

Traffic Offloading to Millimeter Wave Access Network based on Content-Centric Networking

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ABSTRACT

In this paper, we propose a novel traffic offloading technique based on Content-Centric Networking (CCN). This technique does not require any change in applications, but provides traffic offloading and high-speed communication. It achieves this by using the advantages of CCN, which include a connection-less data stream and a time independence. This paper presents a system design for mobile traffic offloading and its implementation.

Categories and Subject Descriptors

C.2.1 [Computer-Communication Networks]: Network Architecture and Design

General Terms

Design, Performance

Keywords

Content-Centric Networking; Mobile Traffic Offloading; Millimeter Wave

1. INTRODUCTION

Mobile traffic offloading to Wi-Fi is widely practiced as a way to maximize the use of multiple frequencies and to reduce data traffic on mobile networks. According to a survey conducted by the Ministry of Internal Affairs and Communications of Japan in 2012 [4], 32.7% of the total amount of traffic involved smartphone offloads to Wi-Fi networks, which include personal Wi-Fi access points at home. Meanwhile the advantage of Wi-Fi's line speed over mobile networks has declined with the spread of LTE. Wi-Fi demands the use of a higher frequency band, i.e., the 60 GHz bands, for high-speed communication [3].

This paper focuses on offloading mobile traffic onto 60 GHz millimeter wave band, which is an unlicensed band that is expected to be widely used in the near future. This frequency band can provide high-speed wireless data transfer by its wide bandwidth, however its directionality and strong absorption limit the coverage area. The

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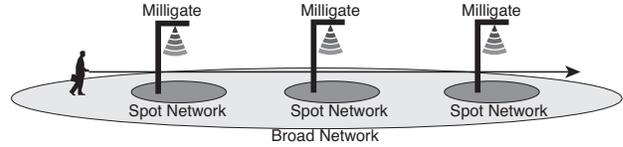


Figure 1: Concept of Milligate Access Network which Consists Broad Network and Spot Networks

extremely small coverage area has both advantages and disadvantages. An advantage is that a user is able to monopolize a high-speed link since the number of users in the same area is very small. A disadvantage is that line disconnection occurs frequently since a user passes through the small area in a very short time. Thus the utilization of the high frequency band requires the transfer of a large amount of data in a short connection time. But keeping the connection and congestion control make it difficult to apply the existing offloading technique to the extremely high-frequency band access network.

The authors have studied about mobile traffic offloading on the CCN architecture with an eye to using the high-frequency band. The key idea of our study is dynamic preemptive transferring on the extremely high-frequency band. This idea ensures efficient mobile traffic offloading even if residence time in the area covered by high-frequency band is as short as a few seconds.

2. MILLIGATE ACCESS NETWORK

Figure 1 illustrates the concept of the proposed access network which is called the *milligate access network*, which consists of a broad network and spot networks. The broad network covers a wide area, but its bandwidth is not very high, like a 3G/LTE mobile network. The spot network covers only extremely narrow areas, but provides higher bandwidth, like a 60 GHz millimeter wave network. A user walks through the networks with a device that can make use of both of them. The user starts to download a content via the broad network. When the user enters into a spot network coverage area, part of the content is transferred via the spot network. After multiple passages through spot network coverage, the user will get the complete content. Help from the spot networks improves the content download time and offloads some portion of the broad network traffic onto the spot networks.

The spot network's access points (hereinafter referred to as *milligate*) are located at places frequented by walkers, such as a ticket gate, facility entrance or a utility pole near a sidewalk. These places are sufficiently confined so that users are constrained to cross the spot network's coverage area. In addition, such placements make it easy to predict the next transit. For example, if a user passes under

a utility pole, the user would likely pass by the next utility pole on the street within a predictable time. However the coverage of the spot network is considerably smaller than 20 meters in diameter and a working user passes through the spot network within a few seconds.

3. CHALLENGES

The aim of our research is to develop a content delivery system on the milligate access network and to establish mobile data traffic offloading onto the spot network. As discussed in earlier sections, the spot network provides a monopolized high-speed bandwidth for a very short time. For an efficiently utilized spot network, burst transmission seems to be suitable, but it is not compatible with the broad network. Thus we require a method to aggregate the different transmission methods, i.e., burst transmission and congestion-control based transmission. The content-centric approach helps the aggregation by the removal of connection-oriented sessions and the independency from transmission methods. The challenge of us is to develop an aggregation method with the following features:

- Network Compatibility: The proposed method must be developed without any changes to the current mobile network which is assumed as the broad network.
- Application Compatibility: The proposed method must not require any application's supports. Moreover, the modification of network elements, such as mobile devices, router and server, is kept to a minimum.

4. SYSTEM OVERVIEW

The basic idea of seamless aggregation of broad and spot networks is to leverage the content store function of mobile devices. A mobile device downloads content via the broad network and the system preempts a part of the content via the spot network. Since the preemptive part does not need a delivery via the broad network, it relieves a traffic load on the board network.

Figure 2 shows the system diagram, which includes mobile device, repository node, control node and milligate. This system is based on CCNx [1], and the shadowed boxes refer to the new functions in the proposed method. The arrowed line shows the two data transmission flows. The first flow carries data from the repository to the application via the broad network using the CCNx protocol. The application recognizes only this data flow, similarly to current CCNx applications. The second flow carries preempted data to the content store of mobile device via the spot network.

CCNx transfers data based on a request-reply procedure, and a CCNx node checks its content store before it forwards a request message, i.e., interest message. If there is a required data segment in the content store, it replies the data segment instead of the original node, i.e., repository. The prefetcher monitors the mobile device and uploads the monitored information, e.g., the received data segment number and the user's geographical location and velocity, to the controller. The controller predicts user mobility from this information and decides the range of preempted data segments, and the corresponding booster. When the mobile device enters into the spot network's coverage area, the prefetcher receives data segments from the booster with burst transmission and puts it into content store. The CCNx protocol stack uses the prefetched data segments when the segment is required, and the downloaded data is offloaded to the spot network seamlessly.

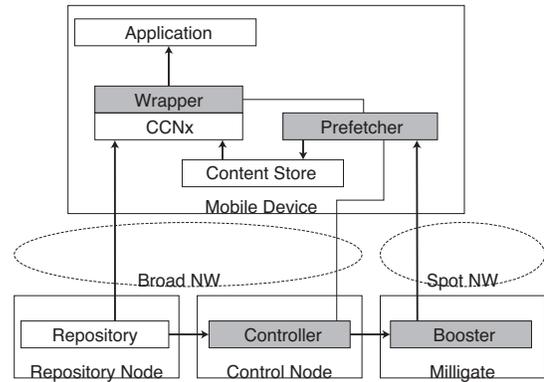


Figure 2: System Diagram of Content Distribution System on Milligate Access Network

5. IMPLEMENTATION

We constructed the proposed system using a prototype of the milliwave device[2]. Each functions were implemented on the Linux OS and CCNx 0.8.8 [1]. The trial environment consists of two PCs that have a 60 GHz device. A device is located at one meter away from another device. The PCs join a Wi-Fi network (802.11n) which is used as the broad network. On the elementary evaluation, if the spot network's coverage spots were closely spaced, e.g., every a ten meters, 94% of a 1 Gbytes content downloading was transferred on the spot network.

6. CONCLUSION

This paper presented a novel access network consisting of a broad network and a spot network and proposed a content delivery method for it. The method took advantage of CCNx functions, in particular content store and connection-less communication, and established seamless aggregation between burst transmission and congestion-control based transmission. The prototype implementation on CCNx demonstrated the proper operation and the performance of the proposed method. The method considered practical compatibility with the current mobile network, required no supporting applications, and would be easy to develop on the current mobile network.

7. ACKNOWLEDGEMENT

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