NDN Codebase and Tools

Introduction and getting started info

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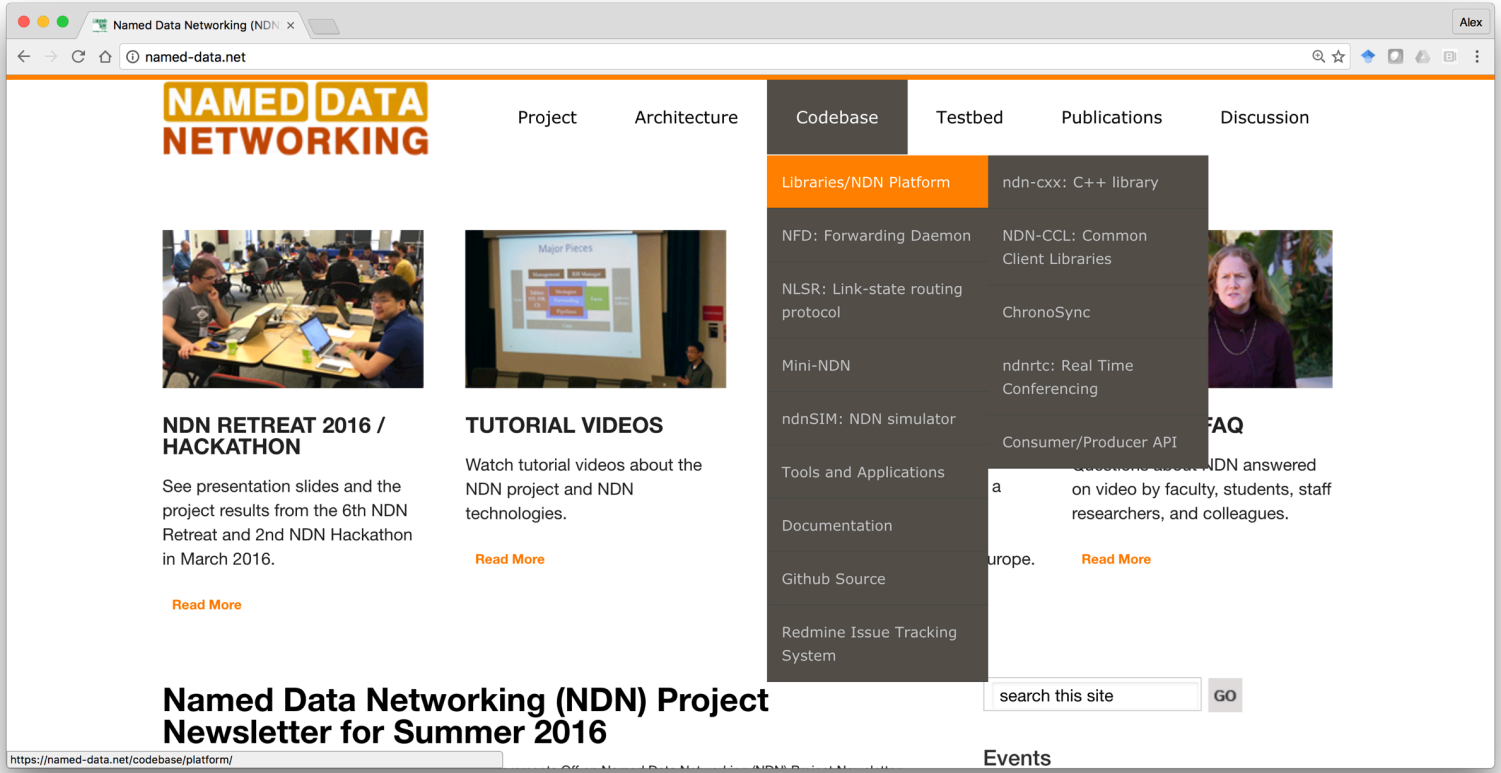
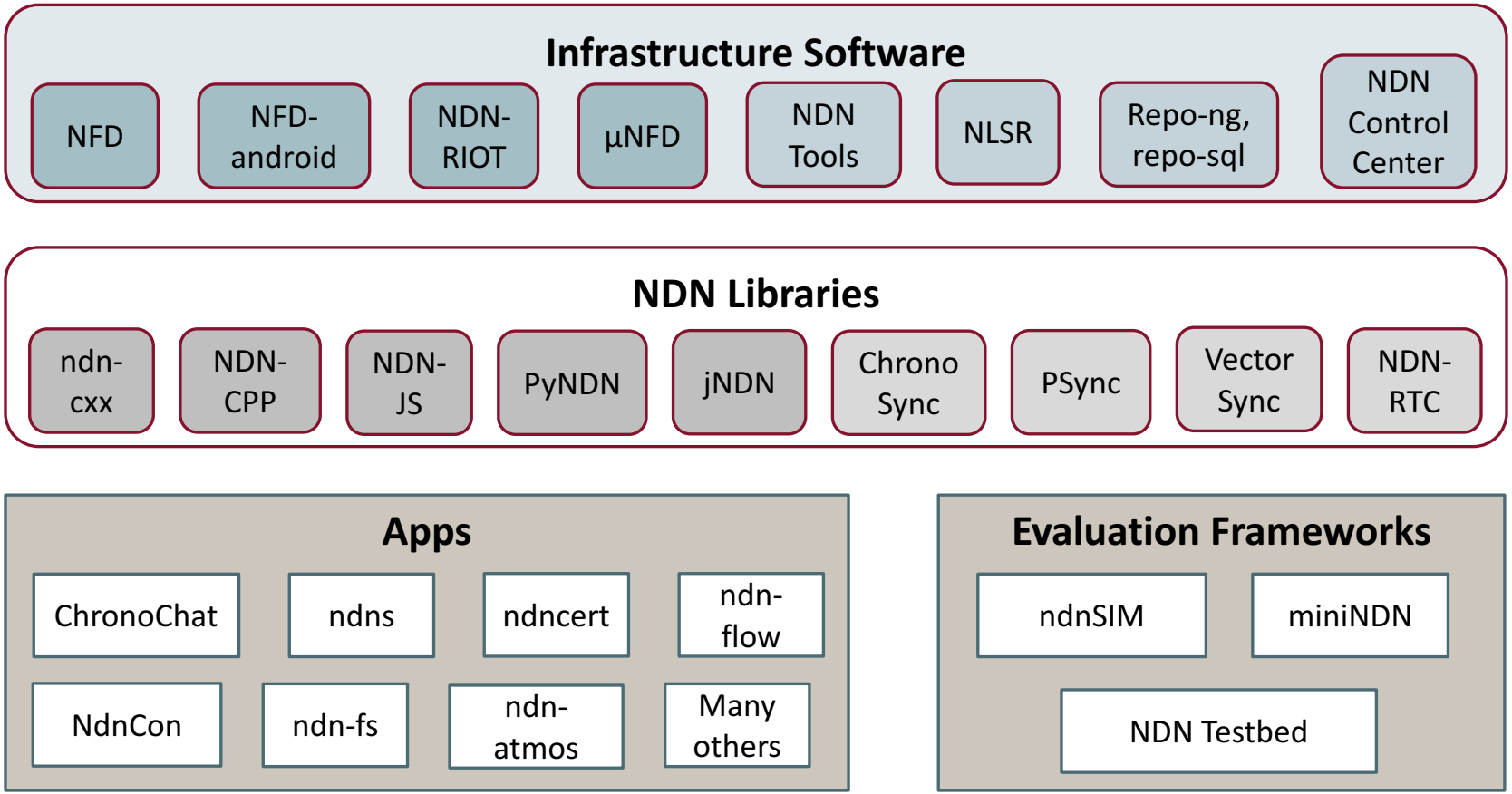
Starting Point: https://named-data.net/ ➠ Codebase



NDN Codebase Overview



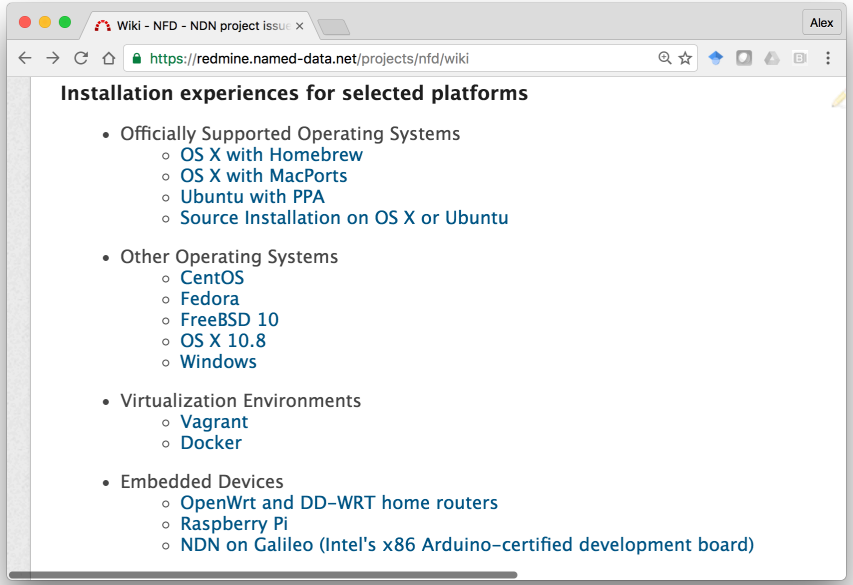
Where to Find Source Code for NDN Codebase

- Most linked from https://named-data.net ➠ Codebase
- Github organizations
  - https://github.com/named-data
    - NFD, core libraries, and other general use software
  - https://github.com/named-data-mobile
    - Android and related software
  - https://github.com/named-data-iot
    - IoT related software
  - https://github.com/named-data-ndnsim
    - ndnSIM core, example and real simulation scenarios

Supported Platforms

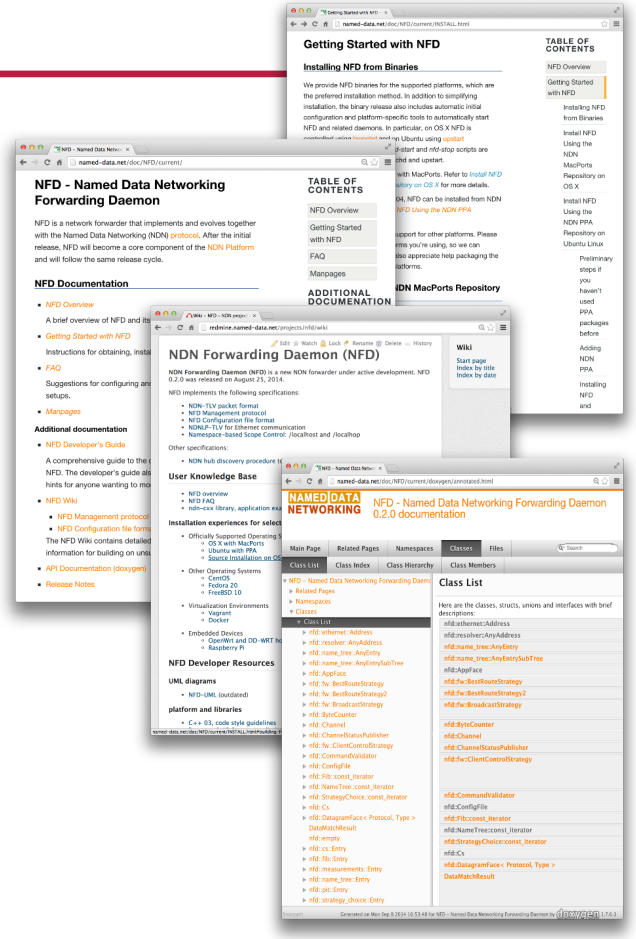
- Desktop Systems
  - Ubuntu, OSX, FreeBSD and other Linux distributions
- Home routers
  - OpenWRT, DD-WRT
- Mobile:
  - Android
  - iOS (library only)
- IoT:
  - Arduino, ESP8266
  - RIOT-OS
  - Raspberry Pi (runs NFD, available binary packages)
- Web browser
  - NDN-JS library + microforwarder
  - Firefox extension to support ndn:// URLs

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



NDN Forwarding Daemon (NFD)

- The reference implementation of NDN forwarder
- 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.**



Getting Started with NFD

- To enable NDN communication in Ubuntu Linux:
  - `sudo add-apt-repository ppa:named-data/ppa`
  - `sudo apt-get update`
  - `sudo apt-get install nfd`
- Done. Now you have enabled new generation of networking on your machine

- Next required steps
  - Managing Identities for mandatory data-centric security
    - Self-signed certificate for local trust operations (home networking)
    - Authority-based
  - https://yoursunny.com/t/2016/ndncert/

```
vps3 $ ndnsec list -c
* /ndn/edu/arizona/cs/shijunxiao
  +->* /ndn/edu/arizona/cs/shijunxiao/ksk-1457557007329
       +->* /ndn/edu/arizona/KEY/cs/shijunxiao/ksk-1457557007329/ID-CERT/%FD%00%00%01S%5D+%B3
```

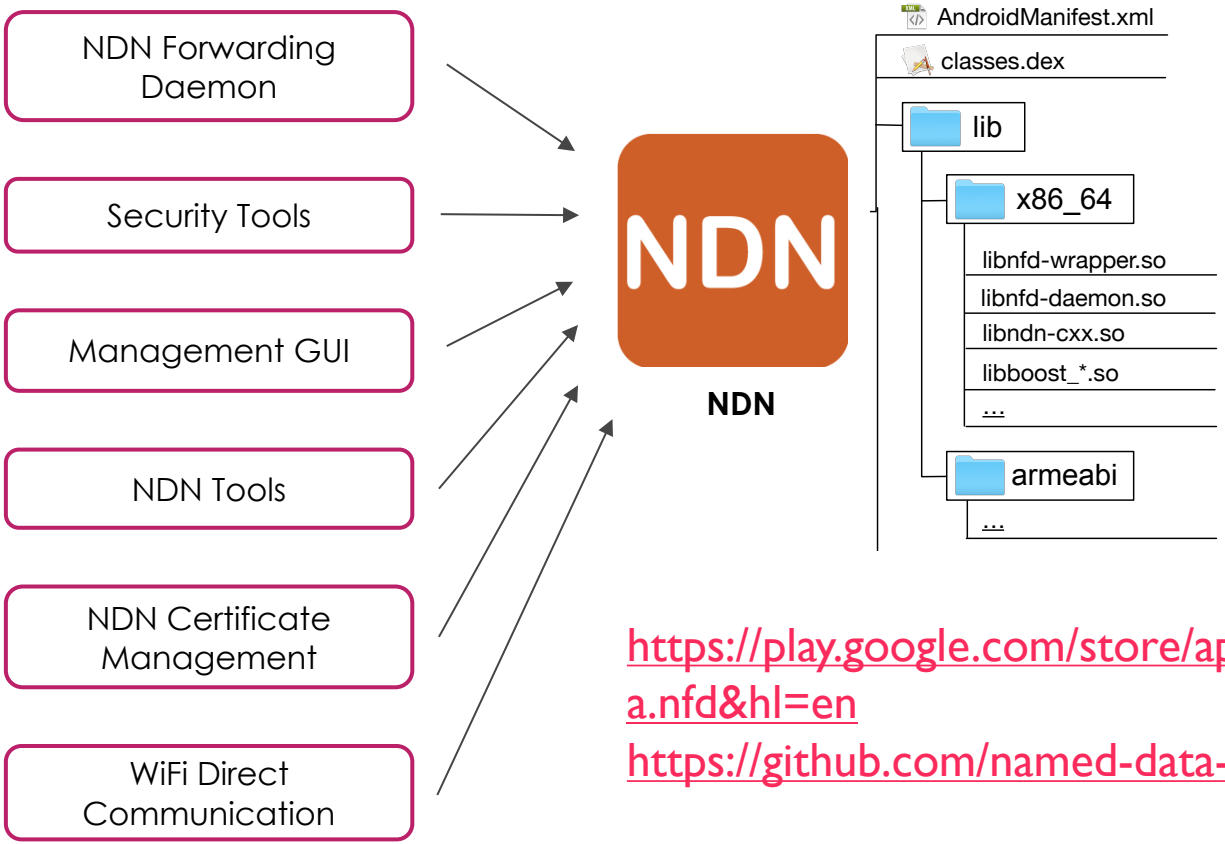
I want to issue a certificate to my other machine, `sunnyq`. To do that, I first generate a certificate request on `sunnyq`:

```
sunnyq $ ndnsec key-gen -tr /ndn/edu/arizona/cs/shijunxiao/sunnyq > sunnyq.ndncertreq
```

Then I copy the certificate request file to `vps3`, and issue the certificate by signing it with my existing trusted certificate:

```
vps3 $ ndnsec cert-gen -N '' -s /ndn/edu/arizona/cs/shijunxiao - < sunnyq.ndncertreq > sunnyq
```

NDN-Android: NDN Stack for Android



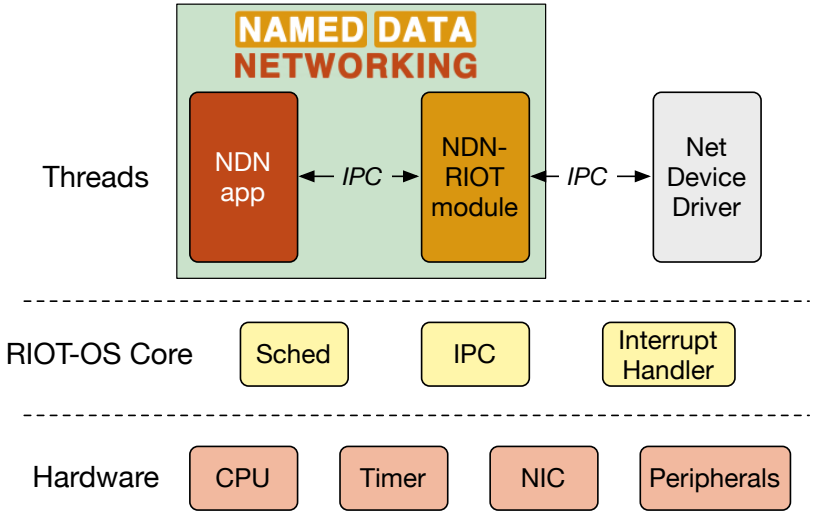
- Embeds actual NFD, compiled using NDK
- Works with all (non-rooted) Android devices

https://play.google.com/store/apps/details?id=net.named_data.nfd&hl=en

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

NDN-RIOT: NDN for RIOT-OS

- Optimized for IoT apps
- Support
  - Data-centric security
  - Stateful NDN packet forwarding
  - Replaceable forwarding strategies
  - 802.15.4 and Ethernet
- Simple application APIs
- Several simple examples to get started



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

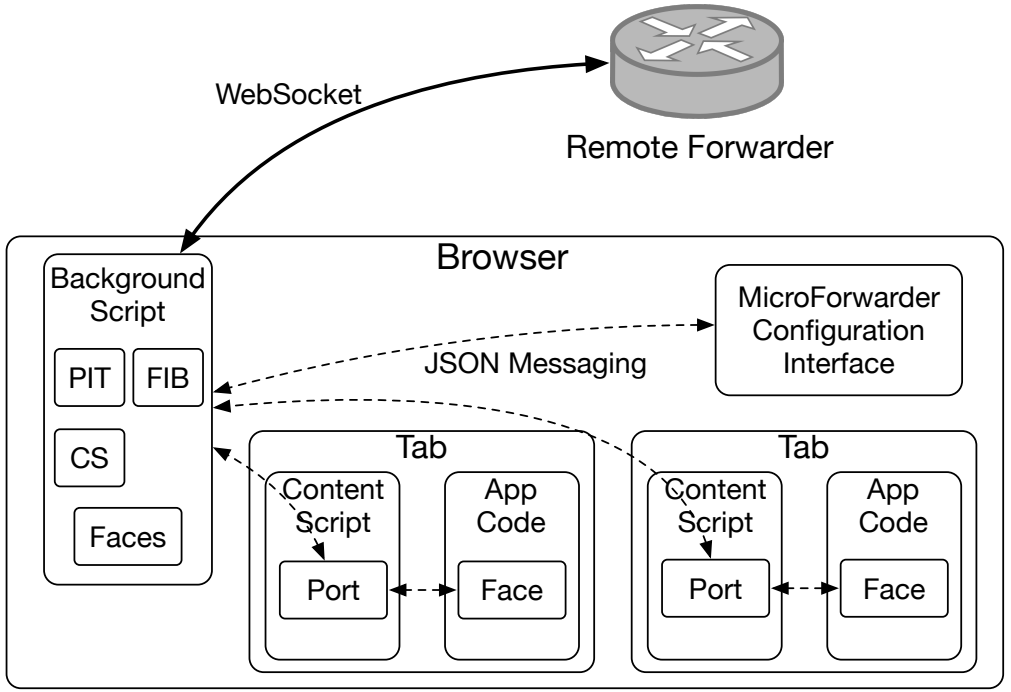
Getting Started with NDN-RIOT Examples

- Downloading
  - `mkdir riot`
  - `cd riot`
  - `git clone https://github.com/named-data-iot/RIOT`
  - `git clone https://github.com/named-data-iot/ndn-riot`
  - `git clone https://github.com/named-data-iot/ndn-riot-examples`
- Compiling an example
  - cd ndn-riot-examples/<APP>
  - For host architecture (for debugging)
    - make
  - For a specific RIOT board
    - make BOARD=samr21-xpro
    - make flash BOARD=samr21-xpro # to flash firmware
    - make term BOARD=samr21-xpro # to access board via serial interface

ndn-benchmark
ndn-consumer
ndn-ping
ndn-producer
ndn-rtt
ndn-template

NDN Micro Forwarder in browsers

- NDN forwarder as a Firefox/Chrome extension, written in JavaScript
- The cross-browser plugin (built upon NDN.JS and the WebExtensions API) provides shared connectivity to remote forwarders and enables shared data cache
- Allows browser tabs to communicate with each other through a local channel even when remote connectivity is lost



https://github.com/named-data/ndn-js/tree/master/tools/micro-forwarder

NDN Tools

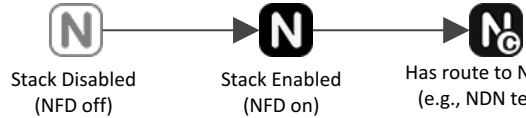
- ndnping, ndnpingserver
  - Rechability testing tools
- ndncatchunks, ndnputchunks
  - Segmented file transfer between a consumer and producer
- ndnpeek, ndnpoke
  - Transmit a single packet between a consumer and a producer
- ndndump, dissect, wireshark-dissect
  - Debug NDN packet flow

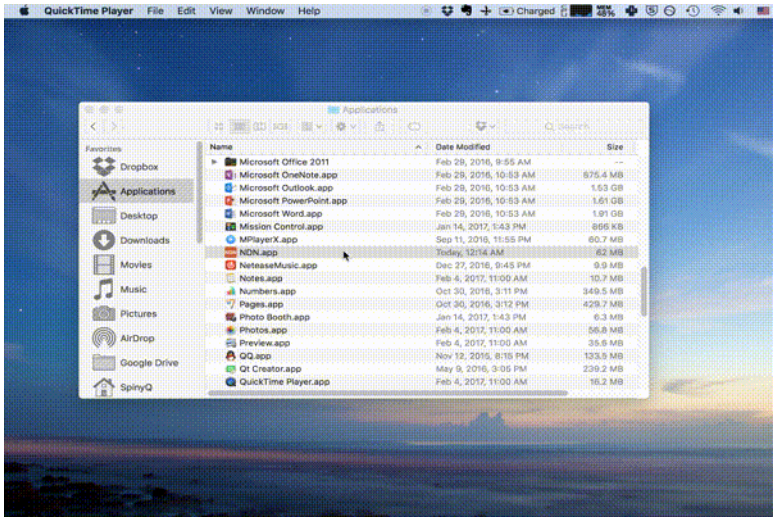
- repo-ng, repo-sql: NDN repositories providing managed persistent storage

NDN Control Center (macOS, Linux)

- NDN Forwarding Daemon
- Security Tools
- Management GUI
- NDN Tools
- NDN Certificate Management
- WiFi Ad Hoc Communication

NDN Control Center





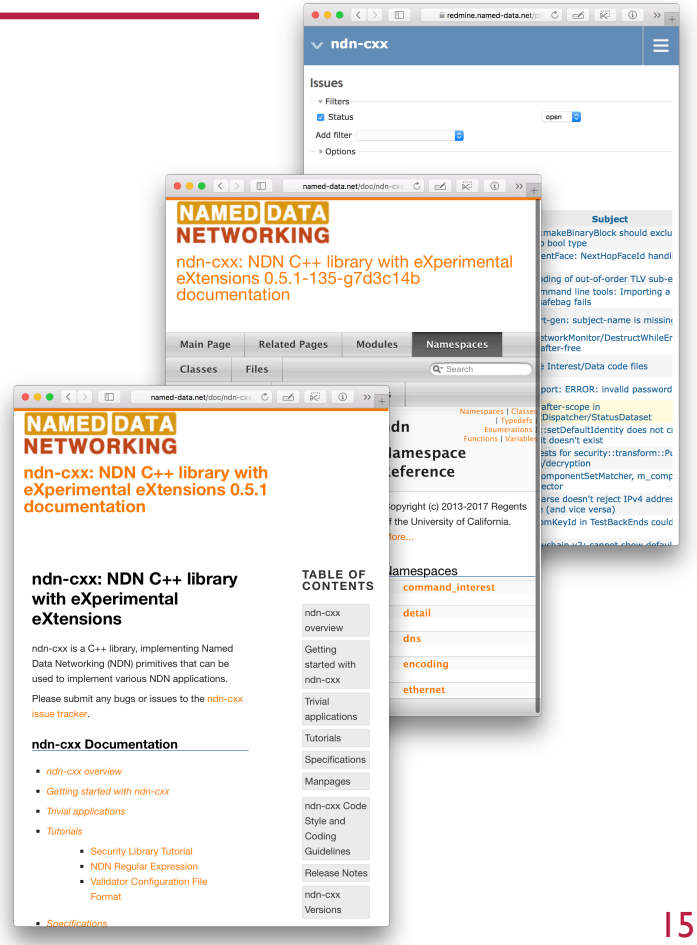
https://named-data.net/codebase/applications/ndn-control-center/

An app that provides a simple way to start playing with NDN apps

Libraries

ndn-cxx: NDN C++ library with eXperimental eXtensions

- C++11
- The reference library and security library implementation
- Used in: NFD, NLSR, ndn-tools, ChronoChat, etc.
- https://named-data.net/doc/ndn-cxx/current/
  - Overview
  - Getting started
  - Trivial applications
  - Tutorials
  - Specifications
  - Manpages
  - API documentation (doxygen)
- Feedback, suggestions, and contributions are welcome.



- NDN protocol stack
  - NFD as NDN packet mux/demuxer
  - Name prefixes / interface (routing) configuration
  - (Discovery of local hub & prefixes)
  - (Local data prefixes propagation)
- **Identity/Certificate**
  - To ensure data-centric security

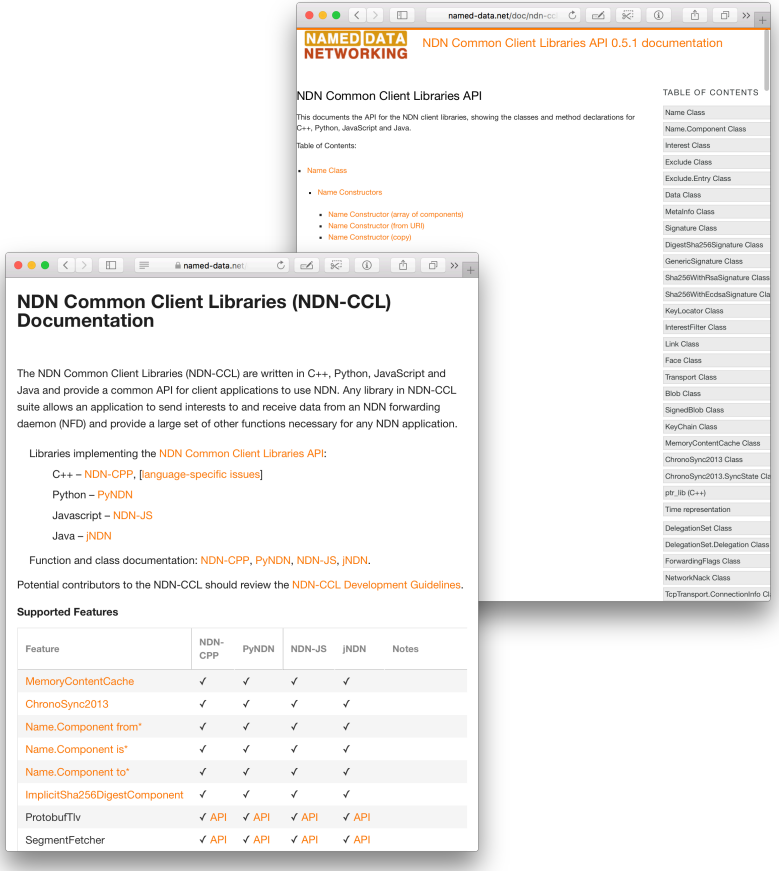
Demo

https://github.com/cawka/ndn-skeleton-apps/tree/master/ndn-cxx-makefile

- Client
  - ndn::Face face;
    - // start async
    - face.expressInterest(ndn::Interest("/some/name"). setMustBeFresh(true), onData, onNack, onTimeout);
  - face.processEvents();
  - // async onData
  - // async onNack
  - // async onTimeout
- Server
  - ndn::Face face;
    - // start async
    - face.setInterestFilter("/some/name" , onInterest,, onSuccess, onFailure);
  - face.processEvents();
  - // async onInterest
    - ndn::Data("/some/name");
    - data.setContent(…);
    - **keyChain.sign(data);**
    - face.put(data);

NDN Common Client Libraries (NDN-CPP, NDN-JS, jNDN, PyNDN)

- C++, Java, Python, JavaScript, C#, Squirrel
- Used in: NDN-RTC, NdnCon, NFD-Android, etc.
- https://named-data.net/codebase/platform/ndn-ccl/
  - NDN Common Client Libraries API
  - NDN-CPP API
  - PyNDN API
  - NDN-JS API
  - jNDN API



Demo

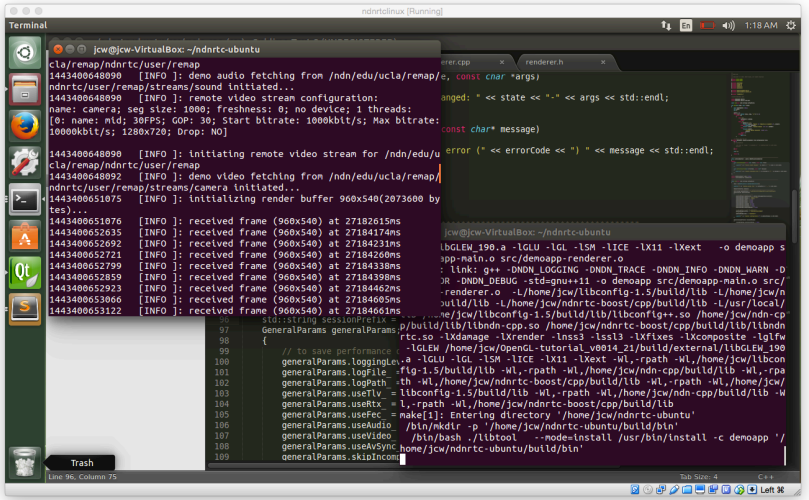
https://github.com/cawka/ndn-skeleton-apps/tree/master/PyNDN

- Client
  - loop = asyncio.get_event_loop()
  - face = ThreadsafeFace(loop, None)
    - // start async
    - face.expressInterest(ndn.Interest(ndn.Name("/some/name")), onData, onNack, onTimeout)
  - loop.run_forever()
  - face.shutdown()
  - // async onData
  - // async onNack
  - // async onTimeout

- Server
  - loop = asyncio.get_event_loop()
  - face = ThreadsafeFace(loop, None)
  - // start async
    - face.registerPrefix(ndn.Name("/some/name"), onInterest, onFailure)
  - loop.run_forever()
  - face.shutdown()
  - // async onInterest
    - data = ndn.Data("/some/name");
    - data.setContent(…);
    - **keyChain.sign(data, …);**
    - face.putData(data);

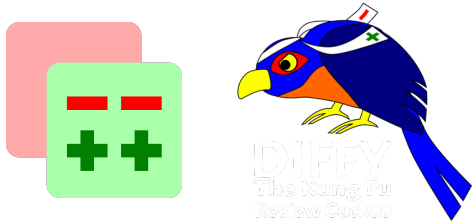
NDN-RTC

- C++ library for low-latency audio/video streaming over NDN
- VP8/9 encoder
- WebRTC audio processing pipelines
- Forward error correction (OpenFEC)
- Pull-based streaming control by consumers



Main collaboration tools

- **Redmine** – issue tracking, wiki
  - Coordination of NDN code development across the world
  - > 3100 issues (>2400 closed)
- **Gerrit** – code review
  - Ensuring code quality and high-quality coding training
  - > 4100 changes



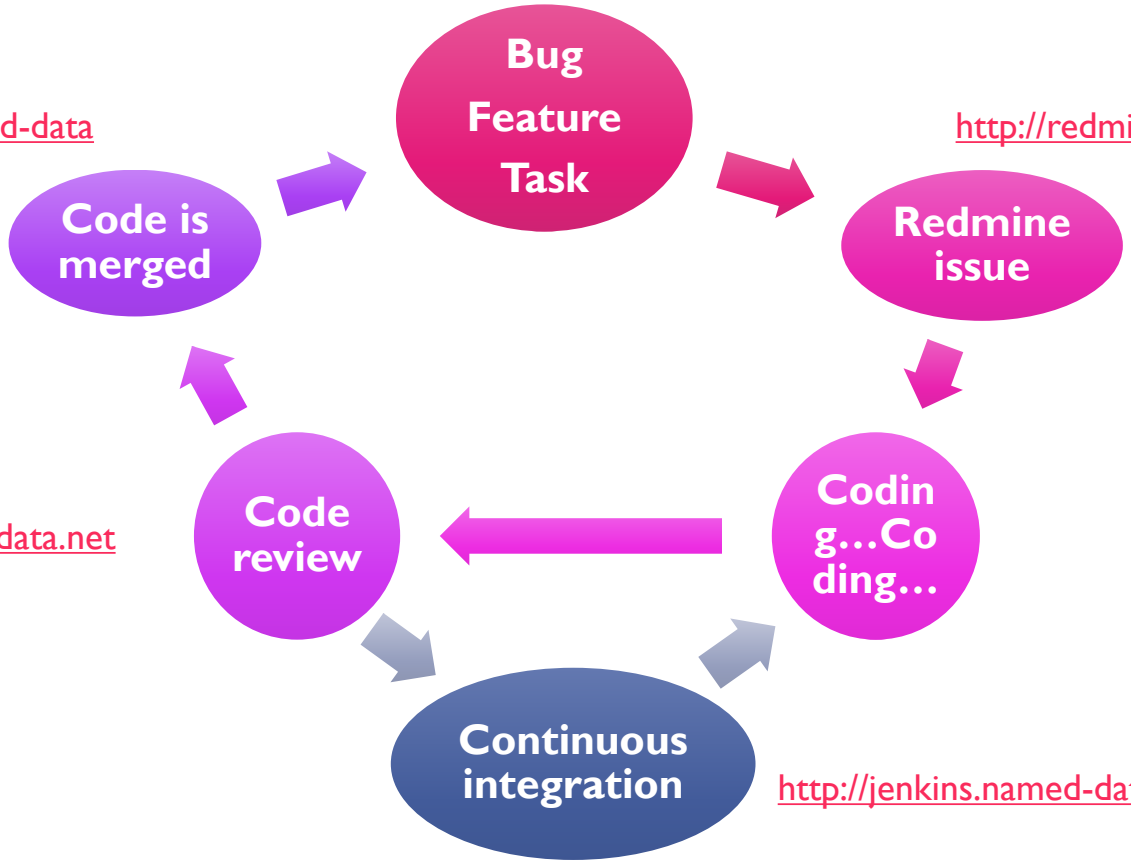
- **Mailing lists** – wider discussions, announcements

https://named-data.net/codebase/platform/support/mailing-lists/

Development Model

https://github.com/named-data

http://redmine.named-data.net



http://gerrit.named-data.net

http://jenkins.named-data.net

Evaluation at Different Scales

NDN Testbed

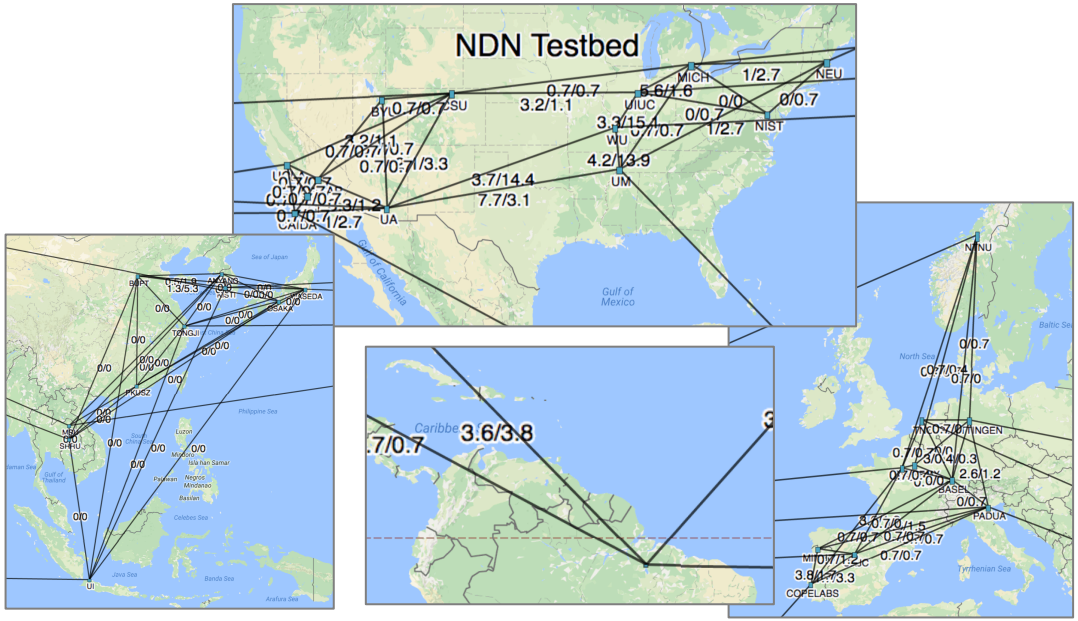
- Network of 37 sites across 4 continents, 14 countries

Open to join and use

https://named-data.net/ndn-testbed/policies-connecting-nodes-ndn-testbed/

- Examples applications and experiments: videoconferencing, network management, virtual machine migration, strategies, nTorrent, etc.

- Small scale evaluations



Open Network Lab (ONL)

- Remotely accessible network testbed
  - Operated and maintained by Applied Research Lab in Department of Computer Science and Engineering at Washington University in St. Louis
  - Real Hardware for running repeatable network experiments with trusted results. (NOT simulations)
- Use for NDN
  - NDN installed on each host/VM
  - NFD performance study
  - NDN Testbed Emulation to test new releases
- How to join?
  - https://onl.wustl.edu/
    - And "Get an account"

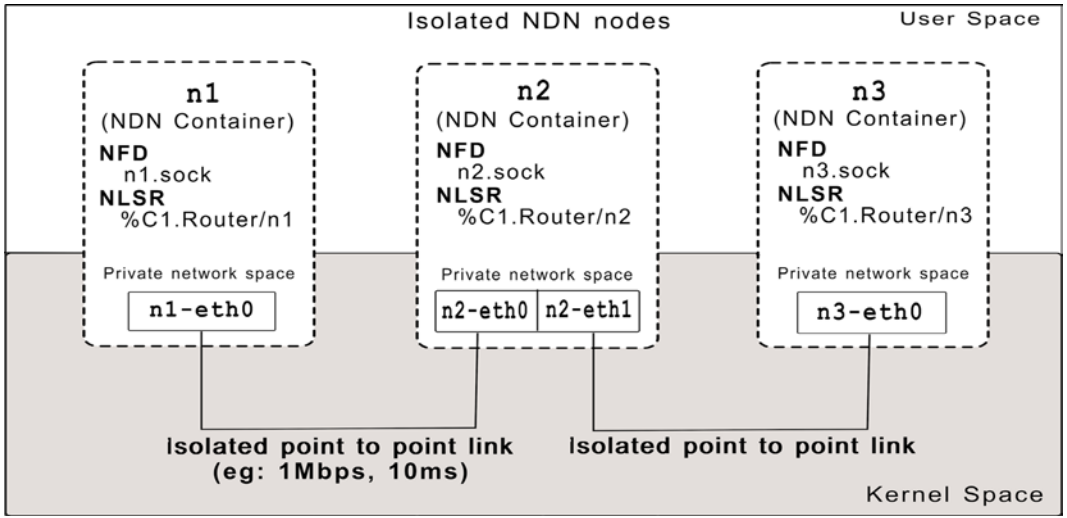
MiniNDN: NDN Emulation Framework (Based on MiniNet)

https://github.com/named-data/mini-ndn

Runs actual instances of NFD, NLSR

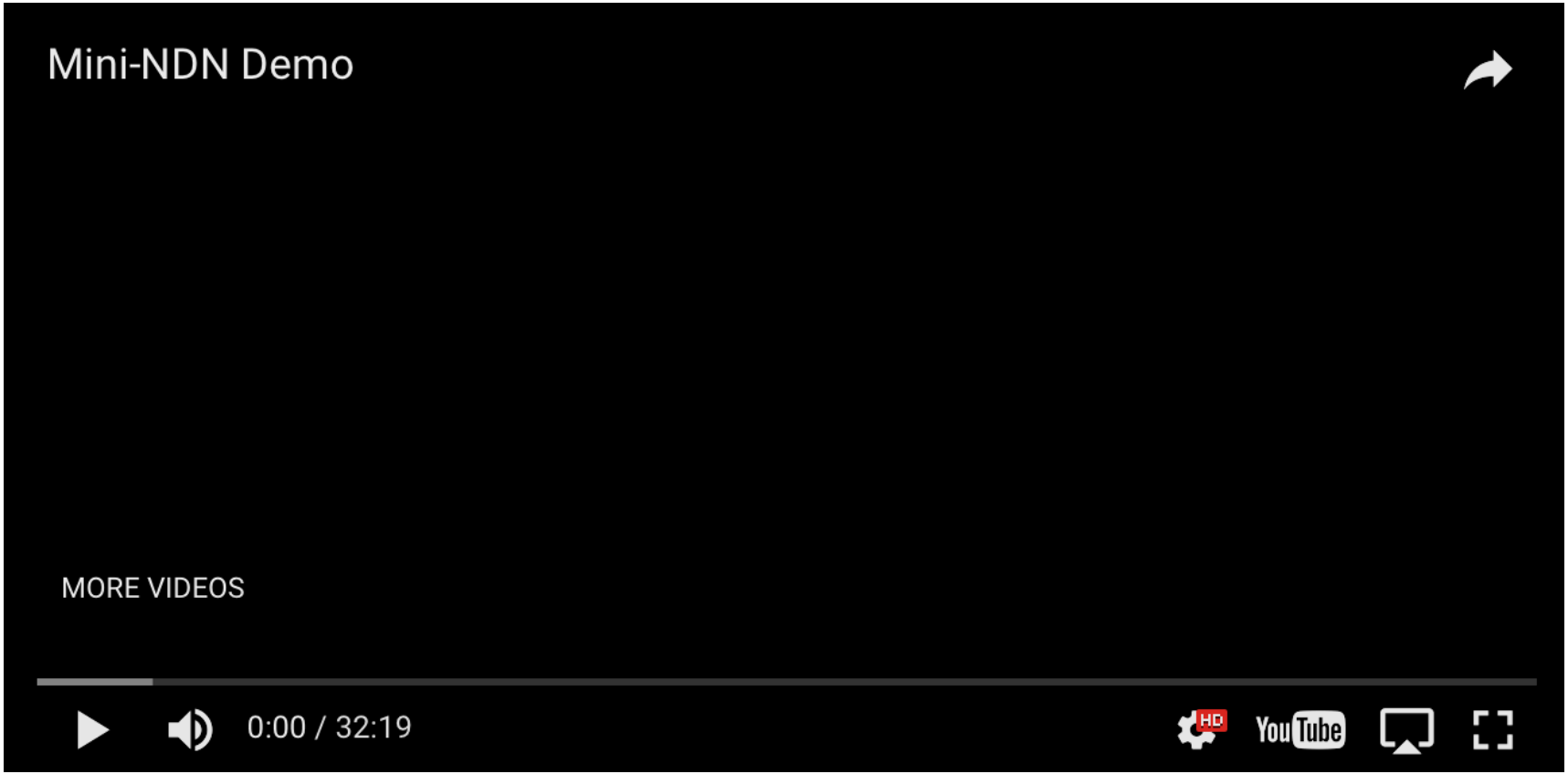
Medium-scale evaluations

- Easy to configure network emulation
- Runs any real application
- Number of emulated nodes ∝ CPU power
- Cluster edition can be used to scale emulations



Demo

https://www.youtube.com/watch?v=Da7t8yBWzv0



ndnSIM: NDN Simulation Framework (Based on NS-3)

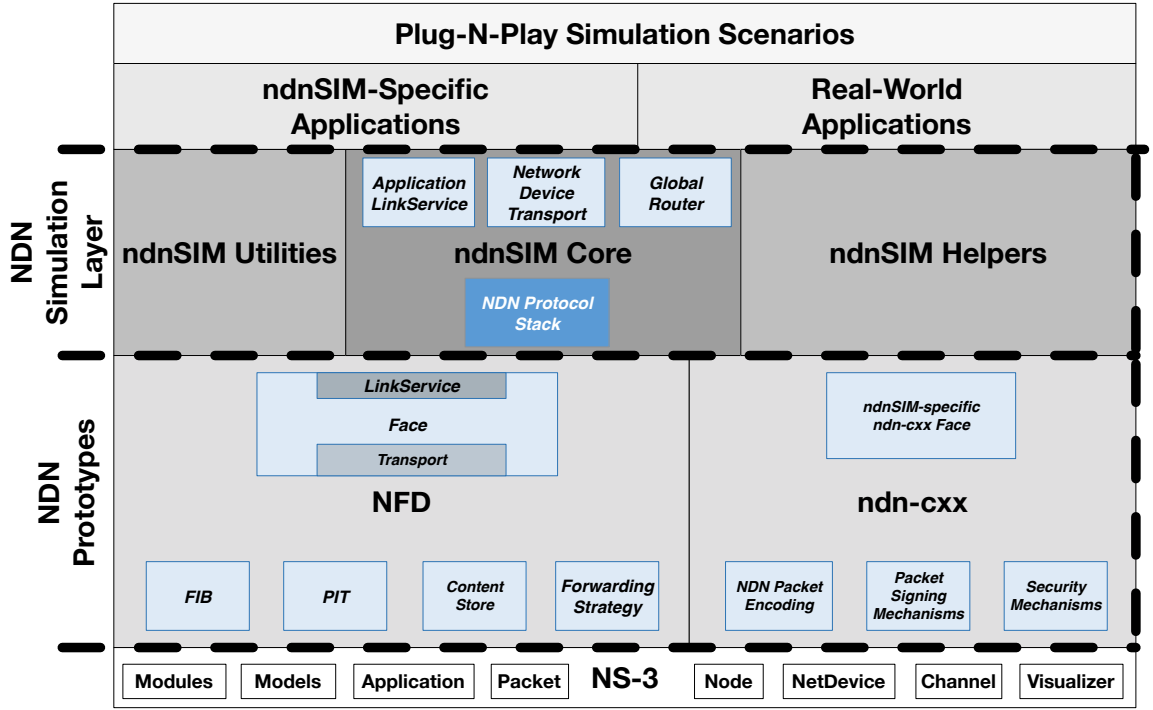
https://ndnsim.net/

Fully integrated with NDN prototype implementations: NFD & ndn-cxx

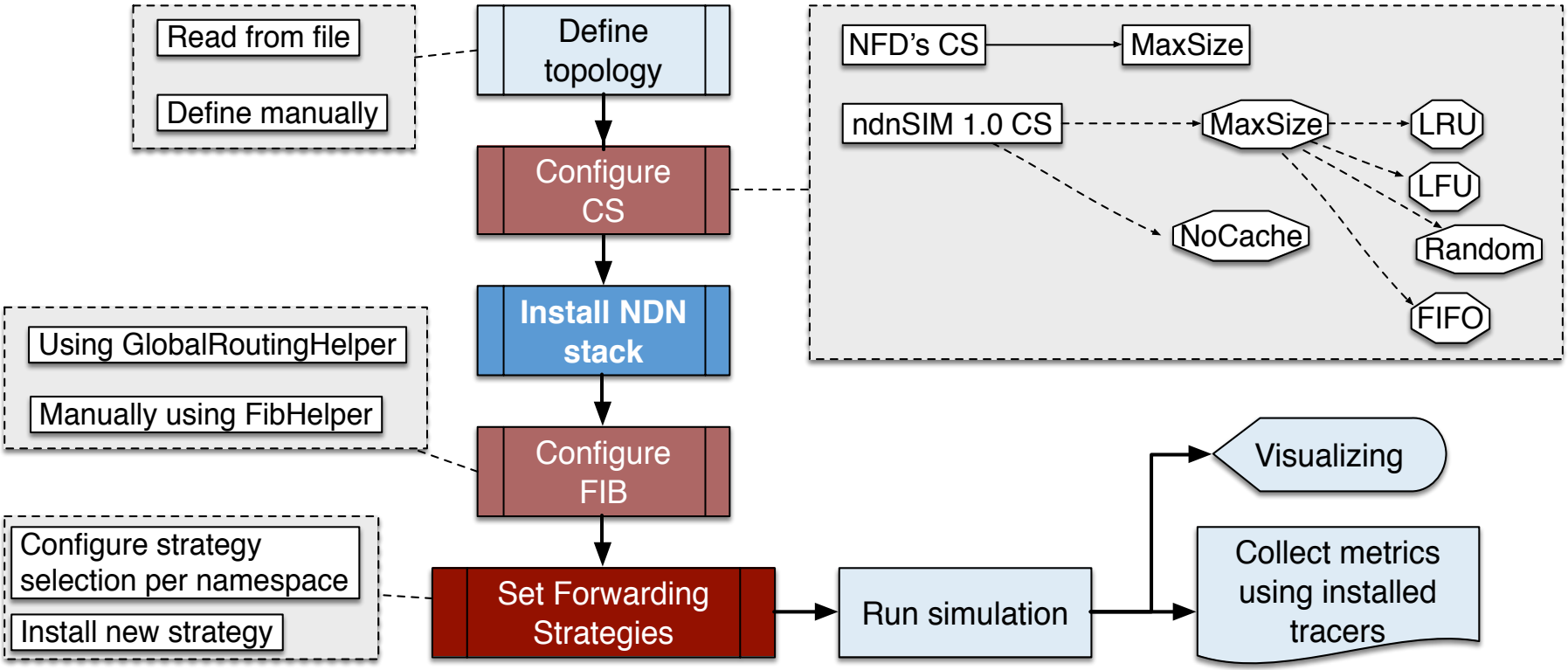
Large scale evaluations

- Provide interoperability between simulation and prototyping
- Enable a two-way of experimentation and evaluation
- Enable high-fidelity NDN simulations

- 1500+ nodes with WiFi channels in the evaluation of NDN for vehicular networking



Typical Workflow with ndnSIM



ndnSIM 101

https://github.com/named-data-ndnSIM/scenario-template

Install NDN stack

```
ndn::StackHelper ndnHelper;
ndnHelper.InstallAll();
```

Install consumer app(s)

```
NodeContainer consumerNodes;
consumerNodes.Add(grid.GetNode (0,0));
ndn::AppHelper cHelper("ns3::ndn::ConsumerCbr");
cHelper.SetPrefix("/prefix");
cHelper.SetAttribute("Frequency",
                     StringValue("10"));
cHelper.Install(consumerNodes);
```

Install producer app(s)

```
Ptr<Node> producer = grid.GetNode(2, 2);
ndn::AppHelper pHelper("ns3::ndn::Producer");
pHelper.SetPrefix("/prefix");
pHelper.SetAttribute("PayloadSize",
                     StringValue("1024"));
pHelper.Install(producer);
```

Configure FIB (manually or like here using the helper)

```
ndn::GlobalRoutingHelper ndnGlobalRoutingHelper;
ndnGlobalRoutingHelper.InstallAll();
ndnGlobalRoutingHelper.AddOrigins("/prefix", producer);
ndnGlobalRoutingHelper.CalculateRoutes();
```