NDN-RTC

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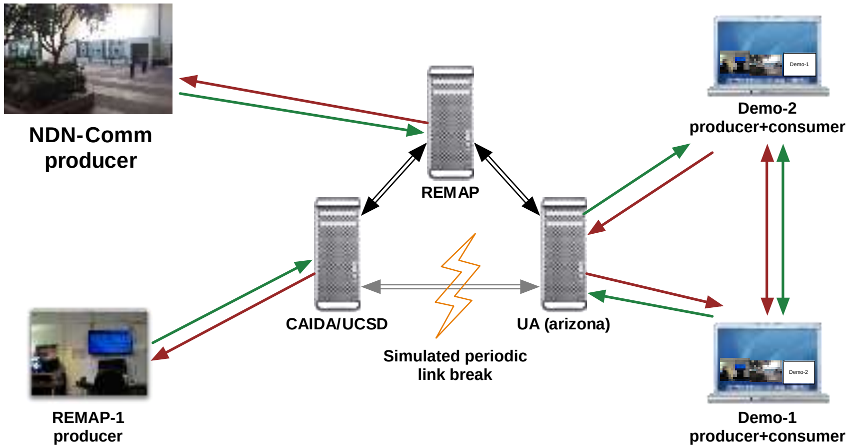
NDNComm 2014 Demo

- **Producer 1:** Live NDNComm HD streaming (1080p 30fps, 1.5Mbps)
- **Producer 2:** REMAP office webcam producer (SD, 30fps, 500Kbps)
- **Demo 1:**
  - **Consumer for 3 streams:** NDNComm, REMAP and Demo-2
  - **Producer:** webcam producer (SD, 25fps, 500Kbps)
- **Demo 2:**
  - **Consumer for 3 streams:** NDNComm, REMAP and Demo-1
  - **Producer:** webcam producer (SD, 25fps, 500Kbps)



NDN Real Time Conferencing Library

Goals:

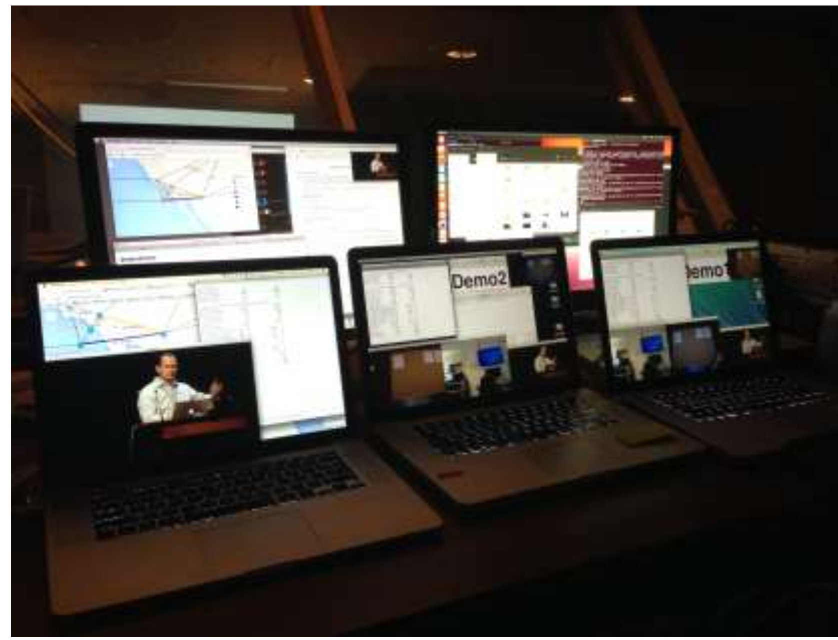
- Real-time audio/video/text chat library which allows many-to-many conferencing over the NDN network and requires no direct communication between peers
- Starting point for NDN traffic congestion control algorithm research
- Test NDN-CPP library and NFD
- Traffic generator for the testbed

Initial gains over IP:

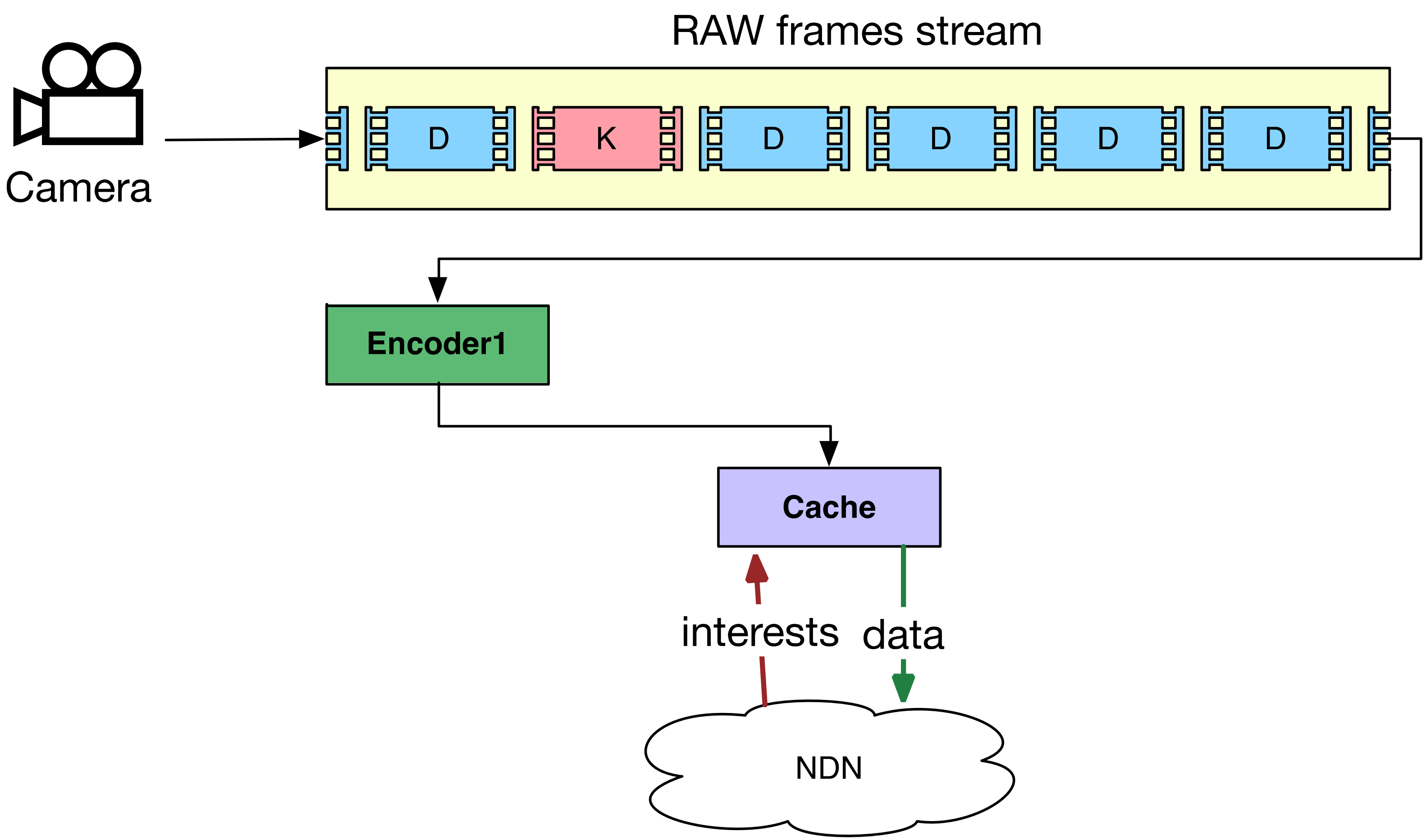
- No load on a publisher (network does content distribution)
- Intrinsic multicast (one-to-many and many-to-many scenarios)
- On track for peer-to-peer with no STUN, TURN, etc.

NDN-RTC library

- C++ code
- Linked against NDN-CPP and WebRTC libraries
- Interfaces:
  - Publish media (audio/video) streams
  - Fetch media (audio/video) streams from multiple producers
- Demo app is provided
  - Publishing audio/video stream
  - Fetching audio/video streams (multiple)

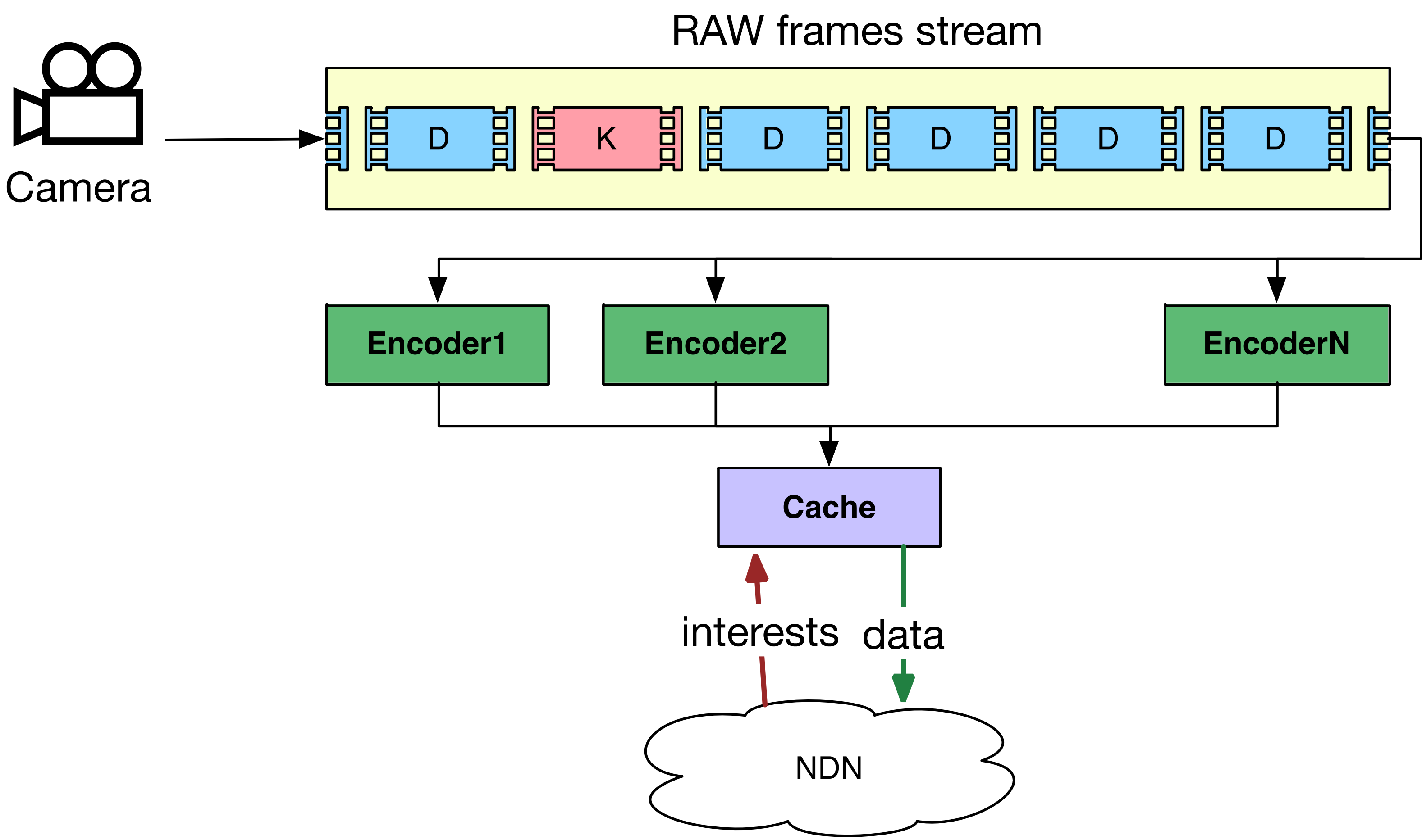


Publisher

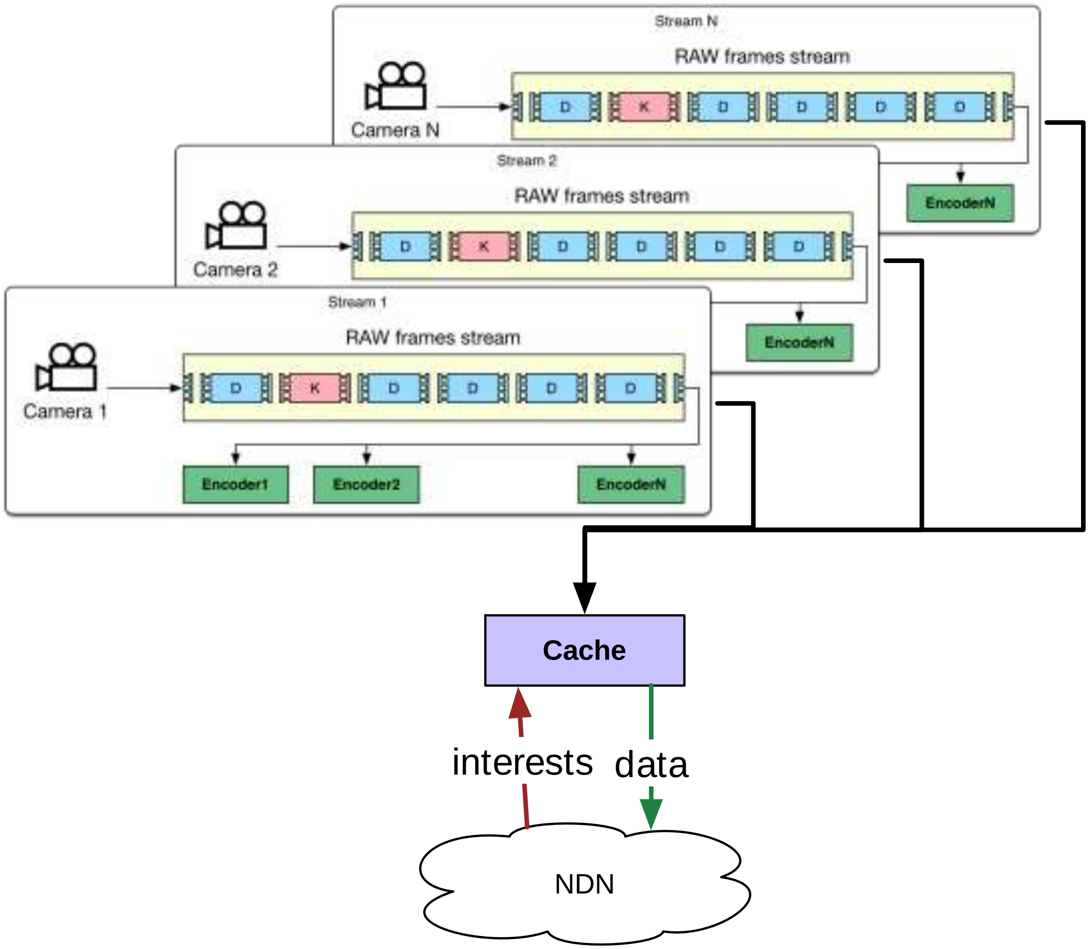


RAW frames stream
Camera
D
K
D
D
D
D
Encoder1
Cache
interests
data
NDN

Publisher. Multiple encoder threads

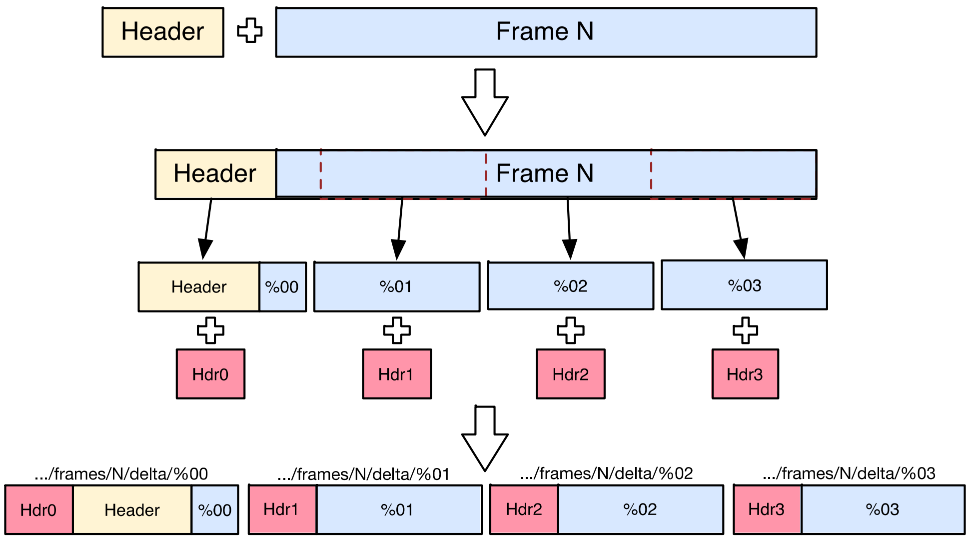


Publisher. Multiple media streams



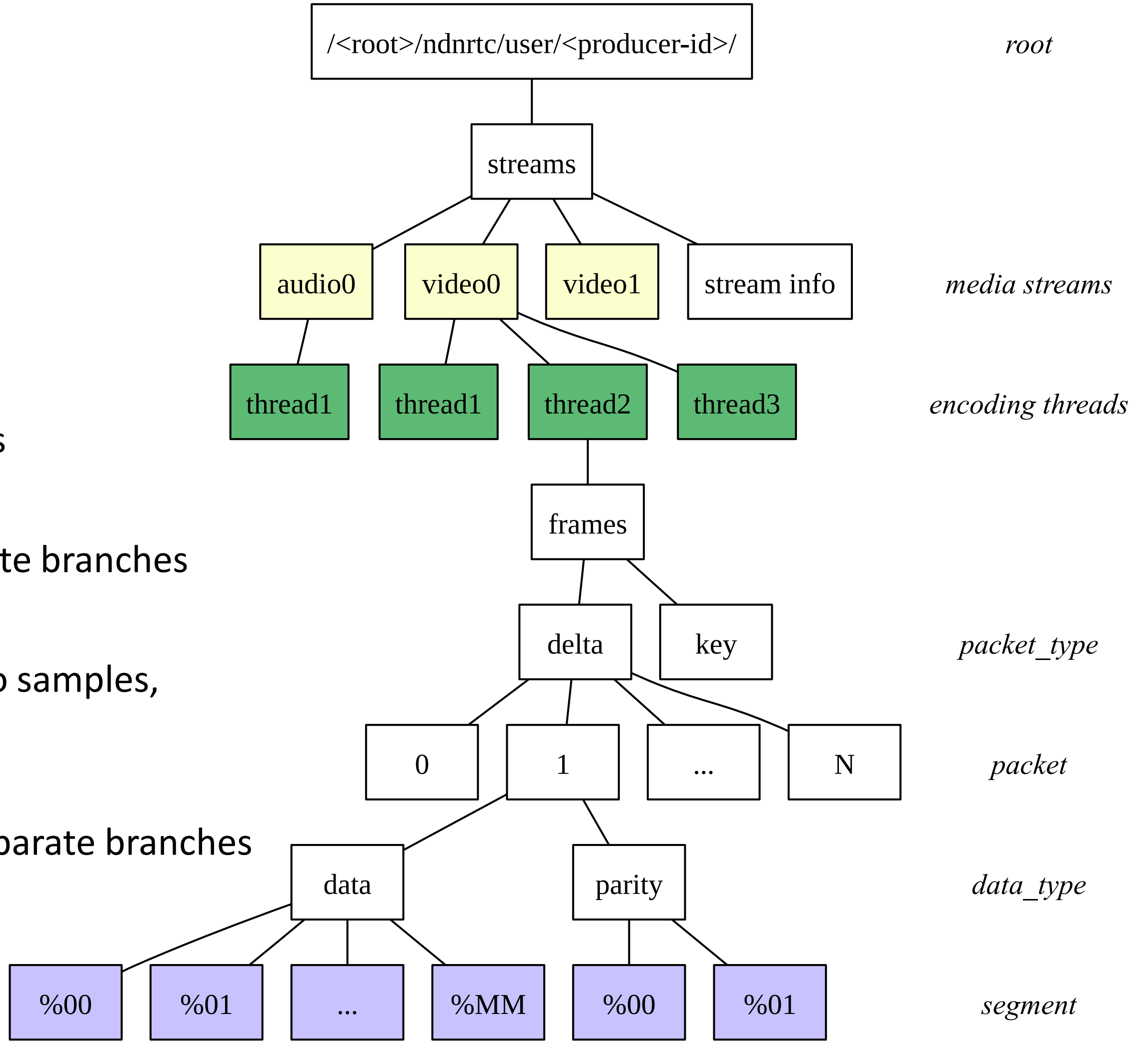
Segmentation

- Encoded frames (1Mbps):
  - Key: ~30KB (20 segments)
  - Delta: ~1-6KB (~4 segments)
- Producer stores segments in app cache
  - Segment size - 1000 bytes
  - NDN overhead - ~330-450 bytes
  - Complete segment less than MTU

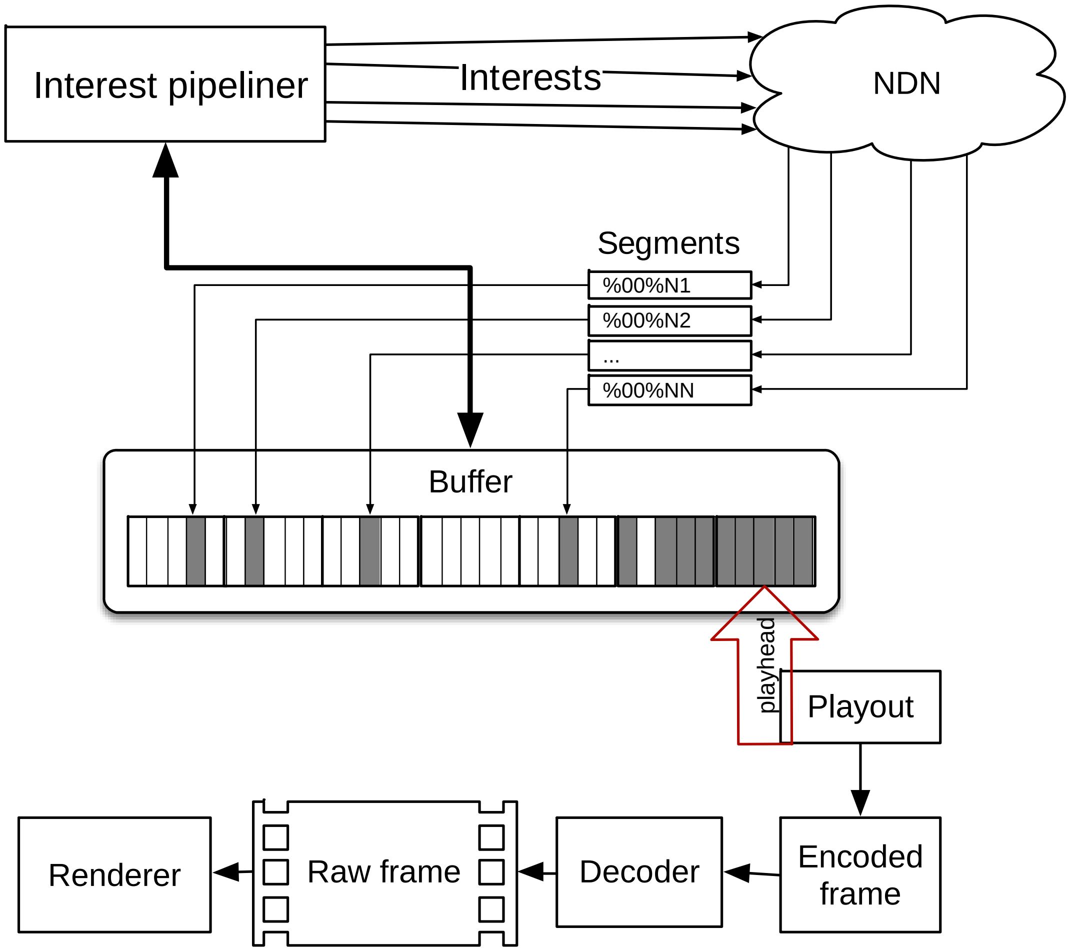


User namespace

- *Root:*
  - User prefix (username)
- *Media streams:*
  - Media streams (audio/video)
  - Streams meta info
- *Encoding threads:*
  - Individual encoding parameters
- *Frame type:*
  - **Key** and **Delta** frames in separate branches
- *Packet:*
  - Individual media packets (audio samples, encoded video frames)
- *Data type:*
  - Data and Parity segments in separate branches
- *Segments:*
  - Actual NDN-data objects

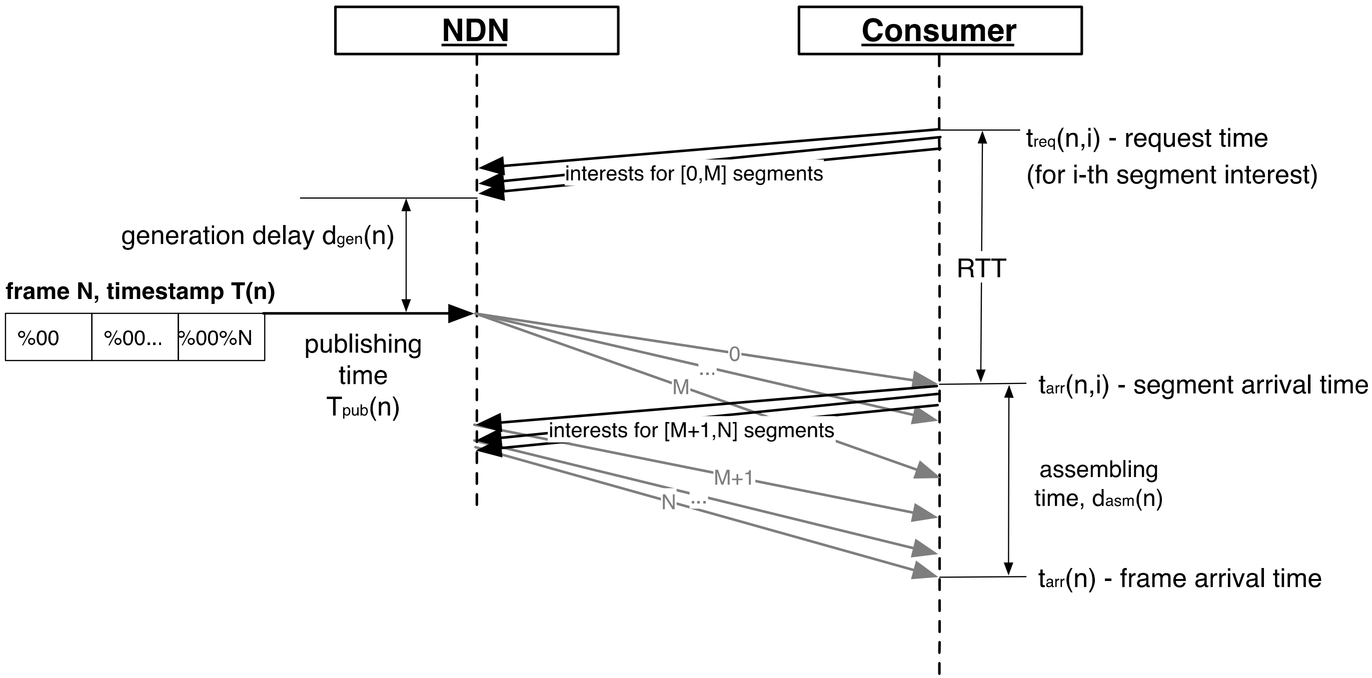


Consuming



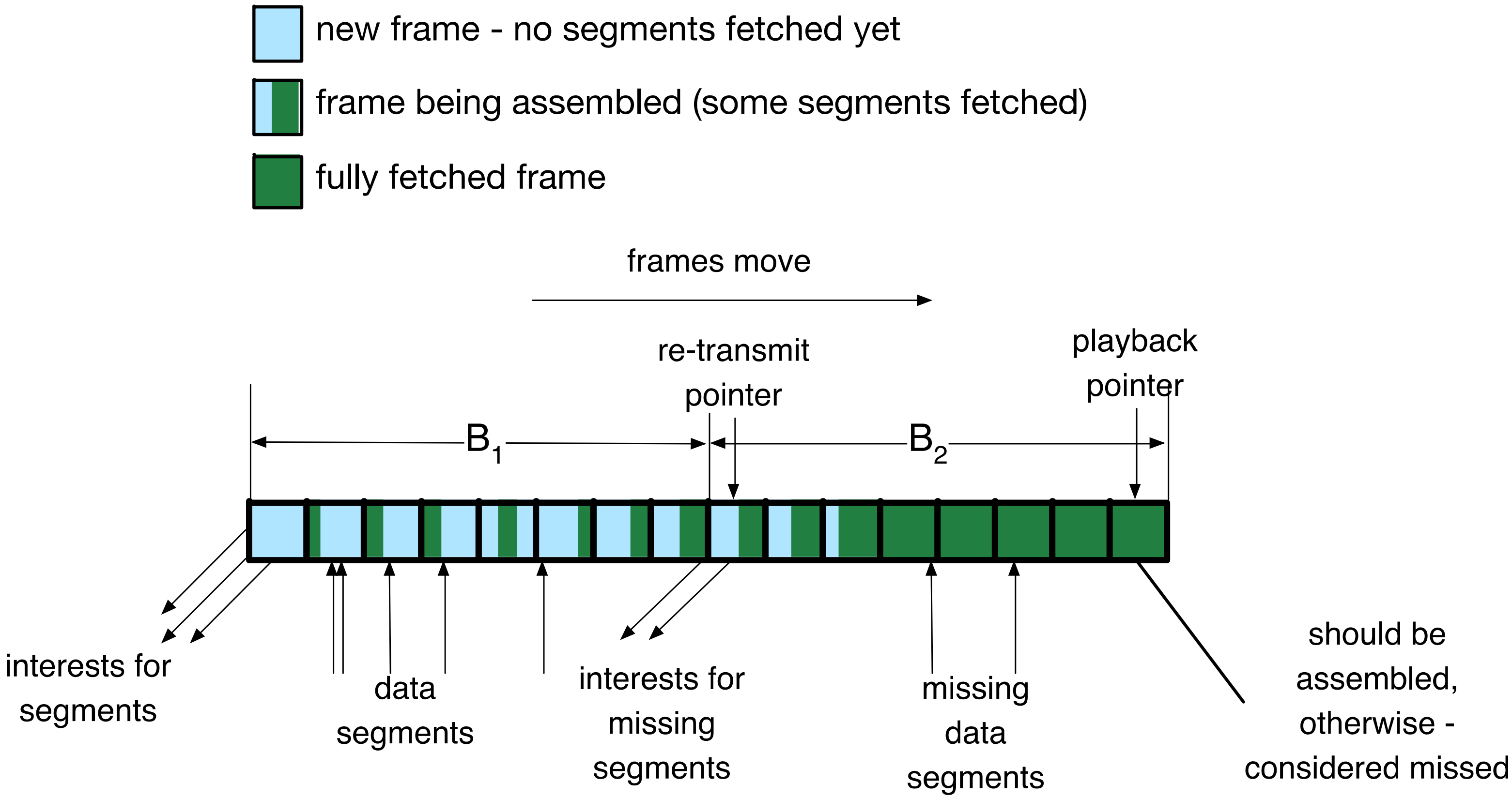
Interest pipeliner
Interests
NDN
Segments
%00%N1
%00%N2
...
%00%NN
Buffer
playhead
Playout
Encoded frame
Decoder
Raw frame
Renderer

Frame fetching



- **Generation delay d_n^{gen}** – time interval between receiving an interest and satisfying it with data (*producer-side*)
- **Assembling time d_n^{asm}** – time needed to fetch all frame segments (*consumer side*)
- **RTT_n** – consumer-measured round trip time for the interest (*consumer side*)

Interest pipeline and retransmission



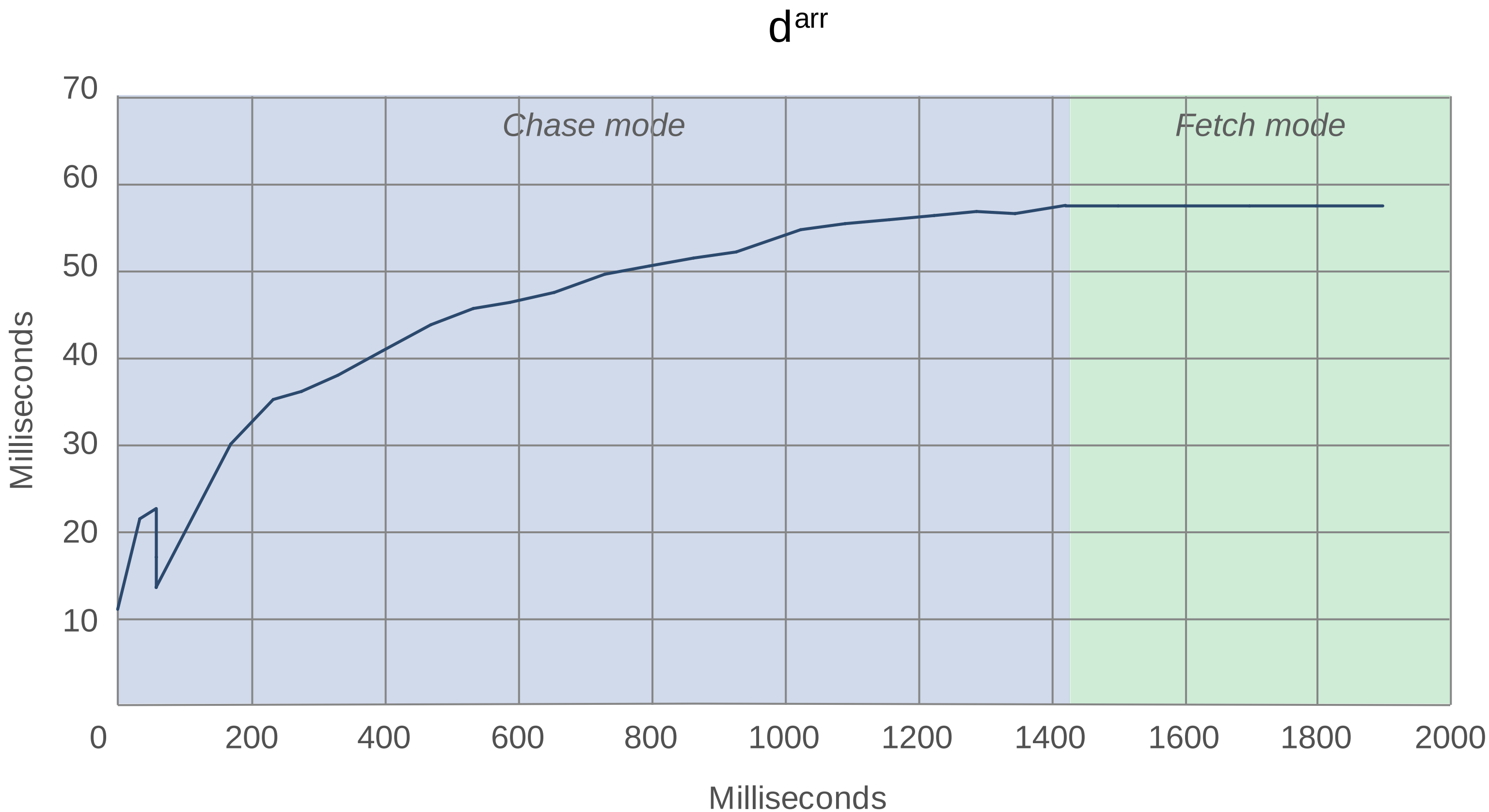
B_1 >= RTT, B_2 >= RTT

Minimal buffer size >= 2*RTT milliseconds

Chase mode

- There is no direct coordination b/w consumers and producers
- Producer generates data at high rate (~20-30FPS) and this data becomes outdated fast
- **Start-up time:** consumer is aware that stale data is present in the network and tries to avoid playing it back
- **Chasing mechanism:**
  - Cache exhaustion:
    - **Latest data can not arrive faster than it's being produced – it arrives at producer's rate**
    - **Cached data arrives with the same frequency it was requested**
  - Chase mode:
    - issue interest for the RIGHTMOST segment
    - upon receiving first segment – start issuing interests for the next frames with interval $\boldsymbol{d^{int}}$ ***< Producer rate***
    - Monitor $\boldsymbol{d^{arr}}$ – frame inter-arrival interval:
      - If d^{arr} is increasing – continue fetching
      - If d^{arr} is stable – switch to "Fetch" mode

Chase mode (cont.)



Future improvement (suggested by Dave Oran)**:**

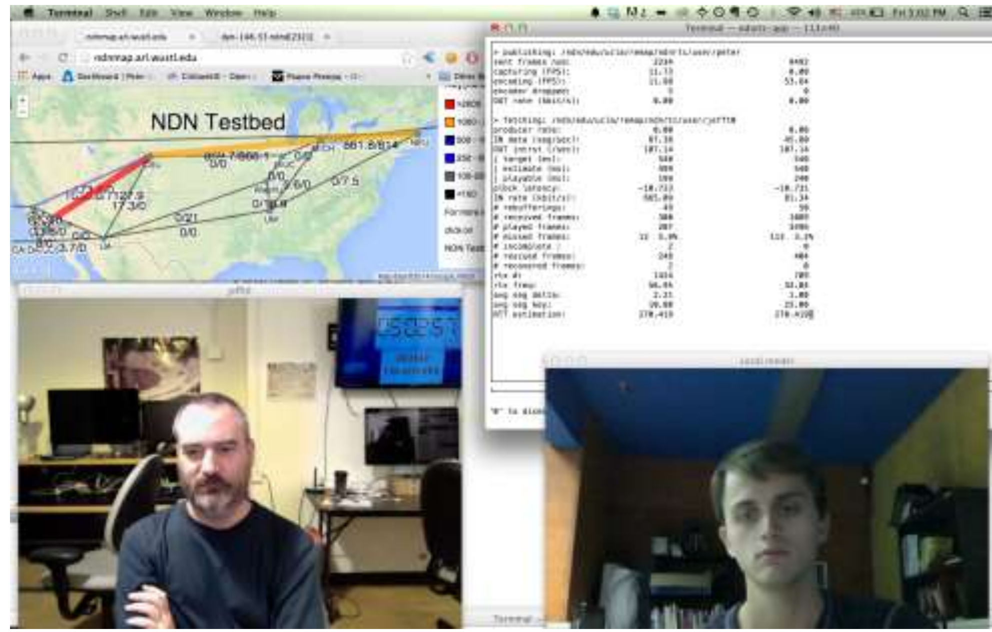
1. piggyback video sync data on audio stream
2. use audio stream for chasing instead of video

Forward Error Correction

- OpenFEC library
- Producer publishes parity data under separate namespace:
  - *<frame prefix>/<frame#>/parity/<segments>*
- Consumer **may** additionally fetch parity data for enabling FEC
- If by the playback time frame is missing any segments – FEC is applied as the "last resort"
- Amount of parity data is configurable (currently 20%)
- Collaborated with Daisuke Ando (Exchange student from Japan)
- **Future improvement** (suggested by Dave Oran)**:** use frame-level parity data rather than segment-level

Demo app

- Console app
  - MacOS X 10.9 and up
  - Buildable from sources
    github.com/remap/ndnrtc
  - Redmine
    redmine.named-data.net/projects/ndnrtc
- Functionality:
  - Publish audio/video stream
  - Fetch multiple audio/video streams



Future steps

- Real-time Adaptive Rate Control:
  - In collaboration with Panasonic R&D department (Muramoto-san, Yoneda-san)
  - Keep low-latency transmission & best throughput
  - Maintain RTT fairness (self-fairness)
  - Consumer-driven
  - NW bandwidth estimation based on RTT and timeouts
  - Control interest rate according to bandwidth estimation
- Conference discovery (Zhehao Wang)
- Text chat (Zhehao Wang)
- Browser integration (Zhehao Wang)
- Security
- Desktop conference tool
  - Adding modularity to the existing code
- Compare to existing solutions
  - Can be RTC over NDN better than IP?
- Scalability tests

Areas for future research

- Interests pipelining
  - Express just enough interests to fetch needed frames and meet the deadline, but keep low latency
- Alternatives to cache exhaustion
  - How consumer can be sure that it's getting the latest data from the network without explicit producer-consumer signaling?
- Security
  - Trust model; signing and verification; encryption approach?
- Scalability
  - How many conference peers can there be?
  - What are the requirements for the forwarder?
  - What are the requirements for the peers?
- Relationship between forwarder strategy and application
  - Best route strategy 2

Links

- Source code
  - https://github.com/remap/ndnrtc
  - branches:
    - master – current released version (v0.9.alpha4)
    - dev – current development branch (v0.9.alpha5)
- MacOS binaries (library, demo, supporting files)
  - https://github.com/peetonn/ndnrtc-archive
  - Special branch for demo events:
    - demo/ndncomm2014
- Redmine
  - http://redmine.named-data.net/projects/ndnrtc/issues

Thanks

Q&A

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