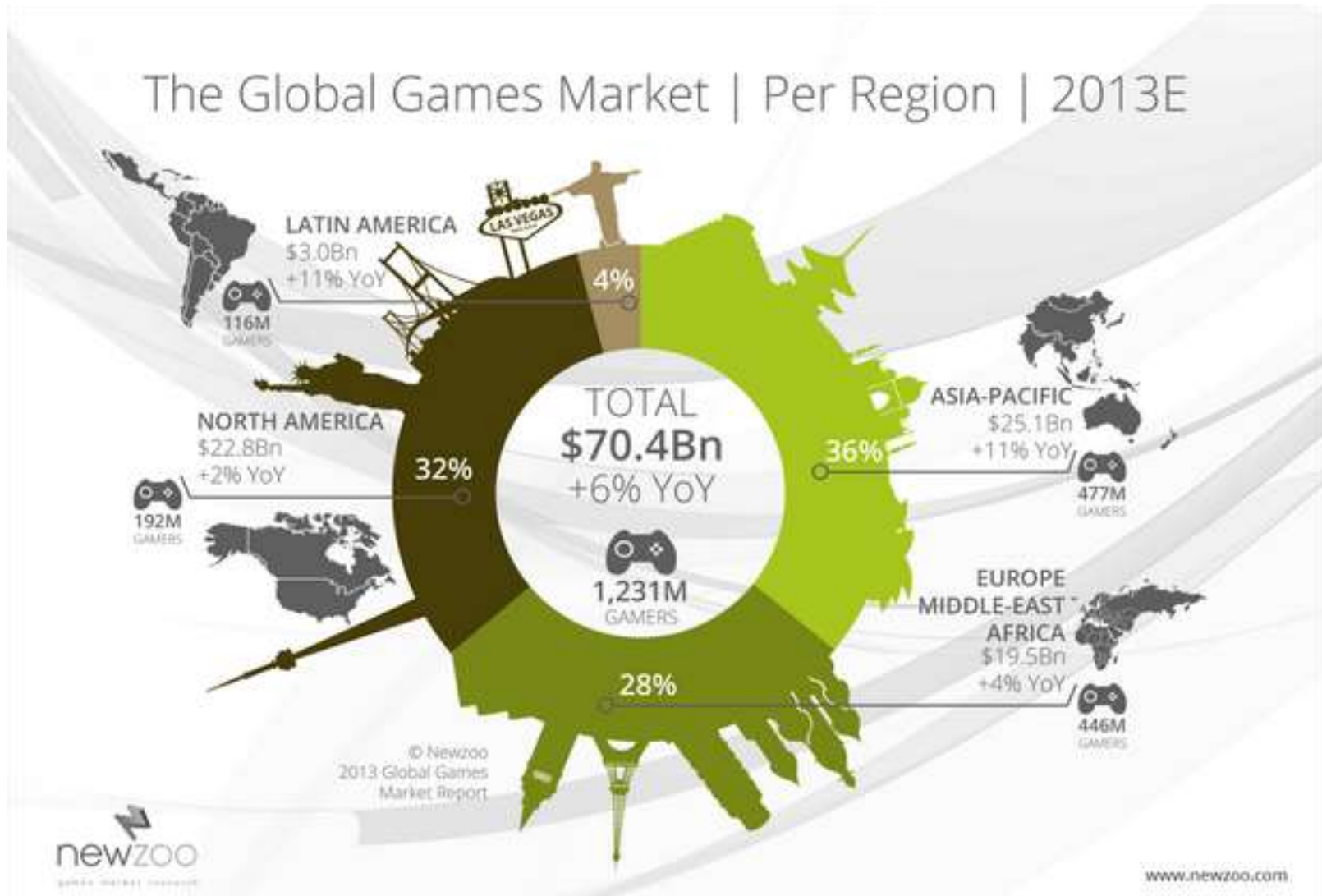# Networking Issues and Solutions in Online Games
Lecture I

Claudio E. Palazzi

Goals of this presentation

- Current practices/trends in online games

- Traffic of online games – characteristics

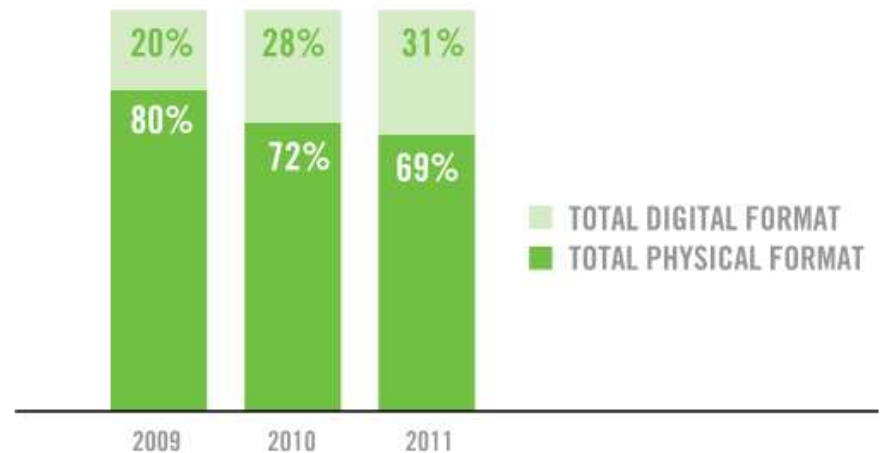- Current issues, requirements and solution
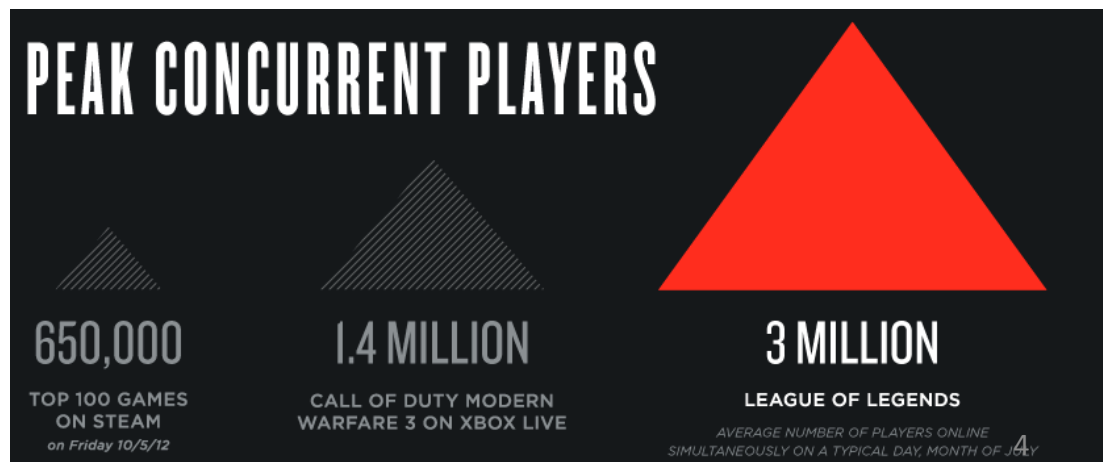
Size of the gaming industry

The Global Games Market | Per Region | 2013E

LATIN AMERICA
$3.0Bn
+11% YoY
116M GAMERS

4%

NORTH AMERICA
$22.8Bn
+2% YoY
192M GAMERS

32%

TOTAL
$70.4Bn
+6% YoY

1,231M GAMERS

36%

ASIA-PACIFIC
$25.1Bn
+11% YoY
477M GAMERS

EUROPE
MIDDLE-EAST
AFRICA
$19.5Bn
+4% YoY
446M GAMERS

28%

© Newzoo
2013 Global Games
Market Report

newzoo

www.newzoo.com

3

Shift towards online

- Multiplayer games
- Social games
- Content distribution

Recent Digital* and Physical Sales Information

	2009	2010	2011
TOTAL DIGITAL FORMAT	20%	28%	31%
TOTAL PHYSICAL FORMAT	80%	72%	69%

Source: The NPD Group/Games Market Dynamics: U.S

facebook. GAMES
> 250 million monthly players

PEAK CONCURRENT PLAYERS

650,000
TOP 100 GAMES ON STEAM
on Friday 10/5/12

1.4 MILLION
CALL OF DUTY MODERN WARFARE 3 ON XBOX LIVE

3 MILLION
LEAGUE OF LEGENDS
AVERAGE NUMBER OF PLAYERS ONLINE SIMULTANEOUSLY ON A TYPICAL DAY, MONTH OF JULY

Content distribution

• DRM

faceb

> 250 million mo

Shift towards online

- Multiplayer games

20% 28% 31%
80%

Marc Whitten (executive in charge of Xbox Live):
"When we launched Xbox Live in 2002, it was powered by 500 servers. With the advent of the Xbox 360, that had grown to over 3,000. Today, 15,000 servers power the modern Xbox Live experience. This year (2013), we will have more than 300,000 servers for Xbox One, more than the entire world's computing power in 1999."
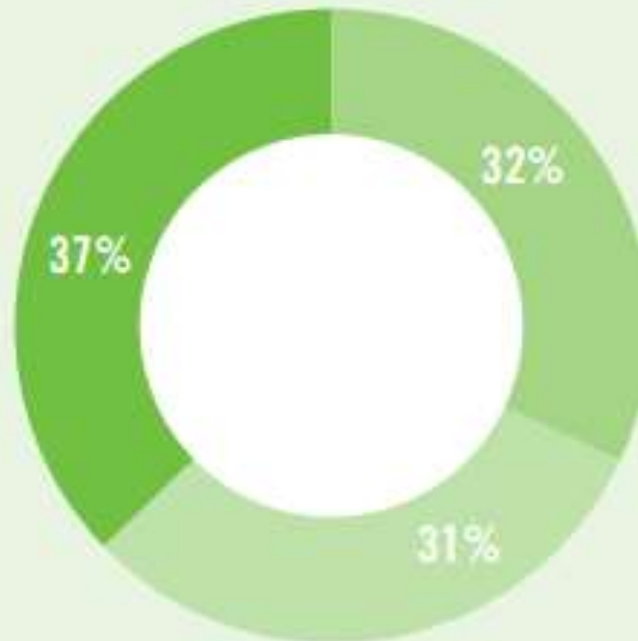
Cloud infrastructure to increase the number of servers (available for free for game developers)

facebook® GAMES
> 250 million monthly players

650,000
TOP 100 GAMES ON STEAM
on Friday 10/5/12

1.4 MILLION
CALL OF DUTY MODERN WARFARE 3 ON XBOX LIVE

3 MILLION
LEAGUE OF LEGENDS
AVERAGE NUMBER OF PLAYERS ONLINE SIMULTANEOUSLY ON A TYPICAL DAY, MONTH OF JULY

Who are the consumers?

The average game player age is:

30

AGE
of Game Players

32% under 18 years
31% 18-35 years
37% 36+ years

32%
37%
31%

Source: Entertainment Software Association (ESA) http://www.theesa.com/facts/gameplayer.asp

Are video games only for kids?

Did You KNOW? According to ESA's 2012 Essential Facts, 49 percent of American households own a game console.

Game Player Data

- About the ESA
- Become a Member
- Industry Facts
  - Economic Data
  - Sales & Genre Data
  - Game Player Data
  - Games & Violence
  - Video Game Research
- Public Policy
- Games: Improving What Matters
- News Room

Video games are now a mass medium, widely enjoyed on a variety of platforms by a diverse audience. The ESA's *2012 Essential Facts About the Computer and Video Game Industry* reveals interesting demographic facts about today's gamers and the games they play, including:

- The average gamer is 30 years old and has been playing for 12 years. Sixty-eight percent of gamers are 18 years of age or older.
- Forty-seven percent of all players are women, and women over 18 years of age are one of the industry's fastest growing demographics.
- Today, adult women represent a greater portion of the game-playing population (30 percent) than boys age 17 or younger (18 percent).
- Sixty-two percent of gamers play games with others, either in-person or online. Seventy-eight percent of these gamers play with others at least one hour per week.
- Thirty-three percent of gamers play social games.
- Gamers play on-the-go: 33 percent play games on their smartphones, and 25 percent play on their handheld device.

Source: Entertainment Software Association (ESA)
http://www.theesa.com/facts/gameplayer.asp

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Game Architectures

- Stand alone
  - No network
- Client-server
  - Classic architecture
- P2P
  - All clients are also servers (or no-server)
- Hybrid
  - A mix of CS and P2P (e.g., multiple servers synchronized through P2P technology)
- Cloud-based
  - Cloud-based or dematerialized console (aka *thin client*)

Client-Server Architecture

- Dominance of client-server architecture
  - Cheating avoidance
  - Easier synchronization
  - Billing
- Server organization
  - Server included in the game and one client acts as the server (e.g., *Warcraft 3*)
  - Dedicated server application released and players create their own servers (e.g., *Call of Duty*)
  - ***Server fully controlled by the developer/publisher*** (e.g., *World of Warcraft*)

itecture

– server

server (e.g., *Warc...*
– Dedicated server...
  create their own s...
– *Server fully contr...*
  (e.g., *World of Wo...*

Client versions

- Specific application per game
- Clients encompassing multiple games
  - Browser based games
  - Cloud based games (thin clients)

- Client version highly affects traffic characteristics

Business models

- Pay to play
  - Game client/account
  - Subscription
  - Additions to existing games
- Free to play (F2P)
  - Advertisement
  - Micro transactions ("Freemium" aka "Not Really"*)
    - Additional content
    - Cosmetic/usability improvements

* South Park – Season 18, Episode 06 - http://southpark.cc.com/

13

Google

tes   Tools   Help

uggested Sites ▾   Web Slice Gallery ▾

ount Management

Page ▾   S

Account Management

Blizzard Support
Click here

ACCOUNT MANAGEMENT

» Return to Account Management

Mounts Application Trial

lease use the form below to confirm your account information, including your e-mail address and your and Secret Question Answer. Once the fields have been completed, press the "Update" button below.

*Note: Please ensure that your e-mail and Secret Question Answer is currently accessible submit this form, as future regarding this account Trial mounts will be sent to the you account

Email and Secret Question Answer:

* Current e-mail address:

* Secret Question: Please Select A Secret Question

* Answer:

Update

Cancel

Online Game's Requirements

- *Scalability*:
  - the number of contemporary players should not be bounded
  - Massively Multiplayer Online Games (MMOGs)

- *Interactivity*:
  - multiplayer gaming is extremely delay-sensitive

- *Consistency*:
  - uniformity of game state view in all nodes

- *(Network) Fairness*:
  - simultaneous game evolution regardless of network conditions

Client-Server: Bottlenecks

- Three potential bottlenecks:
  - uplink: gamers send their actions
  - server: calculation of the next state
  - downlink: send the state to players

Server processing capacity limit
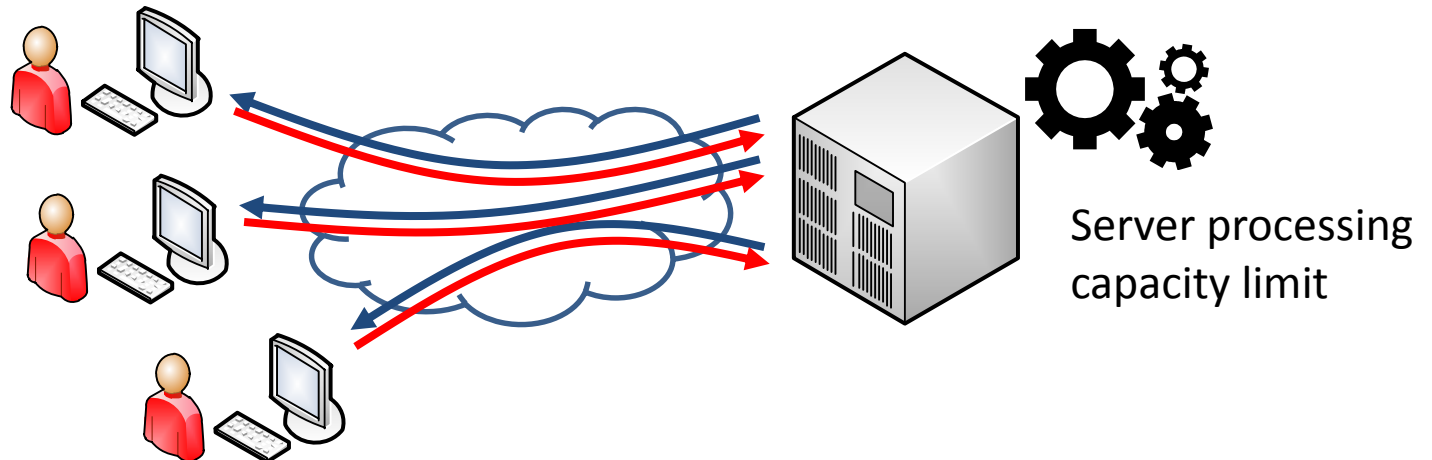
Networking issues: Delay

- Interactivity requires small delays
  - VoIP and FPS: less than 150ms of delivery delay
  - Professional FPS players need less than 50ms of delay
- Causes
  - Network equipment
 - Applications
  - Speed of light
  - Network congestion
  - Computational load

Networking issues: Jitter

- **Jitter**: different network delivery delays for different packets
 - Caused by bursty traffic (e.g., web browsing)

Transmission

Reception

Delay 1   Delay 2   Delay 3   ...   Delay i
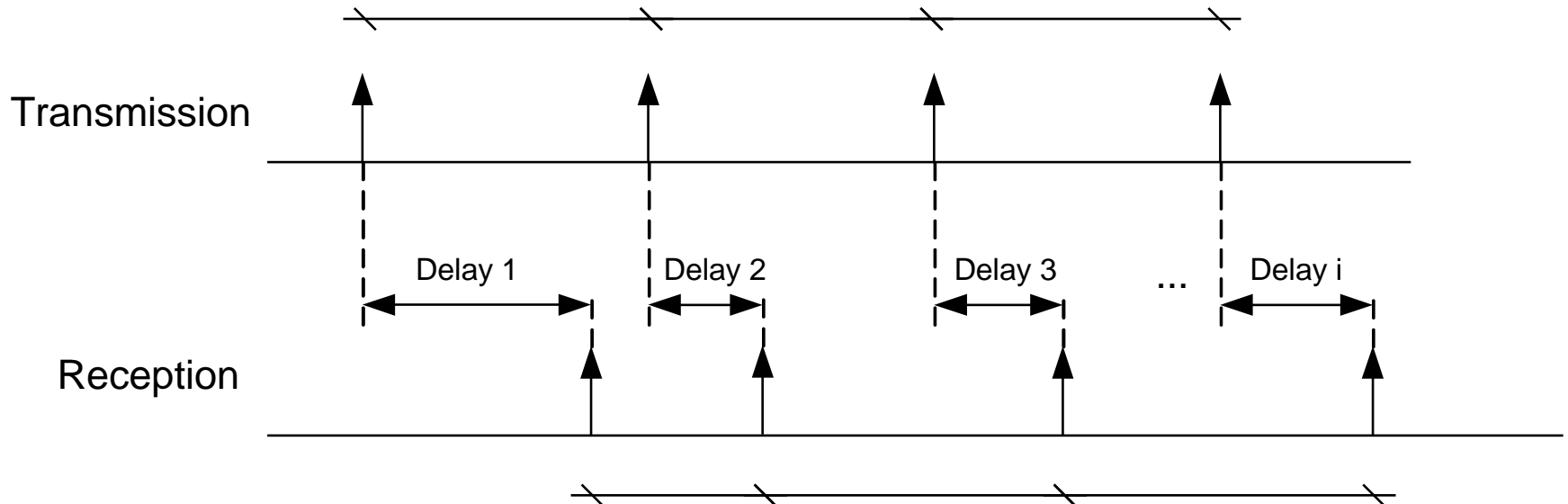
Networking issues: Packet loss

- There are networks bottlenecks
  - So buffers are used
  - Buffers have limited capacity
  - Sometimes packets are dropped
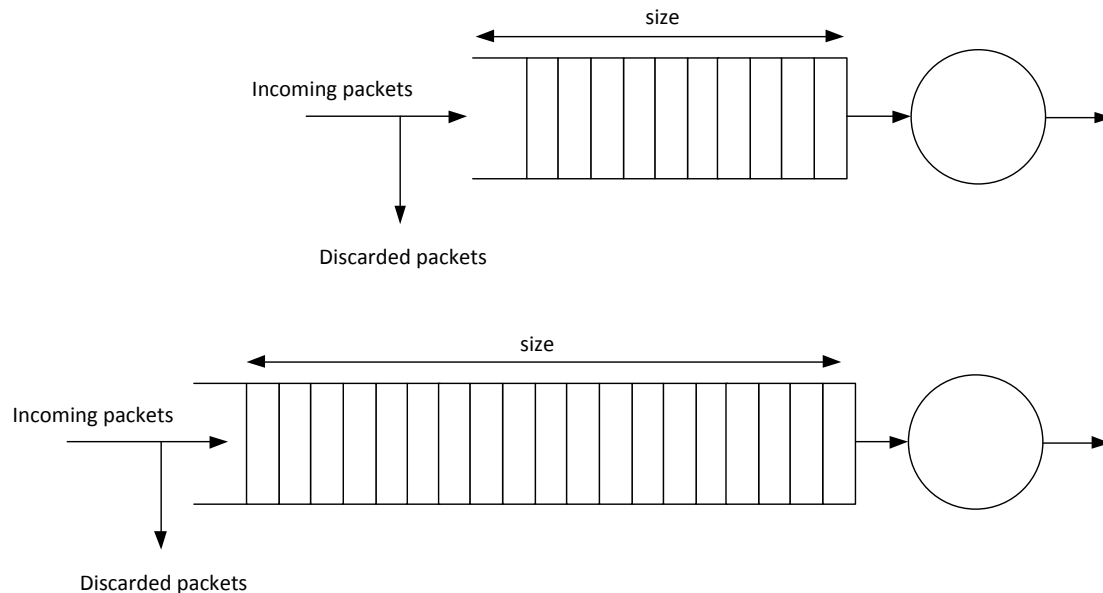
Networking issues: Efficiency

- Every packet needs a header
  - Origin, destination, sequence number, type, ecc.
- It is not the data we are transmitting
  - Overhead (from 28B to 60B per each packet) can become even 75% of the total traffic sent
- Maximum packet size: 1500B
  - Nagle's algorithm waits (hence delay) to pile up the 1500B before transmitting a packet

Consistency and Network Fairness

Jack

Wang

Question

Answer

Are you there?

time
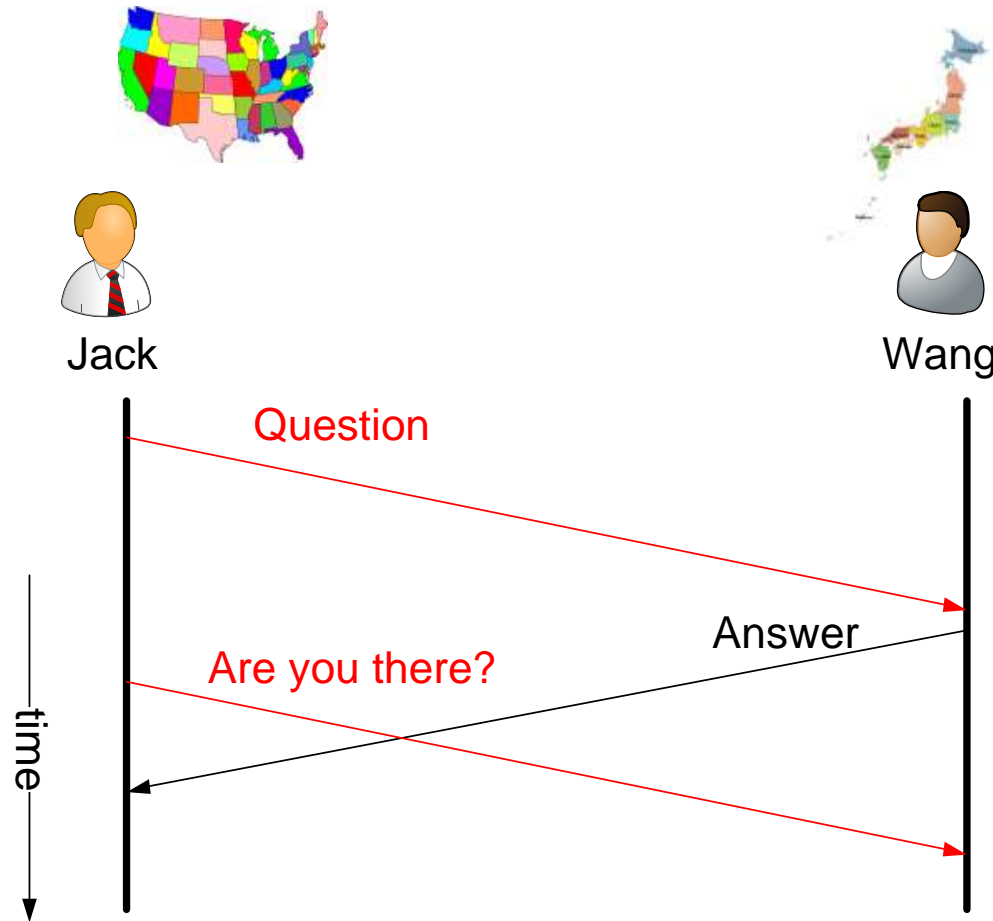
Network delay scheme
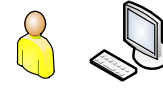
Consistency and Network Fairness
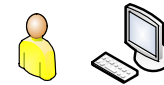
"Shooting around the corner"

Jack

Wang

Wang

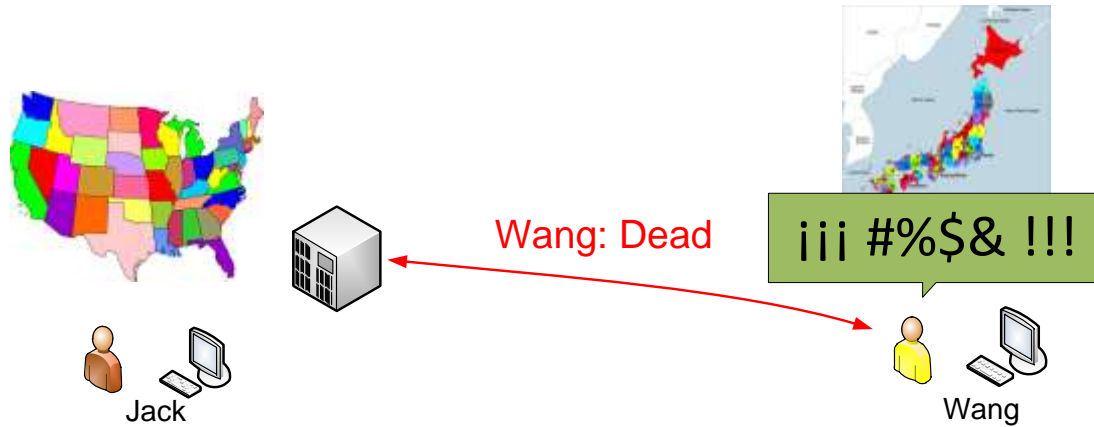# Consistency and Network Fairness
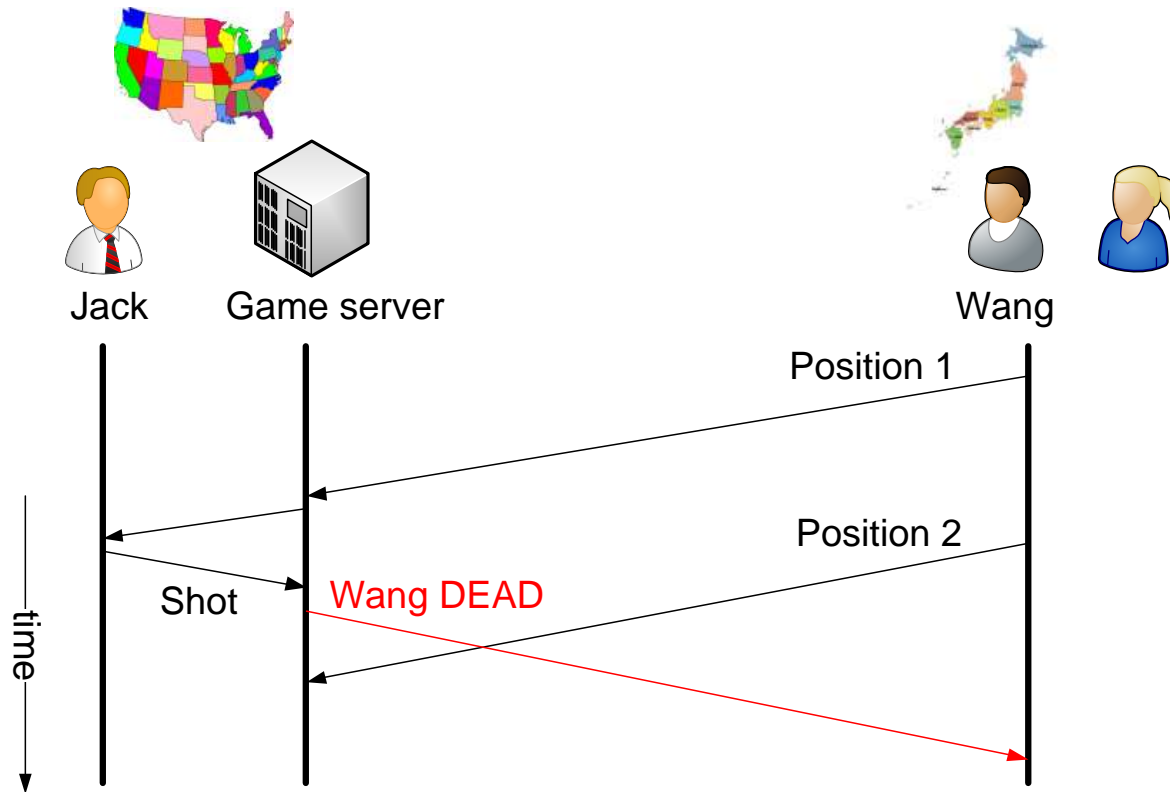
"Shooting around the corner"

Consistency and Network Fairness

"Shooting around the corner"

Consistency and Network Fairness

"Shooting around the corner"

Jack   Game server   Wang

Position 1

Position 2

Shot   Wang DEAD

time

Network delay scheme

Information transferred

- What information does the traffic comprise?
  - Player commands/inputs
  - Virtual world state refreshes
  - Chat
  - Audio flows for player communication
    - Some games have in-built VoIP systems
    - Many players use stand alone applications (Teamspeak, Ventrilo, Skype…)
  - 3D data describing virtual world (Second Life)
  - Video
    - Sent by cloud based (thin client) games
    - Streaming of gaming sessions

Traffic characterization

- Game flows:
  - Long lived
  - High packet rate
  - Small payload sizes
  - Low bandwidth usage
  - Using both UDP and TCP
  - ***Dependant on the game genre***
- Identified issues:
  - Delay sensitivity
  - Low but very inefficient bandwidth usage
  - Variable delivery requirements
- Thin client games are an exception

Traffic: Why so small?

- Market penetration!
- *World of Warcraft* was released in 2004 – in order to reach as much users as possible it needed to work on 33,6k modem
- *Unreal Tournament* on 14,4k ☺

- High broadband penetration – will games use more and more bandwidth?
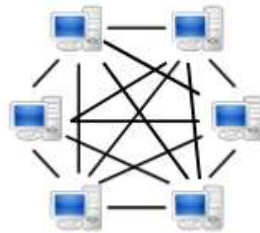 - No (and yes)
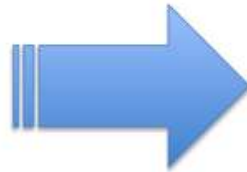
Game traffic evolution? – Not really

StarCraft I (1998-2010)

Peer-to-peer Architecture

StarCraft II (2010-present)

Server-client Architecture

1-5kbps
(2-8 players)

2-3 kbps
(independent of
number of players)

M. Claypool, D. LaPoint, and J. Winslow, "Network Analysis of Counter-strike and Starcraft," in Proceedings of the 22nd IEEE International Performance, Computing, and Communications Conference (IPCCC), USA, April 2003.

C.-S. Lee, "The Revolution of StarCraft Network Traffic" in Proceedings of the 11th Annual Workshop on Network and Systems Support for Games NetGames 2012

– Not really
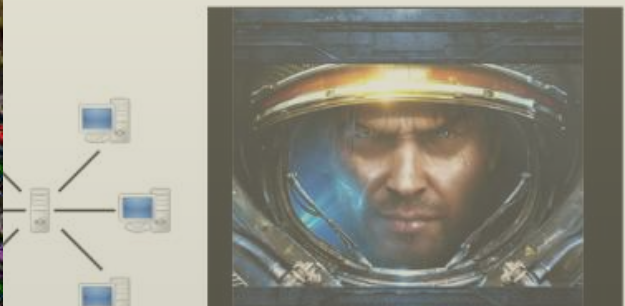
1-5kbps
(2-8 players)

M. Claypool, D. LaPoint, and J. Winslow, "Netw[...]
22nd IEEE International Performance, Comput[...]

C.-S. Lee, "The Revolution of StarCraft Netwo[...]
Systems Support for Games NetGames 2012

Game traffic revolution? Yes*

- Cloud gaming traffic
  - Very high bandwidth usage
  - High quality video
  - Very delay sensitive (no client side optimization)
  - * no high market penetration

RTP/UDP flows of the OnLive Streaming Protocol

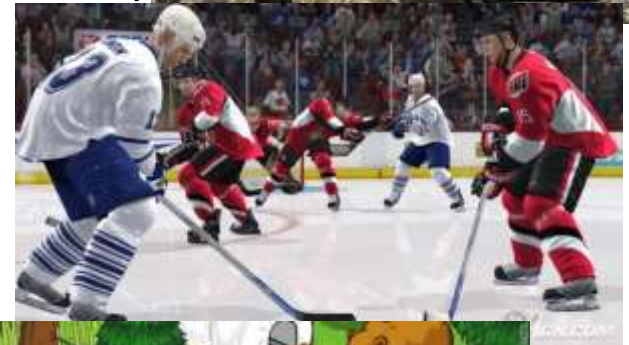| Direction	RTP SSRC	RTP Payload Type	Flow description
Downstream	0x00000000	100	QoS monitoring flow
Downstream	0x00010000	100	OnLive Control
Downstream	0x00030000	100	Audio stream (CBR Codec)
Downstream	0x00040000	100	Cursor position
Downstream	0x00050000	101	Audio stream (VBR Codec)
Downstream	0x00060000	96	Video stream
Downstream	0x00080000	100	Voice Chat (Sound from other players)
Upstream	0x0000XXXX	100	User input (keyboard and mouse buttons)
Upstream	0x0001XXXX	100	Cursor movement
Upstream	0x0004XXXX	100	OnLive Control ACK
Upstream	0x0008XXXX	100	Voice Chat (Microphone from the user)

Global trends

- Global game traffic
  - Very small share of the global volume
  - 22% CAGR (Compounded Annual Growth Rate)

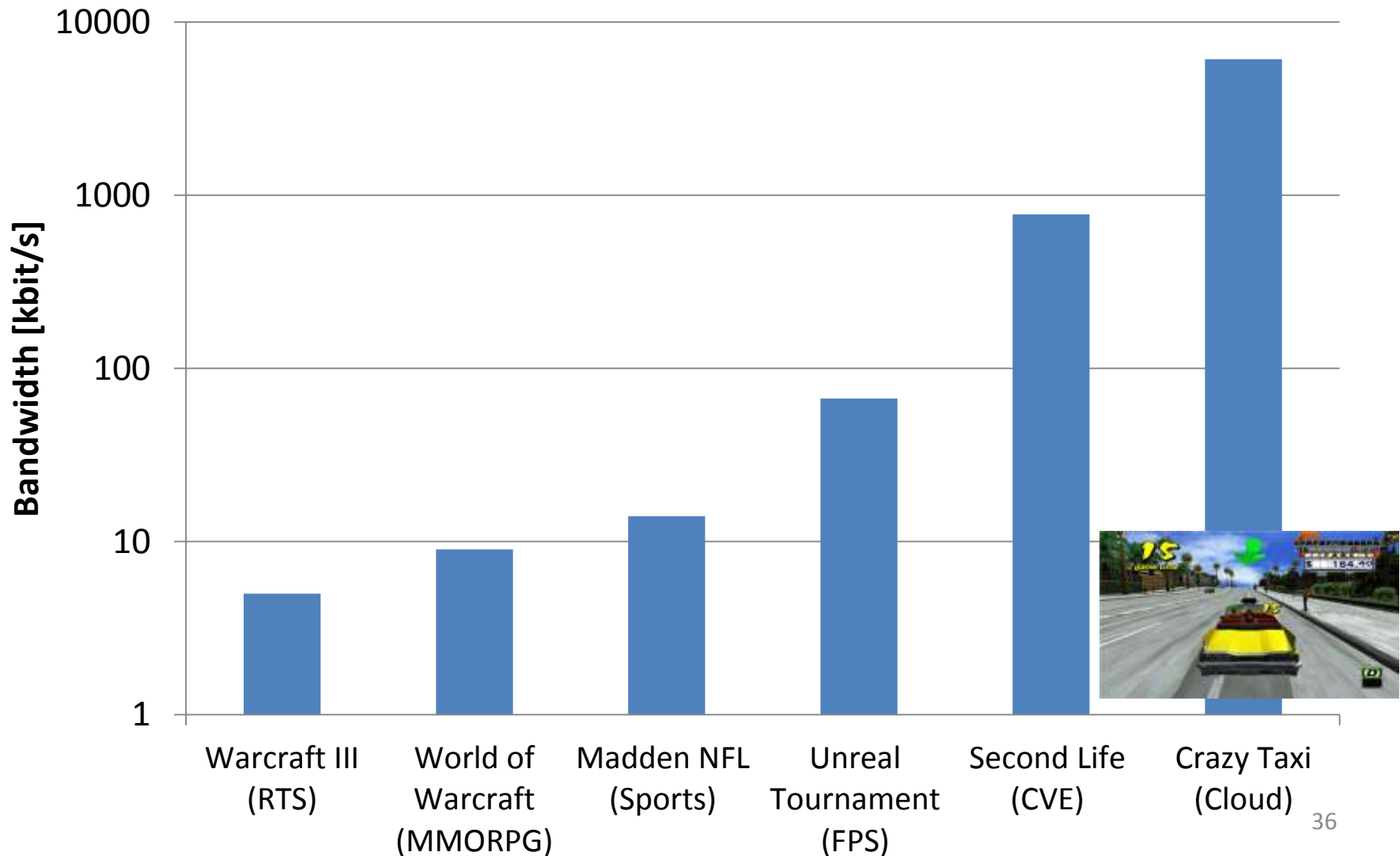| Consumer Internet Traffic, 2012–2017							
	2012	2013	2014	2015	2016	2017	CAGR 2012–2017
By Subsegment (PB per Month)							
Internet video	14,818	19,855	25,800	32,962	41,916	52,752	29%
Web, email, and data	5,173	6,336	7,781	9,542	11,828	14,494	23%
File sharing	6,201	7,119	7,816	8,266	8,478	8,667	7%
Online gaming	22	26	32	39	48	59	22%

Game genres

- Game categorization:
  - Action (e.g., Grand Theft Auto)
  - Adventure (e.g., *Broken Sword*)
  - Arcade (e.g., Pinball)
  - Children's Entertainment (e.g., Bob the Builder)
  - Family Entertainment (e.g., Mahjong)
  - Fighting (e.g., Mortal Combat)
  - Flight (e.g., Wing Commander)
  - ***Racing*** (e.g., Need For Speed)
  - ***Role Playing*** (e.g., World of Warcraft)
  - ***[First Person] Shooter*** (e.g., Quake)
  - [Real Time] Strategy (e.g., *Starcraft*)
  - Other Games

NPD Group Inc., NDP Software Category Definitions, 2008,
https://www5.npd.com/tech/pdf/swcategories.pdf.

Bandwidth usage across genres

(y-axis) **Bandwidth [kbit/s]**: 1, 10, 100, 1000, 10000

(x-axis categories): Warcraft III (RTS), World of Warcraft (MMORPG), Madden NFL (Sports), Unreal Tournament (FPS), Second Life (CVE), Crazy Taxi (Cloud)

First Person Shooters (FPS)

- Gameplay characteristics:
  - Very fast paced
  - Very delay sensitive
  - Several tens of players in one virtual world
- Traffic characteristics
  - Use UDP
  - Loss tolerant
  - Latency very important (usually displayed on server lists, or score lists)
  - Very high packet rate
  - Fairly regular packet sizes
  - Fairly regular packet inter-arrival times

CDF's of different FPS games
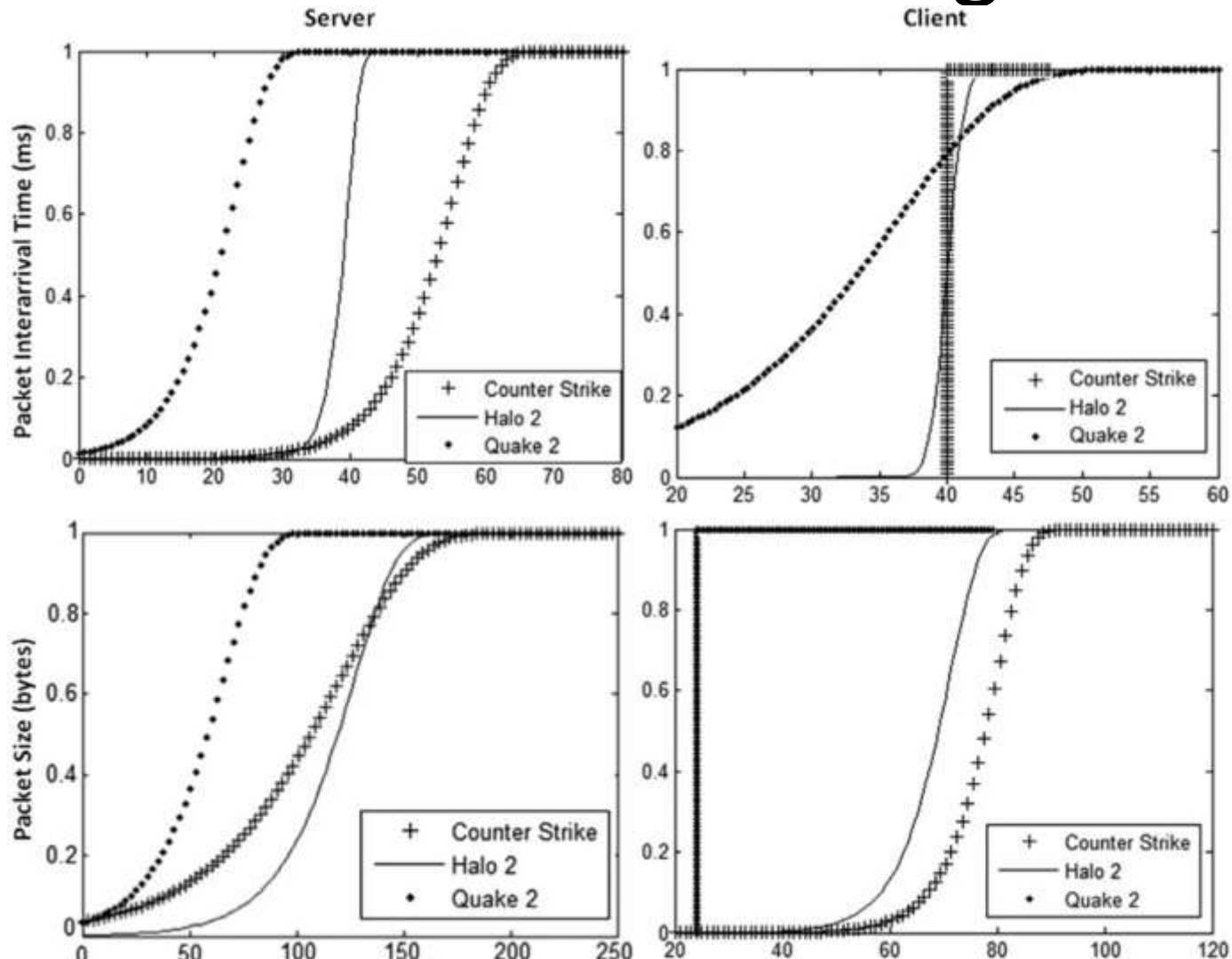
X. Che and B. Ip, "Review: Packet-level traffic analysis of online games from the genre characteristics perspective", Journal of Network Computing Appl. 35, 240–252 (2012)

CDF's of d

Server

X. Che and B. Ip, "Review: Packet
characteristics perspective", Jour

Quake2 - 800x600
Rage128 (OEM)
www.xlr8yourmac.com

Massively Multiplayer Role-Playing Games (MMORPGs)

- Gameplay characteristics
  - Wide range of possible activities
  - Very large virtual worlds
  - Virtual economies
  - Large number of players in same virtual world (up to tens of thousands)
- Traffic characteristics
  - Much more variable traffic characteristics
  - Less fault tolerance
  - TCP and UDP
  - Looser latency constraints
  - Lower packet rate
  - Lower bandwidth usage

MMORPGs and TCP

- TCP not designed for a real time interactive application
  - yet it works
- Application-limited not network-limited flows
- Multiple thin TCP flows behave unlike one fat TCP flow
- Mechanisms in TCP directly deteriorate the experience of the players (delayed ACK, Nagle algorithm)
- Mechanisms of TCP do not work efficiently for MMORPG (low cwnd due to application not having something to send)
- High signaling overhead due to small packets
- High number of "pure" ACKS (with no piggy-back)

Specific game transport protocol?

- Game transport protocol
  - Suggested in 2002 for MMORPGs
  - Not really accepted
- Prerequisites of MMORPG Transport Protocol
  - Must be transmitted in order and reliably (chat)
  - Reliable but not in order (attack)
  - Not reliable or in order (move)
- Transport options
  - Multi-streaming
  - Optional ordering
  - Optional reliability

S. Pack, E. Hong, Y. Choi, I. Park, J-S. Kim, and D. Ko, "Game Transport Protocol: A Reliable Lightweight Transport Protocol for Massively Multiplayer On-line Games (MMPOGs)", Multimedia Systems and Applications, Vol. 486 pp. 83-94, Oct, 2002)

C-C. Wu, K-T. Chen, C-M. Chen, P. Huang, and C-L. Lei , "On the Challenge and Design of Transport Protocols for MMORPGs", Multimedia Tools and Applications Vol. 45, No. 1, pp. 7--32, Oct, 2009.

CDF's of different MMORPGs
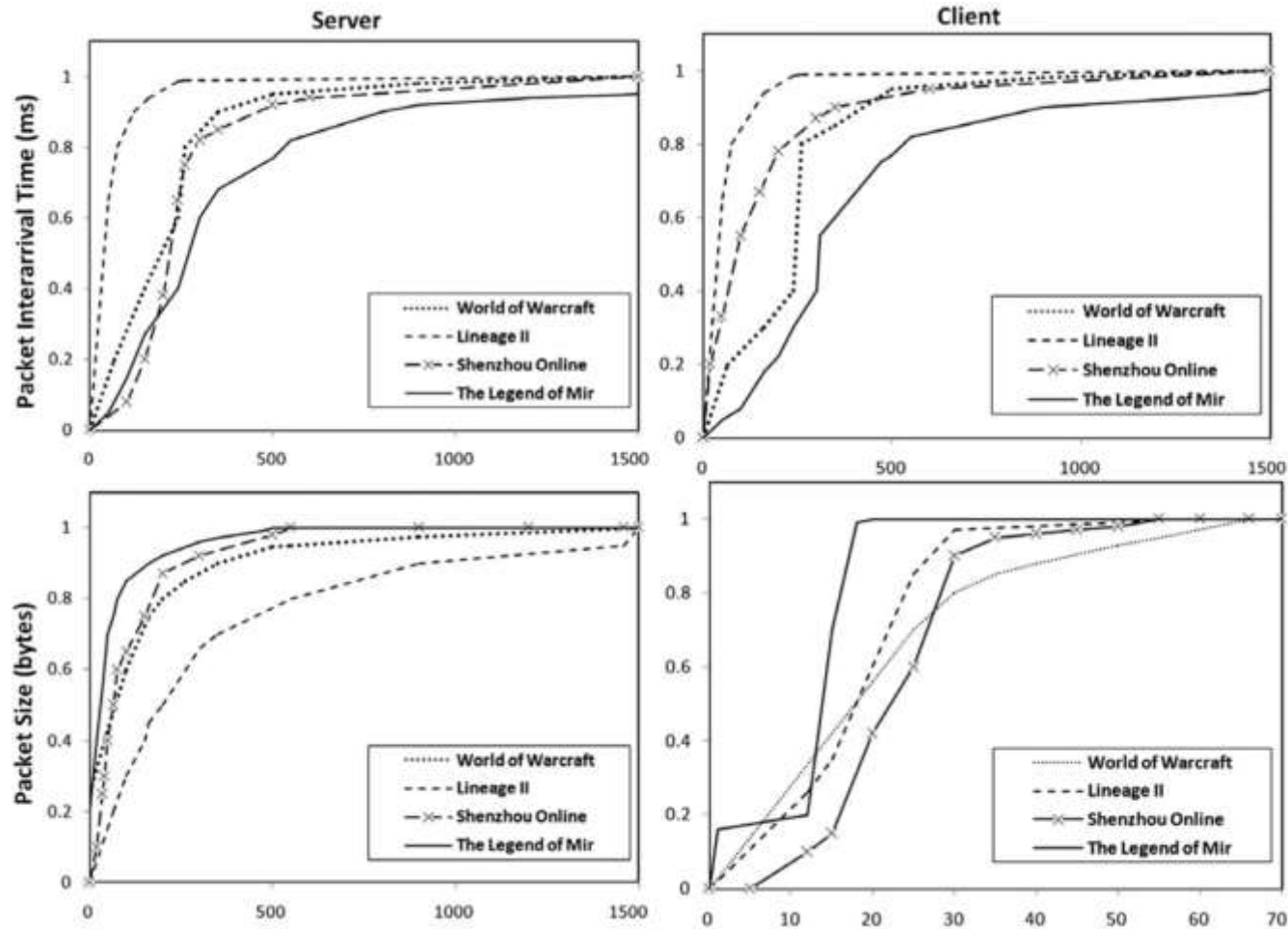
X. Che and B. Ip, "Review: Packet-level traffic analysis of online games from the genre characteristics perspective", Journal of Network Computing Appl. 35, 240–252 (2012)

MMORPG action diversity

Summary of problems

- Delay sensitivity
- Very low and inefficient bandwidth usage of "regular" [not cloud based] games
- Very high bandwidth requirements of cloud based games
- Networking Fairness
- Scalability problems
- Adapting to player behavior
- Protocol related issues