Topology-aware Content-centric Networking

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ABSTRACT

Making data the first class entity, Information-Centric Networking (ICN) replaces conventional *host-to-host* model with *content sharing* model. However, the huge amount of content and the volatility of replicas cached across the Internet pose significant challenges for addressing content only by name. In this paper, we propose a topology-aware name-based routing protocol which combines the benefits of location-oriented routing and content-centric routing together. We adopt a URL-like naming scheme, which defines register locations and content identifier. Node with copies sends Register messages towards a register using location-oriented routing protocols. All en-path routers record forwarding entries in forwarding table (FIB) as the "bread crumb" to this content. Following the bread crumb, routers know the "best" topology path to the available copies. An Interest is either forwarded towards a "known" copy by the content identifier, or towards the register nodes where it would find the bread crumb to the "best" copies. Compared with the existing flooding or name resolution methods, Our design shows a good potential in terms of scalability, availability and overhead.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design

Keywords

information-centric networking, name-based routing, topology-aware FIB, URL-like naming, distributed registration

1. INTRODUCTION

Information-Centric Networking [1], also named Content-Centric Networking (CCN), is emerging as promising clean-slate Internet design in recent years. It takes content as primitive, and retrieves content by name, not by host IP again. It is able to decouple location from identity, and replace widely used host-to-host conversation model with content sharing communication model [3]. However, the huge amount of content and the volatility of replicas cached across the Internet pose significant challenges for addressing content only by name. It is still an open issue for ICN how to retrieve a copy of content from the "best" available sources.

An ideal name-based routing protocol is able to address all permanent and temporary caching copies, and find the "best" available replica (e.g. closest in topology). There are three main challenges for this objective.

1. **Scalability**. According to the current size of web, the number of content object is huge, and rapidly growing. The scheme of centralized name resolution or query flooding are not suitable for a large scale internet.

2. **Availability**. Copies are stored in networks anywhere. ICN should at least find one copy even nodes are moving. If there are many copies, it should know the topology and forward the request to the closed one.

3. **Low overhead**. It is necessary for ICN to maintain routing FIB with low overhead, especially for a Internet scale network.

Prior works can be classified into two categories: name flooding and name resolution. CCN [3] employs a human-readable hierarchical naming scheme in order to aggregate name prefix. But the topology is static. It is hard to aggregate routing entries in case of there are many copies in different locations. It also employs a flooding method to announce content name, which is not suitable for large scale networks. Other pioneering name resolution schemes have also been proposed, such as TARID[2], DONA[4], NetInf [1], etc. They employ centralized or distributed indexing infrastructure to map content name to appropriate locations. But the overhead to maintain the index is very high.

In this paper, we propose a topology-aware name-based routing protocol to combine the benefits of location-oriented routing and content-centric routing. Packets are forwarded by content identifier while FIB entries are built by topology-based routing protocols. We employ a URL-like naming scheme which defines register location and content identifier. All routers also acts as registers which form a distributed registration system. A source selects a nearby router as register node whose location is embedded in the published URL-like name. We also introduce a Topology Routing Table (TRT) into name-based routing to describe network topology. When an Interest message arrives, router first lookups

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Figure 1: URL-like naming scheme.

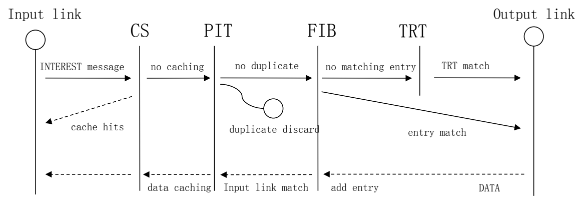

Figure 2: Topology-aware Content Routing.

its forwarding table (FIB) by content identifier. If found, it forwards the message toward content providers. If no matching entry, it lookups TRT and forwards it to the register node indicated in the URL-like name. Any node with a copy would send a Register message toward the register by location-oriented routing protocols. And all en-path routers will record forwarding entries in FIB as "bread crumb". Following the bread crumb, the routers thus know the "shortest" topology path to the "best" available copies. The distributed registration and topology-aware FIB entries enable the proposed design being scalable, available, resilient, and better support for local service and mobility.

2. URL-LIKE NAMING SCHEME

The proposed URL-like naming scheme defines register location and content identifier as Fig. 1. Differing from traditional URL which indicates to source servers, the location embedded in the name is pointed to register node. The identifier is the unique identification of content. Here we assume it is persistent and authenticated as defined in CCNx [3].

When a source wants to share a original content object, it first selects a local router as the register node, and sends a Register message towards it by the procedures in Sec. 3.2. A unique content name is then generated which consists of register location and content identifier. This name will be published on public web pages or portal. Any user who is interesting in it can obtain this name through search engine, recommendation system, etc.

3. NAME-BASED ROUTING

3.1 Content Router

Content router consists of four components as Fig. 2. Besides the same components as CCNx, we also introduce a Topology-aware Routing Table (TRT) to exploit network topology information. TRT is generated using classical topology-based routing protocols.

Interest messages are forwarded either towards a "known" copy by name, or towards a register node by location. Once the Interest arrives on a router, CS will look up local cache on the content name. If there is a copy in the CS, it will be sent back along the path the Interest arrived on. Otherwise, the router will check the PIT table. If there is an exact-match PIT entry, the Interest's arrival link will be added to the PIT entry. Otherwise, it looks up FIT table. If there is a match entry, the Interest is forwarded along the matching FIB entry. Otherwise, it looks up TRT and forwards Interest towards the location of register, which knows the routing information of all available replicas.

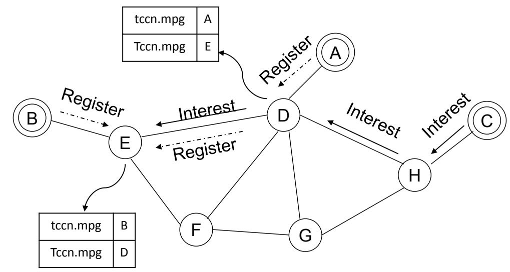

Figure 3: Registration.

3.2 Topology-aware FIB

The topology-ware FIB entries are built by using topology-based routing protocols. Any node with a copy would send a Register message towards registers nodes. And all en-path intermediate routers will record FIB entries pointed to the arriving links. Since the path towards register nodes is topology-aware, obtained FIB entries are also topology-aware. Besides that, in the Interest forwarding procedure, routers also add a FIB entry in data reverse path.

Now we give an example in Fig. 3. Assume Node B has a file *tccn.mpg* to share, it registers the file in a local router E. A new content name *ccn://E/tccn.mpg* is published. Router E also adds a new entry pointed to Node B. A requester C wants to retrieve the file, but local router has no entry for this file. Interest is forwarded to the register E by the short path routing protocols. All en-path routers H and D record FIB entries for this file. If a copy moves to Node A, it sends a Register toward the register E. All intermediate nodes D and E would record a new entry pointed to the input links.

4. CONCLUSIONS

In this paper, we introduce a topology-aware name-based routing protocol. Data is forwarded by content identifier while FIB entries are build by topology-based routing protocols. The distributed registration and topology-aware FIB routing enable the proposed design being scalable, available, and better support for mobility.

5. ACKNOWLEDGMENTS

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