

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)

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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)

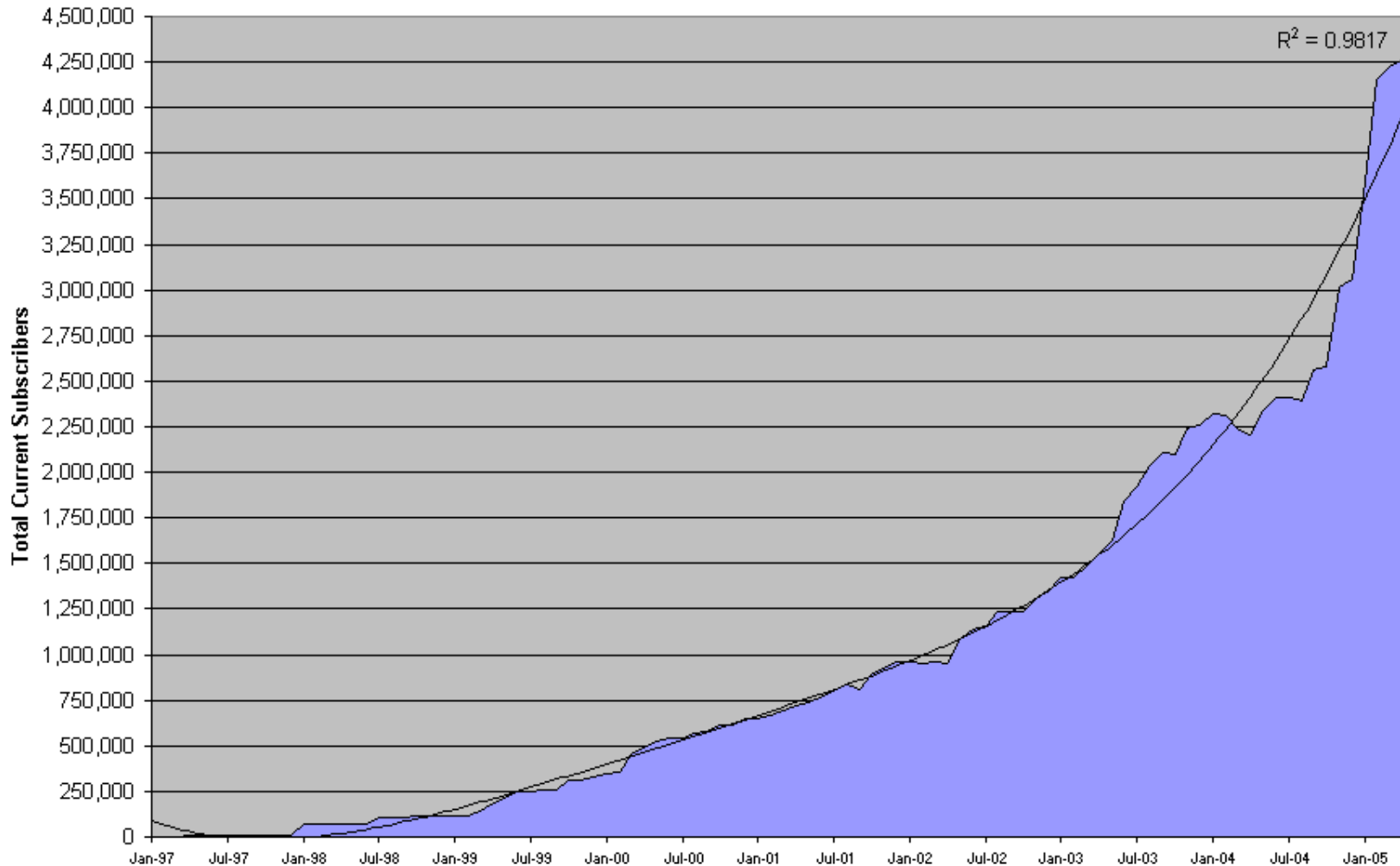


Figure courtesy of <http://www.mmogchart.com/>

Popular Genres in MMORPG

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

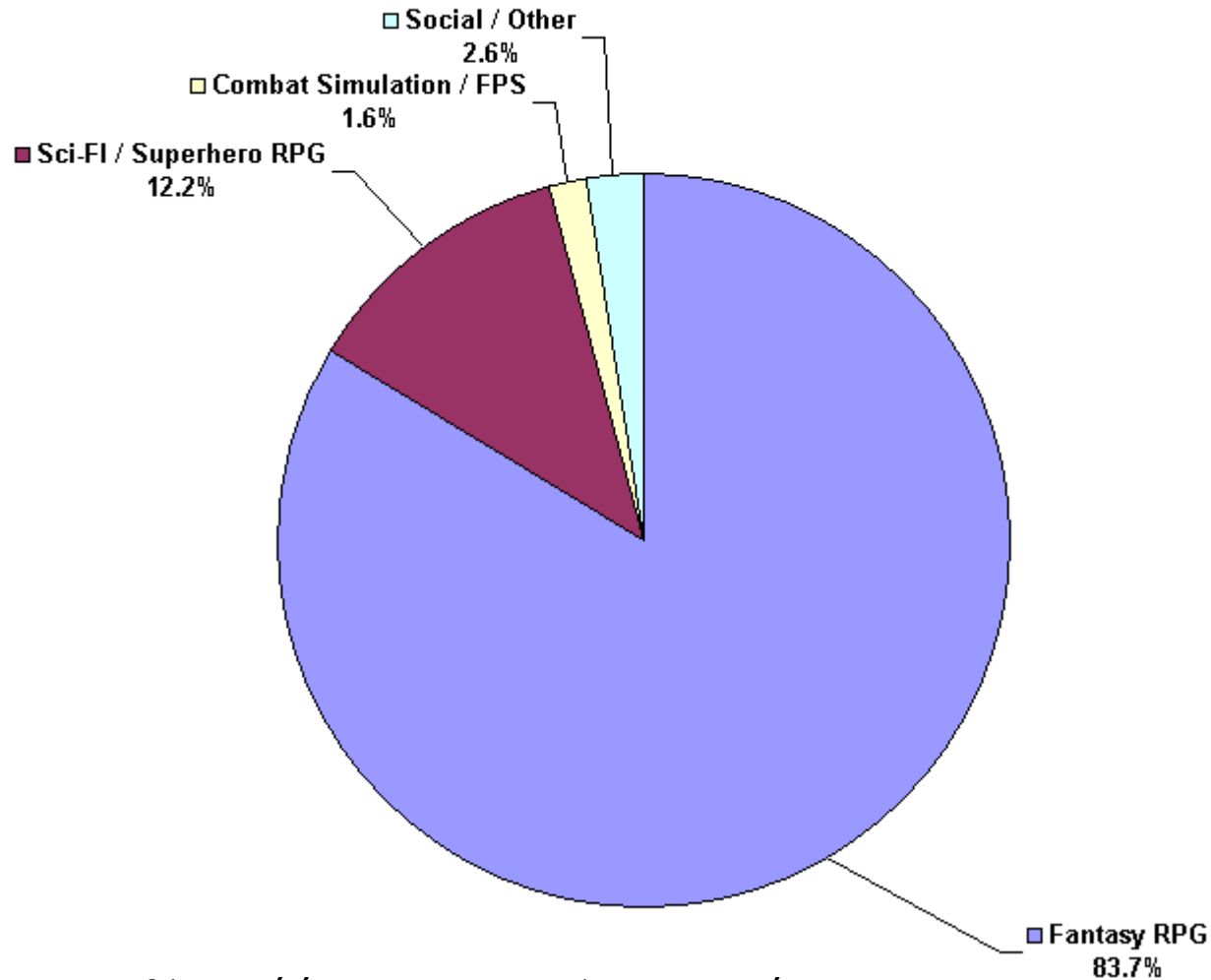


Figure courtesy of <http://www.mmogchart.com/>

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

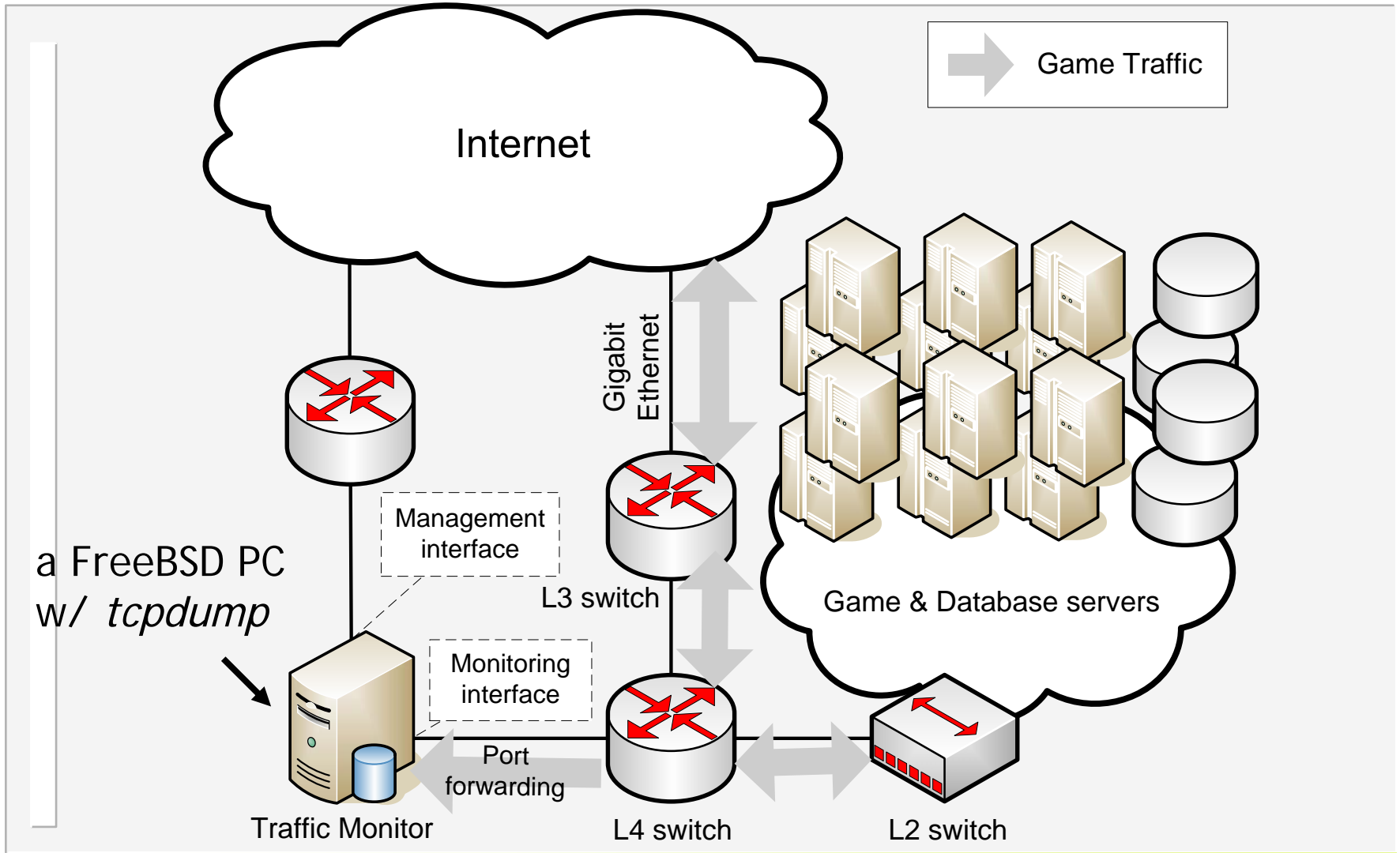
神州 Online

- 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



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"			
6 級	760	抓圖成功(cap\cap0061.jpg)°			
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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

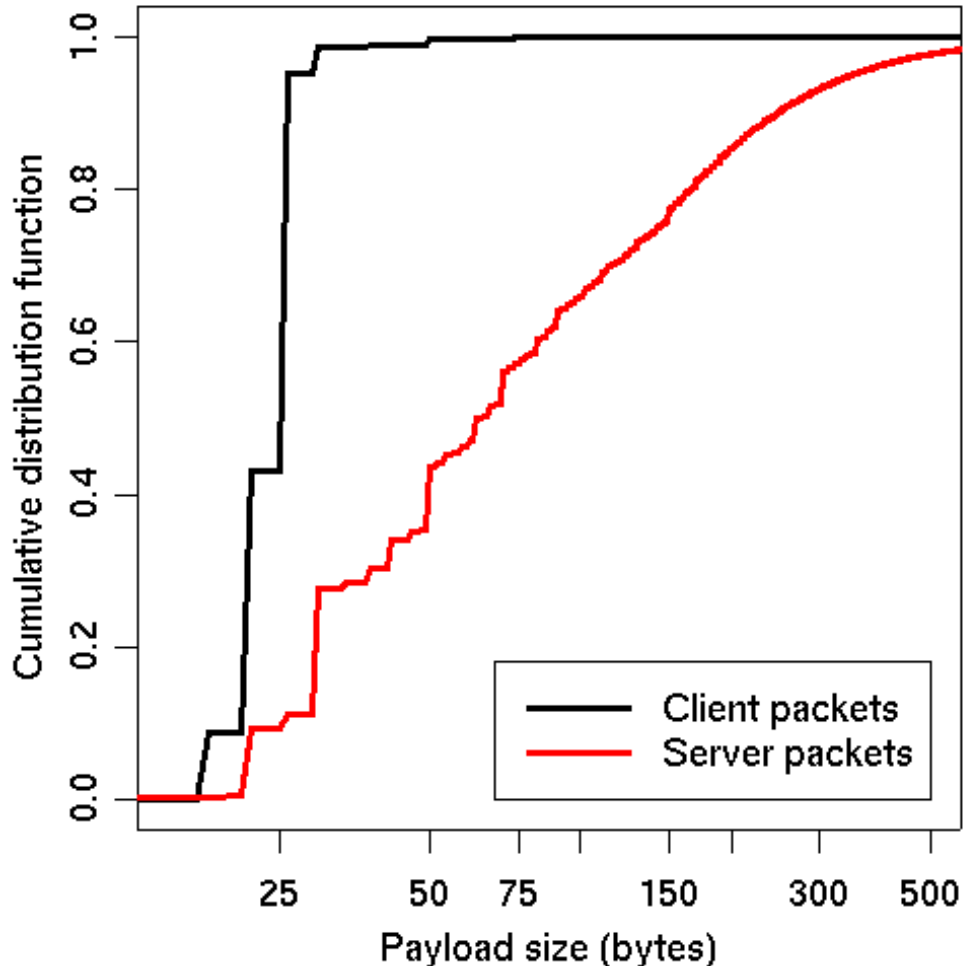
<i>Client traffic</i>	all traffic sent from clients
<i>Client packets</i>	all packets sent from clients
<i>Client data packets</i>	all packets excluding “pure TCP ack packets” (40 bytes) sent from clients

- 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

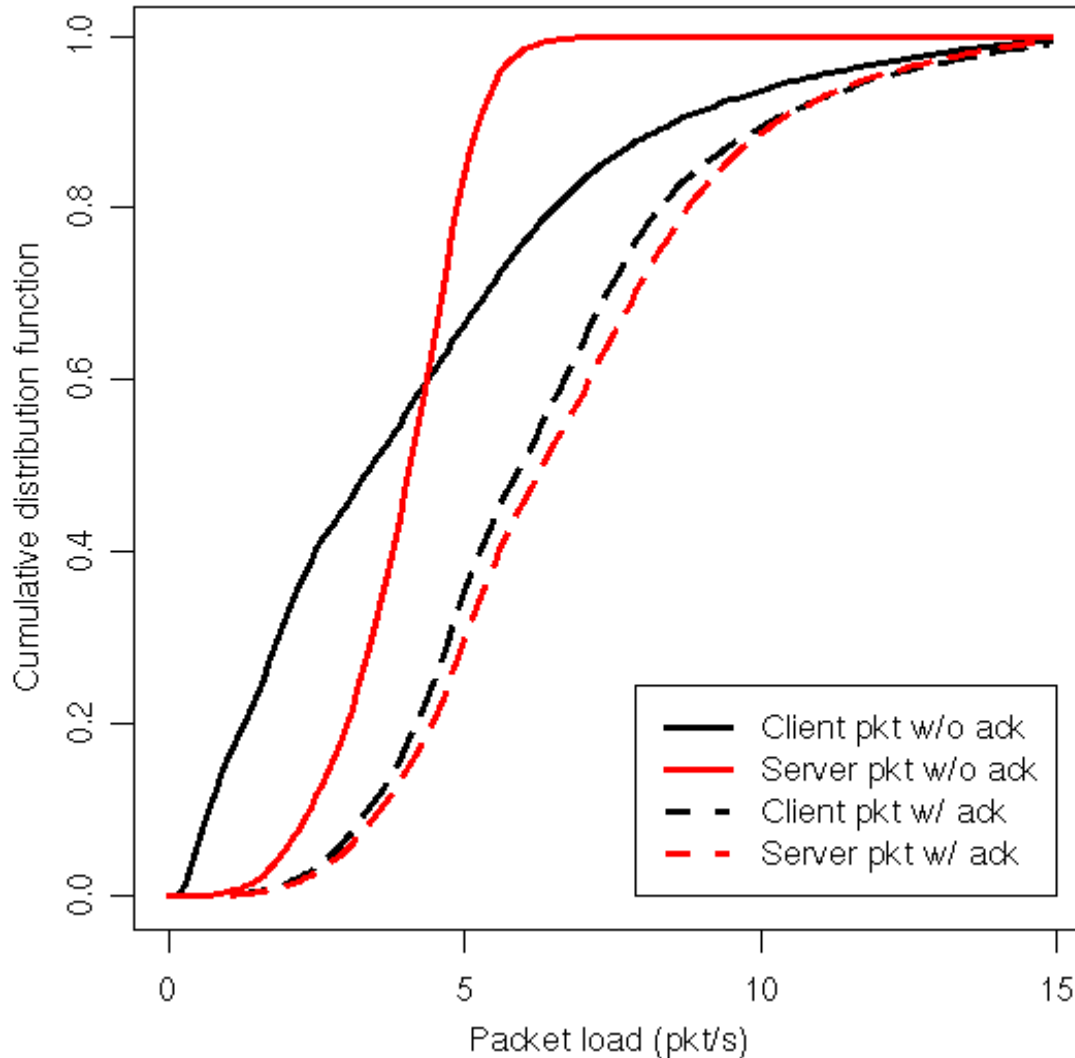


- client packets
 - 98% pkts' payload \leq 31 bytes
 - the most two modes occupy 90% \Rightarrow certain commands are popular
- server packets
 - avg. payload size 114 bytes
- contrast to the mean packet size 400 bytes observed in backbones

The consequence of tiny packets

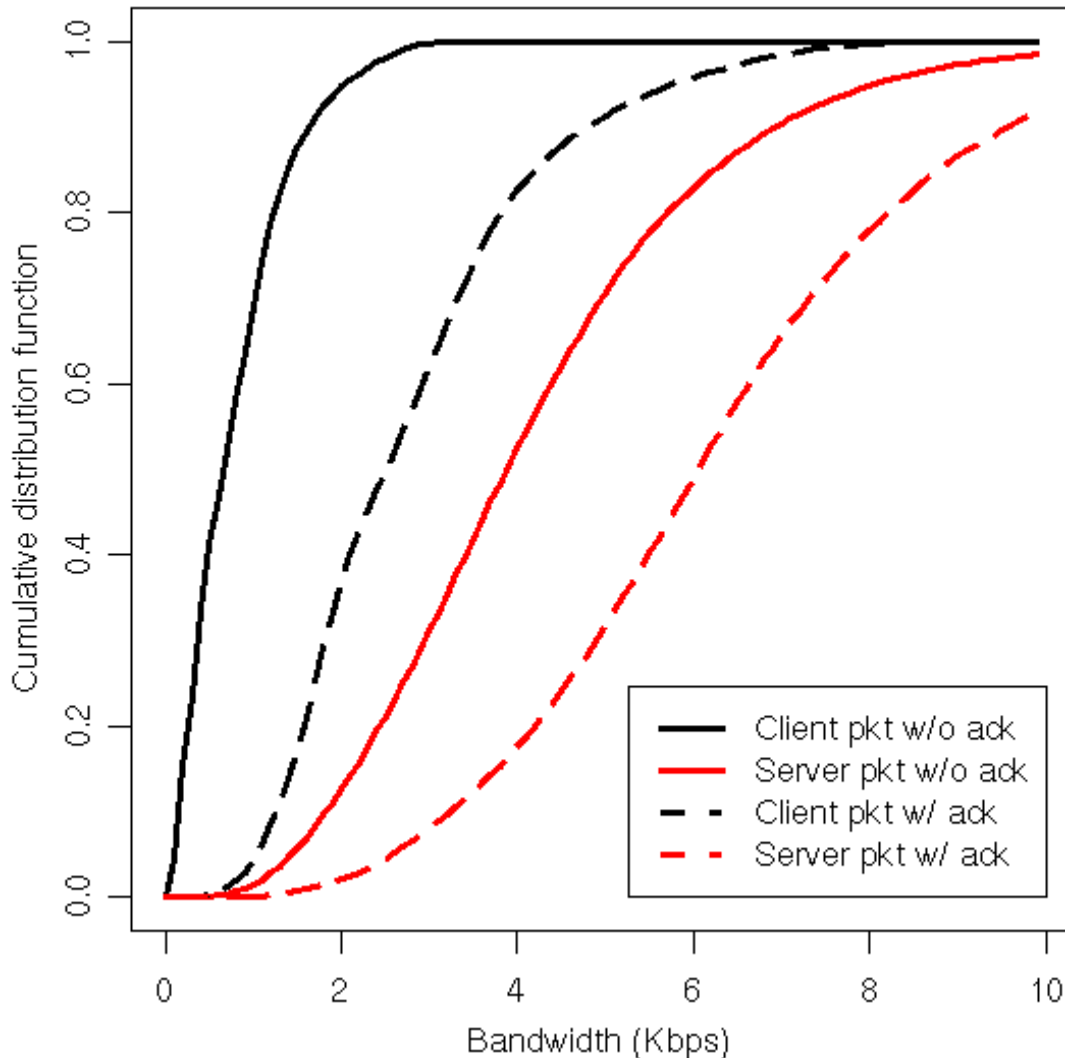
- overhead of protocol in client traffic
 - 73% bytes are headers
 - 30% bytes (38% pkts) are for pure TCP acks
- The challenge on infrastructures
 - overall avg. pkt size is 84 bytes
 - routers generally assume pkt size within 125 -- 250 bytes
 - when vendors claim 1 Gbps rate, they may indicate 5M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

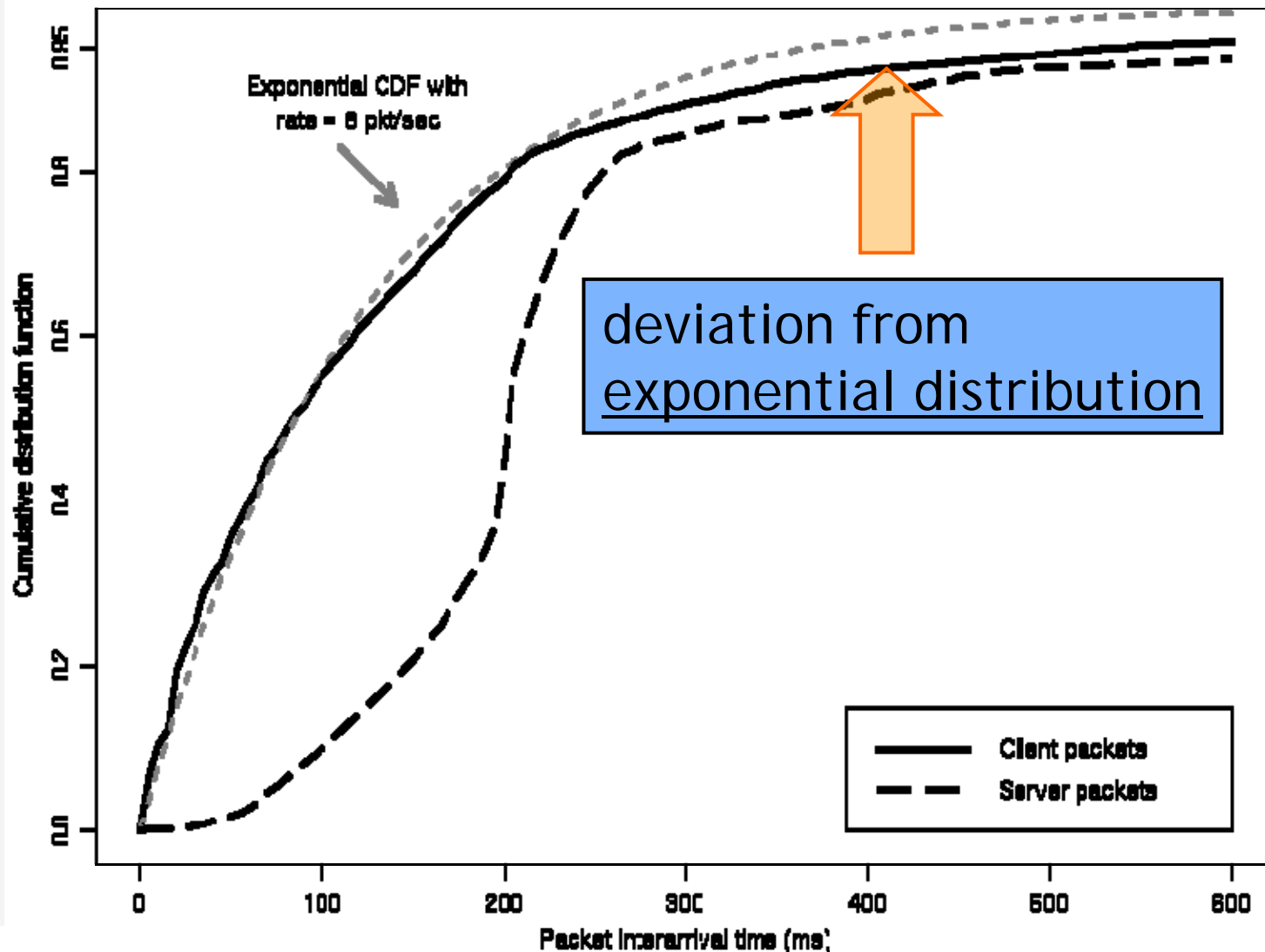
Cannot Overlook the Traffic of MMOGs

- 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.

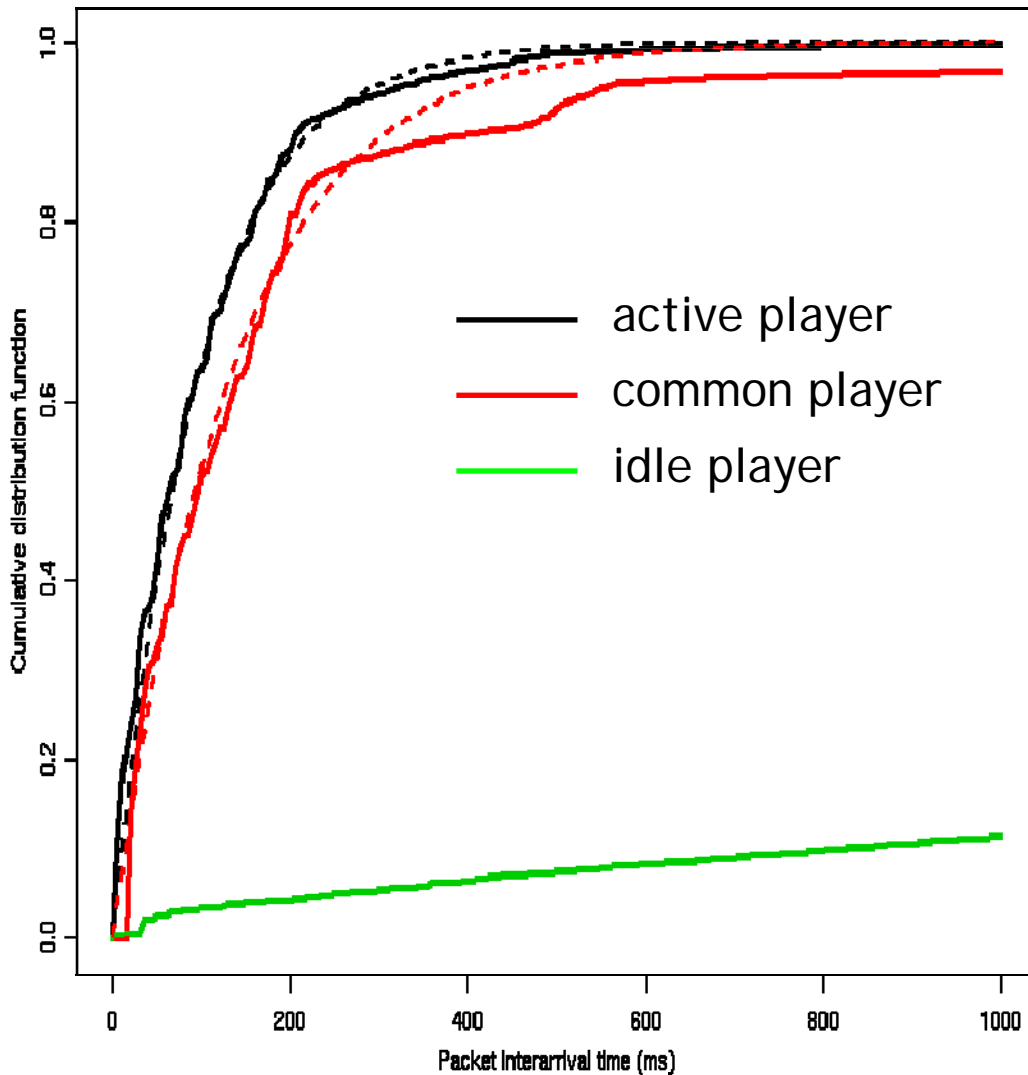
Packet Interarrivals within a Connection

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

CDF of Packet Interarrival Times

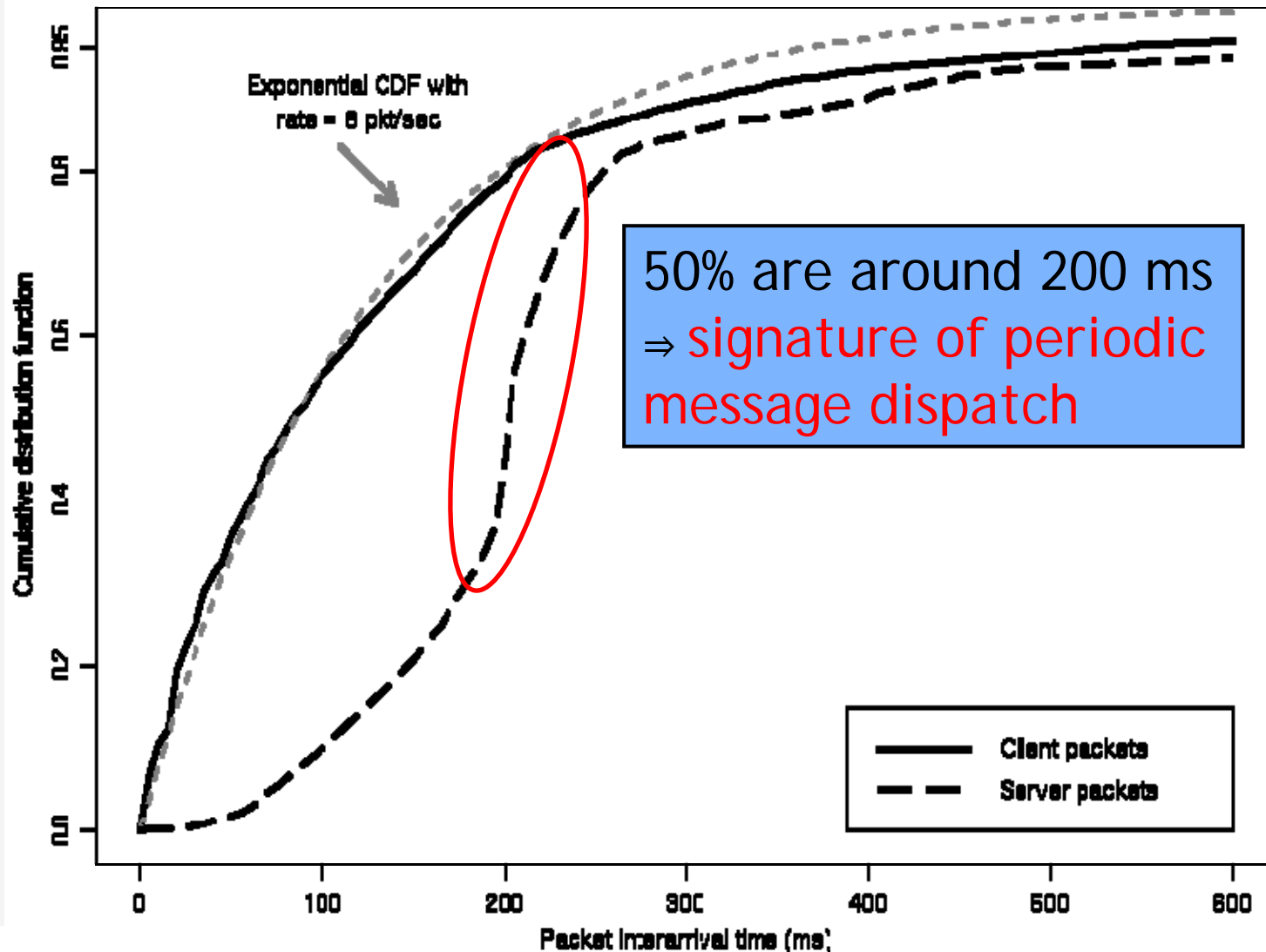


Diversity in User Behaviors

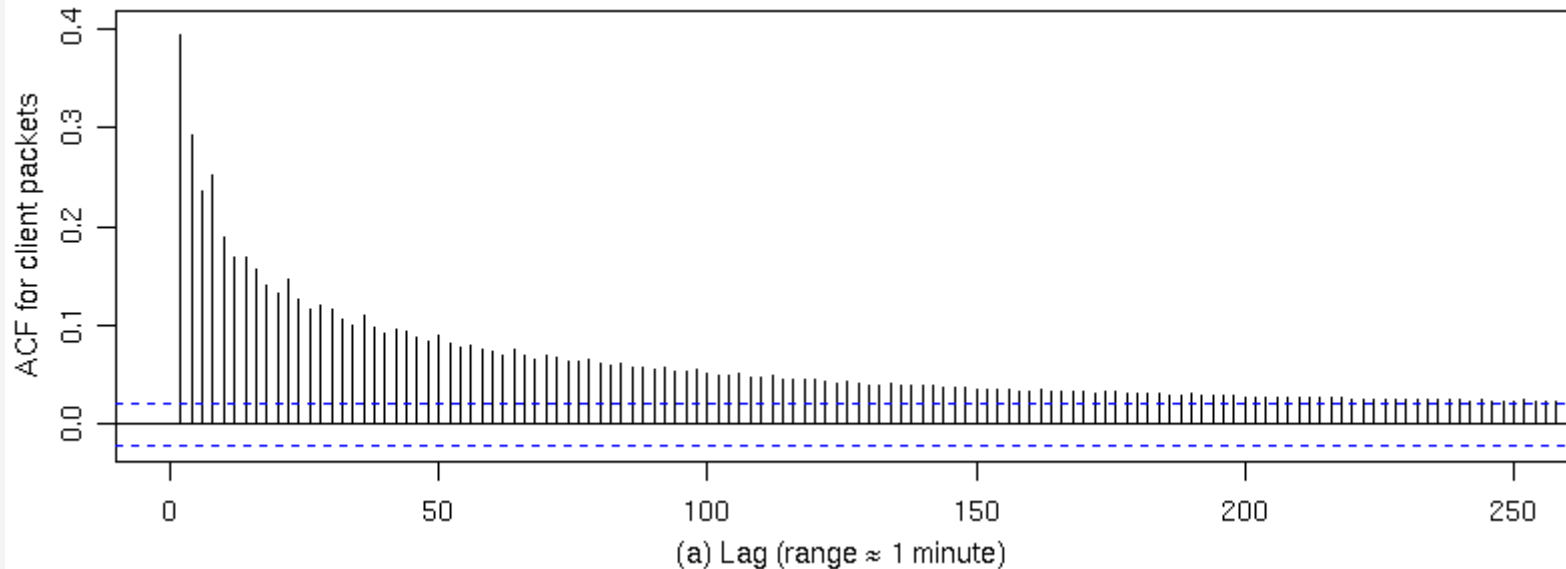


- active player: close to *exponential*
- idle player: *uniform* + *determinist distr.*
- common player: in-between the two extremes

CDF of Packet Interarrival Times

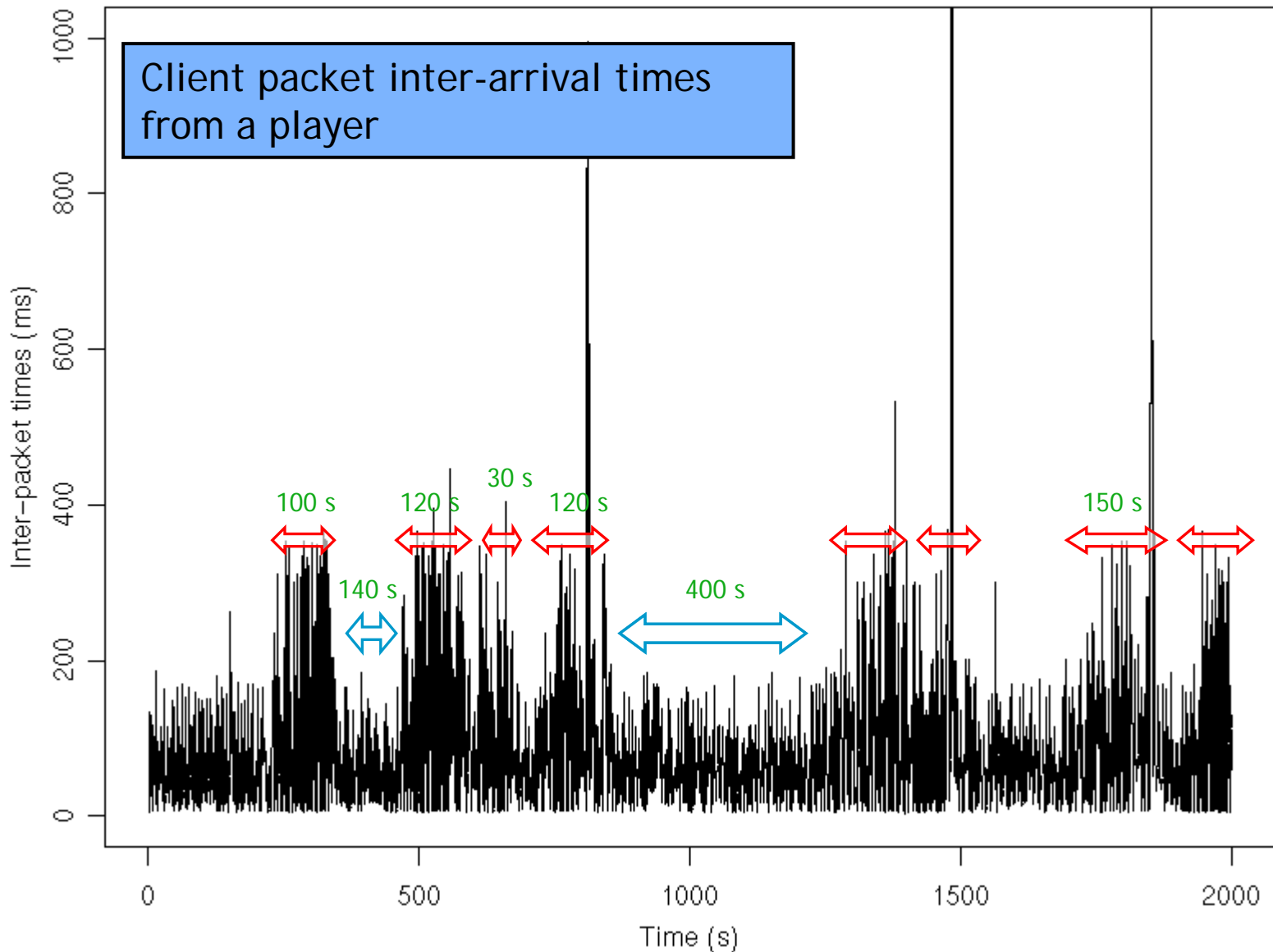


Temporal Locality in Client Traffic

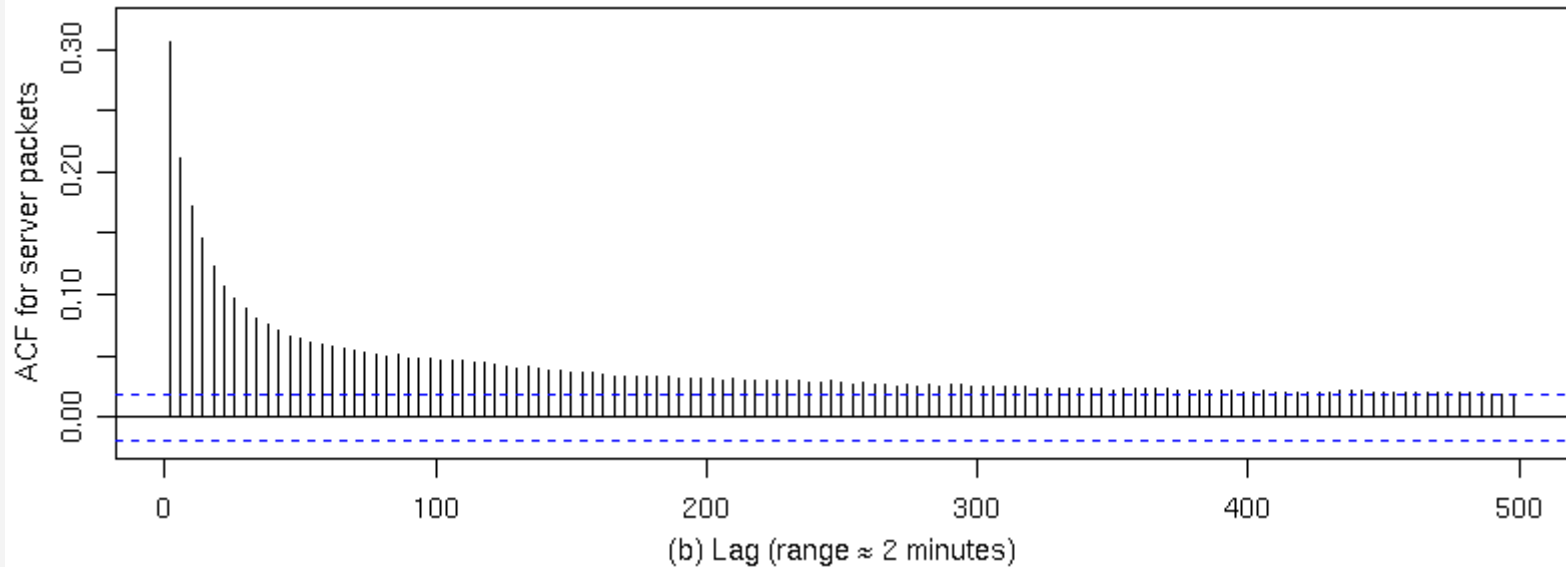


- ACF: auto-correlation functions
- clustering nature in player actions
- active actions: walking, fighting
- inactive actions: talking, viewing equipments, trading, idle

Clustered nature in user actions

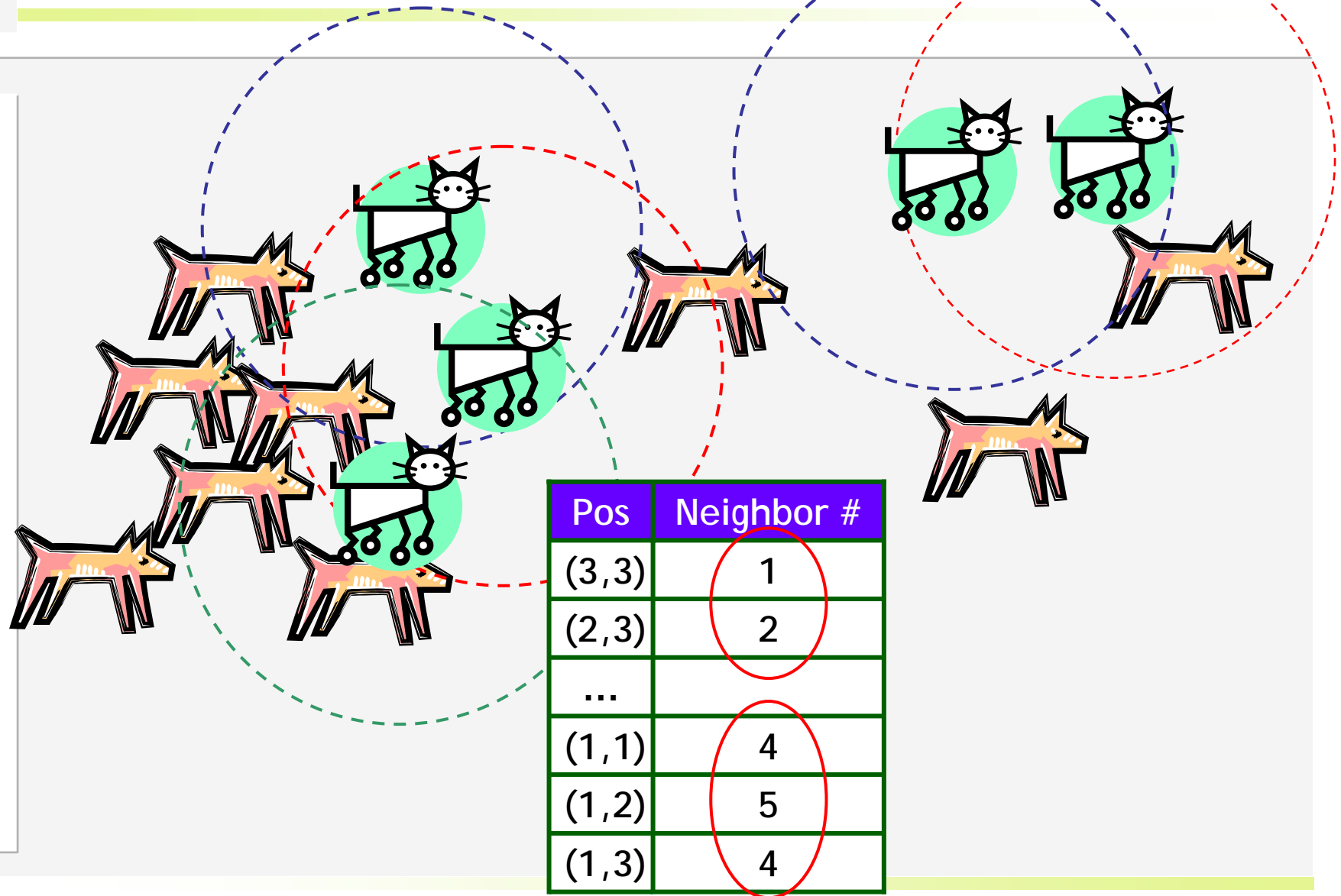


Temporal Locality in Server Traffic



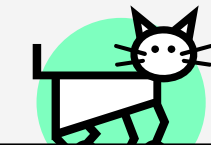
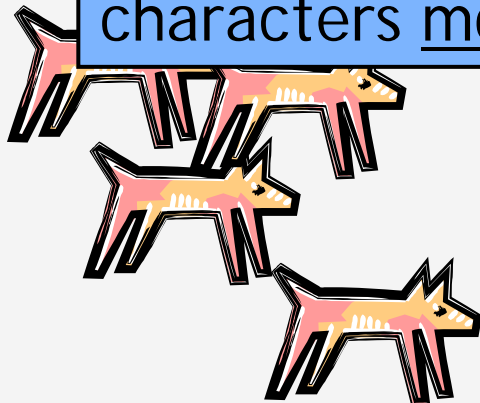
- Server pkt primarily convey *position updates*
- the rate of position updates depends on the number of *nearby characters*

Spatial Locality in # of Neighbors



Transformation: Spatial Locality to Temporal Locality

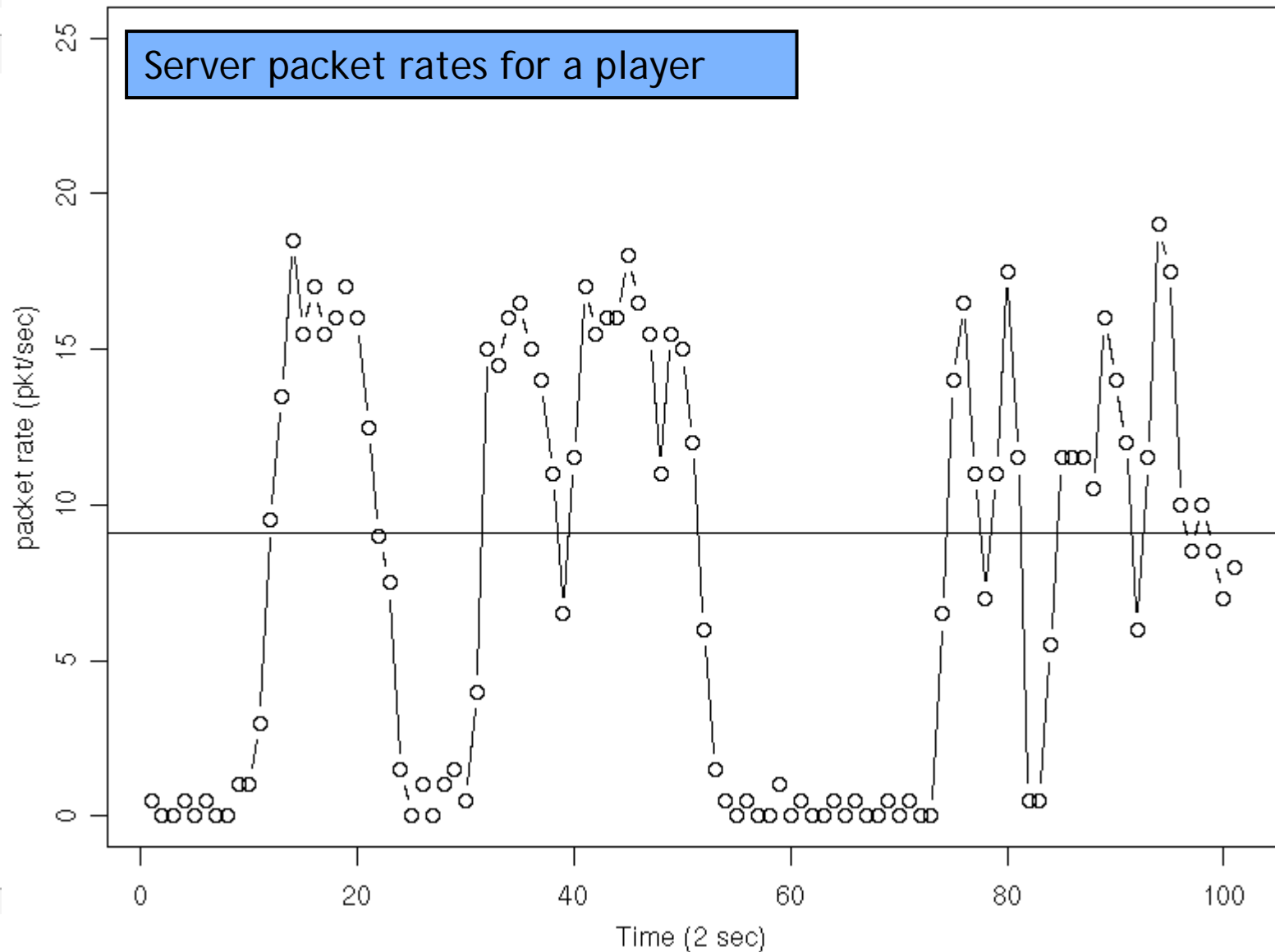
The **spatial locality** shows up in terms of **temporal locality** in the traffic as the characters move continuously on the map.



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



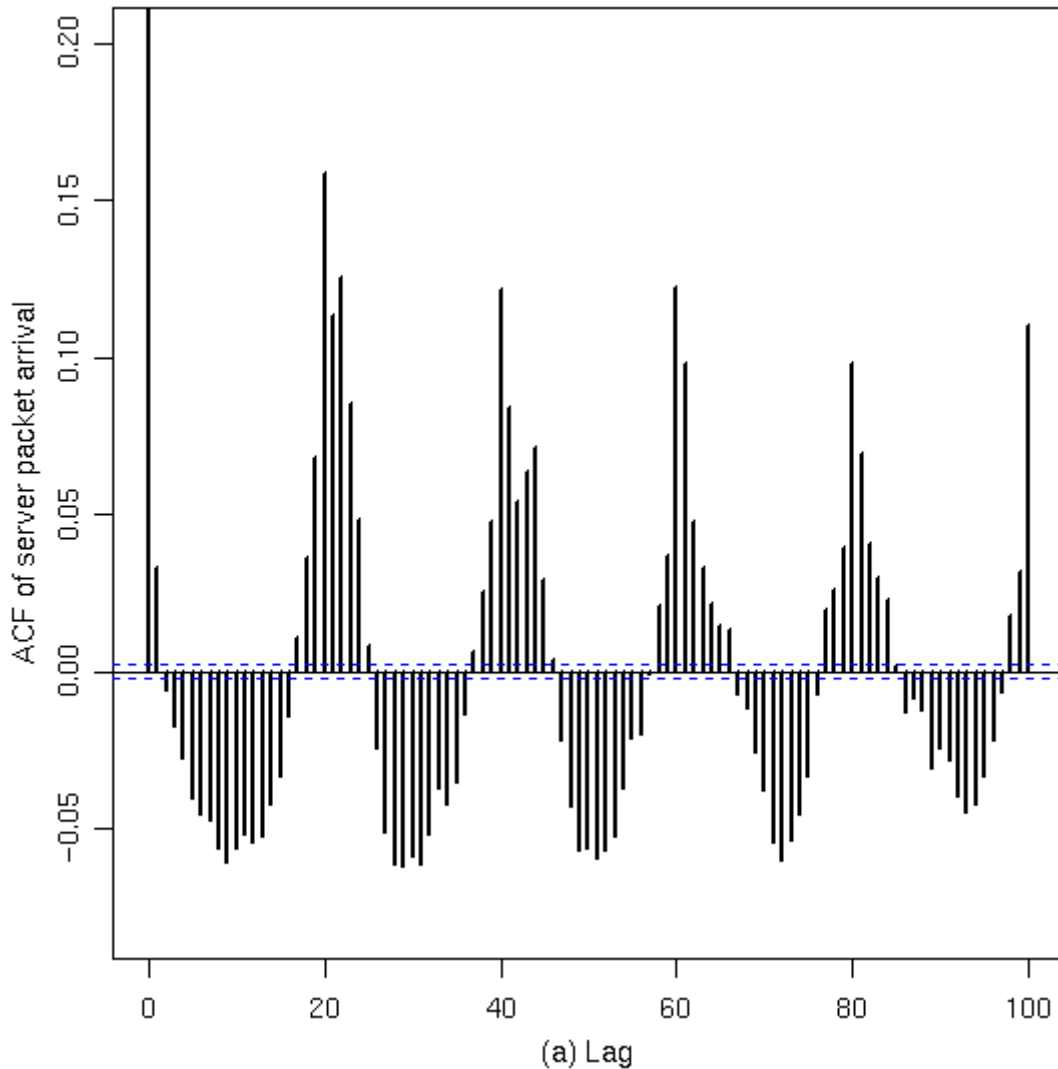
Temporal locality in server traffic



Aggregate Packet Arrivals

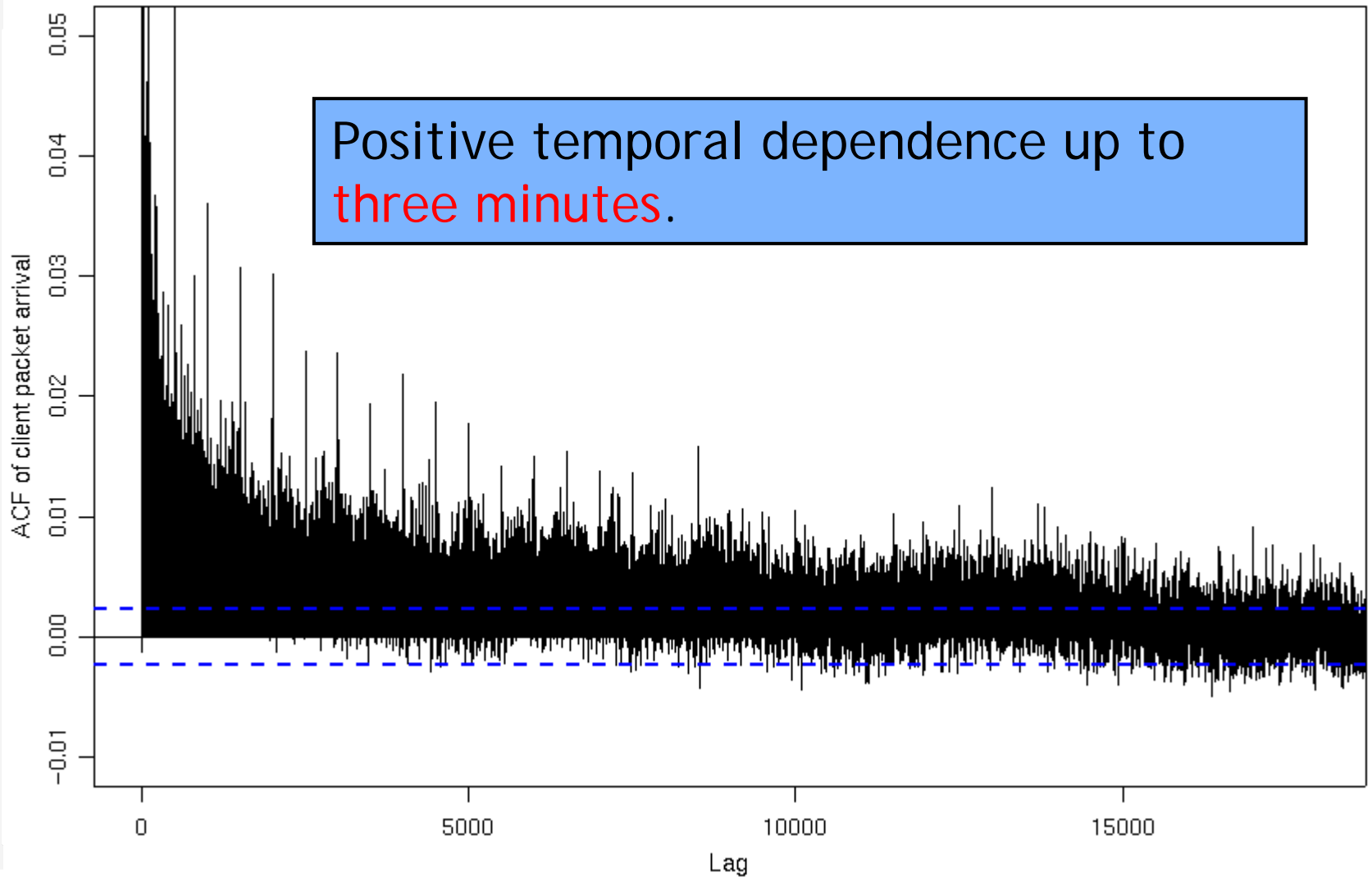
- the aggregate packet arrival time series
 - count the number of incoming/outgoing packets regardless of connections
 - take samples every 10 ms
- Patterns identified
 - temporal dependence
 - periodicity

ACF of aggregate server pkt arrivals

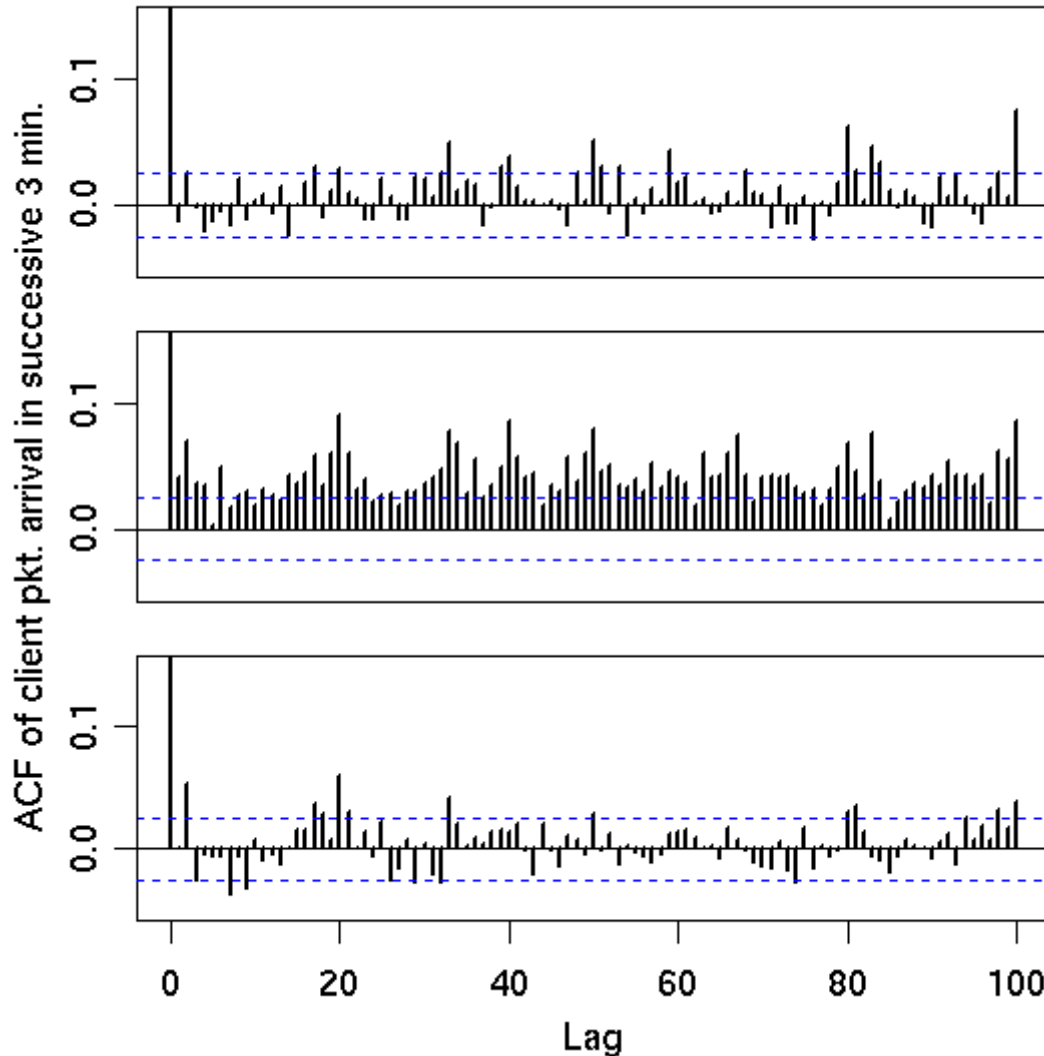


- periodity: 200 ms
- position updates are synchronous to all clients
- incurring packet bursts

ACF of aggregate client pkt arrivals

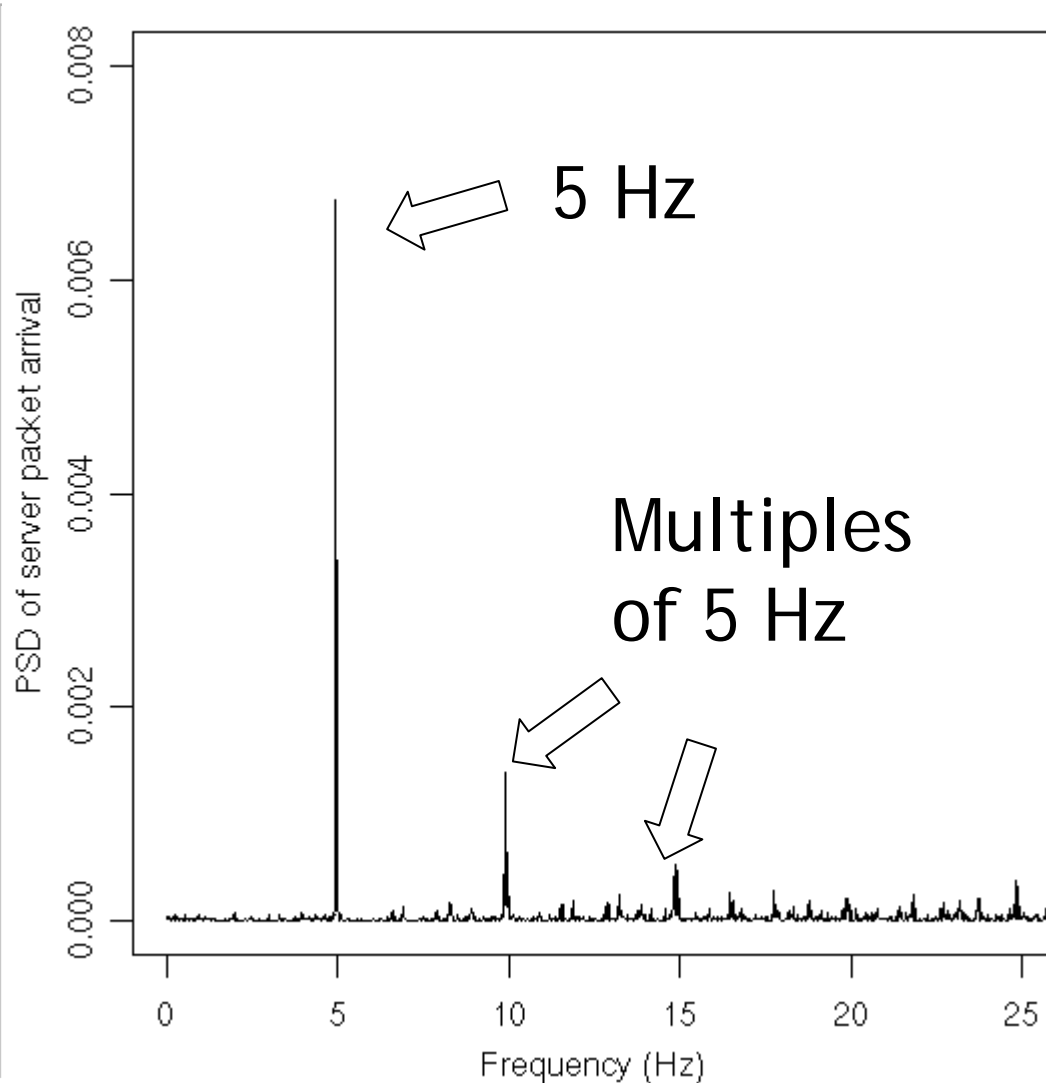


The “flash crowds” effects



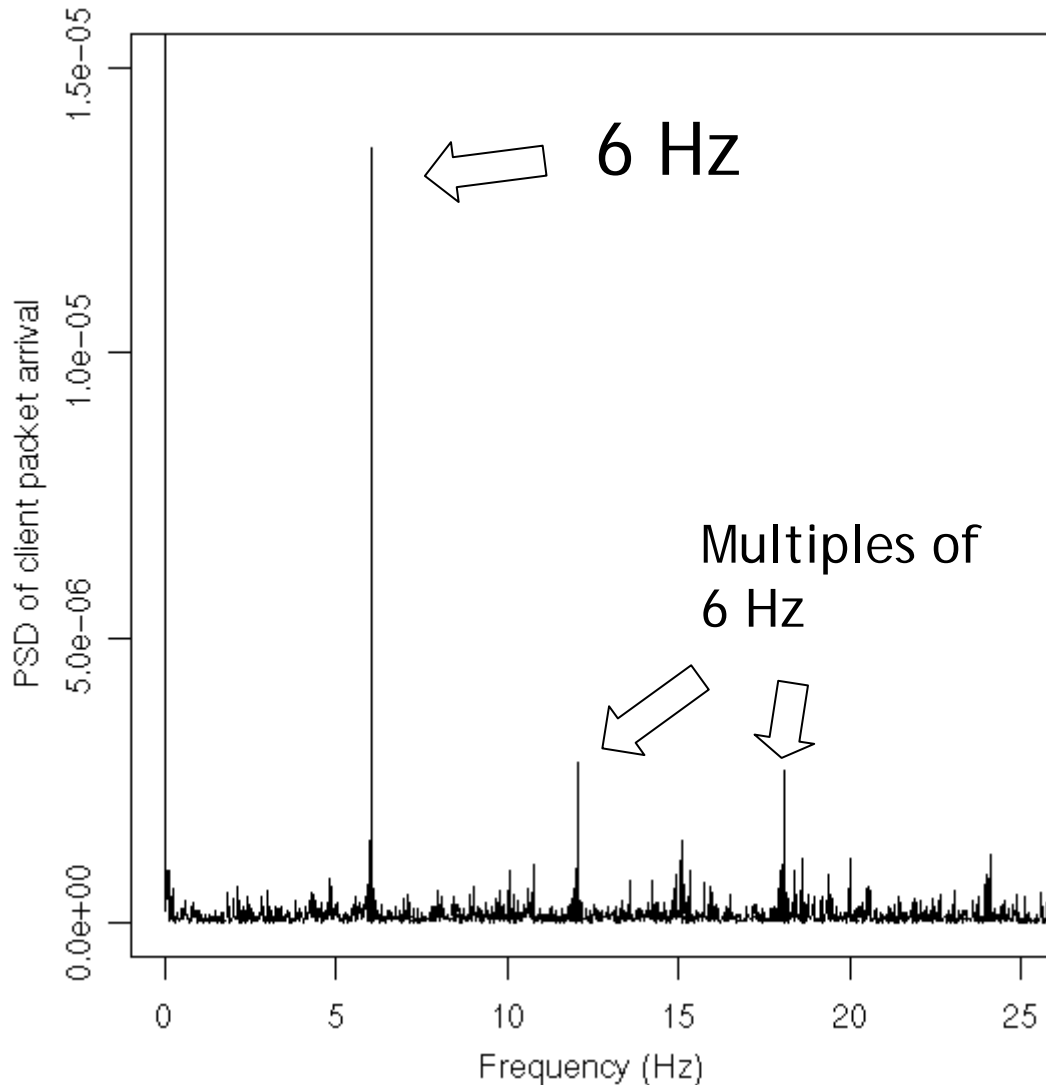
- ACF for successive 3 minutes
- Players are active *simultaneously* at times
- “global events” lead to flash crowds effects

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!

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