Transforming the very fabric of the Internet into a high-performance video game machine

Massively Multi-player Games and the Systems That Love Them

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What is “Massive” anyway?

A Simple Definition of MMOGs

1000's of players simultaneously connecting
Sharing actions and state
Persistent worlds
MMOGs are not limited to...
- Specific Game Genres
- Deep/long term commitment
- 3D immersive environments

MMOs are breaking out of their molds

The History of MMOGs

MIT Spacewar

Year: 1962

Platform: PDP-1 + CRT

Programmers: Steve Russell *et. al.*

Multiplayer games in pre-history

The History of MMOGs

Empire/Avatar

Year: Late 70's early 80's

Platform: Plato Computer system (CDC)

Multiplayer games in pre-history

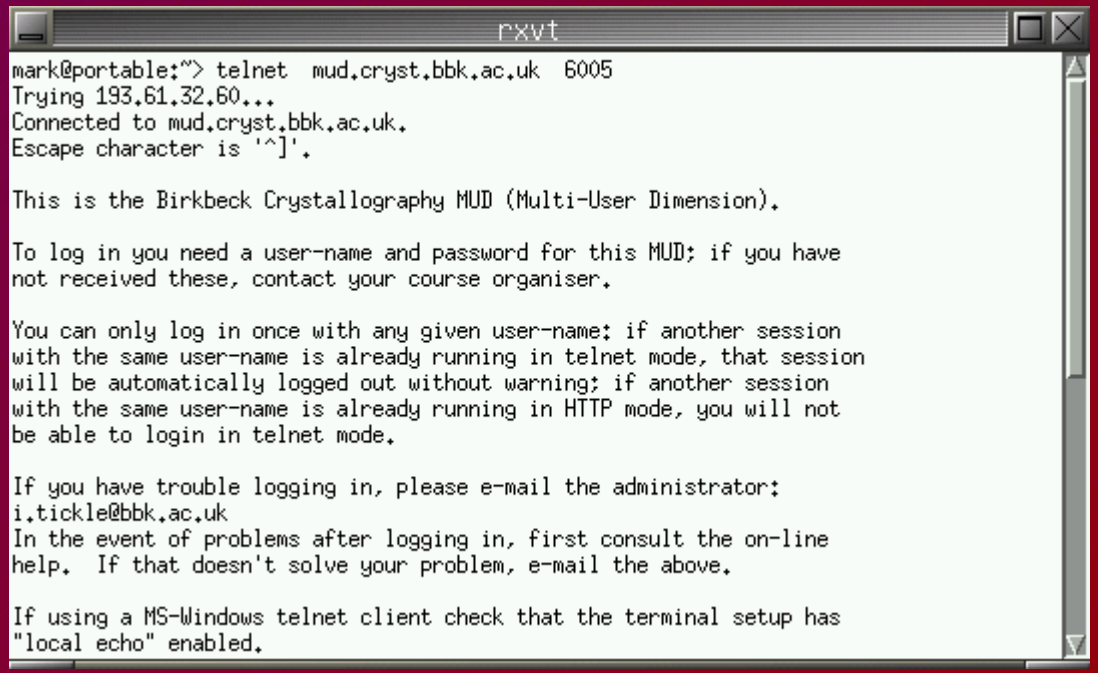
The History of MMOGs

Multi-User Dungeon (MUDs)

Year: 1978 onward

Platform: DECSystem-10

Programmers: Roy Trubshaw, Richard Bartle



Multiplayer games start to evolve to their present form

The History of MMOGs

Meridian 59

Year: 1996

Platform: Intel/PC

Programmers: 3DO

First “Modern” MMO

The History of MMOGs

Ultima Online

Year: 1997

Platform: Intel/PC

Origin Systems

The MMO is truly born

What makes an MMOG Unique

- MMOGs may have 100,000's of simultaneous players
- Increasingly (de)-optimized for Broadband
- Proliferation of Objects/Assets
- Potentially Hostile Customers (“griefers”)
  - Cheating
  - DOS attacks

The Growth of the Market

The Real-Life Economics of Games

Enormous Potential Driven by Consumer Demand

Massively-multiplayer (MMP) Subscribers Doubled from 2002-2003
5 million at the end of 2001
10 million at the end of 2002

Subscription price-points and subscribers Q1 2003

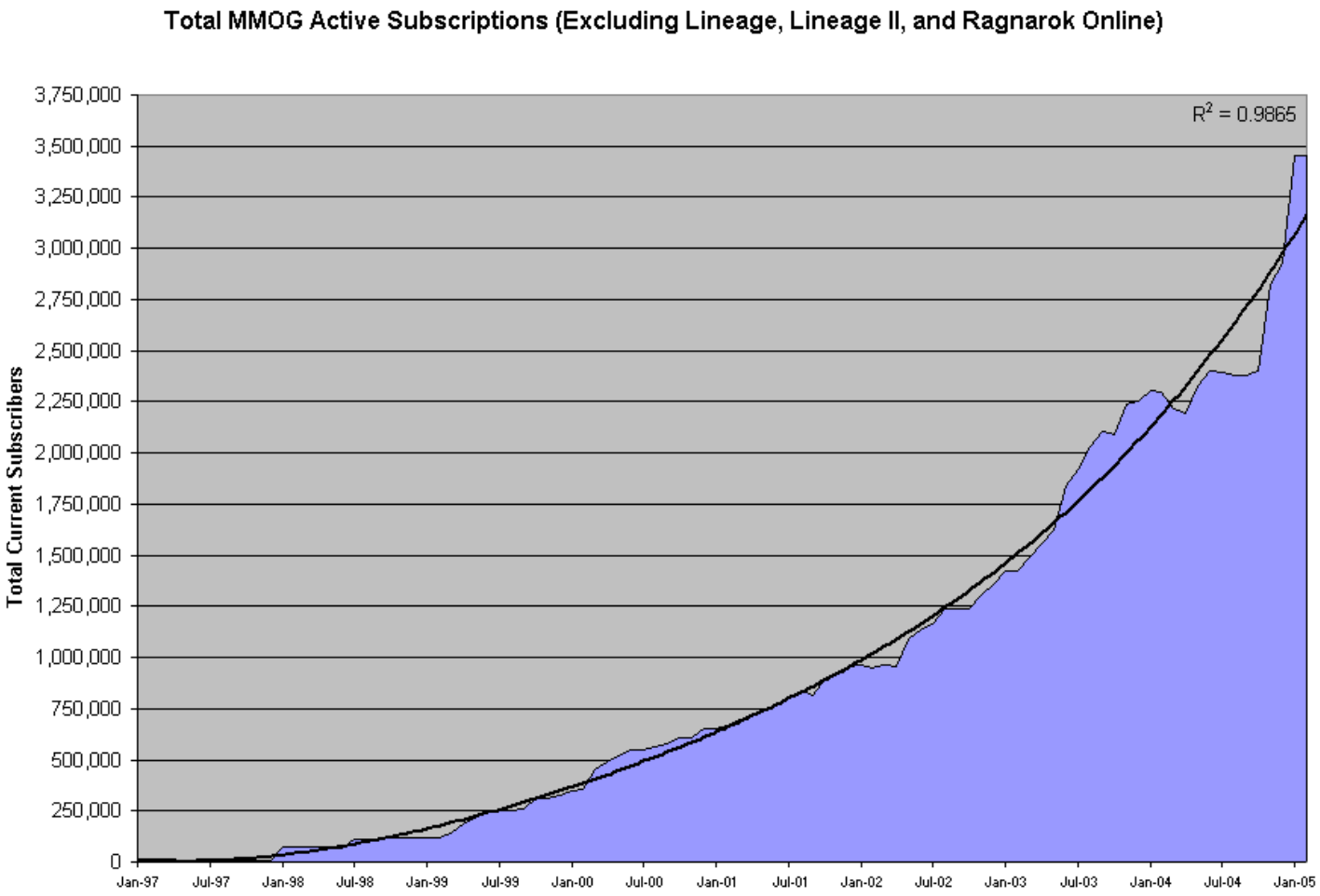
MuOnline/Legend of Mir (Asia)	5,000,000	$ 8.00/mo
Lineage (S. Korea)	4,000,000	$15.00/mo
EverQuest	435,000	$12.95/mo
Star Wars: Galaxies	300,000	$12.95/mo
Ultima Online	250,000	$ 9.95/mo

Also: 25,000,000 gamers playing free "session-based" games

(sources: Mercer Consulting & Informedia Group, Company Sources)

The Growth of Games

Identify the Curve



(sources: MMOGCHART.COM, Sir Bruce

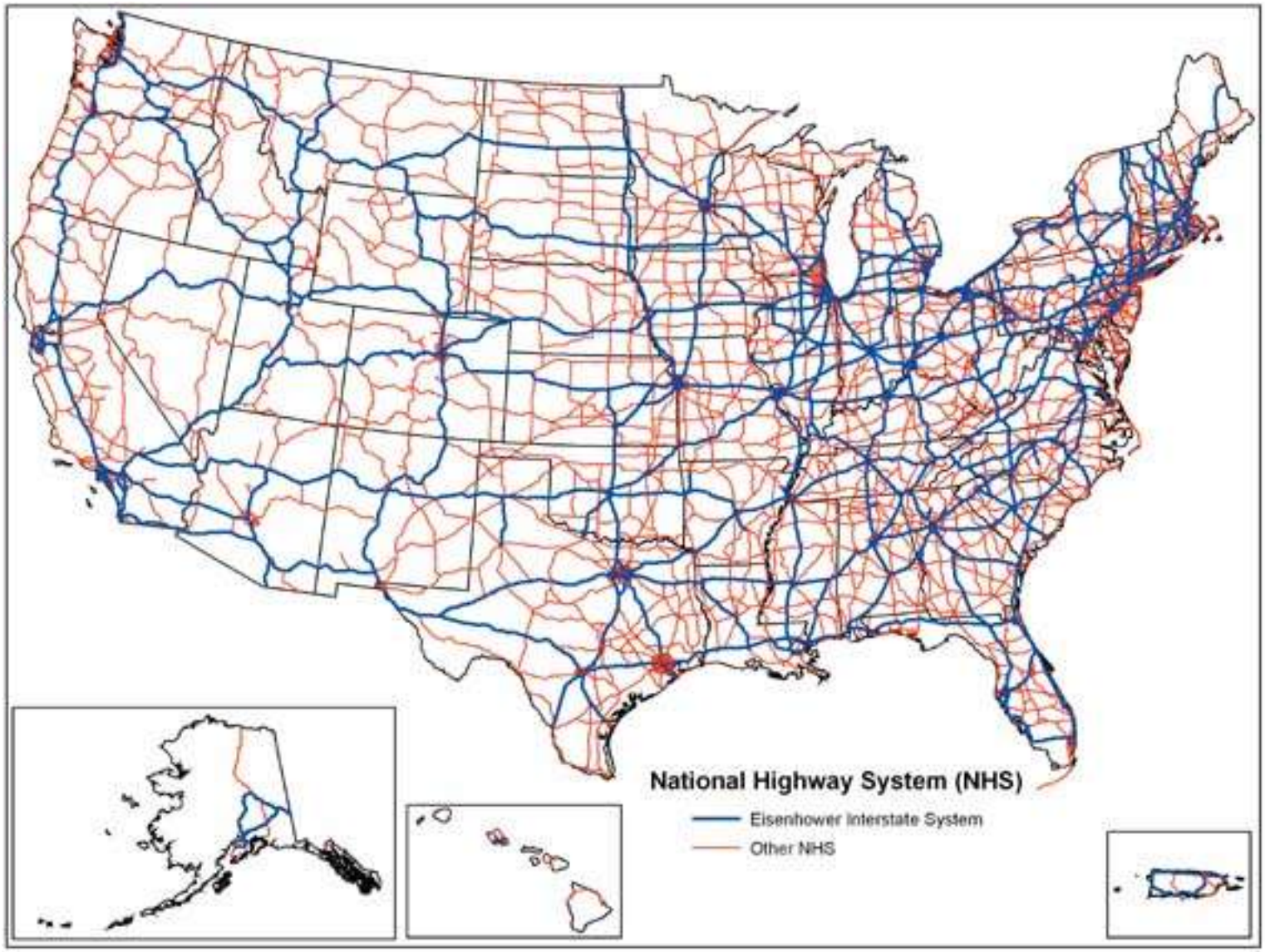
The Size of On-line Economies

Some popular on-line MMOGs have economies (as determined by real-life financial transaction) larger than many countries

Based on a study of Ebay auctions, in 2002 Edward Castronova characterized the economic size of Sony's *Everquest*

- Average player earns over $3.00US an hour
- Annual gross exports of more that $5,000,000US
- 77th richest "country" in the world, with a per capita gross income greater than Russia's.

20th Century Topology

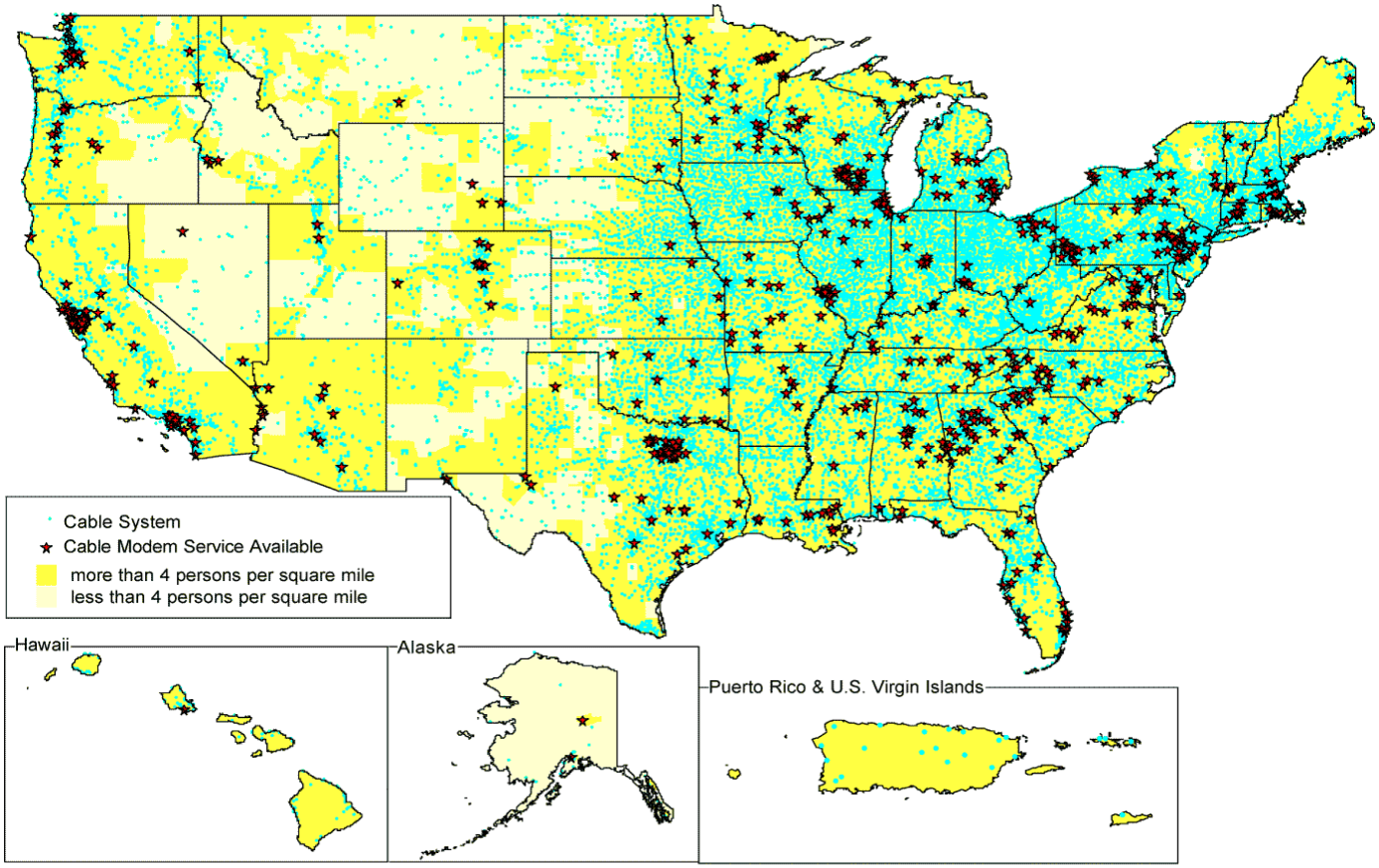


The 21st Century Evolving Geography (cont.)

Federal Communications Commission

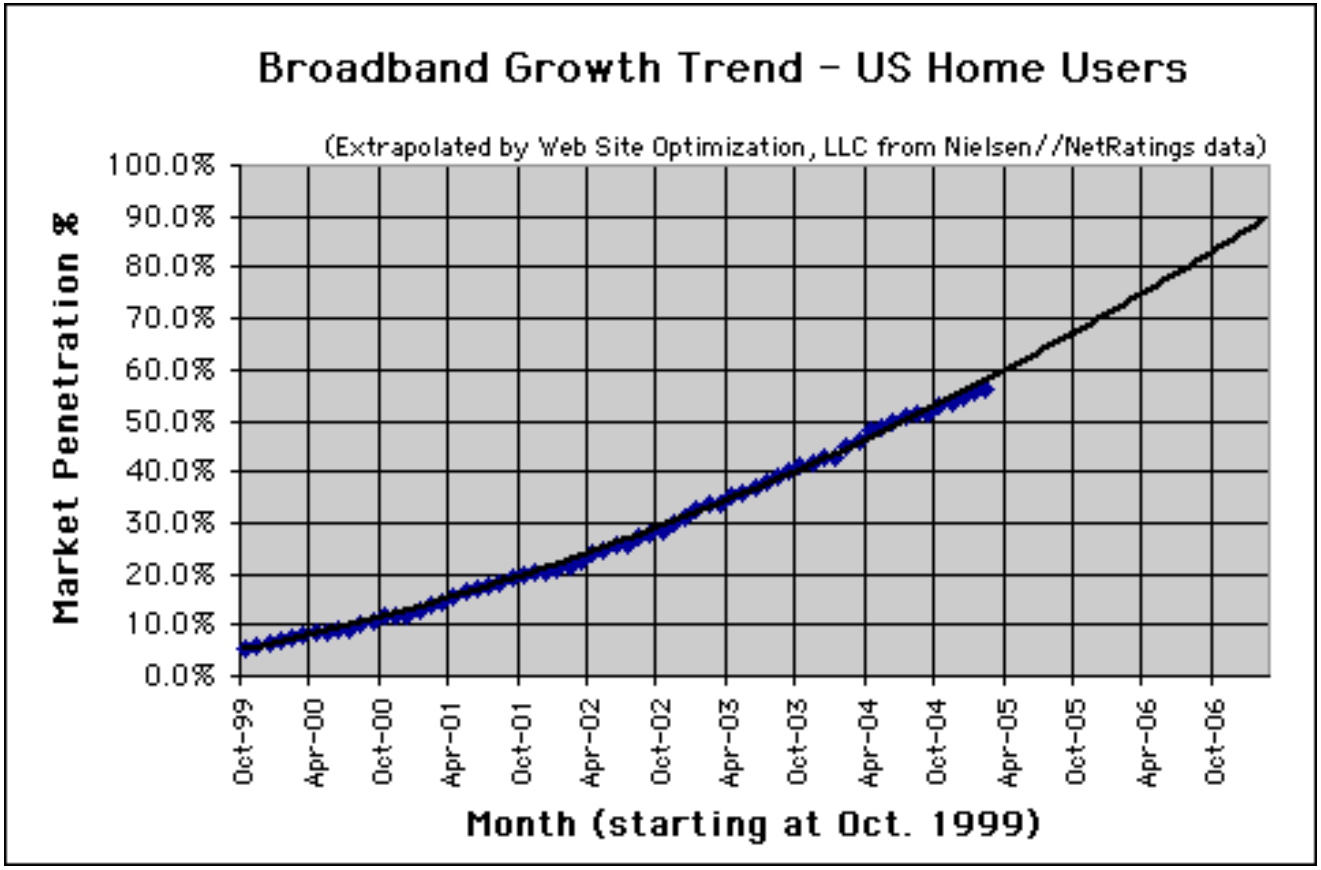
FCC 00-290

Figure 12
Cable Modem Deployment in the United States



Source: FCC cable system registrations and aeronautical frequency notifications; "Advanced Telecommunications in Rural America," NTIA, RUS.

The 21st Century Evolving Geography



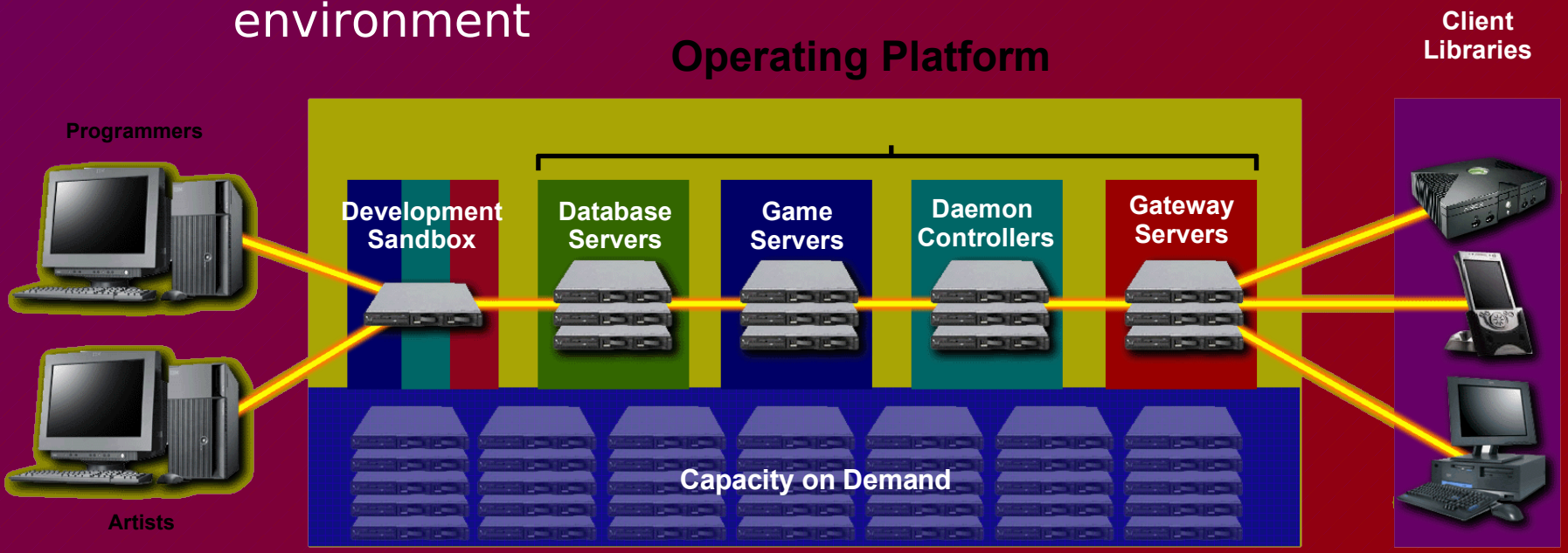
(Source: www.websiteoptimization.com)

Technical Challenges

Technology

IRL, one builds scalable, reliable, distributed systems in a well defined environment

In MMOGs, one builds scalable, reliable, distributed systems in a dynamic, non-deterministic environment

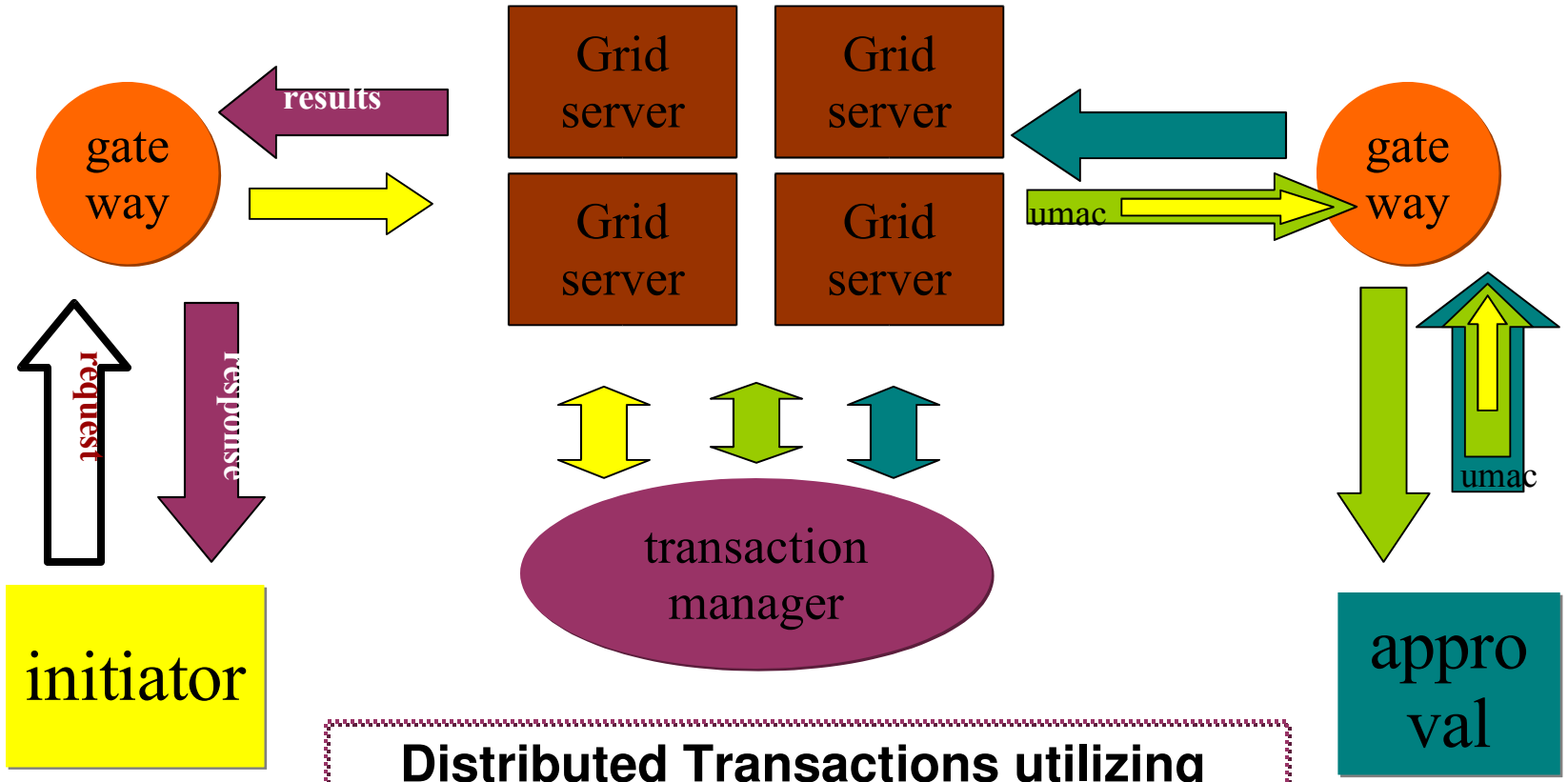


Bits and Bytes: The Wire Protocol

Protocols supporting MMOGs must be well-chosen

- TCP vs. UDP?
- Low latency vs. Reliability (optional)?
- Base on existing protocols? (ex. Datagram Congestion Control Protocol (DCCP), Stream Control Transmission Protocol (SCTP, RFC 2960))
- Security (message hashing, encryption, anti-spoofing)?
- Heterogeneous platform support?

Distributed ACID Transactions



Distributed Transactions utilizing cryptologically strong encapsulation, and allowing for remote authorization provide for conditional commitment "in game".

Distributed State

- State for millions of objects on thousands of clients must be distributed and synchronized
  - Low latency requirements
    - As play styles move away from traditional role-playing games, latency requirements become even more challenging.
  - Calculation of occlusion, visibility
  - State as perceived on any client must be internally consistent and in consonance with other clients ("good enough").
  - Dynamic, stochastic, and capricious nature of play is, er, problematical
    - (Imagine doing CFD on a mesh which is controlled by thousands of users. At the same time. And they like to break things.)
  - State not only needs to be distributed; it must also be transformed.

Security

People cheat, so all systems much be secure

- Transport Layer: packets veracity and integrity must be maintained. Spoofing must be prevented. Packet rewriting but be prevented.
- Protocol Layer: Sensitive data must be protected though encryption or blind protocols – it if is clear-text, it *will* be compromised.
- Resource Level: If your machines can be compromised, they will be. The player's machines will be compromised.
- Service Level. Denial of Service attacks *will* be directed at your service and your users.
- Software exploits. They exist. They *will* be found. Plan for it.

When Security Fails

Ultima OnLine (Wildly Popular MMP Role Playing Game)

On August 8th, 1977, Lord British (alter-ego of game designer Richard Garriot) was murdered. The weapon used was Fire Field. Murderer was banned from world.

Early on, a server bug allowed the cloning of Gold on some Ultima Worlds. Hyper-inflationary economics resulted

Artificial Intelligence and Non-player Characters

- Not only do you have 100,000 players, you have 100,000 automated Self-transforming Machine Elves, and they don't pay you any money.
  - Level-of-detail AI in a distributed environment
  - Highly efficient algorithms and implementations
  - How to make stupid processes seem smart?
  - State transmission between AI processes, in a distributed environment.

Advanced Clustering Techniques

In a dynamic environment, static clustering may not work

- Load balancing may necessitate ad-hoc clusters
- Functions and processes may need to be migrated in real-time.
- The complexity of the content (and the domain) necessitate very complex interactions between physical resources (this isn't MPI!).
- Resource management in a profoundly heterogeneous environment.
- Game clusters can easily generate/receive Gigabits of data per second.
- Malleable network topologies.

Game Instancing

- Create games where 1,000s of players can have private experiences.
  - User-driven spawning of game spaces and computational resources
  - E.g. Every war party gets there own musty dungeon, complete with dragons and kobolds.
  - Seamless transitions between shared and private spaces.

Content Abstraction

The current state of the art is "automatic legacy"

- All games are custom crafted, with game content tied to infrastructure (but some companies, such as Butterfly.net, are addressing this)
- How does one abstract functionality, engender generality, and create content-agnostic technology *without* loosing performance?
  - (Imagine trying to address the previous technical challenges with a general solution, for multiple game types/play styles.)
  - Game are difficult, expensive, and slow to develop. Until technology can be leveraged across titles, the industry will not flourish.

Episodic Content

- The current state of the art are game snapshots with monolithic updates
  - As games evolve, the industry is moving towards more episodic content
  - Configuration management on a distributed system, with multiple concurrent versions.
    - Distribution of content
    - Compatibility with client software
    - Non-deterministic paths of unfoldment

Testing: Development

- The distributed nature of the beast makes replicability "problematical at best."
  - 10's – 100's of servers, 100's – 1,000's of clients
- Combinatorics of interactions daunting
  - 10's of player classes, 100's of interaction, 1,000's of objects. Tested daily if possible
- Many types of development tests needed
  - Regression, both in unit and end-to-end
  - Stress/Loading
  - Live testers and scripted clients
- Instrumentation of systems key to testing in non-deterministic/heterogeneous environment.

Testing: Beta

The scale of MMOs makes in neigh well impossible to test at load, at scale.

> *"This 7-day test will help Blizzard optimize World of Warcraft to deliver the best online-gaming experience possible when it launches later this year. Gamers in North America will have the opportunity to become one of over 100,000 people chosen to participate in the stress test and try out World of Warcraft before its release. "*
>
> *--Blizzard Press Release, WoW*

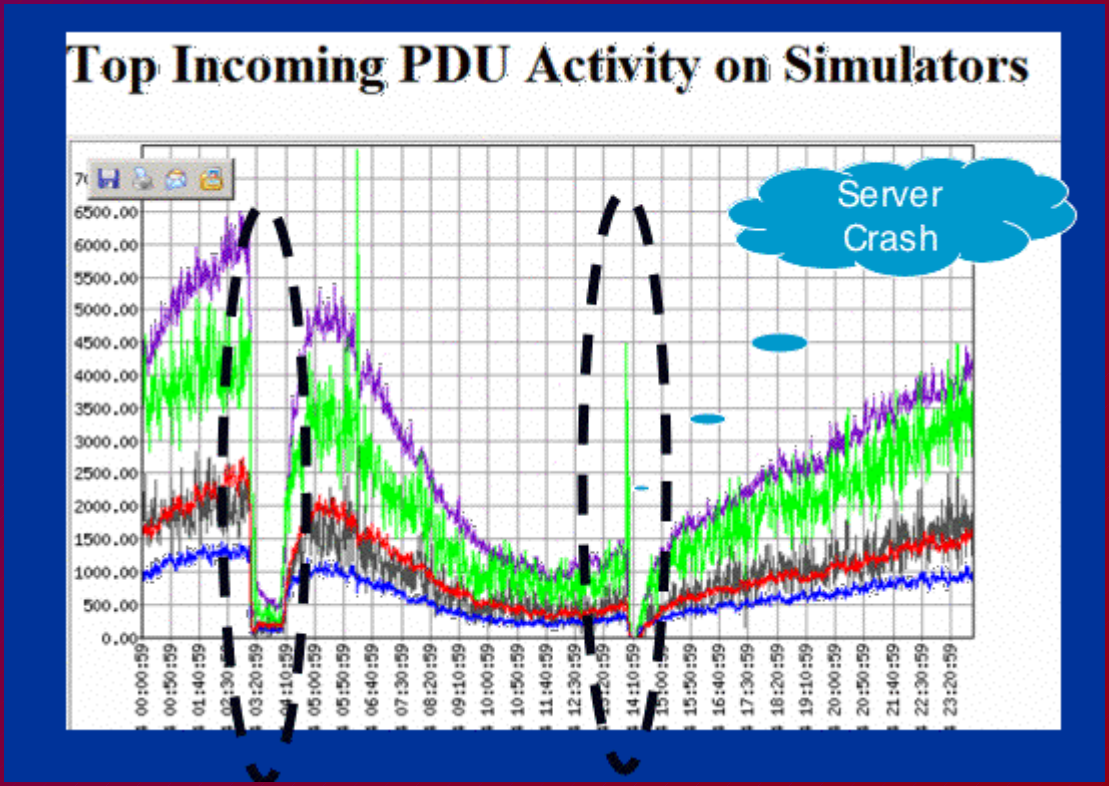
(In the first day of open play, over 200,000 players created accounts, and 100,000 played at the same time)

Testing: Live

A variety of testing must be performed wit the live system

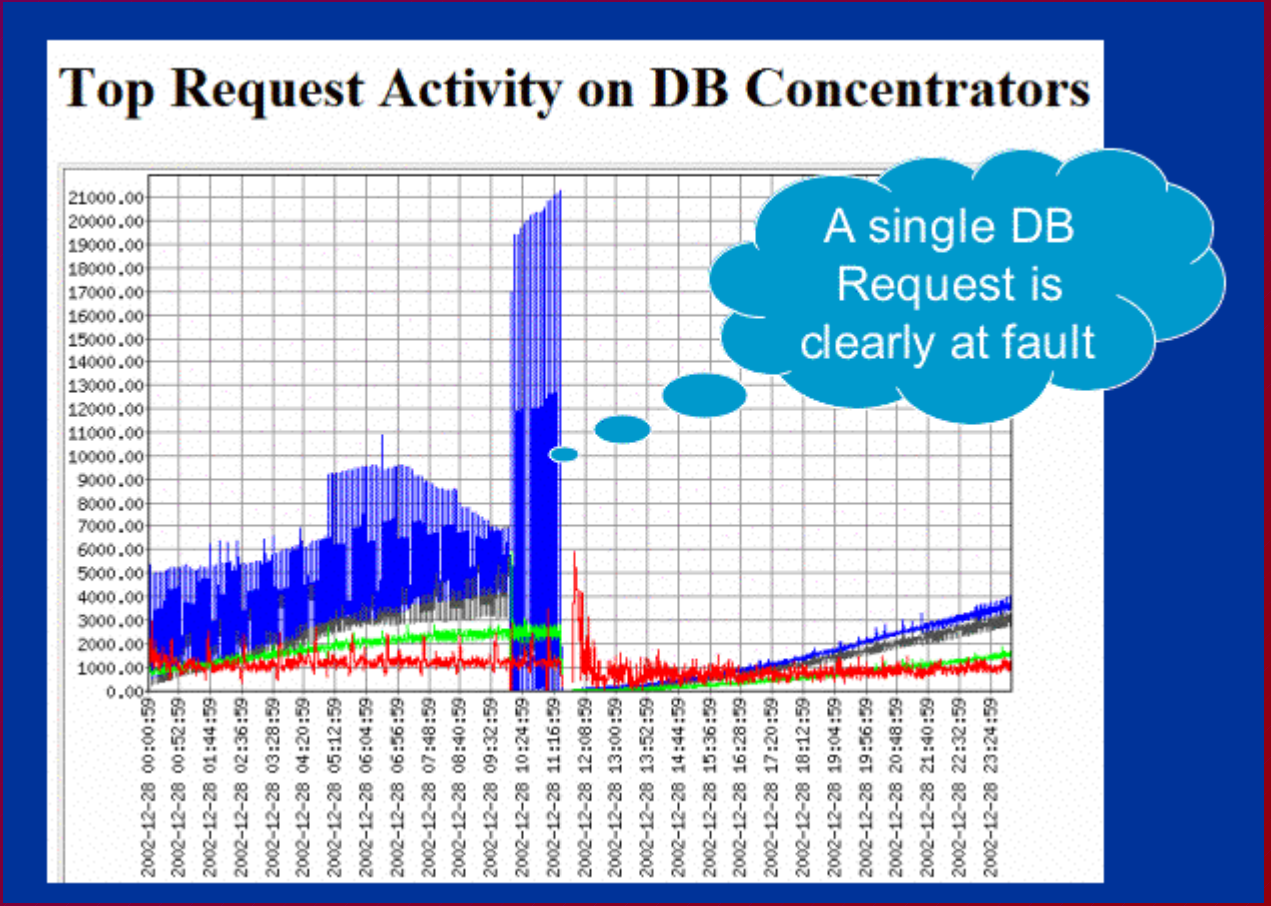
- Playability cannot be entirely predicted beforehand.
  - What are players doing?
  - What are they *not* doing?
- What anomalies are seen?
  - A Bug?
  - Design Flaw?
  - Cheating?
- Can you predict what will break next?

Testing: An Example from TSO
Instrumentation is Key for finding Bugs



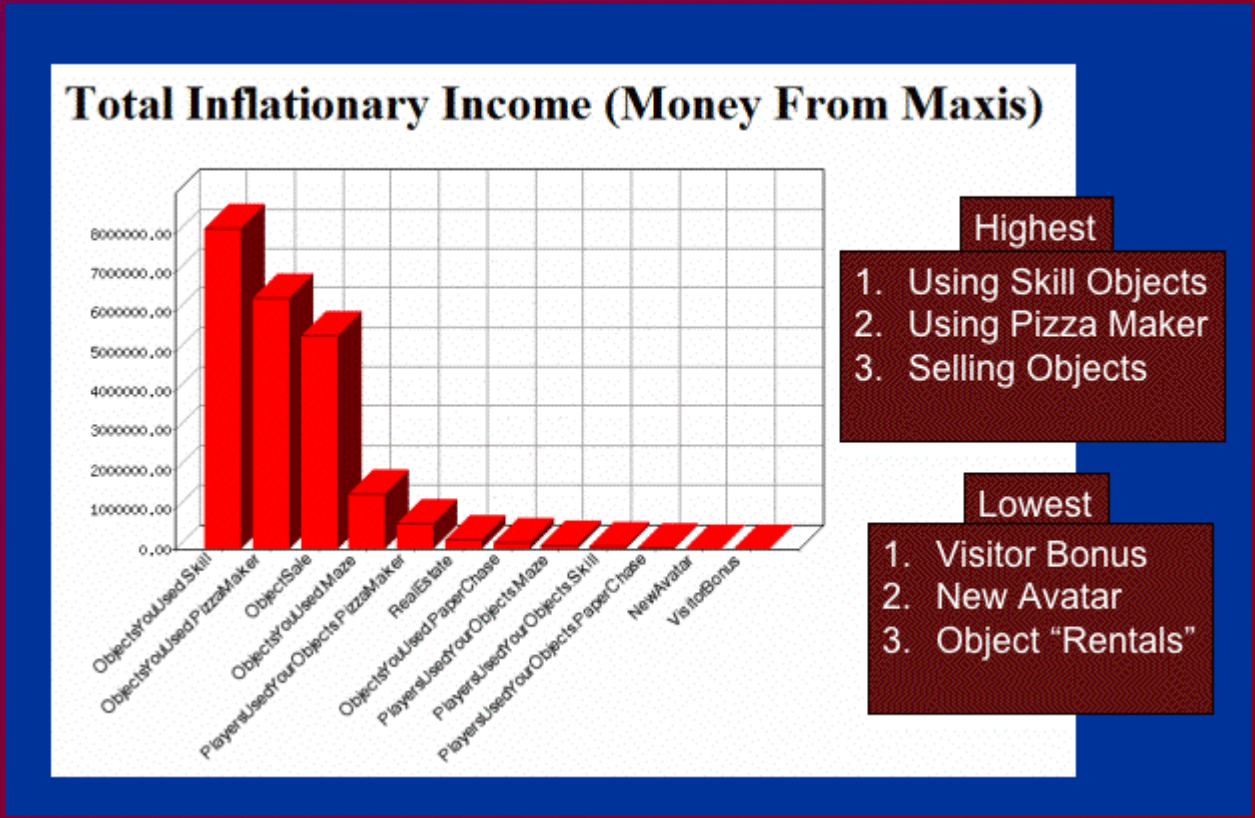
Source: Larry Mellon,Executive Director of Development, Butterfly.net (formerly EA/Maxis)

Testing: An Example from SOL (Continued)
Instrumentation is Key



Source: Larry Mellon,Executive Director of Development, Butterfly.net (formerly EA/Maxis)

An Example from SOL (Continued)
Live testing



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Challenges, Not completely Technical

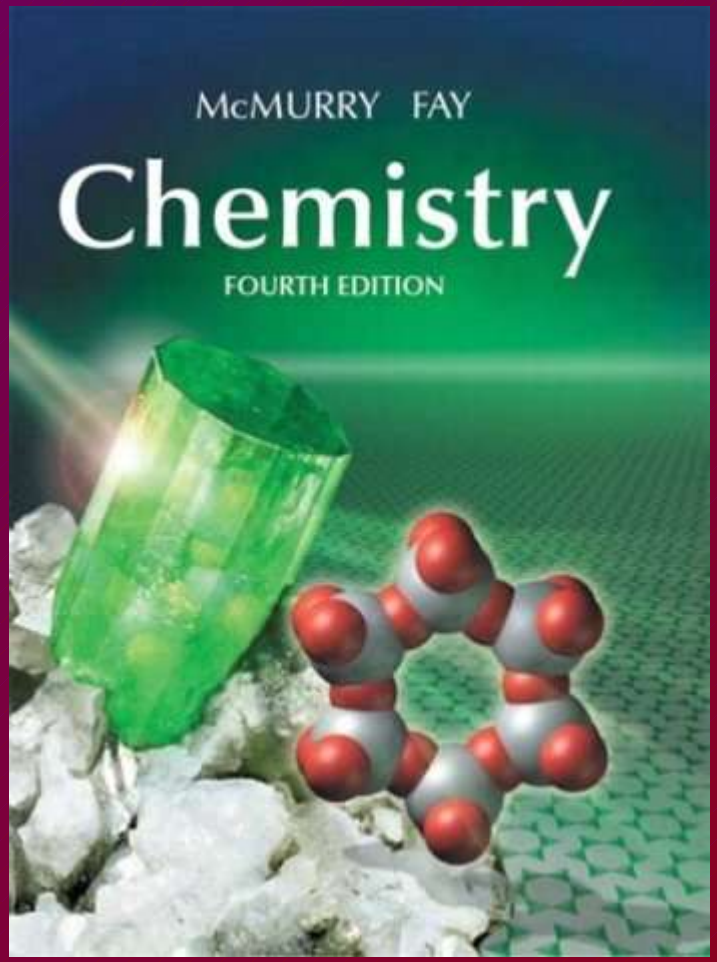
The Fundamental Distinction between Games and so-called Real Life

In Games, the computer knows what is true, and the challenge is to convince the player he is wrong

In Real Life, the universe knows what it true, and the challenge to to convince the funding source that you're "right enough."

The Fundamental Distinction (continued)

Real Life - Chemistry



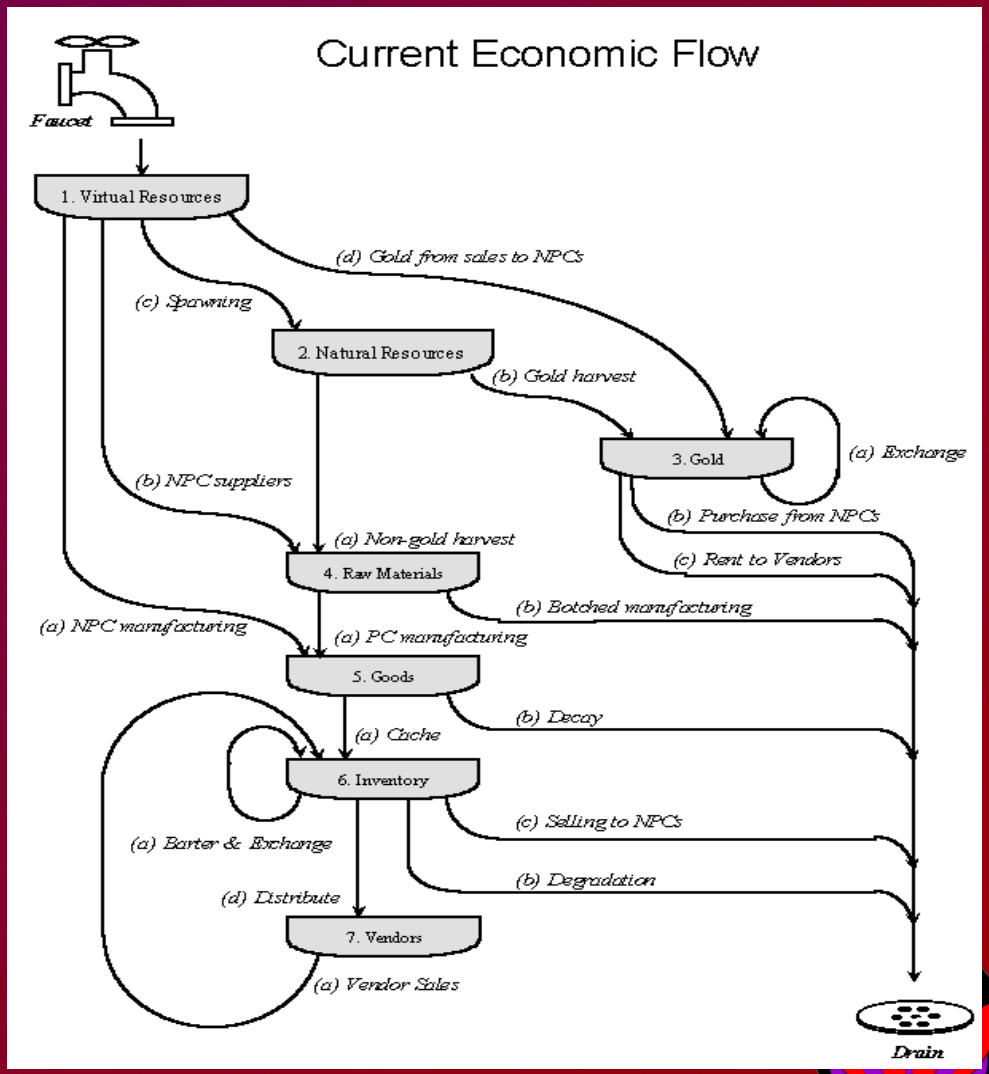
Games - Alchemy

Economics

In Real Life, one models economies, usually to predict economic behavior

In MMOGs, one creates real economies

(Source of Figure: *The In-game Economics of* Ultima Online, Zachary Booth Simpson)



The Challenges of Economies

The availability of supplies and the controlling of the supply curve

Shadow economies

NPC's (Non-player characters) and other forms of slavery

Hording

Taxes and fees

Methods of exchange and transactions

- Transaction and contract support
- Auctions and Markets

Regulation vs. free-market economies

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Lest you doubt the Reality of Game Economies...

Societies

- In real life, one models some aspect or aspects of society to gain sociological insight
- In MMOGs, one creates societies

The Challenges of Building Societies

- Designing (and implementing) for emergent behavior
  - IRL, the boundary conditions are well defined and well known
  - In MMPs, discrete boundaries and limits degrade game-play
- Punishment and Law (mechanized karma)
  - Banning, Policing, Limiting, Incarceration, Conflict Resolution, etc.
- Economies
- Delineating Allowed behavior in an open-ended environment
  - Many different play styles must be accommodated (Bartle's Killer, Socializer, Achiever, Explorer)

Serious Games

- IRL, Bad things happen: People Starve; Economies Fail; People Die.
- In MMPs, We Can Help Prevent This

"*The Serious Games Initiative is focused on uses for games in exploring management and leadership challenges facing the public sector. Part of its overall charter is to help forge productive links between the electronic game industry and projects involving the use of games in education, training, health, and public policy.*"

-- http://www.seriousgames.org

Lastly...

Game are fun, and the challenges are interesting!

Proof that it *is* fun: Disney's *Toontown*

"*Making an MMORPG is hard! Anyone who has worked on one of these will tell you this. We had to develop several core competencies from scratch, rewrite our development software, work for years, and are even still revising our operations plan on a regular basis. The number of skill sets necessary to produce and run an MMORPG surpasses anything we had experienced before.*"

"*Unfortunately, an MMORPG requires a persistent, relatively low-latency connection that is reliable and sustainable for up to hours at a time. This is extremely difficult to deliver using today's Internet.*"

Thank You

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Q&A