A Network Measurement Framework for Named Data Networks

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ABSTRACT

In this poster, we propose a network measurement framework for NDN. We define the goals of network measurement and discuss how these goals can be achieved by identifying the necessary measurement operations that must be built on top of NDN's primitives. Our main design goal is to empower NDN with a built-in measurement framework that can support multiple use cases and can be used by different applications that need to produce and/or consume network measurements. The framework uses NDN's native Interest/Data exchange to request and collect both active and passive measurements. Being a work-in-progress, we also discuss open issues and future work.

CCS CONCEPTS

• **Networks → Network measurement**; *Network monitoring*;

KEYWORDS

Network measurement, Named data networking, Information centric networking, NDN, ICN

1 INTRODUCTION

Our goal is to take the first step toward developing a general-purpose NDN measurement framework that supports a variety of use cases with maximum flexibility and extensibility. Such a framework would allow for built-in measurement and diagnostic capabilities so that as new applications are developed, they can be instrumented with measurement probes and make use of the framework to meet their measurement needs. We also want to leverage existing NDN mechanisms and features such as stateful forwarding, signed Interests, NFD management tools, etc. Our approach includes defining the requirements that a measurement framework needs to satisfy to support a diverse set of use cases such as real-time measurements for diagnosing and troubleshooting network anomalies, historical measurements for network planning and resource optimization, as well as analysis of applications and associated protocols/algorithms instrumented with appropriate probes.

Interest in network measurement has existed since the early days of the Internet [5]. However, today's IP network has very limited measurement capabilities used for diagnostic services (namely the ICMP-based traceroute). Consequently, complex and ad-hoc procedures are frequently combined to assess network behavior, often using techniques that rely on inference rather than direct measurement. In an attempt to remedy this situation, Allman et al. [1] argue for measurement as a first-class component of the network architecture, rather than conducting measurements through inference from convoluted techniques. They propose measurability as a goal of protocol design and argue that measurements should be available to all network protocols through the IP stack. They also introduce IPIM (In-Protocol Internet Measurement) as a proposal for explicit measurability in protocol design. In [3], a related project (mPlane) is documented, focusing on building an IP measurement plane by designing a common infrastructure to allow for the collection, storage, and processing of measurement data from a set of probes spread across the Internet.

For NDN, a path tracing utility is discussed in Khoussi et al. [2] as a diagnostic tool similar to traceroute in IP. Here, we discuss a comprehensive measurement framework for NDN, with the detailed protocol specification being a work-in-progress.

2 FRAMEWORK DESIGN

While our framework is still at an early stage of development, some aspects have already been designed, including: the types of entities composing the measurement framework, the naming convention used in Interests requesting measurements, and the interactions between the aforementioned entities.

2.1 Entities

The NDN Measurement Framework (NMF) uses an architecture built around three main types of entities:

- **Probes**: Expose measurement capabilities, process measurement requests, perform measurement operations, and produce measurement results when directed by an Agent.
- **Clients**: Issue measurement requests and receive results.
- **Agents**: Receive measurement requests from Clients, dispatch requests to the corresponding Probes, and reply to Clients with measurement Data packets.

Figure 1 depicts a measurement agent (MA) within a node and the different probes it interacts with.

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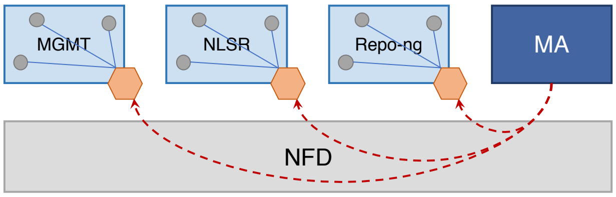

Figure 1: Measurement Agent and Probes

2.2 Naming

Figure 2 includes an example of a naming scheme with name components containing: the target Agent, the verb (e.g., `measure` for requesting measurements), the metric to be measured (e.g., latency or bandwidth), the measurement parameters `MParams`, and cryptographic material for authenticating the Interest (as described in the NDN `CommandInterest` specification [4]).

2.3 Interactions

The basic interaction in NMF occurs when a Client requests a measurement from the network. Measurement requests are expressed in Interest packets, using a measurement naming scheme to route the Interest to the appropriate Agent. The Agent evaluates the request and dispatches it to the appropriate Probe(s). The Probe(s) perform the requested measurement(s) and produce results, which are returned to the Agent. Then, the Agent incorporates the results in a Data packet that satisfies the Client's Interest.

Figure 2 is a sequence diagram representing the Interest/Data exchange during this basic interaction. The diagram shows two alternatives: instant measurements, where results can be produced immediately, and long-term measurements, where results are deferred until they are available. During the former, the Client sends a measurement Interest for the target Agent. Upon receiving this Interest, the Agent triggers the Probe(s) responsible for the measurement, which will then perform the measurement, producing results (e.g., a face counter for incoming Interests, which requires a simple read from a counter). The Agent will put these results in a Data packet, which satisfies the Client's Interest. In the latter case (long-term measurements), the Client will start by sending the measurement Interest. Knowing that the results will take some time to be produced, the Agent will return a Data packet containing a token identifying the measurement, along with a manifest describing it (e.g., when to retrieve the results). Once the measurement is completed, an Interest containing this token will be used by the Client to retrieve the results.

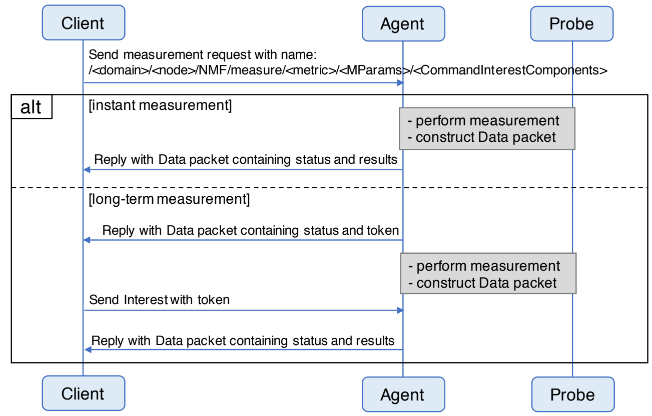

Figure 2: Measurement Interest/Data Exchange

3 DISCUSSION

3.1 Open issues

In a comprehensive measurement framework, Clients should be able to utilize new Probes not described in the framework specification. Therefore, the framework must be designed to allow Clients to discover new types of Probes. There are a number of possible solutions to this issue, including to: (1) assign Probes well-known names and have Clients send requests for them; (2) create a device- or network-level registry of available Probes, having Probes "check-in" to indicate their availability via an Agent; or (3) use ChronoSync [6] or a similar protocol to synchronize the list of Probes available on an Agent with Clients on the network.

The framework must allow measured data to remain confidential. An organization may not wish to expose the internals of their network to competitors or the general public. This requirement must be balanced with the need to keep the protocol design and trust hierarchy as simple as possible. In addition, there should be a method to control who can request measurements from an Agent (authorization).

3.2 Future Work

In the future, we plan to: (1) develop a complete framework specification to allow a wide variety of device- and network-level measurements to be conducted in a flexible and standardized manner; (2) implement a prototype to demonstrate the correctness and functionality of the framework; and (3) conduct performance evaluations to determine the impact of measurement traffic on a network and improve the framework design.

DISCLAIMER

Any mention of commercial products or reference to commercial organizations is for information only; it does not imply recommendation or endorsement by NIST, nor does it imply that the products mentioned are necessarily the best available for the purpose.

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