

Content Delivery in Smart Ubiquitous Network

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Abstract— As a large-scale content distribution becomes an important challenge in Internet, there are developed various approaches to address the challenge. ITU-T has standardized SUN (Smart Ubiquitous Network) as an evolved network concept that handles emerging Internet issues and now they are standardizing a functional architecture for content delivery in SUN. In this paper, we provide an overview of the functional architecture and operational procedures for content delivery in SUN.

Keywords— Smart ubiquitous network, SUN, content delivery

I. INTRODUCTION

As the World Wide Web is being richer in content, a large-scale content distribution becomes an important challenge in Internet. Recently, a “clean-slate” approach has been proposed to deliver content efficiently. Clean-slate approach suggests radical changes to the current Internet. It considers content as a main object and provides a general platform for obtaining the contents, not end-to-end communication between hosts. Such a resulted Internet redesign is now considered as one of candidate architectures for Future Internet [1]. Today, the clean-slate approach has been studied under several research projects: SAIL [2] and PURSUIT [3] in Europe, and DONA [4] and CCN [5] in USA.

However, when it comes to Internet history, the “clean-slate” approach has not seen large-scale deployment in real world [6]. Instead, Internet has adopted evolutionary approaches such as peer-to-peer (P2P) and content distribution networks (CDN). P2P and CDN place copies near the end-users to provide content with high availability and high performance. While P2P and CDN become popular now, they are application-level solutions and they are not fundamental enough to handle an explosive increase of content and services. Hence we need more evolutionary solution to distributed content in current Internet.

ITU-T is standardizing Smart Ubiquitous Network (SUN) [7], which is an IP-based packet network that can provide transport and delivery of a wide range of existing and emerging services to people and things. Content delivery has been considered as one of the essential services in SUN and thus functional architecture for content delivery in SUN is being standardized now [8]. This paper aims at providing an overview of the functional architecture and operational

procedures for content delivery in SUN. The functional architecture consists of three different functionalities such as content service coordination function, content delivery control function, and content delivery service function. These functions perform four operations such as content publication, content service provisioning, content routing, and content caching.

The remainder of the paper is organized as follows. Section II introduces a functional architecture for content delivery in SUN and Section III presents operational procedures to deliver content in SUN. Finally, Section IV concludes this paper.

II. CONTENT DELIVERY FUNCTIONAL ARCHITECTURE

A. Content Service Coordination Function

Content service coordination function (CSCF) play a role of coordination between the network and its customers, content providers and end-users, who provide and consume content in the network. CSCF includes two functional entities as follows.

- Content Publication Functional Entity (CP-FE)
- Content Service Functional Entity (CS-FE)

CP-FE generates IDs for the content to be published and extracts the optimal service node at which the content provider will store the content in SUN. CP-FE informs the optimal service node of the content provider so that content provider stores its content at the service node. CP-FE also registers the published content in content name resolution functional entity in CDCF, which will be described in Section B.

CS-FE provides end-users with an interface to SUN. CS-FE decides another optimal service node that delivers content to the end-user and redirects the end-user to the selected optimal service node using HTTP Redirection or DNS-based routing mechanism

B. Content Delivery Control Function

Content delivery control function (CDCF) maintains optimal service nodes based on content ID. CDCF consists of two functional entities as follows.

- Service Optimization Functional Entity (SO-FE)

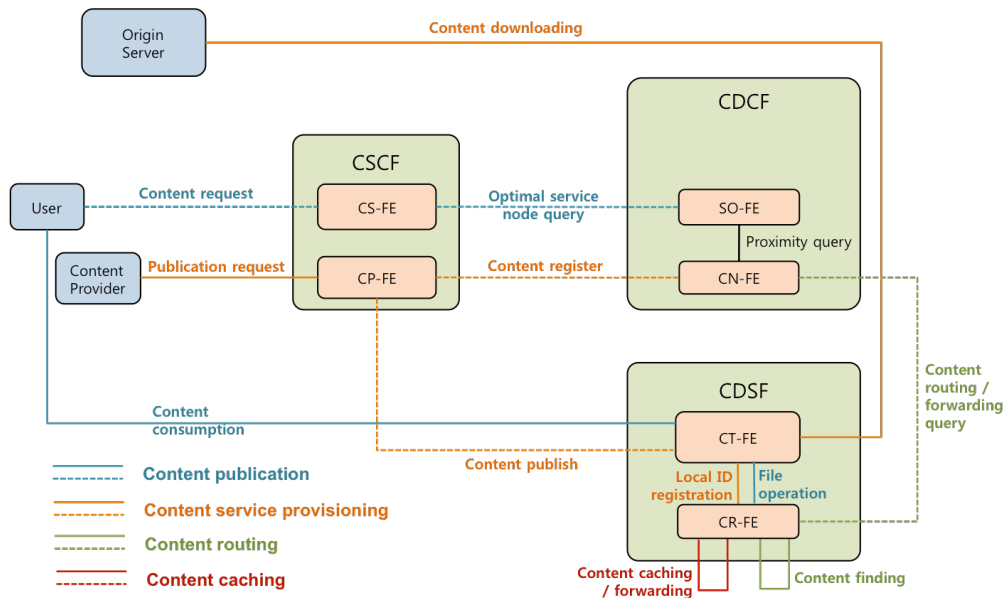


Figure 1 SUN content delivery functional architecture

- Content Name resolution Functional Entity (CN-FE)

SO-FE determines optimal selection of the service node based on proximity, network topology and service availabilities. CN-FE maintains content IDs along with their locators through registration, de-registration, and updating actions. Hence CN-FE responds ID-location query from forwarding service nodes such as routers.

C. Content Delivery Service Function

Content delivery service function (CDSF) provides the requested content to end-users through the name based content routing and delivery. CDSF could be built on forwarding service nodes. CDSF is composed of two functional entities as follows.

- Content Transport Functional Entity (CT-FE)
- Content Routing & caching Functional Entity (CR-FE)

CT-FE ingests content from the content provider by the request of CP-FE and deliveries the ingested content to the user via streaming, file transfer service and so on. If the requested content is not available at CT-FE, CT-FE initiates content routing procedures at CR-FE. CR-FE discovers the requested content and caches the discovered content. When CR-FE is given a content request, it first looks up its cache to find the requested content. If the cache stores the content, CR-FE responds to requester with the stored content. Otherwise, CR-FE requests the content to another CR-FE built on another service node. Once CR-FE receives requesting content from another CR-FE, it caches the received content and relays the content to the requester.

III. CONTENT DELIVERY OPERATIONAL PROCEDURES

A. Content Publication

Content publication is procedures in which content providers request SUN to publish their content. Figure 2 shows an information flow between functional entities for content publication. As shown in Figure 2, a content provider requests CP-FE to publish its content. The content provider presents URL and metadata for the content publication. The metadata includes network address (e.g., IP address) of the origin server for the content, content owner, content size, content type, and content format. Upon receiving the publication request, CP-FE generates a unique name (e.g., content ID) for the content and requests CN-FE to register the content. The content registration is the process that establishes content as a service item in SUN. CP-FE provides the generated name, URL, and metadata for the content registration. After receiving the content registration request, CN-FE queries SO-FE for the optimal service node where the content will be published. CN-FE provides URL of the content so that SO-FE select the optimal service node with URL and metadata. SO-FE selects the optimal service node for publishing the content and notifies the locator of the determined optimal service node. With the generated content name and notified locator, CN-FE updates the CRIB (Content name Resolution Information Base) that is a data table listing the locators associated with content names. Once updating the CRIB, CN-FE responds with the locator of the optimal publication service node to CP-FE. CP-FE makes a request for publishing content at CT-FE with the content name and URL to CT-FE. With given URL, CT-FE tries to download publishing content from the content provider. The content provider provides the its publishing content to CT-FE. Once the content downloading is completed, CT-FE registers the content at CR-FE so that CR-FE can be known the content is available. CR-FE registers the downloaded content and responds with the result of local registration to CT-FE. CT-FE

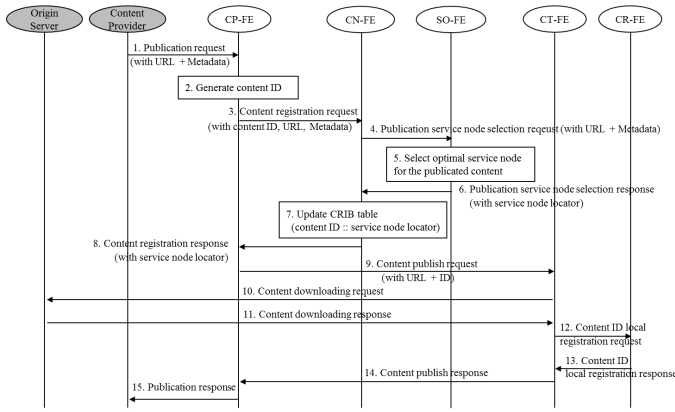


Figure 2. Content publication procedures

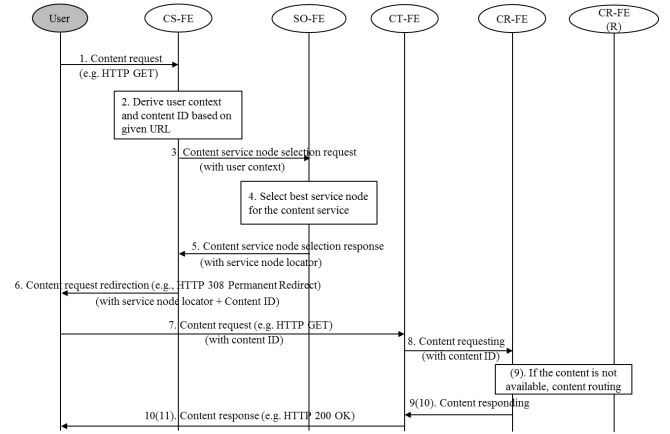


Figure 3. Content service provisioning procedures

responds with the result of content publication to CP-FE. Finally, CP-FE responds with the result of publication request to the content provider.

B. Content Service Provisioning

Content service provisioning is a kind of CDN (Content Delivery Network) request routing. Figure 3 shows an information flow between functional entities for content service provisioning after user's content request was redirected to SR-FE. In Figure 3, user requests content from CS-FE. Upon receiving content request from user, SR-FE derives user context information such as user IP address, content URL, and user device information. Also CS-FE derives the unique name of content (e.g., content ID) based on the content URL. With the derived user context information, CS-FE queries SO-FE for the optimal service node that provides the content for users. SO-FE selects the optimal service node for content service provisioning and notifies CS-FE of the locator of the selected optimal service node. After learning the optimal service node, CS-FE requests user to redirect its content request toward the selected optimal service node. With given optimal service node, user requests content from CT-FE that is running in the selected optimal service node. To identify the content, user makes use of the name of content (e.g., content ID) and then CT-FE requests content from CR-FE with the name of content (e.g., content ID). If the requested content is not registered to CR-FE in the selected optimal service node, CR-FE initiates a name-based content routing that will be presented in Section F. Otherwise, CR-FE responds with the content and then CT-FE provides the content to the user.

C. Content Routing

Content routing is to discover content location based on the content locators determined by content name. Figure 4 shows an information flow between functional entities for name-based content routing. Content routing procedures are initiated when local CR-FE (L) doesn't store or cache content requested by local CT-FE. Local CT-FE requests the local CR-FE (L) to find content with the name of content (e.g.,

content ID). If the local CR-FE (L) does not know the location of content, it queries CN-FE for the content locators with the name of content. The content locator is subject to be an IP address of the node in the SUN with additional forwarding information to it. Upon receiving content locator query, CN-FE resolves the content locators binding to the name of content. CN-FE responds the content locators to the local CT-FE. The local CR-FE (L) requests content from a remote CR-FE (Up) that is on the upstream path to the content locator. If the remote CR-FE (Up) stores or caches the requesting content, it transfers the requesting content to the local CR-FE (L). Otherwise, the remote CR-FE (Up) requests content from another remote CR-FE.

D. Content Caching

SUN architectures consider caches as an integral part of the network to keep popular contents resident throughout the network. Service nodes store copies of the passing content into their caches and subsequent content requests can be satisfied from the caches. Figure 5 shows an information flow between functional entities for content caching. In Figure 5, remote CR-FE (R) receives the responding content requests from another remote CR-FE (Up) on the upstream path to content locator. The remote CR-FE (R) caches the received

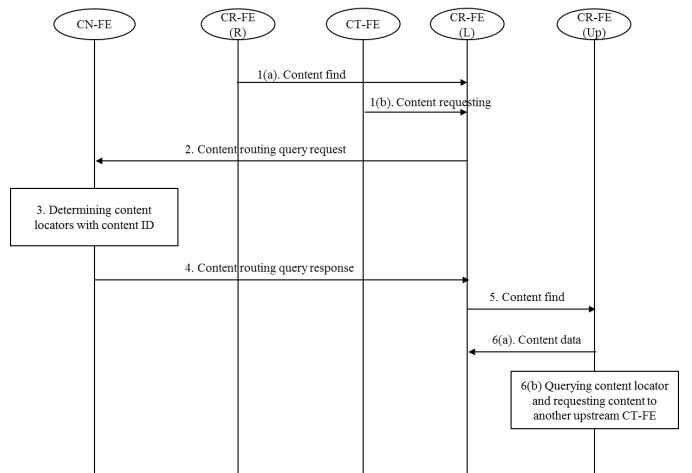


Figure 4. Content routing procedures

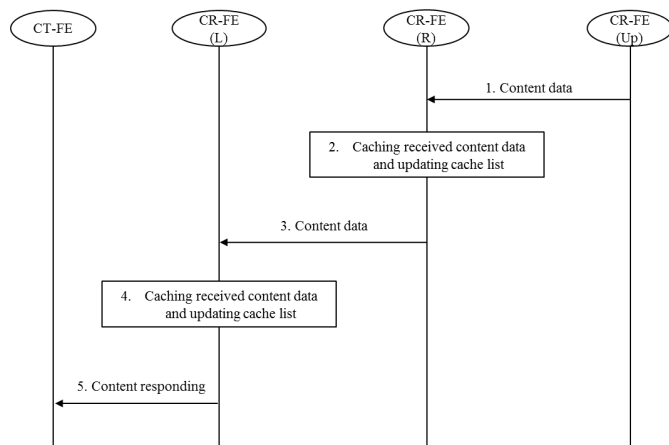


Figure 5. Content caching procedures

content in its storage and updates its caching list that maintains records of cached content. Subsequently, the Remote CR-FE (R) forwards the received content to local CR-FE (L) that requested it. Local CR-FE (L) caches the received content in its storage and updates the caching list that maintains records of cached content. Finally, the local CR-FE (L) delivers the responding content to local CT-FE.

IV. CONCLUSIONS

In this paper, we have discussed the functional architecture and operational procedures for content delivery in SUN. The functional architecture has three different functionalities such as content service coordination function, content delivery control function, and content delivery service function. These functions have four operations such as content publication, content service provisioning, content routing, and content caching.

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Internet.

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