

Supporting Publish-Subscribe-based ICN in 5G Core Network

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Abstract— In 5G, publish-subscribe-based applications, such as Internet of Things (IoT), are considered as important services. Also, Information-Centric Networking (ICN), which delivers content based on content name, instead of IP address, is considered as an efficient content delivery network, especially for IoT. In this paper, we propose how to support publish-subscribed-based ICN in 5G core network.

Keywords—ICN, publish-subscribe, 5G core network

I. INTRODUCTION

In information-centric networking (ICN), data is delivered based on content name, instead of IP address of nodes. In ICN, consumer sends Interest packet which includes the requested content name. Data packet which includes the requested content is returned to the consumer by a content producer or an intermediate node which caches the requested content [1],[2]. Forwarding information base (FIB) is used to deliver Interest packet towards producer. Incoming face of the received Interest is stored in pending interest table (PIT), and it is used for future Data packet delivery.

Recently, works on supporting ICN in 5G core network have been proposed [3]-[5]. In these works, extended 5G core network architectures which interwork with ICN data network (DN), were proposed, where network functions (NFs) of current 5G core network were extended, too, to support ICN in 5G core network. In our previous work [5], a detailed procedures for content name registration, ICN PDU session establishment, Interest/Data delivery have been proposed.

In [5], however, only pull-based ICN support was proposed, where consumer pulls content by sending Interest packet firstly and Data is returned in response to the Interest packet. However, interest on push-based ICN based on publish-subscribe has been increased due to the increased IoT applications, where producer pushes content to subscribed consumer, whenever content is generated. In this paper, we propose how to support publish-subscribe-based ICN in 5G core network.

In Section II, procedures for publish-subscribe-based ICN support in 5G core network are proposed. Summary and future work are presented in Section III.

II. PROCEDURES FOR PUBLISH-SUBSCRIBED ICN SUPPORT IN 5G CORE NETWORK

In this paper, we consider an extended 5G core network, as shown in Fig. 1, which is similar to those in [3]-[5], where 5G core network is interworked with ICN DN and NFs are extended to support ICN. AMF and SMF are extended to AMF++ and SMF++ to deal with ICN related messages.

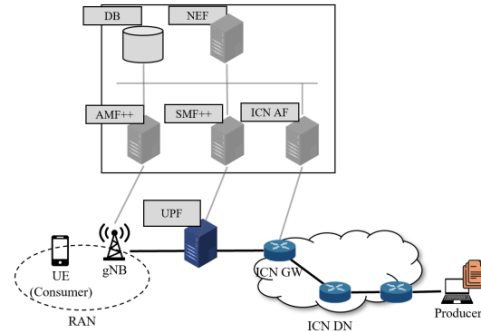


Fig. 1. An extended 5G network architecture interworked with ICN DN.

NFs and proposed procedures to support publish-subscribe-based ICN in 5G core network are basically based on the architecture [6] and procedure [7] standardized in 3GPP. Similar to the work in [5], an overlay model is assumed, where ICN is deployed over IP between 5G user equipment (UE) and ICN gateway (GW), which interfaces between 5G core network and ICN DN.

In this paper, we classify procedures to support publish-subscribed-based ICN in 5G core networks as 5 steps: 1) content advertisement by producer in ICN DN and content name registration at 5G core network, 2) PDU session establishment for content subscription, 3) delivery of content subscription message to ICN GW, 4) subscription to content by ICN GW, and 5) delivery of published content to subscribed consumers. Since pull-based and push-based ICN supports share much in common basically, many parts of the proposed procedures are largely based on those presented in our previous work on pull-based ICN support [5]. To avoid redundancy and account for space limitations, procedures for similar parts are not described in detail repeatedly and readers interested in these details are encouraged to refer to our previous work [5]. Instead, we focus on highlighting the differences in supporting publish-subscribe-based ICN compared to pull-based ICN support in 5G core network [5].

A. Content Advertisement by Producer in ICN DN and Content Name Registration at 5G Core Network

This procedure is similar to ICN application registration procedure in pull-based ICN support [5]. In publish-subscribe-based ICN, publisher in ICN DN advertises its content to neighbor nodes and this information spreads throughout ICN DN. FIB of each node in ICN DN records the incoming face of the received advertisement and this information is used to deliver subscription message to producer later. When ICN GW receives this content advertisement, it stores the received content name and incoming face of the content. Then, ICN AF

in ICN GW requests to register the content name and the IP address of the ICN GW to NEF. This mapping information is used to deliver content subscription message from UE to ICN GW. Finally, NEF stores the received information in content-to-ICN GW mapping database.

B. PDU Session Establishment for Content Subscription

In conventional publish-subscribe-based ICN, subscription message is delivered to a specially designed node, such as rendezvous point (RP) and publishers also delivers content to the RP [8]. However, since nodes in 5G core network, such as gNB and UPF, do not support ICN protocols as well as FIB and PIT, publish-subscribe based ICN using the RP cannot be applied directly in 5G core network. If consumer UE wants to subscribe to interested content, it firstly sends ICN PDU session establishment request with content name to AMF++. AMF++ interacts with SMF++ to get the IP address of ICN GW from content-to-ICN GW mapping database and establishes PDU session from UE to appropriate UPF which connects to the ICN GW. We note that only uni-directional PDU session from UE to UPF is established and PDU session from UPF to UE is not established at this time. This is because since the time interval between subscription and content publish is not short, it is not efficient to establish PDU session from UPF to UE at the time of content subscription, since the session may be released if content is not published in a short time. This is a major difference from ICN PDU session establishment procedure in pull-based ICN support [5], where bi-directional ICN PDU sessions are established at PDU session establishment step. We assume that UE has list of contents and how to obtain content list is out of scope of this paper.

C. Delivery of Content Subscription Message to ICN GW

After PDU session is established, UE sends content subscription message to gNB with ICN GW IP address as destination IP address, where the subscription message is encapsulated in the payload of IP packet, whereas UE sends Interest packet as a payload of IP packet to get Data from content provider in pull-based ICN support. Then, the packet including subscription message is tunneled from gNB to UPF. Upon receiving the packet, UPF extracts the payload from the content subscription message, and sends it to ICN GW. Then, the ICN GW stores content name, subscribed UE IP address, and UPF IP address in its subscription management database.

D. Subscription to Content by ICN GW

If the requested content already exists in subscription management database, since it was subscribed by another UE already, there is no further action after storing content name, subscribed UE IP address, and UPF IP address. If the requested content subscription is new, however, ICN GW sends content subscription message towards the content producer acting as a proxy of UE, which is new to the proposed push-based ICN support, contrary to the pull-based ICN support [5]. Subscription message management in ICN DN can be performed similarly, as in conventional publish-subscribe-based ICN protocol [8], and it is out of scope of this paper.

E. Delivery of Published Content to Subscribed Consumers

When producer publishes content, it is delivered to ICN GW based on the forwarding operation of ICN nodes in ICN

DN, since ICN GW has subscribed to the content already. Then, ICN GW buffers the received content, and searches for subscribed UEs IP addresses and corresponding UPF IP addresses for the published content. After that, ICN GW delivers published content to corresponding UPFs with subscribed UE IP addresses as destination IP addresses.

In pull-based ICN support based on Interest/Data exchange, PDU session from UPF to UE already exists when ICN GW receives content, since bi-directional PDU sessions are established when UE sends Interest packet [5]. However, PDU session from UPF to UE is not established yet in push-based ICN support when ICN GW receives content. Therefore, PDU session from UPF to UE should be established when UPF receives subscribed content from ICN GW. To do this, UPF performs network triggered service request procedure [7]. If UE is in connection management (CM)-idle state, UPF sends session report to SMF++ and SMF++ sends PDU session information with the UPF tunnel endpoint information to AMF++. Then, paging is carried out to notify UE the incoming content, UE performs UE triggered service request procedure, and content is delivered to UE successfully. If UE is in CM-connected state, only part of the mentioned network triggered service request is carried out, without paging, where PDU session update between AMF++ and SMF++ are executed mainly [7].

III. SUMMARY AND FUTURE WORK

In this paper, we proposed how to support publish-subscribe-based ICN in 5G core network. Implementation of the proposed procedures based on 5G open-source and consumer mobility support in publish-subscribe-based ICN will be carried out in our future work.

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