occupy 90% \Rightarrow certain commands are popular
- server packets
 - avg. payload size 114 bytes
- contrast to the mean packet size 400 bytes observed in backbones

The consequence of tiny packets

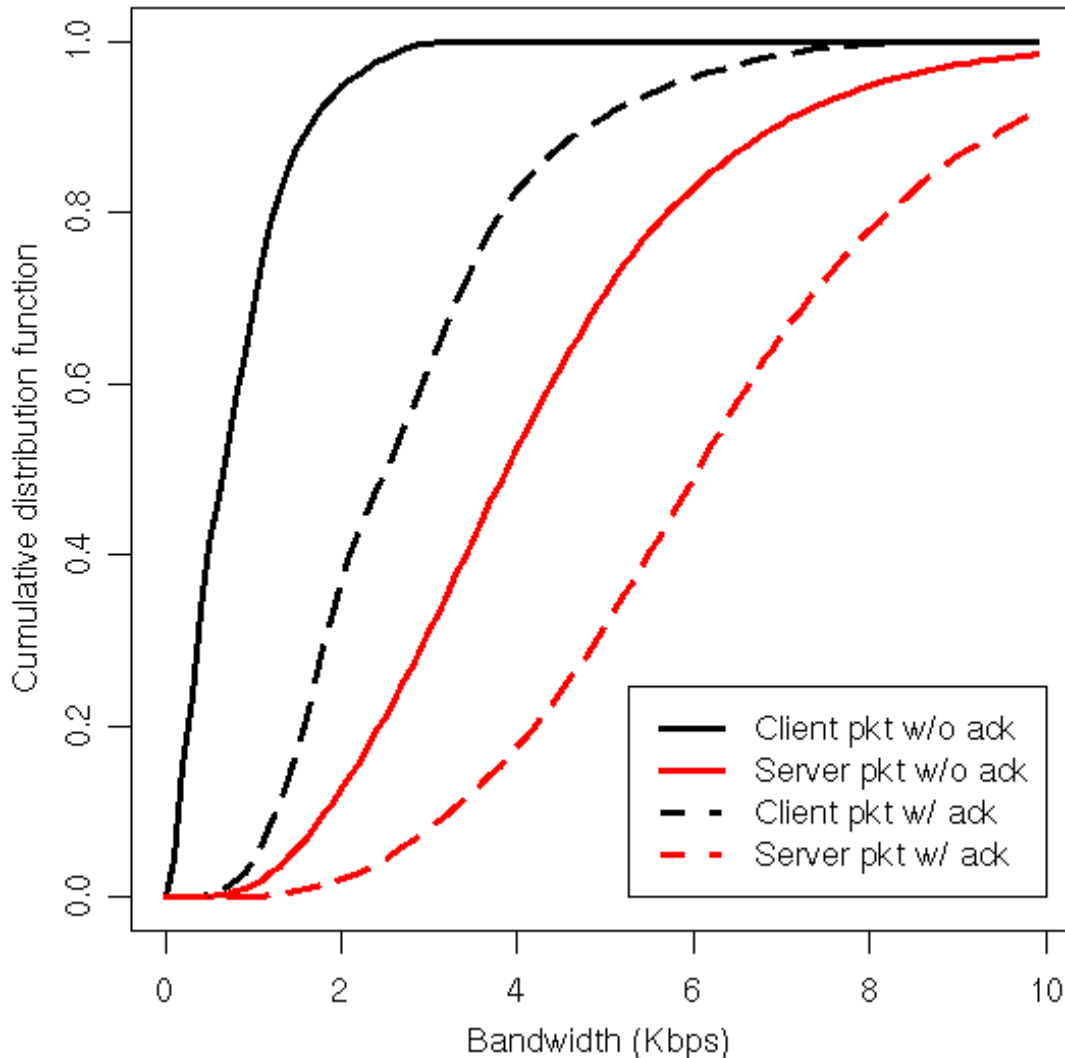
- overhead of protocol in client traffic
 - 73% bytes are headers
 - 30% bytes (38% pkts) are for pure TCP acks
- The challenge on infrastructures
 - overall avg. pkt size is 84 bytes
 - routers generally assume pkt size within 125 -- 250 bytes
 - when vendors claim 1 Gbps rate, they may indicate 5M pkt/sec for avg. pkt size = 200 bytes

Packet load distribution



- < 5 pkt/sec for server data pkt in most of conn.
- < 15 pkt/sec for 99% of conn.

Bandwidth Usage



- client traffic
 - < 3 Kbps data
 - < 8 Kbps w/ ack
- server traffic
 - < 13 Kbps

- << 40 Kbps for a FPS (First Person Shooting) game, Counter-Strike
- Similar to Warcraft III, a RTS (Realtime Strategy) Game

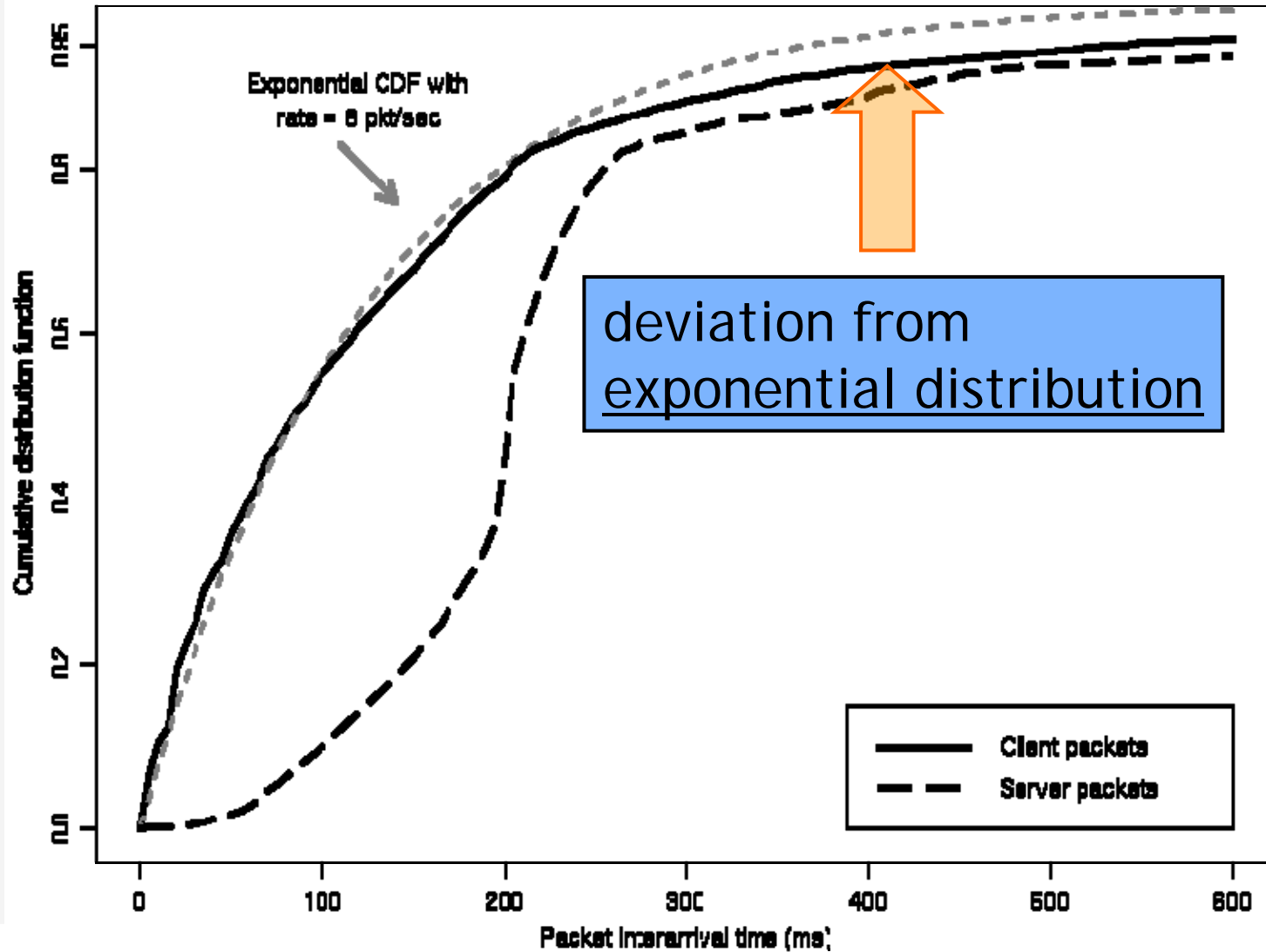
Cannot Overlook the Traffic of MMOGs

- R. O. in Taiwan announced a record of 370,000 online players
- assuming each user use 10 Kbps \Rightarrow total 3.7 Gbps is required in average for just A game.

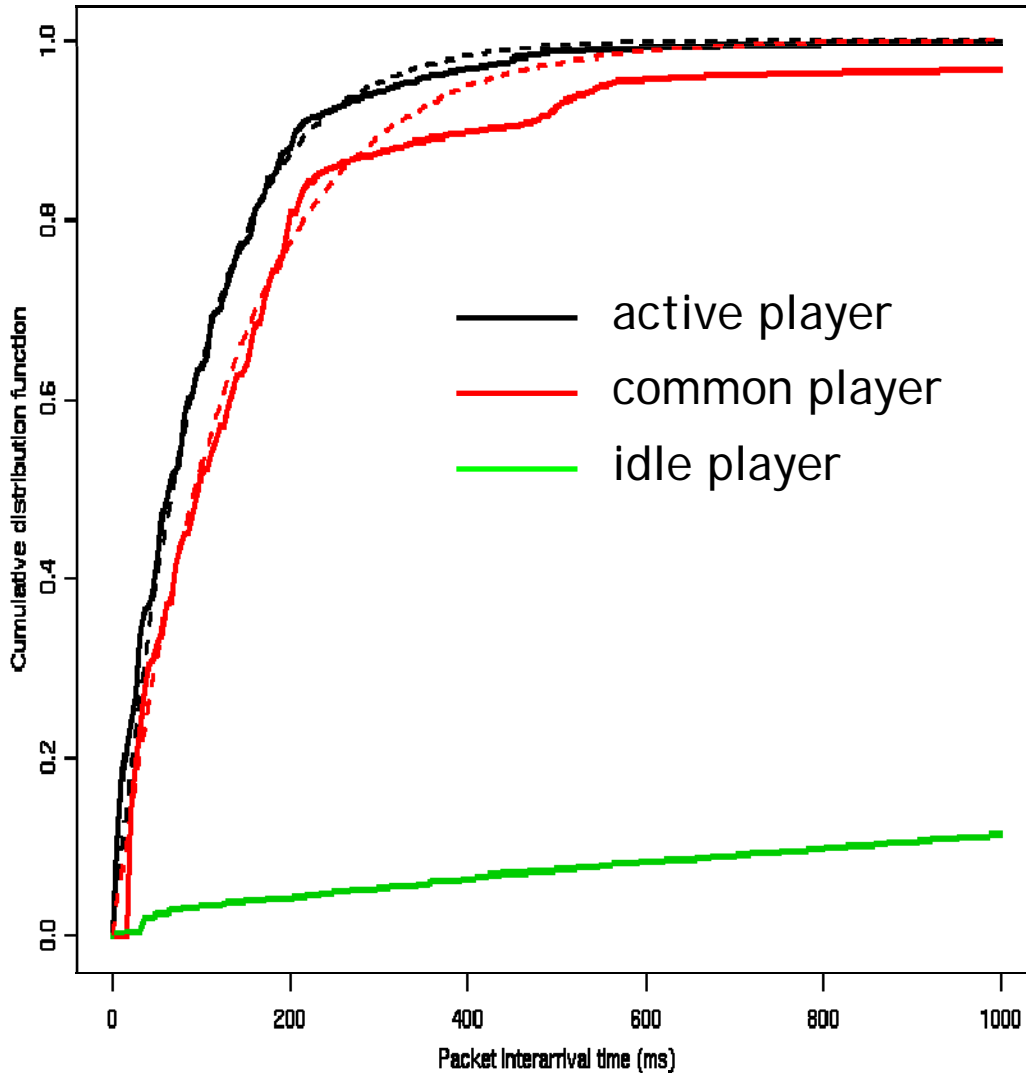
Packet Interarrivals within a Connection

- User inputs is not *Poisson*
- *Temporal dependence* exist in both client traffic and server traffic

CDF of Packet Interarrival Times



Diversity in User Behaviors



- active player: close to *exponential*
- idle player: *uniform* + *determinist distr.*
- common player: in-between the two extremes



神水專賣店
開幕特價



浴血·神魔神醒神
貝殼寶具神聚強行
包子云：2015

kuoette擺攤



These players are keeping stalls.

便宜

武器御雷天
闕火甲龍手

強聚強
神幣

灣入玄頭?
父頓符

莫煩擺攤

祁州城

241 / 241

93 / 93



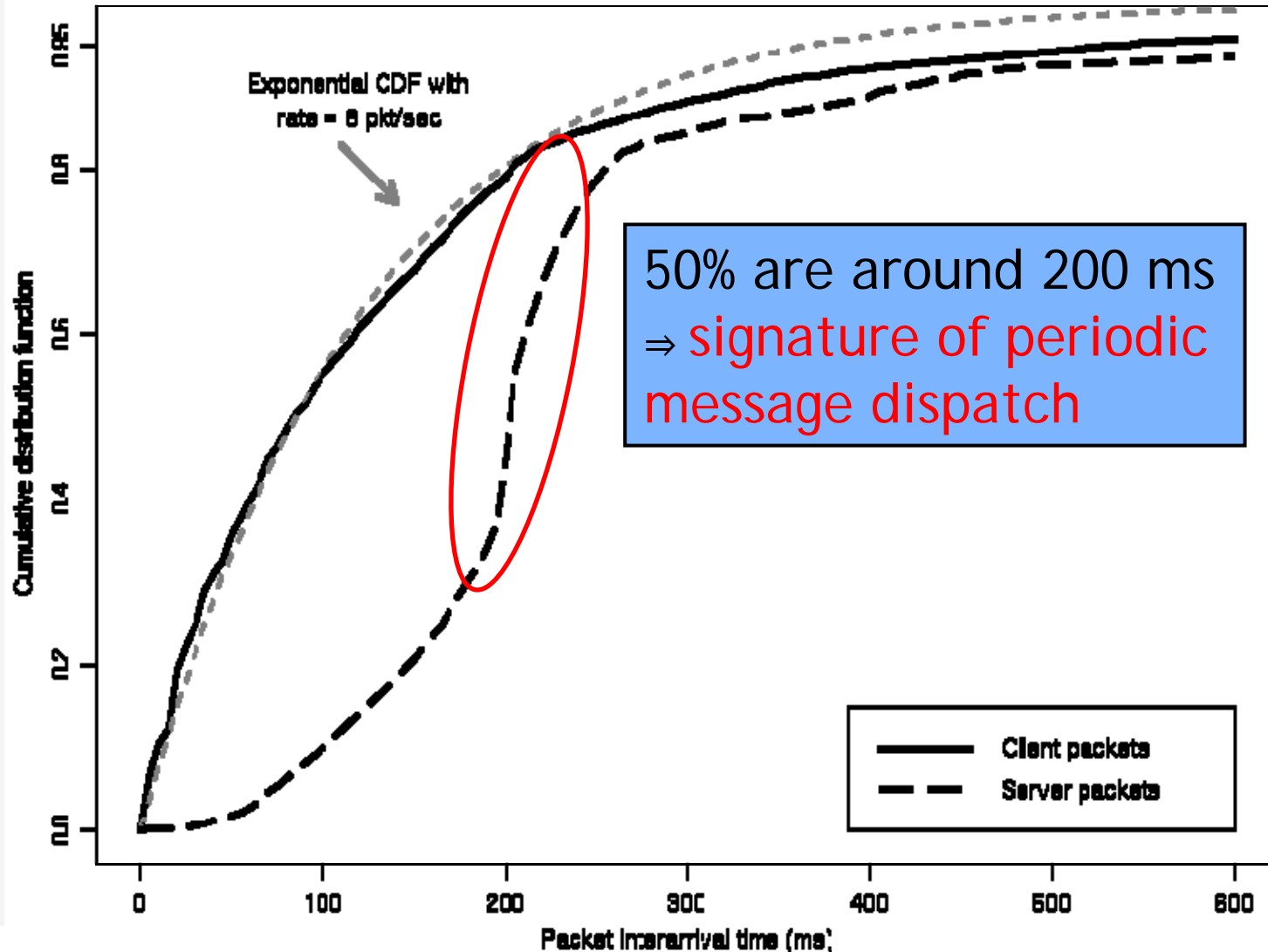
姓名 小寬
編號 劍俠
名聲 無名小卒
生日 水曜日
負重 27 / 75

愛戀小精靈>等
水晶喵喵>冒煙刀火山好巧愛乙 0.0
抓圖成功(cap\cap0071.jpg) =
愛戀小精靈>價格
抓圖成功(cap\cap0072.jpg) =
抓圖成功(cap\cap0073.jpg) =

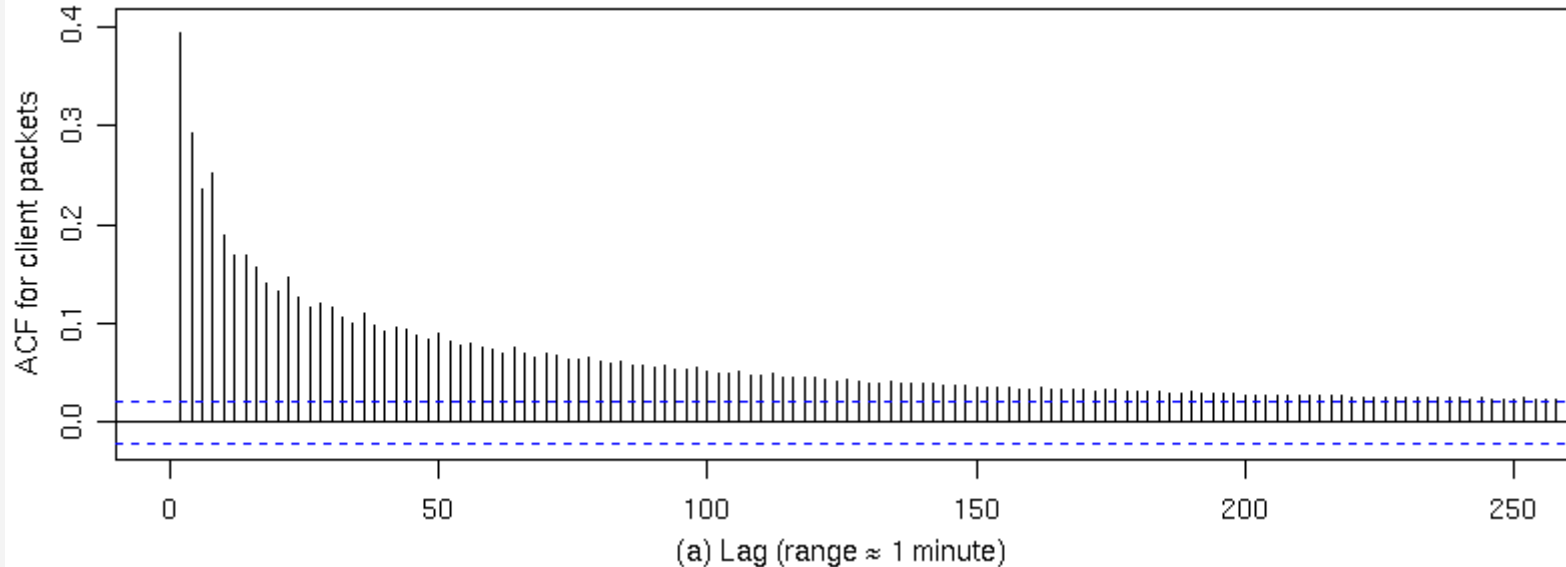
6 級 7630

密名

CDF of Packet Interarrival Times

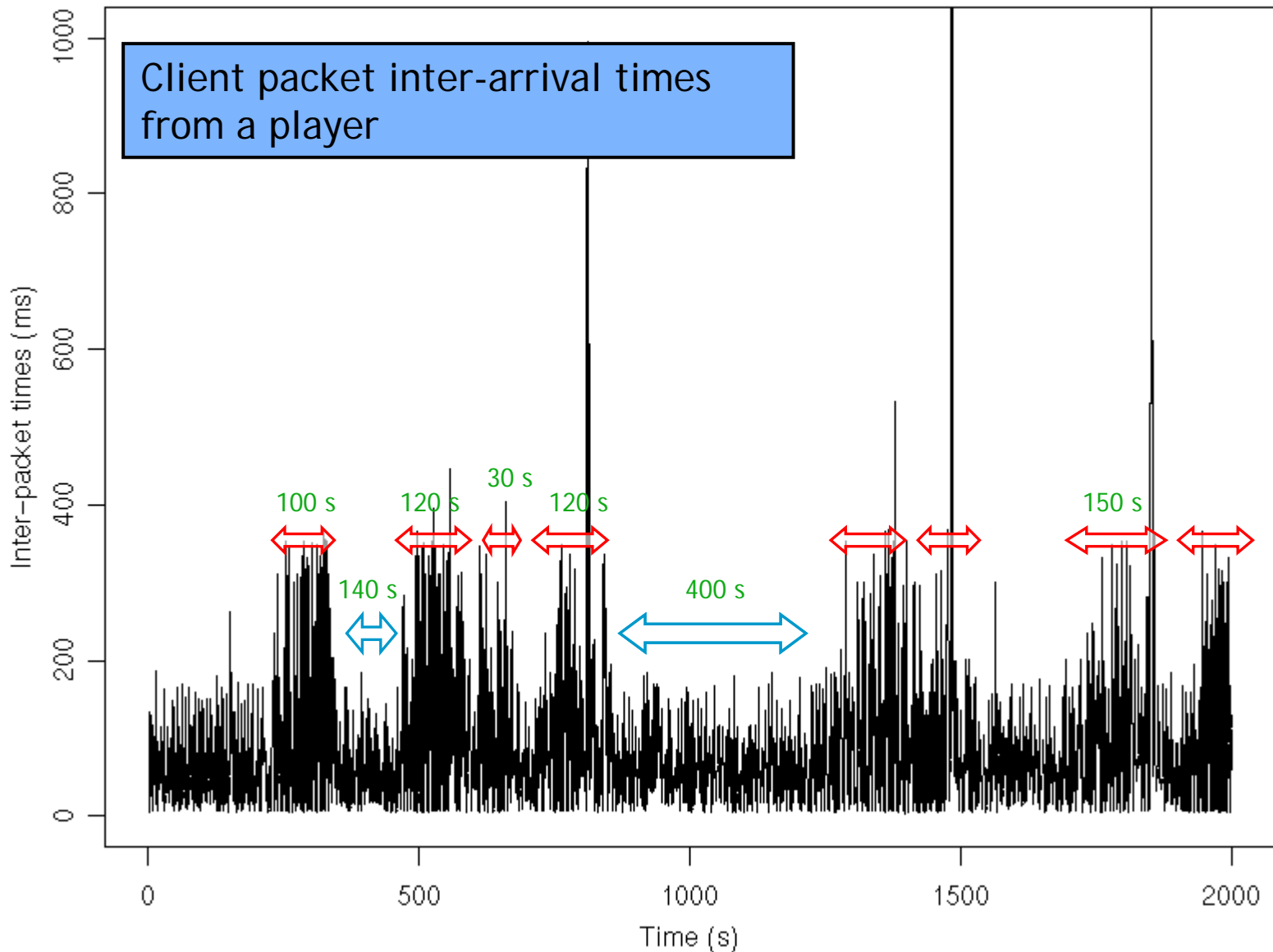


Temporal Locality in Client Traffic

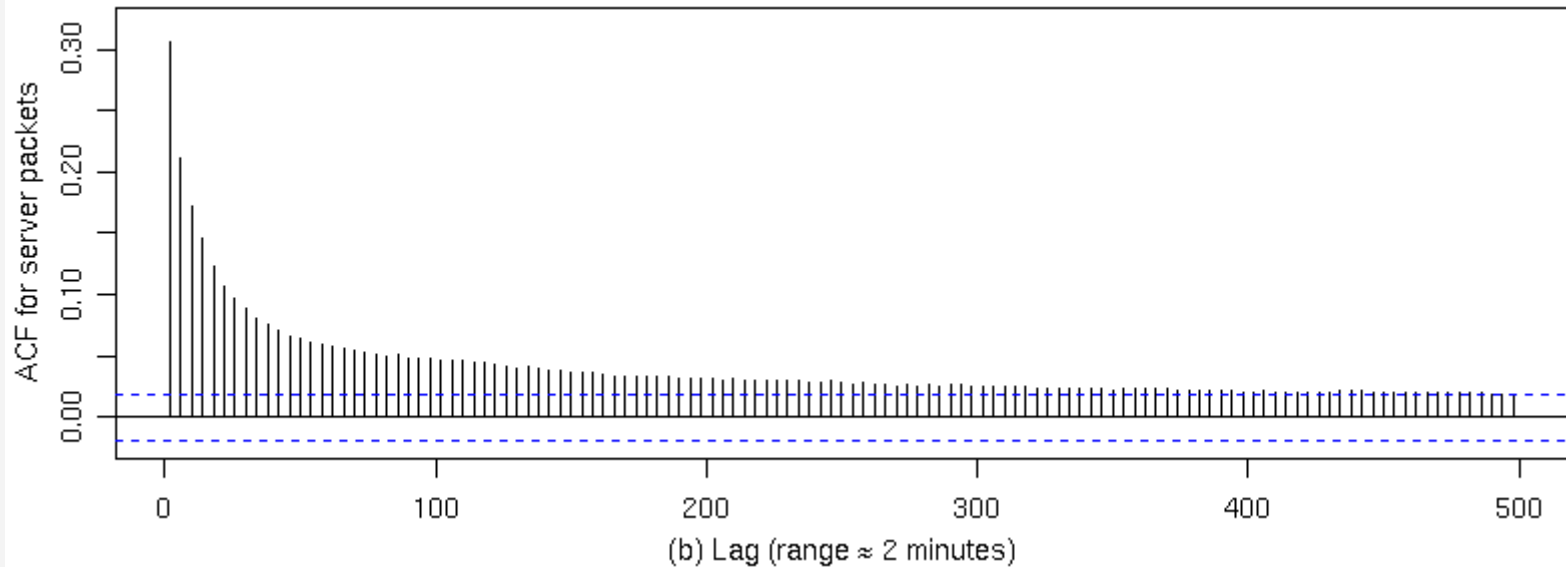


- ACF: auto-correlation functions
- clustering nature in player actions
- active actions: walking, fighting
- inactive actions: talking, viewing equipments, trading, idle

Clustered nature in user actions

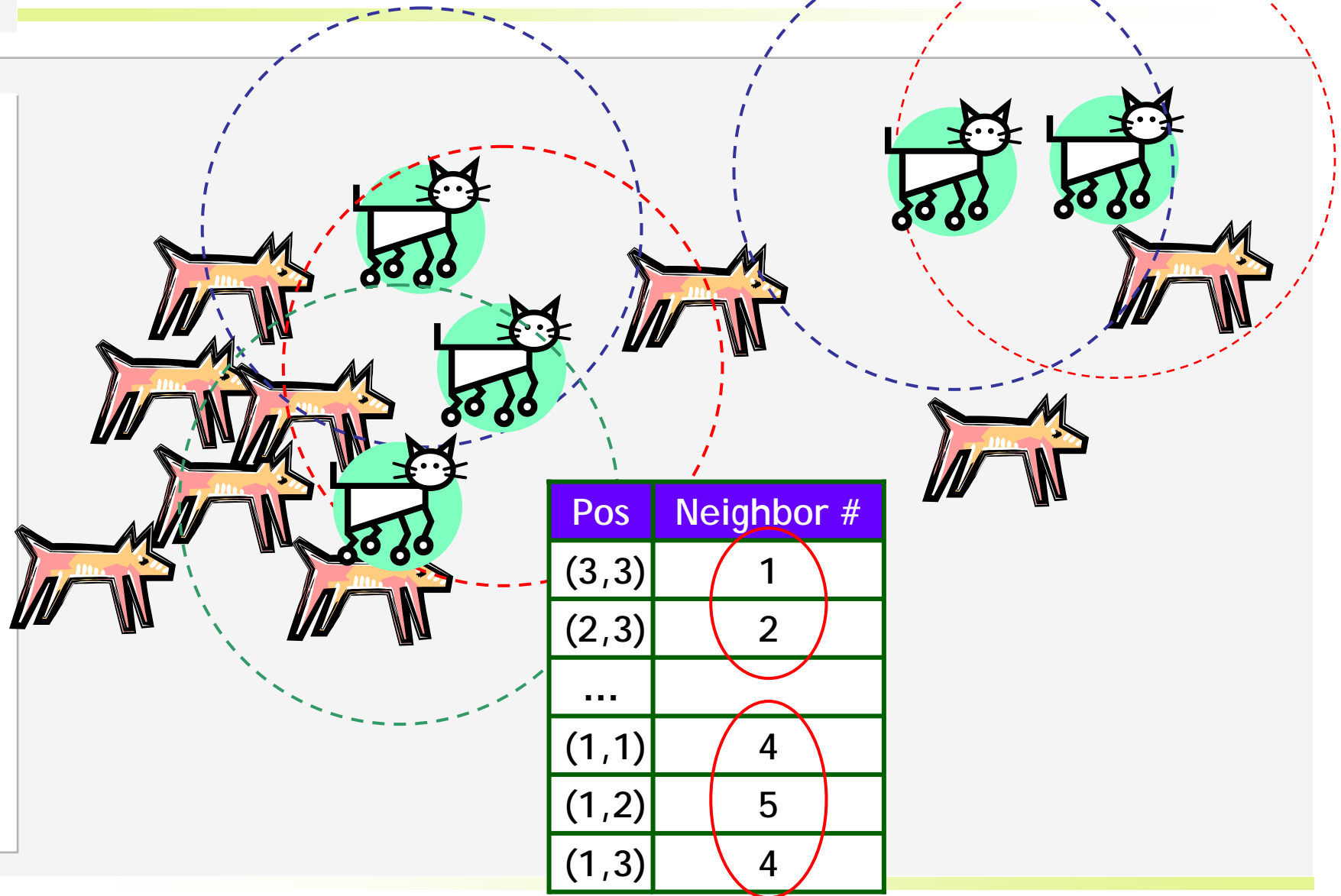


Temporal Locality in Server Traffic



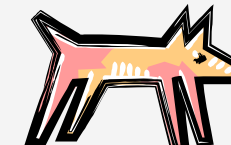
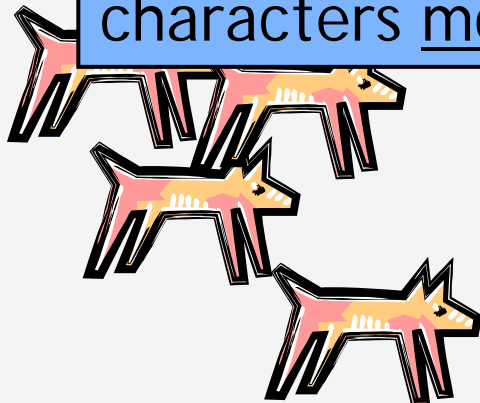
- Server pkt primarily convey *position updates*
- the rate of position updates depends on the number of *nearby characters*

Spatial Locality in # of Neighbors

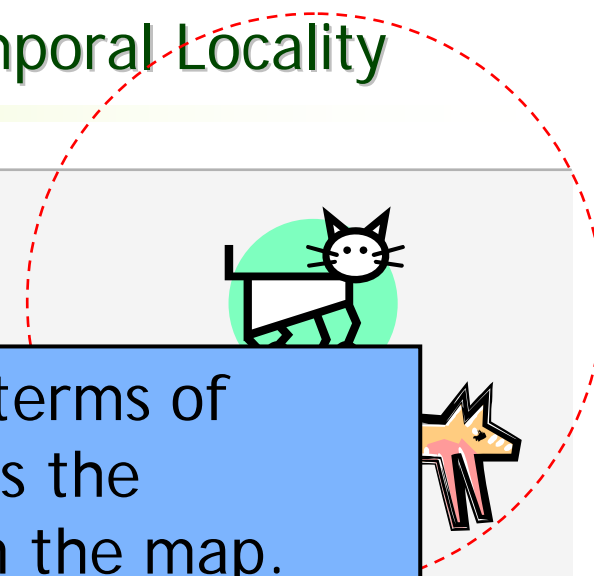


Transformation: Spatial Locality to Temporal Locality

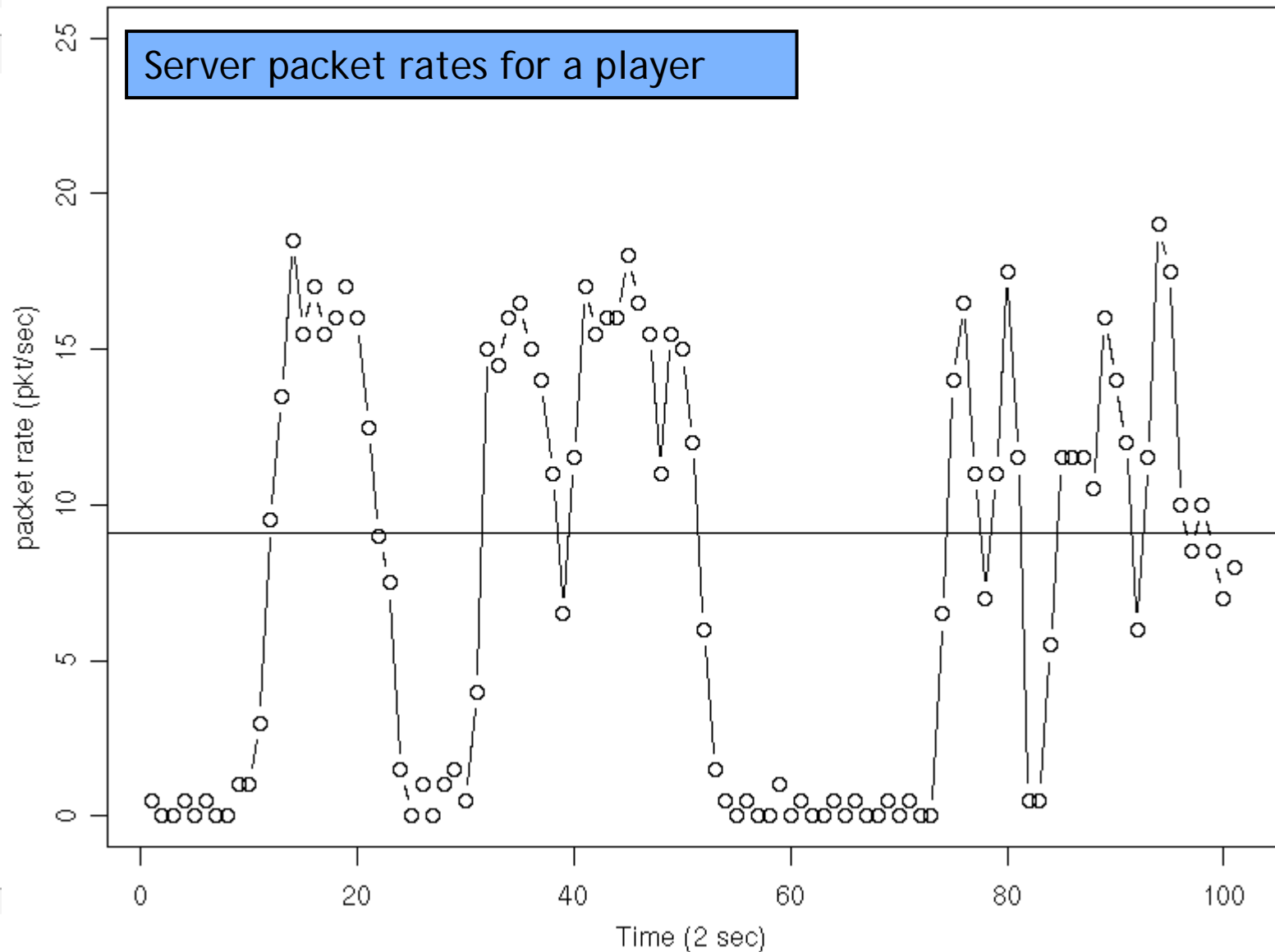
The **spatial locality** shows up in terms of **temporal locality** in the traffic as the characters move continuously on the map.



| t | Neighbor # |
|-----|------------|
| 1 | 1 |
| 2 | 2 |
| 3 | 1 |
| ... | |
| 10 | 4 |
| 11 | 5 |
| 12 | 4 |



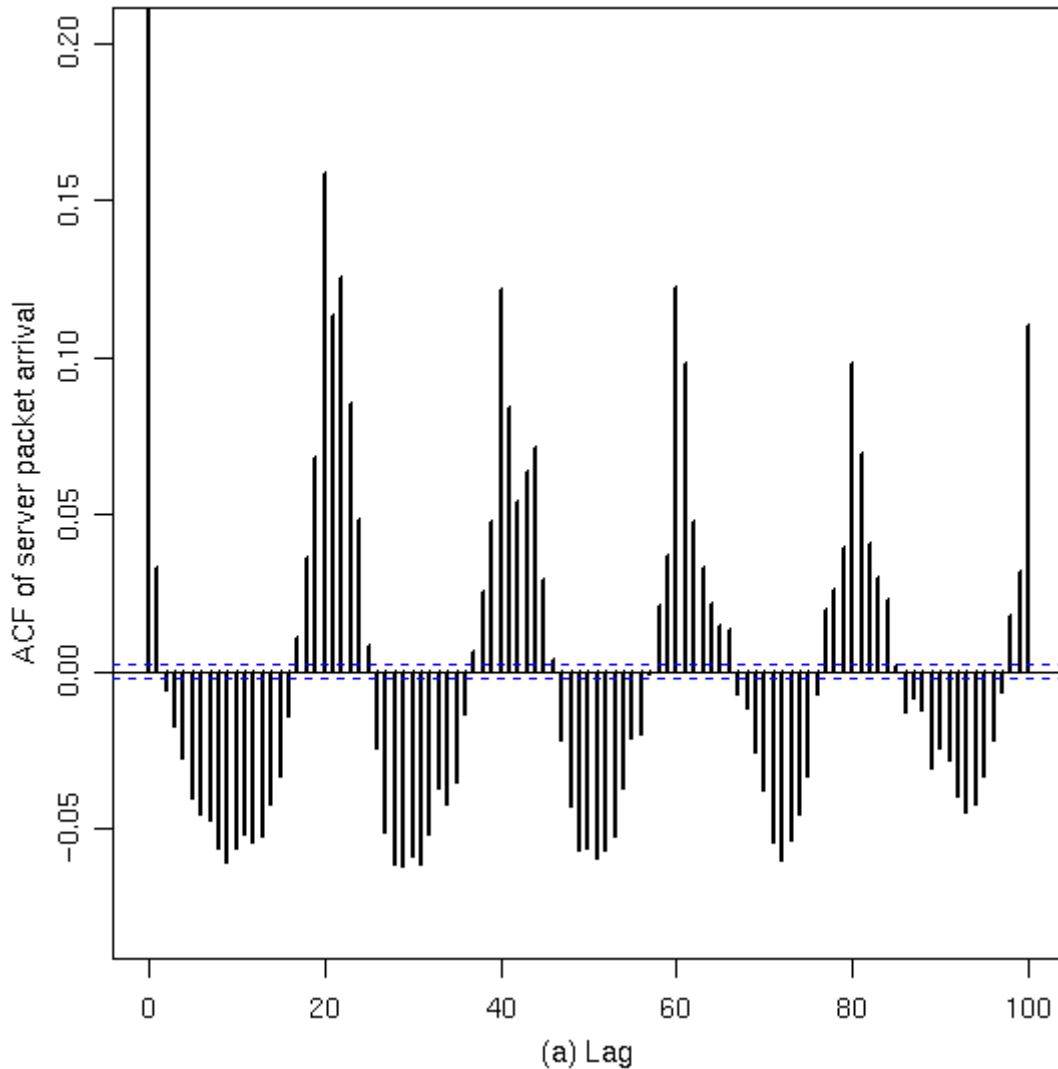
Temporal locality in server traffic



Aggregate Packet Arrivals

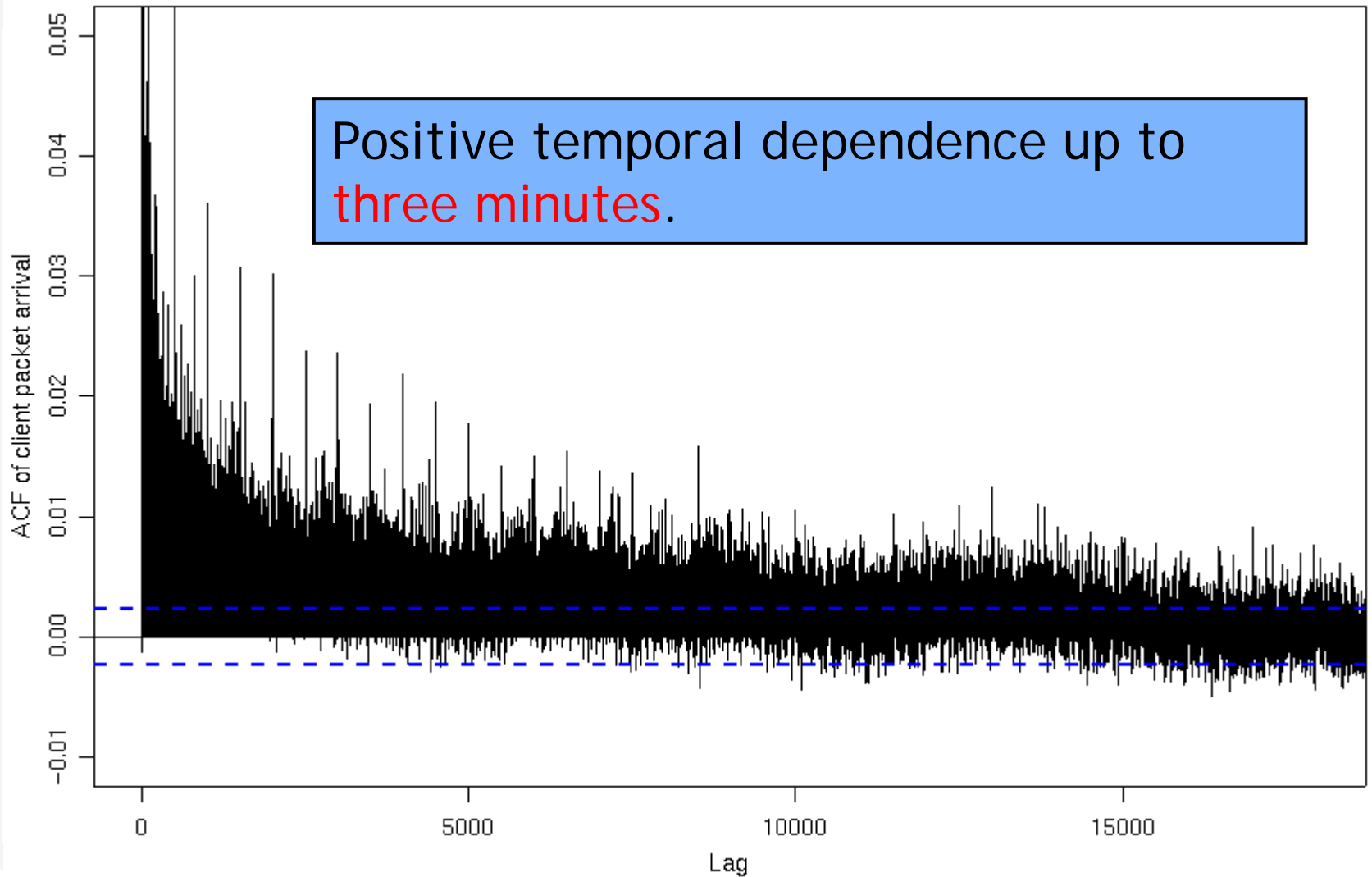
- the aggregate packet arrival time series
 - count the number of incoming/outgoing packets regardless of connections
 - take samples every 10 ms
- Patterns identified
 - temporal dependence
 - periodicity

ACF of aggregate server pkt arrivals

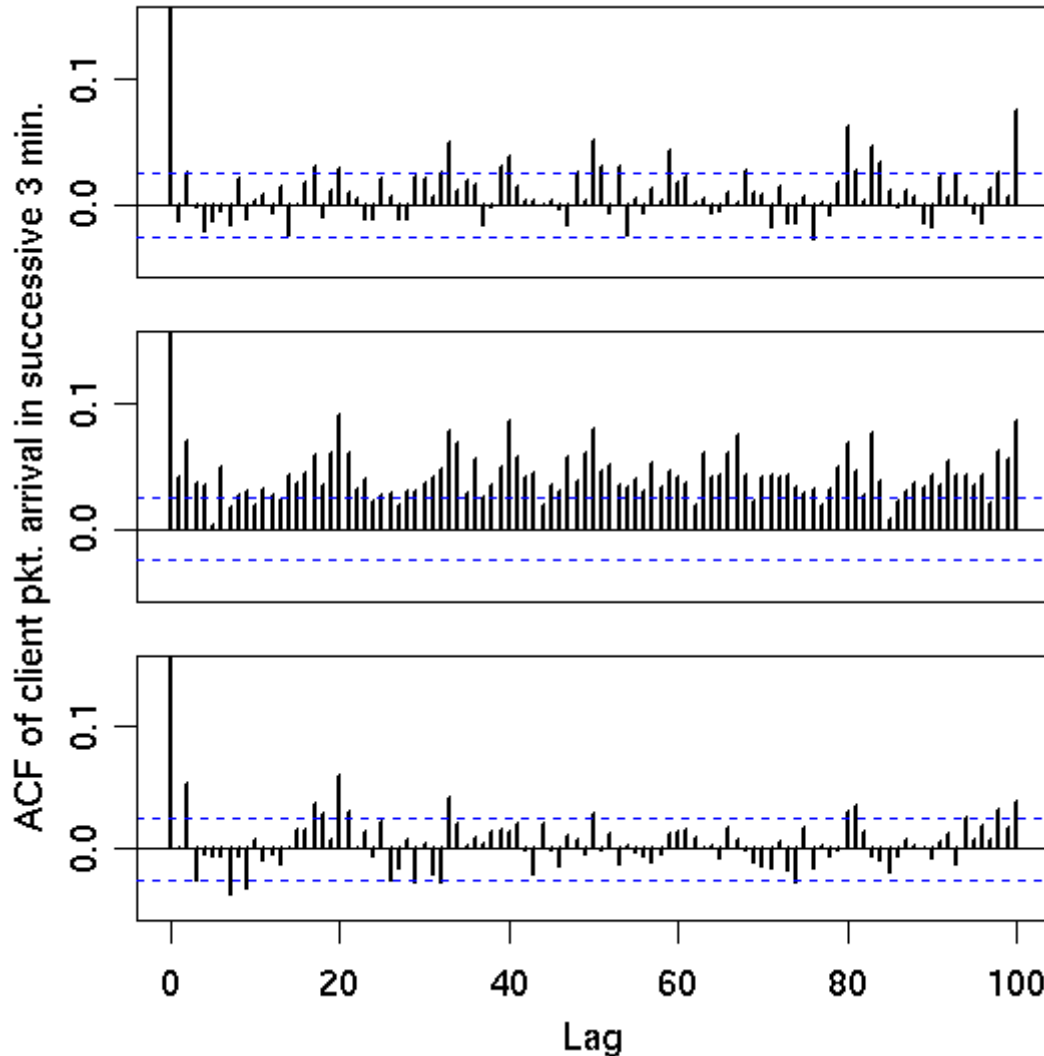


- periodity: 200 ms
- position updates are synchronous to all clients
- incurring packet bursts

ACF of aggregate client pkt arrivals

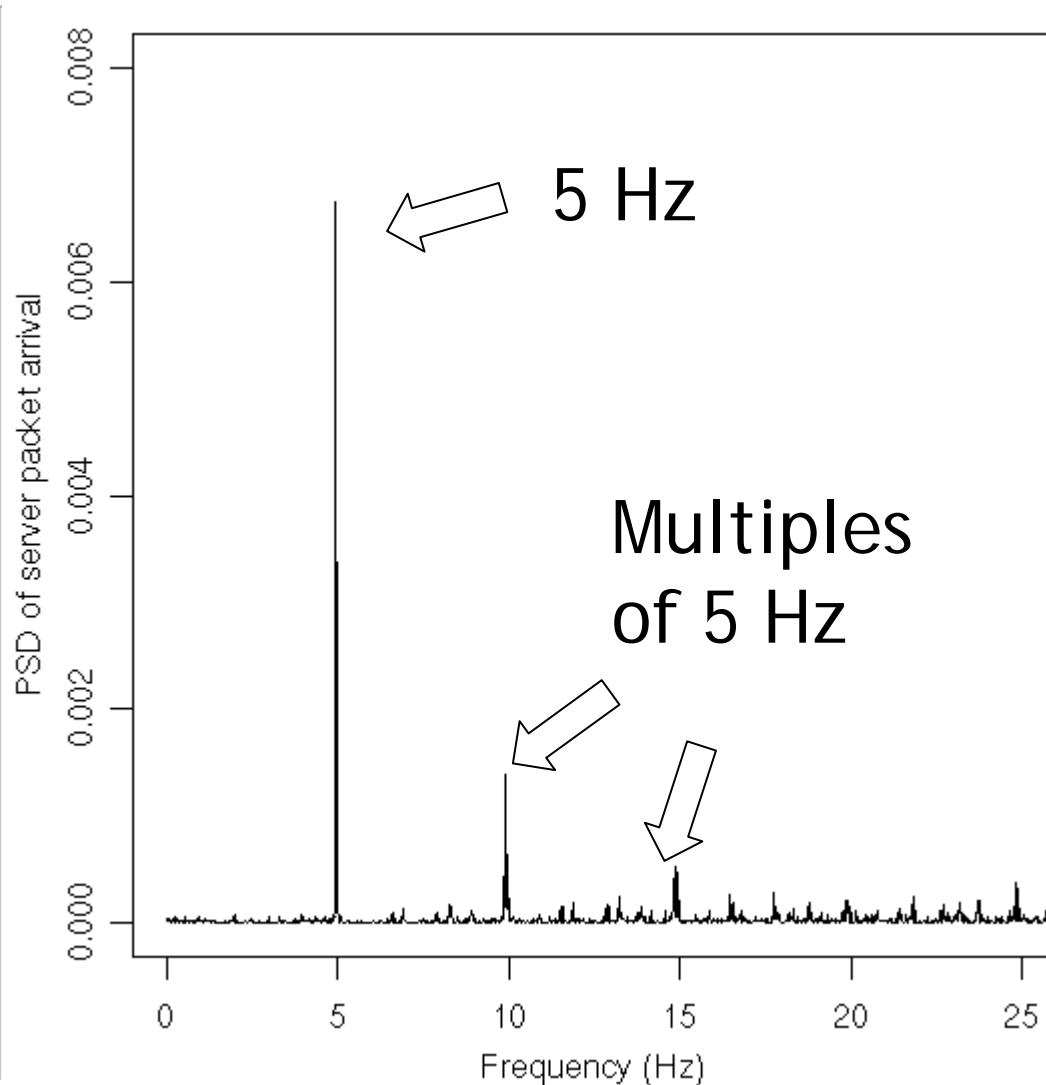


The “flash crowds” effects



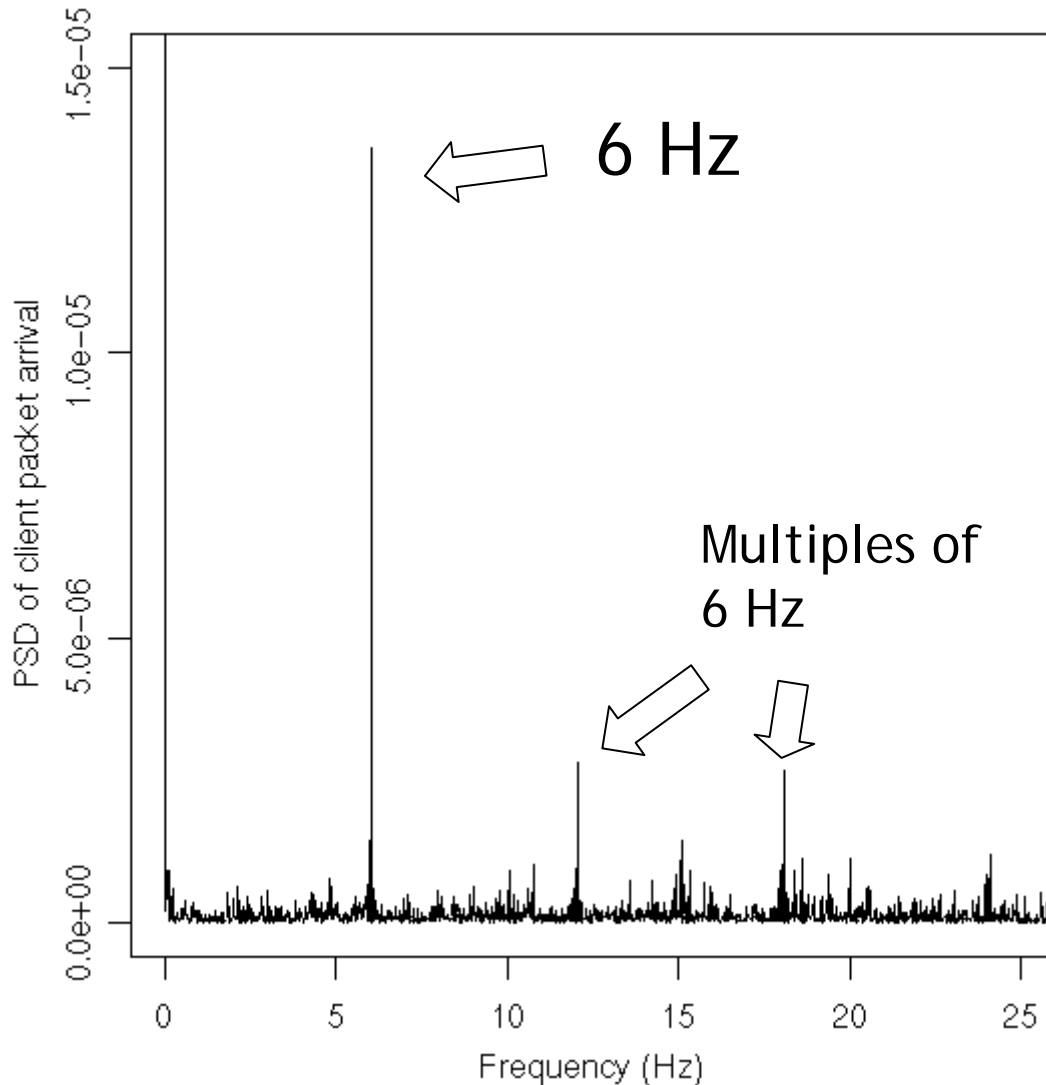
- ACF for successive 3 minutes
- Players are active *simultaneously* at times
- “global events” lead to flash crowds effects

Frequency Components in Server Traffic



- PSD: power spectral density
- another proof of the 200 ms round
- Servers seem to adapt frequency by certain metrics, such as number of nearby characters

Frequency Components in Client Traffic



- by auto-walk and auto-attack timers
- Adjust frequency by level/skill and weapons held
- client timers are *synchronized*

Does the sync. lead to performance problems?

Conclusion

- Traffic characteristics & physical explanations
 - Tiny packets
 - Low bandwidth requirement for individual client
 - Non-poisson user inputs
(*diversity of user behaviors*)
 - Temporal dependency in within-connection traffic
(*clustering nature in user inputs*)
 - Temporal dependency in aggregate traffic
(*flash crowds effects*)
 - Periodicity and synchronization
(*common implementation practice*)

Conclusion (cont.)

- TCP maybe an overkill for MMORPG, e.g., in overall client traffic
 - 73% bytes used by TCP/IP headers
 - 30% bytes used by pure TCP acks

Future Work

- assessment for impacts of network QoS
- more traffic characterization
 - Identify abnormal sessions, e.g., bots in Lineage & Ragnarok Online
 - Identify game traffic
- performance evaluation

To provide a better network infrastructure for netgames



Questions?

Thank You!

陳寬達

kuan@ilife.cx
http://kuan.ilife.cx/
