# NDN Libraries
# Progress and Plans

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# Overview

- Common Client Libraries (CCL)
- PSync
- Common Name Library (CNL)
- NDN-RTC
- Quick summary of recent research progress

# What are the Common Client Libraries (CCL)?

- Enable client applications to use NDN in C++, Python, JavaScript, Java, .NET
- Common API across languages: http://named-data.net/doc/ndn-ccl-api
- Interest/Data, signatures, encryption, transports, app utilities, unit tests, examples
- Track ndn-cxx research (security, NAC, NDN protocols, NFD interaction)
- Backwards compatibility, platform flexibility for development stability
- Used in NDN-RTC, BMS, mHealth, neighborhood network, web page apps, ICE-AR
- Specialized libraries: NDN-CPP Lite (Arduino), Imp, Android, browser speedups
- Stats (total): 10,771 commits, 277 closed issues, 79 pull requests, 80 forks

# Example

```
face = Face("memoria.ndn.ucla.edu")
name = Name("/ndn/edu/ucla/remap/demo/ndn-js-test/hello.txt/%FDU%8D%9DM")
def onData(interest, data):
    print(data.content.toRawStr())
face.expressInterest(name, onData)
```

# CCL Features

- Certificate signing/validating − RSA, ECDSA, HMAC
- Configurable cert chain policies, regex name matching
- Flexible public/private key database API
- Signed Interests − verify with same API as certs
- Name-base access control (AES encryption, RSA key protection)
- MemoryContentCache, SegmentFetcher
- Optional thread-safe network I/O
- Configurable wire format (see below)
- ChronoSync, PSync (see below)
- Unit tests, example programs

# CCL wire format abstraction

- API is not hard-wired to one wire format
- Enable backwards compatibility if running with old forwarders

```
WireFormat.setDefaultWireFormat(Tlv0_1WireFormat.get())
```

- Can specify on ad hoc basis if sending to a various networks

```
face.expressInterest(name, onData, Tlv0_1WireFormat.get())
```

- Was used for transition from CCN 0.x
- Plans to support other ICN wire formats

# CCL – Next steps

- NDN wire format v0.3 (with backwards compatibility)
  - Typed name components
  - Removed (most) Interest selectors
  - Interest hop count
  - Interest defaults to exact name  (optional CanBePrefix)
  - Extra application parameters in the Interest
  - Explicit fields for signed interests (instead of using name components)
- New wire formats
- Support new network autoconfig protocols

# What is PSync?

- Developed as improvement to ChronoSync
- Used in NLSR to sync routes on the NDN test bed
- Part of the CCL
- Invertible Bloom filter of a set of hashed names
  - Send interest with my IBF, receive interests with others' IBF
  - Stable state: Everyone sends the same IBF – Interest aggregation, no Data
  - Update: I receive a different IBF with missing names and provide in reply Data
  - IBF efficiently updates a set difference of ~275 names
- Eventual consistency from pairwise updates – broadcast not needed
- Option to subscribe to partial namespace updates

# Example PSync app

```
face = Face()
def onNamesUpdate(names):
    print("Got names, starting with " + names[0].toUri())

updateSize = 80
pSync = FullPSync2017(updateSize, face, Name("/sync"), onNamesUpdate)
pSync.publishName(Name(”/edu/ucla/jefft/paper.txt"))
```

# PSync – Next steps

- Implement in Python, JavaScript, Java (currently in C++)
- Use as native sync for the Common Name Library (see below)
- Stress test “eventual consistency” without broadcast
- Support partial PSync (waiting for use case)
- NDN Project: A Quick Summary of Recent Progress

# What is the Common Name Library (CNL)?

- Library enabling applications to work with hierarchical, named data collections.
  - Namespace object (root and child nodes)
  - Application interacts with a Namespace node (attach handlers, receive notifications)
- Provides a lightweight way to integrate various:
  - Sync mechanisms (i.e., PSync, vector sync)
  - Data access patterns (i.e., Consumer/Producer API, fetch latest),
  - Publishing models (i.e., publish/subscribe, in-memory content cache),
  - Complex namespace queries / pattern matching (i.e., regexp, wildcards),
  - Triggered data generation (supporting security)
- Currently using in ICE-AR mobile client application
  (No interest-data exchange exposed to developers of that app.)
- Segmented content with a Meta packet and versioning
- Built-in encode/decode, encrypt/decrypt, sign/verify as part of the pipeline
- New names added to the Namespace tree through PSync, app is notified

# CNL Motivation

- Provide tools for working with namespaces as they represent collections, in an *information-focused* rather than communication-oriented way
- Assume asynchronous network operations will be used to sync the namespace and consume/publish objects in the collection
- Insulate non-networking developers from communication details
- Make progress towards NDN as a middleware-replacement in terms of high-level, application-facing features, but try to stay as general as possible
- Work with aggregate application-specific objects, not (segmented) blobs in packets
- As a result, support namespace synchronization the way that is conceived / described at a high-level, and promote it as an application-level concept to explore

# Example segmented content consumer app

```
face = Face("memoria.ndn.ucla.edu")
page = Namespace("/ndn/edu/ucla/remap/demo/ndn-js-test/named-data.net/project/ndn-ar2011.html/%FDX%DC5B")
page.setFace(face)

def onSegmentedObject(namespace):
    print("Got segmented object size " + str(namespace.obj.size()))

page.setHandler(SegmentedObjectHandler(onSegmentedObject)).objectNeeded()
```

# CNL Handlers

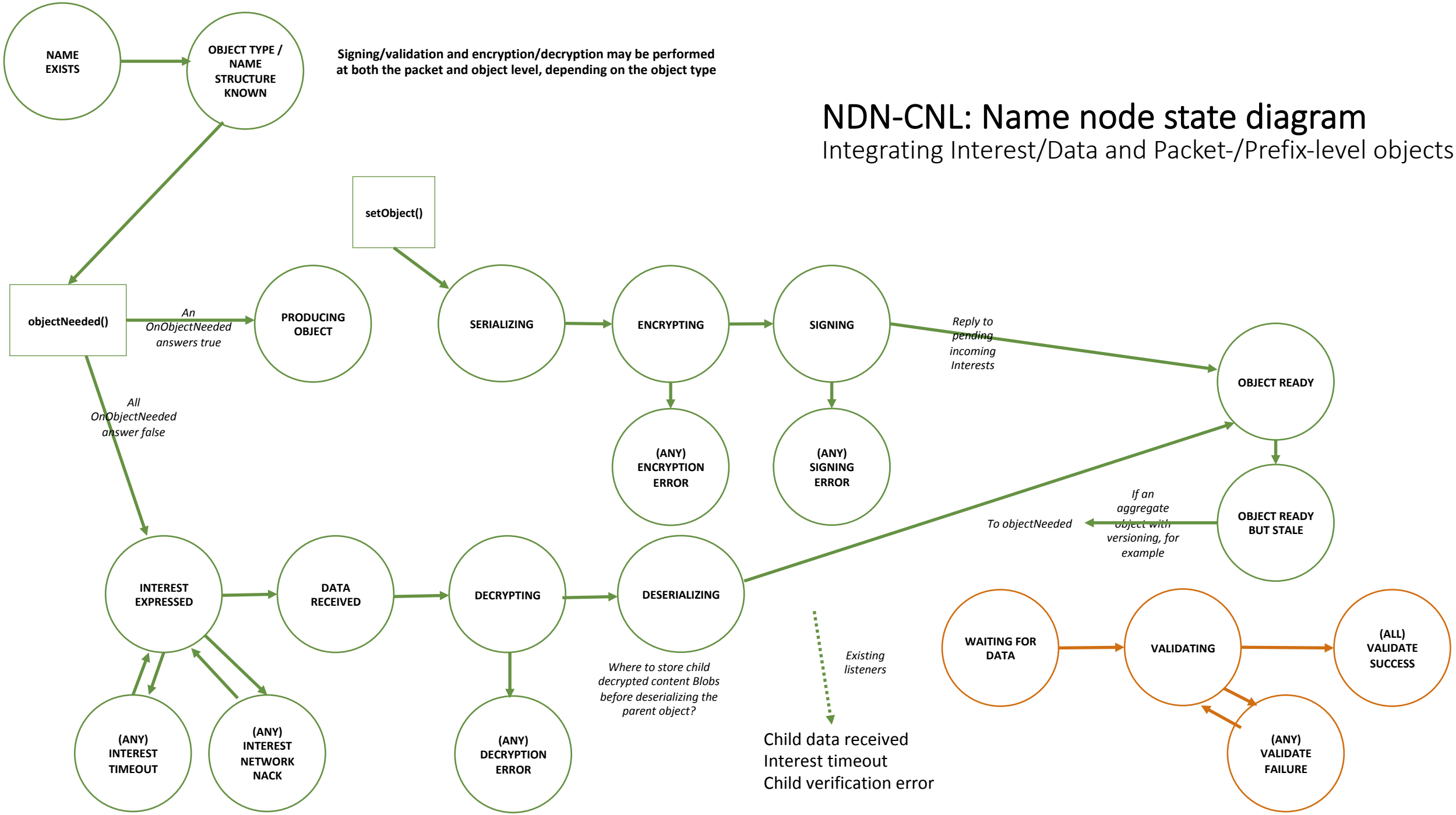
- Support extensibility
- Set Namespace for special fetching, publishing, object representation
- Unified API for developers too
- https://github.com/named-data/PyCNL/blob/master/python/pycnl/segmented_object_handler.py

# Unified publisher/consumer

- objectNeeded() – From application (producer) or network (consumer)
- Producer
  - CNL receives Interest, adds to PIT, calls OnObjectNeeded (if not already in cache).
  - Handler’s OnObjectNeeded answers True.
  - CNL waits for application to produce data asynchronously.
  - Application calls setObject().
  - CNL does serialize/encrypt/sign and satisfies PIT.
- Consumer
  - Application calls OnObjectNeeded for a Namespace node.
  - (All handlers answer False.)
  - CNL does Face.expressInterest and waits for Data.
  - CNL receives Data, does verify/decrypt/deserialize and OnStateChanged(OBJECT_READY)

# NDN-CNL: Name node state diagram

## Integrating Interest/Data and Packet-/Prefix-level objects

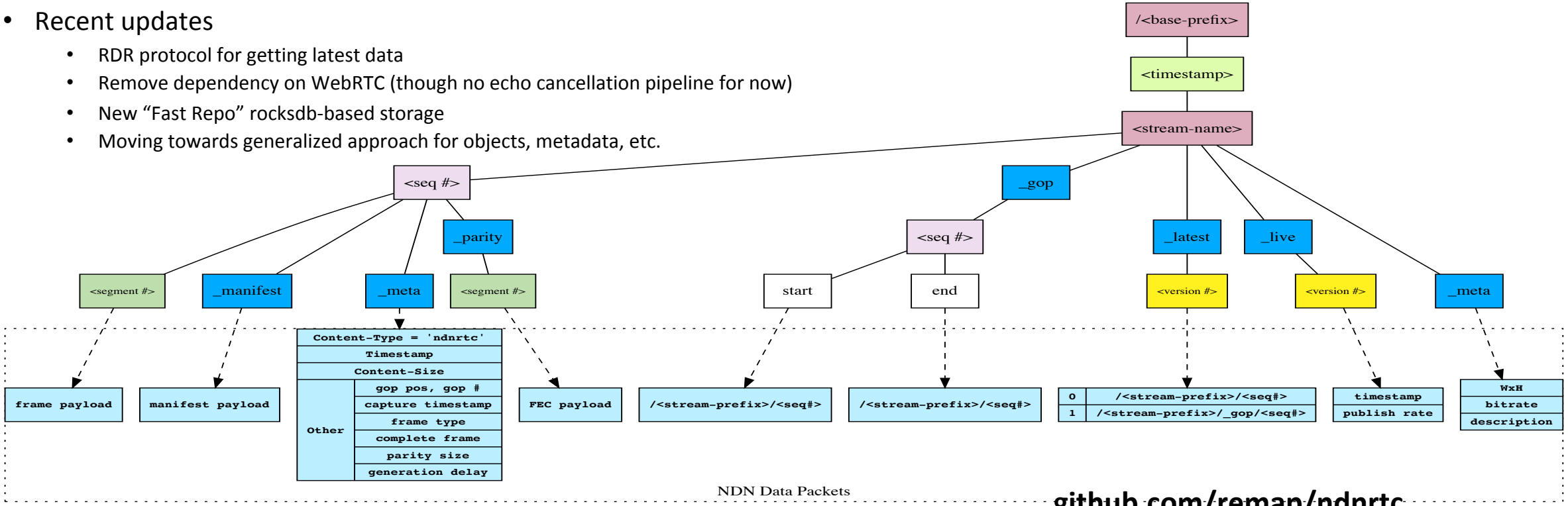


# CNL – Next steps

- High-performance persistent storage
- Port to Java and JavaScript
- More applications
  - Currently used in augmented reality mobile client application

# What is NDN-RTC?

- NDN C++ video (HD) streaming library for macOS, Ubuntu, Android
- Sub-second (~150ms) latency
- Based on VP9 video encoder
- Pipelining, retransmission, FEC
- Unified consumer for live and stored video
- Recent updates
  - RDR protocol for getting latest data
  - Remove dependency on WebRTC (though no echo cancellation pipeline for now)
  - New “Fast Repo” rocksdb-based storage
  - Moving towards generalized approach for objects, metadata, etc.


/<base-prefix>
<timestamp>
<stream-name>
<seq #>
_gop
_parity
<seq #>
_latest
_live
<segment #>
_manifest
_meta
<segment #>
start
end
<version #>
<version #>
_meta
Content-Type = 'ndnrtc'
Timestamp
Content-Size
Other
gop pos, gop #
capture timestamp
frame type
complete frame
parity size
generation delay
frame payload
manifest payload
FEC payload
/<stream-prefix>/<seq#>
/<stream-prefix>/<seq#>
0 /<stream-prefix>/<seq#>
1 /<stream-prefix>/_gop/<seq#>
timestamp
publish rate
WxH
bitrate
description
NDN Data Packets

**github.com/remap/ndnrtc**

# Applications

Current

- ICE-AR (AR browser as part of Intel/NSF ICN-WEN)
  - NDN-RTC streams phone POV video for edge processing (object, face, pose recognition)
  - processed information delivered back to the phone to enrich phone's environmental understanding (deep context)
- TouchNDN (integration with Derivative's Touchdesigner)
  - aiming to replace NDI for live video production
  - leverage NDN to efficiently disseminate live video over L2 (or L3) to multiple nodes for simultaneous processing & storage
  - nodes integrate "historical" playback from repo data seamlessly with live streaming, for scrubbing real-time streams
- Assorted command line tools

Previous

- ndncon/flume – pure P2P conferencing app
  - not up to speed with latest library

# Future Plans

- Scalable video coding (VP9)
- Region-of-Interest-based fetching (360$^{o}$ video use case)
- Volumetric video streaming
- Congestion control, when apps need it (based on Schneider 2016)

=> Looking for app users and codebase collaborators

# Recent NDN Code Release Updates

- NFD and ndn-cxx version 0.6.5
- ndn-tools version 0.6.3
- NDN Android version 0.6.5-3
  - Based on the latest version of NFD (0.6.5)
  - Including updated GUI based on work at NDN hackathon
- ndnSIM 2.7
  - Based on the latest released versions of NS-3 (version 3.29) and NFD (version 0.6.5)

  https://ndnsim.net/2.7/RELEASE_NOTES.html
- Mini-NDN 0.40

  https://github.com/named-data/mini-ndn/releases/tag/v0.4.0
- Named-data Link State Routing Protocol (NLSR) version 0.5.0

  https://named-data.net/doc/NLSR/0.5.0/RELEASE-NOTES.html

# Recent New Code Releases / In progress

- pSync, a synchronization protocol for NDN
  https://named-data.net/doc/PSync/0.1.0/RELEASE-NOTES.html
- NDN IoT Package
- Mini-NDN-WiFi

# NDN IoT Package

- An NDN-based IoT framework with two goals
  - Localized trust and automated security management
  - Ease-of-use IoT software development kit
- Features
  - Lightweight NDN software stack and forwarder, specifically tuned for constrained devices
  - Seamless integration of heterogenous link layer protocols (BLE, WiFi, IEEE 802.15.4, etc.)
  - Ease-of-use high-level APIs for bootstrapping, service discovery, access control, and schematized trust management
  - Easy adaptation to new IoT hardware/software platforms
- Ongoing efforts
  - Further memory-saving NDN forwarder design
  - Demonstrative application to illustrate how to build an IoT system in a fundamentally different way from today's IP-based solutions
- More detailed to be reported @ next IETF

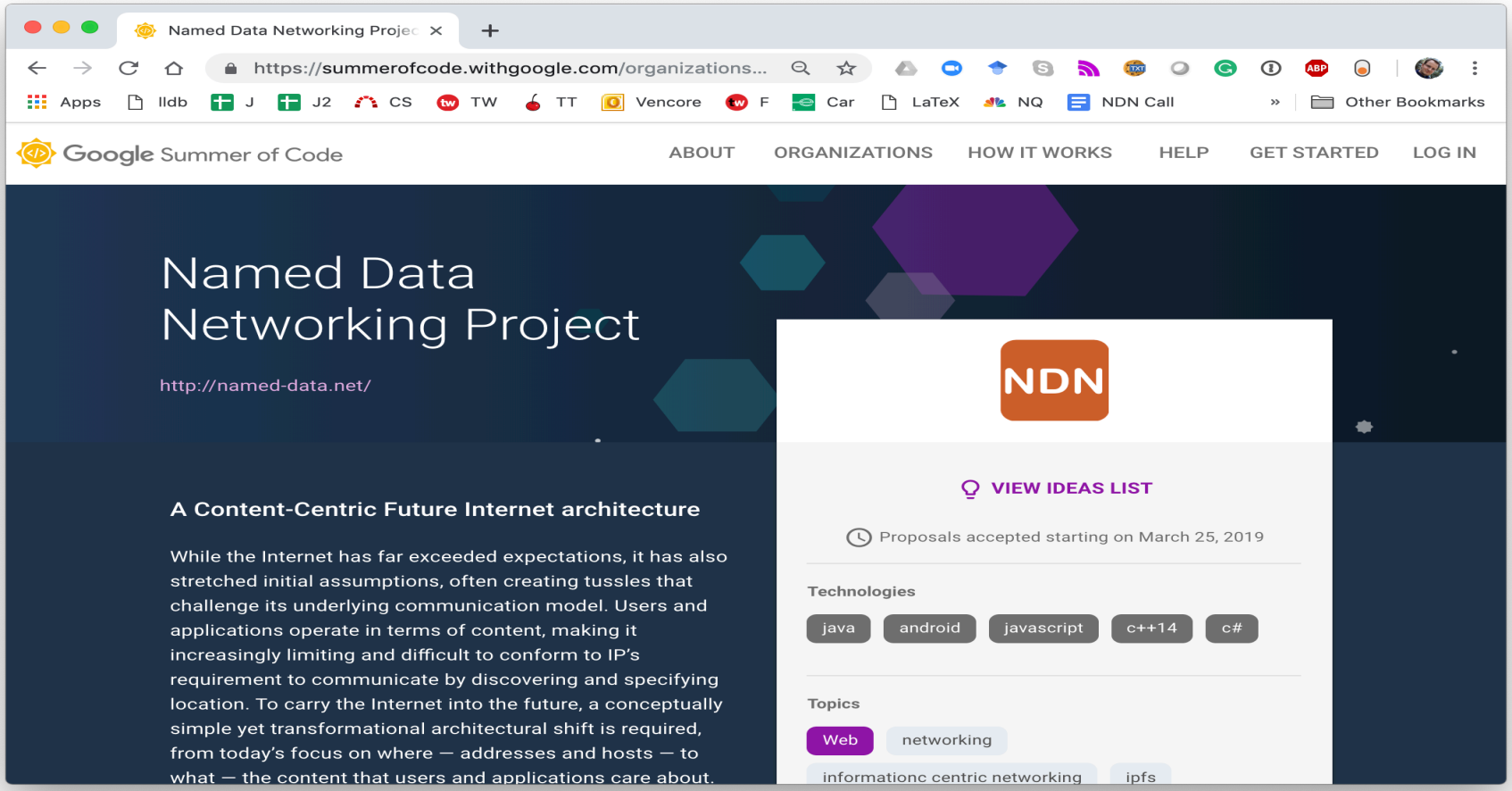
# 8th NDN Hackathon (March 8-10, 2019)

http://8th-ndn-hackathon.named-data.net/hacks.html

- **First Prize:** *NFD-Android Enhancements*
  - Alex Afanasyev, Ju Pan, Sanjeev Kaushik Ramani, Davide Pesavento
- **Second Prize:** *Sigcomm Tutorial App (NDN-IoT demo)*
  - Zhiyi Zhang, Xinyu Ma, Edward Lu, Yu Guan, Erynn-Marie Phan, Laqin Fan
- **Third Prize**
  - *Self-Learning for Ad Hoc Wireless Networks*
    - Md Ashiqur Rahman, Davide Pesavento
  - *Sync in MANET Library + Demo*
    - Tianxiang, Zhaoning, Spyros
  - *Addressing ndncatchunks Performance Issues*
    - Klaus Schneider, Saurab Dulal

# NDN Project at Google Summer of Code

- https://summerofcode.withgoogle.com/organizations/6559809451589632/



# Publications/Presentations/Tech Reports

Since last IETF

- "A Note on Naming and Forwarding Scalability in Named Data Networking" Yu Zhang et al, ICC 2019 Workshop, May 2019
- "The Role of Data Repositories in Named Data Networking" Lixia Zhang et al, ICC 2019 Workshop, May 2019
- "Proof of Authentication for Private Distributed Ledger" Zhiyi Zhang et al , NDSS 2019 workshop, Feb 2019
- "On the Granularity of Trie-based Data Structures for Name Lookups and Updates" Chavoosh Ghasemi et al, to appear in ACM/IEEE Transactions on Networking 2019
- "Packet Forwarding in Named Data Networking Requirements and Survey of Solutions" Zhuo Li et al, to appear in IEEE Communications Surveys & Tutorials 2019
- "An Overview of Security Support in Named Data Networking" Zhiyi Zhang et al, IEEE Communications Magazine, Nov 2018.

# How to learn more

- Common Client Library (CCL)
  - C++: https://github.com/named-data/ndn-cpp
  - Python: https://github.com/named-data/PyNDN2
  - JavaScript: https://github.com/named-data/ndn-js
  - Java: https://github.com/named-data/jndn
  - C# (.NET Framework): https://github.com/named-data/ndn-dot-net
- PSync: Scalable Name-based Data Synchronization for Named Data Networking
  - https://named-data.net/publications/scalable_name-based_data_synchronization/
- Common Name Library (CNL)
  - C++: https://github.com/named-data/cnl-cpp
  - Python: https://github.com/named-data/PyCNL
- NDN-RTC: https://github.com/remap/ndnrtc