Networking Issues and Solutions in Online Games
Part I

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Goals of this presentation

- Information about current practices in online games industry
- Traffic of online games – trends and characteristics
- Current issues, requirements and solutions

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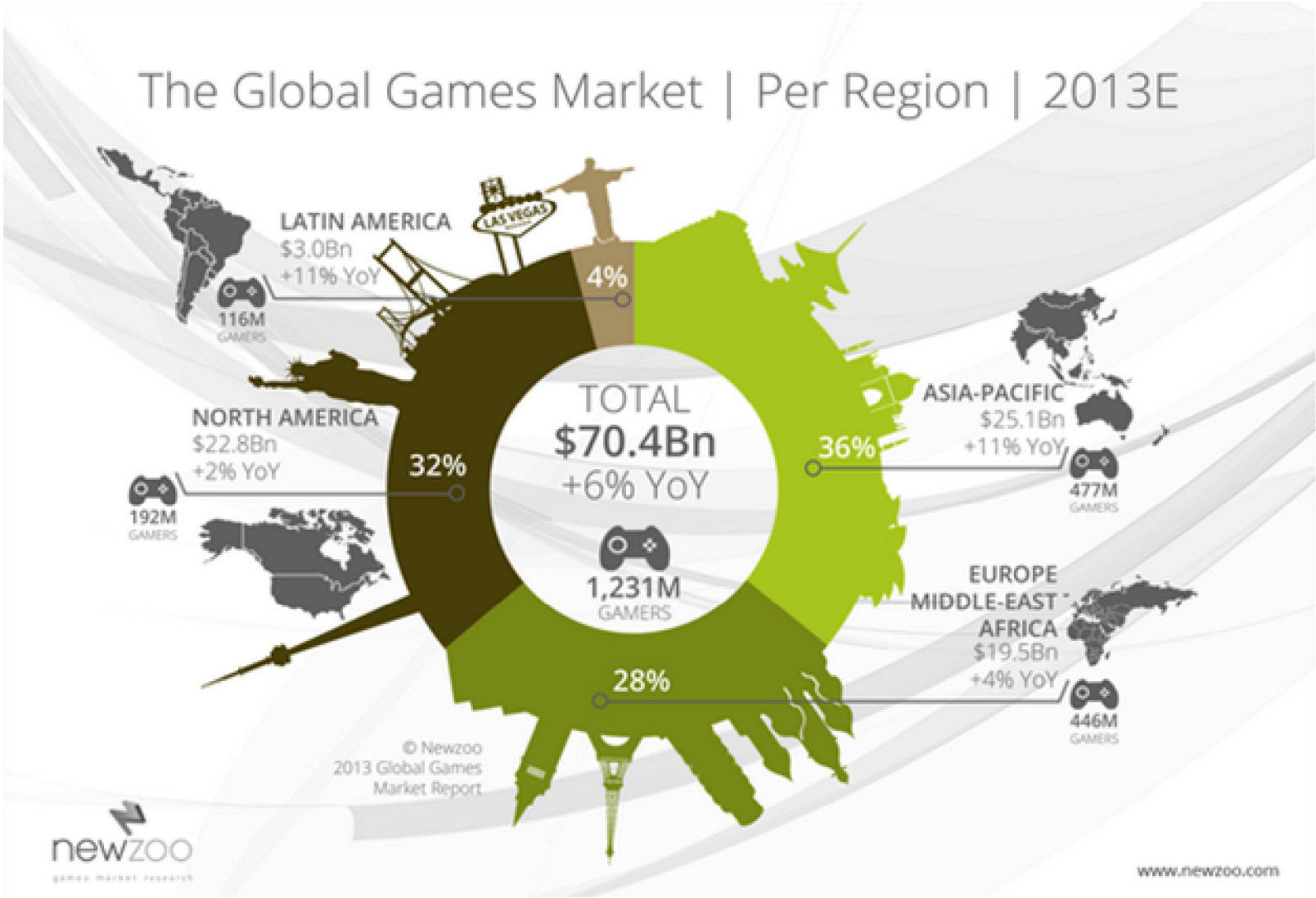
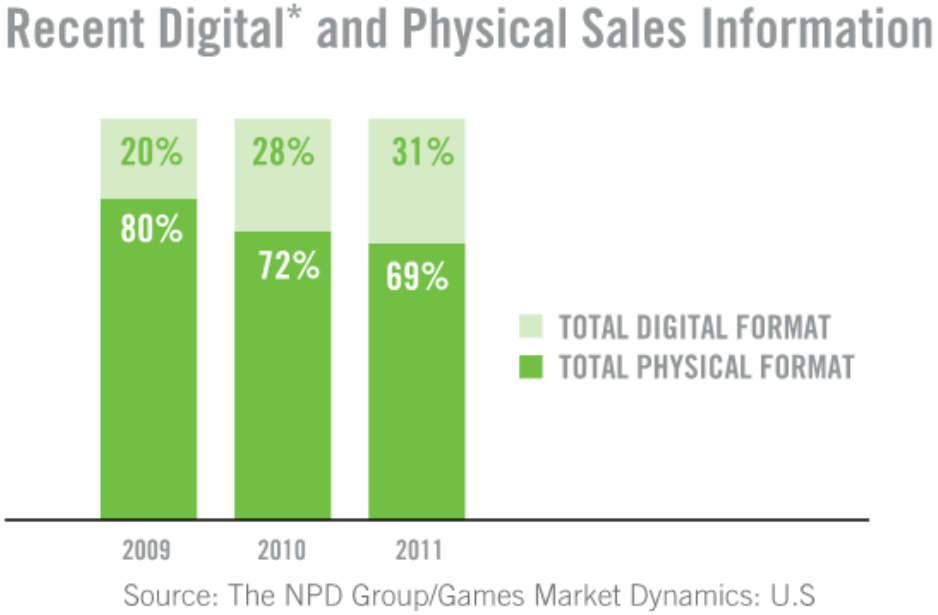
- Information about current practices in online games industry
- Traffic of online games – trends and characteristics
- Current issues, requirements and solutions
- A perfect excuse to play for a while…

Size of the gaming industry

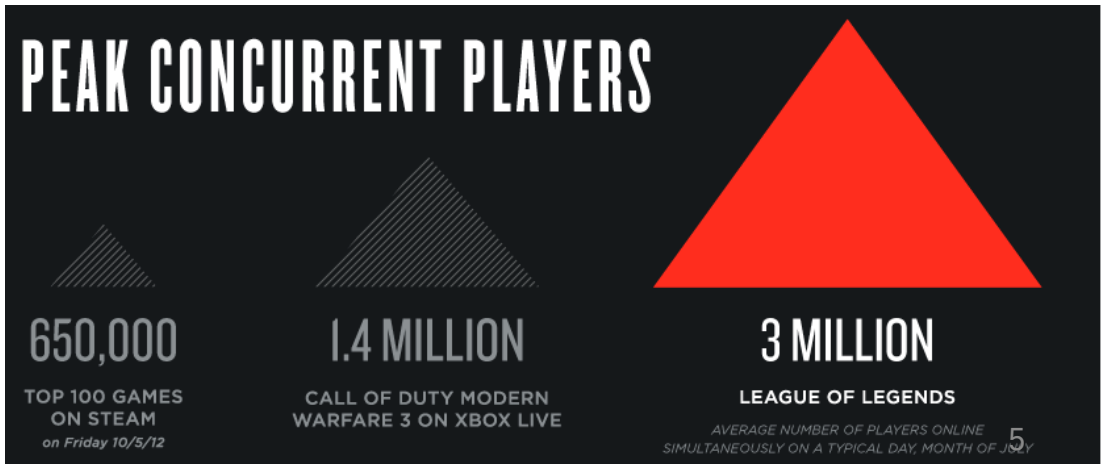


Shift towards online

- Multiplayer games
- Social games
- Content distribution
- DRM



facebook GAMES
> 250 million monthly players




FarmVille

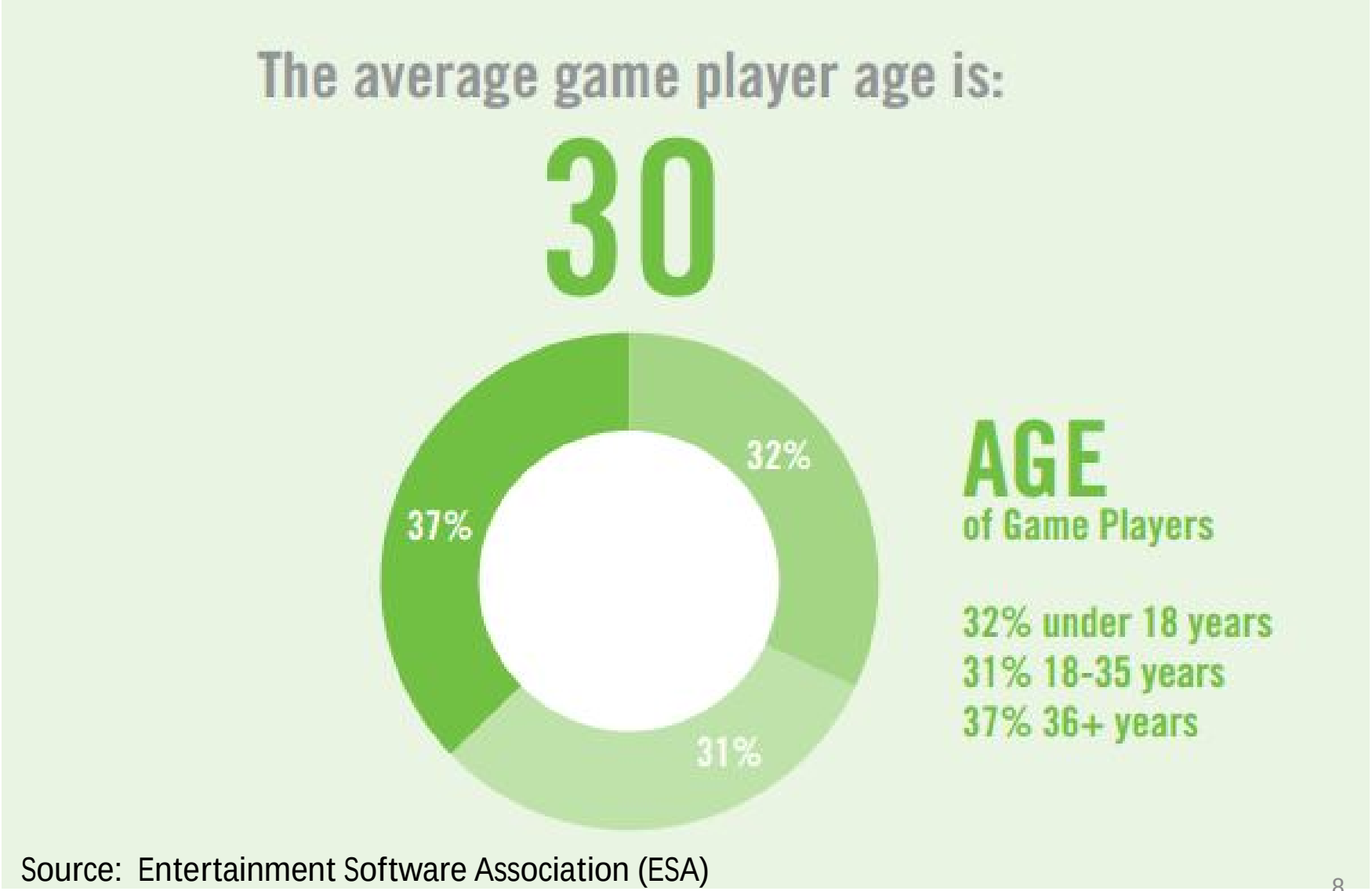

CHEZ LE POISSON
CAFE RESTAURANT
GRILLADES PLAT DU JOUR SELON ARRIVAGE


Hurizen has destroyed an enemy turret!
Agneqne
Hurizen
Hoe4Athene
506 / 2083
1420 / 1699

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)

Who are the consumers?



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.

- 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

Game Player Data

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: …es, a… device.

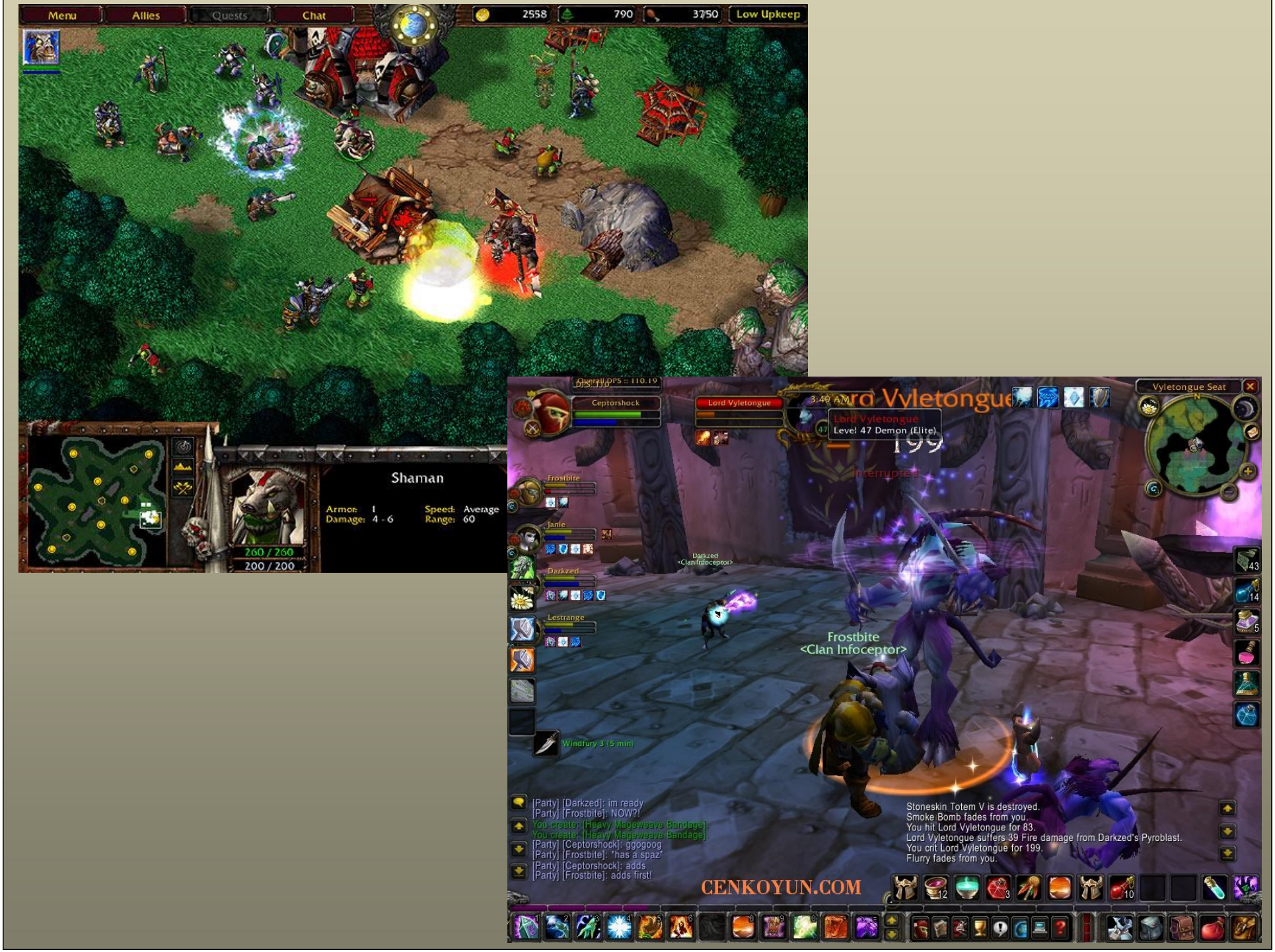
Source: Entertainment Software Association (ESA) http://www.theesa.com/facts/gameplayer.asp

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
- Cloud-based
  - Cloud-based or dematerialized console?

Client-Server Architecture

- Increasing dominance of client – server
  - 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*)


Menu
Allies
Quests
Chat
2558
790
37/50
Low Upkeep
Shaman
Armor: 1
Damage: 4 - 6
Speed: Average
Range: 60
260 / 260
200 / 200
Lord Vyletongue
Level 47 Demon (Elite)
Vyletongue Seat
Ceptorshock
Frostbite
Janie
Darkzed
Lestrange
Windfury 3 (5 min)
Frostbite
<Clan Infoceptor>
[Party] [Darkzed]: im ready
[Party] [Frostbite]: NOW?!
You create: [Heavy Mageweave Bandage].
You create: [Heavy Mageweave Bandage].
[Party] [Ceptorshock]: ggogoog
[Party] [Frostbite]: *has a spaz*
[Party] [Ceptorshock]: adds
[Party] [Frostbite]: adds first!
Stoneskin Totem V is destroyed.
Smoke Bomb fades from you.
You hit Lord Vyletongue for 83.
Lord Vyletongue suffers 39 Fire damage from Darkzed's Pyroblast.
You crit Lord Vyletongue for 199.
Flurry fades from you.
CENKOYUN.COM

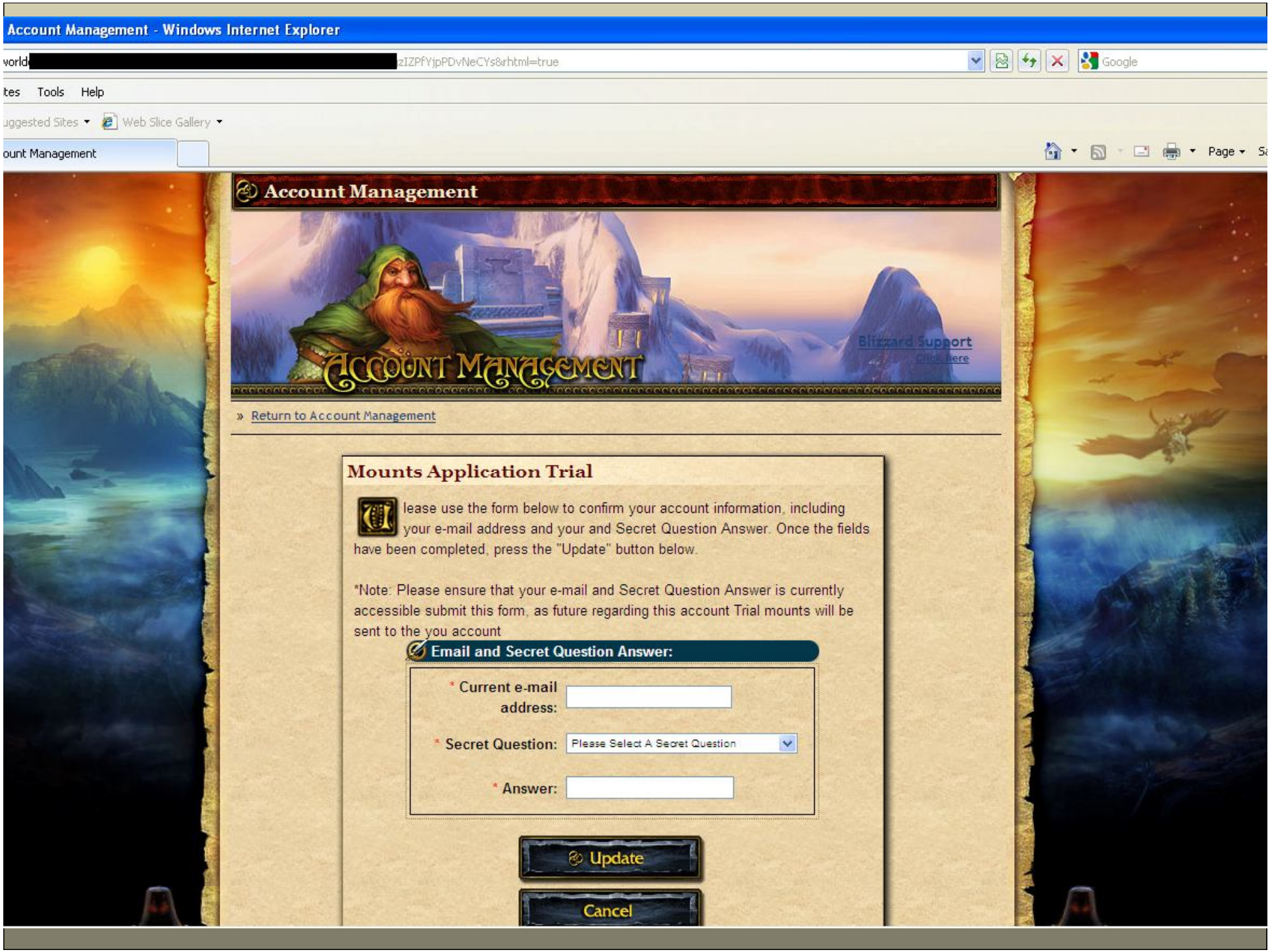
Client versions

- Specific application per game (hybrid clients)
- 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)
  - Micro transactions
  - Additional content
  - Cosmetic/usability improvements
- F2P may require full server control


Account Management - Windows Internet Explorer
[redacted]zIZPfYjpPDvNeCYs&rhtml=true
Google
tes Tools Help
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Web Slice Gallery
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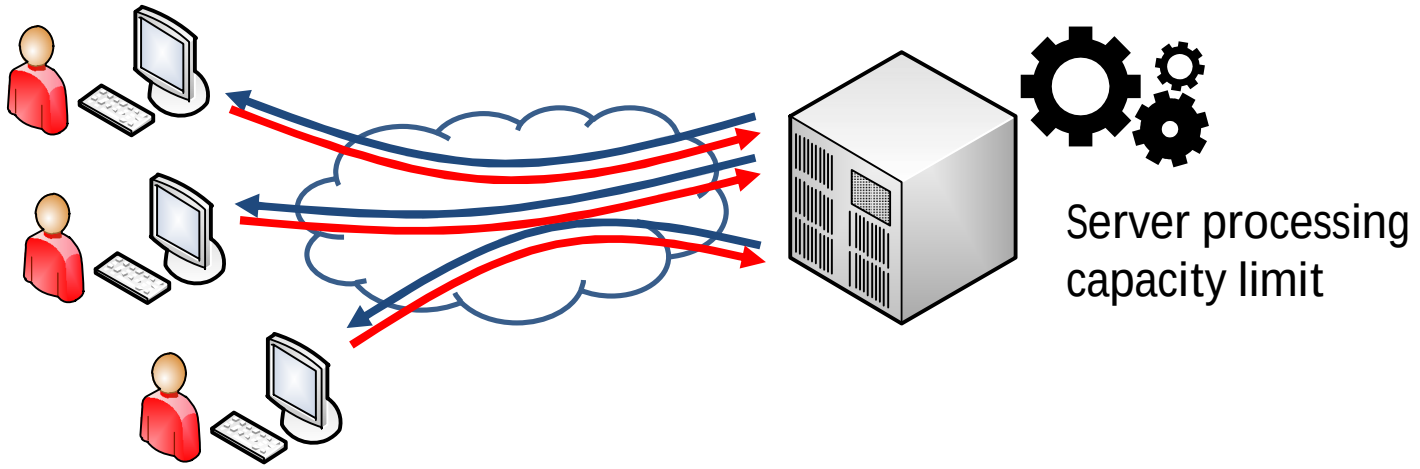
Account Management
ACCOUNT MANAGEMENT
Blizzard Support
Click here
» Return to Account Management
Mounts Application Trial
lease use the form below to confirm your account information, including your e-mail address and your and Secret Question Answer. Once the fields have been completed, press the "Update" 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


Recruit player Forum Help Settings Premium Ranking (96.|167.737 P) Tribe Reports Mail
Village Headquarters Recruit Academy Smithy Rally point
Scouts Traders Claim Recruit Farm Calculator
Map World - 01 (447|492) K44
185748 154143 229152 325337
Production Transports Troops Commands Incoming Buildings Research
Village Headquarters Recruit Academy Smithy Rally point
Scouts Traders Claim Recruit Farm Calculator
22 3:06:36
20 110/110
20 0:24:13
24 24:08:56
Mostra la Mappa
Opzioni visualizzazione
Mostra la mappa politica
Mostra pianificatore d'attacco
Attiva il menu contestuale
Mostra popup
Centra la mappa
Combinato Produzione Trasporti Truppe Comandi In arrivo Edifici Ricerca Gruppi Account manager
Modifica gruppi
Gestore Truppe
Fattoria
21946/24000
19154/24000
9395/24000
23977/24000
16823/24000
23823/24000
Nascondi i villaggi con la fattoria piena
Mostra risultati

Client-Server: Bottlenecks

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



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 games
    - Streaming of gaming sessions

Traffic characterization

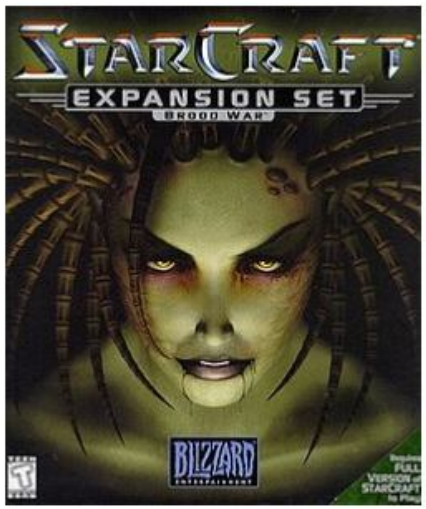
- Game flows:
  - Long lived
  - High packet rate
  - Small payload sizes
  - Low bandwidth usage
  - Using both UDP and TCP
  - ***Dependant on the game genre***
- Identified issues:
  - Delay sensitivity
  - Low but very inefficient bandwidth usage
  - Variable delivery requirements
- Thin client games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

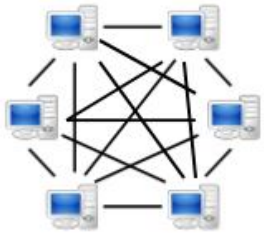
Why so small?

- 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





Peer-to-peer Architecture

Server-client Architecture

StarCraft I (1998-2010)

1-5kbps
(2-8 players)

StarCraft II (2010-present)

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


2294
1270
100/106

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)

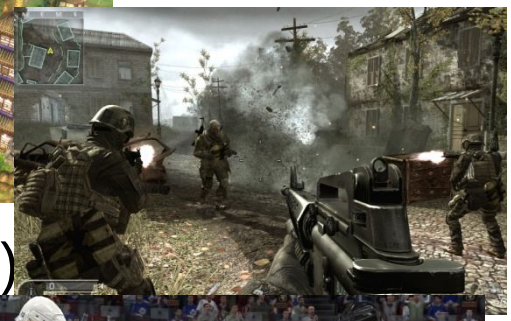
Global trends

- 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%

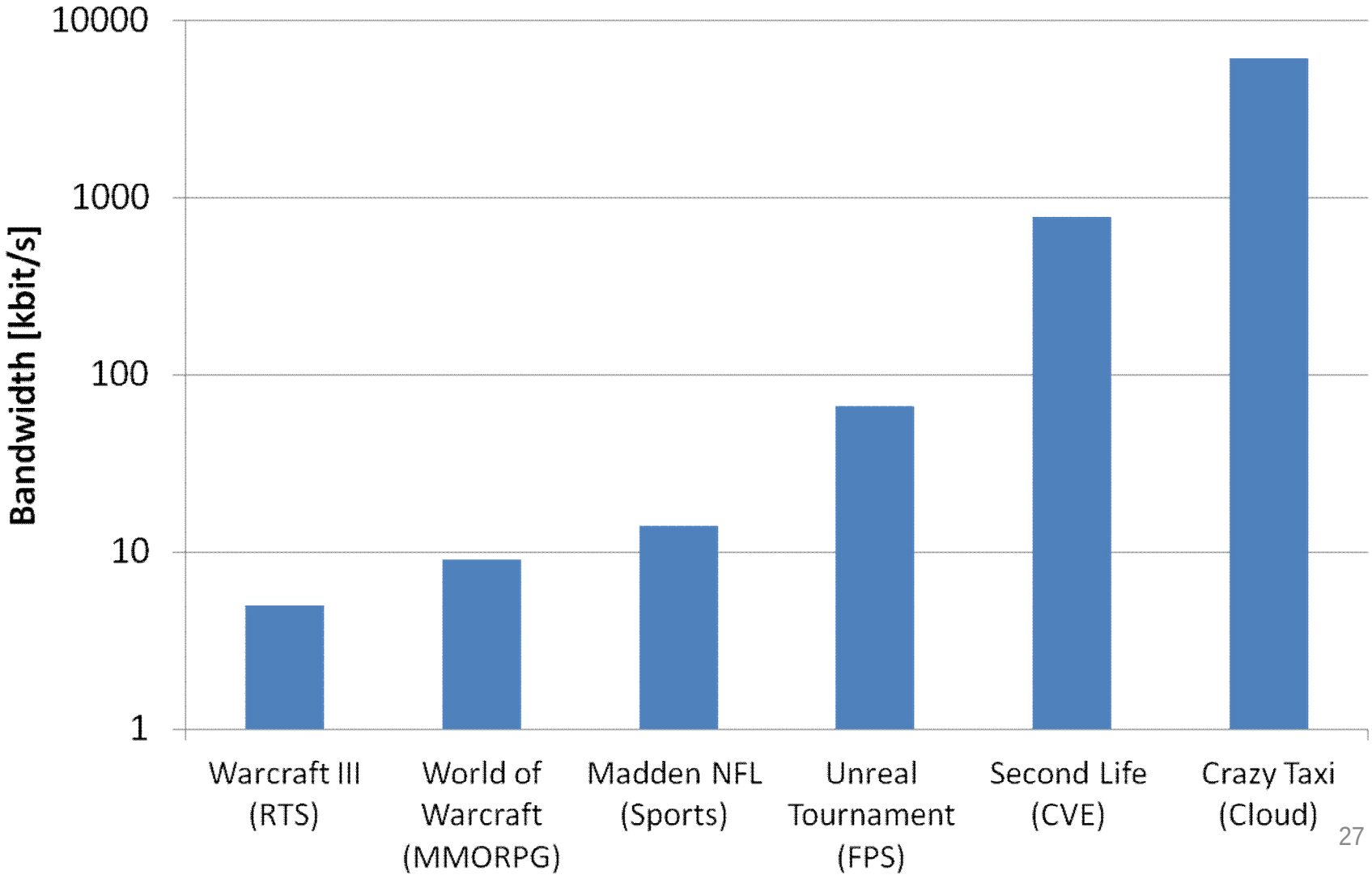
Game genres

- 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.

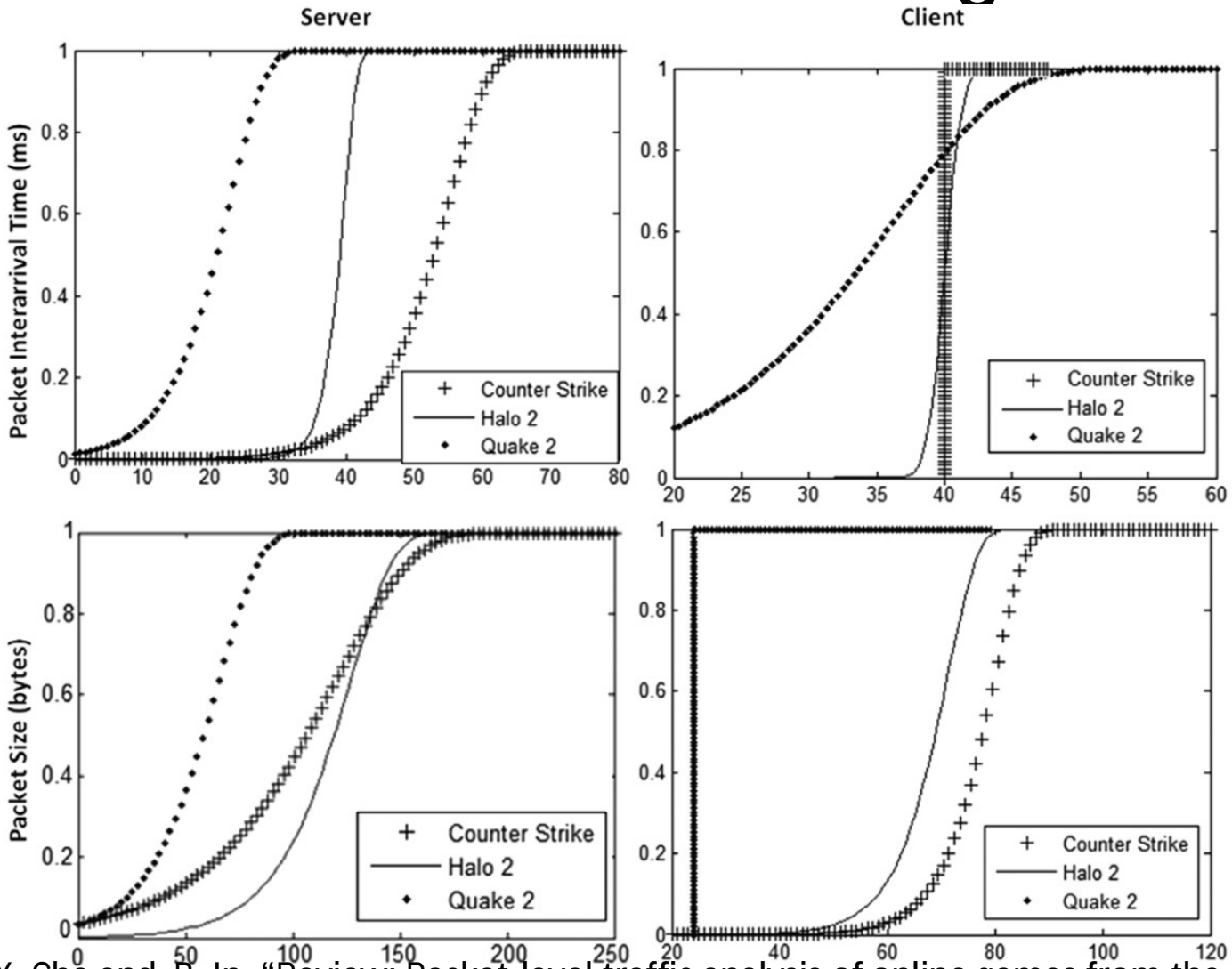
Bandwidth usage across genres



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)


79
[CWC]FreeZer left the game (Disconnect by user.)
-]Ax1s[- J4y-C =:HHx:= left the game (Disconnect by user.)
go cry left the game (Disconnect by user.)
Curlee has joined the game
(3) unnamed has joined the game
Jose Jimenez has joined the game
64
79
4:18
340
Quake2 - 800x600
Rage128 (OEM)
www.xlr8yourmac.com
Bullets

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)

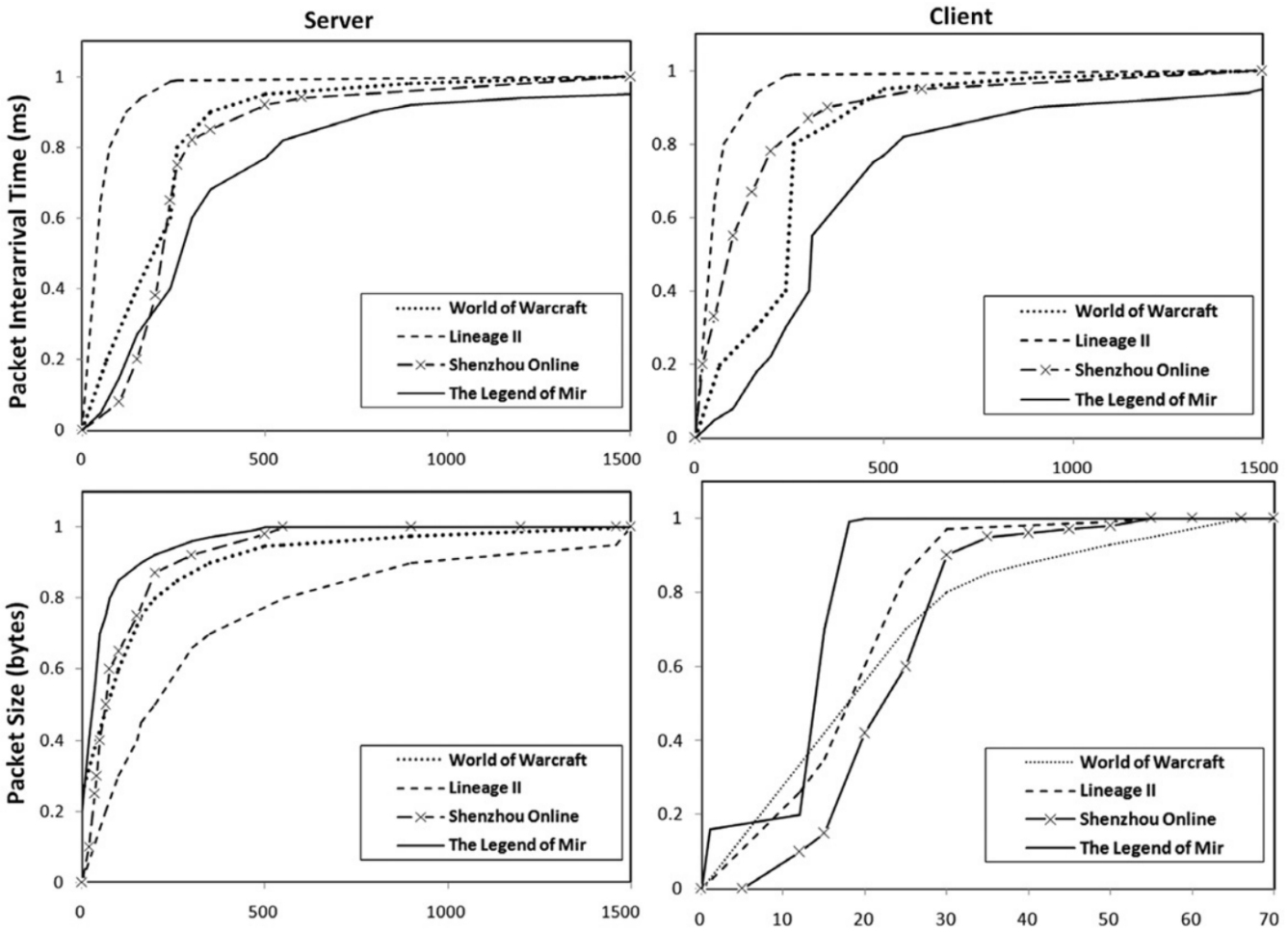
Specific game transport protocol?

- 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



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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