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CCN Naming Scheme for Scalable Routing and Incremental Deployment

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***Abstract*-- In this paper, we propose a Content-Centric Networking (CCN) naming scheme which combines 16bytes of Internet Protocol (IP) address with uniquely identified CCN name. The IP address is used to find destination of a packet, and CCN name is used to identify the content when the packet is forwarded. This approach enables for CCN protocol to use same Forwarding Information Base (FIB) of current internet, as a result it allows incremental deployment of CCN on current networking infrastructures.**

I. INTRODUCTION

Today, typical consumers widely use their devices for both generating and consuming multimedia content, thus adding large volumes of traffic to the Internet. Many proposals have been actively researched for efficient data sharing and distribution [1], and CCN [2] is one of the most promising approaches. In CCN, content is found and retrieved by its name. The name-based routing takes the advantage of utilization of network cache while the content is retrieved [3], but it has drawn lots of concerns about managing and processing of large routing table index. Another concern for CCN is its deployment. Therefore, we propose a naming scheme which combines the IP address with CCN name, so that to use IP address for finding location and to utilize CCN name for caching.

II. MOTIVATION: THE CHALLENGES ON NAME-BASED ROUTING

Unlike the IP which transmits a packet by a host-centric destination address, CCN forwards a content request packet called *Interest* directly based on the content name. This new paradigm change includes two challenges: routing scalability and incremental deployment.

Currently, the biggest Internet routing table contains around $4x10^5$ [4], but the number of addressable content names for CCN is anticipated to be several order of magnitude higher than the biggest routing index. The most approximated examples are the number of indexed URLs of Google [5] and the registered second level domain in the Internet [6] , and they are estimated around 10^8~10^{12}.

On the other hand, CCN takes a clean slate approach against the current Internet [2]. This means deployment of CCN may require additional networking entities. For instance, a gateway such as a home network server will be needed to translate all generated CCN packets from a smart phone at inside of home to IP packets to be forwarded to out of the home boundary.

III. PROPOSED SCHEME: IP-CCN COMBINED NAME

As addressed in Section 2, the new paradigm still has weakness points in deployment although they have shown the opportunity in efficient content distribution and retrieval. As a way to one step forward for CCN to coexist on the current Internet infrastructure, we propose a new naming scheme that combining IP address with CCN name to use IP address as a locator and CCN name as an identifier of a packet.

A. An Example of Network Architecture

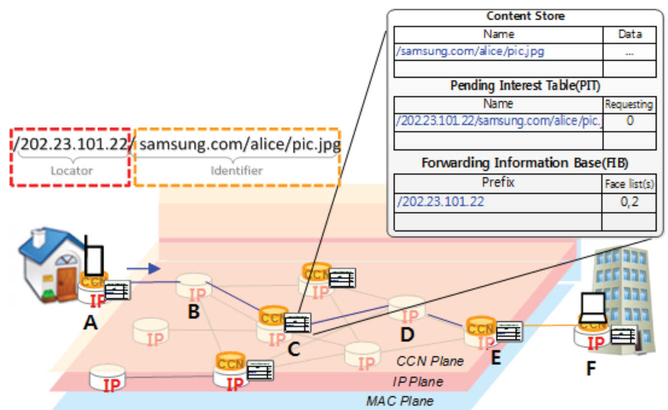

Fig. 1. An Overview of Network Architecture.

This is an example scenario most likely to happen when CCN protocol deployment is driven from the consumer electronics manufacturer such as Samsung Electronics. The devices A and F which have enabled CCN protocol stack can be a smart phone and a Personal Computer (PC). Many CCN protocol stacked network nodes are located on the way the packets are forwarded to enhance performance using cache storage. These nodes seen around the path can also be media servers, switches, router, Network Attached Storage (NAS), etc., be provided by network or service providers, and be readily seen in a typical network system. The CCN enabled consumer devices are dispersed over the network.

B. Forwarding Engine Design

Let us assume that an *Interest* "202.23.101.22/samsung.com /alice/pic.jpg" is transmitted by a consumer device A towards F which is working as a home media server. The devices B, C, D, and E are located in the area where the *Interest* is forwarded. The devices C and E have not only IP but also CCN protocol.

The flow is depicted in Fig. 2, and each step references each table maintained in the CCN forwarding engine shown in Fig.

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1. As depicted in Fig. 2, forwarding process starts with checking if the device is capable of processing CCN protocol or not. If the device has only IP capability, it handles the packet as an IP packet, and if it has IP and CCN capability at the same time, the device regard the packet as CCN packet as well as IP packet. The CCN capable devices operate like this: When an *Interest* packet is received, the engine starts to check if the identifier “samsung.com/alice/pic.jpg” exists in Content Store (CS) or not. If the CS has it, the engine returns the content back on backward path. If not, it takes the next steps: Pending Interest Table (PIT) lookup using “202.23.101.22/samsung.com/alice/pic.jpg”, and FIB lookup using “202.23.101.22”. The engine updates the PIT table for flow control, and forwards the *Interest* by FIB table by longest prefix matching to find content. To use “202.23.101.22” for routing instead of a globally routable CCN name such as “samsung.com” makes CCN packet routable with IP FIB table. This makes CCN protocol operable with current IP packet forwarding without any modifications, and FIB table index of it will have the same order of magnitude of one of IP.

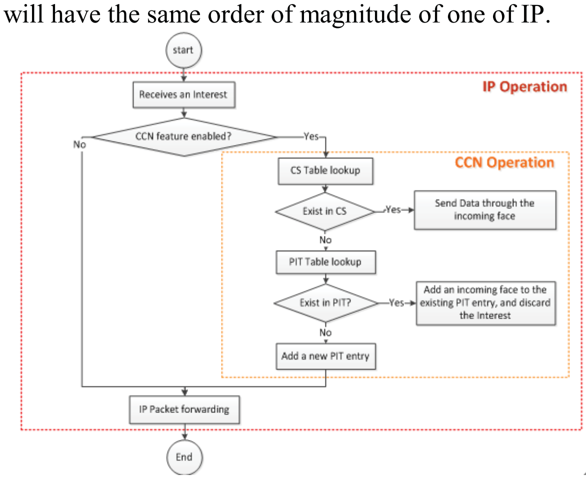

Fig. 2. The Flow of IP and IP operable CCN Engine on a Device.

C. *IP operable CCN Packet Structure*

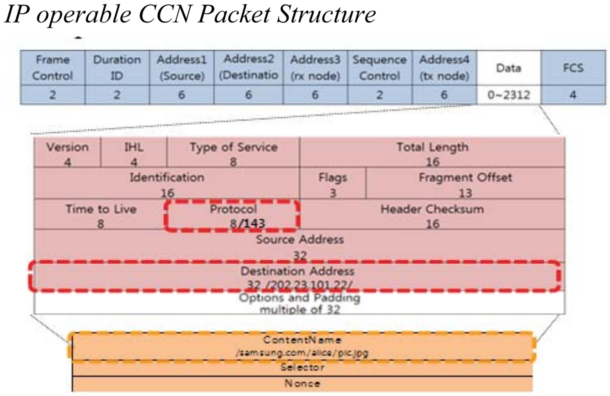

Fig. 3. Implementation of CCN over IP using Proposed Naming Scheme.

The “Protocol” field in the IP packet structure indicates the next protocol which is encapsulated as a payload of the current IP packet. According to the Internet Assigned Numbers Authority (IANA) Internet protocol number, 143 to 252 remain as unassigned by now [7]. By using one of these decimals, CCN can be implemented without any structural modification. Fig. 3 shows an example implementation of an IP operable CCN name using the number 143.

IV. Simulation Results

To answer the question about necessity of deployment of CCN and to show effect of CCN caching, we took a simulation using OPNET simulator. On simulation, CCN over IP was implemented. The content size was 1MB. The scenario was downloading content using IP operable CCN and IP. The former had 20 nodes with single cache among 100 nodes, while the latter had only one content server to distribute the content. Since it is a simple simulation, the routing followed longest prefix matching only. As shown in Fig. 4, the nodes’ average Round Trip Time (RTT) of segments had decreased about 1/3 by utilizing CS on IP. The nodes located apart from the server had downloaded the target file faster since they retrieved the content from CS instead of original server.

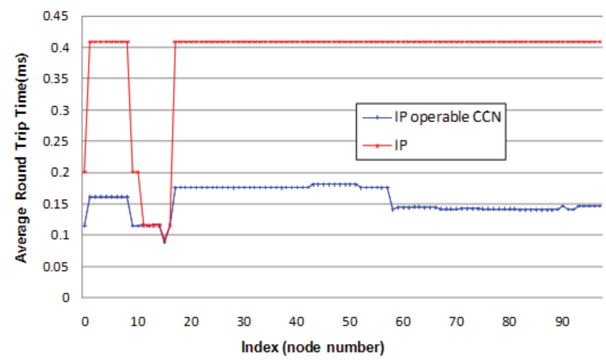

Fig. 4. Average Round Trip Time of IP operable CCN and IP.

V. Conclusion

In this paper, we proposed a naming scheme of CCN. The proposed naming scheme eliminates the need for additional network entity while it keeps advantages of the network caching. This approach also enables for CCN to use the current FIB so that it can grow in the current Internet infrastructure. The packet structure, composed with practical IP and CCN packets, has shown the feasibility of the proposed scheme, as well as the simulation result showed the benefit of utilizing in-network caching in IP using CS.

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