



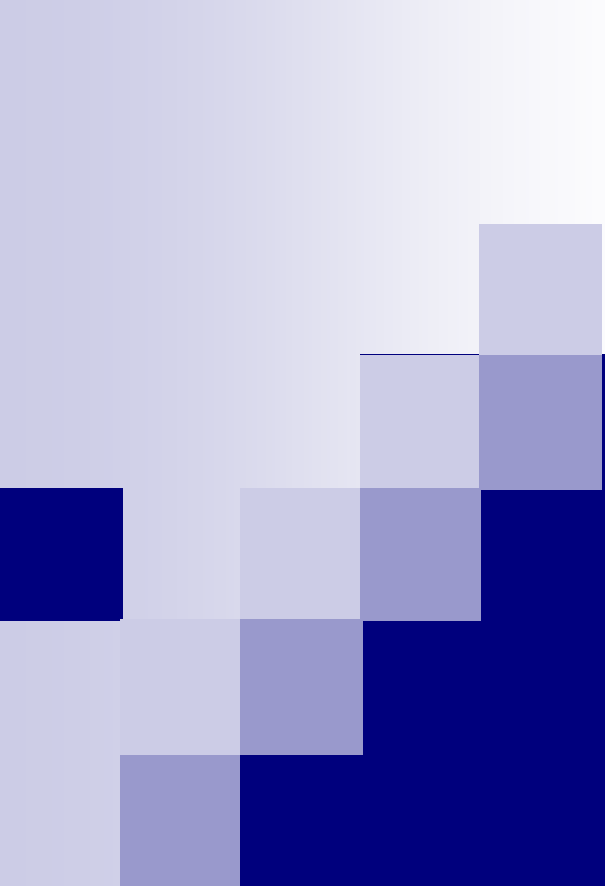
Peer-to-Peer Systems and Massively Multiplayer Online Games

Speaker:

Jehn-Ruey Jiang

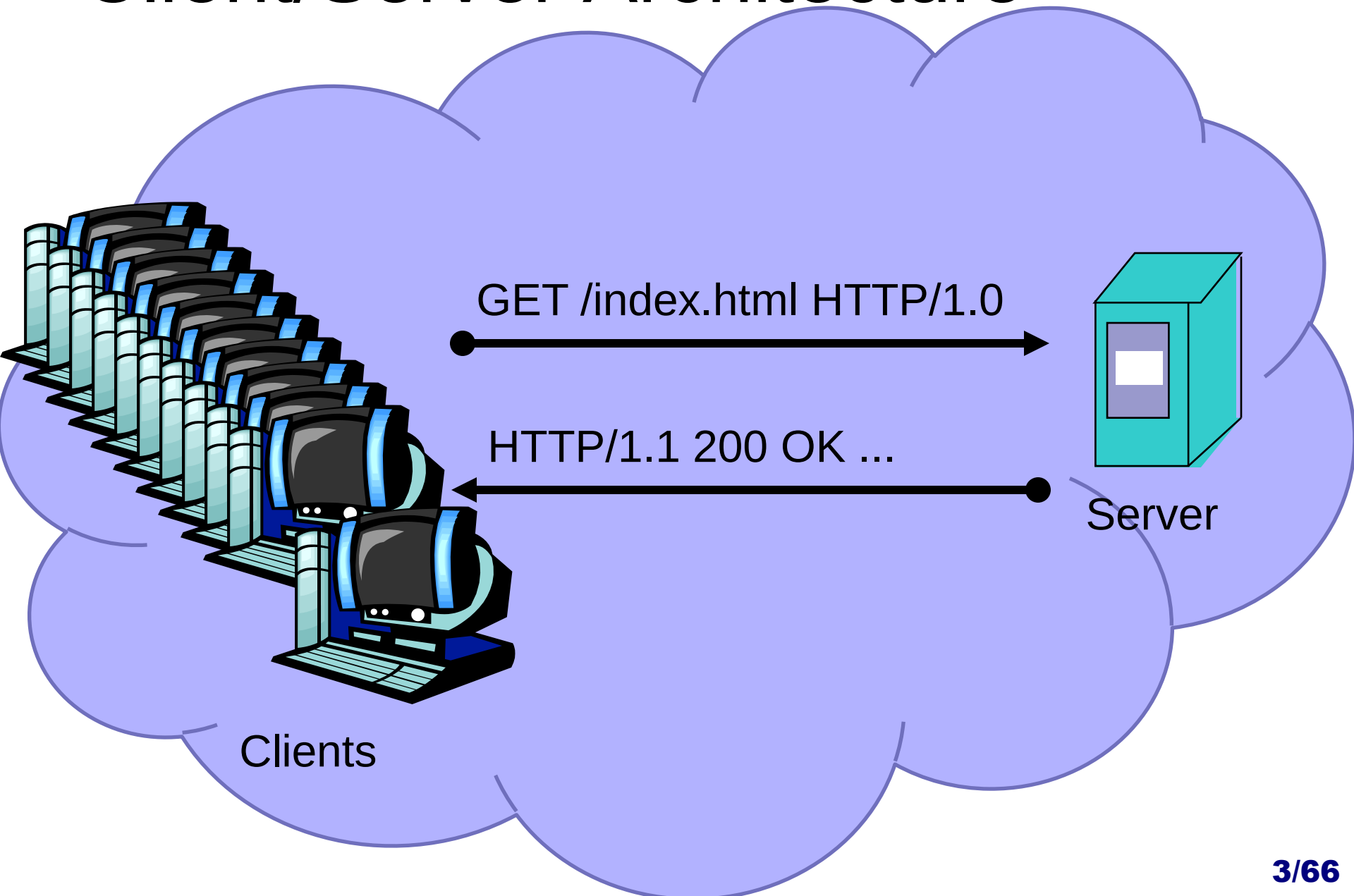
CSIE Department

National Central University

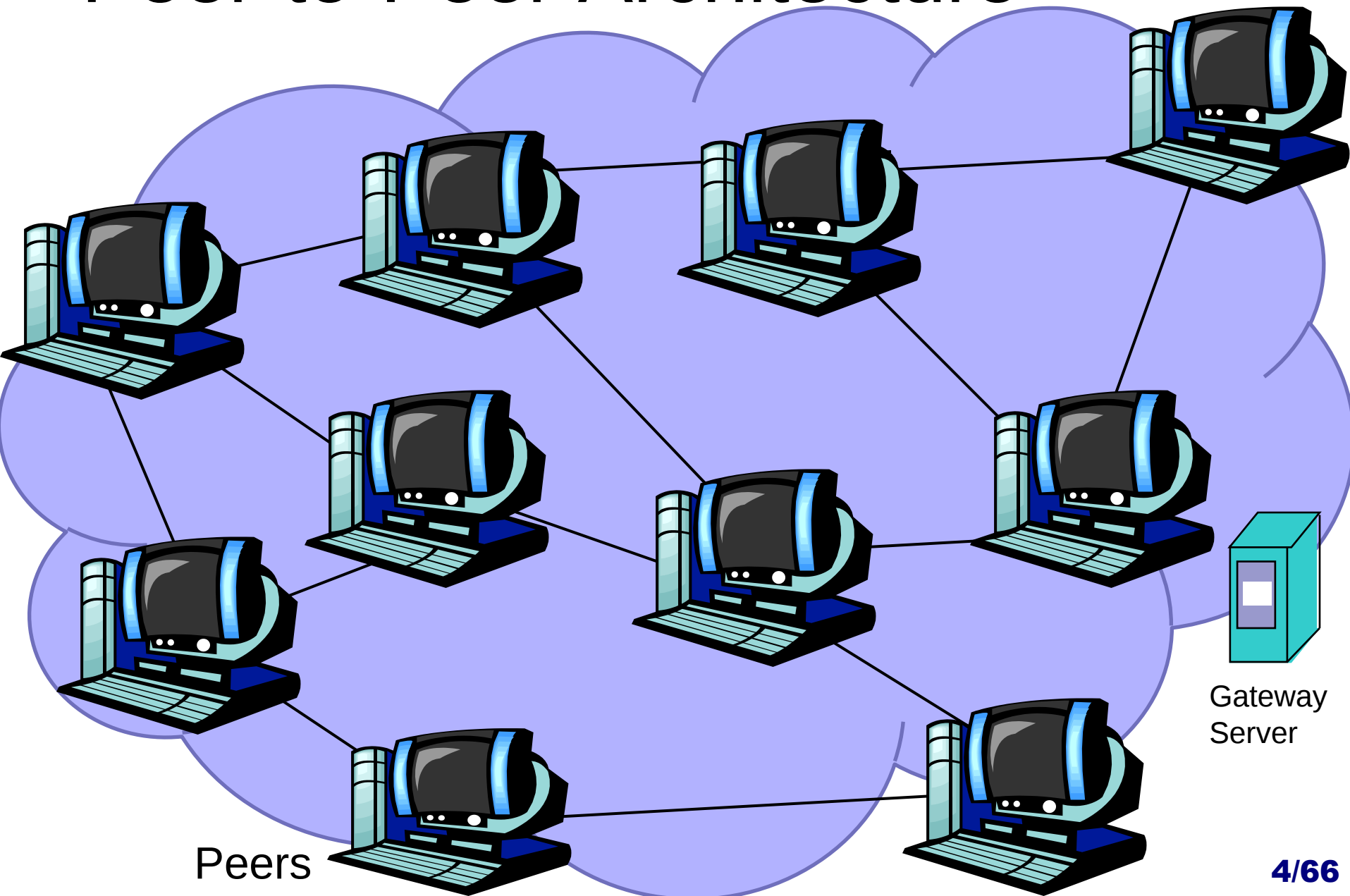


P2P Systems

Client/Server Architecture



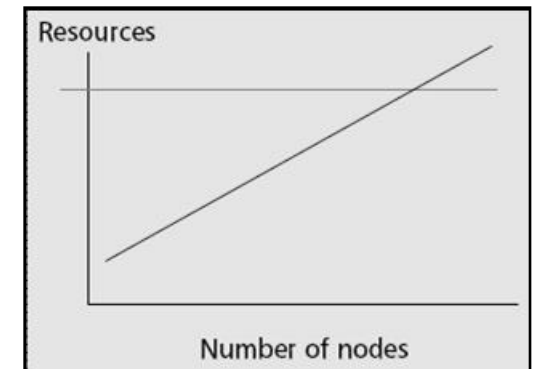
Peer-to-Peer Architecture



The architectures

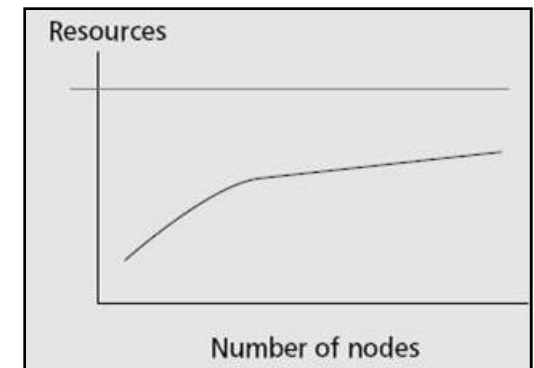
■ Server-based architecture

- Client-Server / Server-Cluster
- Problems :
 - Limited resources
 - All loads are centered on the server
- Server-based architecture has low scalability.
- The setup and maintenance cost is high.



■ Peer-to-Peer (P2P) architecture

- Advantages :
 - Distributing loads to all users
 - Users consume and provide resources
- P2P architecture has high scalability.
- The setup and maintenance cost is low.



The Client Side

- Today's clients can perform more roles than just forwarding users requests
- Today's clients have:
 - more computing power
 - more storage space
- Thin client → **Fat client**

Evolution at the Client Side



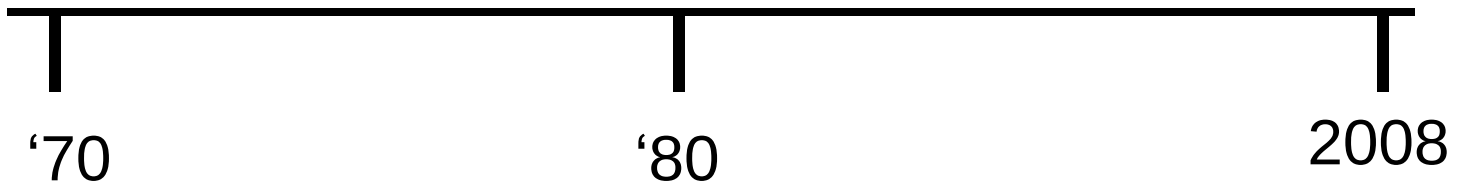
DEC'S VT100
No storage



IBM PC
@ 4.77MHz
360k diskettes



PC @ 4-core 4GHz
300GB HD



What Else Has Changed?

- The number of home PCs is increasing rapidly
- Most of the PCs are “fat clients”
- As the Internet usage grow, more and more PCs are connecting to the global net
- Most of the time PCs are idle
- How can we use all this?

Peer-to-Peer (P2P)

What is peer-to-peer (P2P)?

- “Peer-to-peer is a way of structuring distributed applications such that the **individual nodes have symmetric roles**. Rather than being divided into clients and servers each with quite distinct roles, in P2P applications **a node may act as both a client and a server**.”
 - Charter of Peer-to-peer Research Group, IETF/IRTF, June 24, 2004
(<http://www.irtf.org/charters/p2prg.html>)

Resources Sharing

- What can we share?

- Computer-related resources

- Shareable related-computer resources:

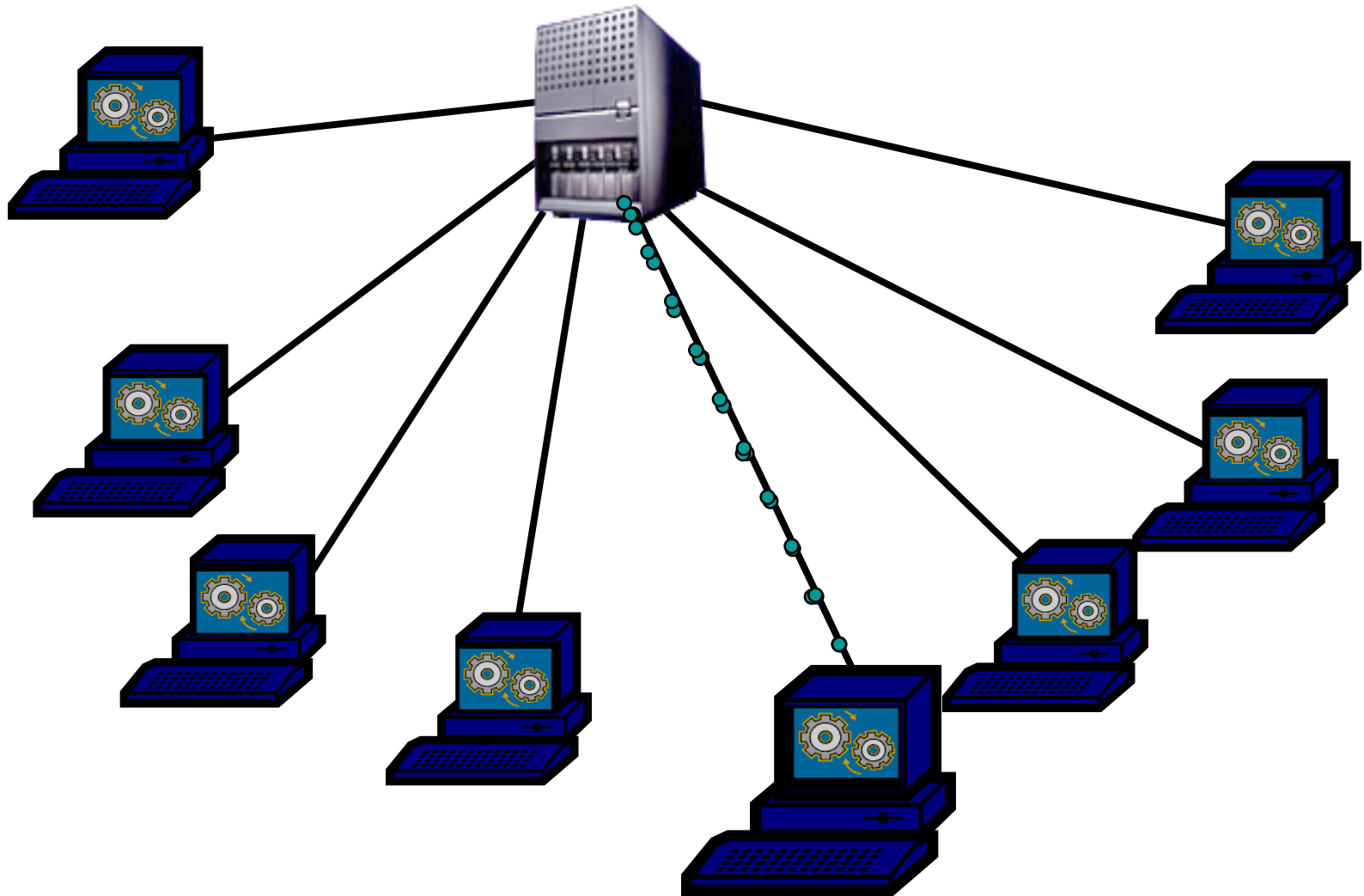
- CPU cycles - seti@home, GIMPS
 - Bandwidth - PPLive, PPStream
 - Storage Space - OceanStore, Murex
 - Data - Napster, Gnutella
 - People - Buddy Finder
 - Camera, Microphone, Sensor, Service???



SETI@Home

- SETI – Search for Extra-Terrestrial Intelligence
- @Home – On your own computer
- A radio telescope in Puerto Rico scans the sky for radio signals
- Fills a DAT tape of 35GB in 15 hours
- That data have to be analyzed

SETI@Home - Example



Getting Started Main page How it works Download FAQ Benchmarks Prizes Project Status Status Top producers PrimeNet	 GIMPS The Great Internet Mersenne Prime Search Finding 10 World Record Primes!	2^P-1 MAY BE PRIME! Learning More History The math Source code Mailing list Miscellaneous Manual testing Credits Links Feedback Other projects
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GIMPS Home Page

September 2006: [New Mersenne Prime!](#)

Pages available in [Chinese](#), [Danish](#), [Dutch](#), [French](#), [German](#), [Italian](#), and [Spanish](#). Warning: These translations may not be up-to-date - use [AltaVista](#) as necessary.

44th Known Mersenne Prime Found!!

Lightning strikes twice. On September 4, 2006, in the same room just a few feet away from their last find, Dr. Curtis Cooper and Dr. Steven Boone's [CMSU](#) team broke their own [world record](#), discovering the 44th known Mersenne prime, $2^{32,582,657}-1$. The new prime at [9,808,358 digits](#) is 650,000 digits larger than their previous record prime found last December. However, the new prime falls short of the 10 million digits required for GIMPS to claim the [Electronic Frontier Foundation \\$100,000 award](#).

With five record primes found in less than 3 years, GIMPS has been on an incredible lucky streak. Never before have Mersenne primes been bunched so closely together. When looking at the exponents, we expect only 1.78 Mersenne primes between powers of two, and prior to 2003, a maximum of 3 Mersenne primes were found between powers of two. The last 5 Mersenne prime exponents all fell between 2^{24} and 2^{25} -- and we haven't finished testing all the exponents in that range!

The new prime was independently verified in 6 days by Tony Reix of Bull S.A. in Grenoble, France using 16 Itanium2 1.5 GHz CPUs of a [Bull NovaScale 6160 HPC](#) at Bull Grenoble Research Center, running the [Glucas program](#) by Guillermo Ballester Valor of Granada, Spain.

Dr. Cooper and Dr. Boone could not have made this discovery alone. In recognition of contributions made by the project coordinators and the tens of



http://www.mersenne.org/



Yahoo! Search



Getting Started

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- [PrimeNet](#)



GIMPS

The Great Internet Mersenne Prime Search
Finding World Record Primes Since 1996

2^{P-1}
MAY BE
PRIME!

Learning More

- [History](#)
- [The math](#)
- [Source code](#)
- [Mailing list](#)
- [Miscellaneous](#)
- [Manual testing](#)
- [Credits](#)
- [Links](#)
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GIMPS Home Page



選擇語言
size:10px,color:#0000cc;">Google ?

August/September 2008: [New Mersenne Primes!](#)

Pages available in [Chinese](#), [Dutch](#), [French](#), [German](#), and [Italian](#). Warning: These translations may not be up-to-date, use the google widget above as necessary.

45th and 46th Known Mersenne Primes Found!!!!

GIMPS set to claim \$100,000 EFF award!

[Download free software](#)

On August 23rd, a UCLA computer discovered the 45th known Mersenne prime, $2^{43,112,609}-1$, a mammoth [12,978,189 digit number](#)! The prime number qualifies for the [Electronic Frontier Foundation's \\$100,000 award](#) for discovery of the first 10 million digit prime number. Congratulations to Edson Smith, who was responsible for installing and maintaining the GIMPS software on the UCLA Mathematics Department's computers.

On September 6th, the 46th known Mersenne prime, $2^{37,156,667}-1$, a [11,185,272 digit number](#) was found by [Hans-Michael Elvenich](#) in Langenfeld near Cologne, Germany! This was the first Mersenne prime to be discovered out of order since Colquitt and Welsh discovered $2^{110,503}-1$ in 1988.

The nearly decade long quest for the EFF award came down to a close race to the finish - with just two weeks separating the discovery of the two primes.

As promised, GIMPS will give \$50,000 of the EFF award to the UCLA Mathematics Department for discovering the first 10 million digit prime. \$25,000 will go to charity, and most of the remainder will go to discoverers of the previous six Mersenne primes.



ELECTRONIC FRONTIER FOUNDATION

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EFF Cooperative Computing Awards

Cooperative Computing Awards

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The Electronic Frontier Foundation (EFF), the first civil liberties group dedicated to protecting the health and growth of the Internet, is sponsoring cooperative computing awards, with over half a million dollars in prize money, to encourage ordinary Internet users to contribute to solving huge scientific problems.

Through the EFF Cooperative Computing Awards, EFF will confer prizes of:

- **\$50,000** to the first individual or group who discovers **a prime number with at least 1,000,000 decimal digits** ([awarded Apr. 6, 2000](#))
- **\$100,000** to the first individual or group who discovers **a prime number with at least 10,000,000 decimal digits**
- **\$150,000** to the first individual or group who discovers **a prime number with at least 100,000,000 decimal digits**
- **\$250,000** to the first individual or group who discovers **a prime number with at least 1,000,000,000 decimal digits**

(Prize money comes from a special donation provided by an individual EFF supporter, earmarked specifically for this project. Prize money does NOT come from EFF membership dues, corporate or foundation grants, or other general EFF funds.)

EFF hopes to spur the technology of cooperative networking and encourage Internet users worldwide to join together in solving scientific problems involving massive computation. EFF is uniquely situated to sponsor these awards, since part of its mission is to encourage the harmonious integration of Internet innovations into the whole of society.

"The EFF awards are about cooperation," said John Gilmore, EFF co-founder and project leader for the awards. "Prime numbers

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ACTION ALERTS

 [Keep Wireless Broadband on Track at the FCC](#)

 [Sunlight for ACTA](#)

 [Protect Digital Privacy at the Border and Beyond](#)

 [Repeal the REAL ID Act](#)

[» Action Center](#)

[Help EFF Continue the Fight Against Warrantless Wiretapping](#)

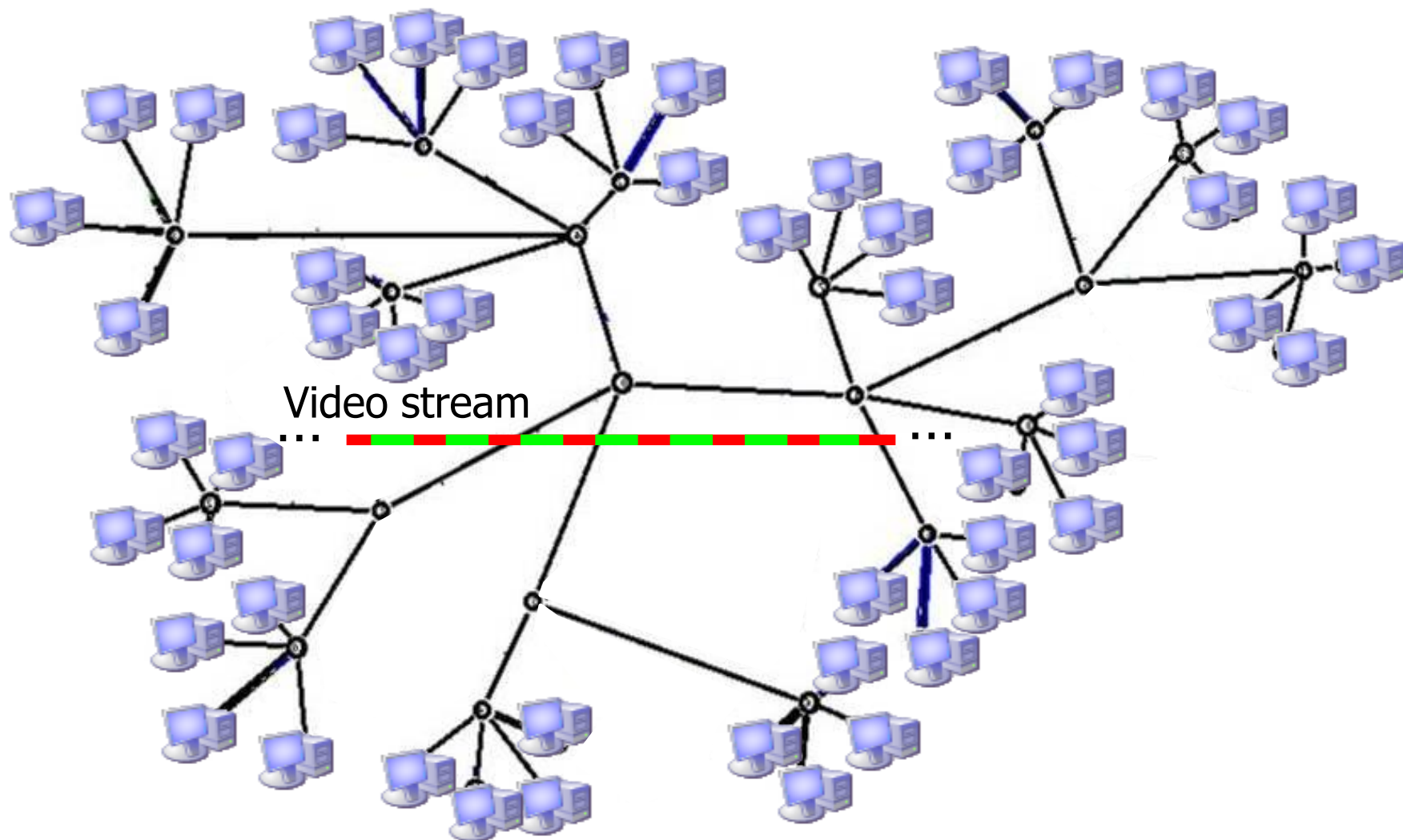
MUREX: A Mutable Replica Control Scheme for Peer-to-Peer Storage Systems



Murex: Basic Concept



Peer-to-Peer Video Streaming



Napster -- Shawn Fanning



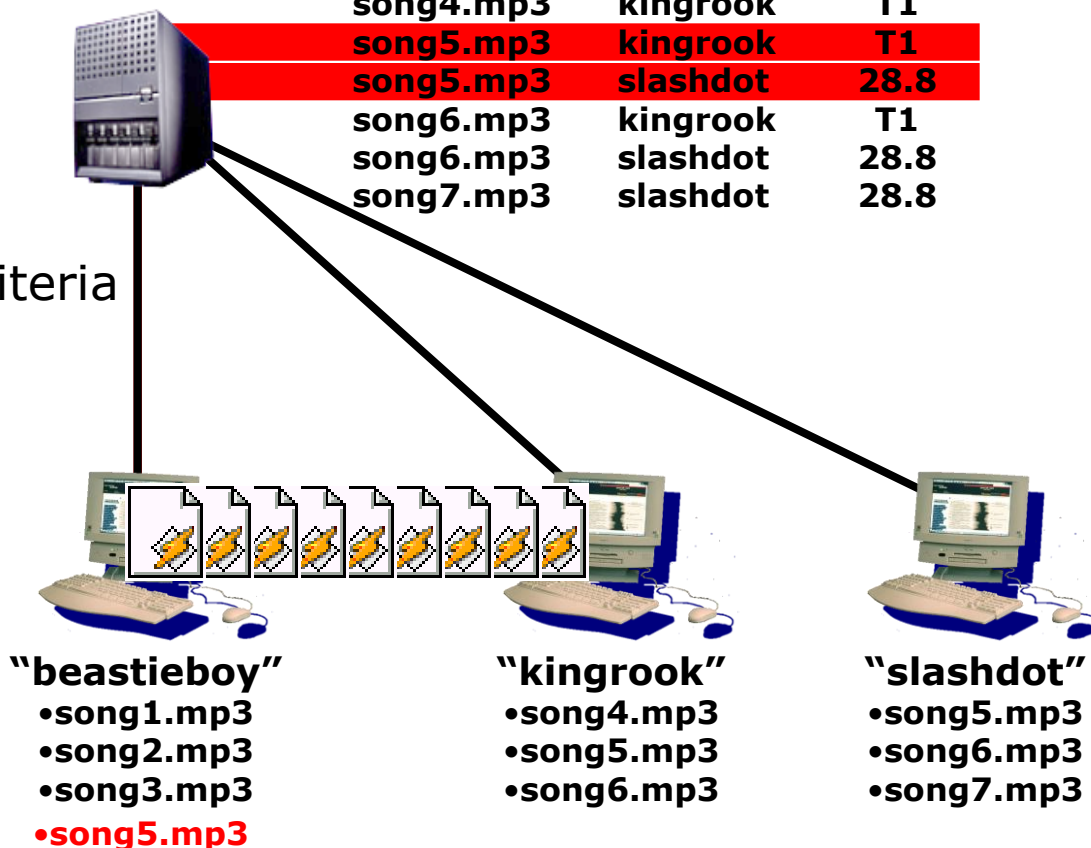
Napster Sharing Style: hybrid center+edge

1. Users launch Napster and connect to Napster server
2. Napster creates dynamic directory from users' personal .mp3 libraries
3. **beastieboy** enters search criteria



4. Napster displays matches to **beastieboy**
5. **beastieboy** makes direct connection to **kingrook** for file transfer

Title	User	Speed
song1.mp3	beasiteboy	DSL
song2.mp3	beasiteboy	DSL
song3.mp3	beasiteboy	DSL
song4.mp3	kingrook	T1
song5.mp3	kingrook	T1
song5.mp3	slashdot	28.8
song6.mp3	kingrook	T1
song6.mp3	slashdot	28.8
song7.mp3	slashdot	28.8



History of Napster

- 5/99: Shawn Fanning (freshman, Northeastern University) founds Napster Online (supported by Groove)
- 12/99: First lawsuit
- 7/01: simultaneous online users 160K
- 6/02: file bankrupt
- ...
- 10/03: Napster 2 (Supported by Roxio) (users should pay \$9.99/month)



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SEARCH FOR MUSIC

MORE ABOUT NAPSTER

NAPSTER RINGTONES

FAQ



UNLIMITED ACCESS TO 1,000,000+ SONGS

Here's what you get with your Napster Membership:

- Listen to and download an unlimited amount of music
- Enjoy 50+ commercial-free, interactive radio stations
- Discover and share music with other Napster Members
- With Napster To Go, you can fill and refill any compatible MP3 player without paying per song or album*
- Fast, safe and legal

All the music you want. Any way you want it.

Try it
now
[click here](#)

"Being able to
download anything
you want is really
a lot of fun..."

[See more reviews](#)



February 15, 2005
Napster 3.0

Click Here to
Start 7-Day FREE Trial!

DOWNLOAD NAPSTER

Free Download; 11MB



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FREE
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REDEEM

[More Info](#)



Gnutella -- Justin Frankel and Tom Pepper

gnutella

are you ready for the ride of your life?

one day that there will be a protocol of protocols



The 'Animal' GNU
GNU: Recursive Acronym
GNU's Not Unix



GNU



Nutella

Gnutella =



Nutella: a hazelnut chocolate spread
produced by the Italian
confectioner *Ferrero*

Gnutella History

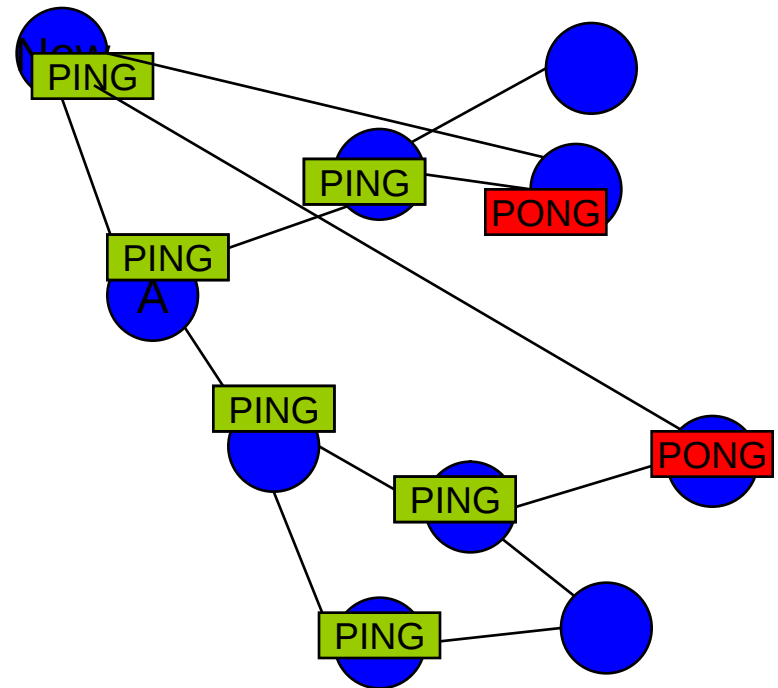
- Gnutella was written by Justin Frankel, the 21-year-old founder of Nullsoft.
- (Nullsoft acquired by AOL, June 1999)
- Nullsoft (maker of WinAmp) posted Gnutella on the Web, March 14, 2000.
- A day later AOL yanked Gnutella, at the behest of Time Warner.
- Too late: 23k users on Gnutella
- People had already downloaded and shared the program.
- Gnutella continues today, run by independent programmers.

Gnutella Protocol

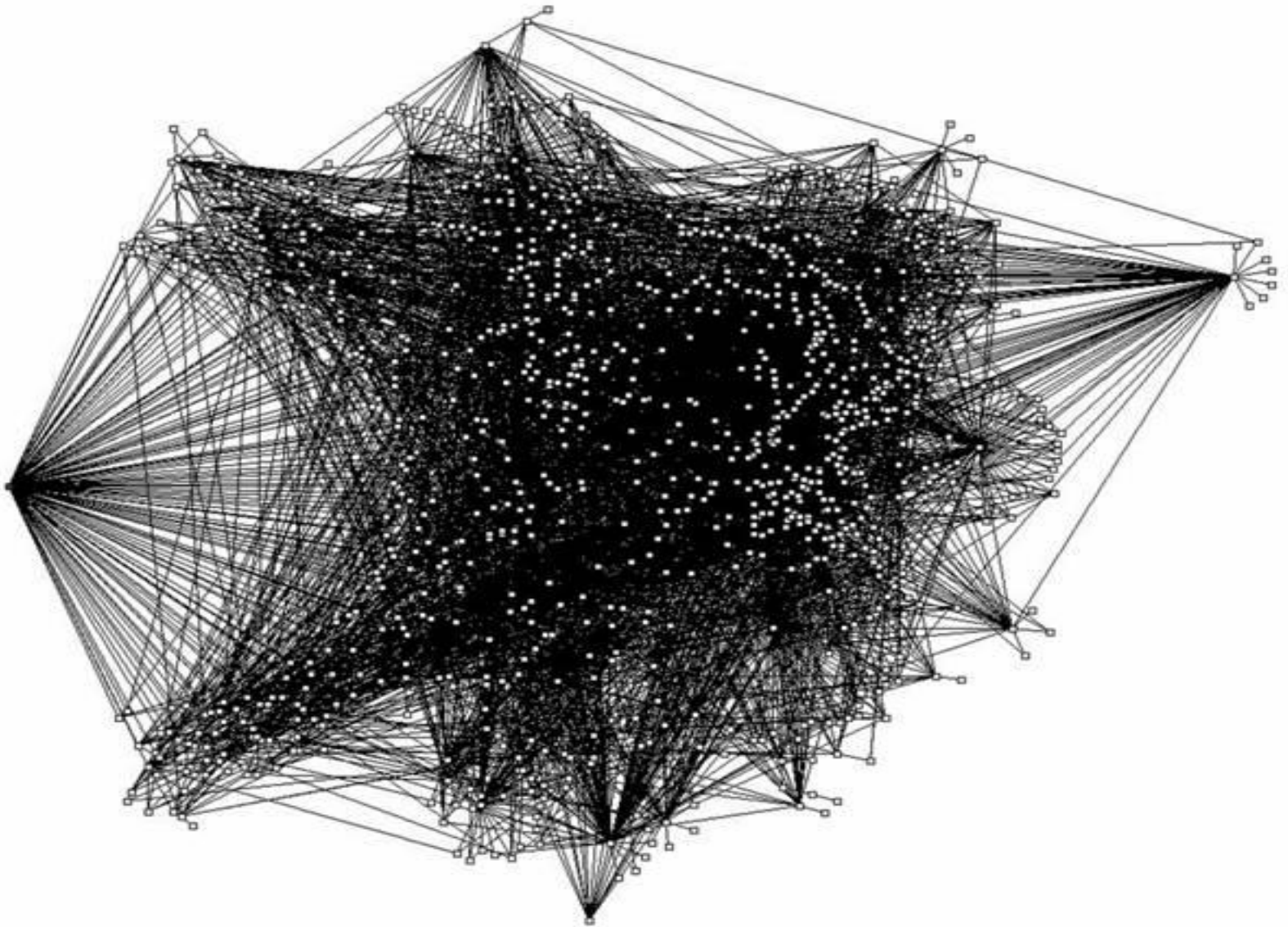
Scenario: Joining Gnutella Network

- The new node connects to a well known 'Anchor' node or 'Bootstrap' node.
- Then sends a PING message to discover other nodes.
- PONG messages are sent in reply from hosts offering new connections with the new node.
- Direct connections are then made to the newly discovered nodes.

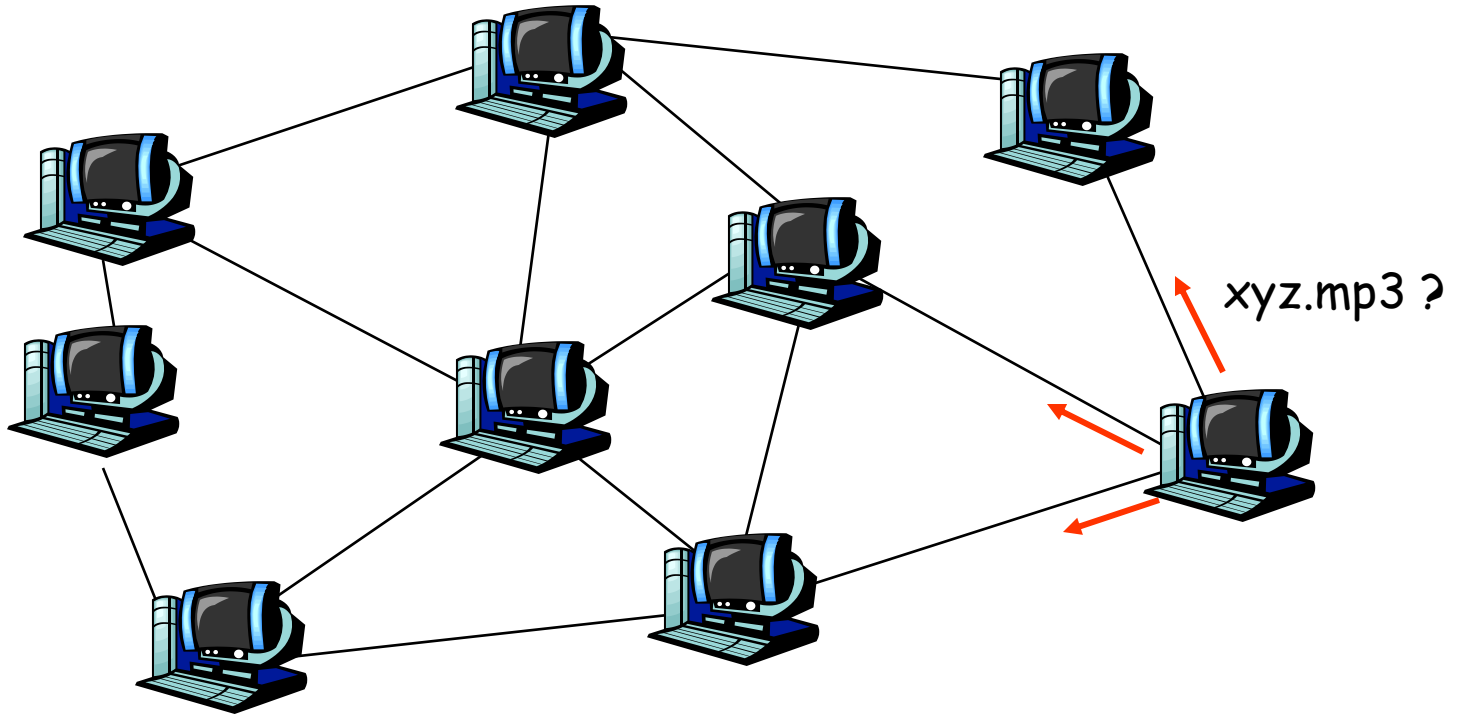
Gnutella Network



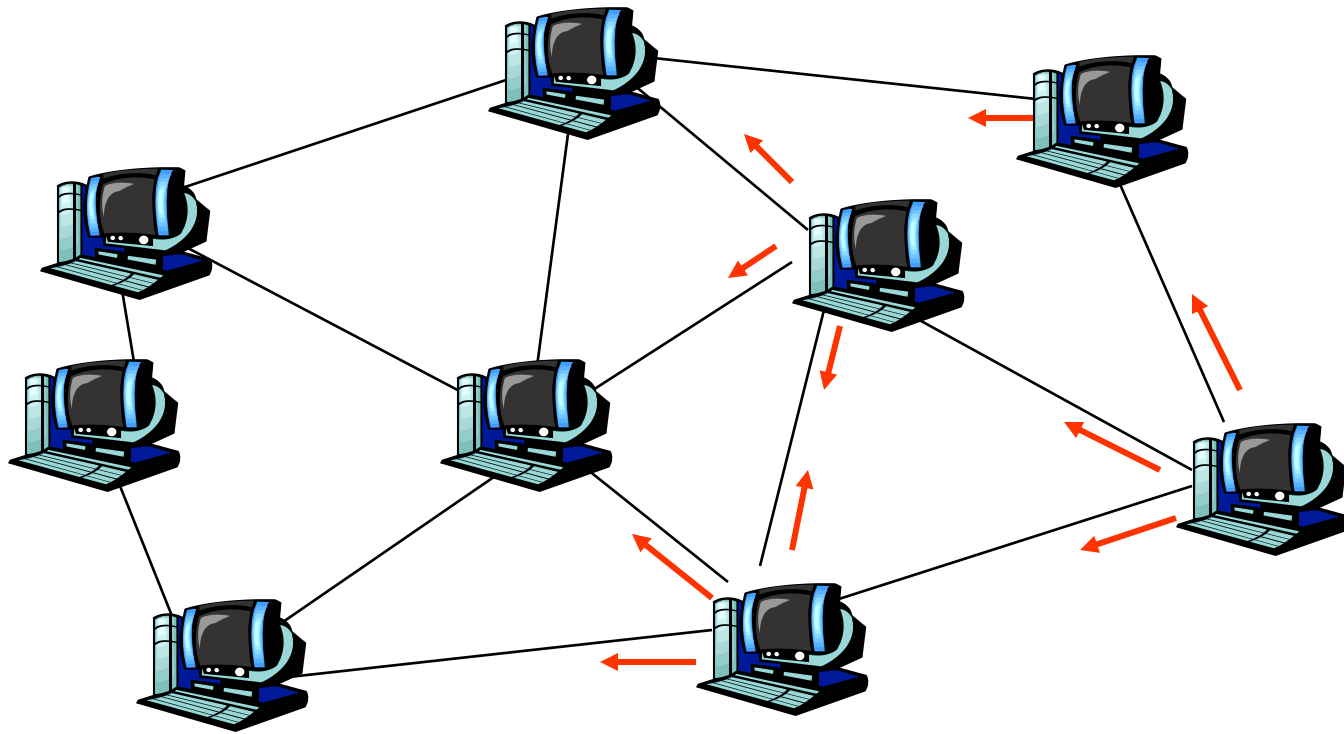
Topology of a Gnutella Network



Gnutella: Issue a Request

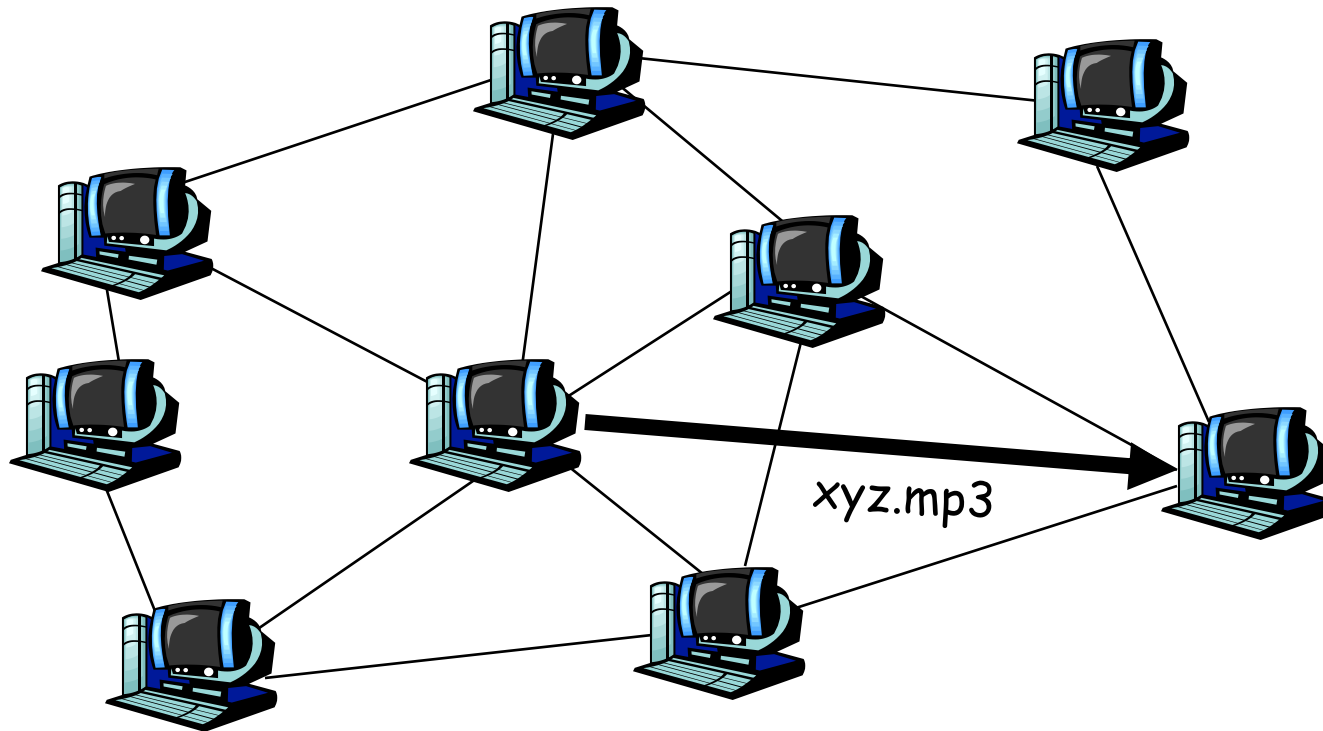


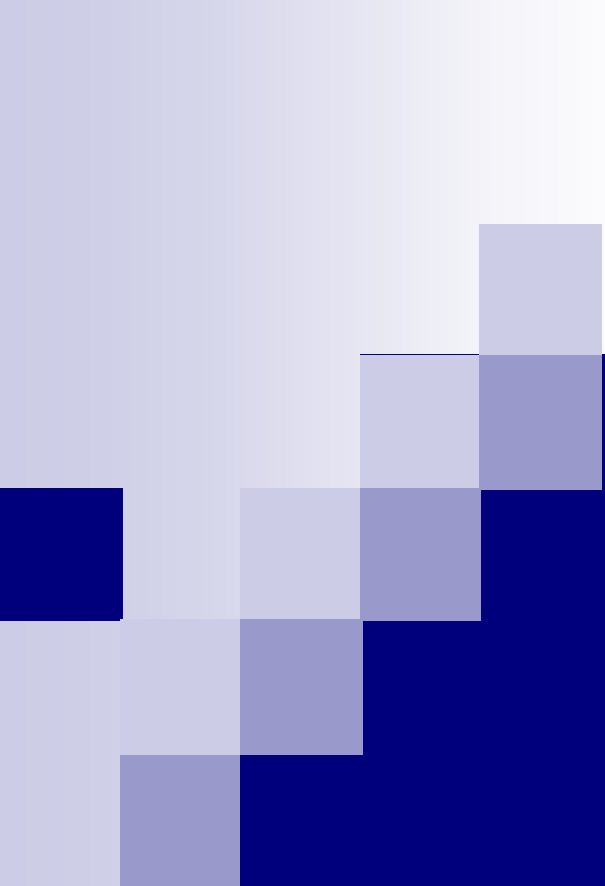
Gnutella: Flood the Request



Gnutella: Reply with the File

Fully distributed storage and directory!





MMOGs

Massively Multiplayer Online Games

- MMOGs are growing quickly
 - Multi-billion dollar industry
 - 10 million subscribers for *World of Warcraft*
 - 600,000 concurrent users







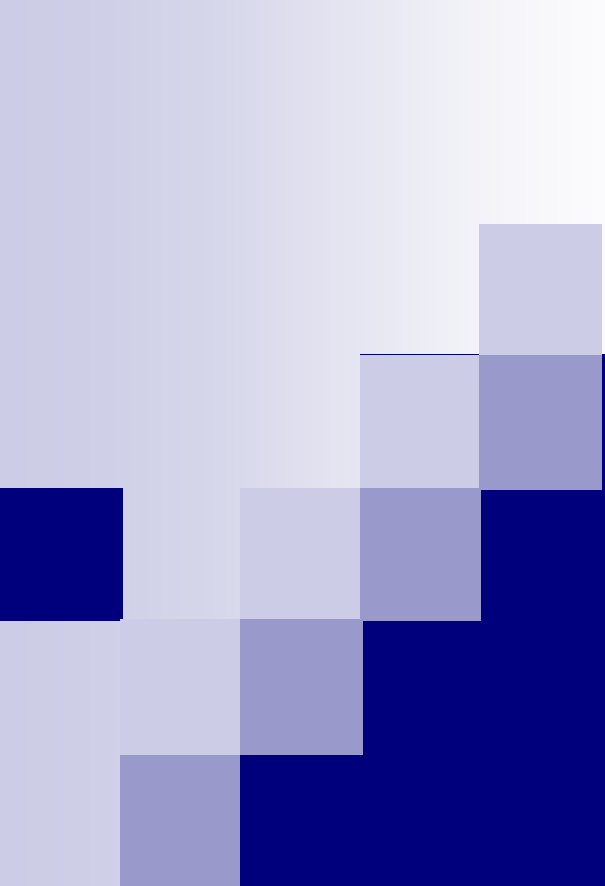






Question

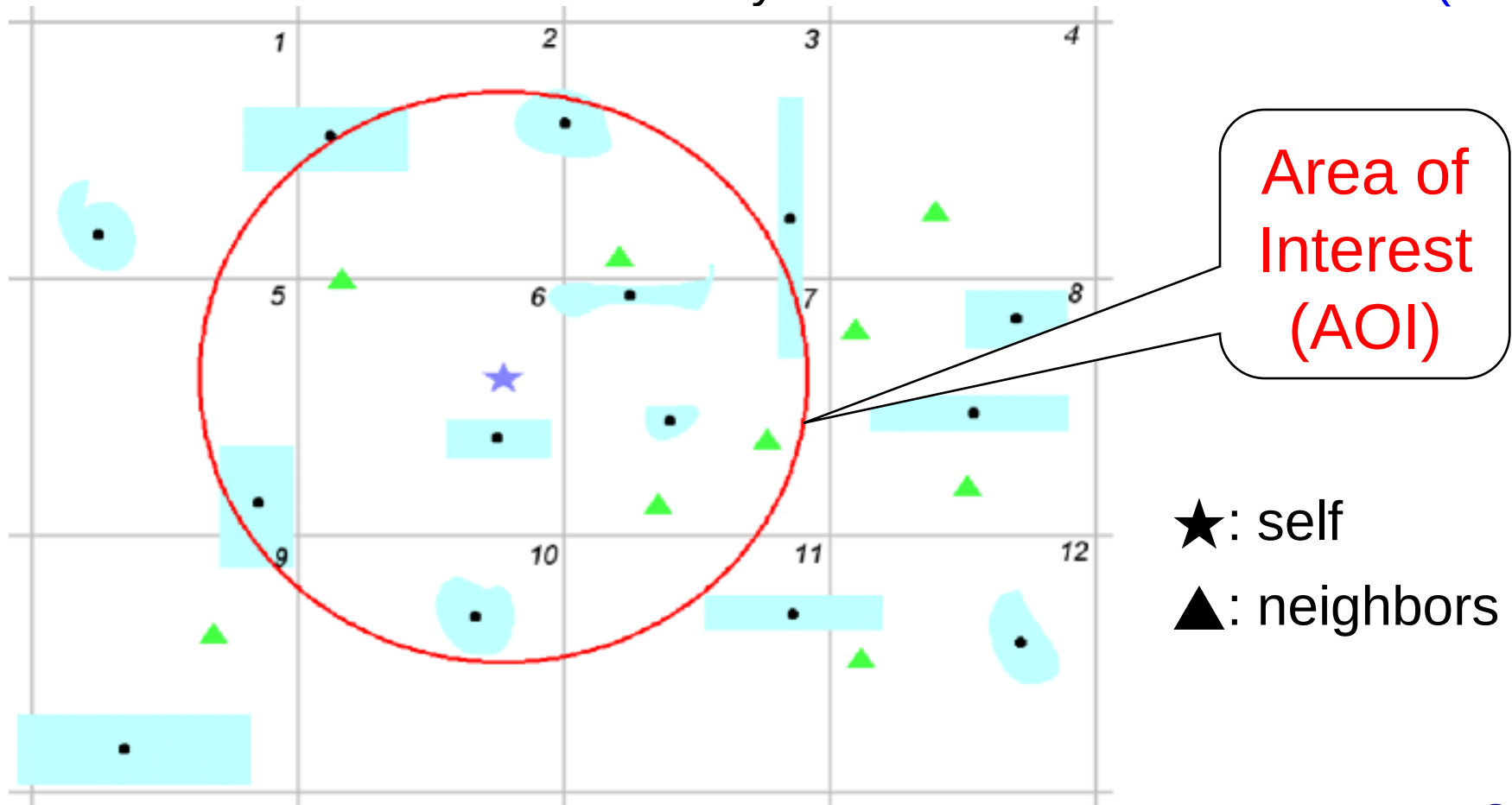
- Most MMOGs are server-based and thus suffer from the scalability problem.
- Can we apply the P2P concept to MMOGs?



P2P and MMOGs

Model for MMOGs

- Many *nodes* on a 2D plane
- An avatar needs to know only those within **Area of Interest (AOI)**



P2P AOI Neighbor Discovery

- We need to solve the **neighbor discovery problem** in a fully-distributed, message-efficient manner with specific goals:
 - **Consistent**
 - Good neighborhood consistency
 - **Scalable**
 - Limited overhead
 - **Responsive**
 - Short latency

Neighborhood Consistency (1)

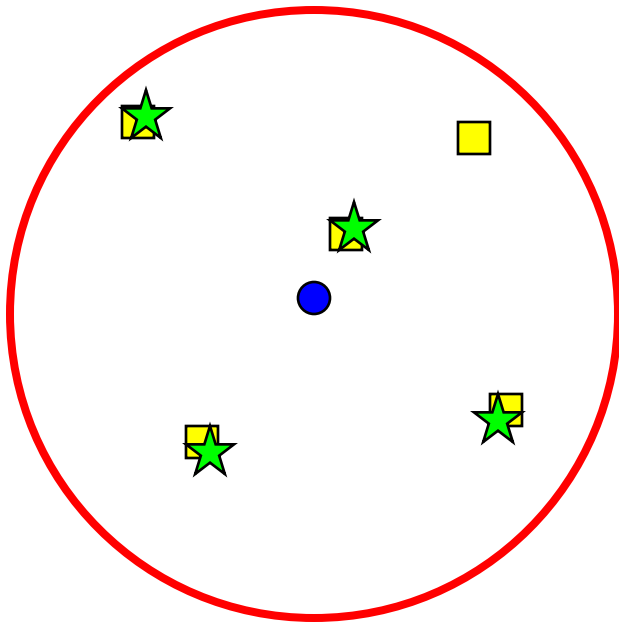
■ Definition

no. of current AOI neighbors *observed*

no. of current actual AOI neighbors

Neighborhood Consistency (2)

■ An example



□ : actual neighbor

★ : observed neighbor

Neighborhood Consistency

= 4 / 5

= 80%

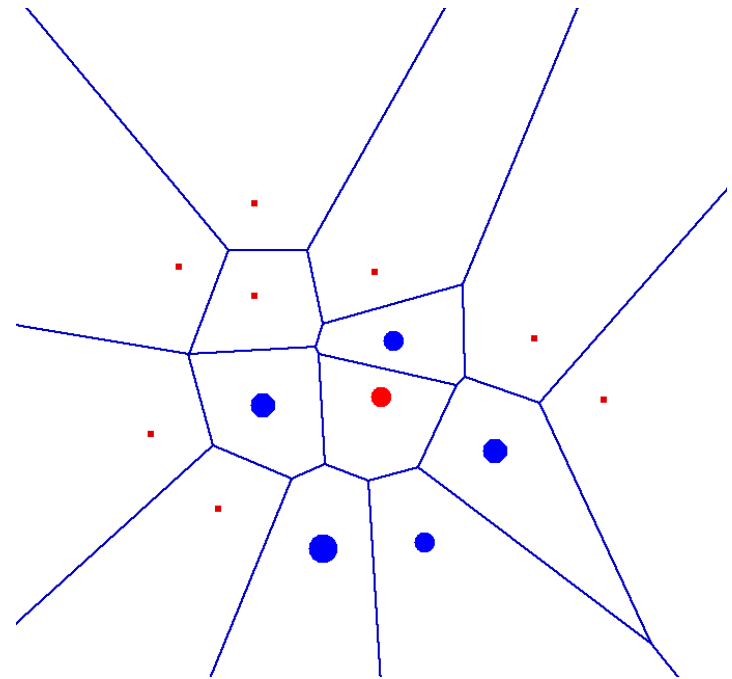
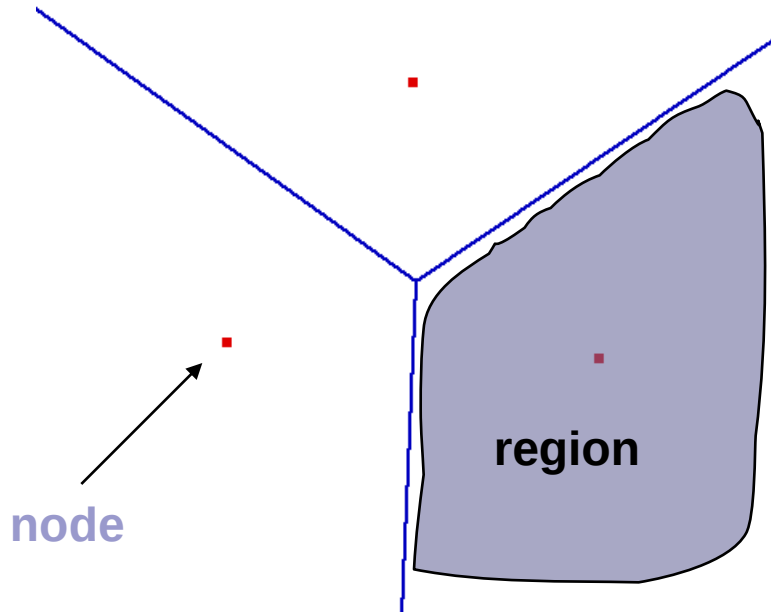


Voronoi-based Overlay Network : VON

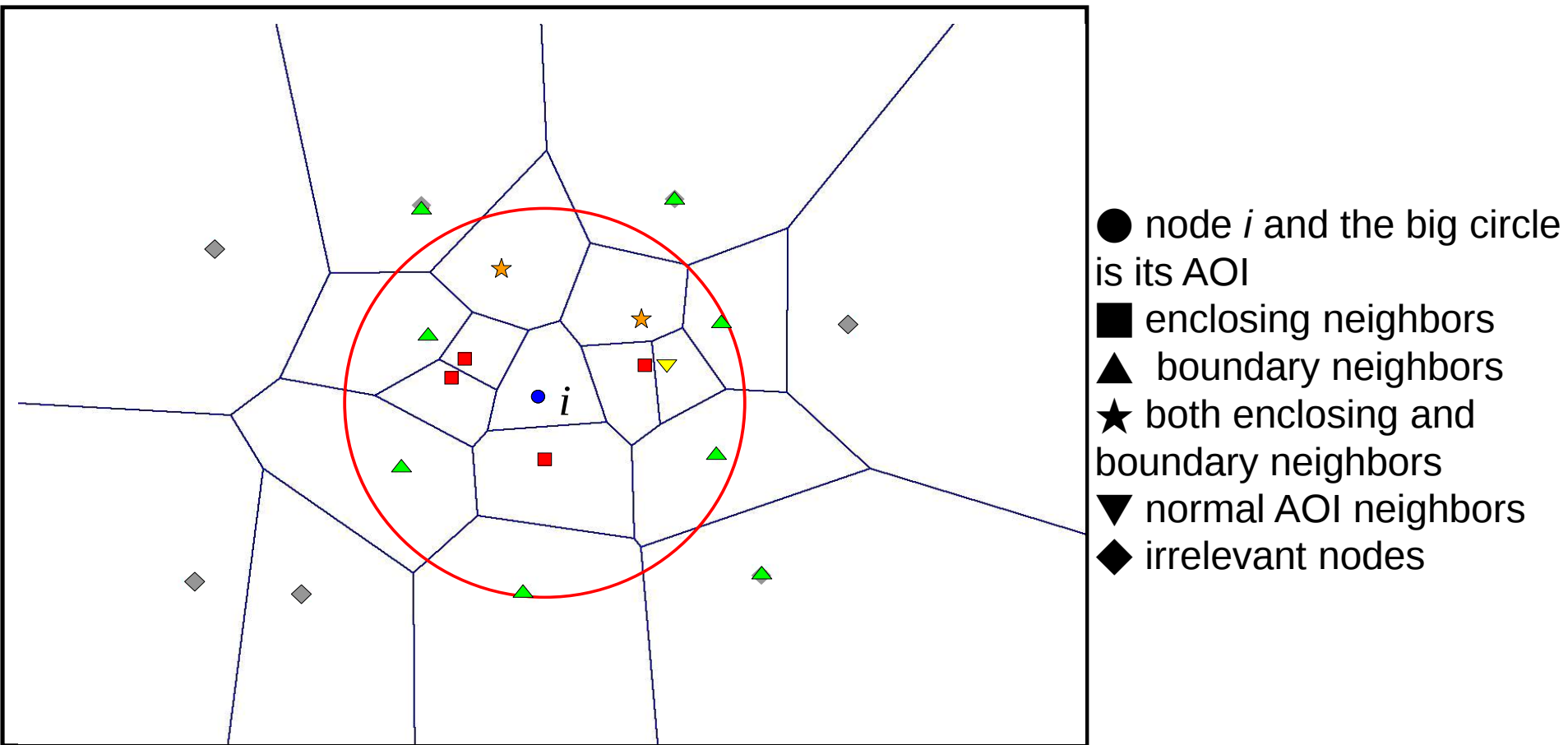
- Use Voronoi diagram to solve the neighbor discovery problem
 - Each node constructs a Voronoi diagram of its neighbors
 - Identify *enclosing* and *boundary* neighbors
 - Mutual collaboration in neighbor discovery

Voronoi Diagram

- 2D Plane partitioned into *regions* by *nodes*, each region contains all the points closest to its node

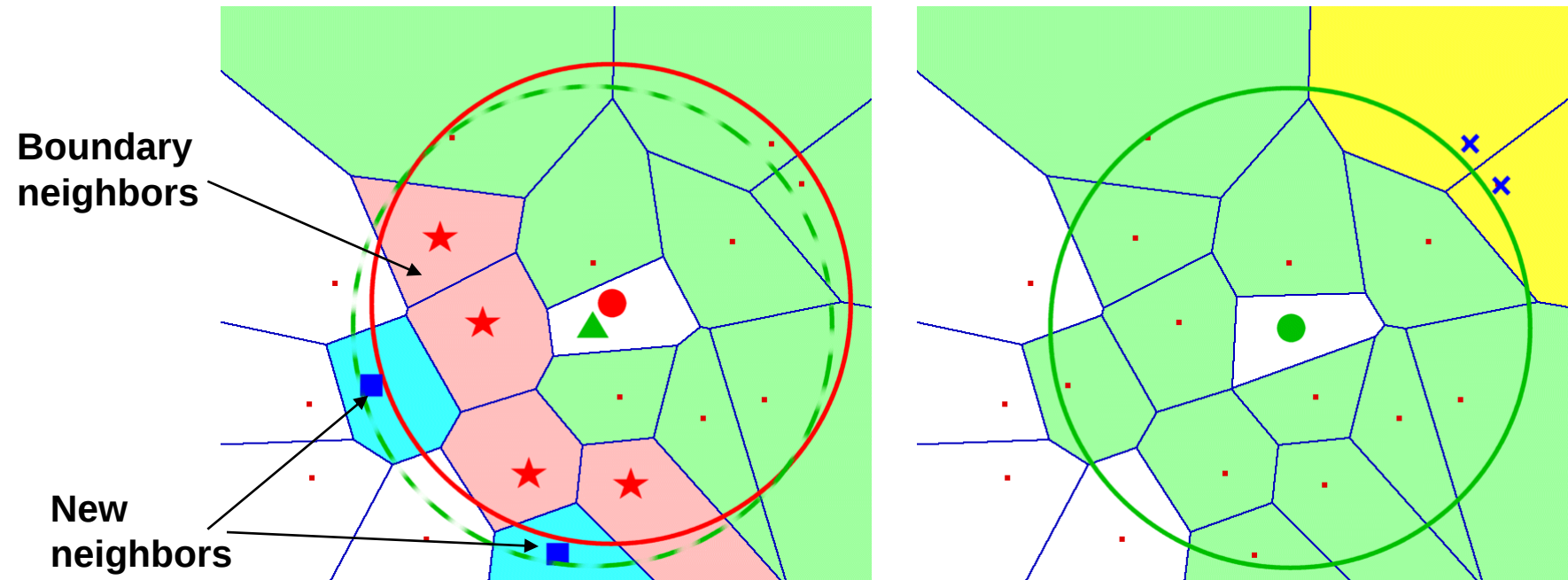


Voronoi-based Overlay Network : VON



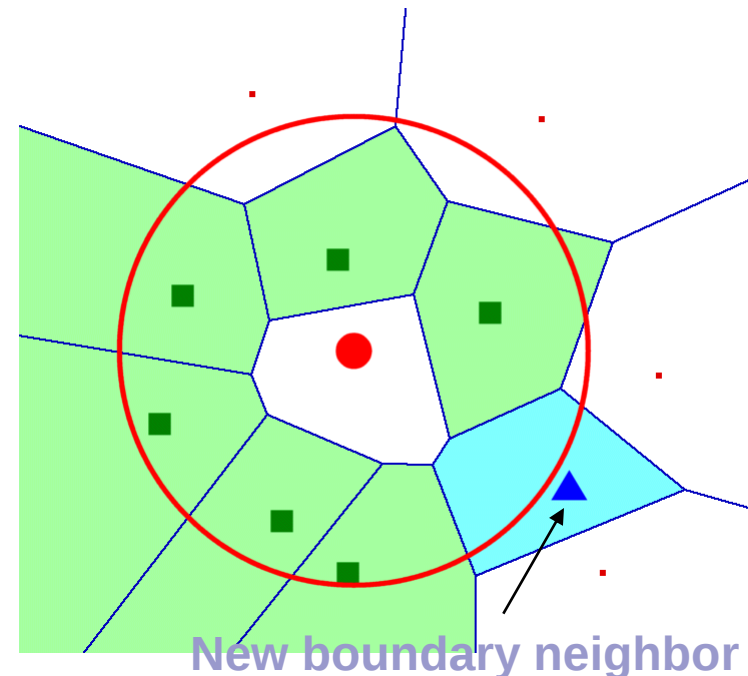
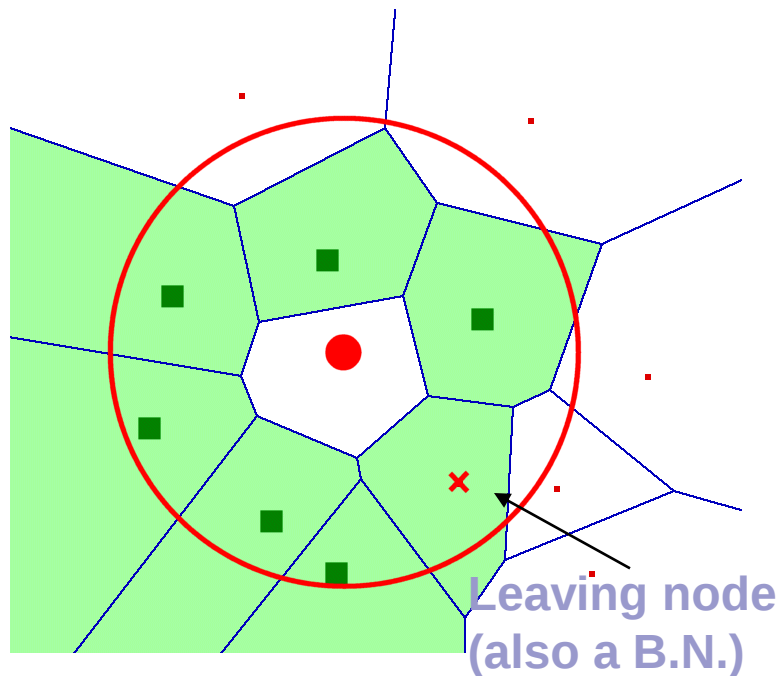
Procedure (MOVE)

- 1) Positions sent to all neighbors, mark messages to B.N.
B.N. checks for overlaps between mover's AOI and its E.N.
- 2) Connect to new nodes upon notification by B.N.



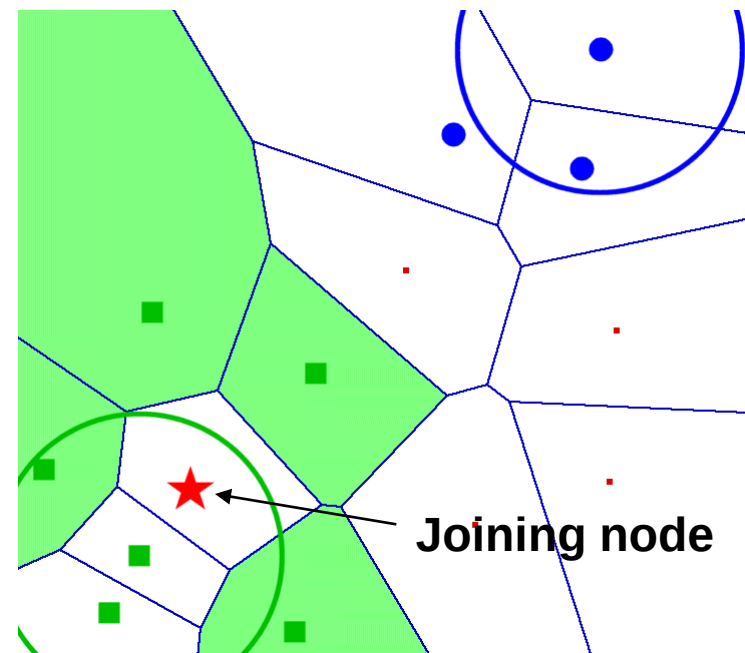
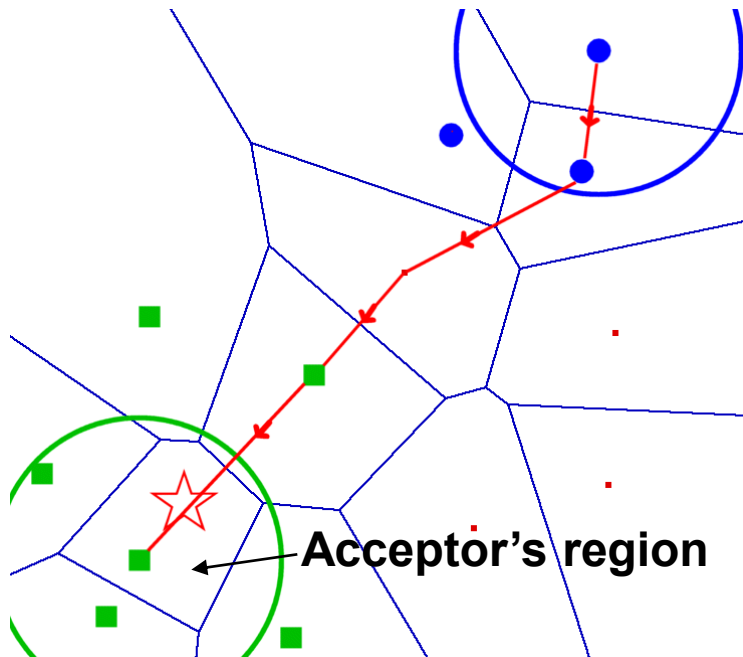
Procedure (LEAVE)

- 1) Simply disconnect
- 2) Others then update their Voronoi diagram
new B.N. is discovered via existing B.N.



Procedure (JOIN)

- 1) *Joining node* sends coordinates to any *existing node*
Join request is forwarded to *acceptor*
- 2) *Acceptor* sends back its own neighbor list
Joining node connects with other nodes on the list





3D Streaming

- Continuous and real-time delivery of 3D contents over network connections to allow user interactions without a full download.
- Contents are fragmented, transmitted, reconstructed, and then displayed.

3D streaming vs. media streaming

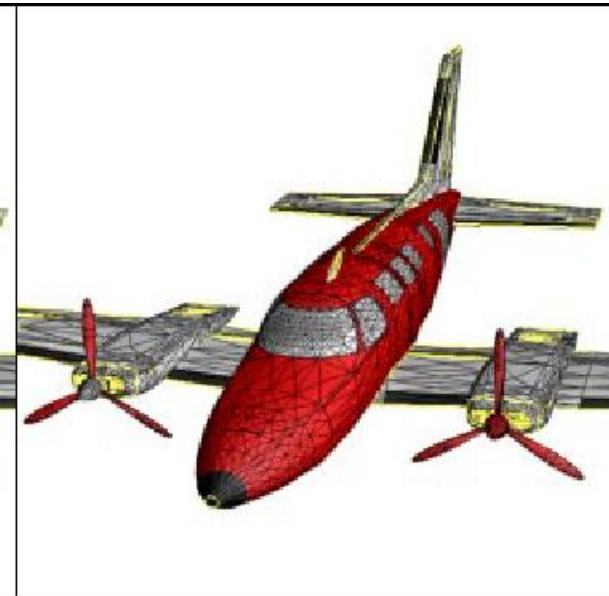
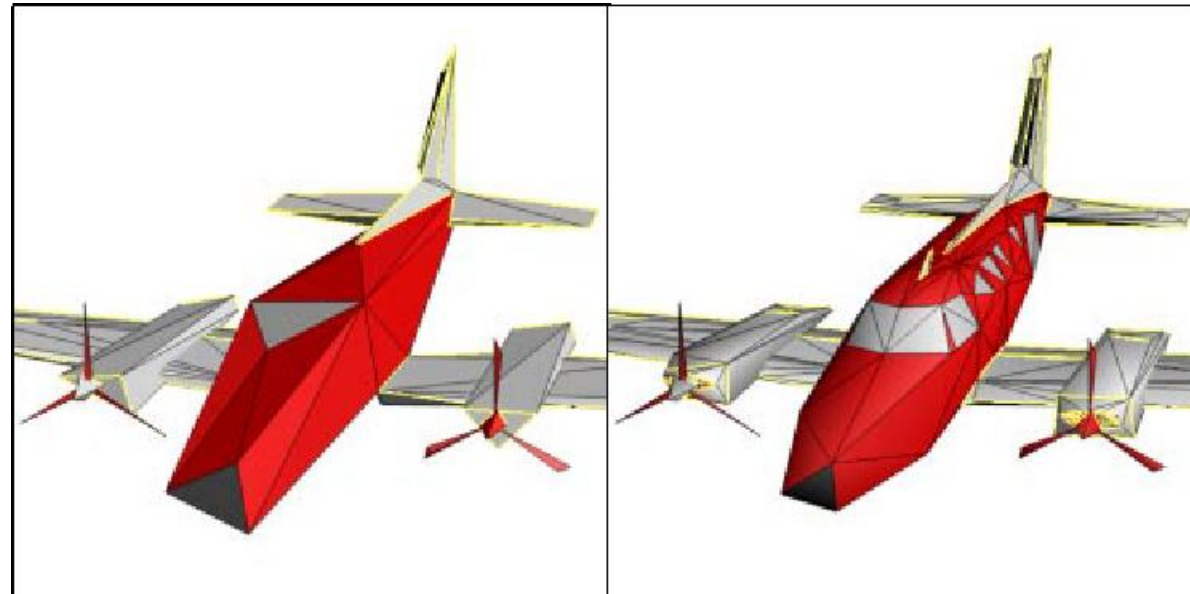
- Video / audio *media streaming* is very matured
- User access patterns are different for 3D content
 - Highly interactive → Latency-sensitive
 - Behaviour-dependent → Non-sequential



4 types of 3D streaming

- Object streaming
- Scene streaming
- Visualization streaming
- Image-based streaming

Object streaming

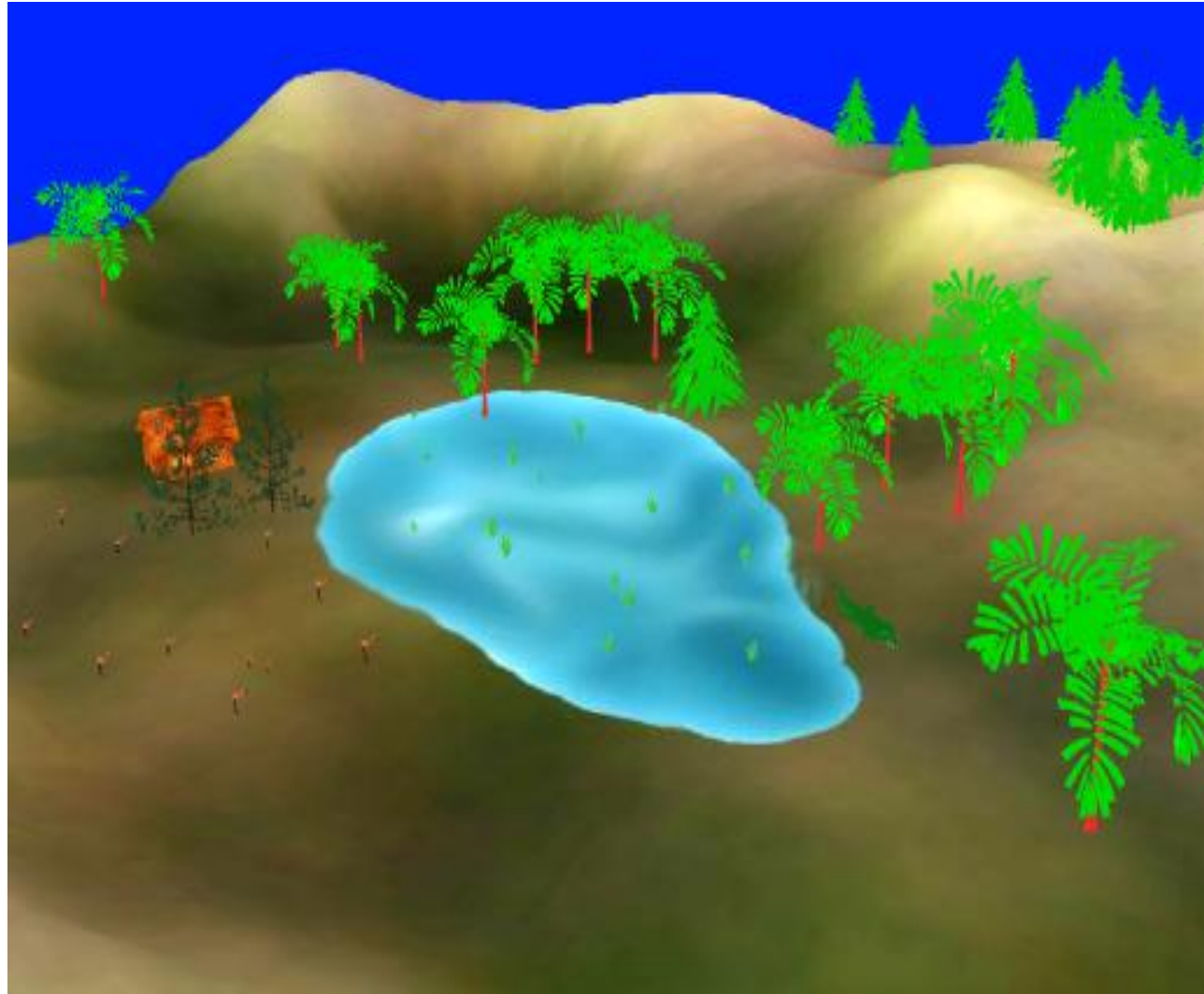


Hoppe 1996
*Progressive
Meshes*

Scene streaming

- Many objects
- Object selections & transmissions

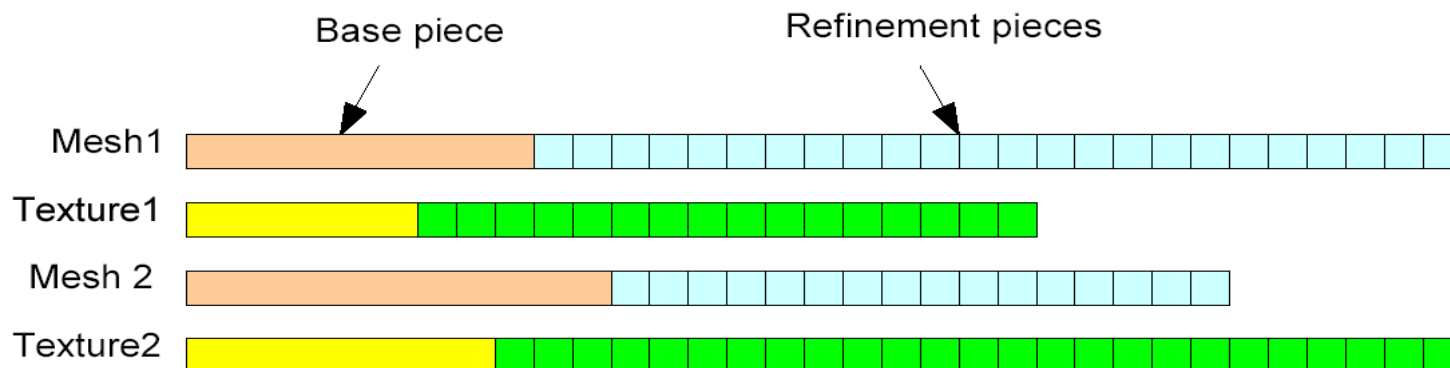
Teler & Lischinski
2001



P2P-based 3D Streaming

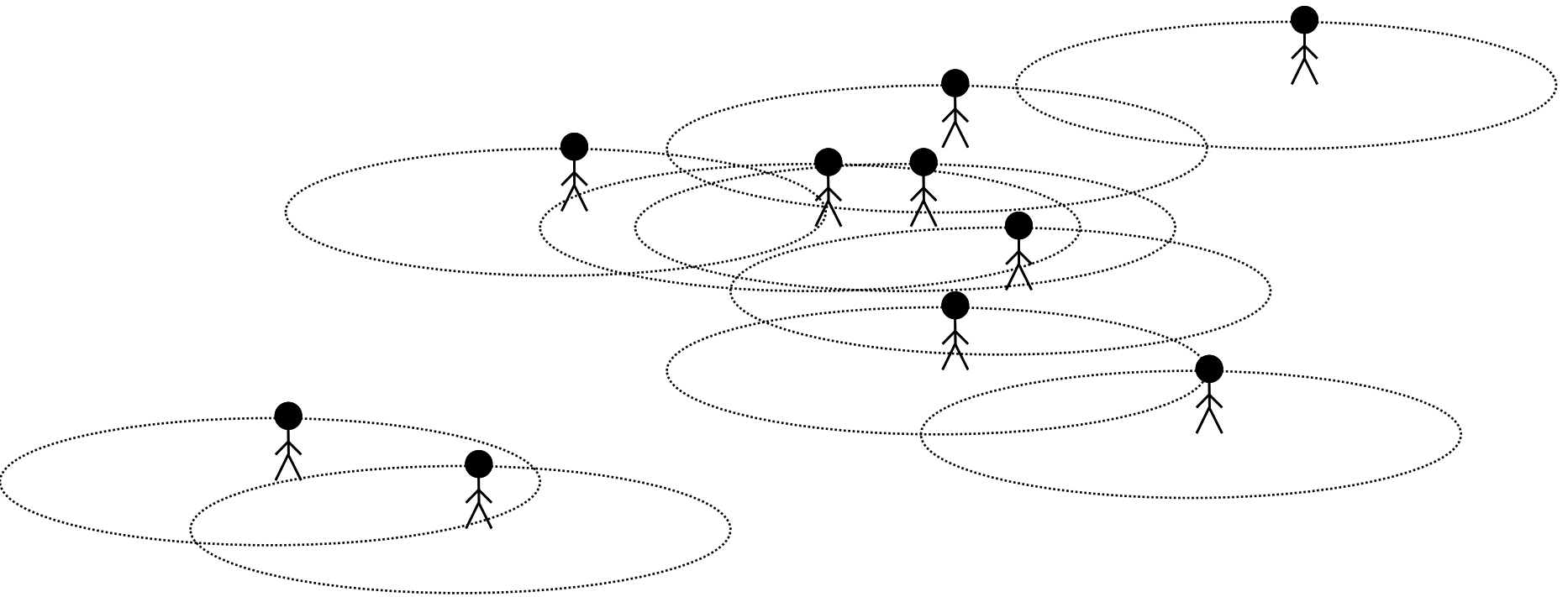
■ Models & assumptions

- Many 3D objects (position, orientation)
- User navigations with AOI visibility
- Objects are fragmented (base & refinement pieces)
- Data are initially stored at the server



Observation

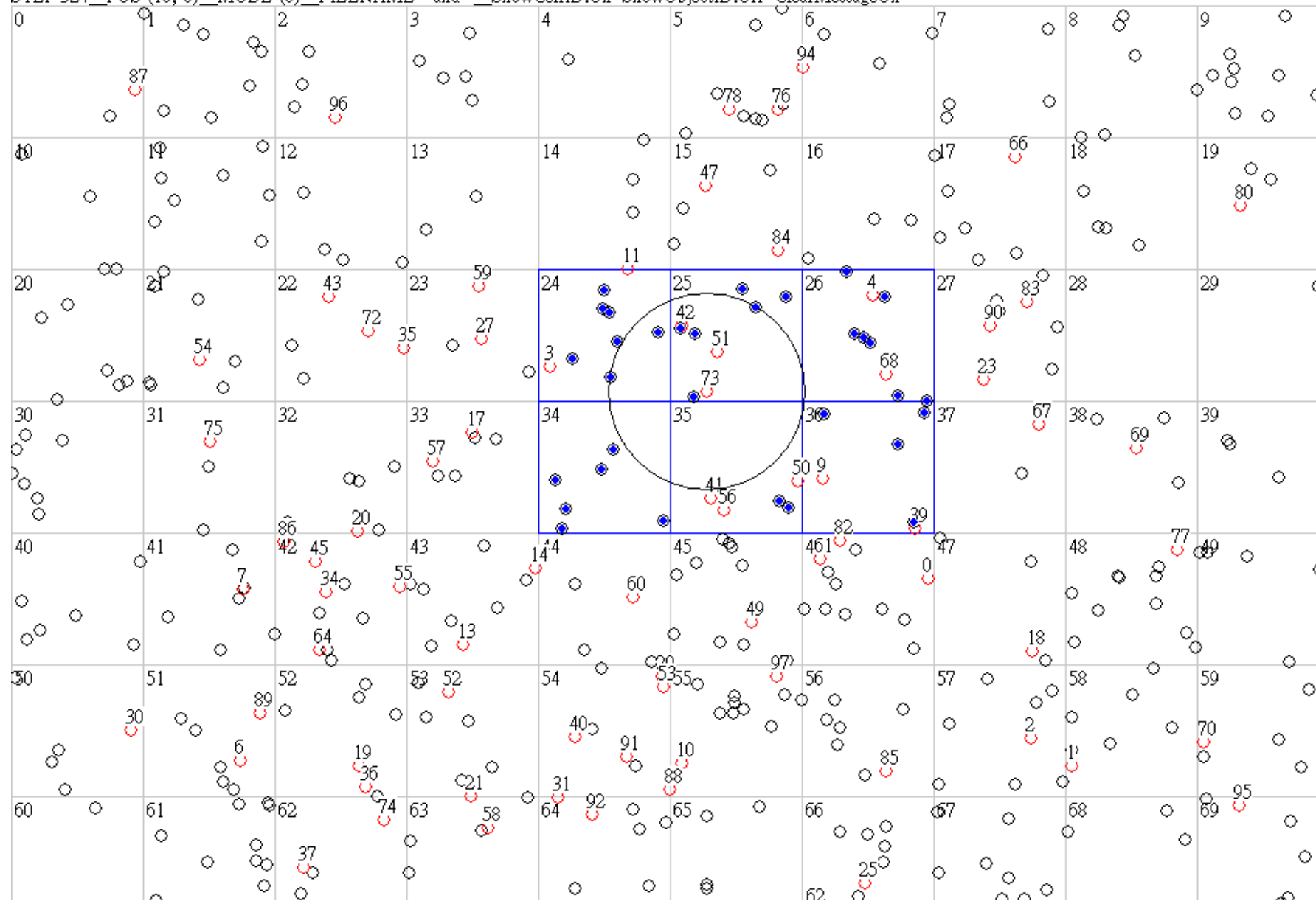
- AOI neighbors share content in memory
- Former AOI neighbors share content in disk



FLoD: Flowing Level-of-Details

- Assume P2P-NVE overlay, such as VON
- Download 3D content from **AOI neighbors**
- Basic design
 - Each object has a unique ID and associated progressive mesh data
 - **Scene description** records object ID, orientation, and scale
 - World is partitioned into **cells**

STEP 324_POS (18,-8)_MODE (0)_FILENAME "and "_ShowCellID:On ShowObjectID:Off ClearMessageOn



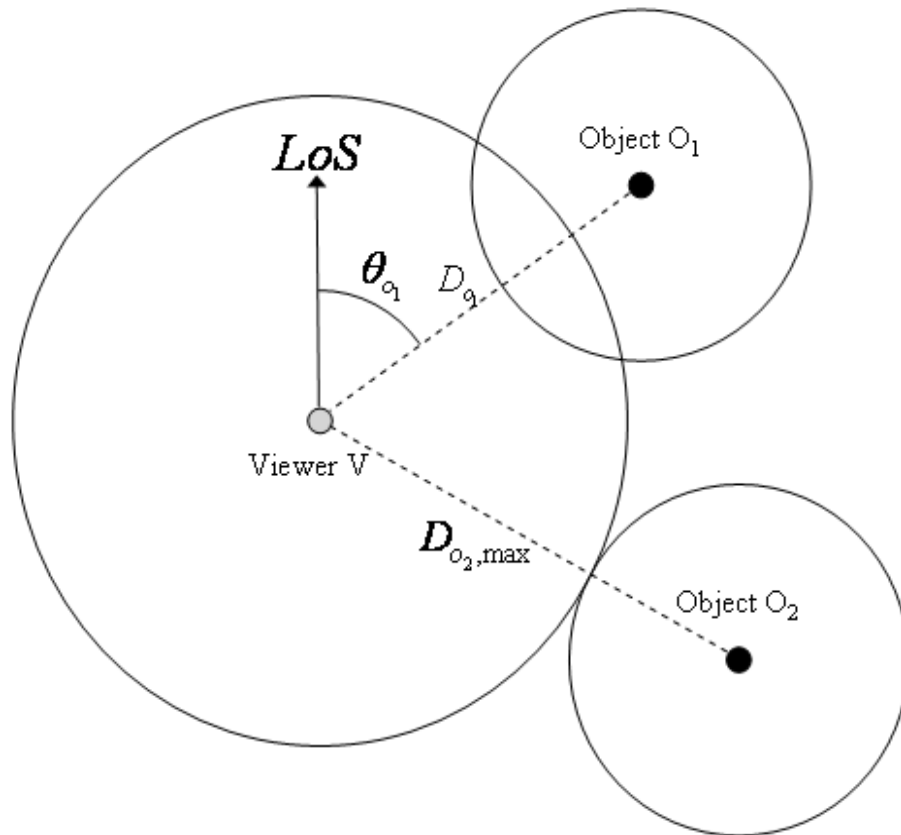


Steps of FLoD

1. Peers exchange incremental formation of cached 3D data periodically
2. A peer sends requests for downloading scene descriptions
3. A peer sends requests for downloading object data
4. A peer asks the server if none of the peers responds

Object Prioritization

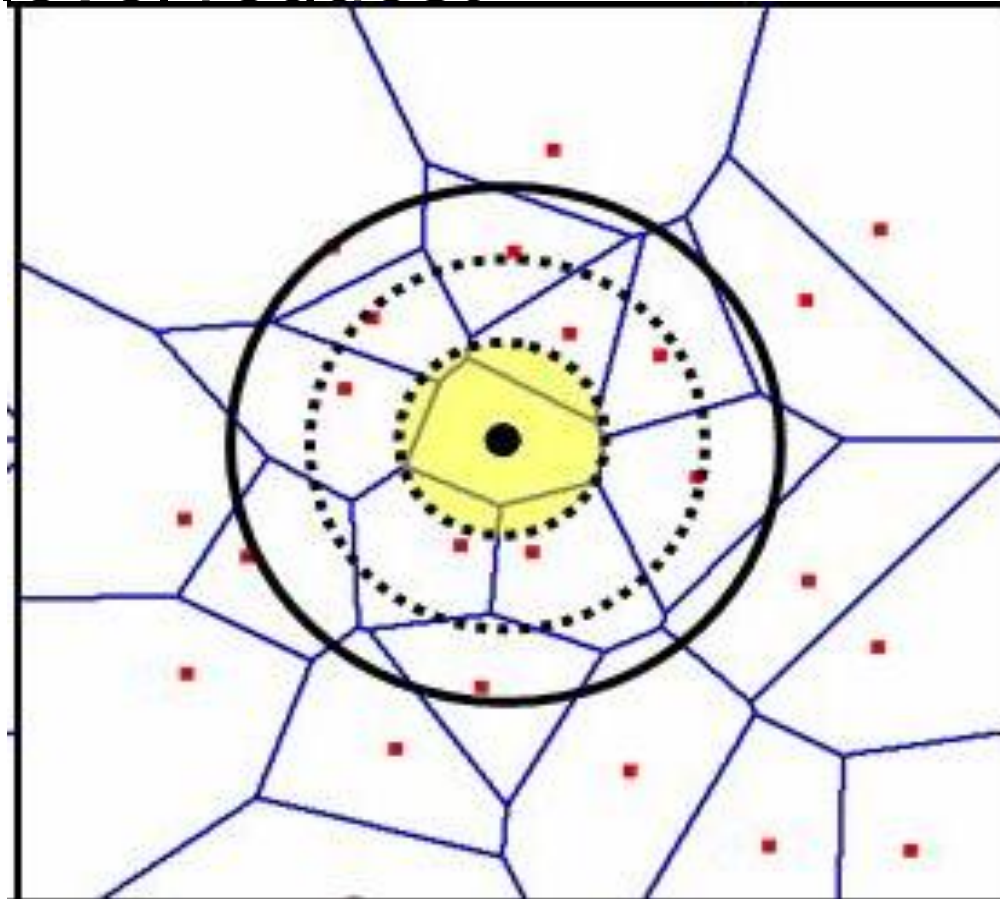
- Visual importance



$$I_o = \left(\frac{D_{o, \max} - D_o}{D_{o, \max}} \right)^2 \exp^{-K_o |\theta_o|}$$

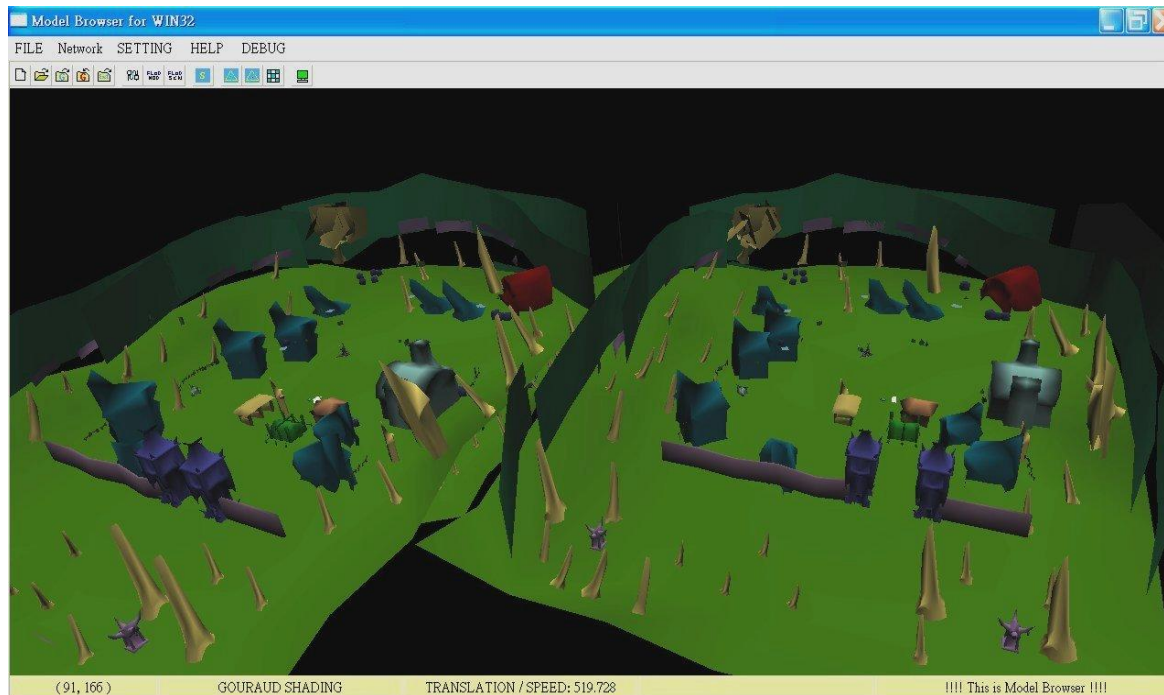
Peer selection

- Multi-level request



Prototype experiment

- Cell-based construction
- Use an actual game scene
- 100 x game scene (514KB -> 51.8MB)

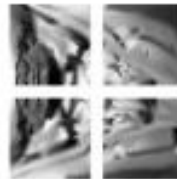


Fragmentation

Level 0



Level 1



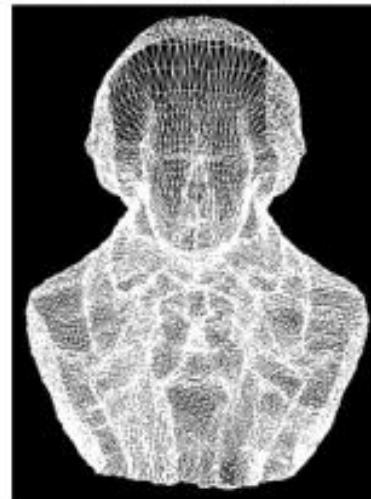
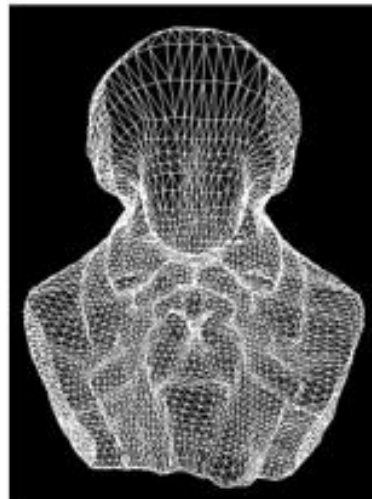
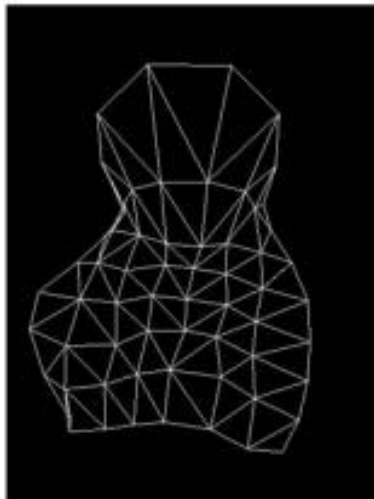
Level 2



...

...

...





Other P2P MMOG Topics

- Cheat Proof
- Reputation Management
- AOI Cast Mechanisms
- AOI Voice Chatting
- ...

Related Publication

- Mo-Che Chan, Shun-Yun Hu, Jehn-Ruey Jiang, “An Efficient and Secure Event Signature (EASES) Protocol for Peer-to-Peer Massively Multiplayer Online Games,” ***Computer Networks***, Vol. 52, No. 9, pp. 1838-1845, 2008.
- Jehn-Ruey Jiang, Chung-Ta King, Chi-Shiang Liao and Ching-Hao Liu, “MUREX: A Mutable Replica Control Scheme for Structured Peer-to-Peer Storage Systems,” ***International Journal of Pervasive Computing and Communications***, to appear.
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- **NIME 2008**: Shun-Yun Hu, Shao-Chen Chang, and Jehn-Ruey Jiang, “Voronoi State Management for Peer-to-Peer Massively Multiplayer Online Games”
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Q & A

Thank you!

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