NDN Design and development: an interim report

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First-Principle Driven NDN Efforts

♢ Are we heading toward the right direction?

♢ Are we solving the most urgent problems?

♢ Are the solutions we are developing adhering to the NDN architecture goals?
  ○ What are/should be the relations between the architecture and the specific solution approaches?
The Feynman Lectures on Physics
The principle of science, the definition, almost, is the following: the test of all knowledge is experiment. Experiment is the sole judge of scientific "truth".

But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints.
Translating to NDN team actions

♢ Application-driven architecture design and development

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♢ Supporting the community at large in ICN design and development

10/29/15
Progress in the past year

◊ Expand and improve supporting libraries

◊ One major release and five minor releases
  o next full major release this month

◊ Expanded list of supported platforms, new features and bug fixes
Reference Implementation Status

♢ Free software open source community efforts

♢ NFD: NDN Forwarding Daemon
  o New flexible packet format based on TLV
  o Modular and extensible design
  o Support for multiple forwarding strategies

♢ Libraries: full featured implementations in a variety of languages
  o C++ (full + lightweight), Java (se+android), JS (in-browser+nodejs), Python

♢ Apps: https://github.com/named-data
Community Involvement

♢ Mailing lists
  o nfd-dev: 100+ (http://www.lists.cs.ucla.edu/mailman/listinfo/nfd-dev)
  o ndn-interest: 340+ (http://www.lists.cs.ucla.edu/mailman/listinfo/ndn-interest)
  o ndnSIM: 300+ (http://www.lists.cs.ucla.edu/mailman/listinfo/ndnsim)

♢ Code contributors across NDN projects
  o 70+ (many outside of NDN team)
    • NDN on Github
      o https://github.com/named-data
      o 20+ forks of NFD, ndn-cxx
      o 48+ forks of ndnSIM

♢ 1st NDN Hackathon: http://ndncomm.github.io/

♢ Annual DN Communy Meetings
NDN Consortium

Founding Universities (8)
- Colorado State University
- University of Arizona
- University of California, Los Angeles (UCLA)
- University of California, San Diego
- University of Illinois, Urbana-Champaign
- University of Memphis
- University of Michigan
- Washington University in St. Louis

Academic / Non-profit (9)
- Anyang University, Korea
- Northeastern University
- The MITRE Corporation
- Tongji University, China
- Tsinghua University, China
- University of Basel, Switzerland
- University of Maryland, College Park
- Université Pierre et Marie Curie Sorbonne Universités, France
- Waseda University, Japan

Industry (10)
- Alcatel-Lucent
- Brocade
- Cisco Systems
- Fujitsu Laboratories of America
- Huawei Technologies
- Intel Corporation
- Juniper Networks
- Panasonic Corporation
- Verisign, Inc.
- ViaSat

http://named-data.net/consortium-members/
Multi-Platform Support

◊ NFD now runs on Android
  o  https://github.com/named-data-mobile/NFD-android
  o  A few pilot applications
     ▶  Simple game https://github.com/dchimeraan/ndn-hangman
     ▶  NDN Whiteboard https://github.com/sumitgouthaman/NDNWhiteboard
     ▶  Photo sharing app https://github.com/ohnonoho/photoSharing

◊ Raspberry Pi, Arduino, Odroid
  o  Used to prototype smart home devices, IoT

◊ DD-WRT and OpenWrt
  o  Home routers

◊ Other embedded systems
  o  http://redmine.named-data.net/projects/ndn-embedded/wiki
Evaluation Platforms

◇ Every release of NFD is tested and deployed on the global NDN testbed.

◇ For evaluation, users now have a set of choices with different tradeoffs between scale and fidelity
  - **NDN Testbed**
    ▶ 26 sites in US, China, France, Switzerland, Spain, Norway, Italy, Korea, Japan
    ▶ [http://named-data.net/ndn-testbed/](http://named-data.net/ndn-testbed/)
  - **Open Network Lab, Emulab, …**
    ▶ [https://onl.wustl.edu/](https://onl.wustl.edu/)
  - **Mini-NDN**
    ▶ [https://github.com/named-data/mini-ndn](https://github.com/named-data/mini-ndn)
  - **ndnSIM 2.1**
    ▶ [http://ndnsim.net/2.1/](http://ndnsim.net/2.1/)
Architectural functions/features for experimentation

- **Edge support**
  - minimize manual configurations

- **NDNLPv2**
  - hop-by-hop packet delivery assistance

- **Network NACK**
  - router-level “no”

- **LINK object**
  - name referrals (“delegations”)

- **Forwarding strategies**

- **Security support libraries**
Edge Support

◊ Autoconfig and local hub discovery
  - Combination of various techniques to automatically discover and connect hosts to NDN testbed.

◊ Automatic Prefix Propagation
  - Producer connects to gateway and securely register its content prefixes with the gateway.
  - Needed for the last hop delivery of interests to the producer
NDNLpv2: Link Protocol for NDN

◊ Within one hop, under the NDN Interest/Data layer.

◊ A set of link services over underlying transport
  o Fragmentation/reassembly
  o Loss detection/recovery
    ▷ done extensive simulations already
  o Link failure detection
  o Network NACK

◊ Services are optional depending on the type of transport
  o E.g., TCP, UDP, Ethernet

```
LpPacket
  LpHeaderField
  ...
  LpHeaderField
  Fragment

Sequence
FragIndex
FragCount
Nack
  NackReason
```

```
Fragment
  Data/Interest
```

10/29/15
Network NACK

◊ When a node cannot fetch the data, generate a NACK to signal the downstream to explore other options.
  o Loop, link failure, no route, congestion, ...

◊ Return the unsatisfied Interest together with an error code as the NACK

◊ Downstream node explores other forwarding options.

◊ http://redmine.named-data.net/projects/nfd/wiki/NDNLPv2

◊ http://redmine.named-data.net/issues/2520
LINK Object

◊ LINK is a new type of content object, which links one name to another.

◊ Used to support mobility, and routing scalability.

◊ Available in NFD/libraries
  ○ http://redmine.named-data.net/issues/2587

Strategy

◊ Version 4 of the Best Route Strategy
  o Support Interest retransmission with exponential back-off of the suppression interval
  o [http://redmine.named-data.net/issues/3156](http://redmine.named-data.net/issues/3156) v4
  o [http://redmine.named-data.net/issues/1913](http://redmine.named-data.net/issues/1913) v3
  o [http://redmine.named-data.net/issues/1871](http://redmine.named-data.net/issues/1871) v2

◊ The Access Strategy for end hosts
  o Multicast to learn which host provides the content and remember what has been learned
  o [http://redmine.named-data.net/attachments/download/201/access-router-strategy_20141220.pptx](http://redmine.named-data.net/attachments/download/201/access-router-strategy_20141220.pptx)

◊ The Adaptive SRTT-based Forwarding strategy for hyperbolic routing

◊ Support LINK object for mobility and routing scalability
Security

◊ Tutorial
  o http://named-data.net/doc/ndn-cxx/current/tutorials/security-library.html

◊ Schematized trust (see ICN’15 paper)
  o application to NFD, NLSR, and other apps

◊ PIB service to manage public keys and publish certs
  o http://redmine.named-data.net/projects/ndn-cxx/wiki/PublicKey_Info_Base

◊ Improved signing APIs for better usability

◊ Signed Interest
  o http://named-data.net/doc/ndn-cxx/current/tutorials/signed-interest.html

◊ New NDN certificate format
  o http://named-data.net/doc/ndn-cxx/current/tutorials/certificate-format.html

◊ Automated testbed certificate issuance
Work for next step: a lot

- **Forwarding Strategy**
  - new strategies to support IoT, sensors, mobile and DTN environments
  - composable strategy towards the vision of a limited VM

- **NDN over constrained communication channels**

- **Secure autoconfiguration**

- **Scoped communication**
  - within enterprise, homes, etc.

- **Hop-by-hop interest limit mechanism for congestion control**

- **Moving towards the plug-in-play model**
  - auto-configuration, self-discovery, self-configuration

- **Optimizations and refinements**
  - Packet format, packet processing, data structures and algorithms, crypto

- **Facilitate usable content-based security**
  - authenticity, confidentiality, privacy
“The principle of science, the definition, almost, is the following: the test of all knowledge is experiment. Experiment is the sole judge of scientific "truth".

But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints.

But also needed is imagination to create from these hints the great generalizations—to guess at the wonderful, simple, but very strange patterns beneath them all, and then to experiment to check again whether we have made the right guess.”
Join the efforts!

♢ Mailing lists
  ○ nfd-dev: http://www.lists.cs.ucla.edu/mailman/listinfo/nfd-dev
  ○ ndn-interest: http://www.lists.cs.ucla.edu/mailman/listinfo/ndn-interest
  ○ ndnSIM: http://www.lists.cs.ucla.edu/mailman/listinfo/ndnsim

♢ Open source development: NDN on Github: https://github.com/named-data

♢ NDN testbed: open to all interested parties
Future of networking lies in recognizing the right communication abstraction:

**named data**