Extending Named Data Networking with support for Names with Range Indications

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ABSTRACT

Within Information-Centric Networking (ICN) data is divided into chunks, each of which is given a unique and hierarchical name. This concept allows applications to ask the network for a given Named Data Object (NDO), without knowledge of its location.

Current ICN implementations support matching hierarchical names in Interest messages to NDOs via exact or longest prefix matching. This poses challenges with regards to naming in certain situations, when the application does not know the name of a specific object, or is not interested in one specific object but rather in an instance of "similar" objects. An example is retrieving sensor data from a geographical area covered by multiple sensors.

To address the issue, we introduce the concept of a *name with range indications* in the Interest, in order to ask for an object whose name is contained in the indicated range. We demonstrate the feasibility of this approach by extending the Named Data Networking (NDN) architecture with a support for handling Interest messages with range indications.

CCS Concepts

•**Networks** → **Naming and addressing; Network protocol design;**

Keywords

ICN, NDN, ranged name, implementation, experimentation

1. INTRODUCTION

When asking the network for a given Named Data Object (NDO) through an Interest message, current ICN implementations will either perform an exact match (CCN and NDN) or a longest prefix match (NDN) between the name within the Interest and the name within the NDO. As a consequence, an application is required to know the exact name of the object it needs to retrieve, or, if it only knows and requests a partial name, it might receive an object which it is not interested in. Although the NDN implementation provides the possibility to use so called Selectors within the Interest for selecting the data that matches best to what the application wants[2], this only provides the application with limited flexibility. In some circumstances, it might be desirable for an application to be able to specify "the range" within which a certain name should be in order to ensure that the returned object satisfies that application's requirements.

In an Internet-of-Things (IoT) use case for example, an application might be interested in sensor data related to a particular geographical area without knowing the exact location of a specific sensor within that particular area, e.g. a temperature sensor near a certain train station. In this case the application might not be concerned with which sensor returns the data, as long as it receives a temperature reading from within the area around the train station. Assuming that for example geographical coordinates are used in the naming scheme, a solution with exact or longest prefix matching would be to sequentially poll for different locations (e.g. send out Interests with different locations in the name) until the required data is retrieved, which is obviously inefficient. In an architecture supporting range indications in the Interest name (e.g., specifying geographical boundaries which are relevant to this case), the application will only need to send out one Interest message, thereby reducing the traffic of messages in the network for receiving the data the application is interested in.

Another example relates to a video streaming application requesting chunks of a video stream for which multiple qualities are available (cached) within the network. The application would typically start by requesting the lowest quality and gradually increase the requested quality in time, while higher quality chunks might possibly be cached on nearby nodes. In this case, if the application would be able to specify a range of qualities to retrieve, it could potentially provide the user with a superior service.

A technique allowing an application to request an object of which it does not (or not need to) know the exact name, but rather an approximation of that name, appears therefore to be beneficial in different scenarios.

We implement this technique with the concept of a *name with range indications*, which is used in the Interest to ask for an object whose name is contained in the indicated range. We will demonstrate this concept through a surveillance use case where one can request a video stream of a certain view point, e.g. between the South and East directions outwards a building, without the need of addressing a specific camera

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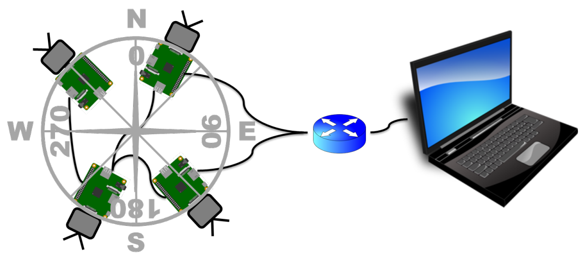

Figure 1: Architecture for the NRC demo.

in that area.

2. APPROACH AND DESIGN

To demonstrate the concept of *name with range indications*, we have extended the open-source implementation of the Named Data Networking (NDN) architecture [1]. Specifically, we have introduced a new type of Name Component, a Name-Range Component (NRC), that includes special syntax to indicate (different types of) ranges for use in Interest messages. An Interest for a name containing an NRC may be potentially satisfied by multiple NDOs, of which only one will be returned. A name containing NRCs may look as follows:

/sensor/temperature/latitude/[40:42]/longitude/[36:39]

As a basis for our implementation, we have used the NDN version 0.4.1, which contains two modules, ndn-cxx-0.4.1 (the NDN protocol library) and nfd-0.4.1 (the network forwarder to run on each NDN node) [3, 4].

Both the NDN library and the NFD network forwarder have been extended to support the use of Interests with NRC. Specifically, we introduced a new Type-Length-Value (TLV) type in the library to easily distinguish name components with range indication from regular name components. Based on this new TLV type, NFD will be able to recognize whether the name in an Interest contains a NRC - without the need to parse the actual name. Handling this new TLV type requires extending the implementations of Name, Name-Component and Interest in the NDN library.

For what concerns the NDN network forwarder, extensions are needed in the way in which the Forwarding Information Base (FIB), the Pending Interest Three (PIT) and the Content Store (CS) are processed. In particular, incoming Interest messages with NRC need to be matched to non-NRC entries in the FIB and CS, and incoming Data messages with names without a NRC need to be matched to entries in the PIT with a NRC. This has also lead to extensions to the implementation of the overall NameTree table in order to administer entries with NRC.

3. DEMONSTRATION

For the demonstration, we consider the scenario of a user wishing to retrieve a video feed from one of multiple surveillance cameras, which are filming the same area but from a different orientation, without the need for the user to know the exact orientation of each camera.

The demonstration will consist of a number of producer nodes (single-board computers such as Raspberry Pi's) equipped with a compass and a camera, which are connected among each other, and with a requester node (Figure 1). Each producer will act as data source, making its video feed available using its orientation, in degrees of arc, in the name. For example, a producer facing South-East will make its video feed available at the following address:

/demoroom/videofeed/orientation/135

Using the requester node, demo visitors will be able to send Interest messages asking for a video feed relating to a particular range of orientations of the cameras, e.g.

/demoroom/videofeed/orientation/[135:225]

A producer with a camera whose name is in the range of the expressed Interest, will then start streaming video to the requester.

Visitors may also change the orientation of the producer on display, possibly triggering retrieval of the video feed from a new source in the range.

4. DISCUSSION AND FUTURE WORK

In this paper we have presented an extension of NDN with support for *names with range indications* to cope with the limitations of exact or longest prefix matching on hierarchical names. Our approach provides an application with the possibility to request an NDO of which it does not (or not need to) know the exact name, but rather an approximation of it, which is expressed through a range. This method allows more flexibility and efficiency in retrieving an object of interest as compared to the standard NDN protocol, which may require multiple Interest messages to be issued to achieve the same result.

The authors expect that performing range based matching will influence the processing performance of look-ups in comparison with longest prefix matching. Such evaluation will be the scope of future work.

5. ACKNOWLEDGEMENTS

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