ROUTING CHALLENGES IN INFORMATION-CENTRIC NETWORKING

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Abstract: The article presents a comparative analysis of existing ICN projects by caching, naming, routing and security. The methods of the name resolution process are described. Emphasis is placed on the main challenges in ICN. The authors proposed the classification of transmitted data by types and requests. Reviewed some scenarios of data transmission base on the three-dimensional address.

Key words: architecture, routers, name resolution, types, transmissions.

The present architecture of the Internet is based on a host-centric communication model. However, the problem is that Internet usage has increasingly rocketed up, and nowadays, the Internet users are willing to get access over great amounts of information, regardless of the physical location of the information source [1,2]. As a result, the researchers started to look for a solution to change the architecture of the Internet infrastructure. In this regard, Information-Centric Networking (ICN) is a newly introduced concept on which many of the researchers are working as a new foundation for future Internet [3,4].

There are two concepts, which are considered as core concepts in the Information-Centric Networking: naming and routing. In order to solve these two problems, the content in the ICN architecture is named directly, put into network by publishers, copied in caches by network, and finally, asked by name through usage of a find or fetch primitive.

ICN has attracted extensive attention during the last decade, and several proposals have been presented regarding pros and cons of its fundamentals, which differ from each other in terms of routing algorithms, naming schema, deployment models, and interoperability of name-based and IP-based solutions or different name-based solutions[4]. A review of the main functionalities of each architecture is presented in the Table 1 below.

There are two roles defined for routers in the ICN architectures at the time of a request for a particular Named Data Object (NDO). The first task of the routers is finding a node that has a copy of the required piece of information, and forwarding the request. The second task is finding a route from the node to the user who had asked for the information piece. A method of doing these two tasks is called name resolution. This method includes finding one or more lower-layer locators for the name of NDO. These locators are able to call back the requested NDO. The other way to do the routing tasks is called name-based routing. In this method, the request for the NDO is directly routed to the node that has a copy of the content (based on the NDO's name). The name resolution phase in the name-based routing is removed[5].

The name resolution is an important process in ICN routing and has two approaches: explicit name resolution and name-based routing approach.

Table 1: Comparison of different ICN architectures

Feature / ICN architecture	Naming	Security	Routing	Caching	Evaluation
DONA	flat, P:L form	cryptographic information contained data name	name-based routing	on-path caching	prototype
PURSUIT	mixed, Scope ID; rend ID form	self-certifying names	name resolution	on-path caching with additional registrations	prototype
SAIL	Ni: //a /L form	self-certifying names	name resolution	on-path caching	prototype
COMET	unspecified	unspecified	name-based resolute on	probabilistic on-path caching	simulator
CONVERGENCE	either flat or hierarchical	in–packet meta-data information	name resolution	on-path caching	tested, prototype
MobilityFirst	flat, 160-bit unique IDs	self-certifying names	name resolution	on-path	-
NDN	hierarchical, /A/B/C/ form	in–packet meta-data information	name-based routing	caching	tested, prototype, simulators
CBN/CBCB	set of attribute-value pairs	not ensured	name-based routing	caching	
KBN	hierarchical	not ensured	name resolution	on-path caching	prototype
G-ICN	either flat or hierarchical	in–packet meta-data information	name resolution	on-path caching	prototype
NetInF	flat	a public key chaining information stored in meta-data	name resolution	on-path caching	prototype

Explicit name resolution approach separates name resolution from the content discovery. It could take to return the client with the locators of the content, which will be used by the underlying network as the identifier to route the client's request to one of the producers. DONA, PURSUIT, NetInf, SAIL, MobilityFirst are ICN projects used this.

Name-based routing approach integrates with the content discovery (content request message routing). The name resolution mechanism also determines the routing path for the data. NDN and CCN use this approach.

The name resolution approach could also take hybrid. This approach performs the name-based routing from the start but when it fails at any router, the router starts to perform the explicit name resolution.

ICN is a completely new subject matter for the researchers, nonetheless, there are a great number of solutions provided by the scholars that cover a wide range of related issues to this topic. Notwithstanding, still there are many challenges to be addressed by the scholars, and there are many practical aspects left to be investigated deeply. Routing and name resolution are exactly two of the aspects that need to be discussed with in-depth details.

A challenges in name resolution and routing process are the following: ensured delivery and detection of the nearest copy of required content, scalability (this includes the development of an information model and a naming framework which support efficient information dissemination with improved security properties. It also includes the development of a world-wide scalable name resolution mechanism for the new namespace), excessive current on routing tables (if overflow takes place, the router rejects the request packets, the user experience a low transmission rate, and whole network will crash as a result), single point for failure (this problem happens when a great number of published and registered NDOs in the Name Resolution System (NRS) go unavailable), security and filtering.

Most of the proposed techniques in ICN are not suitable to deal with all data transmission types between *Publishers*/*Subscribers*. Another problem that resides in the proposed ICN schemas is the limitation to deal with knowledge searching.

To solve these problems and to design the new network architecture, the types of data communication were examined. In this manner, we classified data transmission into four types based on the number of subscriptions and frequency of data object use, as shown in Table 2.

Table 2. ICN Data Transmission Types

Type	Subscription	Number of usage	Example

A	one	one	Voice call
B	one	many	Cloud Storage
C	many	one	Live video Streaming
D	many	many	YouTube song

Besides, to the classifying data into four types, we also classifies the subscriber's requests into types. Subscribers Requests may be of four types as shown in Table 3.

However, none of proposals in Table 1 introduces a solution that fit perfectly to all requests. For example, CBCB can route requests to the content to solve R4, but it consume a lot of processing at the node to serve R1 and R2 subscriber.

Table 3. Subscribers Requests Types

Type	Description	Example
R1	Requesting *any Data Content* from *Specific Publisher*	Voice call with specific user
R2	Requesting *Specific Data Content* from a *Specific Publisher*	Accessing Cloud Storage
R3	Requesting *Specific Data Content* from a *Specific Publisher*	Downloading a song or a software installation file
R4	Requesting Information with *Any Data Content* from *Any Publisher*	Searching for information using Google «How to make a soup»

Let's consider the components necessary for the operation of the network model and some scenarios. A *Subscriber* interested in specific information will send a pull message: *Interest Request Message (IRM)* to its gateway (Fig.1). This *IRM* would be one of the four types of subscriber requests **R1**, **R2**, **R3** and **R4** (Table 3). In **R1** type, the user *IRM* will carry only publisher ID, and it will be broadcasted to the router. Thus, routers will search only in GEO-ID table to retrieve IPv6 to it. In **R2** type, the user *IRM* will contain semantic and publisher ID, and it will be broadcasted to the routers and the routers will search in GEO-ID table only to retrieve IPv6 to it. In **R3** type, the user *IRM* will contain semantic only, and it will be broadcasted to the routers and the routers will search in GEO-semantic table and semantic ID-table and retrieve IPv6 to it. In **R4** type, the user *IRM* will contain semantic only, and it will be broadcasted to the routers and the routers will search in GEO-semantic table and semantic ID-table and retrieve IPv6 to it.

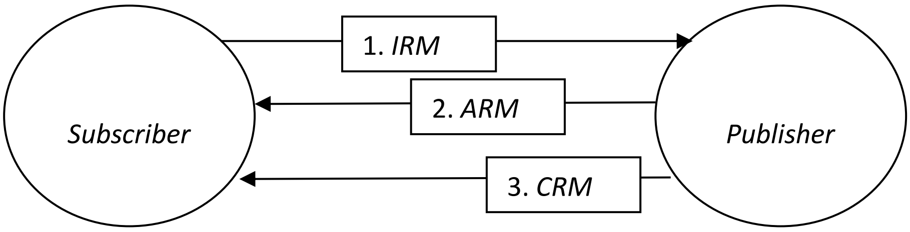

Figure 1. Message communication path *Publisher* and *Subscriber*

Address Reply Message (ARM) sent from the *Publisher* routers or any in path router holding the needed content towards the *Subscriber* requesting certain content by *IRM*. *ARM* holds the addresses. The *Content Request Message (CRM)* contains the data requested and the addresses.

This article suggest the ways to solving the challenges of content retrieving according to the classification of requests and data types. Scenarios are based on three aspects of address: GEO-address, IP-address, and data semantic name [5].

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