

Towards the Application of WebRTC Peer-to-Peer to Scale Live Video Streaming over the Internet

Flávio Ribeiro Nogueira Barbosa
Luiz Fernando Gomes Soares

Workshop de Redes P2P, Dinâmicas, Sociais e Orientadas a Conteúdo (Wp2p+)
Simpósio Brasileiro de Redes de Computadores (SBRC)
Maio, 2014



Towards the Application of WebRTC Peer-to-Peer to Scale Live Video Streaming over the Internet

Flávio Ribeiro Nogueira Barbosa
Luiz Fernando Gomes Soares

Workshop de Redes P2P, Dinâmicas, Sociais e Orientadas a Conteúdo (Wp2p+)
Simpósio Brasileiro de Redes de Computadores (SBRC)
Maio, 2014



Schedule

- ▶ Motivation
- ▶ Background
- ▶ Proposed Solution
- ▶ Conclusion & Future Work
- ▶ References

Motivation

Motivation

- ▶ Audience growth on the Internet & preference for multimedia content consumption
 - ▶ Red Bull Stratos 2012
 - ▶ **8 million** concurrent users [Katz 2012]

Motivation

- ▶ Audience growth on the Internet & preference for multimedia content consumption
 - ▶ Red Bull Stratos 2012
 - ▶ **8 million** concurrent users [Katz 2012]
 - ▶ FIFA Confederations Cup 2013 to Brazilian residents
 - ▶ **Almost half a million** concurrent users

Motivation

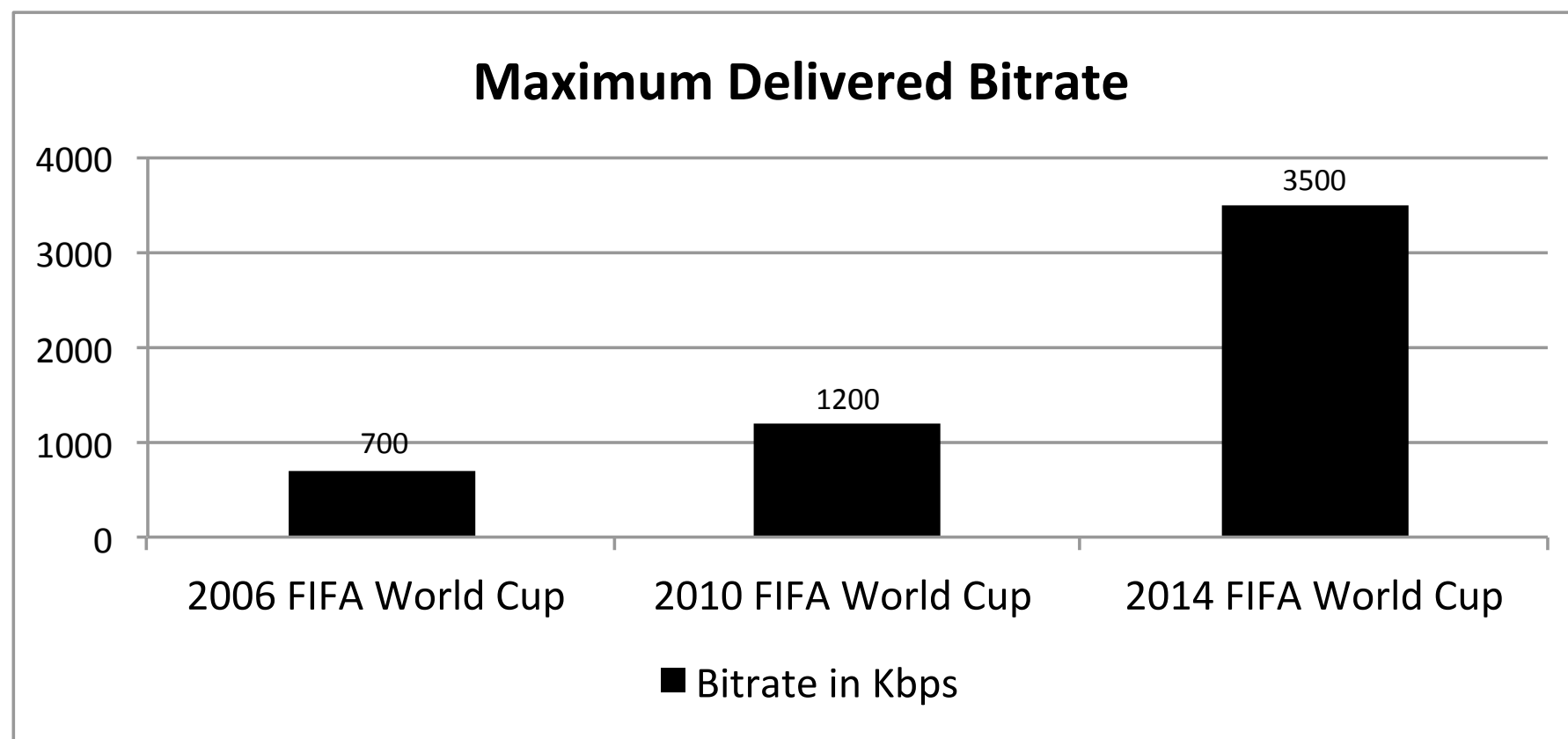
- ▶ Online Video Production Quality

Motivation

- ▶ Online Video Production Quality
 - ▶ Netflix is expecting to deliver 4K videos in 2014/2015 [Sandoval 2013]

Motivation

- ▶ Online Video Production Quality
 - ▶ Netflix is expecting to deliver 4K videos in 2014/2015 [Sandoval 2013]
- ▶ Prediction of transmission quality of FIFA's next World Cup in Brazil



Motivation

- ▶ The use of Content Delivery Networks (CDN)

Motivation

- ▶ The use of Content Delivery Networks (CDN)
 - ▶ *Scalability*: CDNs scales through the addition of point-of-presence (PoP's)

Motivation

- ▶ The use of Content Delivery Networks (CDN)
 - ▶ *Scalability*: CDNs scales through the addition of point-of-presence (PoP's)
 - ▶ *Cost*: Google YouTube spend 1 million dollars per day [Spangler 2009]

Motivation

- ▶ The use of Content Delivery Networks (CDN)
 - ▶ *Scalability*: CDNs scales through the addition of point-of-presence (PoP's)
 - ▶ *Cost*: Google YouTube spend 1 million dollars per day [Spangler 2009]
 - ▶ *Users' Quality of Experience*

Motivation

- ▶ The use of Content Delivery Networks (CDN)
 - ▶ *Scalability*: CDNs scales through the addition of point-of-presence (PoP's)
 - ▶ *Cost*: Google YouTube spend 1 million dollars per day [Spangler 2009]
 - ▶ *Users' Quality of Experience*



The screenshot shows a news article from March 9, 2014, at 10:27 PM PDT. The article is titled "HBO Go Crashes During 'True Detective' Finale" and is by Kimberly Nordyke. It features social media sharing buttons for Facebook (156), Twitter (192), Google+ (3), LinkedIn (5), and SoundCloud (0). There are also links for Email, Print, and Comments (4). An updated section states: "UPDATED: 'Due to overwhelmingly popular demand for #TrueDetective, we've been made aware of an issue affecting some users,' read a tweet from the streaming service Sunday night."

POSTED
MAR
9
2 MOS

HBO Go Crashes During 'True Detective' Finale

10:27 PM PDT 3/9/2014 by Kimberly Nordyke

f 156 t 192 g+ 3 in 5 s 0 Email Print Comments (4)

UPDATED: "Due to overwhelmingly popular demand for #TrueDetective, we've been made aware of an issue affecting some users," read a tweet from the streaming service Sunday night.

<http://goo.gl/zixUr7>

Motivation

- ▶ The use of Content Delivery Networks (CDN)
 - ▶ *Scalability*: CDNs scales through the addition of point-of-presence (PoP's)
 - ▶ *Cost*: Google YouTube spend 1 million dollars per day [Spangler 2009]
 - ▶ *Users' Quality of Experience*

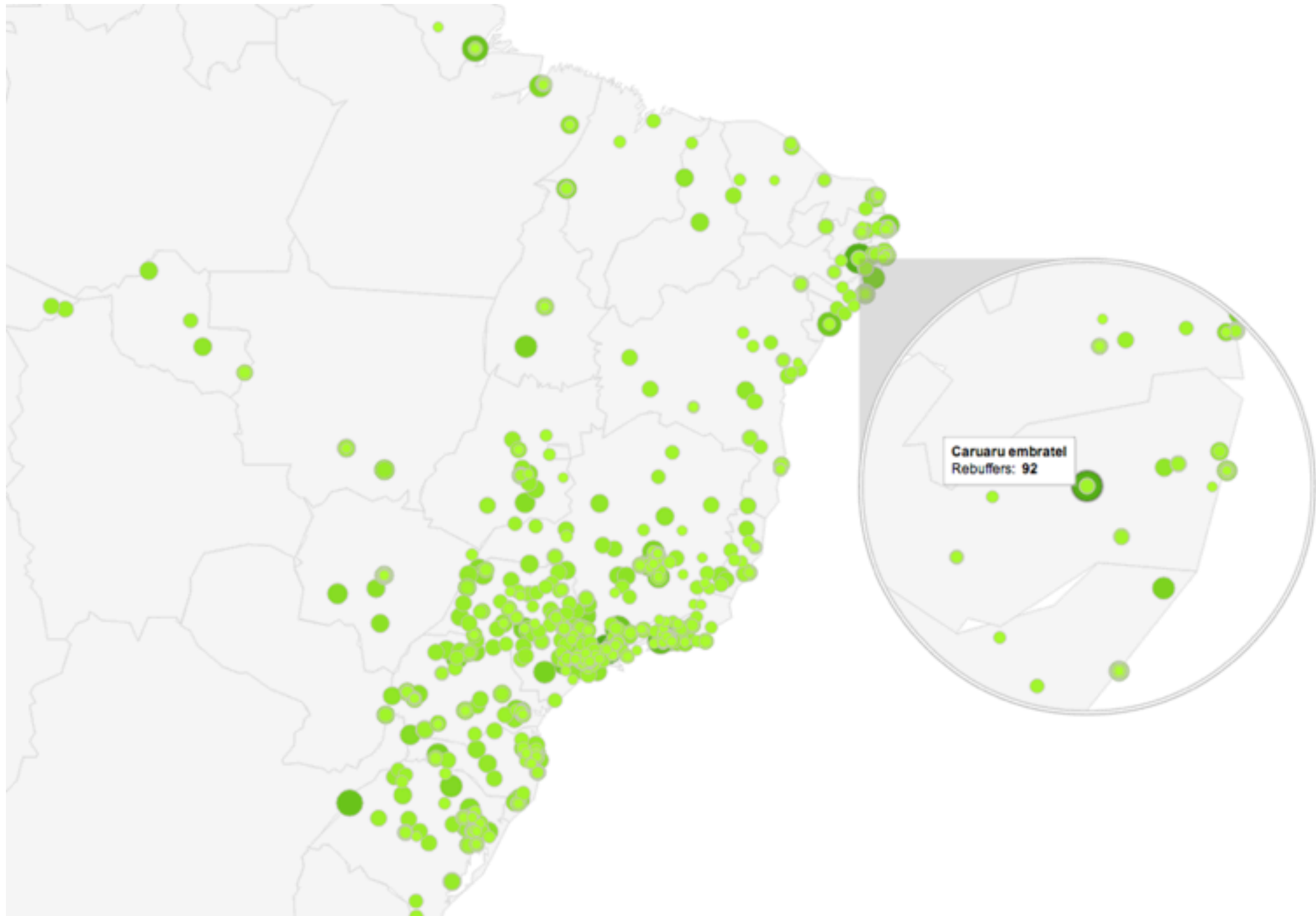
ENTERTAINMENT 03.03.14

ABC Promised to Livestream the Oscars and Totally Failed

ABC placed comically harsh restrictions on the inaugural Academy Awards livestream. Yeah, it was a bit of a disaster.

<http://goo.gl/sTNb7d>

Motivation



Rebuffers by Region and Telecom Carrier at Brazil. Globo.com, 2013.

Background

Background

- ▶ Current Video Distribution Techniques

RTP/RTSP/RTMP	HTTP-Based
Mostly on top of UDP	On top of HTTP
Specialized Media Servers	Segmenter + Ordinary Web Servers
Low Delay	High Delay

Background

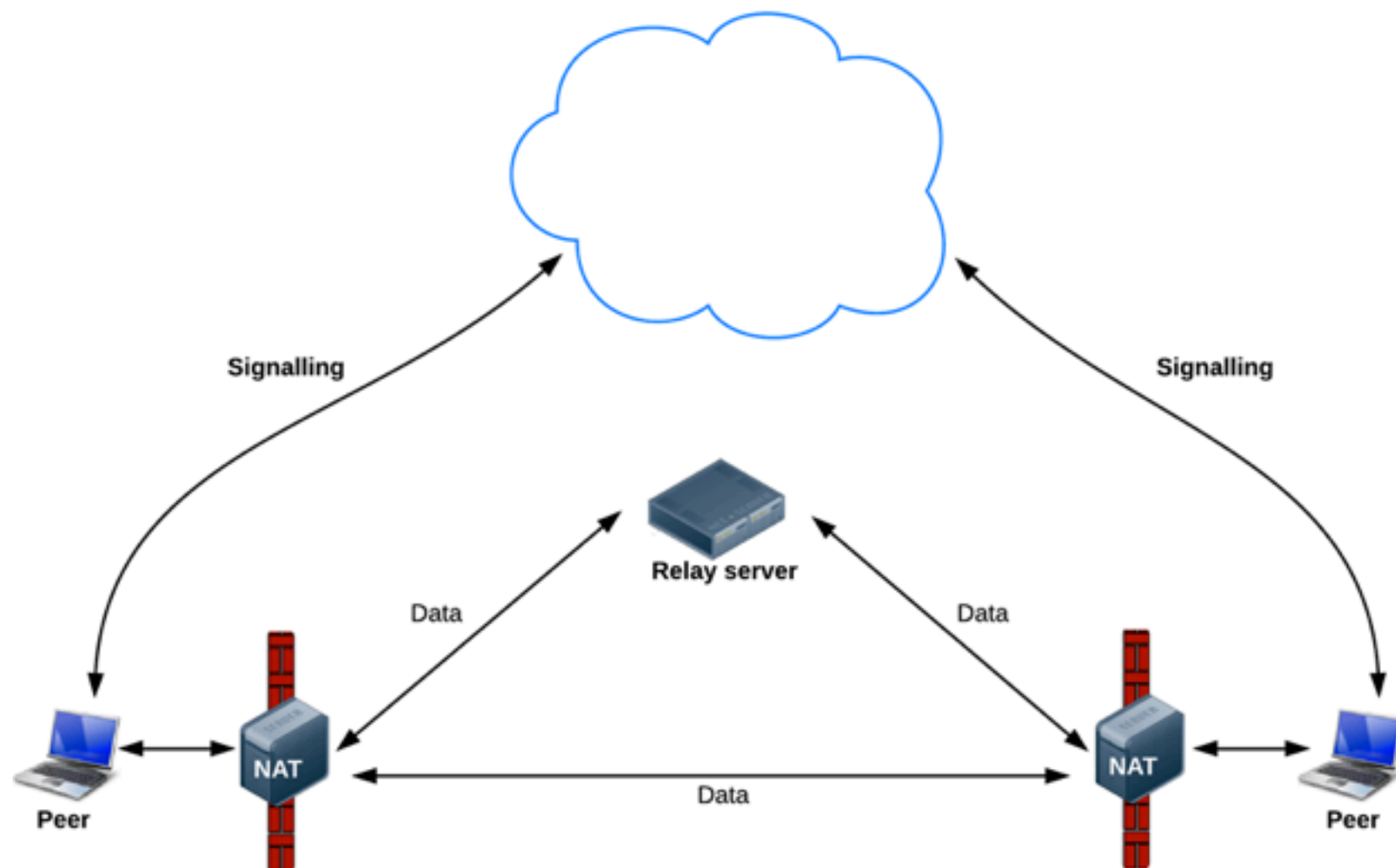
- ▶ HTTP-Based Streaming Protocols
 - ▶ *HTTP Dynamic Streaming (HDS) by Adobe*
 - ▶ *HTTP Live Streaming (HLS) by Apple*
 - ▶ *Smooth Streaming by Microsoft*
 - ▶ *DASH by MPEG*

Background

- ▶ HTTP-Based
 - ▶ *HTTP Dynamic Streaming (HDS) by Adobe*
 - ▶ ***HTTP Live Streaming (HLS) by Apple***
 - ▶ *Smooth Streaming by Microsoft*
 - ▶ *DASH by MPEG*

Background

- ▶ WebRTC
 - ▶ Real-Time Communications, Working Draft
 - ▶ Capability of share video, audio and data between browsers



Proposed Solution

Proposed Solution

- ▶ Hybrid Peer-to-Peer/CDN to assist video chunks delivery

Proposed Solution

- ▶ Hybrid Peer-to-Peer/CDN to assist video chunks delivery
 - ▶ P2P Networks usually improves as network size increases
[Rossoupoulos *et al* 2010]
 - ▶ Peer-assisted data sharing can decrease CDN requests to about 96% [Cho *et al* 2010]

The implementation is available at: <http://github.com/flavioribeiro/bemtv>

Proposed Solution

- ▶ Hybrid Peer-to-Peer/CDN to assist video chunks delivery
 - ▶ P2P Networks usually improves as network size increases
[Rossoupoulos *et al* 2010]
 - ▶ Peer-assisted data sharing can decrease CDN requests to about 96% [Cho *et al* 2010]
 - ▶ Decreases the cost of transmission
 - ▶ Reduces networks bottlenecks
 - ▶ Improves audience's experience

The implementation is available at: <http://github.com/flavioribeiro/bemtv>

Proposed Solution

- ▶ Peer Entrance and Signaling
 - ▶ ISP-Location & Geolocation Awareness [Kovacevic 2009]

Proposed Solution

- ▶ Peer Entrance and Signaling

- ▶ ISP-Location & Geolocation Awareness [Kovacevic 2009]

1. Node A hits a “swarm name discoverer” URL *
2. Node A asks Central Server to publish himself on the swarm
3. Other nodes acknowledge new user entrance
4. Node A establish a P2P connection with each node on the same swarm (using STUN)

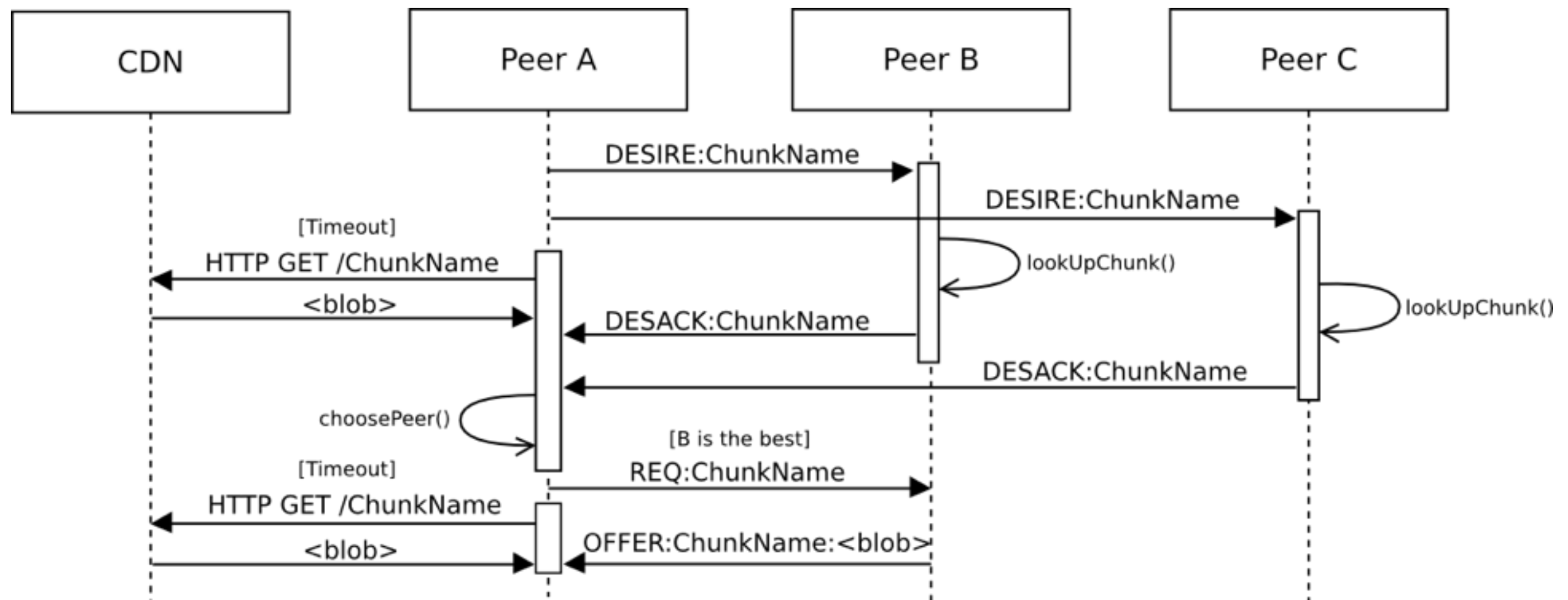
* <http://server.bem.tv/room>

Proposed Solution

- ▶ Video Chunks Exchange Protocol

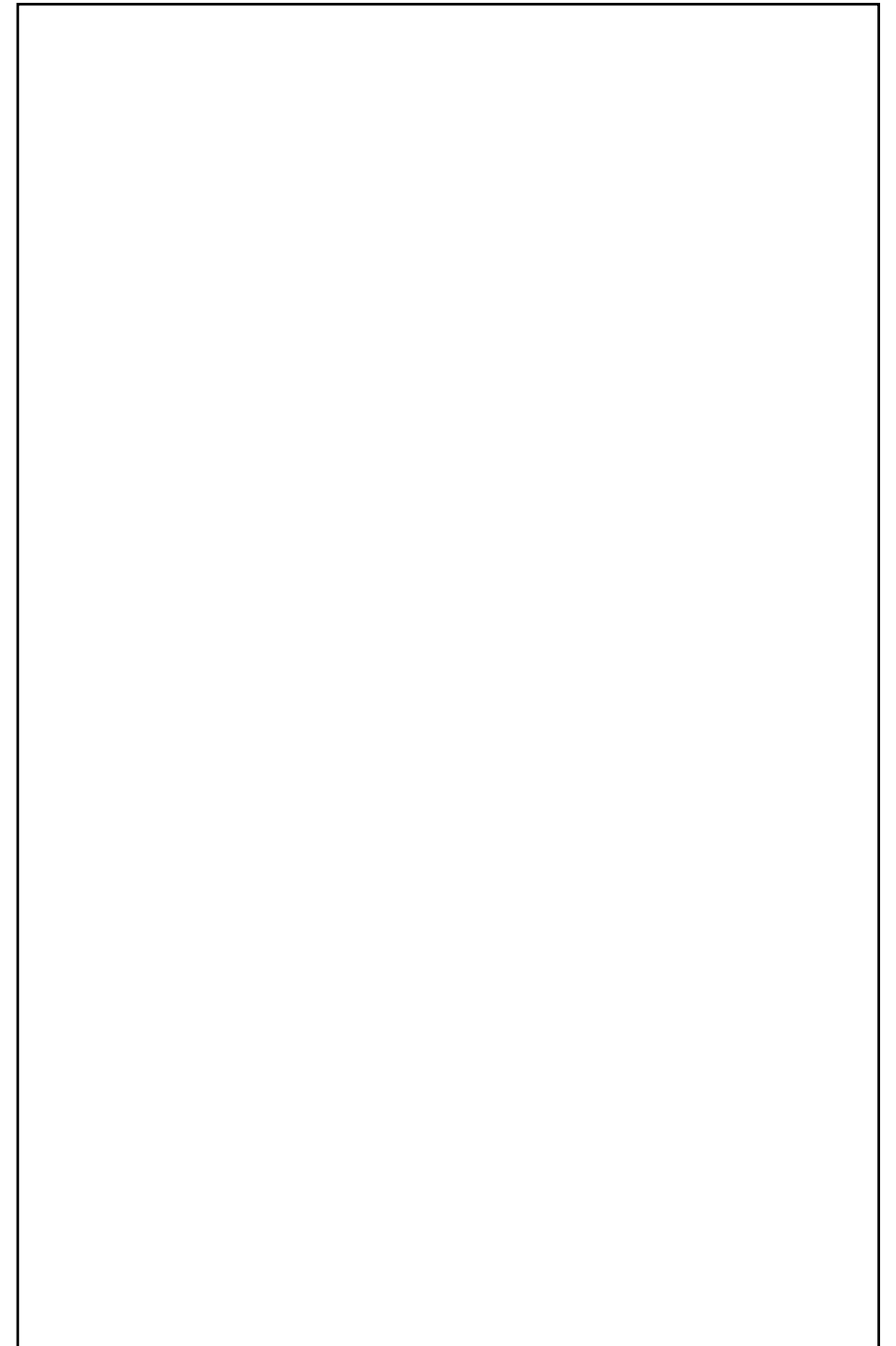
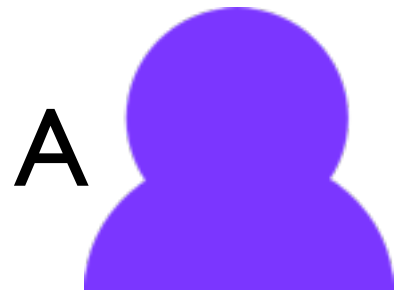
Proposed Solution

► Video Chunks Exchange Protocol



Proposed Solution

- ▶ Video Chunks Exchange Protocol



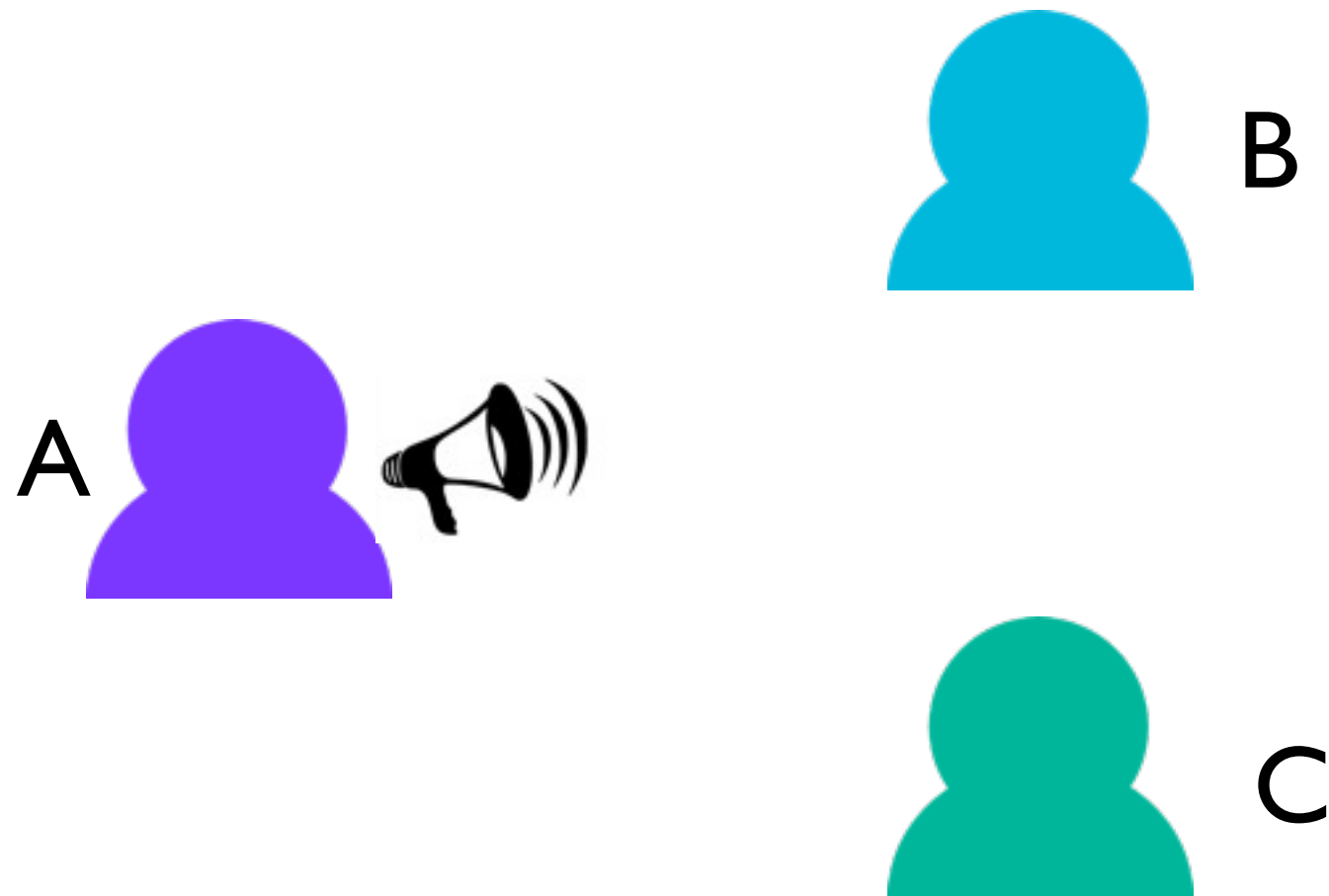
Proposed Solution

- ▶ Video Chunks Exchange Protocol



Proposed Solution

- ▶ Video Chunks Exchange Protocol



<A> *DESIRE:bbb_3.ts*

Proposed Solution

- ▶ Video Chunks Exchange Protocol



B

checking if have *bbb_3.ts*



C

checking if have *bbb_3.ts*

<A> *DESIRE:bbb_3.ts*

Proposed Solution

- ▶ Video Chunks Exchange Protocol



A



B

have bbb_3.ts!



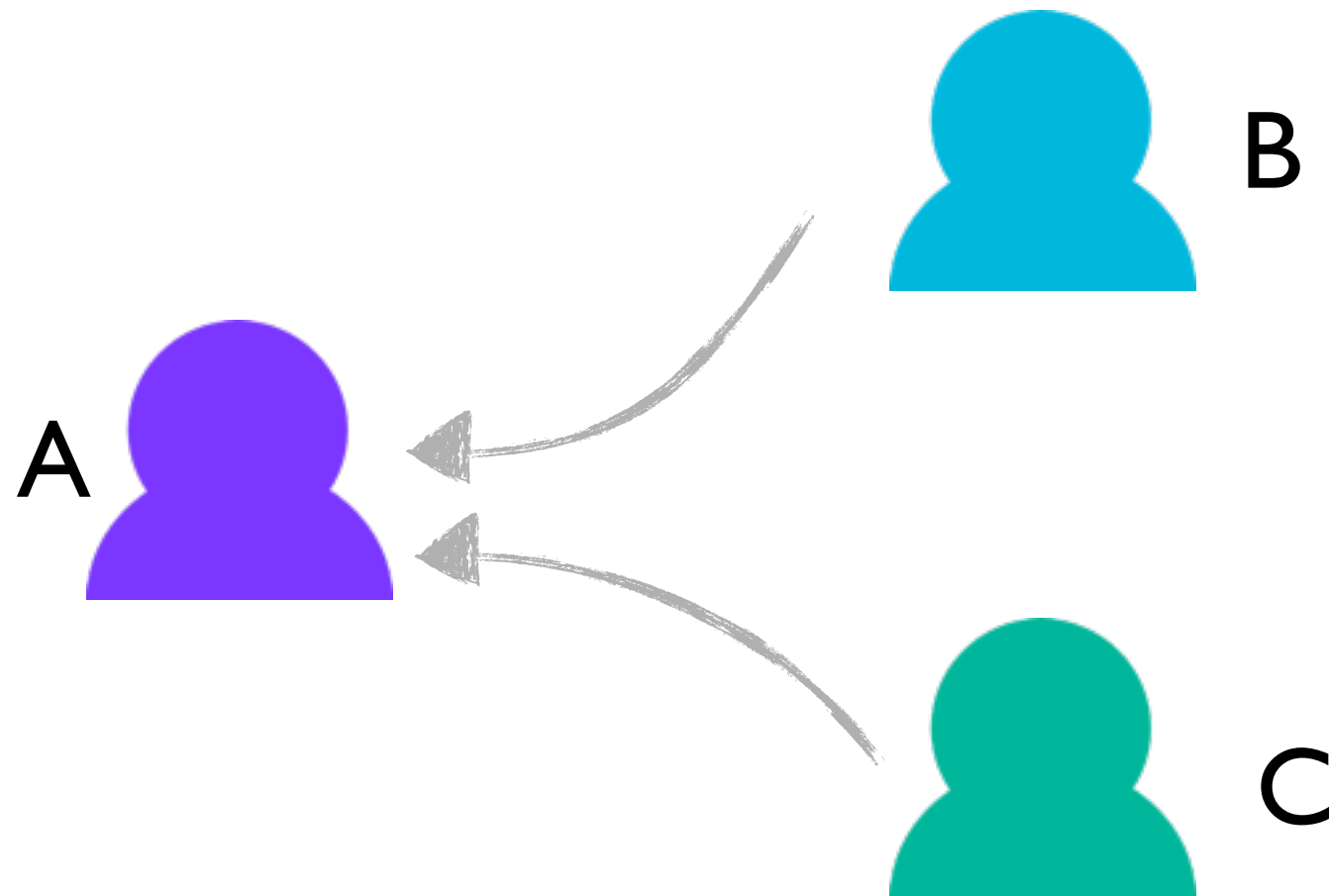
C

have bbb_3.ts!

<A> *DESIRE:bbb_3.ts*

Proposed Solution

- ▶ Video Chunks Exchange Protocol



<A> *DESIRE:bbb_3.ts*

<B-A> *DESACK:bbb_3.ts*

<C-A> *DESACK:bbb_3.ts*

Proposed Solution

- ▶ Video Chunks Exchange Protocol

A
choosing the best peer



B



C

<A> *DESIRE:bbb_3.ts*

<B-A> *DESACK:bbb_3.ts*

<C-A> *DESACK:bbb_3.ts*

Proposed Solution

- ▶ Video Chunks Exchange Protocol

A
C is the best!



B



C

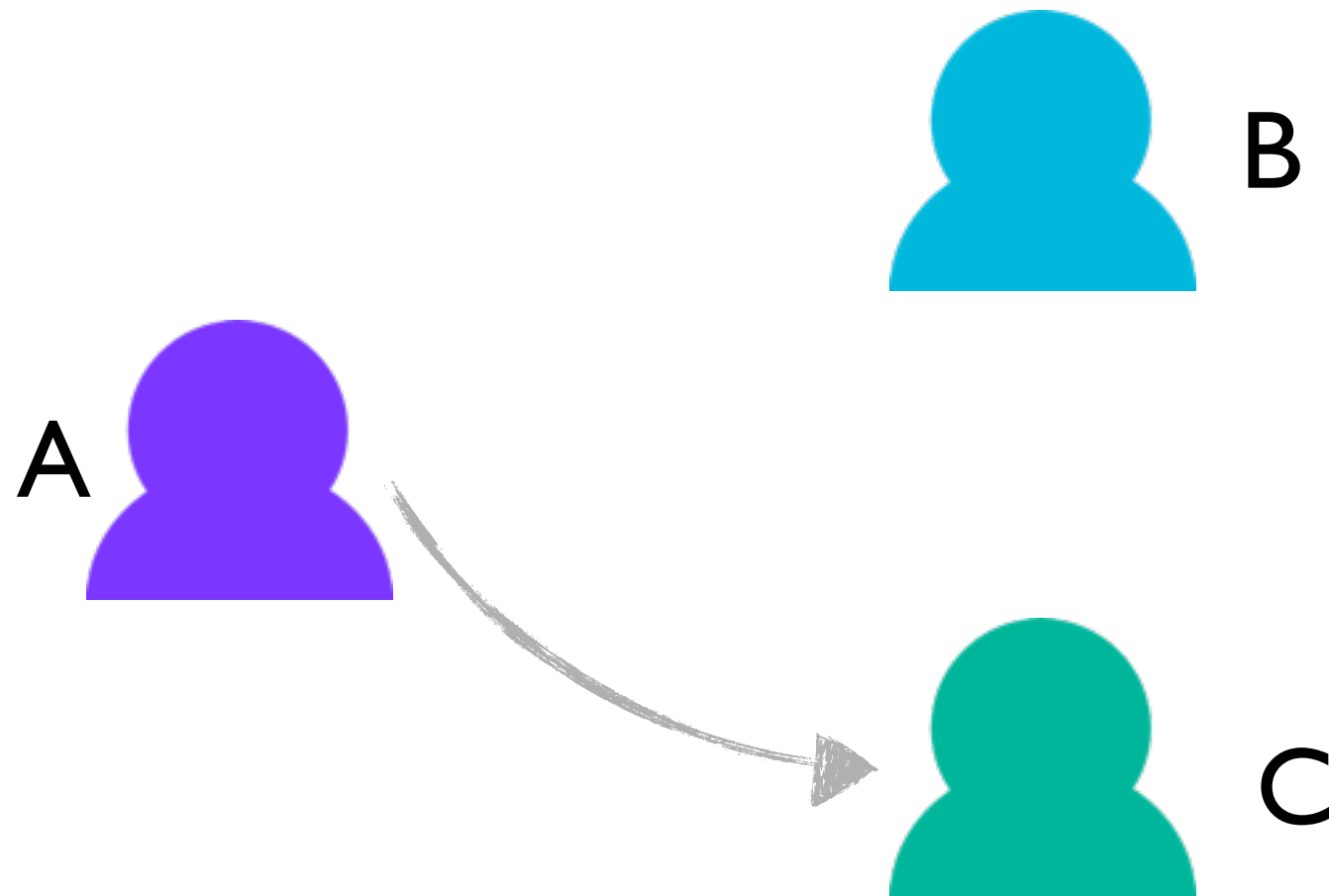
<A> *DESIRE:bbb_3.ts*

<B-A> *DESACK:bbb_3.ts*

<C-A> *DESACK:bbb_3.ts*

Proposed Solution

- ▶ Video Chunks Exchange Protocol



<A> *DESIRE:bbb_3.ts*

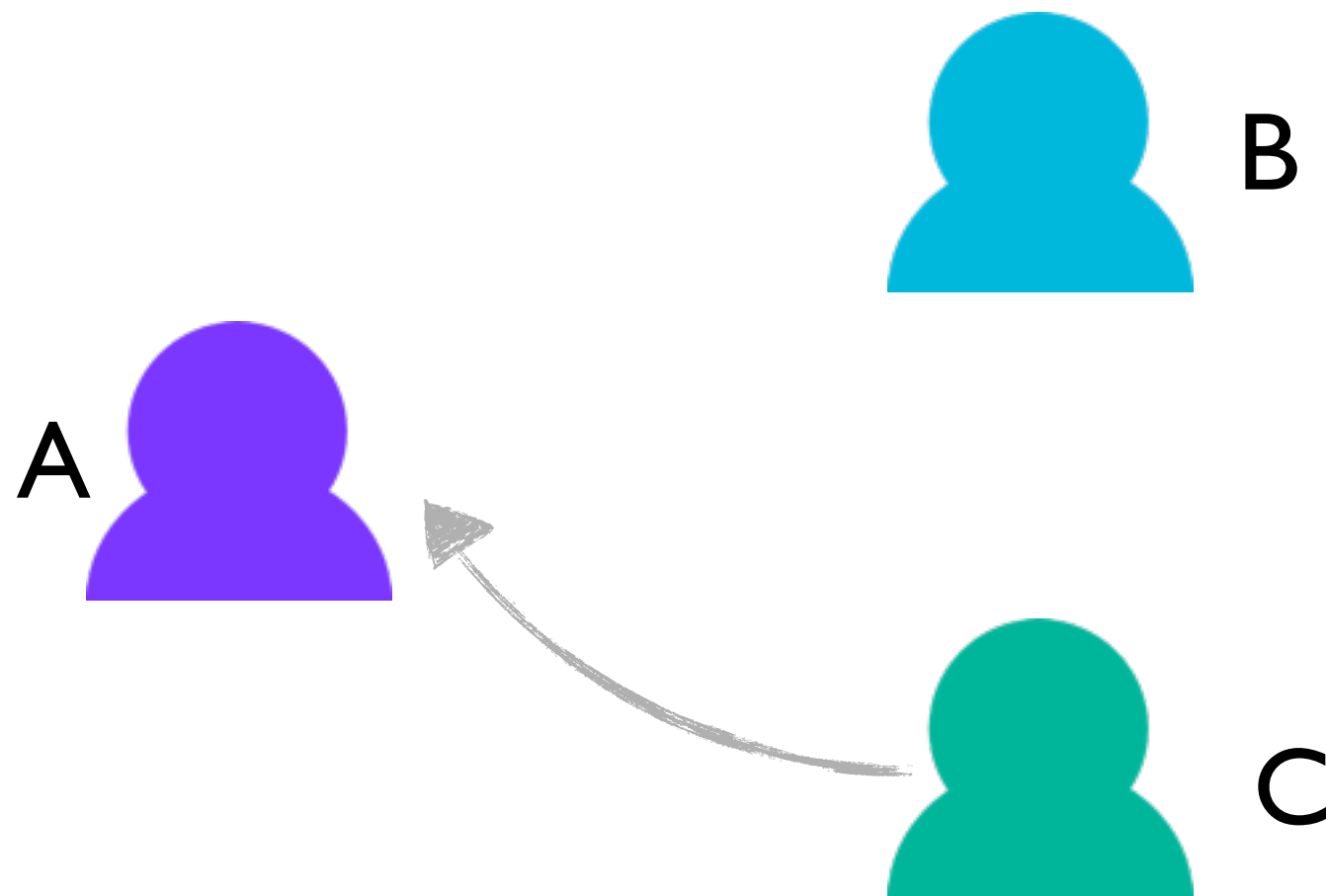
<B-A> *DESACK:bbb_3.ts*

<C-A> *DESACK:bbb_3.ts*

<A-C> *REQ:bbb_3.ts*

Proposed Solution

► Video Chunks Exchange Protocol



<A> *DESIRE:bbb_3.ts*

<B-A> *DESACK:bbb_3.ts*

<C-A> *DESACK:bbb_3.ts*

<A-C> *REQ:bbb_3.ts*

<C-A> *OFFER:bbb_3.ts:<blob>*

Proposed Solution

▶ Video Chunks Exchange Protocol



A



A have chunk *bbb_3.ts*!



B



C

<A> *DESIRE:bbb_3.ts*

<B-A> *DESACK:bbb_3.ts*

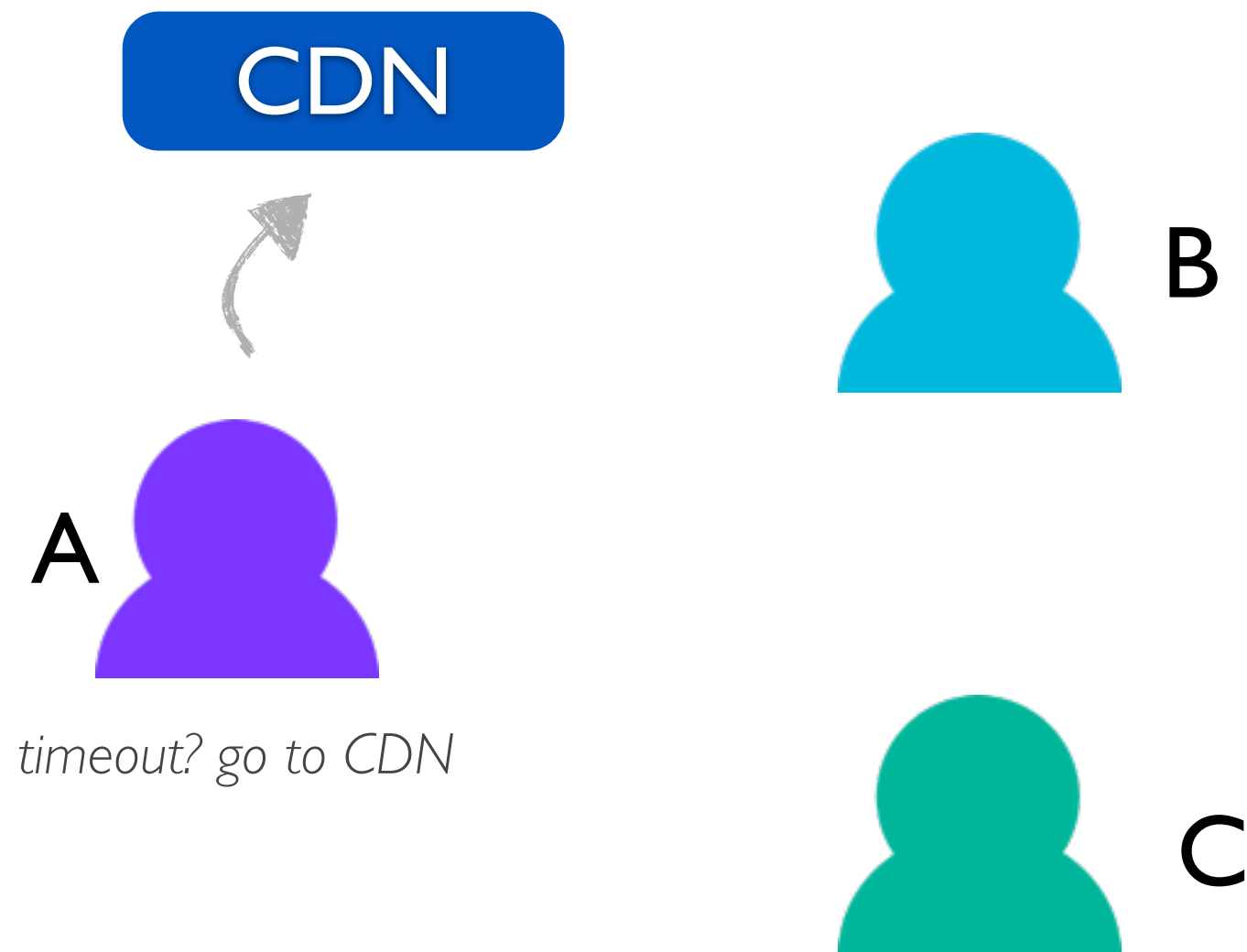
<C-A> *DESACK:bbb_3.ts*

<A-C> *REQ:bbb_3.ts*

<C-A> *OFFER:bbb_3.ts:<blob>*

Proposed Solution

► Video Chunks Exchange Protocol



<A> *DESIRE:bbb_3.ts*

<B-A> *DESACK:bbb_3.ts*

<C-A> *DESACK:bbb_3.ts*

<A-C> *REQ:bbb_3.ts*

<C-A> *OFFER:bbb_3.ts:<blob>*

Proposed Solution

- ▶ Early Experiments

Proposed Solution

- ▶ Early Experiments
 - ▶ 10 Apple MacBooks White (2GB SDRAM)
 - ▶ Mozilla Firefox 27.1 (WebRTC compatible)
 - ▶ Same Wireless hotspot (10/100Mbps)
- ▶ Video Streaming
 - ▶ Chunks with 5 seconds of duration
 - ▶ 600 Kbps of bitrate quality
- ▶ CDN + Room Discoverer + P2P Signaling Server
 - ▶ 1 server with 512MB of SDRAM in New York

Proposed Solution

- ▶ Early Experiments



Proposed Solution

► Early Experiments

BemTV & HLSprovider

bem.tv/hlsprovider.html



LiveSPORT 71:02 MNC 0-1 BAR

<http://cdn.bem.tv/stream/soccer4sec/soccer/playlist.m3u8> LOAD

Play		Pause		Resume		Stop	
state	Position	Duration	Min Buffer Size	Buffer Size	Max Buffer Size	Quality Level	Audio Track Id
PLAYING	18.00	48.17	3.00	30.00	60.00	0	0

Chunks from CDN	Chunks received via P2P	Chunks sent via P2P	Room Name	Swarm Size
205	44	48	Tm92YSBJZ3Vhw6d1QVM3NzM4	3

BemTV & HLSprovider

bem.tv/hlsprovider.html



LiveSPORT 72:09 MNC 0-1 BAR

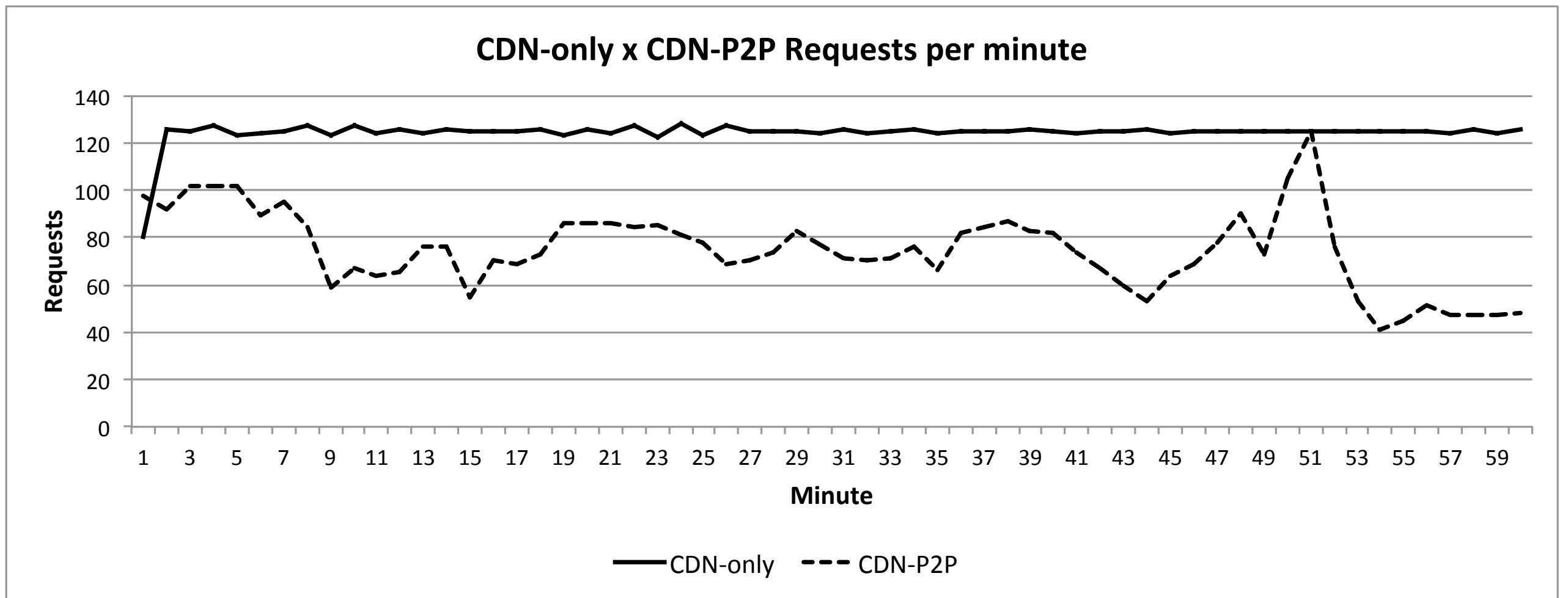
<http://cdn.bem.tv/stream/soccer4sec/soccer/playlist.m3u8> LOAD

Play		Pause		Resume		Stop	
state	Position	Duration	Min Buffer Size	Buffer Size	Max Buffer Size	Quality Level	Audio Track Id
PLAYING	41.94	48.19	3.00	6.19	60.00	0	0

Chunks from CDN	Chunks received via P2P	Chunks sent via P2P	Room Name	Swarm Size
246	49	178	Tm92YSBJZ3Vhw6d1QVM3NzM4	3

Proposed Solution

► Results



Proposed Solution

- ▶ Results
 - ▶ CDN-only: 7457 requests to CDN
 - ▶ CDN-P2P: **4482** requests to CDN

Proposed Solution

- ▶ Results
 - ▶ CDN-only: 7457 requests to CDN
 - ▶ CDN-P2P: **4482** requests to CDN
 - ▶ **Reduction of 39.89%**

Conclusion & Future Work

Conclusion & Future Work

- *Our approach is promising!*

Conclusion & Future Work

- ▶ *Our approach is promising!*
- ▶ Improvements:
 - ▶ Peers Convergence and Over Swarming
 - ▶ Reputation [Xiong and Liu 2004], Partnership [Li et al 2010], Leader Election [Kutten 2013]
 - ▶ Video Chunks Exchange Protocol
 - ▶ Content Security [Medina-López et al 2013]
 - ▶ Poisoned Chunks
 - ▶ DoS Starvation

Towards the Application of WebRTC Peer-to-Peer to Scale Live Video Streaming over the Internet

Flávio Ribeiro Nogueira Barbosa
Luiz Fernando Gomes Soares

Workshop de Redes P2P, Dinâmicas, Sociais e Orientadas a Conteúdo (Wp2p+)
Simpósio Brasileiro de Redes de Computadores (SBRC)
Maio, 2014

References

- Berkvist, A., Burnett, D., Jennings, C. Narayanan, A. (2011) "WebRTC 1.0: Real-Time Communication Between Browsers". Working Draft.
- Bronzino, F. Gaeta, R. Grangetto, M. Pau, G. (2012) "An Adaptive Hybrid CDN/P2P Solution for Content Delivery Networks". VCIP, page 1-6, IEEE.
- Cho, S., Cho, J., Shin, S. (2010) "Playback Latency Reduction for Internet Live Video Services in CDN-P2P Hybrid Architecture". 2013 IEEE International Conference on Communications.
- Huang, C., Wang, A., Li, J., Ross, K. (2008) "Understanding hybrid CDN-P2P: why limelight needs its own Red Swoosh". Proceedings of the 18th International Workshop on Network and Operating Systems Support for Digital Audio and Video.
- Katz, T. (2012) "Mission Complete: Red Bull Stratos lands safely back on Earth". <http://goo.gl/bX3Ihl>, accessed in March 2014.
- Kovacevic, A., Graffi, K., Pussep, K., Steinmetz, R. (2009) "Underlay awareness in P2P systems: Techniques and challenges". IEEE Symposium on Parallel & Distributed Processing.
- Kutten, S., Panduragan, G., Peleg, D., Robinson, P., Trehan, A. (2013) "On the complexity of universal leader election". Proceedings of the ACM symposium on Principles of distributed computing.
- Li, B., Xie, S., Qu, Y., Keung, G.Y. (2008) "Inside the New CoolStreaming: Principles, Measurements and Performance Implications". IEEE 27th Conference on Computer Communications.
- Medina-López, C., Naranjo, J.A.M., García-Ortiz, J. P., Casado, L. G., González-Ruiz, V. (2013) "Execution of the P2PSP protocol in parallel environments". XXIV Jornadas de Paralelismo. Madrid, Spain.
- Naylor, A. (2013) "WebRTC is almost here, and it will change the web". <http://goo.gl/lgx33>, accessed in March 2014.
- Nordyke, K. (2014) "HBO Go Crashes During 'True Detective' Finale". <http://goo.gl/zixUr7>, accessed in March 2014.
- Parmar, H. and Thornburg, M. (2012) "Adobe's Real Time Messaging Protocol". <http://goo.gl/cGMWPI>, accessed in March 2014.
- Rosenberg, J., Mahy, R., Matthews, P., Wing, D. (2008) "Session Traversal Utilities for NAT (STUN)". IETF Proposed Standard.
- Roussopolous, M., Baker, M., Rosenthal D. S. H., Giuli T. J., Maniatis, P., Mogul, P. (2004) "2 P2P or Not 2 P2P?". Third International Workshop, IPTPS 2004.
- Sandoval, G. (2013) ". Netflix Chief Product Officer: expect 4k Streaming within a year or two". <http://goo.gl/F4SI33>, accessed in March 2014.
- Spangler, T. (2009) "YouTube May Lose \$470 Million in 2009: Analysts". <http://goo.gl/oNgAZY>, accessed in March 2014.
- Xiong, L. and Liu, L. (2004) "PeerTrust: Supporting Reputation-Based Trust for Peer-to-Peer Electronic Communities". IEEE Transactions on Knowledge and Data Engineering.
- Yuste, L. and Melvin, H. (2012) "A Protocol Review for IPTV and WebTV Multimedia Delivery Systems". Scientific Letters of the University of Zilina, vol 14.
- Zimmerman, A., (2014) "ABC Promised to Livestream the Oscars and Totally Failed". <http://goo.gl/sTNb7d>, accessed in March 2014.