NETWORK INTERFACE VIRTUALIZATION IN WIRELESS COMMUNICATION FOR MULTI-STREAMING SERVICE

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ABSTRACT

In this paper, we suggest a multiple streaming method with virtualized network interface in wireless environment. A virtualization provides new interface mechanism to system by mitigating restrictions of hardware. Our virtualized system which has virtualized network interface can communicate with multiple AP(Access Point)s as system has several network interfaces in wireless environment. Each several virtualized network interface connect with several APs. The most stable connection becomes main-connection and others become sub-connections. By this mechanism we can improve streaming performance such as multi-path streaming without relay server, ensuring flexibility for mobile communication, providing better quality of service with SVC encoded video and improving error resilience in wireless environment.

1. INTRODUCTION

Recently, many studies of virtualization have been conducted as a method of mitigation hardware restriction. The first appeared of virtualization is to using efficiently resource of server. Then now it used not only to system virtualization but also network virtualization. The virtualization technology can be applied many systems which use computer hardware. Especially, if we can use the virtualization to wireless communication, we can expect performance improvement of mobile devices which use wireless communication. In generally used mobile device which use wireless such as laptop computers, PDAs, cellular phones and many other mobile systems have many restrictions of communication rather than wired. These restrictions are poor bandwidth condition, changing channel when moved on to other access point, retransmission of connecting information when changed channel and etc. And these restrictions cause service delay, low quality of service and downing efficiency of mobile devices.

To solve this problem, we suggest a virtualization of network interface. A device which has one network interface card(NIC) can virtualized as it has several network interface cards. The virtualized network interface card is separated and each separated network interface connects to each AP(Access Point)s. In this paper we suppose general case that there are multiple APs around a mobile device. When we are in library, campus, hospital, café, and many other locations of city which provide internet access, we can find multiple APs with mobile devices like notebook computer or smart phone. Then we select most stable bandwidth connection. However in this case, if we can use other APs as sub-connections, then we can get more bandwidth by sub-connections help when the originally connected communication goes to waiting state.

In our suggested method, each virtualized network interface connects to multiple APs. The most stable connection becomes to main-connection as we select in traditional way that our device has one network interface. And others become sub-connection additionally. When the main-connection state goes to sleep then sub-connection wake up and keep going communication. On the other hand, if a condition of main-connection getting worse, then sub-connection should instead role of main-connection. When the channel condition of main-connection comes to good, or wakes up from sleep state, the communication could be maintained through main-connection because the main-connection always has highest priority. This makes wireless communication to continue.

As we mentioned above, this method provide flexibility to mobile device communication. Although a communication route become unstable or interrupted, the communication of mobile device can be maintained continually by other connection routes. Similarly, it means that this method provides fast recovery for stoppage of communication. Furthermore, It is highly probable that applied with SVC(Scalable Video Codec) streaming. It can support variable video quality more flexible and also multi-path streaming without relay server. There are cost savings with doesn't establish additional equipment for multi-path streaming.

The outline of the paper is organized as follows. In section 2, we introduce related work of virtualization. The architecture of our system is discussed in section 3. And section 4 describes channel swap algorithm of our system. Finally, section 5 gives conclusions and explains future works.

2. RELATED WORK

Virtualization is a technique that efficient controls interaction between user, application, system and computing resource which is abstract of physical specific. Virtualization can be applied almost all part of computer science such as CPU, memory, I/O device, applications and other hardware resource.

If we take advantage of virtualization technology, we can maximize the utilization of current resources. For instance, a hardware or equipment can do several works. On the other hand, several hardware or equipments act as one equipment. As a result, the reduction of administrative costs can be guaranteed. And these properties increase flexibility and availability of system.

The current virtualization technologies of network broadly divided into three parts that host virtualization, link virtualization, routing virtualization [1, 2]. Host virtualization is a method that virtualizes terminal device itself. This method makes various applications which have relation with various operating systems to executable on the host. There are two virtualization techniques that pull-virtualization and para-virtualization. Pull-virtualization virtualizes whole system. And para-virtualization means that virtualizes a part of system. Link virtualization provides VNIC(virtual network interface card) which has several virtualized network interface in one physical network device. Routing virtualization make multiple virtual routers from a physical router by separation of resource.

In this paper, we apply concept of link virtualization to wireless communication. And we suggest a new mechanism of virtualization for efficient communication and streaming SVC encoded video data in wireless environment.

3. VIRTUALIZATION OF NETWORK INTERFACE

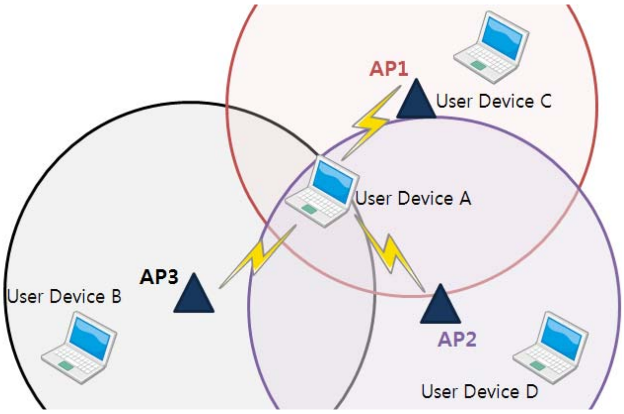

Figure 1. Example of devices in multiple APs signal area

In general case, as we mentioned in introduction, there are several APs near the user device as shown figure 1. The user device A is placed in overlap area of each AP communication in WLAN environment. Each AP has different signal strength. The user device A has only one network interface card for WLAN communication. In position of the user device A, the order of signal strength is AP1, AP2, AP3. In this case, AP1 is selected for communication. Hopefully, It would be like to use all the bandwidth from AP1, but unfortunately, the user device A competes with other devices which choose AP1 to communicate in AP1 signal area. The user device A occupy channel during certain time when the channel is empty. This mechanism is CSMA/CA(Carrier Sense Multiple Access with Collision Avoidance) which is provided by IEEE 802.11 standard[9]. As shown in figure 1, the user device A shares the channel of AP1 with user device C. If the user device C occupies the channel, then user device A goes to waiting state. Long term of waiting state means decrement of transmitted data per unit time. If the channel crowd, there is more decrement and more delay. At that time if there are any other idle channels such as AP2 and AP3 in figure 1, it can use these channels to communicate continuously.

This mechanism is already proposed and verified as Cognitive Radio [7, 8, 14]. However, frequently channel hopping has a big overhead with single interface [11]. And it needs very complex technical supports. Even so it is not to add other interface. It causes burden of additional cost to emplace additional interface hardware. For these reasons, we need virtualization which provides more suitable, flexible and saving costs.

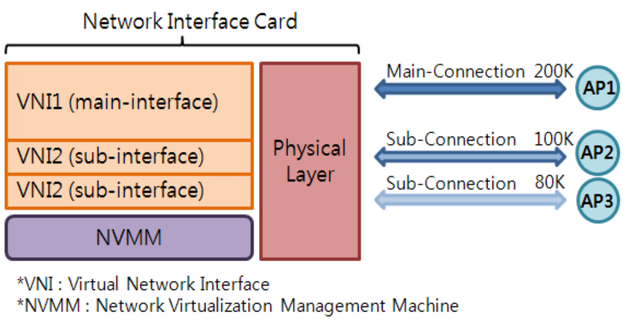

Figure 2. Network Interface Virtualization

We configure network interface virtualization as shown in figure 2. The NVMM is network virtualization management machine. And the VNI means virtual network interface which is separated by virtualization. The NVMM works as a device driver of NIC in a user terminal. It manages functions between VNIs such as priority of communication order and channel swapping mechanism. NIC of user device is separated as the number of APs which is searched around user device. Or it can be separated by a user. And each separated VNI is configured as it has own MAC-address.

The most stable bandwidth connection is connection between VNI1 and AP1. It becomes main connection. And the VNI1 becomes main-network interface while the connection is maintained as good bandwidth. The others (VNI2, VNI3) become sub-network interface and make sub-connection with AP2 and AP3. The main VNI has always highest priority than others and it is scheduled by NVMM. Most part of communication is done through main-connection unless the connection is interrupted or bandwidth getting worse. If the main-connection getting worse or is interrupted, then sub-connection which is secondary quality of connection is replaced for main-connection.

4. CHANNEL SWAPPING ALGORITHM

In this chapter, we describe channel swapping mechanism which is performed by NVMM. In the behavior of virtualization, it needs that changing system state between VNIs, because a VNI is separated from one physical network interface. It means that only one VNI can communicate at a time. Since the virtualization makes system as virtual, and provides virtual interface to user or system itself, but the physical capacity of hardware does not change.

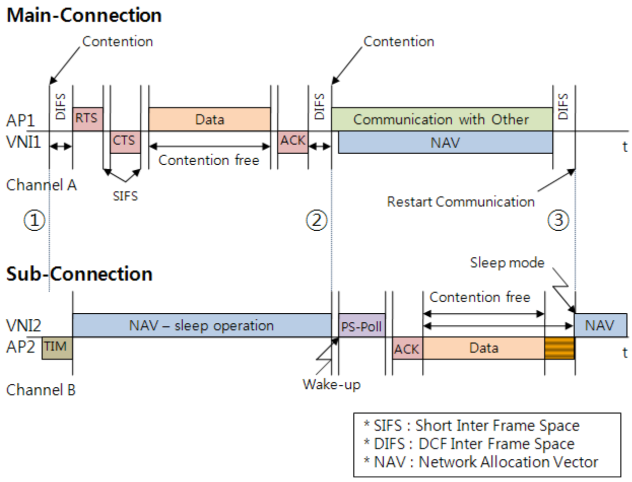

Figure 3. Channel Swap in Virtualized Network Interface

As shown in figure 3, this mechanism follows CSMA/CA mechanism basically. It needs very tight synchronization. When a communication begins, each VNI tries to connect each AP and then they register their own virtualized MAC address sequentially to TIM(Traffic Indication Map) of AP. Thereafter, the NVMM sets the order of VNIs as shown in figure 2. The main VNI which has main-connection with most stable bandwidth is granted highest priority.

We define three channel conditions to swapping VNIs in figure 3. In state 1: AP1 channel is empty. The VNI1 starts to communication after check there is no carrier wave. When the VNI1 in the main-connection is activated, it works the same way as a conventional wireless communication. The sub-connection is sleeping at this time.

But if the main-connection goes to waiting state because of pass over the channel to another user by channel contention such as state 2, then the sub-connection wake up with ps-poll message which controlled by NVMM. The NVMM monitors VNIs, and controls them whether wake up or not. The VNI2, VNI3 which are linked as sub-connection operate like power-saving mode of 802.11 standard. The connection cycle of the sub-connection is done only when the main-connection goes to sleep or does not work. The NVMM always monitors TIM which is sent periodically from AP1. If the TIM from AP1 does not contain communication schedule of VNI1, then the NVMM commands to perform the sub-connection. When user device communicates through the sub-connection, the NVMM observes the channel of AP1 at this point.

The communication channel switching is done when the waiting time of VNI1 longer than DIFS (DCF Inter Frame Spacing) time in basically. Because a device waiting DIFS time before communication with an AP when the device does not sense any carrier wave which means that the channel is empty after other device finished communication with the AP.

In State 3: VNI1 restart communication. If the main-connection has defeated in contention by other device, and it takes long term to waiting, then the communication of the sub-connection has to spare relatively. The NVMM controls that, if the VNI1 is pushed back on the priority list of AP1 for communication subsequently, the VNI1 sets additional waiting time that is random offset. If VNI1 is defeated again after the random offset time when channel becomes free, then sub-connection keep going it's duty. The VNI2 goes to sleep state when the VNI1 wake up time VNI1 during the communication. Data to transmit to VNI2 is buffered in AP2. VNI2 could be received these data by sending a ps-poll message when VNI1 goes to waiting state.

5. IMPLEMENTATION

5.1 Mobile Device

Our system can be applied to mobile device which is moving continuously. Figure 4 shows maintenance of communication when mobile device keeps moving. In this figure, the user device A has virtualized by two network interfaces VNI1 and VNI2. And suppose that user device A is moving start from location 1 and goes to location 3 through location 2.

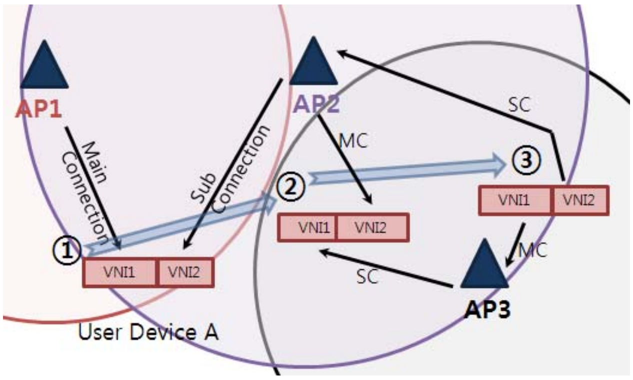

Figure 4. Mobile Maintenance of Virtualized Network Interface

When the user device A is placed in location 1, there are two signals from AP1 and AP2. Suppose that there is no factor which infects to communication such as barriers. The user device A receive more strongly signal from AP1 than signal from AP2. In this case, NVMM of the user device A sets VNI1 as a main VNI which communicate with AP1. This connection becomes main-connection. And VNI2 is set to communicate as a sub-connection. The user device A is going to location 2. When the user device A approach to location 2, then the strength of signals change. The signal from AP2 is stronger than signal from AP1. In this case, VNI2 becomes main VNI instead of VNI1. And the connection between VNI2 and AP2 becomes main-connection.

At location 2, there is no signal from AP1 any longer. But new signal from AP3 is detected. The NVMM compares these signals strength and decides which one occupies main VNI. The VNI2 keeps main-connection until the signal from AP3 is getting stronger than signal from AP2. And VNI2 is set as sub VNI which has sub-connection.

In location 3, the state of affairs is changed again. The VNI1 gets main-connection and the VNI2 becomes sub-connection by comparison of signal strength.

As we have seen above, this implementation can provide maintenance of communication of mobile device which is moving on continuously. It means that it can reduce delay which can occur in mobile communication. And also ensure flexibility for mobile communication.

5.2 SVC Video Streaming

Our method can be also applied video streaming system. For example, it matched perfectly to SVC(Scalable Video Codec) encoded video such as h.264[3,5,6,12]. The SVC means that it is encoded by several level layered video from original video.

A base layer data is most important data for decoding video. It contains necessary basic data like I-frames and P-frames. It must need for decoding video successfully. Enhancement layer is separated several levels. An enhancement layer data has additional information for better quality of video decoding. It is not necessary but needs for improving of video quality.

Figure 5 shows SVC video streaming system of virtualized network interface. The server has separated video data which is encoded h.264 SVC.

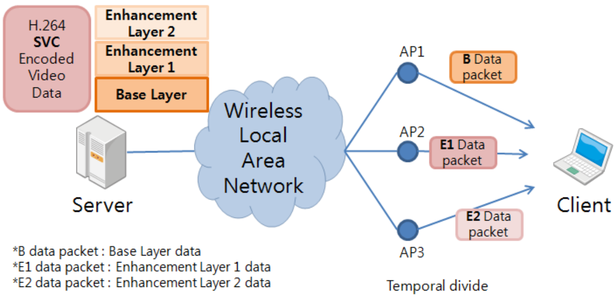

Figure 5. SVC Video Streaming System of Virtualized Network Interface

Most of the data is transmitted through the main-connection such as base layer data and some of enhancement layer data. When the main-connection goes to sleep then sub-connection wakes up as we mentioned before chapter. Then it begins to receive enhancement layer data which could be saved in the buffer of AP through sub-connection with ps-poll message. If the main-connection wakes up, then sub-connection goes to sleep immediately to minimize additional overhead even it is not complete to receive, because more enhancement data can grantee better quality but it is not necessary certainly.

This system can provide more advantage for video streaming that is multipath streaming without relay server. And also it can improve quality of video streaming and error resilience. It means that save cost for additional hardware equipments such as network interface, relay server.

6. CONCLUSION

Virtualization makes possible to serve variable service by mitigating limitations of hardware. And it can use many resources efficiently. The mechanism of mobile system can be changed more efficiently by virtualization.

A virtualized mobile device which has a network interface can be worked as it has multiple network interfaces. In general, if there are several signals from several APs around a user device, virtualized network interface(VNI) of a user device connects multiple APs. A VNI has own virtual MAC address which is granted from NVMM, and registers to connected AP with this MAC address.

The most stable bandwidth connection between VNI and AP becomes main connection. The others become sub-connection. The VNI of main-connection becomes main-interface while the connection is maintained with good bandwidth. The main-connection which is scheduled by NVMM has always highest priority than others. It can communicate continuously through the sub-connections when the main-connection becomes to waiting state. It should be possible for flexible and advanced communication.

Our method can be applied many other systems for mobile device. Especially, video streaming that uses SVC. The SVC encoded video data has base layer data which is basic essential data for decoding video and enhancement layer data which is additional data for better quality of video. If we transmit a base layer data through main-connection and transmit enhancement layer data through sub-connection, we can get more advantage for video streaming such as multipath streaming without relay server, improvement of quality and error resilience. In addition, our method can save additional cost that needs for additional hardware equipments.

For future work, we will analyze comparison between performance improvement and system overhead. And also we will experiment performance of virtualization in variable communication environment to find more optimal channel switching. It is need that stochastic approach of switching algorithm between main-connection and sub-connection. We hope that our suggestion contributes to many other studies.

7. ACKNOWLEDGMENT

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