CS 414 – Multimedia Systems Design

Lecture 37 – P2P Applications/PPLive

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Spring 2009

Administrative

- Peer Evaluation Document is posted on the web
- Peer Evaluations are due May 8 (Friday), 5pm
- Sign-up sheet for Thursday MP4 demonstration will be provided during Wednesday class
- MP4 finalist selection is on Thursday, 5-7pm in 216 SC
- MP4 competition of the finalists is 5-7, May 1, in 216 SC

Outline

- Background
- IP Multicast
- Content delivery networks
- Case study: PPLive

Reading

- “Opportunities and Challenges of Peer-to-Peer Internet Video Broadcast” by Liu et al.
- “Insights into PPLive: A Measurement Study of a Large-Scale P2P IPTV System” by Hei et al.
- “Mapping the PPLive Network: Studying the Impacts of Media Streaming on P2P Overlays” by Vu et al.
- Some lecture material borrowed from the following sources
  - Sanjay Rao’s lecture on P2P multicast in his ECE 695B course at Purdue
  - “Insights into PPLive: A Measurement Study of a Large-Scale P2P IPTV System” by Hei et al.
  - “Mapping the PPLive Network: Studying the Impacts of Media Streaming on P2P Overlays” by Vu et al.

Background

- Large-scale **video broadcast over Internet** (Internet TV such as PPLIve, YouTube)
  - Real-time video streaming
  - Need to support large numbers of viewers
    - AOL Live 8 broadcast peaked at 175,000 (July 2005)
    - CBS NCAA broadcast peaked at 268,000 (March 2006)
  - Very high data rate
    - TV quality video encoded with MPEG-4 would require 1.5 Tbps aggregate capacity for 100 million viewers
    - NFL Superbowl 2007 had 93 million viewers in the U.S. (Nielsen Media Research)

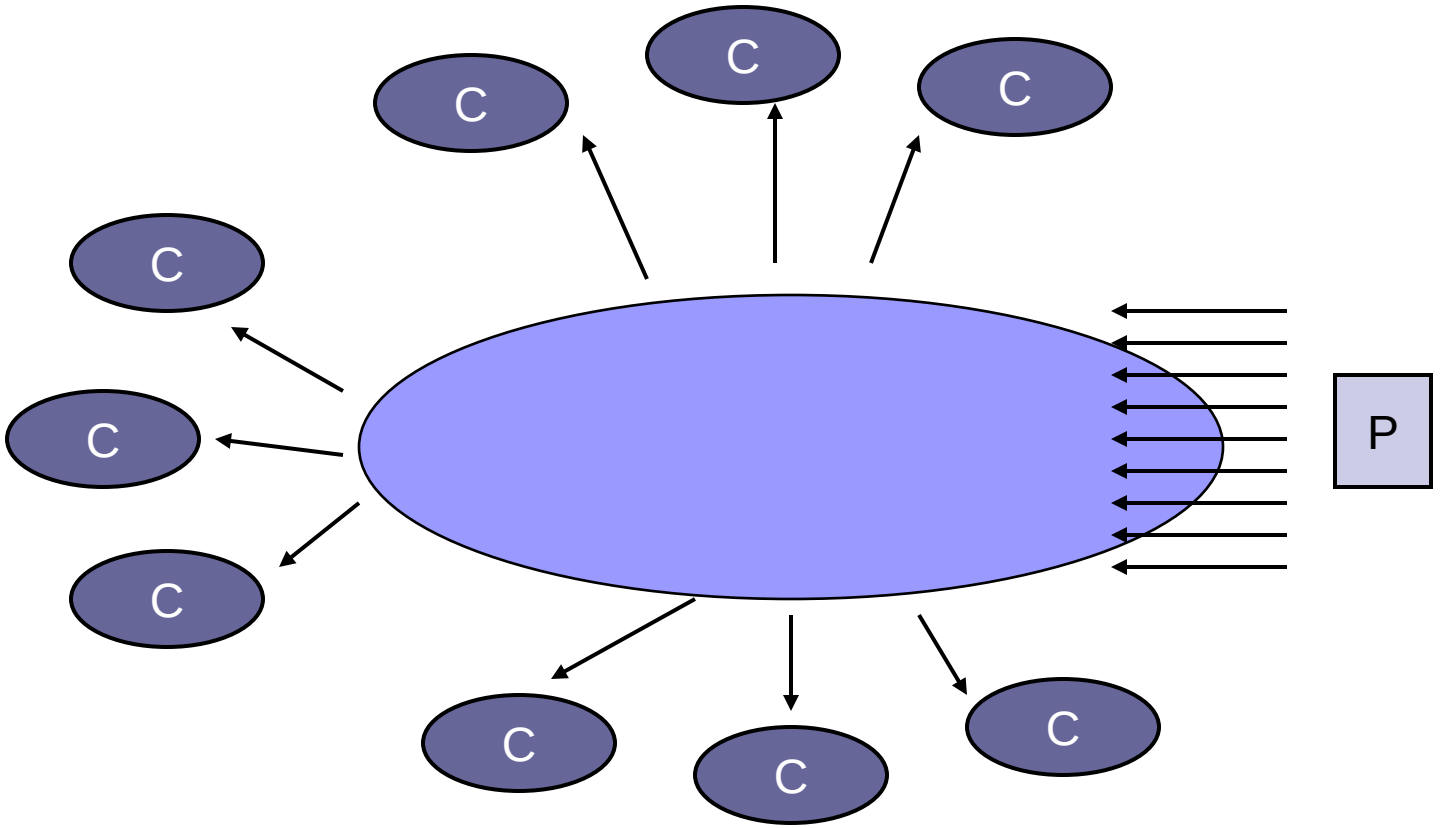
Possible Solutions

- Single server
- IP multicast
- Content delivery networks (CDNs)
- Application end points (pure P2P)

Single Server

- Application-layer solution
  - Single media server unicasts to all clients
- Needs very high capacity to serve large number of clients
  - CPU
  - Main memory
  - Bandwidth
- Impractical for millions of simultaneous viewers

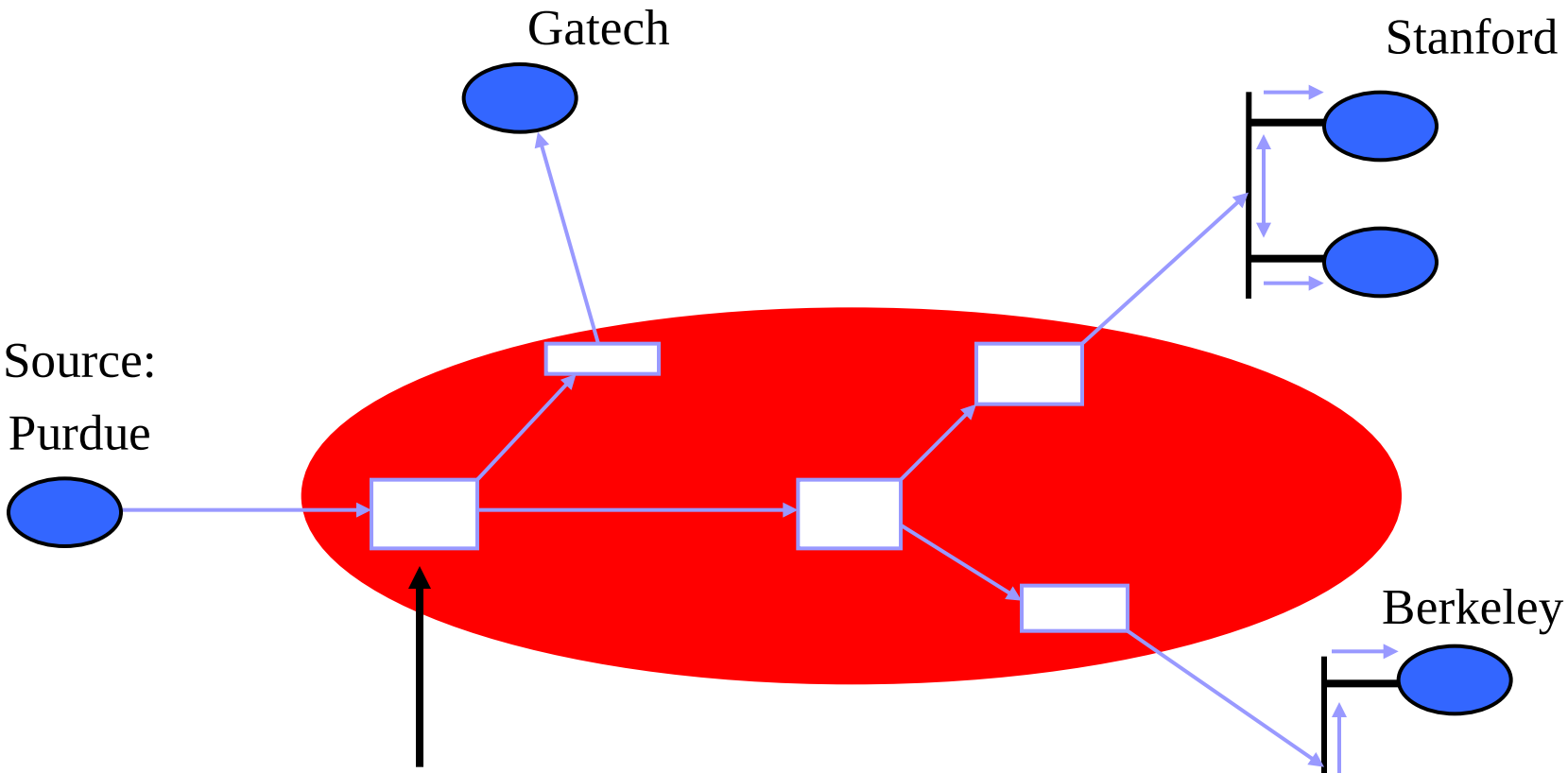
Single Server



IP Multicast

- Network-layer solution
  - Routers responsible for multicasting
- Efficient bandwidth usage
- Requires per-group state in routers
  - Scalability concern
  - Violates end-to-end design principle
- Slow deployment
  - IP multicast is often disabled in routers
- Difficult to support higher layer functionality

IP Multicast



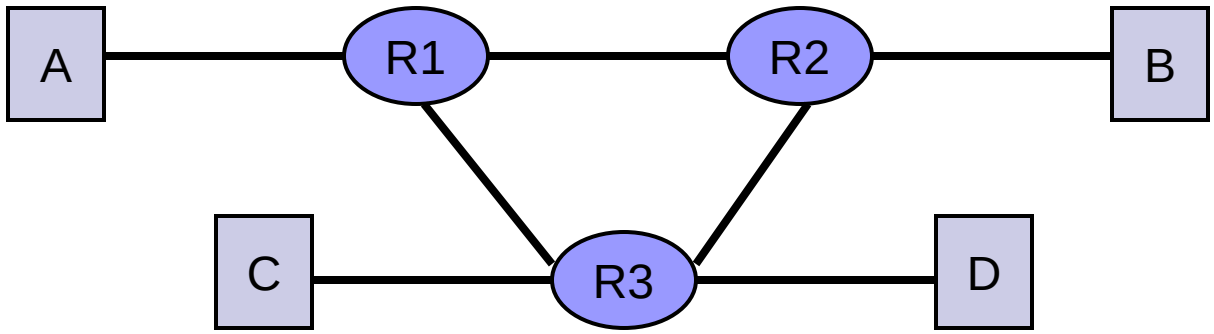
Per-group Router State

"Smart Network"

Source: Sanjay Rao's lecture from Purdue

Overlay Network

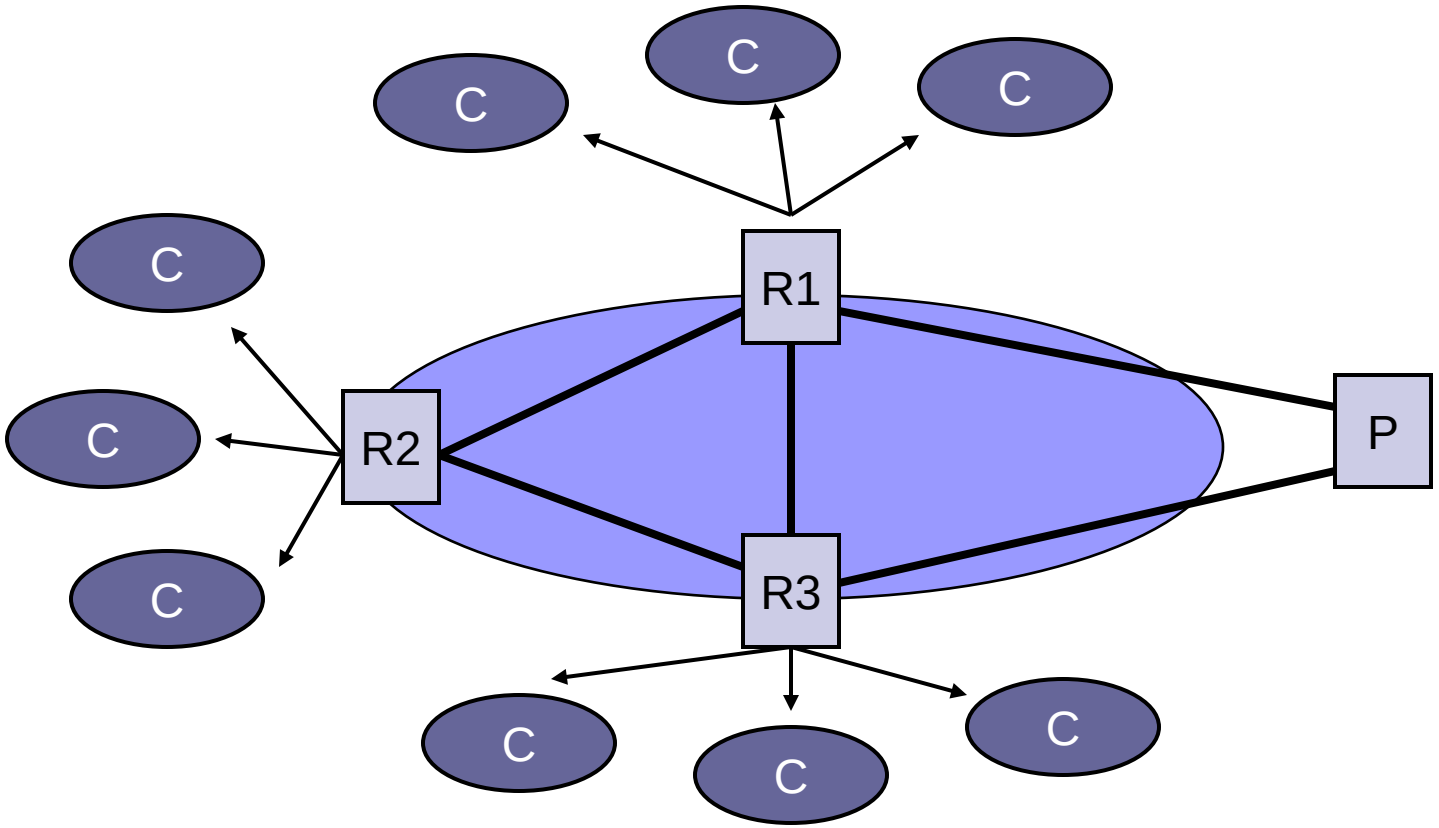
- Consists of application-layer links
- Application-layer link is logical link consisting of one or more links in underlying network
- Used by both CDNs and pure P2P systems



Content Delivery Networks

- Strategically located replicas unicast content to nearby clients
  - Reduces burden on primary server
  - Improves perceived performance at client
- Akamai CDN is the largest
  - Reports peak aggregate capacity of 200 Gbps
  - Not enough for 1.5 Tbps requirement for 100 million simultaneous viewers
- Limelight CDN served YouTube content

Content Delivery Networks



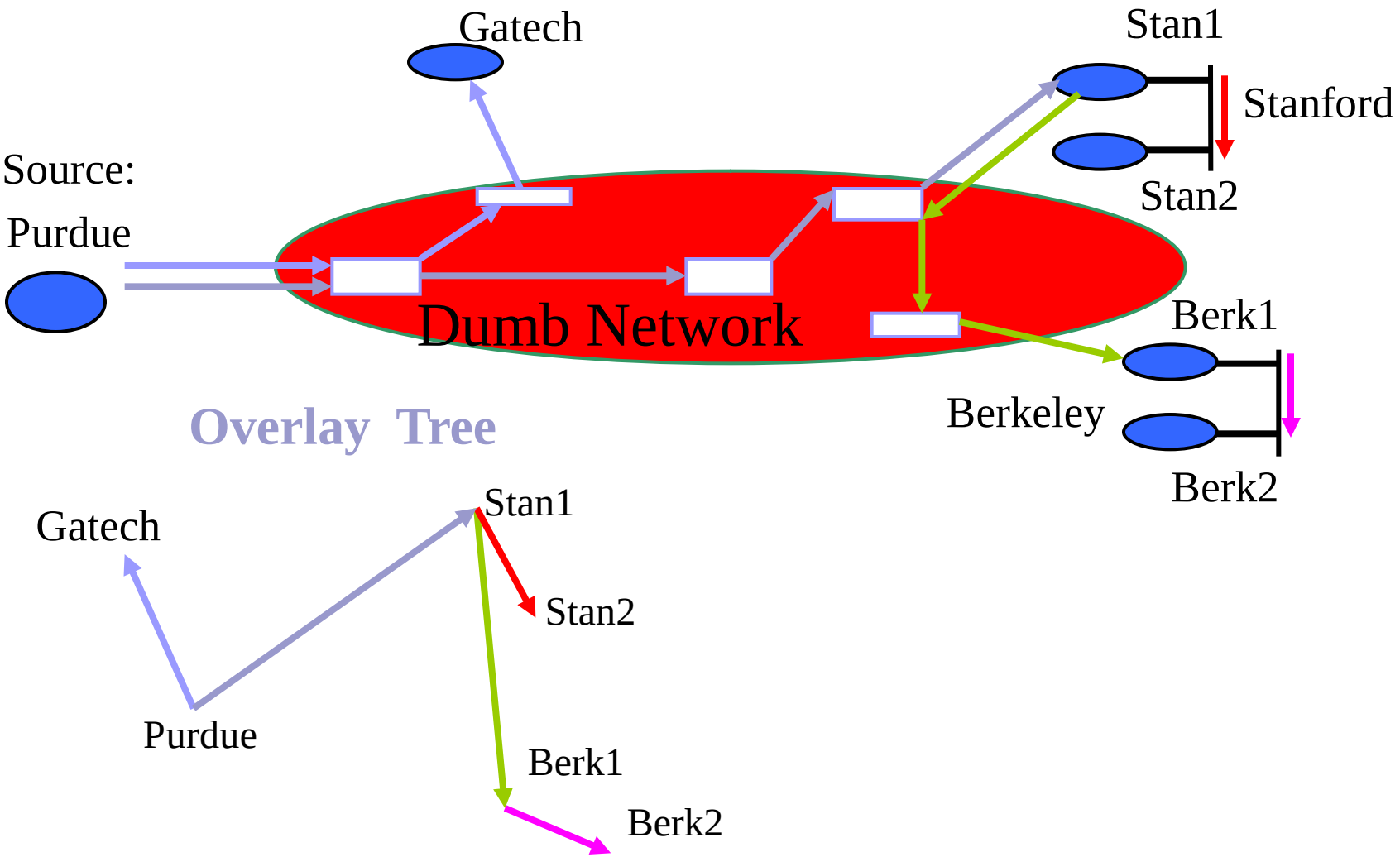
P2P Applications

- Many P2P applications since the 1990s
  - File sharing
    - Napster, Gnutella, KaZaa, BitTorrent
  - Internet telephony
    - Skype
  - Internet television
    - PPLive, CoolStreaming

Why P2P?

- Every node is both a server and client
  - Easier to deploy applications at endpoints
  - No need to build and maintain expensive infrastructure
  - Potential for both performance improvement and additional robustness
  - Additional clients create additional servers for scalability

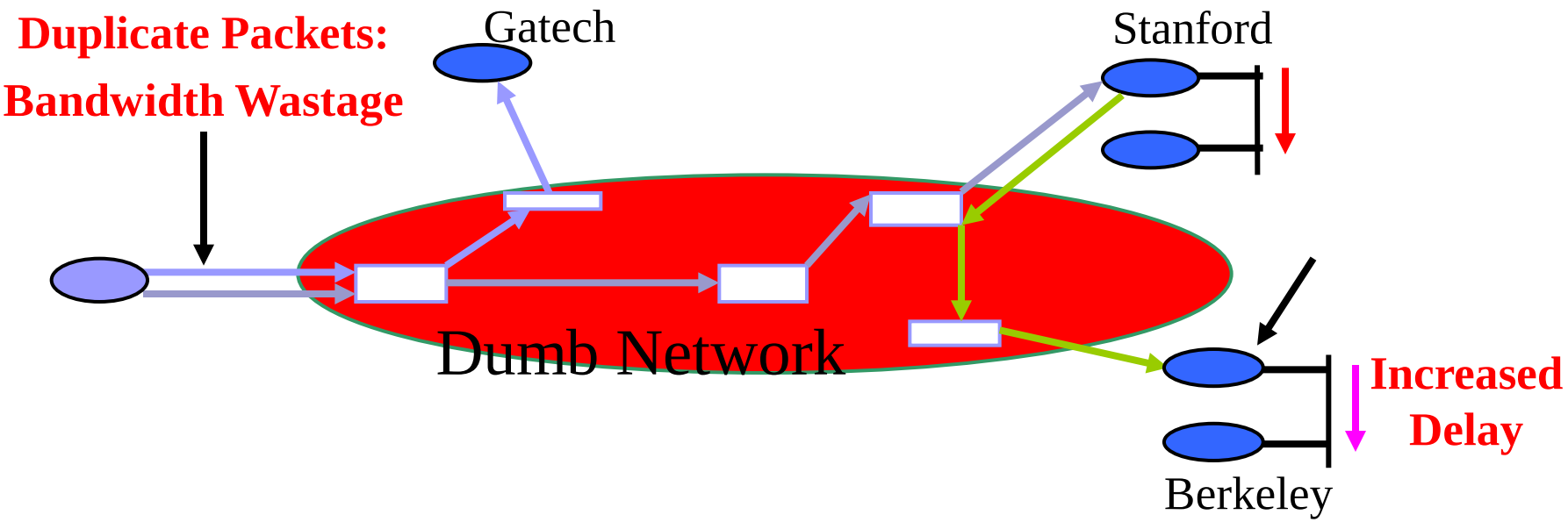
P2P Multicast



Source: Sanjay Rao's lecture from Purdue

Overlay Performance

- Even a well-designed overlay cannot be as efficient as IP Mulitcast
- But performance penalty can be kept low
- Trade-off some performance for other benefits



Source: Sanjay Rao's lecture from Purdue

Case Study: PPLive

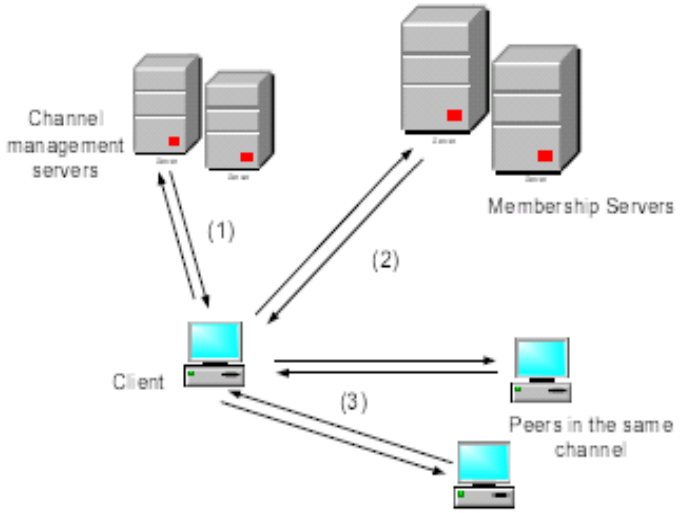
- Very popular P2P IPTV application
  - From Huazhong U. of Science and Technology, China
  - Free for viewers
  - Over 100,000 simultaneous viewers and 400,00 viewers daily
  - Over 200+ channels
  - Windows Media Video and Real Video format

PPLive Overview

Catalog Name	Number of channels
TV	52
Information	29
Sports	1
PhonenixTV	5
Movies	79
Teleplay	66
Entertainment	68
Cartoon	30
Game	28
Others	52
Summary	410

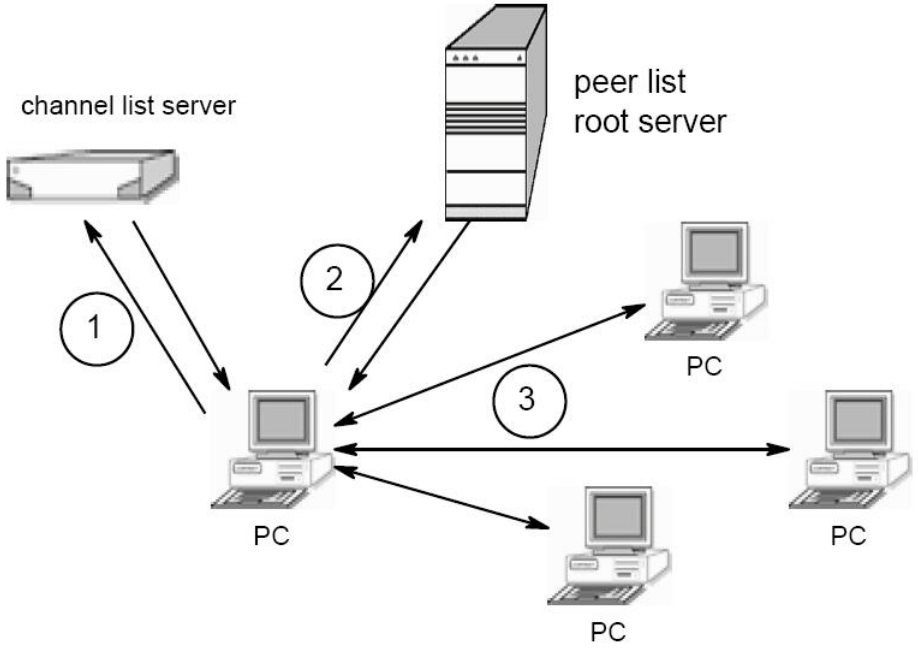
PPLive Design Characteristics

- Gossip-based protocols
  - Peer management
  - Channel discovery
  - TCP used for signaling
- Data-driven p2p streaming
  - TCP used for video streaming
  - Peer client contacts multiple active p of the channel
  - Cached contents can be uploaded from a client peer to other peers watching the same channel
  - Received video chunks are reassembled in oder and buffered in queue of PPLive TV Engine (local streaming)



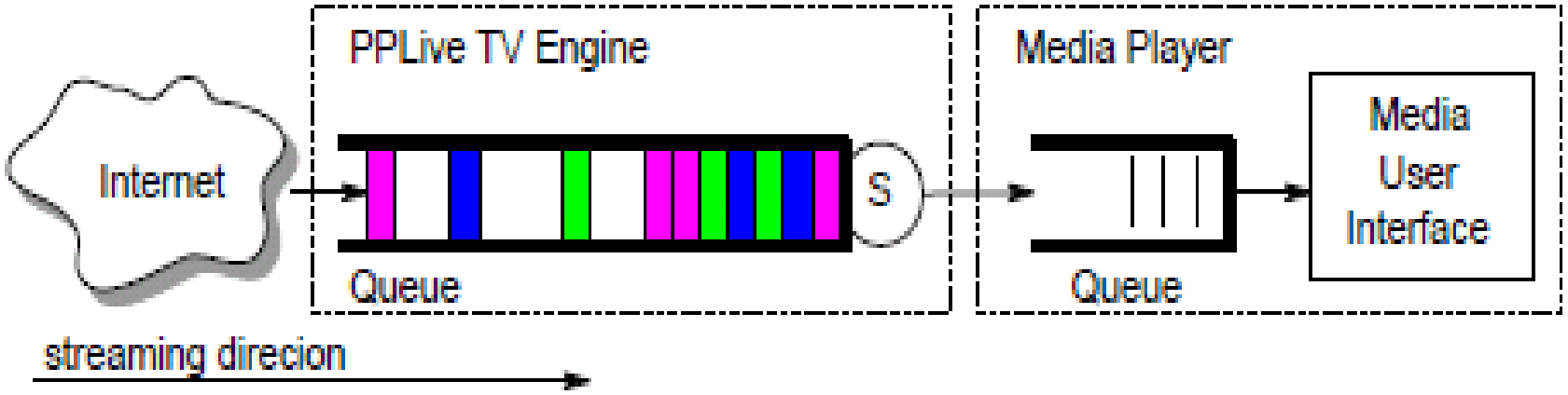
PPLive Architecture

1. Contact channel server for available channels
2. Retrieve list of peers watching selected channel
3. Find active peers on channel to share video chunks



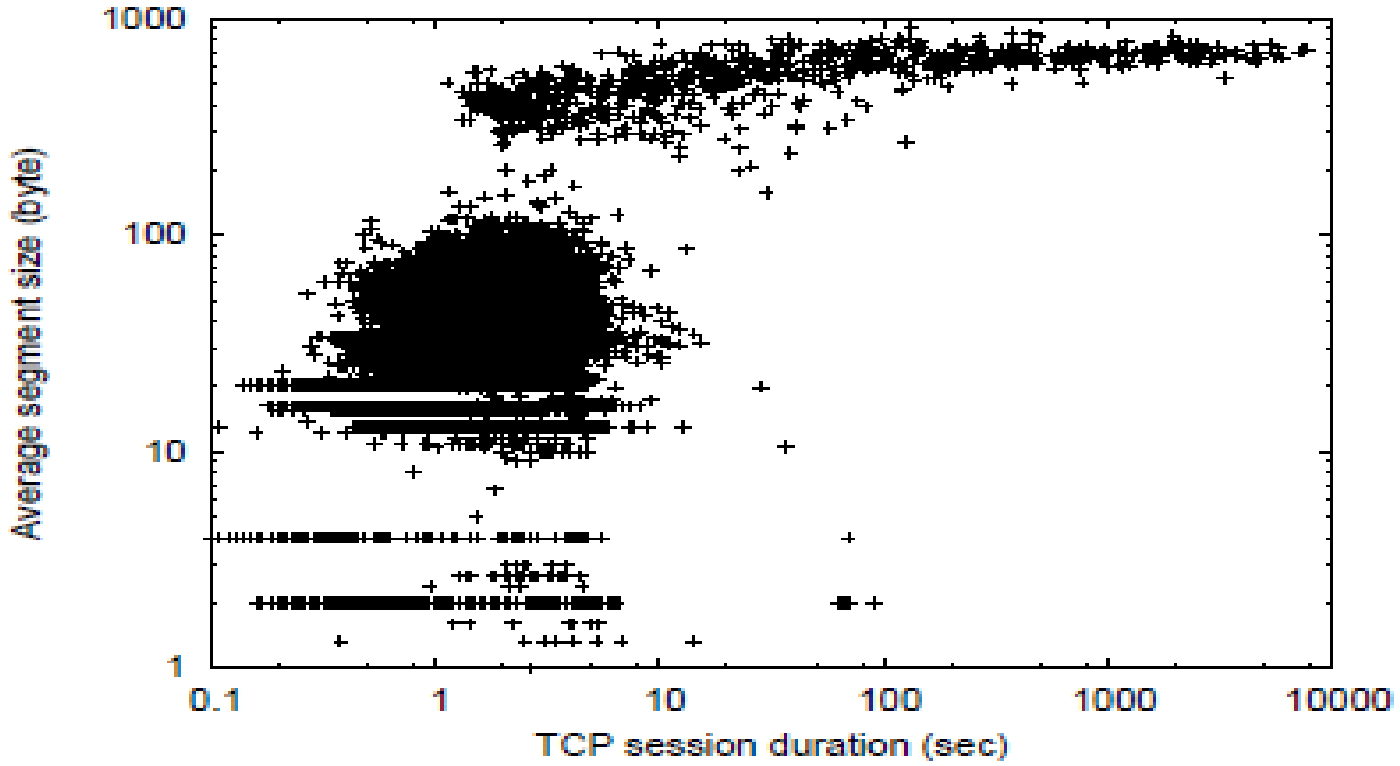
Source: "Insights into PPLive: A Measurement Study of a Large-Scale P2P IPTV System" by Hei et al.

P2P Streaming Process

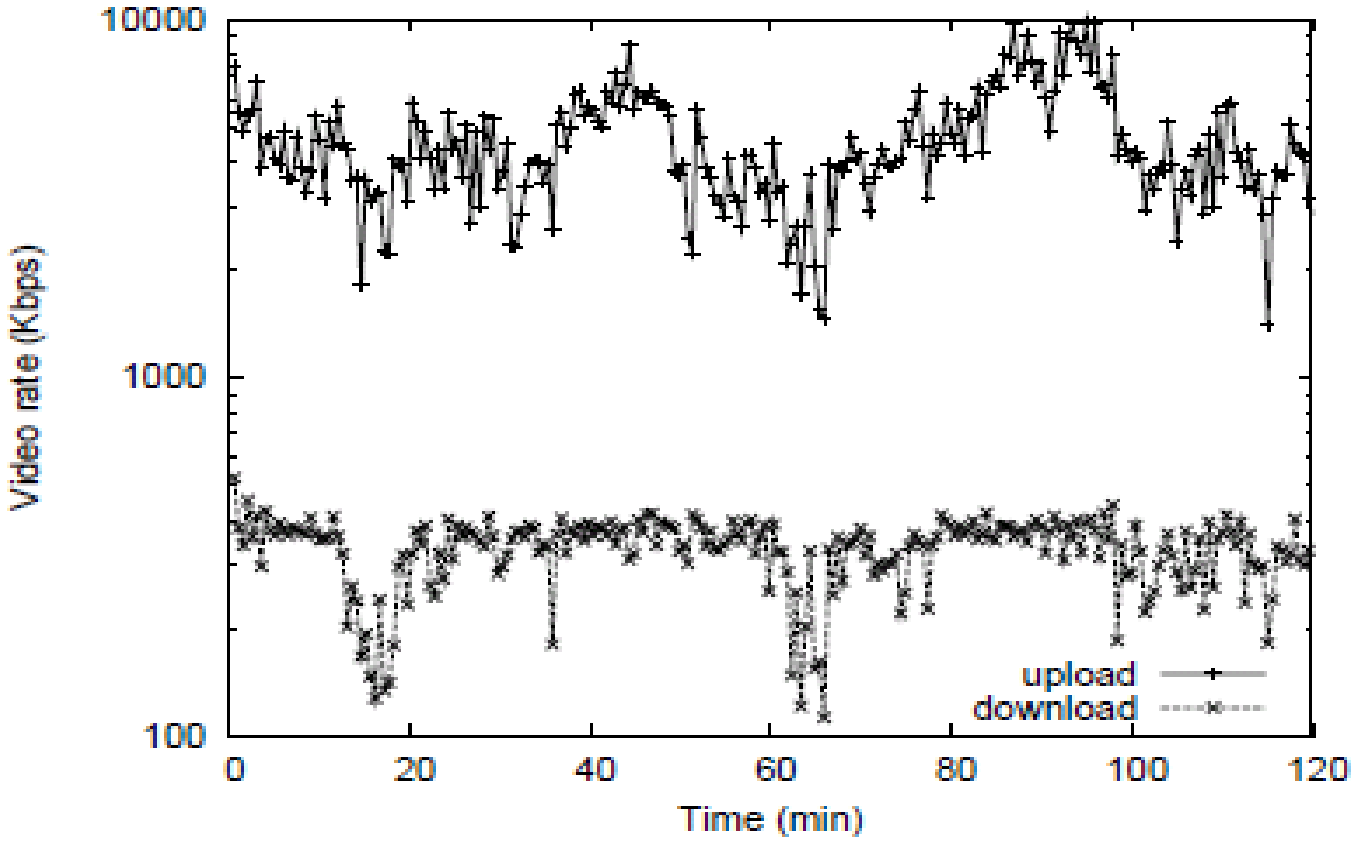


TV Engine – responsible for
- downloading video chunks from PPLive network
- streaming downloaded video to local media player

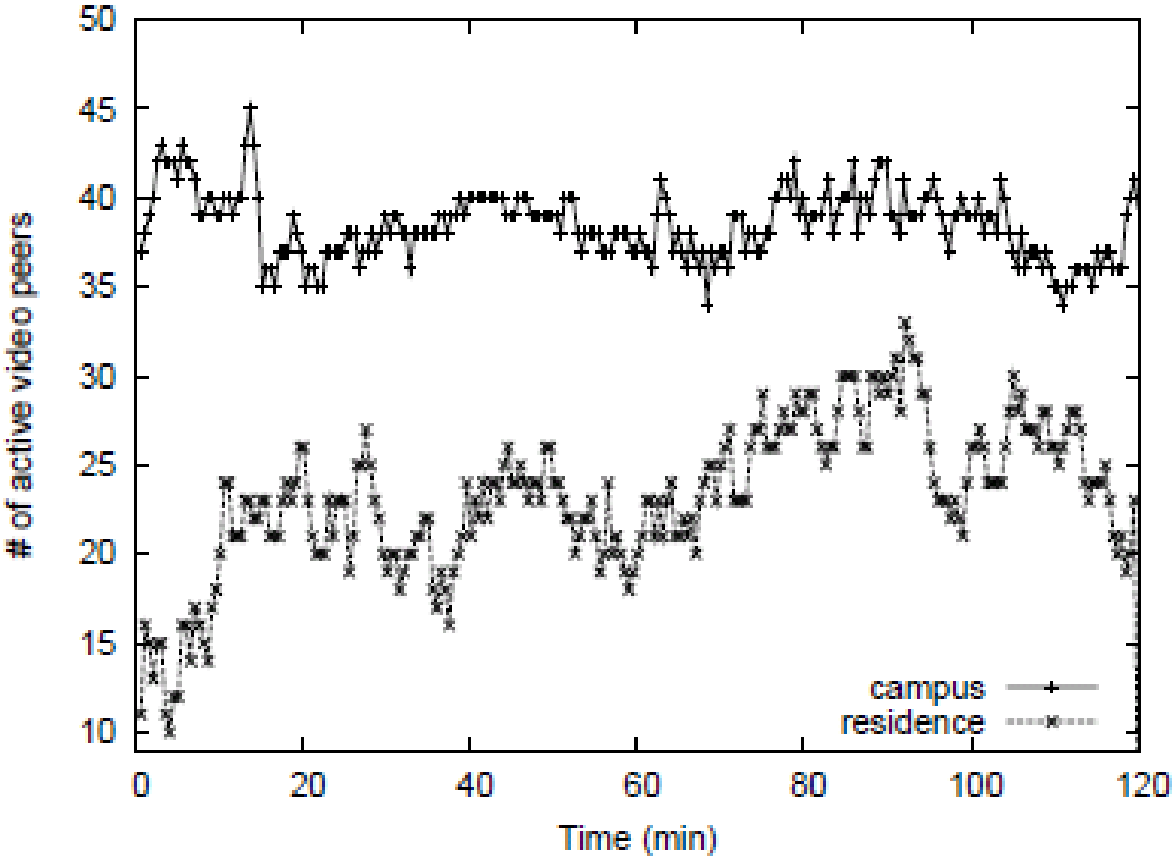
Some Interesting Measurements (TCP session duration versus TCP average segment size for CCTV3-Campus)



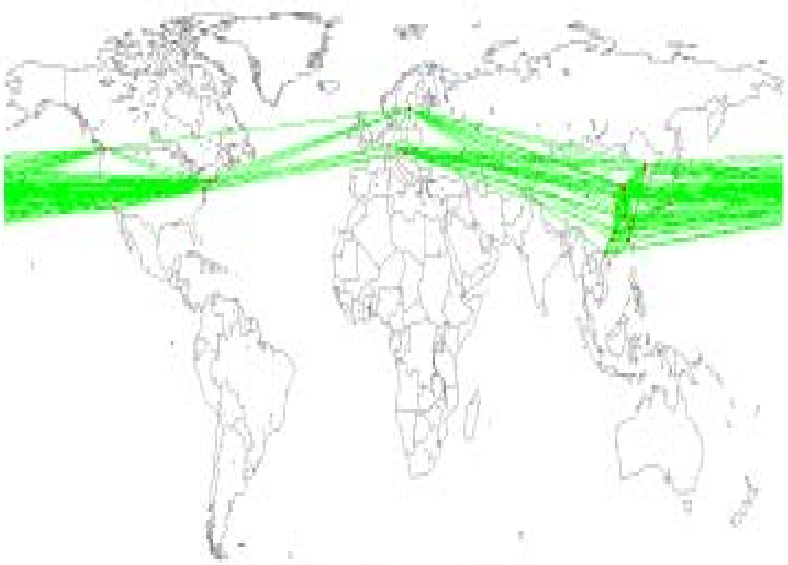
Download and Upload Video Rate over Time at CCTV3 Campus



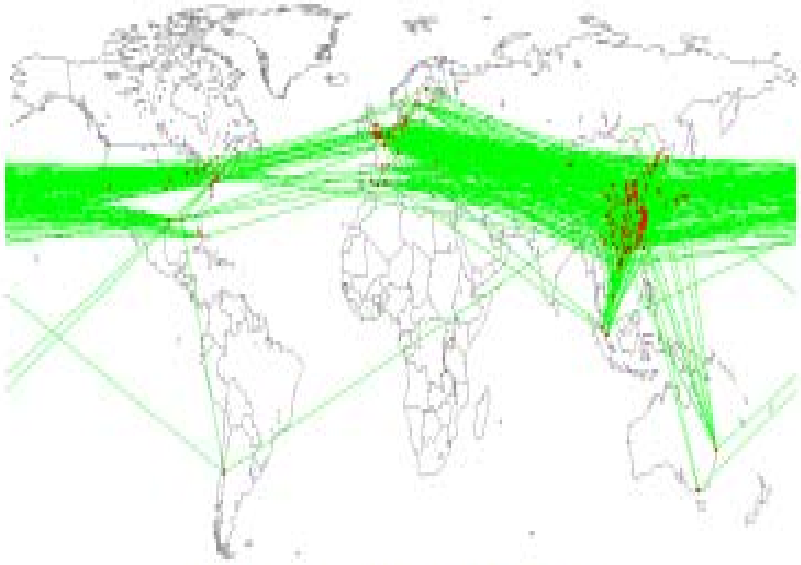
Evolution of active video peer connections on CCTV3 Network



Rendering PPLive Topology

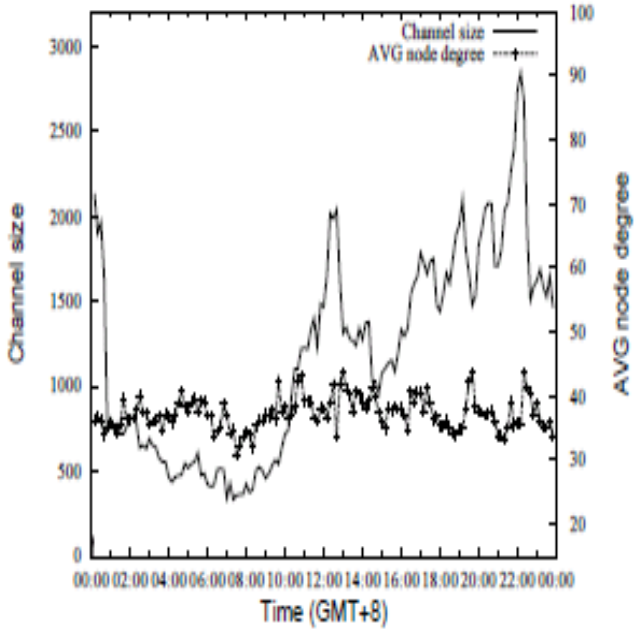


(a) An overlay of 70 nodes

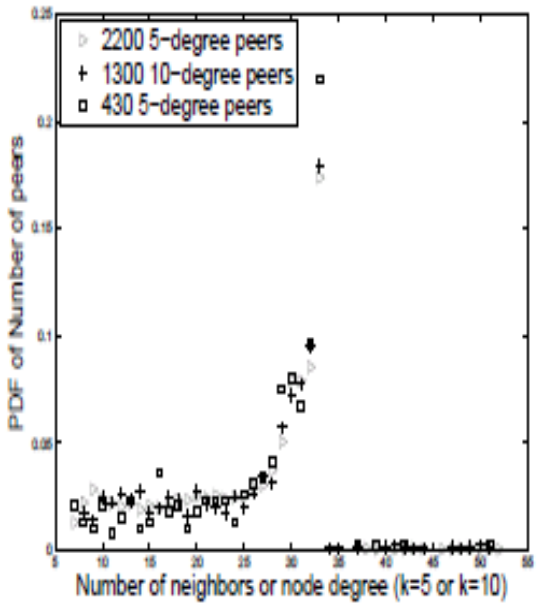


(b) An overlay of 4000 nodes

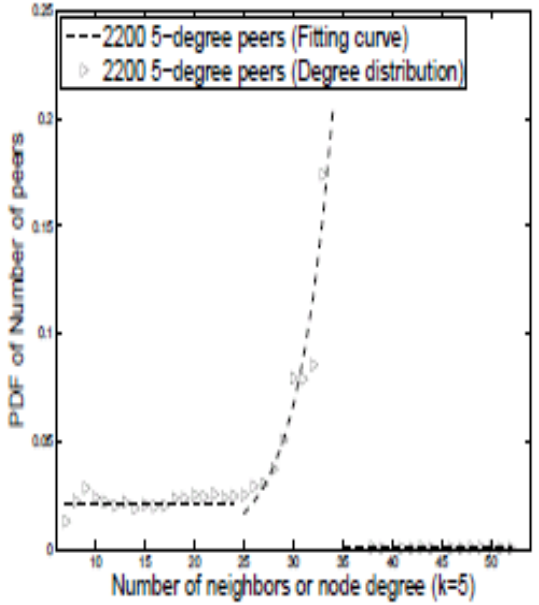
Characterizing and Modeling Node Degree Distribution



(a) Average node degree is independent of channel size (Dec 2006)

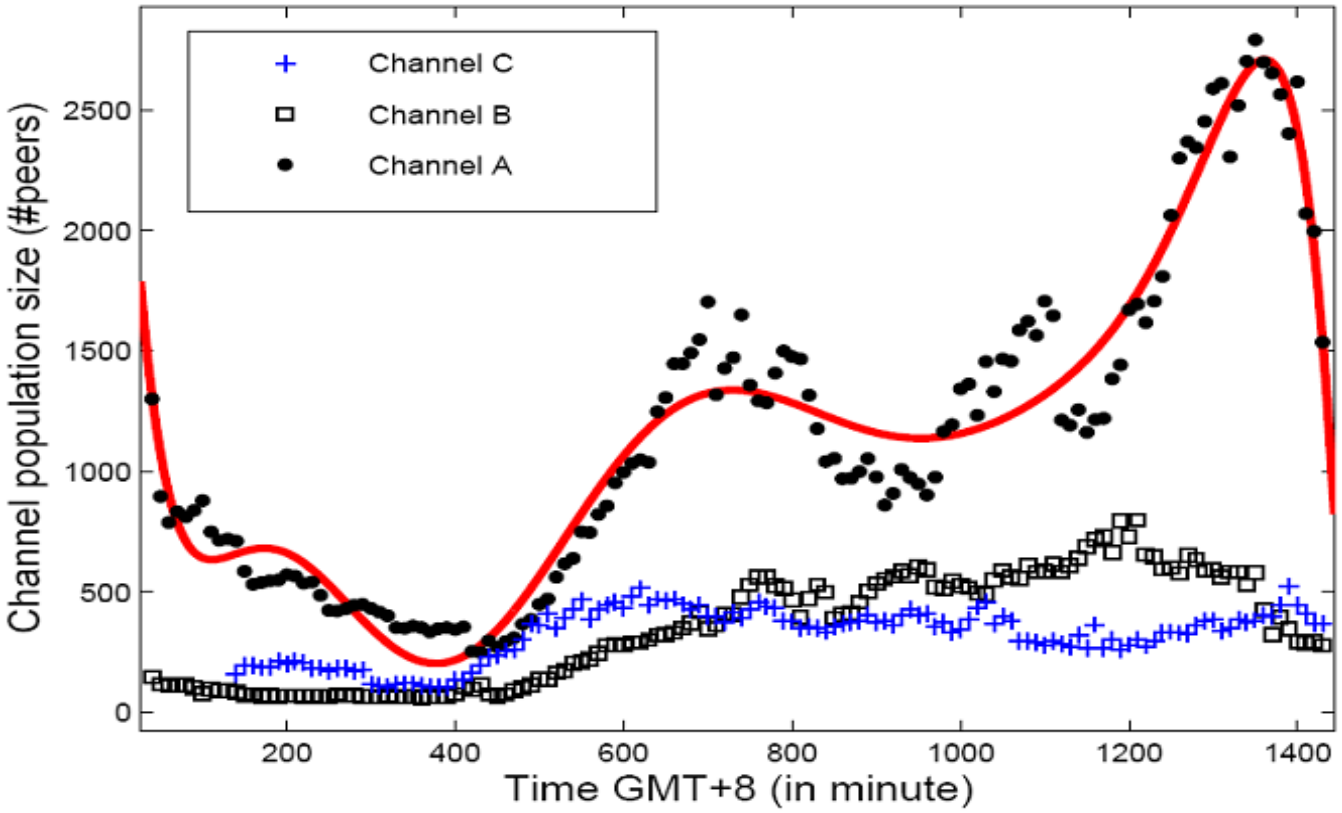


(b) Node degree distribution (May 2008)



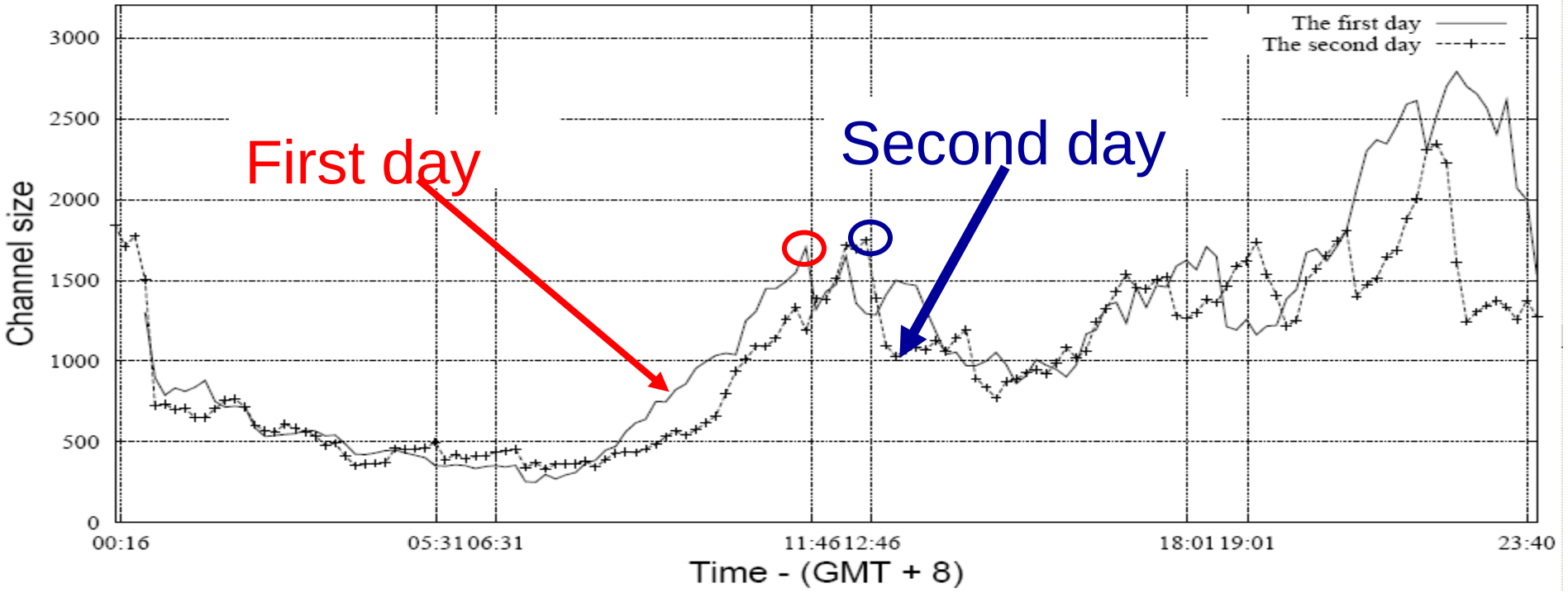
(c) Node degree distribution fitted by Matlab (May 2008)

Channel Size Varies over a day



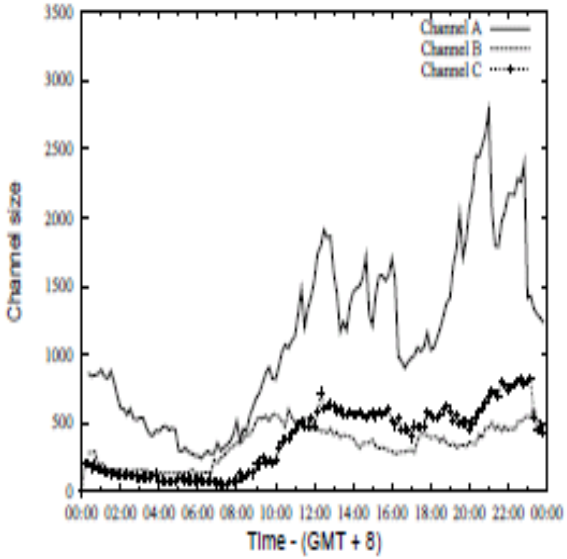
- Peaks at noon and night
- A varies 10 times, B and C varies 2 times
- Different from P2P file sharing [*Bhagwan 03*]

Channel Size Varies over Consecutive Days

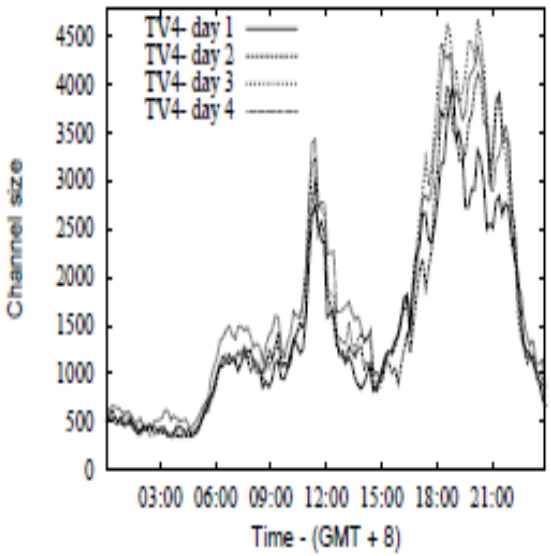


- The same channel, same program: Peaks drift
- Peaks depend on time and channel content

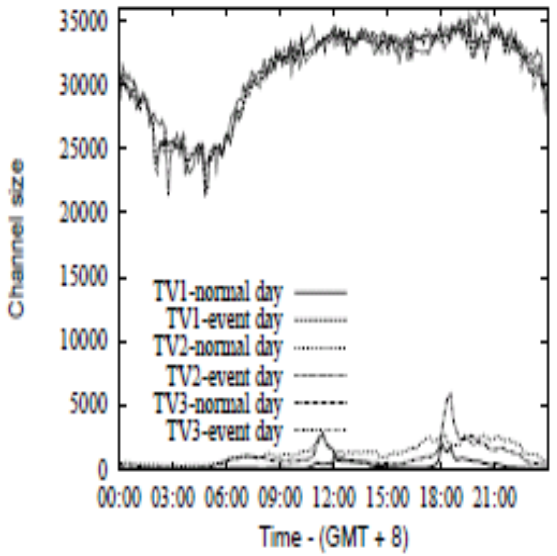
PPLive Channel Size Analysis



(a) Channel size is time-sensitive (12/2006)



(b) Channel Size is self-repeated (05/2008)



(c) Channel size is event-dependent (05/2008)

Conclusion

- Couple of Lessons Learned
  - Structure of PPLive overlay is close to random
  - PPLive peers slightly peer to have closer neighbors and peers can attend simultaneous overlays
    - Improves streaming quality
  - Geometrically distributed session lenghts of nodes can be used to accurately model node arrival and departure
- Major differences between PPLive overlays and P2P file-sharing overlays!!!