An Overview of NDN Codebase

NDN Tutorial – ACM ICN 2016

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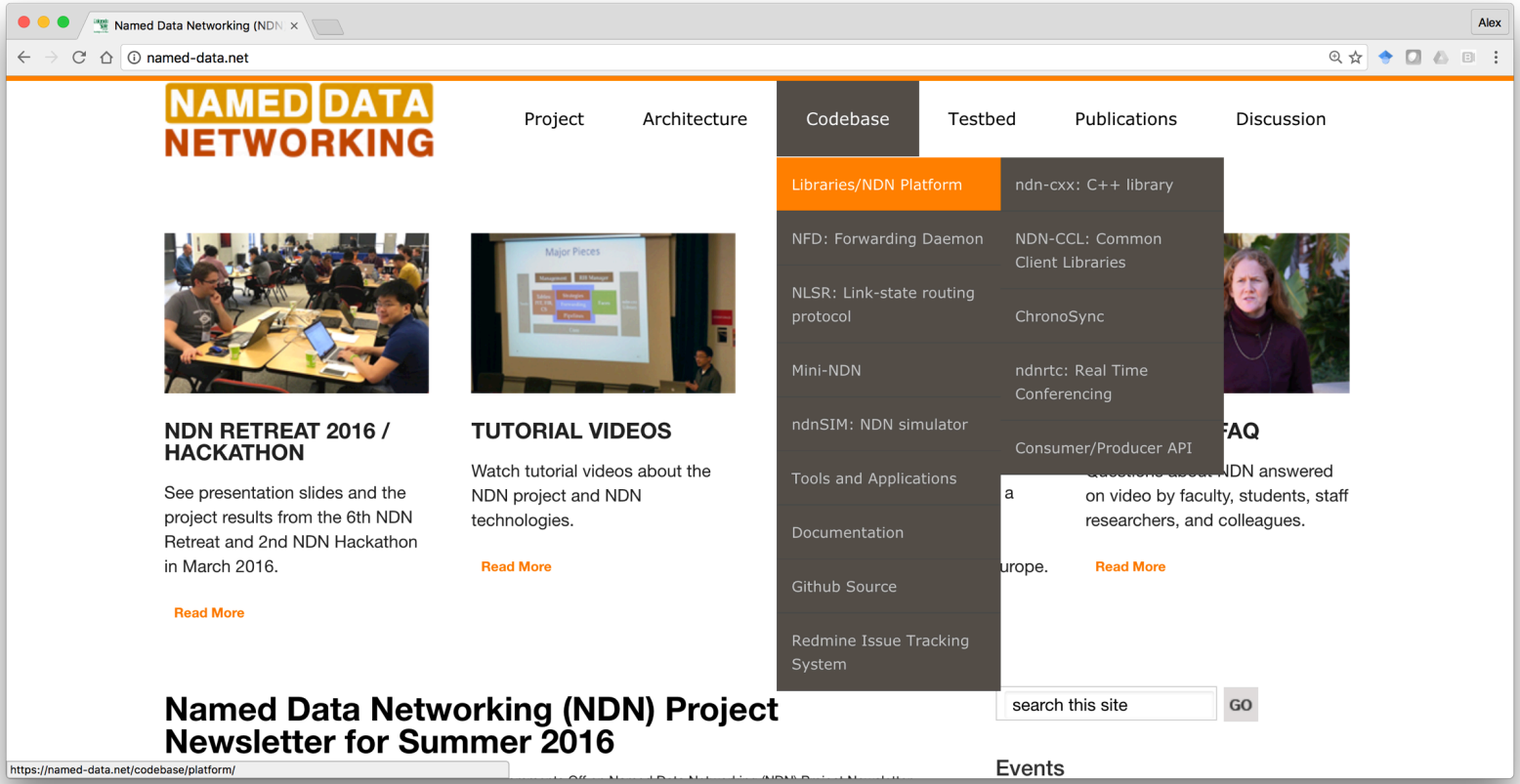
https://named-data.net/icn2016-tutorial

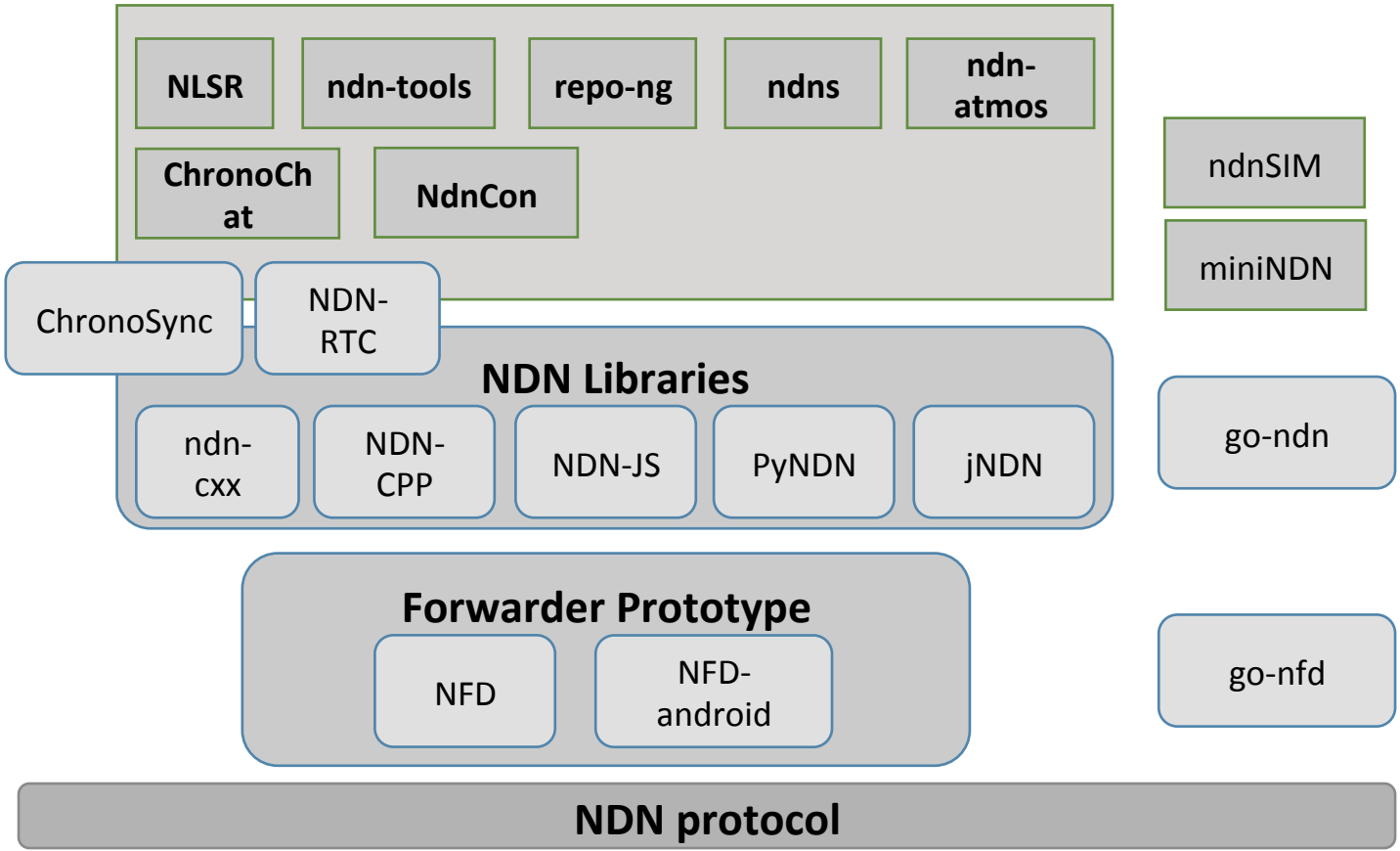
Starting Point for NDN Codebase



NDN Platform: packages of essential software

- Libraries
  - ndn-cxx
  - NDN-CCL (Common Client libraries)
  - NDN-RTC (real-time communication)
  - ChronoSync (multiparty sync)
- Infrastructure software
  - NFD: Forwarding Daemon
  - NFD-Android
  - NLSR: link state routing protocol
  - repo-ng: repository
  - ndn-tools: ndnping, ndn[peek/poke], ndn[cat/put]chunks, ndn-dissect, and others
- Applications
  - ndncon: conferencing
  - ChronoChat
  - Many others
- Simulator
  - ndnSIM: ns-3 based NDN simulator
- Emulator
  - Mini-NDN: Mininet based emulator
- NDN Testbed

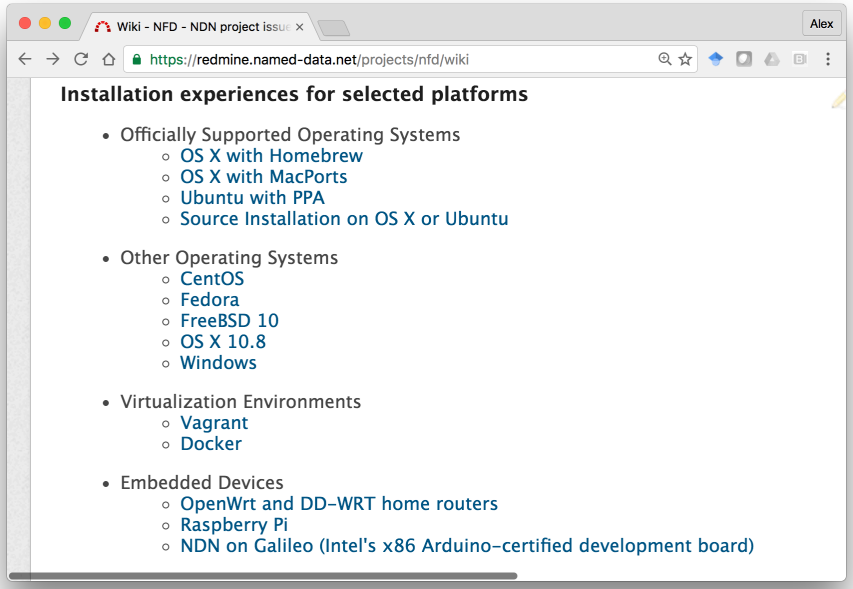
NDN Codebase



Working Platforms

- Desktop Systems
  - Linux, OSX, FreeBSD and other Linux distributions
- Home routers
  - OpenWRT, DD-WRT
- Mobile:
  - Android
- IoT:
  - Arduino, ESP8266
  - RIOT-OS
- Web browser

https://redmine.named-data.net/projects/nfd/wiki



Libraries

ndn-cxx, NDN-CCL, NDN-RTC, ChronoSync, …

ndn-cxx and NDN-CCL

- Both Libraries are under active development with different emphasis.
- ndn-cxx: NDN C++ library with eXperimental eXtensions
  - C++ only, focusing on supporting NFD and new protocol feature development.
  - used in: NFD, NLSR, ndn-tools, ChronoChat, etc.
- NDN-CCL: NDN Common Client libraries suite
  - available in C++, Java, Python, JavaScript; partial C# .NET, Squirrel
  - Common APIs across languages.
  - Focusing on supporting general app development, used in: NDN-RTC, NdnCon, NFD-Android, etc.
- Both libraries support NDN application development, e.g.,
  - Send/receive, encode/decode, sign/verify Interest and Data packets.
  - Asynchronous I/O with various transports
  - Manage certificates and signing keys (RSA, ECDSA, HMAC)
  - Prefix registration on local NFD, manage NFD.
  - Validator to verify signatures and trust model
  - In-memory data storage

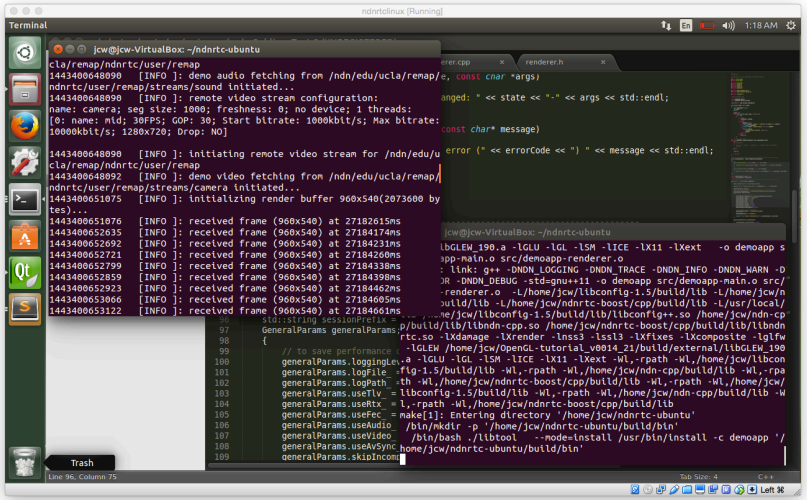
ChronoSync

- Synchronization library for distributed real-time applications.
  - Efficiently synchronize a collection of data among a group of nodes.

- Use cases:
  - group text messaging, example: ChronoChat
  - file sharing, example: ChronoShare

NDN-RTC

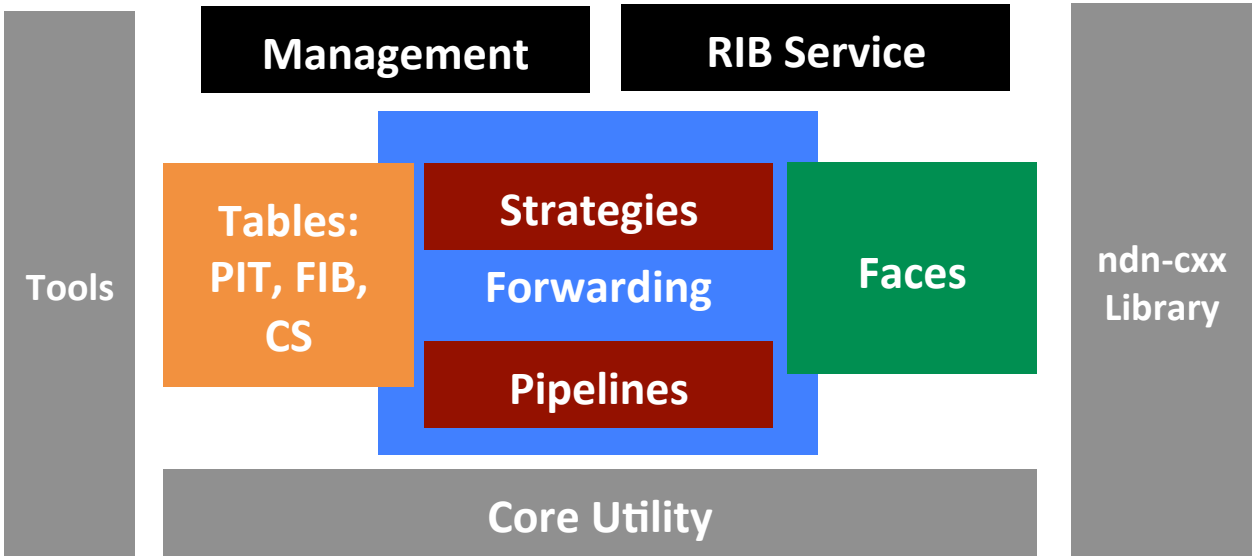
- C++ library for low-latency audio/video streaming over NDN
- VP8/9 encoder
- WebRTC audio processing pipeline
- Forward error correction (OpenFEC)
- Pull-based streaming control by consumers.
- OSX/Ubuntu headless (console) demo application



Infrastructure Software

NDN Forwarding Daemon (NFD)

- The reference implementation of NDN network protocol.
- NFD design emphasizes modularity and extensibility, to support diverse experimentation with NDN architecture.



Faces

- Face = LinkService + Transport

- Transport: works with different socket types
  - Unix stream, UDP unicast, UDP multicast, TCP: implemented with Boost.Asio
  - Ethernet multicast: implemented with libpcap
  - WebSocket: implemented with websocket++

- LinkService: provides best-effort NDN packet delivery service
  - encoding and decoding of Interest, Data, Negative Acknowledgement (NACK)
  - fragmentation and reassembly on MTU-limited links
  - (planned) failure detection, link reliability improvement

Forwarding

- Packet processing is broken into a number of small “pipelines” and strategy callbacks.
- The pipelines are fixed packet processing.
- Strategies are customized for different prefixes and can react to network behaviors.
  - Interest/Data provide a closed-loop control.
  - Can take feedback from past events, make decisions on where to forward future Interests, and can store states in the forwarder.
  - Currently strategy choice is local to the node, and configured via management commands.
  - A number of strategies implemented in NFD, and more have been proposed in literature.

Management

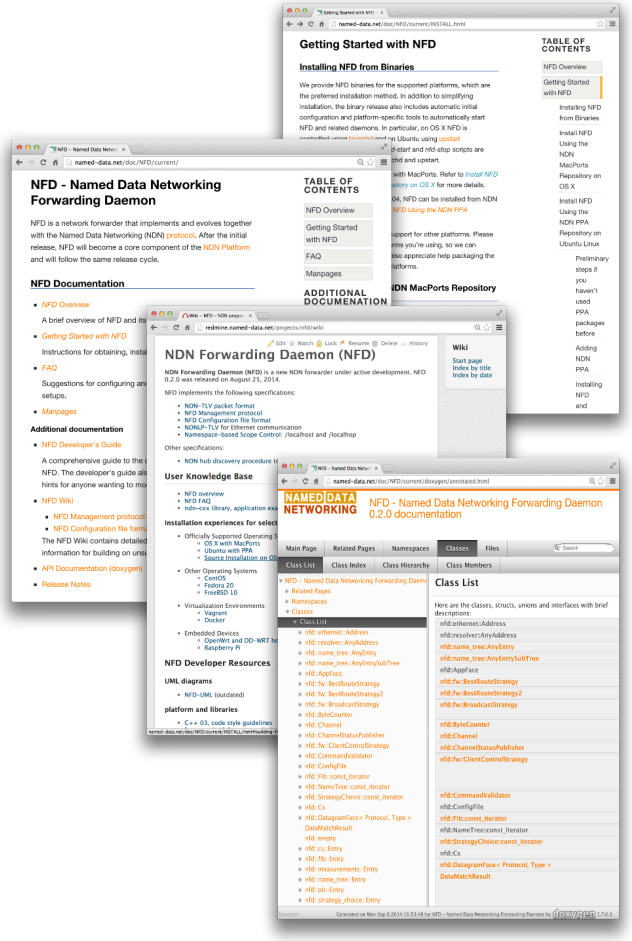
- Protocols to monitor and control NFD
  - Using Interest/Data exchange
    - E.g., ndn:/localhost/nfd/faces/create/….
- Face management
  - faces/create, faces/destroy
- Prefix and strategy management
  - rib/register, rib/unregister
  - strategy-choice/set, strategy-choice/unset
- Status and statistics retrieval

NFD Tools

- nfd-start, nfd-stop
  - scripts to start/stop the forwarder
- nfdc
  - control NFD at runtime via management interface
- nfd-status, nfd-status-http-server
  - read NFD status/statistics via management interface
  - serve status report XML over HTTP
- ndn-autoconfig
  - Find a testbed router through multicast or DNS

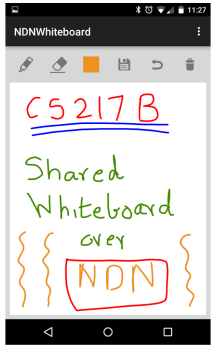
More information

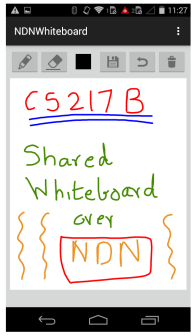
- https://named-data.net/doc/NFD/current/
  - Overview
  - Getting started
  - NFD Developer's Guide
  - Manpages
  - Wiki
  - API documentation (doxygen)
- Feedback, suggestions, and contributions are welcome.

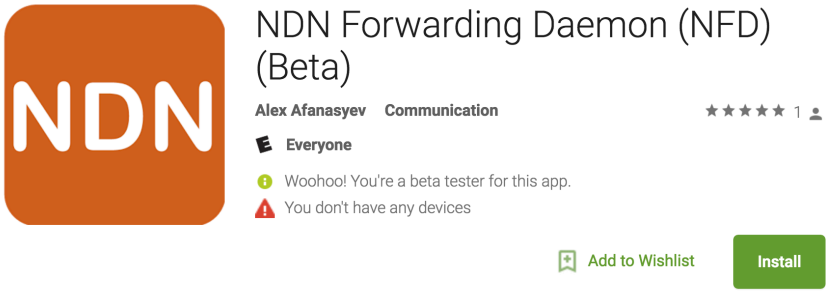


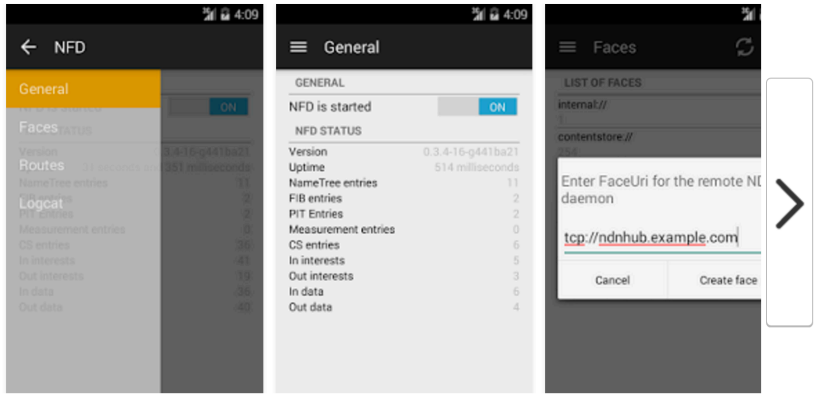
NFD-Android

- NDN forwarding daemon on Android.
- NFD source compiled with NDK.
- Management menus implemented with jNDN.
- Some simple apps such as W





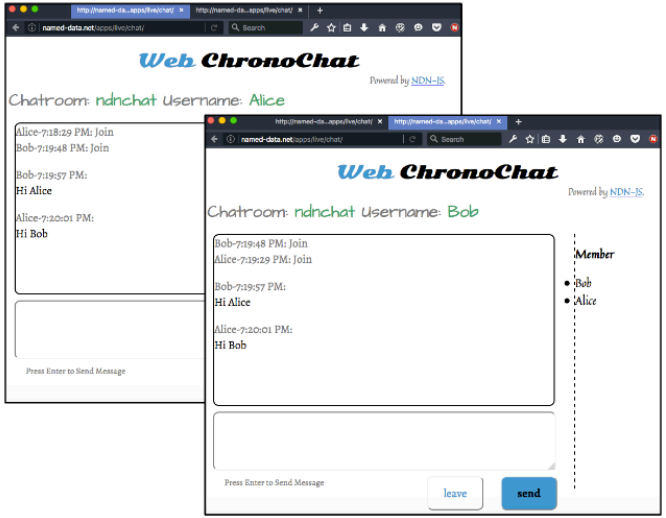


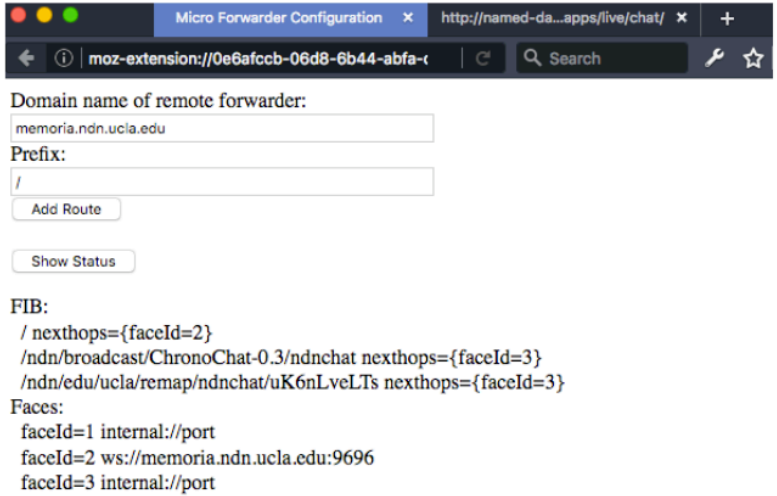


https://play.google.com/store/apps/details?id=net.named_data.nfd&hl=en
https://github.com/named-data-mobile

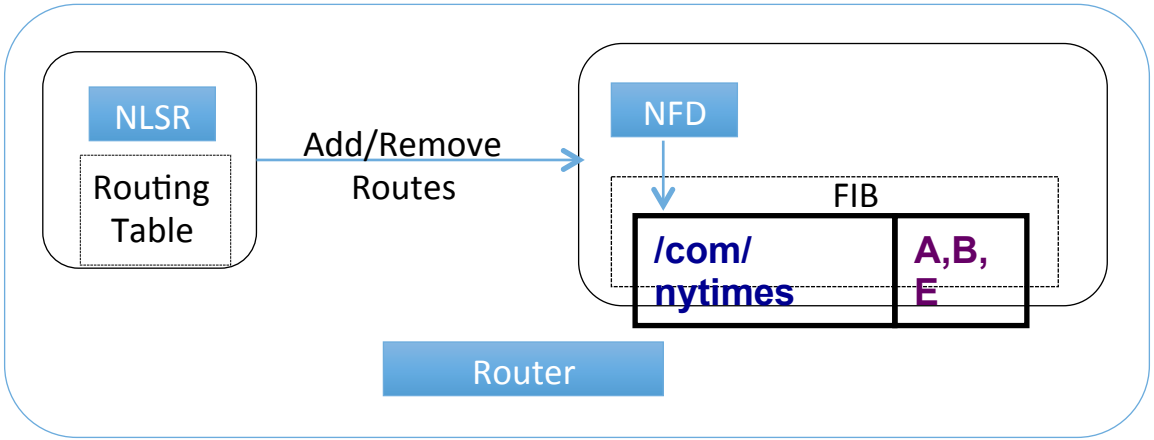
NDN Micro Forwarder in browsers

- NDN forwarder as a Firefox/Chrome extension, written in JavaScript
- Enable users to try NDN without installing NFD.
- NDN-JS apps in browser tabs can inter-communicate through the Micro Forwarder, or communicate with NDN testbed through WebSockets.





NLSR: Named-data Link State Routing



- NLSR implements a link state routing protocol.
- Also supports the hyperbolic routing protocol.
- NLSR instances exchange routing announcements as NDN Interest/Data, and installs learned routes into NFD.
  - Use ChronoSync to sync routing states.
  - Use a hierarchical trust model to validate routing messages.
- NLSR offers command-line tools to manage routes at runtime.

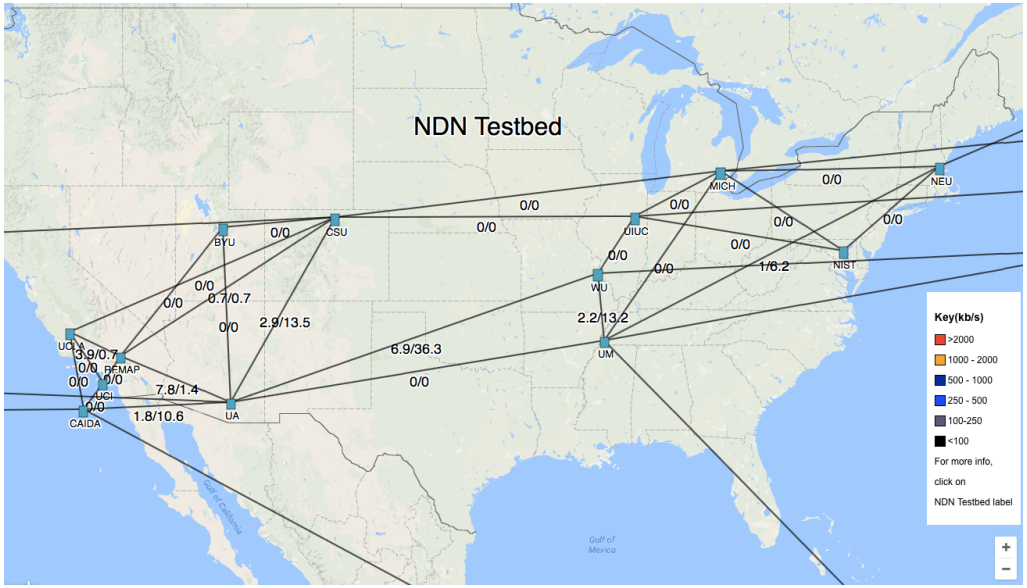
Other infrastructure software and useful tools

- repo-ng: NDN repository providing managed persistent storage.

- ndn-tools: essential tools
  - ndnping: reachability test
  - Ndn[cat|put]chunks: file transfer
  - ndndump: packet capture and analysis
  - ndn-dissect: Wireshark dissector
  - A traffic generator

NDN Testbed

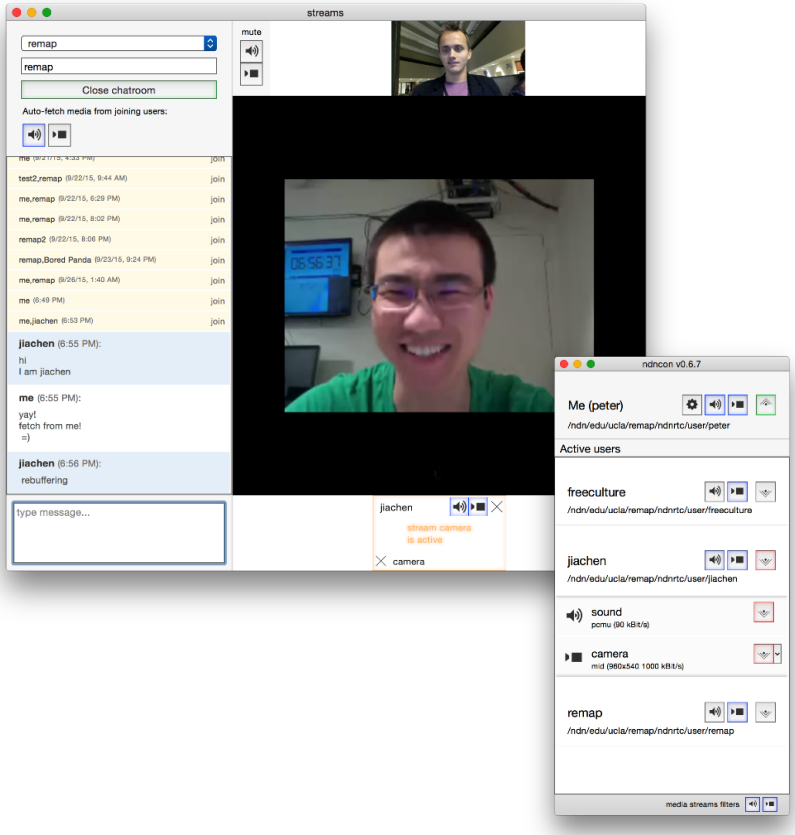
- A global testbed to support NDN research.
- 33 nodes, 90 links, nodes run NFD, NLSR, repo-ng.
- Real-time status monitoring and bandwidth measurement.
- Examples applications and experiments: videoconferencing, network management, virtual machine migration, strategies, nTorrent, etc.



Applications

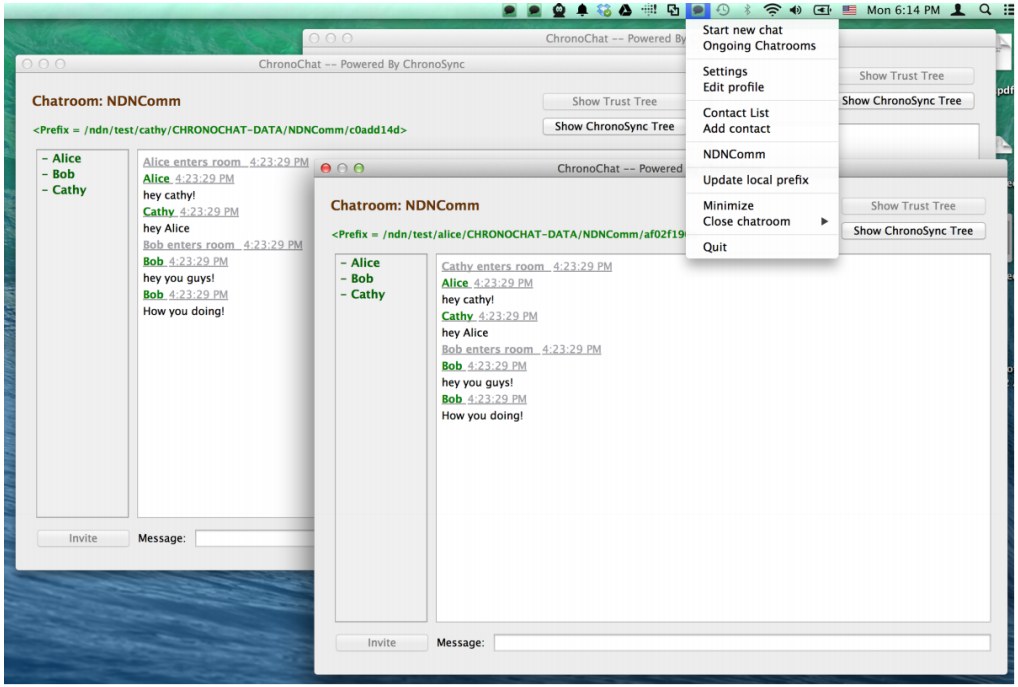
ndncon

- OSX GUI application built on top NDN-RTC library
  - user discovery
  - screen sharing
  - multi-party conferencing
  - group text chat
- HD video capable
- github.com/remap/ndncon



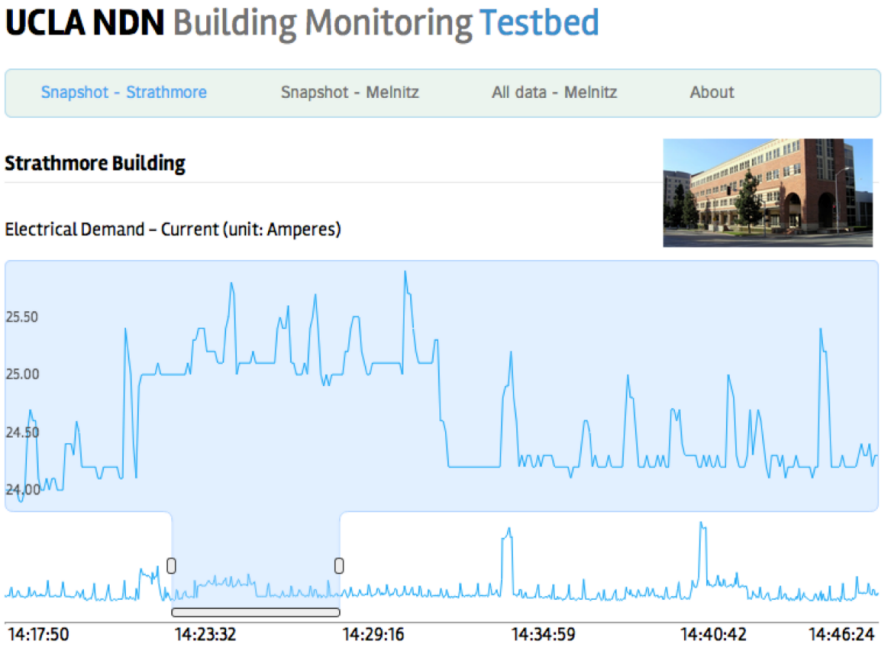
ChronoChat

- Server-less multi-user instant message application.
- Built with ChronoSync protocol.



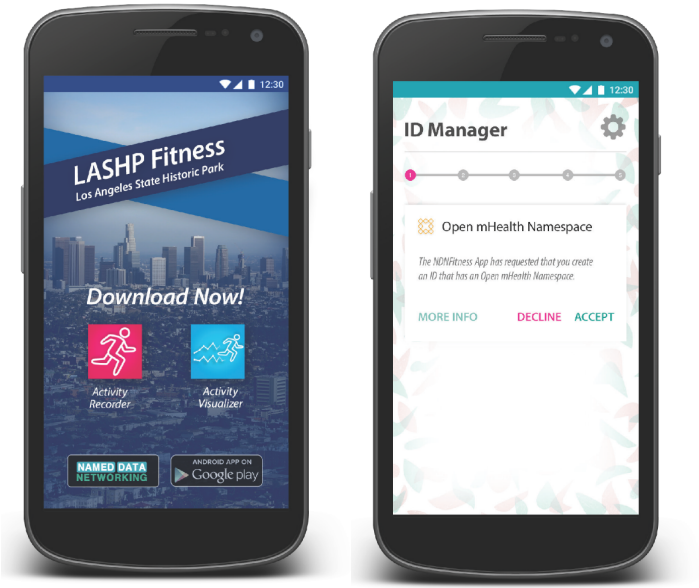
Enterprise Building Automation and Management Systems

- Simpler, secure alternative to middleware and cross-layer stacks in industrial control / SCADA.
- Second-generation prototype bridging live UCLA campus data to NDN testbed with hierarchical aggregation and trust model.



Open mHealth

- User-centric health data exchange
  - inspired by Estrin & Sim Open mHealth project



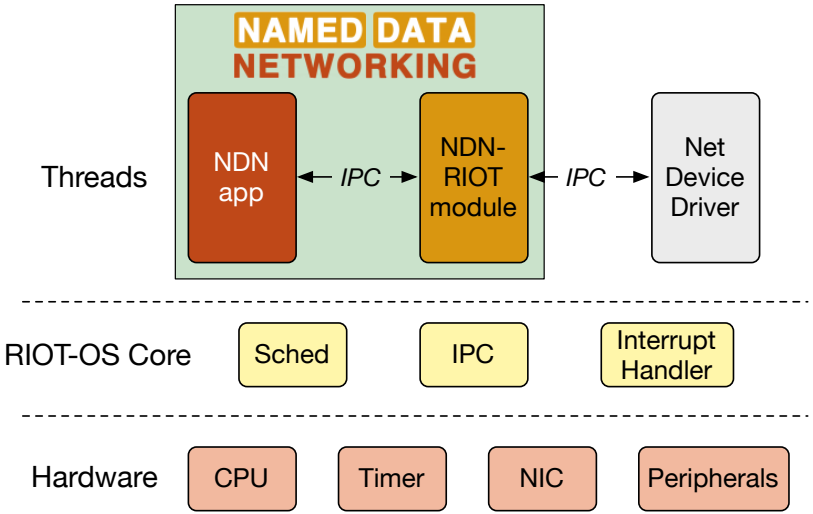
- User at root of trust model for their own health data.
- Simplification of minimum requirements for interoperability.
- Likely better at building distributed processing flows that cross administrative entities.
- End-to-end system with data capture, storage, processing, and visualization using NDN
- Prototype end-user interfaces for identity management (now), and name-based access control (soon).

Some other applications

- NDNFS
  - a FUSE-based filesystem readable over NDN
- ndn-atmos
  - API to publish, query, and retrieve climate science datasets
- NDN-Whiteboard (Android)
  - a shared whiteboard

NDN-RIOT: NDN for RIOT-OS

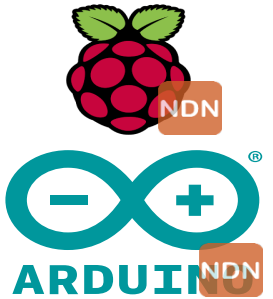
- Optimized for IoT apps
- Memory efficient packet encoding & decoding
- Data-centric security support
- Basic stateful NDN packet forwarding
- Support for 802.15.4 and Ethernet
- Application APIs



https://github.com/named-data-iot

Other IoT-related efforts

- NDN-BMS: encryption-based access control
- NDN-ACE: authorization framework for actuation apps
  - NDN-0036
- NDN-IoT: toolkit for NDN development on Raspberry Pi
  - https://github.com/remap/ndn-pi
- NDN on Arduino: minimal app for Arduino
  - https://github.com/ndncomm/ndn-btle
- esp8266ndn: NDN library for ESP8266 microcontroller



NDN Codebase