Should Internet Service Providers Fear Peer-Assisted Content Distribution?

Thomas Karagiannis, UC Riverside

Pablo Rodriguez, Microsoft Research Cambridge

Konstantina Papagiannaki, Intel Research Cambridge

UNIVERSITY of CALIFORNIA Riverside

Microsoft Research

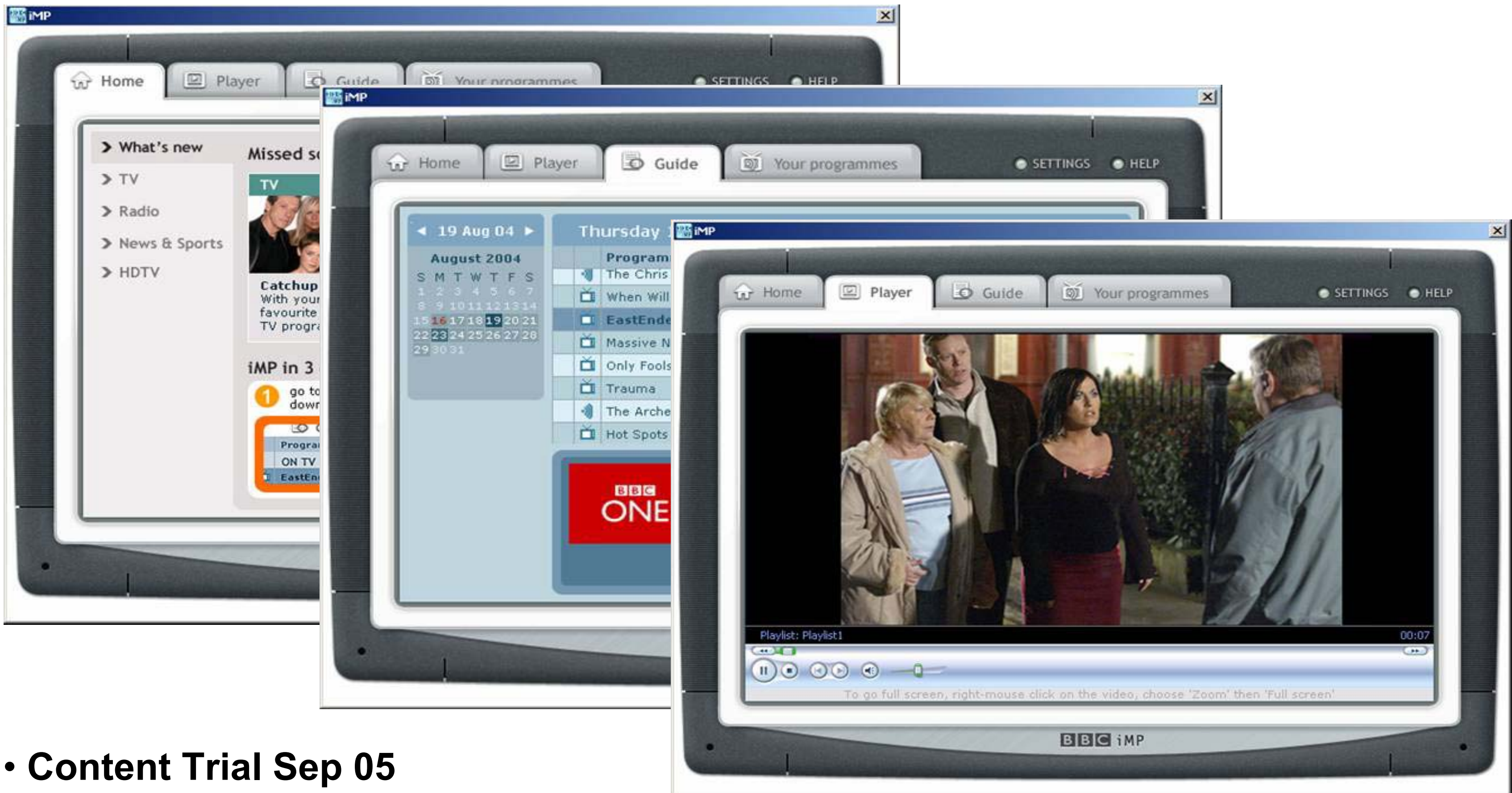
intel

http://www.cs.ucr.edu/~tkarag

P2P networks emerge as content distribution solutions

- No major infrastructure investments.
  - Capitalizing on the bandwidth of end-nodes
- Self-scalable
  - Capacity grows at the same rate as the demand
- Resilient to “flash crowd” events
  - The network spontaneously adapts to the demand

BBC iMP - The future of Film & Television

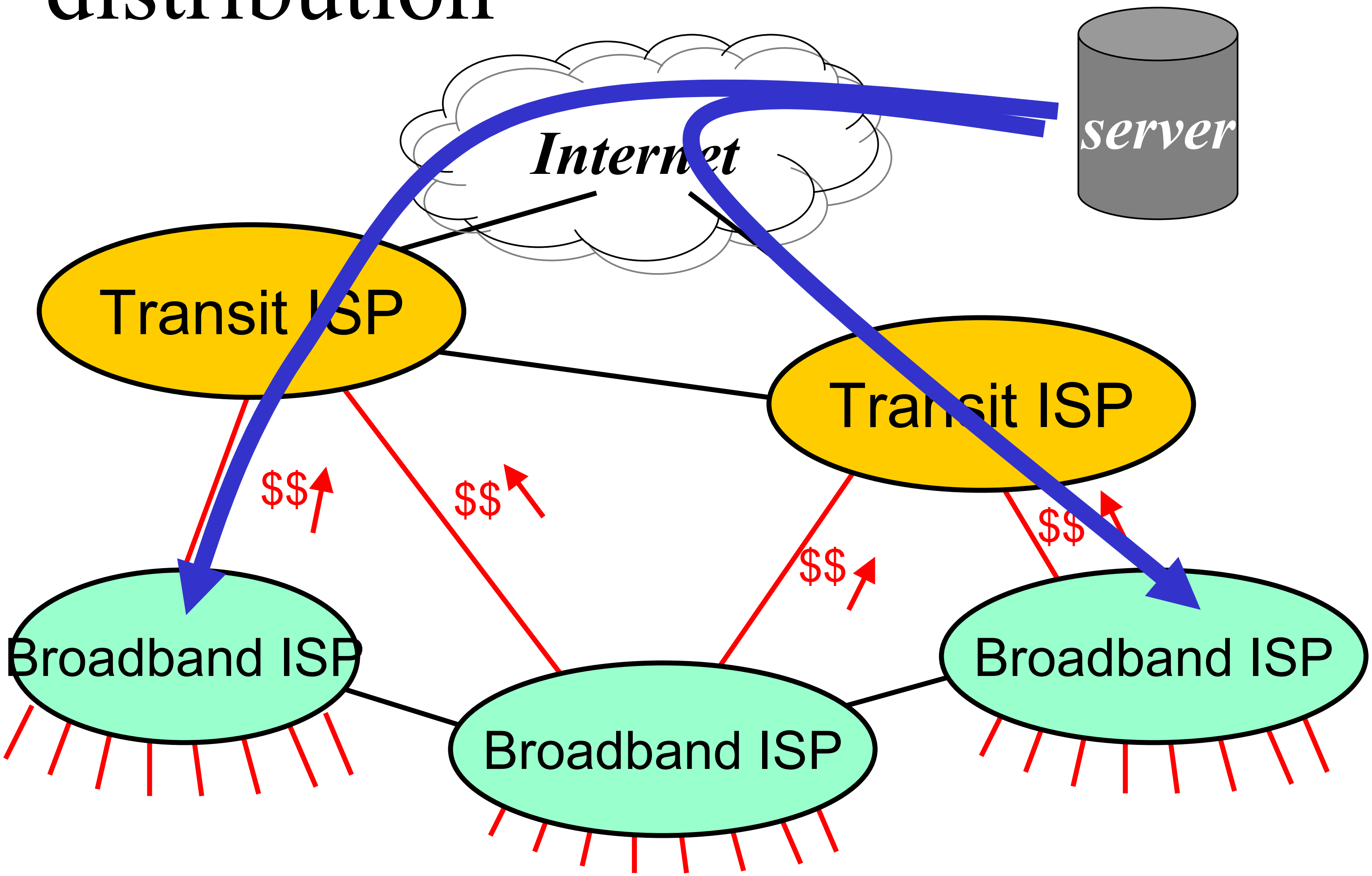


- **Content Trial Sep 05**
- **Sky announced competing offering**
- **Every major broadcaster evaluating P2P**

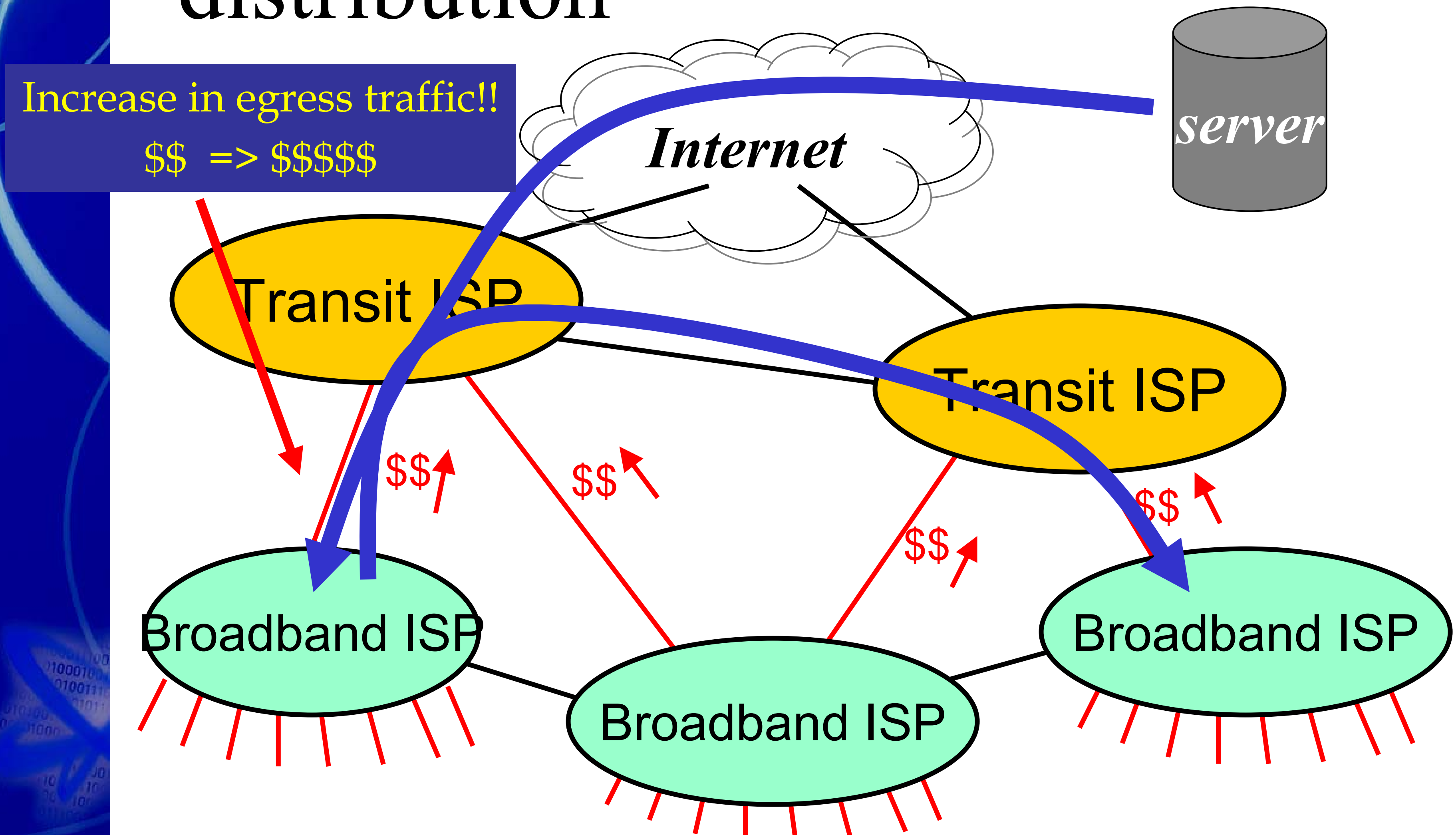
The distribution cost is shifted to the Internet Service Providers!

- ISPs indirectly act as distribution servers
  - Peers become servers
  - Increase of ISP egress traffic
- No revenue from serving the content
  - Increased bandwidth requirements but no extra revenue

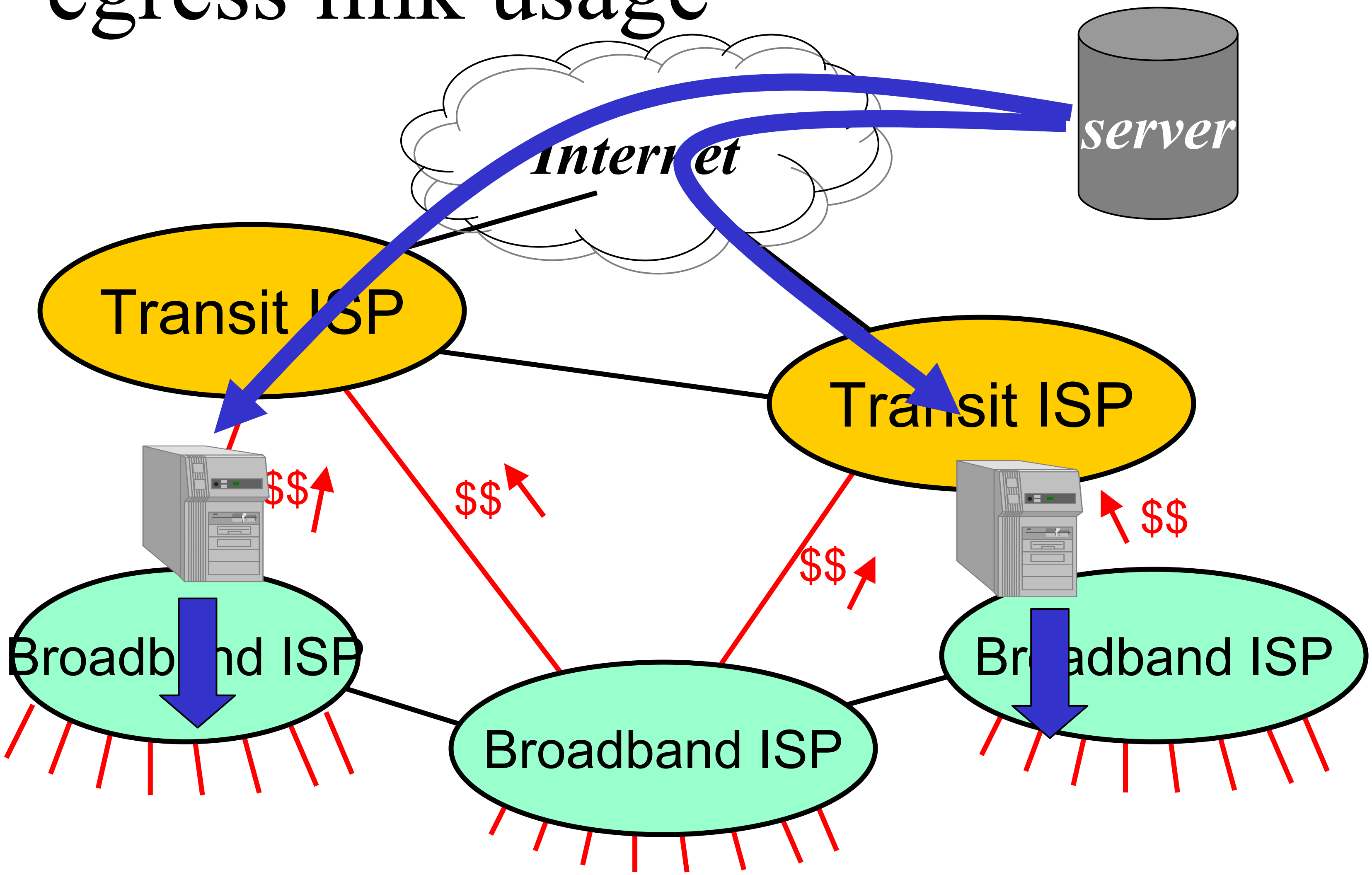
Client/server vs. P2P content distribution



Client/server vs. P2P content distribution



Locality or caching can reduce egress link usage



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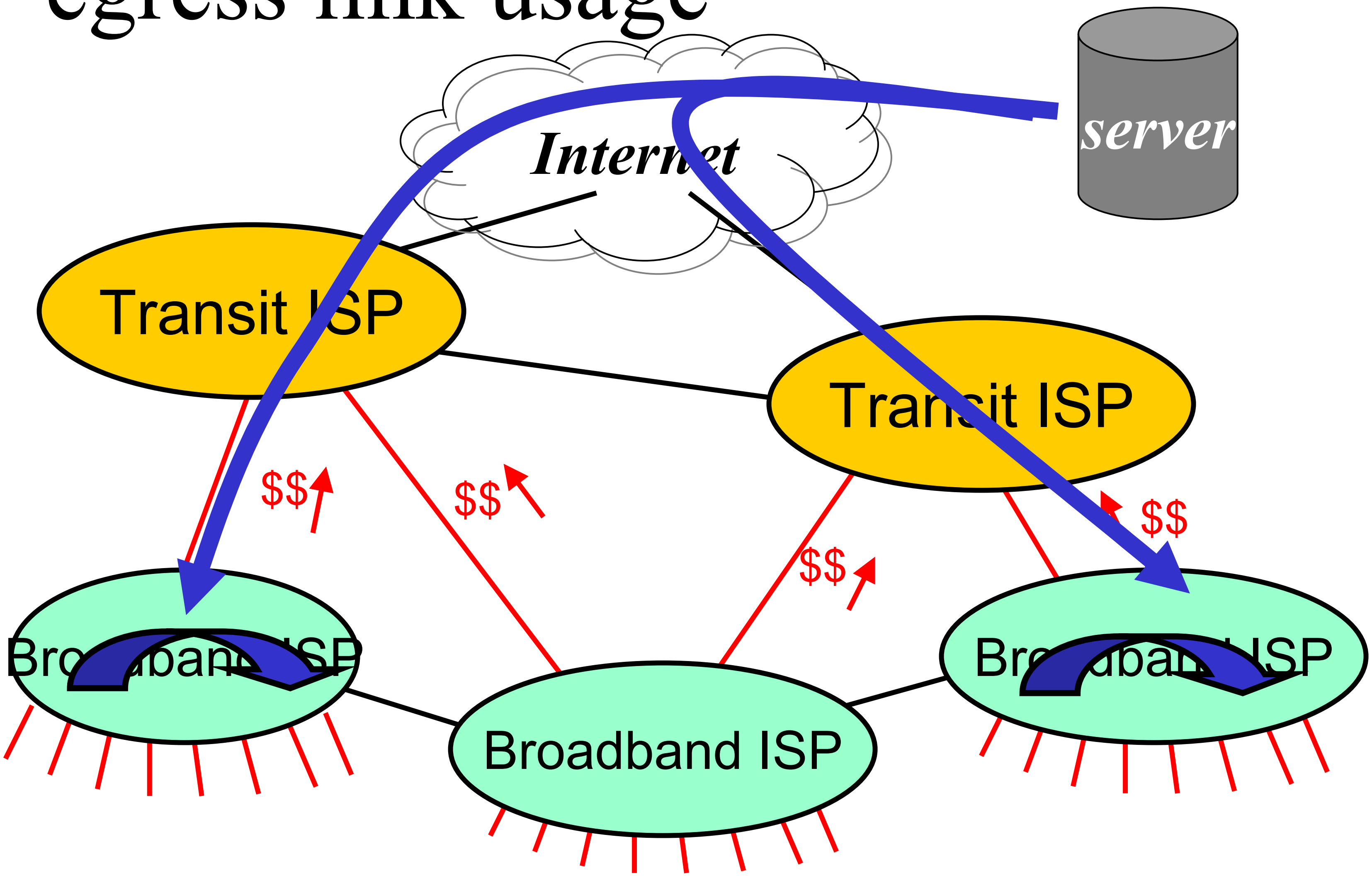

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Our contributions: An empirical cost-benefit analysis using real Internet traces

- We quantify the impact of peer-assisted content distribution solutions on:
  - the ISPs
  - the Content Providers
  - the end users
- We establish the potential for locality-aware "peer-assisted" solutions.
- We evaluate easily deployable architectures for efficient peer-assisted content distribution.

BitTorrent

- Tit-for-tat
  - Choke/unchoke
  - No free-riding
- Three entities:
  - Tracker
    - Coordinates the distribution
  - Torrent
    - Meta-info file
  - Peers
    - Seeds, Leechers

Outline

- **P2P content distribution: The view from an edge network**
  - Examine the potential for locality:
    - File hit ratios
    - Peer overlap in time
  - Potential bandwidth savings
  - Performance implications for the end user

- **Impact on ISPs: A global perspective**
  - Impact on downloaded/uploaded traffic volumes per ISP
  - Impact on the content provider

- **Locality Algorithms and their Performance**
- **Implications of locality**

The view from an edge network: Traces

- Packet-traces with machine readable headers
  - Residential (3 traces)
    - 25/34/29 hours, 110 - 130 Mbps
    - 1M-5M IPs
    - web (35%), p2p (32%)
  - BitTorrent:
    - 13%-15% of the traffic

The view from an edge network: Methodology

1. Reconstruct all BT flows
   - Tracker requests/responses
   - Peer messages (e.g., handshake, HAVE, etc)

2. Identify individual peers per file
   - Pitfalls: NATs, Proxies, Random peer IDs

3. Quantify savings if locality were present
   - Identify “unnecessary” downloads

The view from an edge network: Hit ratios & user overlap

- Hit ratio: How many users request the same content?

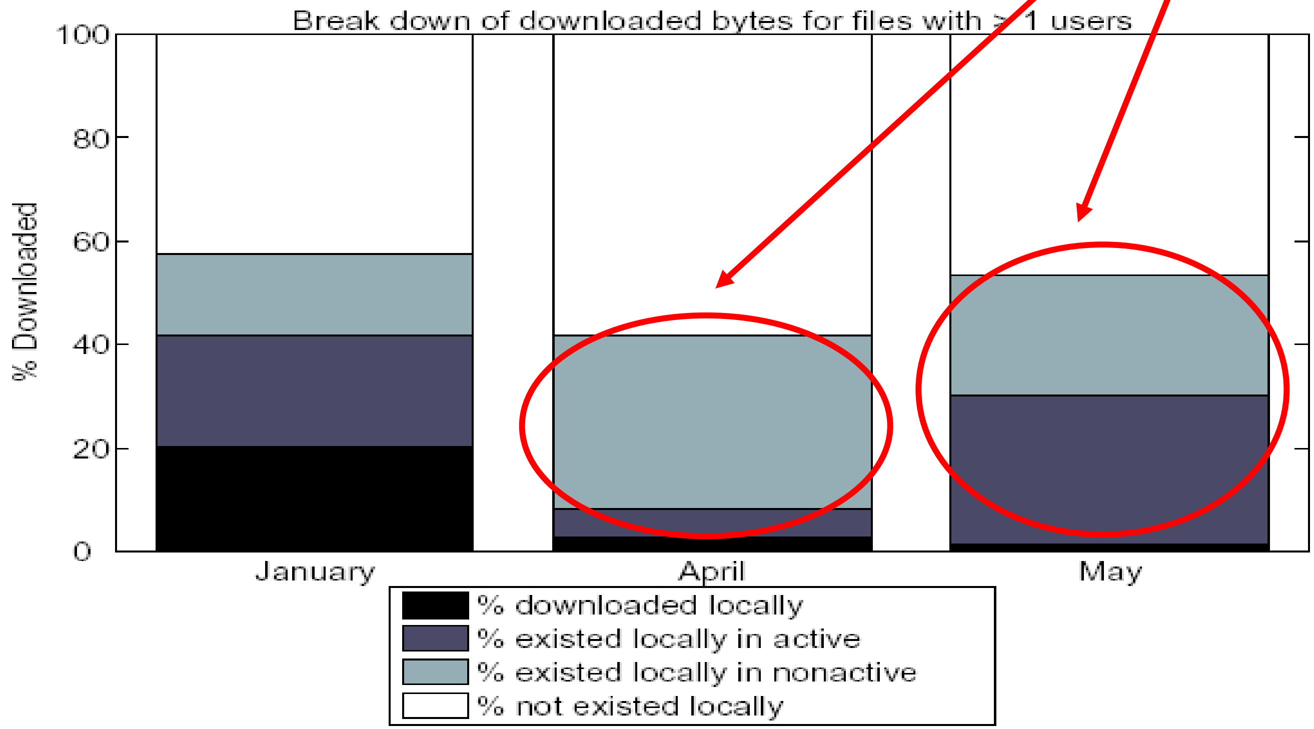
	January	April	May
File Hit Ratio	14%	10.4%	18.2%
Byte Hit Ratio	12%	9.6%	13%
Piece Hit Ratio	6%	6%	11.8%

- User overlap: Number of simultaneous active users for the same file?
  - 30%-70% of the time peers coexist

The view from an edge network: Potential savings

70%-90% of existing pieces are downloaded externally while 50% of these pieces exist in active users

- Two scenarios:
  - Caching (all downloaded bytes are available)
  - Peer-assisted (bytes in active users are available)

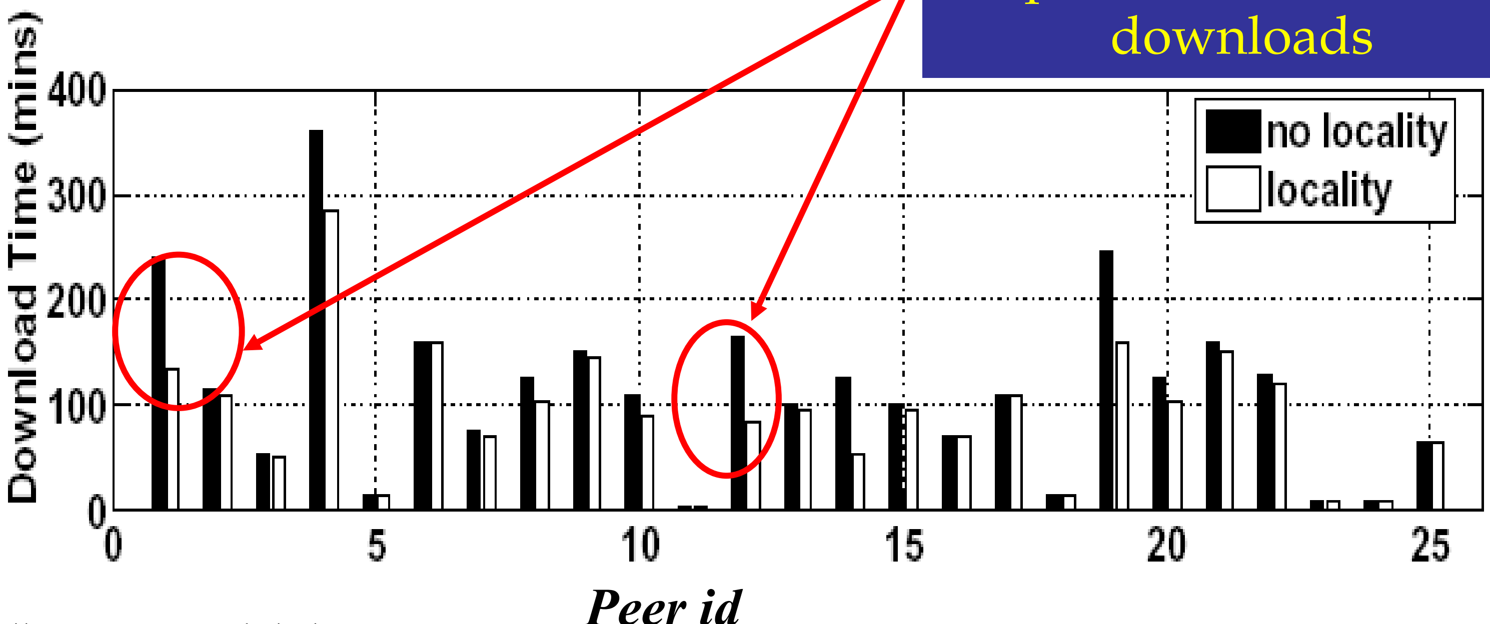


http://

The view from an edge network: Implications for end-user

- Locality will improve end-user performance:
  - Wider bottlenecks locally
  - Higher throughput paths

24% of the clients experience >50% faster downloads



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Outline

- **P2P content distribution: The view from an edge network**
  - Examine the potential for locality:
    - File hit ratios ---- (6% -18%)
    - Peer overlap in time ---- (~60%)
  - Potential bandwidth savings ---- (50% p2p, 70%-90% cache)
  - Performance implications for the end user ---- (50% faster for 24% of the population)
- **Impact on ISPs: A global perspective**
  - Impact on downloaded/uploaded traffic volumes per ISP
  - Impact on the content provider
- **Locality Algorithms and their Performance**
- **Implications of locality**

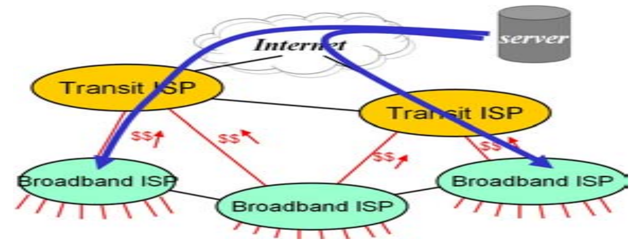
Impact of Peer-Assisted Content Distribution on ISPs: A global perspective

- Traces:
  - BT Tracker log of Redhat v9.0 distribution.
  - April-August 2003

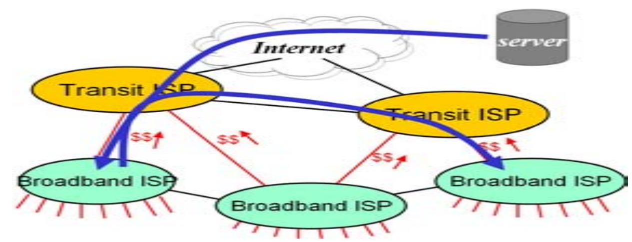
- Network partition in ASes using BGP tables
  - May and August 2003 BGP tables

Content distribution scenarios

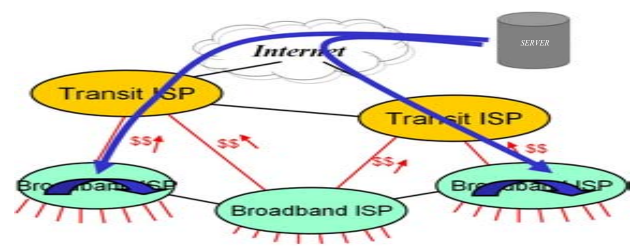
1. Server /server farm/CDN



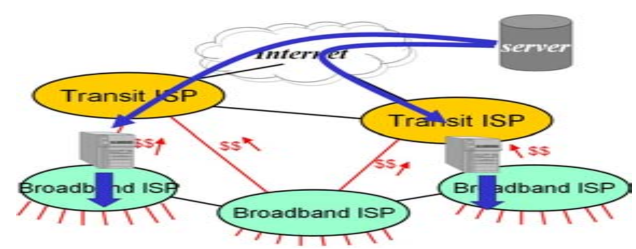
2. P2P random-matching
3. BitTorrent-like P2P



4. Peer-*assisted* content distribution + locality



5. Distributed caching



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A global perspective: Metrics of interest

- ISPs:
  - Ingress traffic per ISP (total & 95th percentile)
  - Egress traffic per ISP (total & 95th percentile)
  - Performance vs. ISP size
  - P2P vs. caching
- Content provider
  - Bytes served

A global perspective: Ingress traffic

Ingress traffic is reduced by a factor of 2 with locality

Requires only rougly 1.5 times the peak capacity compared to caching

Downloaded data (in MB) by each ISP. Percentages show savings compared to client/server.

Scenario	Average	95th percentile
Client/server	14137	804
P2P	13954 (1.3%)	794 (1.3%)
BT	13784 (2.5%)	786 (2.2%)
P2P+locality	6710 (52.5%)	625 (22.3%)
Caching	1191 (91.6%)	459 (42.9%)

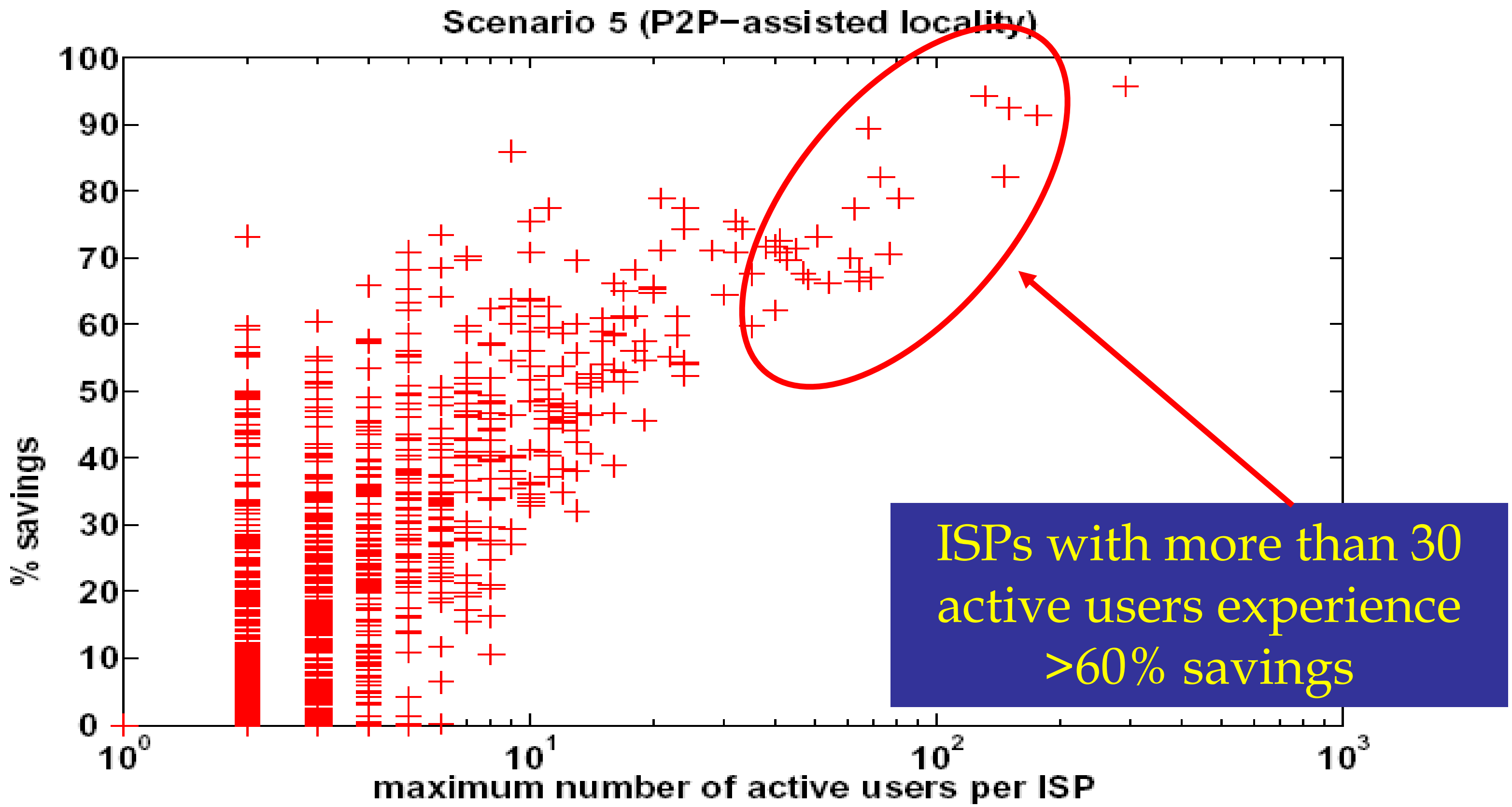
A global perspective: egress traffic

Each ISP is required to upload just over a copy of the file (1.9 GB)

Average uploaded data (in MB) by each ISP. Percentages show savings.

Scenario	Average	95th percentile
Client/server	-	-
P2P	17239	750
BT	17551	759
P2P+locality	2827 (84%)	238 (68%)
Caching	-	-

A global perspective : Savings vs. ISP size



Impact of Peer-Assisted Content Distribution on ISPs: Content Provider

Locality results in less than half the resource requirements compared to the client-server scenario

Total egress server capacity

Scenario	Average	95th percentile
Client/server	59.8 TB	17 TB
P2P+locality	28.4 TB (52.5%)	8.1 TB (52.3%)
Caching	5 TB (91.6%)	1.6 TB (91%)

Locality algorithms and their performance

- Locality algorithms:
  - implemented by ISPs
    - proxy-trackers
    - consistent with peer-assisted locality analysis
  - imposed by content providers
    - IPs grouped by prefix/domain rules
- Imposed solutions are not as efficient
  - Fail to match AS boundaries (contrary to proxy-trackers)
  - 50% of the optimal solution

Downloaded data (in MB) by each ISP for different locality algorithms.

	/24	/16	DOMAIN	Hierarchical	Proxy Tracker
P2P Locality (Avrg)	13964 (1.2%)	11643 (17.7%)	10864 (23.1%)	10227 (27.5%)	6710 (52.5%)
P2P Locality (95^{th})	779 (3.1%)	698 (13.2%)	709 (11.8%)	689 (14.3%)	625 (22.3%)

Issues and implications

- **Peer-assisted vs. existing content distribution solutions**
  - Peer-assisted solutions need to address:
    - Availability when population is limited
    - e2e connectivity (NATs)
    - Security
    - Reliability
- **Impact of peer-assisted content distribution on internal ISP traffic**
  - Re-engineering of internal traffic may prove costly for certain ISPs

Summary

- Current P2P solutions are not “ISP-friendly”
  – Unnecessary traffic downstream & upstream.
- Locality-aware peer-assisted solutions:
  – Decrease egress traffic by a factor of two.
  – Provide >60% savings for ingress traffic.
  – Approximate the performance of a caching architecture in terms of peak load.

Everybody wins!

- Peer-assisted + locality content distribution:
  - CDNs:
    - Push more content with less infrastructure
  - ISPs:
    - Serve more content at the same cost
  - End-users:
    - More content faster