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Efficient Mobile Content-Centric Networking Using Fast Duplicate Name Prefix Detection Mechanism

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Abstract

As the social networking and video services' usage is increased, explosive content creation and content sharing has taken place. Therefore, to meet growth of users' demands, new network architectures are required and then many researcher works for content-centric networking have been actively underway. However, in the content-centric network, mobile content sources create many problems like frequent routing update or many retransmission of interest packet. To solve these problems, tunnel-based redirection (TBR) scheme was proposed. However TBR scheme wastes network resource due to long latency of duplicate name prefix detection (DND) processing. So, this paper proposes a fast DND mechanism in mobile CCN environment to provide lower overhead and to access content data fast.

Keywords: Content-centric networking, Mobile content source, Duplicate name prefix detection

1 Introduction

Today's Internet was created for the purpose of resource sharing in the 1960s and 1970s. It has some problems but it has worked very well for several decades. Also, because of the developments of high speed Internet, a number of devices that attached internet have appeared. So it is expected that the traffic volume of Internet extremely increases. Moreover, on the rapid development of mobile communication technologies and the increasing prevalence of mobile devices has occurred, user-generated contents and content sharing among users have taken place regardless of time and place. So the new network architecture that guarantees more efficient use of network resources is required: information-centric networking that data are routed based on content name instead of Internet's host-based communication like source and destination address. There are typical examples: PSIRP, 4WARD, NetInf, DONA and CCN [1, 2]. Among these proposals, this paper mainly deals with the content-centric networking (CCN) architecture because it is regarded as a globally new networking architecture. In CCN, content query are routed to content sources by longest-prefix matching of hierarchical content names. Content names are used for both routing of requests and identification of requested content. In this architecture due to CCN's receiver-driven nature, content sharing is very efficient but it has fatal problems. In other words, content consumer mobility is handled well because CCN's receiver-driven nature that there is no need for location updates [1, 3, 4]. But, the movement of content sources incurs problems (i.e., frequent routing update, long service disruption etc.). For instance, if the movement of content sources changes its location, routing tables must be updated to ensure that interest packets towards the mobile content source are delivered to the mobile content source at the new location. To handle the problems of mobile content sources, the tunnel-based redirection (TBR) [1] scheme was presented. TBR scheme economically reduces the number of control message and latency by making use of redirection based packet delivery. However, TBR scheme induces long latency due to DND (Duplicate Name prefix Detection) scheme. Thus, this paper proposes a fast DND mechanism to solve the overhead and long latency as well as to increase efficiency.

2 Mobility Problems in Content-Centric Networking

2.1 Basic Concept of CCN

CCN consist of two types of packets: *interest* and *data* (Fig. 1). Interest packet is similar to request of HTTP (Hypertext Transfer protocol) and data packet is similar to response of HTTP. A consumer asks for content by sending its interest over all available connectivity devices. Any node hearing the interest and having data that satisfies it sends data packet. Data is transmitted only in response to an interest and consumes that interest.

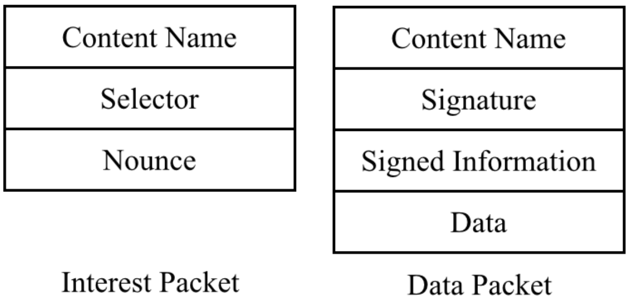

Fig. 1. Interest Packet vs Data Packet

CCN nodes have unusual forwarding model and consist of three tables (content store, forwarding information base and pending interest table). Contents store is the same as content cache. CCN allows data caching in intermediate nodes along the path between a content source and a content consumer. So CCN data delivery is very useful if there are many consumers. PIT is analogous to bread crumbs because it leaves a trail for matching data packet to follow back to the original request. PIT entries are deleted when they have been consumed to forward matching data packet. FIB is used to forwarding interest packet. FIB is similar to the IP router's table. When interest packet and data packet arrive at node, it performs the longest match lookup CS, PIT, FIB in the order.

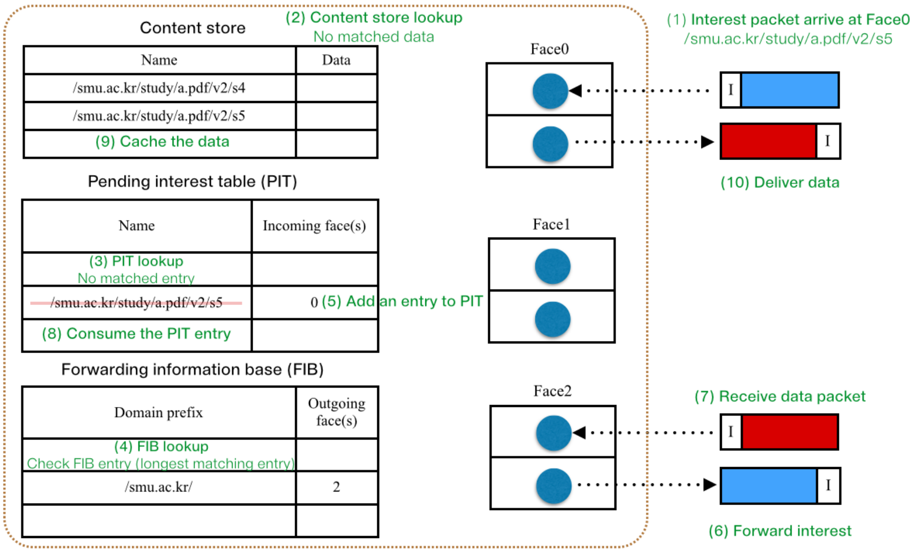

Fig. 2. CCN forwarding engine

In Fig. 2 shows forwarding policy in CCN. When an interest packet arrives at face 0, a content store lookup is conducted based on its content name. If a matched data is found in the content store, the data packet is delivered. Otherwise, it searches a PIT entry to check whether it has already received another request for the same content. If a matched entry is found in the PIT, the CCN node adds the face on which the new interest packet arrived. If the content name doesn't match both the CS and the PIT, the FIB is consulted to determine the outgoing face where the interest packet should be forwarded. Furthermore, the PIT adds entry for the forwarded interest packet. From the added entry, the received data packet can be sent back to the content requester. Also at the node that arrive the data packet that consumes the interest, it is replicated and sent out on all faces in the PIT entry for the content. In other words, CCN data packet's handling is relatively simple and efficient because data packet is not routed. Data packet just simply follows the order of PIT entries back to the content requester.

2.2 The main problems for Mobile Content Sources

In the case of mobile content source movement, problems are much more complex than mobile content consumer movement. (Fig. 3) First, it requires an update of the FIB entry to forwarding interest packet because content consumer doesn't know the content source movement. It takes much time to update the FIB entry of all content routers and cause too many dynamic routing update. As a result the interest packets may not reach when the route to related content source is changed. For that, TBR scheme use is proposed [1]. It utilizes a path redirection from original name prefix to the new name prefix that the mobile content source allocates at the new location. However, it creates long latency due to duplicate name detection. So, whenever the movement to new domain happens, the service disruption is repeated, which results in many packet losses during handover.

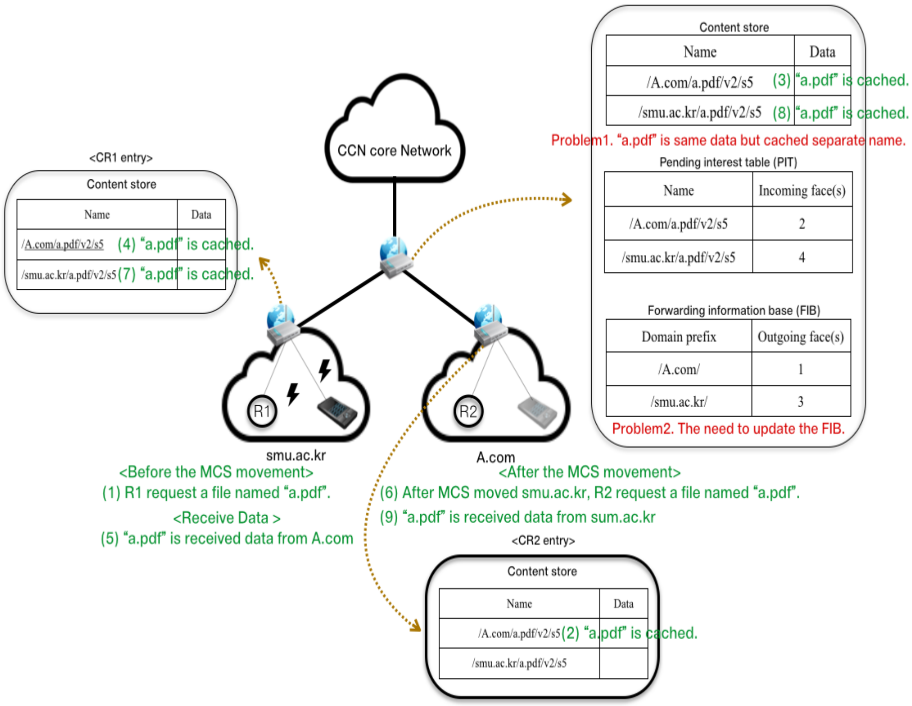

Fig. 3. Situation of major problem in the MCS

Fig. 4 shows the detailed example of the proposed TBR operation. The MCS detects the change of network domain name. After detection, the MCS in CR4 sends PU message to the CR_h. As soon as the CR_h receives PU message, the CR_h sends a PACK message to inform that the prefix update is successful and intermediate CRs look up the routing table again. If the relevant PIT entry corresponds with the name prefix in the received PACK message exist, intermediate CRs delete the relevant PIT entry and then forward the PACK message to the next hop CR. After a little, with no relation to the recognition of the movement of the MCS, content consumer in CR1 sends interest to MCS. The interest packets send to the MCS's previous location. After received interest packets, the CR_h lookup its routing table and it can deliver the interest packets toward the MCS is currently located. At the moment, the CR_h encapsulates original interest packet so it generates new interest packet (tunnel) and then forwards the generated interest packet to the MCS's tentative name prefix. Intermediate CRs deliver the encapsulated interest packet in normal CCN forwarding way. The MCS decapsulates the encapsulated interest packet from the CR_h, and sends the data packet in response to the interest packet to the CR_h.

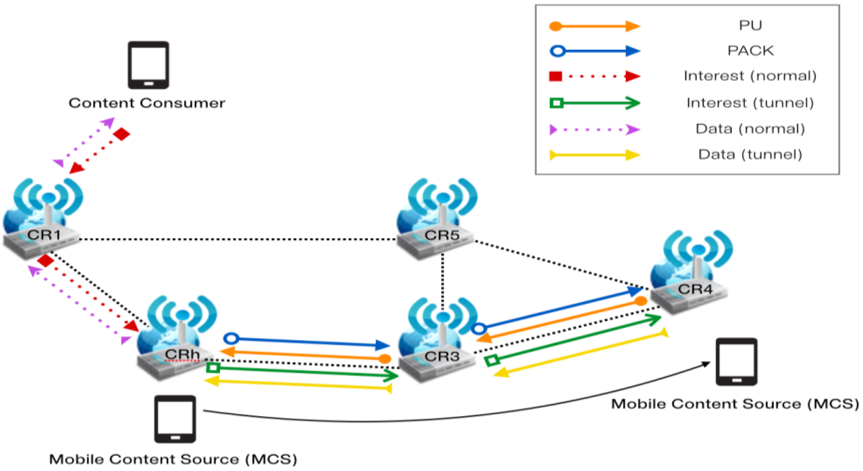

Fig. 4. TBR operation

3 The proposed fast DND mechanism

This paper proposes the effective communication scheme to shorten the latency of DND mechanism in mobile CCN environment by using new fast DND (fDND) mechanism.

3.1. The operation of the fast DND (fDND) mechanism

As indicated in section 2, mobile CCN scheme utilizes DND mechanism to prevent the usage of the same prefix for MCS in the new domain. However, the DND mechanism assumes interest-based operation, which results in long handoff latency. (i.e., over 5 seconds) So, the objective of the proposed mechanism is to reduce the latency of DND operation. The proposed mechanism is composed of 3 steps (as shown in Fig. 5).

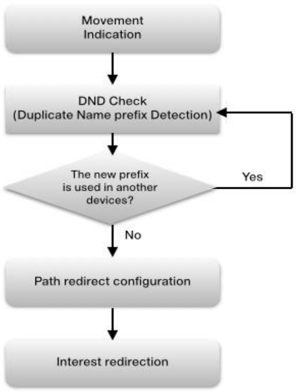

Fig. 5. fDND operation procedures

Step1. Movement indication: An MCS detects network status's change by using physical link information or network domain name. The movement indication is initiated where the MCS enters the network via wireless access points. It is assumed that the initialization data (i.e., domain name prefix) is provided to the MCS by the wireless access points that would contain a collection of CRs available inside the access domain network. The MCS decides whether prefix update message should be sent by the initialization data to the original domain content route (CR_h).

Step2. DND operation: After detecting the movement between domains, MCS initiates the proposed DND operation. For DND checking, the new message named 'DND request' message is presented. To reduce DND operation latency, the proposed mechanism adopts shorter PIT-timeout than TBR scheme. That is, 1 second PIT-timeout for DND registration is assumed. The new format of DND request message is shown in Fig. 6. DND request message is composed of three components. 'Tentative prefix' field means MCS's new prefix. 'DND' field means that this message is for DND operation and then PIT-timeout value is set to 1 second. Finally, 'Hop Count' field is utilized to guarantee that DND request message is transmitted only in the same domain.

Tentative prefix	DND	Hop Counter
a.com/book/smu.ac.kr/tom/mobile/	DND	1

Fig. 6. DND request message and Example of DND request message

For example, in Fig. 7, the MCS moves from smu.ac.kr to a.com. On detecting the new domain a.com, the MCS sends DND request message in the same domain to find whether the tentative prefix, configured by the MCS, is being utilized by other nodes. If any response in data packet type is received, the MCS has to configure another tentative prefix because the tentative prefix is already used and then sends DND request message again for the newly-configured tentative prefix. As a result, the tentative prefix is verified in the uniqueness. If there are no responses for the DND request in 1 second, the MCS sends PU message to the CR_h.

Step3. Path redirection: The MCS registers its tentative prefix to the CR_h. After that, when receiving interest packet for the MCS, the CR_h generates new interest packet encapsulating original interest packet and then forwards the encapsulated interest packet to the MCS's tentative name prefix. So, intermediate CRs deliver the encapsulated interest packet to the MCS through a basic CCN forwarding method.

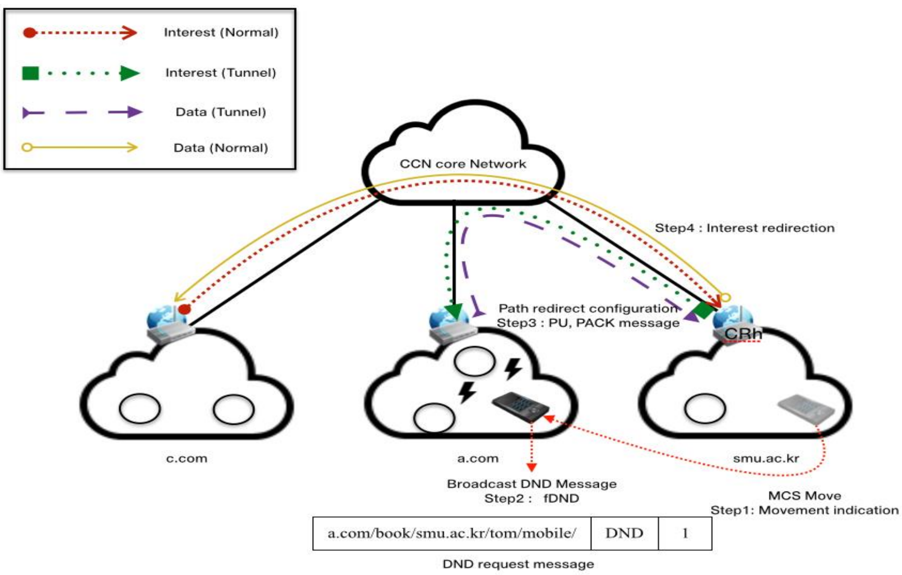

Fig. 7. Operation of the proposed fDND mechanism

3.2 Performance evaluation

In order to evaluate the proposed fDND mechanism, the performance evaluation is done in terms of varying mobility speed and the number of nodes. It is assumed that the inter-arrival rate of interest packets has a random distribution.

Fig. 8 shows the packet loss of TBR's DND and the proposed fDND. As described in section 2, the proposed mechanism has short DND operation latency by using small value for the modified PIT timeout. fDND waits for one second to check the validity of the tentative prefix while TBR waits for five seconds.

Therefore, fDND mechanism has smaller amount of packet loss than TBR scheme because it can provide short service disruption during handover. From that, fDND can reduce content download time and network resource consumption when compared to the original TBR scheme.

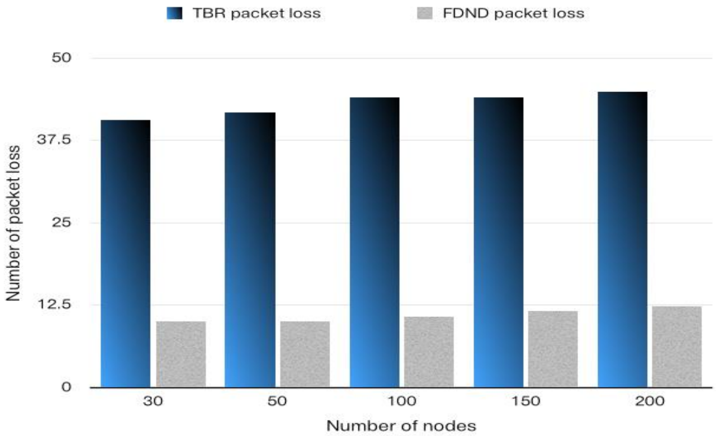

Fig. 8. Packet loss

4 Conclusion and Future works

This paper presents the fast DND mechanism to reduce the side effect due to long handoff latency of mobile content sources' movement. Proposed mechanism is operated when detecting the network change and the mobile content source initiates the uniqueness verification of the new tentative name prefix. For fast DND procedure, the proposed mechanism utilizes shorter timeout value 1 second and utilizes interest-type message format named DND request message to provide backward compatibility. From that, it can save network resource consumption of network devices and reduce content retrieval latency by decreasing the checking time of duplicate name prefix. Future works are required for the performance evaluations of DND mechanism in the real CCN network environment.

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