Realtime Multi-party Video Conferencing Service over Information Centric Networks

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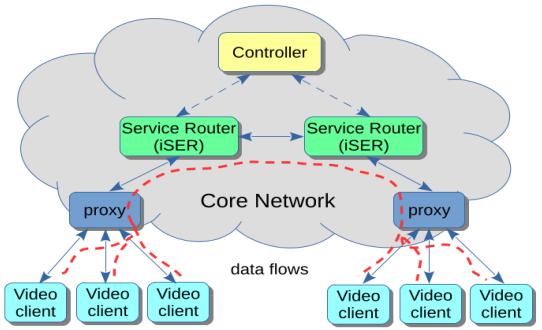
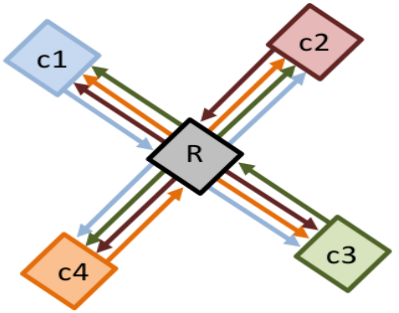
Motivation

- Increasing demand for videoconferencing in business and consumer markets
- Increasing use of video services in social networking domain
- Propose a design of ICN based video conferencing system and evaluate its performance
- Current video conferencing designs based on client-server or peer-to-peer (P2P) architecture do not scale



[A]: ICN based Video Conferencing

- For an iSER nodes with equally distributed participants
- Number of flows/router: O(N*R*|iSER|)
- Each router consumes 3 flows and generates 3 flows



[B]: Client/Server based IP Video Conferencing

- Central server with connected participants
- Number of flows/router: O(N^2 *R)
- Each client consumes 3 flows and generates 1 data flow

Survey of Video Conferencing Apps

	Max. frame rate (frames/second)	Max. # of simultaneous video participants	S/C or P2P
Eedo WebClass		6	web-based S/C
IOMeeting	30	10	web-based S/C
EarthLink	30	24	S/C
VideoLive	30	6	web-based S/C
Himeeting	17	20	S/C
VidSoft	30	10	S/C
MegaMeeting	30	16	web-based S/C
Smartmeeting	15	4	S/C
Webconference	15	10	web-based S/C
Mebeam		16	web-based S/C
Confest	30	15	S/C
CloudMeeting	30	6	S/C
Linktivity WebDemo	30	6	web-based S/C
WebEx	30	6	web-based S/C
Nefsis	30	10	S/C
Lava-Lava	15	5	decentralized P2P
Qnext		4	centralized P2P
Vsee	30	8	decentralized P2P

- Skype, MSN, Yahoo, Gtalk support only multi-party audio conference and 2-party video conference
- P2P systems: High control signaling overhead, security vulnerability, complex client design
- Client/Server: Centralized processing, complex design, expensive, limited scalability
- Due to lack of extensive IP multicast deployments, very few IP multicast based conferencing solutions are available
- NDN Chronos has scalability and recovery challenges due simultaneous updates required

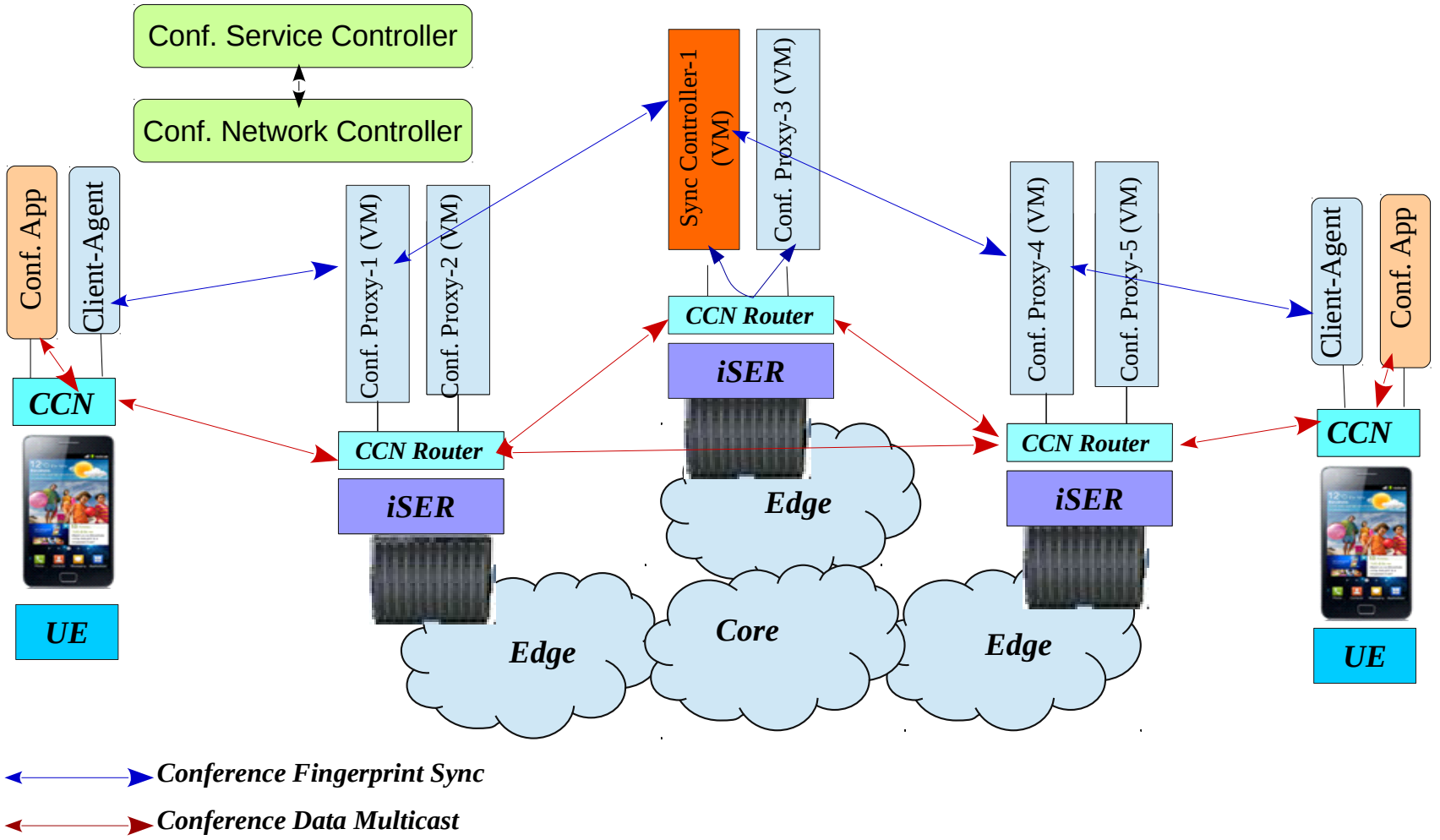
Ref: http://dl.acm.org/citation.cfm?id=2166848

Research Goals

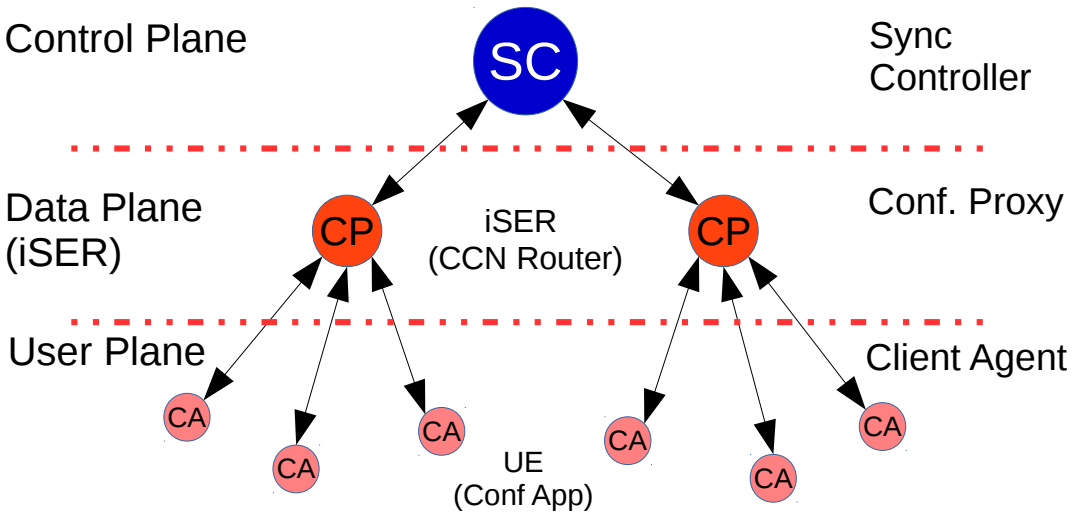
- Conference state synchronization
- Dynamic service and network resource management
- Achieve latency < 350ms[†] for realtime communication
- Simple client design
  - Video creation and ingestion for ICN architecture
  - Simple in-network processing of media (rate control)
- Performance analysis
  - Effect of chunk size and MTU size on bandwidth and E2E latency

[†]J. Jansen, P. Cesar, D. Bulterman, T. Stevens, I. Kegel, and J. Issing, “Enabling composition-based video-conferencing for the home,” Multi-media, IEEE Transactions on, vol. 13, pp. 869–881, Oct 2011

iSER based Conference Architecture



Conference Synchronization#



[A]: Conference Agent

- CA discovers the CP to join the conference. CP returns the namespace to CA to join an active conference session
- Conference session namespace is pushed to CP and also shared with CA
- Namespace contains the time-stamp, sequence identifying the content
- CA maintains a local digest tree of namespaces for recovery

[B]: Conference Proxy

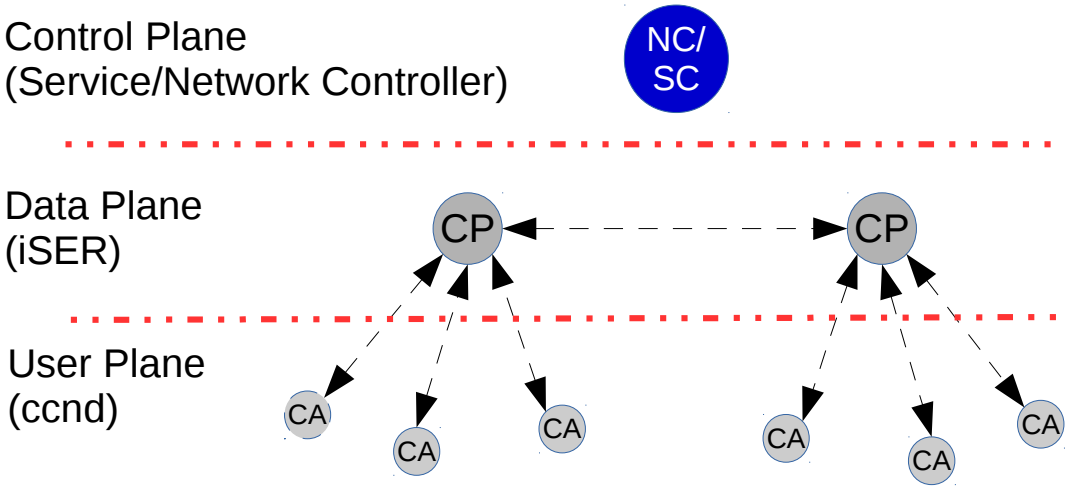
- CP maintains a local digest tree of namespaces for recovery
- Digest updates from remote conference participants are pushed to CA
- CP handles multiple conference sessions simultaneously using conf-Id
- CP pushes the digest updates to SC and receives updates from SC to be pushed to CA

[C]: Sync Controller

- SC relays the namespaces among distributed CP instances
- Maintains a digest tree of conference state updates received from remote CP
- Updates from one CP are pushed to the remote CP based on the conference state and the Interest shown by specific CP

#R. Ravindran, X. Liu, A. Chakraborti, X. Zhang, and G. Wang, “Towards software defined icn based edge-cloud services,” in Cloud Networking (CloudNet), 2013 IEEE 2nd International Conference on, pp. 227–235, Nov 2013

Dynamic Resource Management#



[A]: Network Controller (NC)

- Handle real-time events like participants join and leaving conference. Provisioning of namespace to new participant
- Maintains the state of conference session (# participants), control and forwarding namespaces
- Manage ICN network abstraction and interconnect forwarding and service agents based on the conference logic
- Manage the network topology and FIB configuration

[B]: Service Controller (SC)

- Manage the provisioning to VMs (ie. CP/SC) across the iSERs
- Handles the compute resource management (i.e. VMs) as function of conferece load
- Manage the # of conference sites and scaling of service
- Manage the network controller (NC) that does topology management, FIB configuration.

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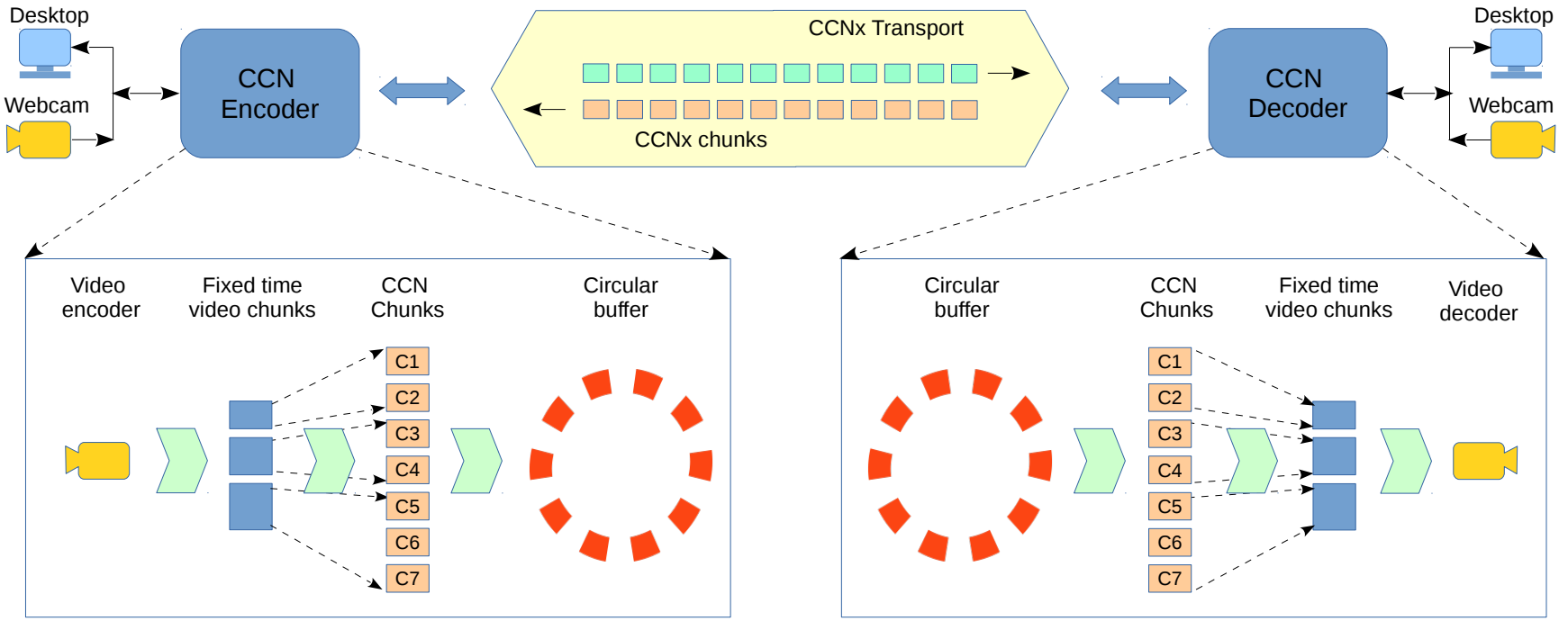
Conference Participant Design



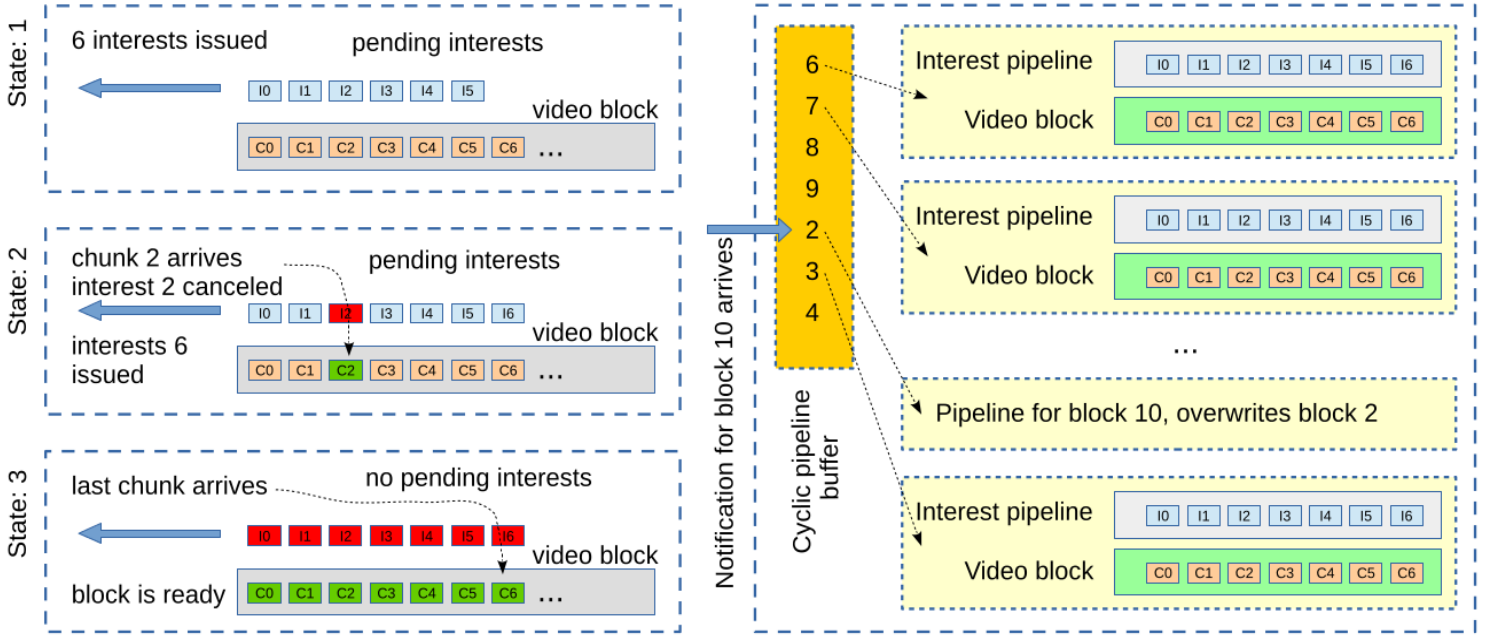
[A]: Producer

- Video frames are encoded to logical video bock following GoP principle
- Block based design allows for contextual processing e.g. in-network processing
- GoP size, Block size, Chunk size

[B]: Consumer

- Data retrieval after receiving notification, which identify the block and # chunks
- Consumer pipelines the configured # of Interests specific to block; parallel retrieval
- Outstanding Interests for block are issued as pending Interests are filled

Interest Pipelining & Block Retrieval



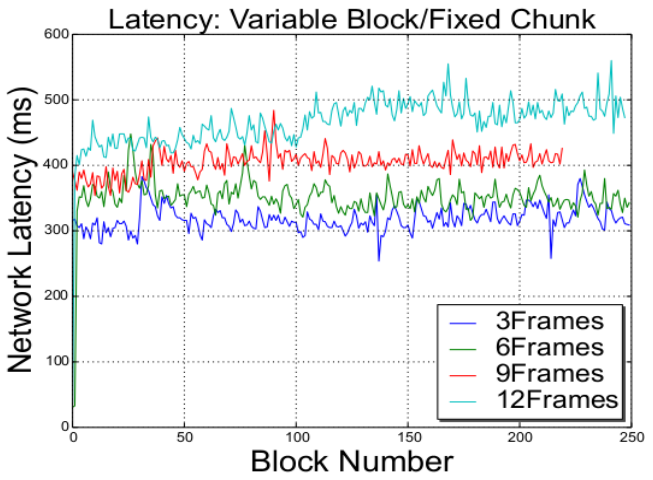
[A]: Interest pipelining

- Pipeline size is configurable and filled with outstanding/pending Interests
- Each Interests fetches the chunk for the given block
- Pipeline remains active as long as Interests are pending

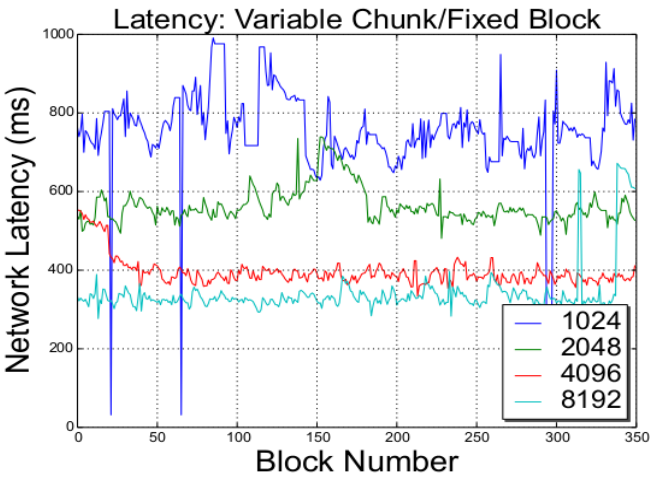
[B]: Block processing

- Limited number of block retrieval in parallel managed through the circular buffer
- Unfilled block or an out of sequence block is discarded to avoid consumer blocking

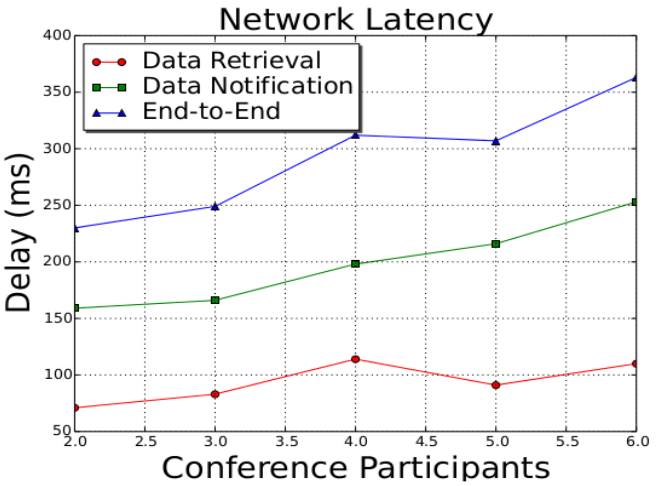
Conference Performance



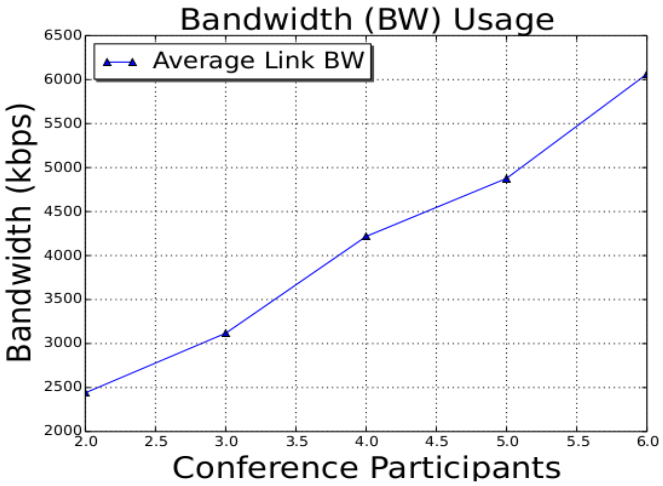
(a) Latency: varying block size



(b) Latency: varying chunk size



(c) Latency: Notification & Content Retrieval



(d) Bandwidth usage

Future Work

- Proactive content retrieval
  - Realtime streaming multimedia
  - Reduce dependency on notification
- Frame level data transmission
- Automatic video quality adaptation
- Effect of caching and forwarding policies on QoE and performance