**FIA: Collaborative Research: Named Data Networking (NDN) 2012 Annual Report**

# Executive Summary

This annual report of the Named Data Networking (NDN) project summarizes our second year research achievements and future plans. Chapter 1 briefly reviews the NDN architectural model. Chapter 2 gives an overview of our research plan, describes the milestones reached through our second year's effort, and the milestones we have set for the third year. Chapter 3 gives a detailed description of the activities and findings in each of the project's research areas.

The heart of the Internet architecture is a simple, universal network layer (IP) which implements all the functionality necessary for global interconnectivity. This "thin waist" was the key enabler of the Internet's explosive growth but one of its design choices is the root cause of today's Internet problems. The Internet was designed as a *communication network* so the only entities that could be named in its packets were communication endpoints. Recent growth in e-commerce, digital media, social networking, and smartphone applications has resulted in the Internet primarily being used as a *distribution network*. Distribution networks are fundamentally more general than communication networks and solving distribution problems with a communications network is complex and error prone.

NDN retains the Internet's hourglass architecture but evolves the thin waist to allow the creation of completely general distribution networks. The core element of this evolution is removing the restriction that packets can only name communication endpoints. As far as the network is concerned, the name in an NDN packet can be anything — an endpoint, a chunk of movie or book, a command to turn on some lights, *etc.* This simple change allows NDN networks to use almost all of the Internet's well tested engineering properties to solve not only communication problems but also digital distribution and control problems.

PARC's CCN project demonstrated this architectural evolution was feasible. Using CCN as a starting point, the NDN project's research challenge is to evolve it into architectural framework capable of solving real problems, particularly in application areas poorly served by today's Internet. Solving real problems forces architectural details to be filled in and, most importantly, verifies and shapes the architectural direction. We believe that an architectural research effort should be fundamentally experimental in nature. Design specifics cannot be derived from an intellectual exercise nor can validation be done through greenhouse testbed demonstrations. The Internet design was matured via actual usage through early deployment and our research plan follows the Internet's successful footsteps.

We successfully achieved all our major milestones for the second year of the project. Highlights include: (1) developing a name-based dynamic routing protocol, OSPFN, and fully deploying it on the NDN testbed connecting all the participating institutions; (2) completing and publicly releasing an open source NDN simulator, ndnSIM; (3) developing an architecture to secure instrumented environments such as industrial lighting and control; (4) completing an analysis of both the potential DDoS attacks against NDN networks and the design space for countermeasures; (5) continued exploration of new application patterns enabled by NDN, including field testing of a scalable, multi-camera, multi-consumer, video streaming solution that doesn't require session semantics, and a Sync-based, *serverless*, multiuser chat application (MUC); and (6) using the NDN testbed, augmented with hundreds of Amazon EC2 hosts, to present a live, large-scale demonstration of NDN's unique capabilities at the GENI engineering conference.

One of the more exciting results of the past year was the discovery of a fundamentally new building block for distributed systems that we are calling *Sync*. Built on top of NDN's basic Interest-Data communication model, Sync enables simple, fully distributed, scalable, efficient and robust sharing of collections of data among multiple parties. The MUC application mentioned above is one of our first experiments in using Sync as a communication primitive. Preliminary experimentation has demonstrated its superior performance and robustness compared to centralized server designs. Over the next year, we expect that Sync's role in the NDN architecture will evolve to one similar to TCP's in the IP architecture.

The first two years of the NDN project have produced a wide range of new applications, a rich set of libraries, a functioning testbed, a much deeper understanding of the NDN architecture, and most importantly, a well trained team that has mastered the skills of architecture research and accumulated a rich set of design principles and experience. These successes make us confident that the project's third year will lead us to a new level of understanding in naming design, distributed data synchronization, trust management, routing and forwarding—core issues in the named-data networking design. We set forth specific milestones for the third year in Section 2.2.2.