

Part 3: Current Networking Topics

Goals:

- Discuss current networking topics
- Learn emerging technologies

Overview:

- Networking at the edge
- Network apps & services
 - Peer-to-peer
 - Multimedia networking
 - Content delivery networks
 - Multiplayer online games
 - Web 2.0
- Network security

Part 3.9 1

Outline

- Overview of multiplayer online games (MOGs)
- Research issues
- Sample of recent papers
- A few observations

Credit: Based on slides of An-Cheng Huang & Bruce Maggs

Part 3.9 2

Types of MOG: Categorization by Genre

- **First-Person Shooter (FPS)**
 - E.g. Quake III, Call of Duty, Counter-Strike, Half-Life, PlanetSide
- **Role-Playing Game (RPG)**
 - E.g. Dungeons & Dragons , Diablo II, EverQuest, World of Warcraft
- **Real-Time Strategy (RTS)**
 - E.g. Halo, Warcraft 3, Age of Empires, Rise of Nation
- **Other types**
 - Sports game (e.g. Football, Basketball, ...)
 - Racing (e.g. Kart Rider, Trackmania, Darkwind: War on Wheels)
 - Rhythm game (e.g. Dance Dance Revolution, Audition Online)
 - Management game (e.g. Hattrick, The Sims Online, Project RockStar)
 - Text-based game (e.g. Cyber Nations)
 - Social game (e.g. Second Life)
 - Real-world simulation (e.g. flight simulation, air traffic simulation)

Part 3.9 3

First-Person Shooter (FPS)



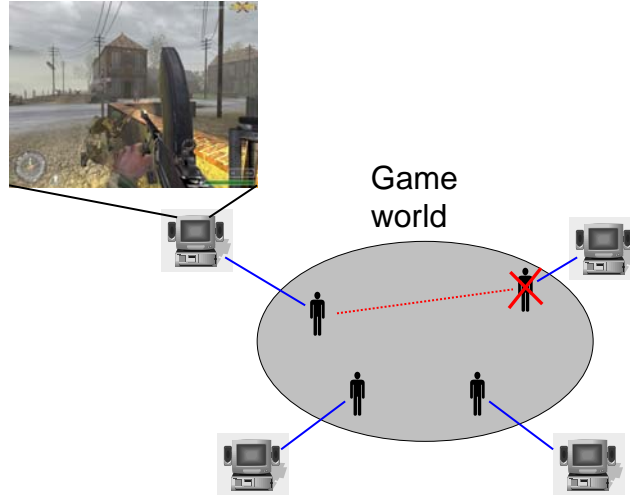
Game world
Player character
Weapons
Aim + shoot



Call of Duty, Activision / Infinity Ward (based on Quake III engine)

Part 3.9 4

FPS (cont.)



Part 3.9 5

Role-Playing Game (RPG)



Game world

Player character

"Weapons"

Accomplish task,
Improve (virtual)
ability, accomplish
harder task, etc.



Diablo II, Blizzard Entertainment / Blizzard North

6

Another RPG (Sort of)



Game world

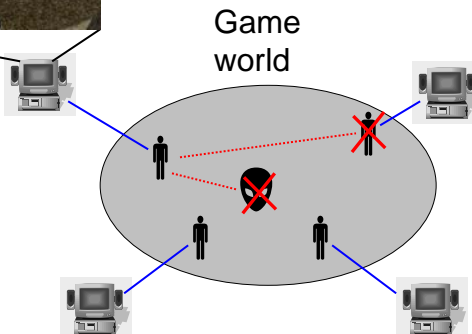
Player character

Accomplish task,
Improve (virtual)
ability, accomplish
harder task, etc.

Robot Factory: manufacture robot soldiers and let them fight

Part 3.9 7

RPG (cont.)



Part 3.9 8

Real-Time Strategy (RTS)



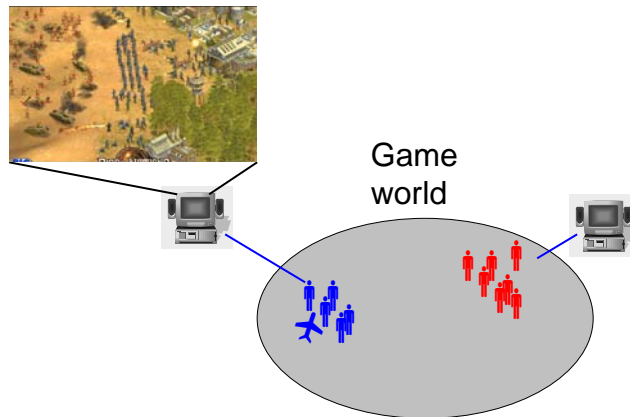
Game world

“Units”

Explore, build,
combat

Rise of Nations, Microsoft

RTS (cont.)



Types of MOG: Categorization by Persistency

- ❑ No persistency
- ❑ Persistent player information
- ❑ Persistent game world

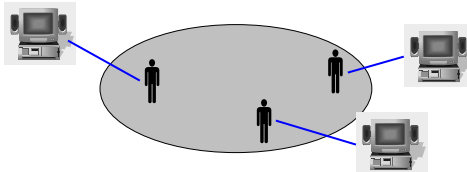
- ❑ Persistency
 - Local: e.g., run a persistent server for a few friends
 - Global: e.g., game company hosts servers for all

Part 3.9 11

No Persistency

Before
gaming
session

During



After

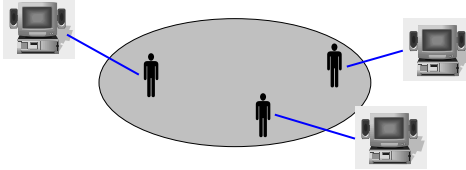
Part 3.9 12

Persistent Player Information

Before
gaming
session



During



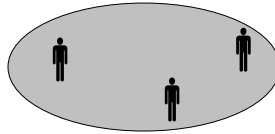
After



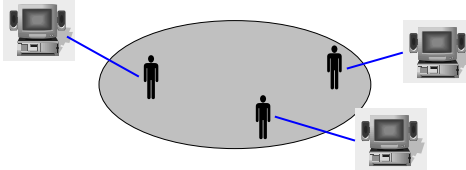
Part 3.9 13

Persistent Game World

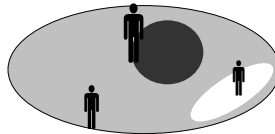
Before
gaming
session



During



After



Part 3.9 14

Scales of MOG

- n : Number of players in a game world
- $n \leq 8$
- $n \leq 64$
- $n > 1000 \rightarrow$ Massively Multiplayer (MMOG)

Part 3.9 15

Interesting Combinations

- $n \leq 64$ (16-32 mostly), no persistency, FPS: e.g., CoD
- $n \leq 8$ (2-4 mostly), no persistency, RTS: RoN
- $n \leq 8$, persistent player information, RPG: Diablo II
- $n > 1000$, persistent game world, RPG: EverQuest
- $n > 1000$, persistent game world, FPS: PlanetSide

Part 3.9 16

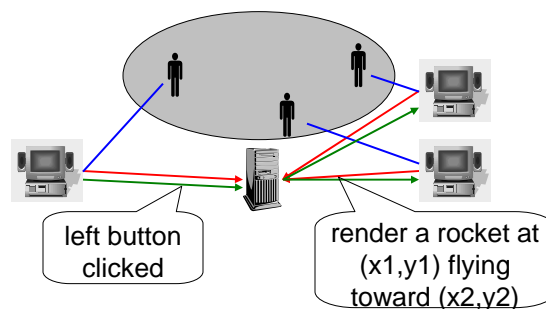
Outline

- Overview of multiplayer online games (MOGs)
- Research issues
- Sample of recent papers
- A few observations

Part 3.9 17

Research Issues (1)

- $n=16-32$, no persistency, FPS (e.g. CoD)
 - Most sensitive to latency, jitter, and relative latency
 - Client/server architecture (anyone can run a server)

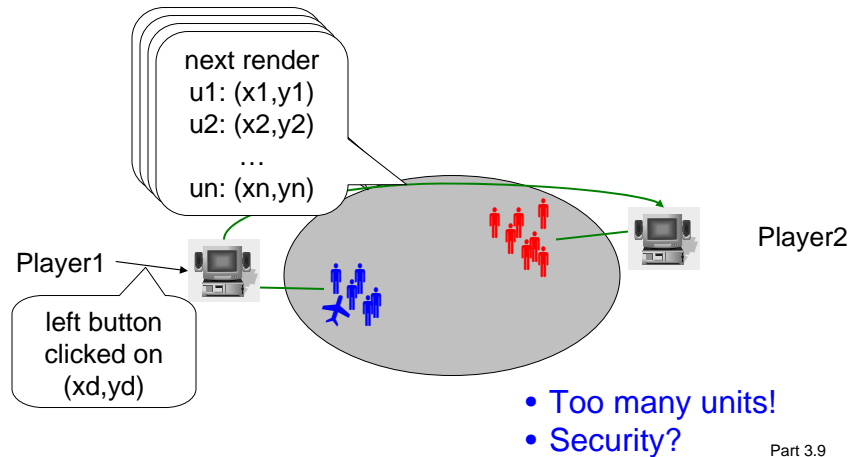


- How to find a (good) server?
- How to meet the performance requirements?
- Security (fairness/anti-cheating)?

Part 3.9 18

Research Issues (2)

- $n=2-4$, no persistency, RTS (e.g. RoN)
 - Each user control many units (e.g., >100s)



Research Issues (3)

- $n \leq 8$, **persistent** player information, RPG
- $n > 1000$, **persistent** game world, RPG & FPS

Subscription-based

- Persistency → Economy



- Performance/Scalability
- Security, Security, Security

Recent Papers

- ❑ Server discovery for FPS
 - [Bernier GDC00], [Henderson NG02]
- ❑ Too many units in RTS
 - [Bettner & Terrano GDC01]
- ❑ Performance requirements of FPS & RTS
 - [Bernier GDC01], [Pantel & Wolf NG02], [Sheldon et al. NG03]
- ❑ Security
 - [Guo et al. NG03], [Baughman & Levine INFOCOM01]

- ❑ Traffic modeling
- ❑ Architecture

Part 3.9 21

Server Discovery for FPS

- ❑ ~50000 servers for Counter Strike [Feng NG03]

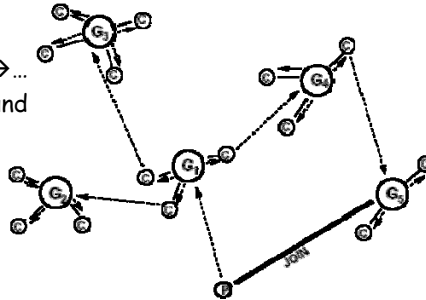
- ❑ [Bernier GDC00] How it's done in Half-Life
 - "Master server" (server directory)
 - Game servers send periodic keepalive messages to master
 - Handle IP-spoofing DoS attacks with challenge/response
 - Reduce bandwidth usage with batched requests
 - Client gets list from directory and polls each server

Part 3.9 22

Server Discovery for FPS (2)

□ [Henderson NG02]

- Problems with centralized: single point of failure, stale/redundant info, client polling servers, etc.
- A peer-to-peer approach
 - Client→server→client→server→...
 - Stop when a suitable server found
- Potential problems
 - Stale/inconsistent info
 - Lack of scalable querying



Part 3.9 23

Recent Papers

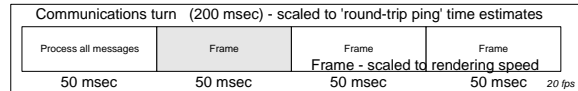
- Server discovery for FPS
 - [Bernier GDC00], [Henderson NG02]
- Too many units in RTS
 - [Bettner & Terrano GDC01]
- Performance requirements of FPS & RTS
 - [Bernier GDC01], [Pantel & Wolf NG02], [Sheldon et al. NG03]
- Security
 - [Guo et al. NG03], [Baughman & Levine INFOCOM01]
- Traffic modeling
- Architecture

Part 3.9 24

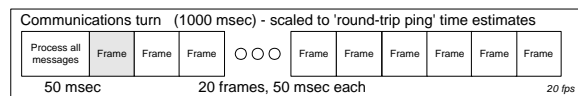
1500 Archers on a 28.8 Modem (3)

❑ Solution: dynamic turn length ("speed control")

200 ms latency
50 ms proc/render

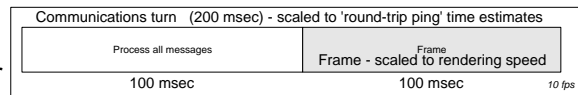


1000 ms latency
50 ms proc/render



high latency + normal processing/rendering

200 ms latency
100 ms proc/render



normal latency + high processing/rendering

Part 3.9 27

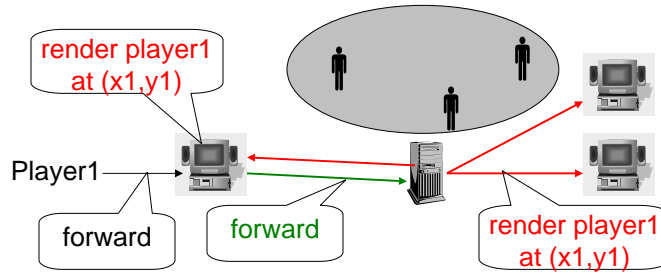
Recent Papers

- ❑ Server discovery for FPS
 - [Bernier GDC00], [Henderson NG02]
- ❑ Too many units in RTS
 - [Bettner & Terrano GDC01]
- ❑ Performance requirements of FPS & RTS
 - [Bernier GDC01], [Pantel & Wolf NG02], [Sheldon et al. NG03]
- ❑ Security
 - [Guo et al. NG03], [Baughman & Levine INFOCOM01]
- ❑ Traffic modeling
- ❑ Architecture

Part 3.9 28

Latency Compensation in Half-Life

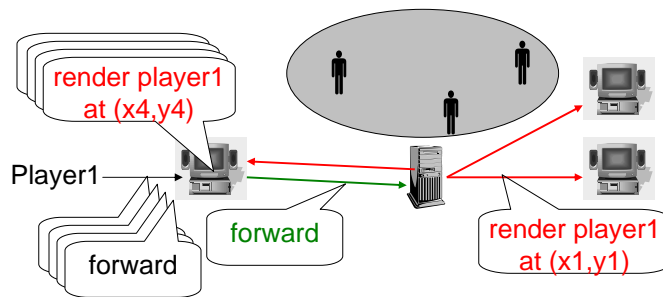
- [Bernier GDC01]
- Naïve approach: dumb client



Response time for player:
round-trip to server + server processing

Part 3.9 29

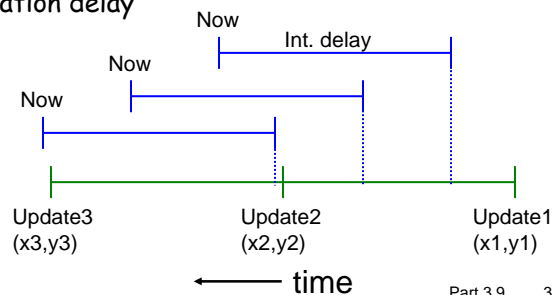
Predicting Where I Am



Part 3.9 30

Predicting Where You Are

- Updates about other players' locations not continuous
- Extrapolation (dead reckoning, or "deduced" reckoning)
 - At last update, player2 is at (x_1, y_1) facing N with speed S
→ It should be at (x_2, y_2) now
 - **Not good**: in FPS, player movement very non-deterministic
- Interpolation
 - Impose an "interpolation delay" for rendering



Part 3.9 31

Lag Compensation

- Interpolation introduces a fixed lag (int. delay)
 - E.g., always see where you were 100 ms ago
 - Need to lead the target when aiming
 - Require players to extrapolate!
- Server-side lag compensation
 - Server uses the old location to compute hit/miss
 - Allows natural aiming/shooting
 - Rationale: game play is about better aiming/shooting, not ability to predict instantaneous latency and leading your shots
 - Possible weird experiences for players being fired upon
→ tradeoff for better game play

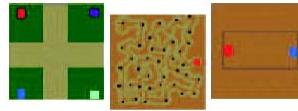
Part 3.9 32

Effect of Latency in Warcraft 3

- [Sheldon et al. NG03]
- Warcraft 3 → RTS (most papers looked at FPS games)

- Methodology

- Categorize RTS player activities: build, explore, combat
- Create maps (game worlds) specifically for these activities
- Two players compete on each map
 - One as server (no latency)
 - 0 to 3500 ms for the other



- Results

- Latency has some effect on exploration (0 to 1000 ms → 25%)
- Little effect on building and combat
- Conclusion: little effect on game outcome, some effect on player gaming experience

Part 3.9 33

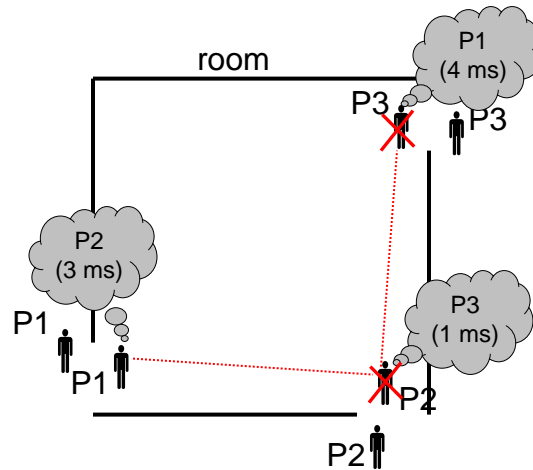
Recent Papers

- Server discovery for FPS
 - [Bernier GDC00], [Henderson NG02]
- Too many units in RTS
 - [Bettner & Terrano GDC01]
- Performance requirements of FPS & RTS
 - [Bernier GDC01], [Pantel & Wolf NG02], [Sheldon et al. NG03]
- Security
 - [Guo et al. NG03], [Baughman & Levine INFOCOM01]
- Traffic modeling
- Architecture

Part 3.9 34

Fair Message Exchange

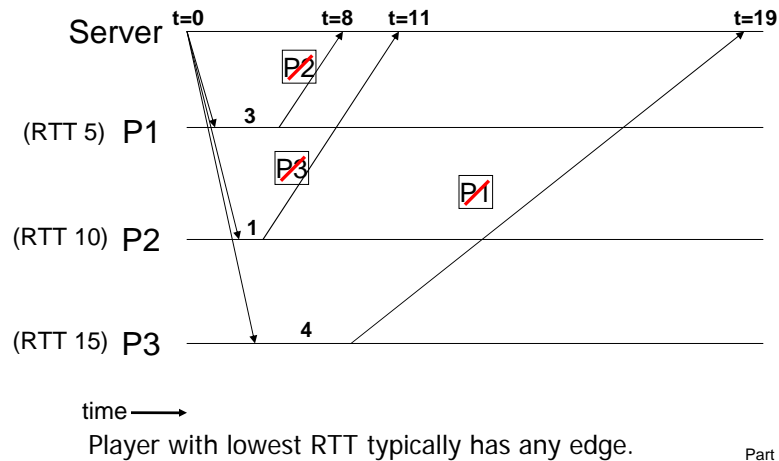
- [Guo et al. NG03]
- Look at "fairness" in client-server games



Part 3.9 35

Fair Message Exchange (2)

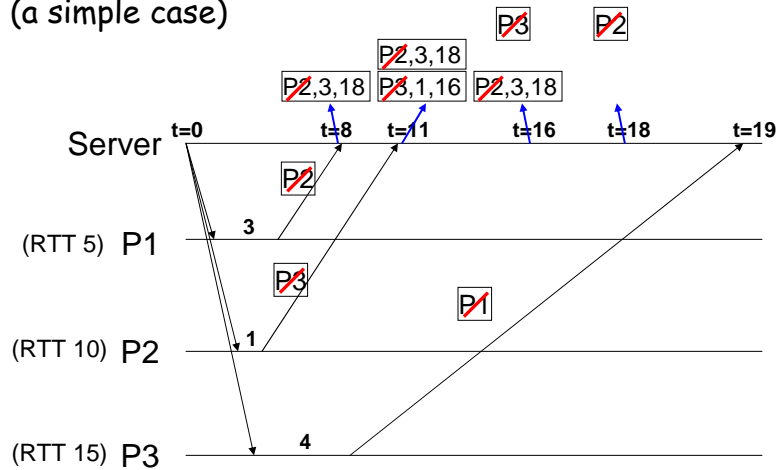
- Different latencies can make the game "unfair"



Part 3.9 36

Fair Message Exchange (3)

- Fair-ordering delivery without synchronized clocks (a simple case)

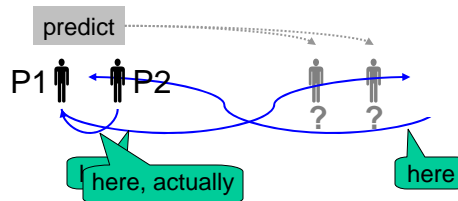


Server waits for max RTT (15) before performing action.
Ordering based on response time.

Part 3.9 37

Cheat-Proof Playout

- [Baughman & Levine INFOCOM01]
- Two types of cheats
 - "Suppress-correct cheat" under dead reckoning (extrapolation)



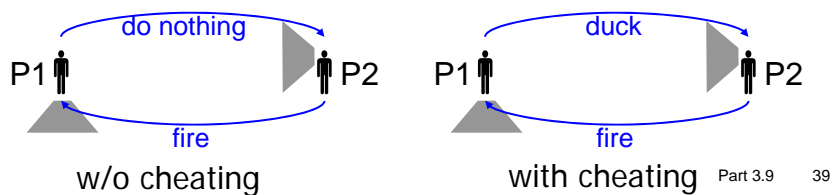
- "Lookahead cheat" game advances in frames

Part 3.9 38

Cheat-Proof Playout

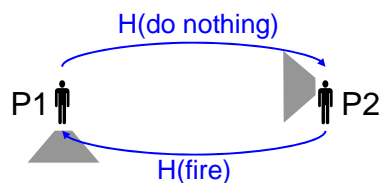
- [Baughman & Levine INFOCOM01]
- Two types of cheats
 - "Suppress-correct cheat" under dead reckoning (extrapolation)

- "Lookahead cheat" game advances in frames



Cheat-Proof Playout (2)

- **Suppress-correct** undetectable under dead reckoning
 - Don't do dead reckoning
- Present **lockstep protocol** that prevents **lookahead**
 - Idea: send crypto hash of action before sending plain text
 - Effectively synchronize all players
 - significant performance penalty
 - only synchronize with players whose actions can affect you



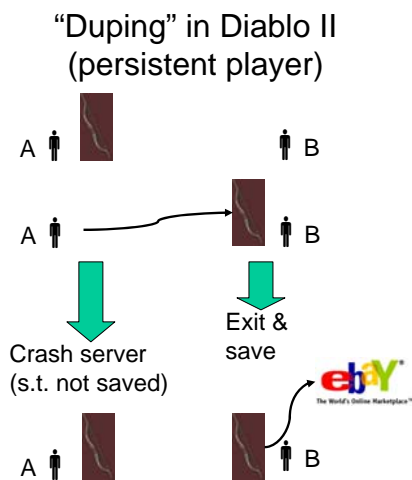
Outline

- ❑ Overview of multiplayer online games (MOGs)
- ❑ Research issues
- ❑ Sample of recent papers
- ❑ A few observations

Part 3.9 41

Security

- ❑ How are cheaters actually cheating in reality?

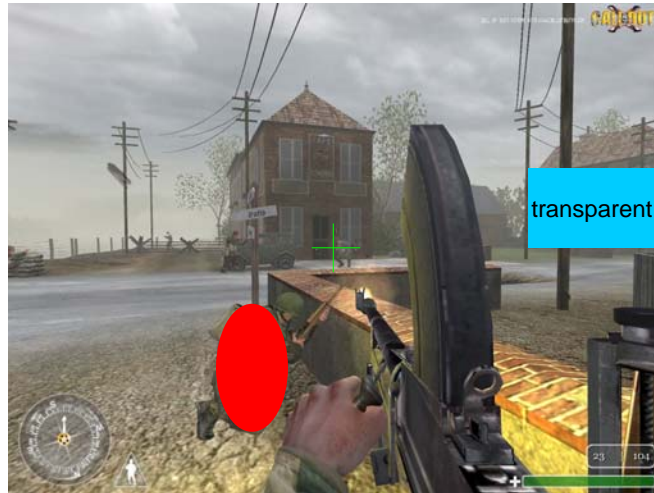


Maphack for RTS
(should only see
occupied area)
→ modify game client
to display everything

Part 3.9 42

Security (2)

- Video card driver / texture, auto-aim / auto-shoot bots



Part 3.9 43

Casual & Wireless Games

- A lot of them in the GDCs: [Gordon GDC01], [Opas GDC01], [Collier GDC03], [Meretzky GDC03], [Oliver GDC03], [Trevett GDC03]

Casual games

| Games | Unique Users |
|------------------|--------------|
| Solitaire | 46.7 M |
| Freecell | 21.3 M |
| Hearts | 6.6 M |
| Minesweeper | 5.4 M |
| Spider Solitaire | 4.6 M |
| MS Ent. Pack | 4.2 M |
| 3D Pinball | 2.6 M |
| The Sims | 1.6 M |
| Snood | 1.5 M |
| Slingo | 1.5 M |

Wireless games

- Cell phone or similar
- Taking off in Japan? [Collier GDC03]
- J2ME?

Part 3.9 44

Additional Slides:

PLATO - Ancestor of MOG

The following slides are FYI

Part 3.9 45

PLATO Computer System

- ❑ PLATO IV Developed by the University of Illinois and the Control Data Corporation
- ❑ 1961 timesharing PLATO II begins
- ❑ 1964 invention of plasma panel
- ❑ 1968 PLATO IV begins
- ❑ Spun off as "NovaNET" late 1980's
- ❑ Revived at www.cyber1.org

PLATO = Programmed Logic for Automated Teaching Operations

Part 3.9 46

Innovations

- ❑ first LARGE on-line community
- ❑ invention of the plasma panel
- ❑ multimedia
- ❑ "personal notes" - email
- ❑ "group notes" - newsgroups
- ❑ "remote consulting mode" - like PC anywhere
- ❑ widely used "term talk" (like Unix talk)
- ❑ multiplayer graphical games
- ❑ IBM correctly attributes Lotus Notes to PLATO

Part 3.9 47

Hardware

- ❑ Control Data mainframes designed by Seymour Cray
- ❑ Cyber 70, 176, CDC 6600, 7600
- ❑ Magnetic core memory
- ❑ 60-bit words, 6-bit characters
- ❑ One's-complement arithmetic
- ❑ Up to 1000 simultaneous users
- ❑ (NovaNET runs on Alpha today?)

Part 3.9 48

PLATO IV Terminal

- ❑ Plasma panel and CRT versions
- ❑ Same 512 x 512 display
- ❑ 8080 processor implemented all graphics

Part 3.9 49

PLATO IV Terminal



From <http://plato.filmtechnik.com/>

Part 3.9 50

Multiplayer Games

- ❑ Dungeons and Dragons
 - orthanc, avatar
- ❑ Space
 - empire

Part 3.9 51

Empire



```
NowaNET
-----
EMPIRE
Total games since 18/08/87 = 166995
Total users since 18/08/87 = 112478
Average * users per day = 18
Number of people now in Empire (including you): 1
Players Total Mine / Monthly
+Rouulans 0 488 0
+Klingons 1 63 0
+Federation 0 181 0
+Orion 0 388 1
-----
Universe Conquered 09/08/84 at 16:52:22.
By: jeff / latech For: Orion
-----
Enter Your Pseudonym: bruce
-----
Copyright © 1977, 1978 -- by Charles Miller & Gary Fritz
```

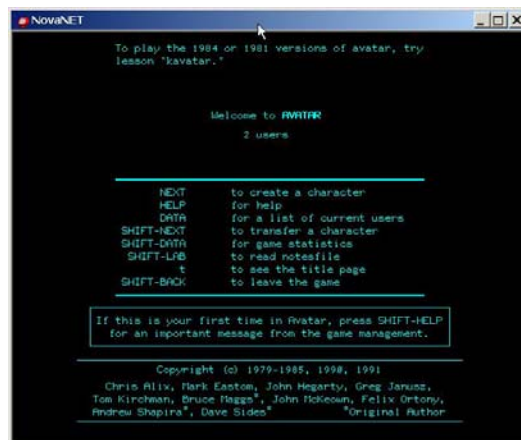
Part 3.9 52

Empire



Part 3.9 53

Avatar



Part 3.9 54

Avatar

