Plan for Future Network Research Collaboration between USTC and WINLAB

(Draft)

1. Goals

Due to the evolution and ever-increasing demand of wireless and mobile technologies, mobility becomes ubiquitous, and "Everything is mobile". As well, the multimedia services have been contributing extensively to our life experience and are expected to be one of the most important applications in future network. However, the mobile multimedia services cannot be supported well by existing cellular networks or Internet. A feasible cost-efficient solution is to form a single mobile converged network within which the telephone, multimedia and data communication efficiently coexist. Given the expertise of WINLAB in mobility, e.g. MobilityFirst, and USTC's extensive works in multimedia technologies, our collaborative research will be aimed to explore new approaches to support emerging trends of network mobility, more specifically, in the area of "multimedia service infrastructure and applications in future network" (or "***Multimedia on MobilityFirst***").

2. Current Research Activities

✧ ***Wireless Scalable Video Coding (WSVC)***

With the rapid development of wireless network and mobile terminals, wireless video services are becoming increasingly important and popular. However, conventional wireless video delivery scheme is unsuitable for the emerging wireless video services. Because it faces some problems like fast unpredictable variations of channel quality, difficulty of instantaneous adaption between video rate and channel bitrate, and bitrate selection between transmitter and receivers. If joint analog and digital approach to broadcast video, we only need broadcast a single stream and each receiver decodes a video quality commensurate with its instantaneous channel quality gracefully. It also doesn't need any source effort and receiver feedback. Aiming at this point, we have proposed a novel wireless scalable video coding (WSVC) framework and published a paper in IEEE Transactions on Circuits and System for Video Technology.

✧ ***A Node for Future Network Testbed (USTC-Rack)***

In order to facilitate the researches and innovations in future network, we design and implement a node for future network testbed called USTC-Rack which enables the research community to conduct experiments in an OpenFlow-enabled cloud computing environment.

USTC-Rack physically integrates all equipment into one rack. The resources of USTC-Rack are gathered into *resource aggregate agent* which include: a) computing manager, which offer servers and Virtual Machines (VMs); b) network manager, which offer Layer 2 (L2) connections with

optional OpenFlow features. USTC-Rack offers a deep programmability for all resources, including computing, storage and network resources and a virtualized infrastructure, which allows for flexible integration of test and production traffic by isolating the traffic domains inside the OpenFlow-enabled network devices.

In addition, in order to enhance the international collaboration and support international experiments and resource sharing, we deployed a federated connection from USTC to Northwestern University of U.S. via UDP-tunnel.

✧ ***DiffServ/Label Switching***

It is well known that packet switching cannot provide guaranteed service, compared to circuit-switching, due to its property of sharing network resources. This drawback greatly impacts the applications that require high availability and low latency. To overcome this weakness, researchers have tried for years to introduce differentiated services into packet-switching networks, such as priority queueing (PQ). However, an application can deceive network nodes and get additional network resources regardless the nature of the application. Such a cheating behavior makes these methods meaningless. The key problem is that these approaches cannot avoid cheating behaviors without excessive cost, and this vulnerability leads to their failures in practice. So the task is that we should design the network so that all applications will honestly label their packets to claim the resources they need.

To solve the cheating problem, we apply game theory into scheduling packets. And we also introduce packet drop as a function of network node. Also, we propose the concept of virtual bandwidth, which provides a method to allocate network resource.

✧ ***SDM^{2}Cast***

Layered multimedia multicast is a promising way to improve the usage of bandwidth resource in the condition of guaranteeing multicast receivers' Quality-of-Experience (QoE), while it isn't widely used in current inflexible internet. Software-Defined Networking (SDN) is a new network architecture supporting intelligent and dynamic nature of future network and applications. We design a layered video multicast framework in the context of SDN (SDM^{2}Cast), which enables in-network identifying, processing and manipulating the media streams and makes prompt bitrate adaptation possible in response to network fluctuations. The framework can also support admission control in a multicast context. A prototype and experiment results show the success of the framework. Fig. 1 depicts the framework of SDM^{2}Cast.

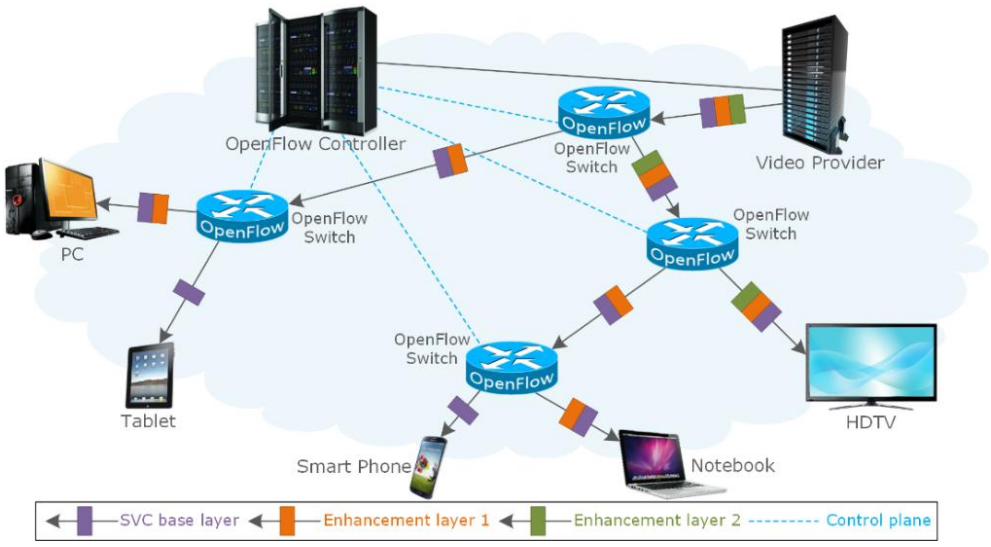

Fig. 1 The framework of SDM^{2}Cast

3. Research Focus of Collaboration

Considering our previous works, research interests and the characteristics of MobilityFirst, the primary research goal of "***Multimedia on MobilityFirst***" is to identify issues pertains to multimedia services in future network infrastructure and to explore efficient mechanisms for supporting explosively growing mobile population and creative mobile applications.

We sketchily classify potential research topics into three clusters as shown in Fig. 2. In the physical layer, the focus is to explore analog-based approach in video broadcasting. For the network layer, the implement of telecom services in future network is considered. As to service layer, we are interested in the typical multimedia transmission paradigm including one-to-one, one-to-many, many-to-many and many-to-one. The details are described in the following sections.

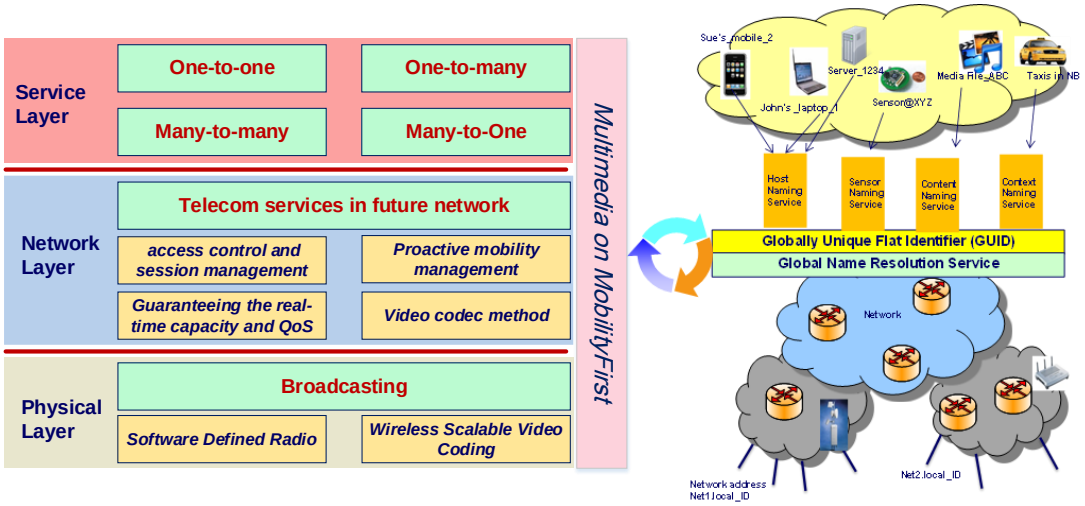

Fig. 2 Overview of research topics

3.1. Physical layer

■ *Broadcasting*

An important issue in wireless environment including MobilityFirst is to take full advantage of the frequency band. However, the radio engineering today leads to a low use-ratio of frequency band. as a consequence, conventional wireless video delivery scheme is not suitable for the emerging wireless video services due to problems such as unpredictable rapid variations of channel quality, difficulty of instantaneous adaption between video rate and channel bitrate, and bitrate selection between transmitter and receivers.

Video broadcasting using an analog approach hold the promise of achieving more efficient video delivery. By using analog approach, we only need broadcast a single stream and each receiver decodes a video quality commensurate with its instantaneous channel quality gracefully. In our previous work, we adopted a joint analog and digital approach as a possible solution. More researches are needed to make a progress in this area. We intended to work on:

- ✓ Wireless Scalable Video Coding: Explore other novel and more efficient linear video coding approaches to realize better performance.
- ✓ Software-defined radio (SDR): SDR is the engineering pursue in wireless communication technology field that some or all wireless signal processing functions, which are typically implemented in hardware today, will be done completely in software. Therefore, here SDR is expected to support us to develop a physical method/device to achieve the analog video signal broadcasting.

3.2. Network layer

■ *Telecom services in future network*

Telecom services like real-time voice call play an important role in our daily life, but the seemingly granted quality of service (QoS) of such applications often cannot be guaranteed over conventional Internet. "Network convergence is also media convergence". The telephone, video and data communication need to be efficiently coexisting within a single converged network. In such a single converged future network, implementing the carrier grade services with the demand of user session management, always online, high QoS, high quality of experience (QoE), robustness, moderate cost, security and privacy is still challenging.

- ✓ A unified access control and session management: In order to meet the demands of user management and session management in converged future network, as well keep users always online once they access the network, a unified access control and session management must be designed on MobilityFirst.
- ✓ Proactive mobility management: It is worth to propose a fundamental for proactive mobility management technology which achieve location management and seamless handover functions based on mobility prediction.
- ✓ Guaranteeing the real-time capability and QoS: The most concerned problem of a phone call

may be the real-time capability and QoS, therefore, special mechanisms, e.g. label switching and adaptive media transmission, should be applied to guarantee the real-time capability and QoS.

- ✓ Video codec method: Researches on video codec method is feasible to make it adapt to the MobilityFirst communication environment. The hop-by-hop transmission as well caching mechanism in MobilityFirst make the control channel signal unnecessary in multi-user video conference scenario.

3.3. Service layer

■ *One-to-one multimedia services*

One-to-one is the basic transmission paradigm in a network which includes both real time and non-real time applications. Typical one-to-one multimedia services contain telephone call, video call, video-on-demand, and common one-to-one media data transmission, etc. Considering the characteristics of MobilityFirst, e.g. named content, storage/caching aware routing and hop by hop routing, it is worth to achieve the basic multimedia transmission paradigm. Of course, adaptive multimedia transmission, label switching, data scheduling, path planning, content management exploiting clouds (including micro-cloud or femto-cloud) and in-network storage, and mobility management (including device mobility, data/service mobility) also need be studied to achieve QoS guaranteeing, cost saving and energy efficiency, etc. These also need be considered for the following topics.

■ *One-to-many multimedia services*

One-to-many, also known as multicast, is a group communication paradigm where data is addressed to a group of destination devices simultaneously. In our previous researches about one-to-many multimedia transmission, we didn't consider much about the mobility of users or media source. Once the mobility occurs, the multimedia services may be interrupted and leads to a poor QoE. Therefore, we intend to extend our previous work to MobilityFirst by considering the caching aware routing, in-network caching/transcoding, etc.

■ *Many-to-many multimedia services*

Many-to-many communication paradigm is characterized by multiple users contributing and receiving information. The data transmission in many-to-many multimedia services is often bidirectional. A typical many-to-many multimedia application is multi-party voice/video conference. However, for such applications, the real-time capability and QoS still cannot be guaranteed in current networks. In a mobile environment, many-to-many multimedia services will face additional challenges including concurrent source and destination mobility, dynamic bandwidth allocation, etc.

■ *Many-to-one multimedia services*

Many-to-one is another important data transmission paradigm with many sender and one receiver, such as video surveillance, data gathering in sensor network, and is a reverse of one-to-many.

4. Implementation Details

4.1. Focused Topics

To achieve the research goal of "***Multimedia on MobilityFirst***", the prime experiments we focus are listed as follows:

- ✓ Some basic experiments such as named media content transmission, named media content management and distribution, and storage aware/hop-by-hop routing.
- ✓ One-to-one multimedia transmission and some typical one-to-one multimedia applications with QoS guaranteeing, adaptive transmission, and real-time capability, source/destination mobility, etc.
- ✓ Wireless scalable video coding and video broadcasting using an analog approach via SDR.
- ✓ The telecom services on MobilityFirst with QoS guaranteeing, real-time capability and proactive mobility management, etc.
- ✓ Pushing forward and realizing the one-to-many, many-to-many and many-to-one multimedia services on MobilityFirst based on the work "one-to-one multimedia transmission".
- ✓ Multimedia applications in different scenarios, e.g. cellular/WiFi multi-homing, M2M, IoT, mobile cloud media services.
- ✓ Experimenting our multimedia technologies in the whole MobilityFirst network by deploying some transnational multimedia applications, such as video conference and telephone call, crossing the domain in U.S. and the domain in USTC.

4.2. Facility Needs

For implementing "Multimedia on MobilityFirst" and running the corresponding experiment listed above, we intend to build a federated **M**ultimedia **M**obility**F**irst domain in USTC (**MMF**) as a part of the entire MobilityFirst network which will be connected to the MobilityFirst domain deployed on GENI. We also expect to utilize the excellent testbed ORBIT.

As shown in Fig. 3, in our lab, there exists experimental network with WiFi and LTE which can be utilized to deploy MobilityFirst. This local Multimedia MobilityFirst domain in USTC makes us a better understanding of MobilityFirst and run some local experiments more conveniently. The federated connection to the MobilityFirst prototype system on GENI can be achieved by deploying a UDP-tunnel from USTC to WINLAB, which can enhance the international collaboration, realize federated resource access and help us to experiment our multimedia technologies in the whole MobilityFirst network.

To enrich the experimental environment and support more experiments, more relevant facilities will be integrated into our **MMF**, e.g. SDR facilities.

(An appended picture in the last page, Fig. 3)

5. List of participants

■ **Faculty**

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■ **Students**

At present, 8 students work on this collaboration project:

Chen Yu, Zheng Zhong, Yuanzun Zhang, Chuanbin Liu, Sanshan Gao, Yang Yue, Yuanlong Lin, Long Sun.

More faculty and students may join the effort later on.

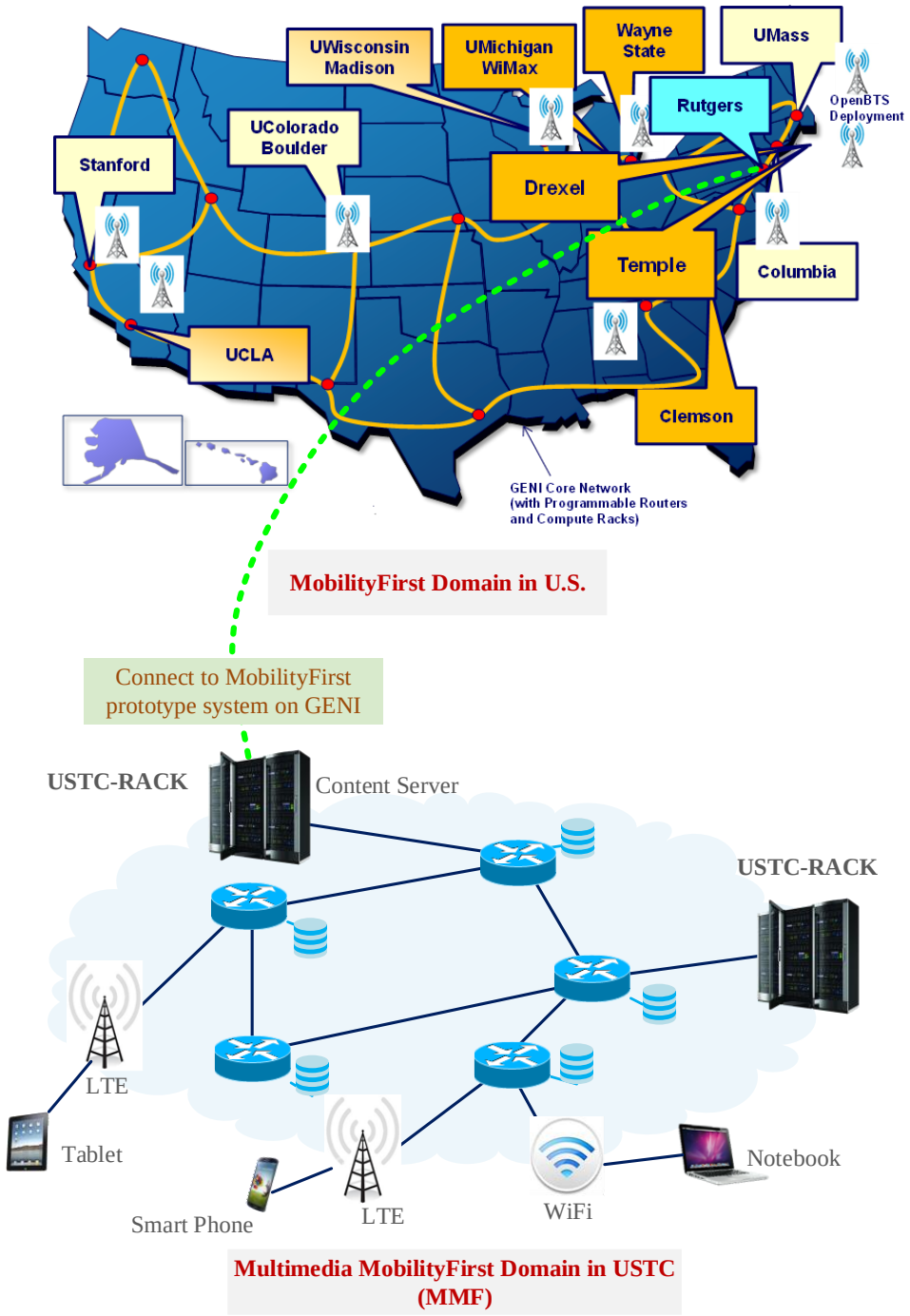

Fig. 3 MMF and a reference connection to MobilityFirst in U.S.