Unified IP Multimedia Mediator Platform to Provide Triple Play Services via Virtual Wireless Network

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Abstract —Provisioning multimedia services via packet switched network is one of the most innovative trends in telecommunication world. IP Multimedia Subsystem (IMS) was a masterwork system that it can provide all services over an IP-based infrastructure. This paper aims to illustrate a new model called IP Multimedia Mediator System (IMM) which is a unified communication system able to provide all communication and multimedia services. IMM uses the idea of virtualized cloud infrastructure to enhance the interoperability between different established systems as well as reduce the overall core network complexity. IMM testbed is assessed as a central system for broadcasting multimedia services via several scenarios.

Index Terms—IMS, 3GPP, WLAN, Virtualization, IMM

I. Introduction

The concurrent researches are concentrating upon evaluation of the 4G and beyond as well as mobile edge computing systems. Thus, there is a need to improve the operation of such core network. IMS is a generic framework platform for conveying IP multimedia services to end users [1].

3rd Generation Partnership Project (3GPP), started from release 6 up to release 14 and beyond to concern with developing the interworking architecture to permit 3GPP service providers to offload data traffic from wide area wireless spectrum to the wireless local area networks (WLANs) in indoor locations, hotspots, and other regions with high user density [2]. In IMS network architecture that is shown in Figure 1, IMS services deployed in 3G/4G domains are accessible only for 3G/4G-customers' via WLAN, while other WLAN-customers, who are not subscribed in the domain, will not be served.

In spite of IMS is a complex architecture and not scalable enough, modern networks that are not based on IMS core would be fraught with inefficiencies and would be suffering from performance degradation. For these reasons, it is vital to reduce complexity and cost of IMS.

On other side, 3GPP is still searching the direction, which to consider, such as operability with WLAN, ranging between the reasonable enhancements in the 3GPP systems for the WLAN selection parameters up to carrier aggregation with the WLAN [2].

This paper sheds further light on the sequence of thought in the IMS system's development, arriving to provide a new blueprint in light of the combination of the best ideas and proposals based on virtualized networking concepts and get out of it a new vision already able to build a unified communications system called IMM. The blueprint constitutes of: delineating the steps to deploy an applicable IMM test-bed in real-world.

The rest of this paper is organized as follows. Section II illustrates the previous work. Then the IMM proposal is highlighted in section III. In this section the main differences between IMM and IMS are delineated. Also, The IMM test-bed architecture is clarified for both hardware as well as software environment. Next to IMM scenarios that are explained in the end of this section. The performance metrics are presented in section IV. Finally, conclusion is made in section V.

II. Related Work

Providing the multimedia services in packet switched networks is one of the most active research fields. Unfortunately, despite of a quite advanced state of research in the field, few IMS based services have been defined and developed. This is partly because the testing and production of IMS-based platforms for developing and validating services appear to be quite difficult and expensive [3], [4]. The main three challenges of current IMS infrastructure are low utilization, poor scalability and excessive cost [4], [5].

Beside the great efforts of 3GPP to resolve these challenges, the initial work in 3GPP-WLAN interworking architecture specified flexible integration (at the core network) and continuously presented potential improvements for tighter integration (at the radio access network) in light of market trends and demands. WLAN is a complementary preference available to mobile operators when they consider expanding the user data traffic capacity further from the unlicensed spectrum. Indeed, WLAN presents complementary characteristics with 3GPP networks which motivate their interworking.

With the increased mobile data usage and the desire of telecom companies to maximize their return investment,

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it has become mandatory that WLAN be more integrated with the 3GPP radio access technologies [2].

One of the proposed solutions to achieve the level of scalability and elasticity required for IMS is to cloudify this Network. Cloudifying IMS can help in wide scale deployment by using cloud computing concepts and principles of reengineering IMS [4].

Using cloud computing technology to reduce the operational cost is a widespread concern in the industry. Also, combination of mobile networks and cloud computing could be advantage for network operators, cloud providers, as well as mobile users.

Virtualization is the main implementing technology for cloud computing, which is one of the most innovative trends of information technology, by providing the agility demanded for speeding up resources operations that led to reduce run time and response time, also reduce server power costs by excessive infrastructure utilization. Virtualization intends to create a virtual version of a resource, that is usually physically provided, to minimize hardware costs, minimize risk when deploying physical infrastructure, and accelerate pace of innovation [4].

In general, Network infrastructure equipment has included both the control plane and the data plane in the same device. Lately there has been a trend to decouple the two planes [6].

Also, the developers have concluded that there are different approaches of the network programming: Network Virtualization (NV), Network Functions Virtualization (NFV), and Software Defined Networking (SDN). All three types of technologies are linked when considering trends to form and implement a modern, scalable, secure, and highly accessible data centre environment for multiple applications.

Although all these strenuous efforts, the researchers noticed that NV is still in its infancy and both SDN and NFV are still on starting progress because there are many inherent research challenges that should be managed [6], [7]. Also, in [4], [5] it was shown that the existing approaches for cloudifying the IMS does not meet the requirements, and does not show how scalability and elasticity could be achieved. Also, it was shown that it will be difficult to remove IMS' roadblocks without using cloudification operations.

Fig. 1. shows that the IMS architecture consists of many blocks such as Proxy Call Session Control Function (P-CSCF) that is considered as the first contact point to User Equipment (UE), also responsible for ensuring that Session Initiation Protocol (SIP) registration is passed to the correct home network and that SIP session messages are passed to the correct Serving CSCF (S-CSCF) once registration has occurred. The Interrogating CSCF (I-CSCF) is considered an entry point for incoming calls, also responsible for determining the S-CSCF with which a user should register. This is achieved by contacting the Home Subscriber Server (HSS), which checks that the user can register. The Application Servers (AS) are entities that host and execute services, such as messaging and multimedia telephony. Once CSCF gets a request, it analyzes the destination address and decides where to route the request based on Domain Name Server / Telephone E.164 Number Mapping (DNS/ENUM) lookup data [8]. Media Resource Function Controller (MRFC) responsible for pooling of all media servers. Breakout Gateway Control Function (BGCF) selects network (MGCF or other BGCF) in which network breakout is to occur. Media Gateway Control Function (MGCF) controls media channels and performs the conversion protocols needs. Media Gateway (MGW) provides conversion between Real-time Transport Protocol (RTP) and Time Division Multiplexing (TDM).

IMS has several functional elements, but it has many obstacles to specify how to be combined or implemented. One of these obstacles is to enhance the load balancing as well as network reconfiguration due to nodes failure. So, the presented work will try to provide a suitable solution to enhance the network operability with its full services in non-complex environment [9].

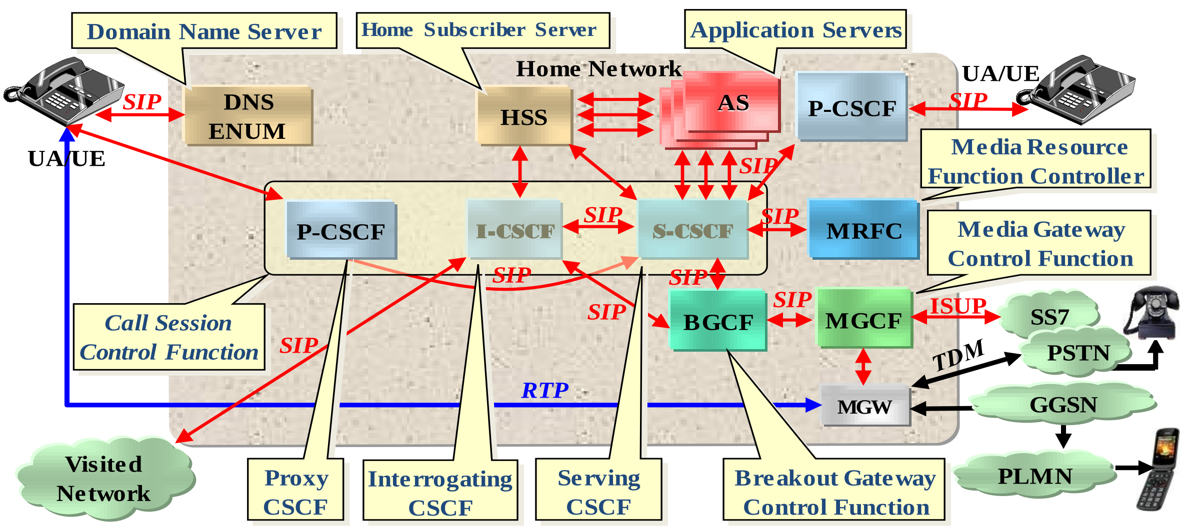

Fig. 1. IMS network architecture.

III. Proposed Model

A. IMM v.s. IMS

IMM is a Unified Communication System, derived from the concept of “IMS”, through its ability to provide all communication and multimedia services.

The novelty of the proposed IMM is to accept different incoming services from their established networks into its Unified IP Multimedia Mediator Platform.

Also, its ability to broadcast these services and other forthcoming smart services/applications via its Virtual Wireless Network.

The main difference between the ordinary IMS and the proposed IMM may be summarized as follows: IMS gathers all the core networks in one block whereas the IMM has many interfaces to dell with the whole existing networks without being as a core network for any one of them as in the IMS. In other words, IMM will serve their clients via its WLAN-Domain through their existing hardware that have WLAN interface and few adopted software. This idea can build a new thinking in scalability and elasticity.

In [10], [11], are concerning in making the ordinary computer into a reliable internet services station by using Mikrotik iso-image.

Whereas [12], is regarding to convert the customary server into integrated server able to route VOIP call on to the public switched telephone network / public land mobile network (PSTN/PLMN) and vice-versa by using Elastix iso-image.

Differently from [10, 11, 12], the concurrent work uses the principle of virtualization based on cloud infrastructure by combining all Mikrotik / Elastix features in one physical device. This device has two integrated virtual machines labors with good cooperability among them namely (VM-1, VM-2).

This combination led to better manage network resources while reducing the cost of operation by connecting them together. IMM uses its WLAN-Domain to serve their customers to obtain an inclusive package that allows them to easy access to Internet, perform wireless VOIP call within IMM-Domain, perform call on to (PSTN/PLMN) through its gateways and any other WLAN applications [12]-[14].

IMM model illustrates the methodology used to reduce communication infrastructure expenses, also could achieve the requirement for smart cities deployment.

B. IMM Test-bed Hardware

Fig. 2, shows that IMM is created on a server that has Processor core-i5, 5-Giga Transfers per second bus speed with average 3.2 GHz, and 16 GB RAM.

This server was supported with telecommunication cards authorized by Elastix Hardware Certification Program (EHCP), also upheld with USB3 to Gigabit Ethernet Network Adapter. IMM sever consists of two integrated virtual machines (VM-1, VM-2).

Each VM instance is configured to run on a dual-core processor and 4 GB RAM. Then we bridge both internal LAN interface and external network adaptor to virtual interfaces that were formed at both virtual machines. VM-1 acts as Internet service provider [10], [11]. VM-2 performs the function of integrating different communication technologies via a single package [13].

C. IMM Test-bed Software

Fig. 3, discusses system creation mechanism whence software as well as hardware. IMM is formed by using Fedora Workstation 22 as Linux base platform before installing the Virtual Machine Manager (VMM) program that could configure and manage the IMM virtualization hosts, networking and storage resources. IMM uses VMM program to create its virtual machines by installing Mikrotik / Elastix iso-images into (VM-1, VM-2) respectively.

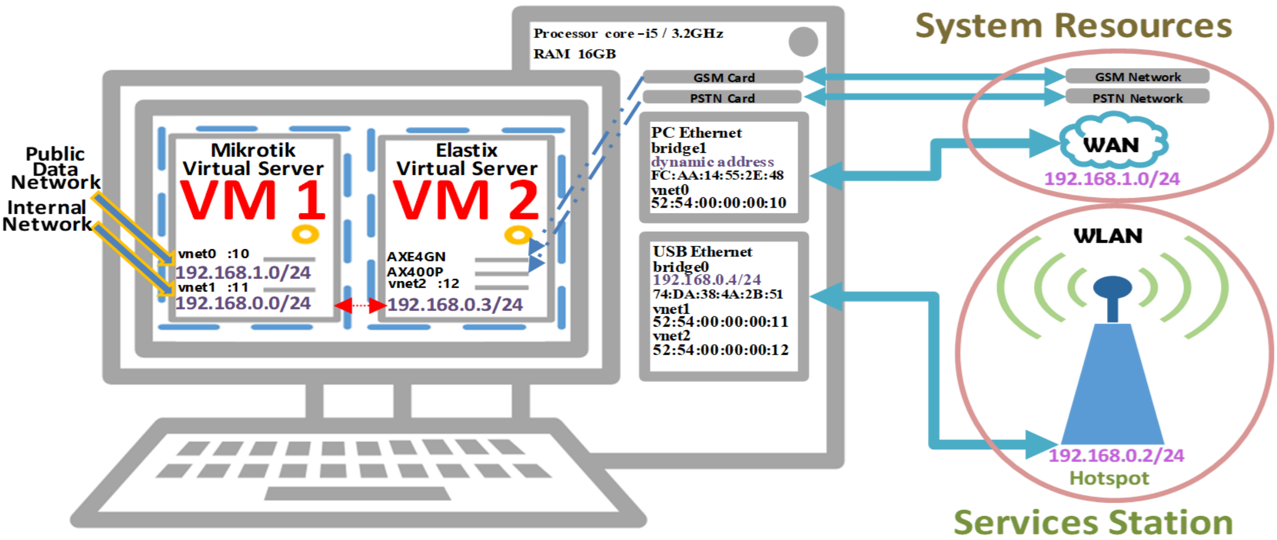

Fig. 2. Proposed IMM test-bed architecture.

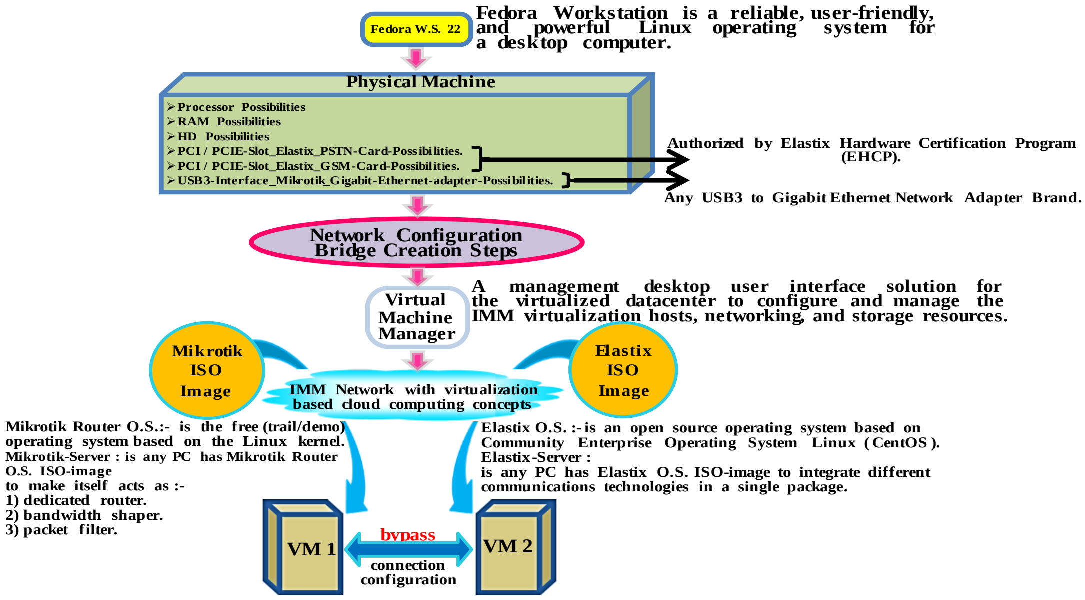

Fig. 3. IMM tools and equipment.

D. *Testing Scenarious*

After each user equipment (UE) successful accessing to the IMM-WLAN-Domain via their authenticated user-names and passwords, IMM service stations able to deal with them individually by broadcasting their services depending on each subscriber packages.

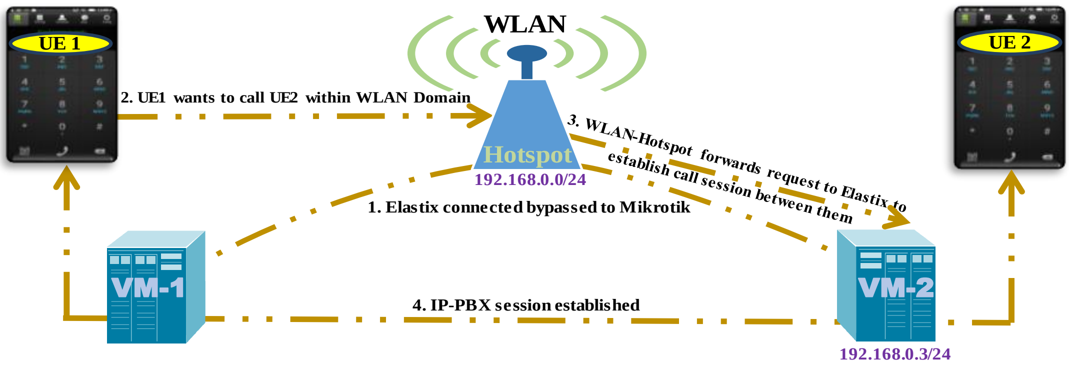

Fig. 4. IMM inbound services.

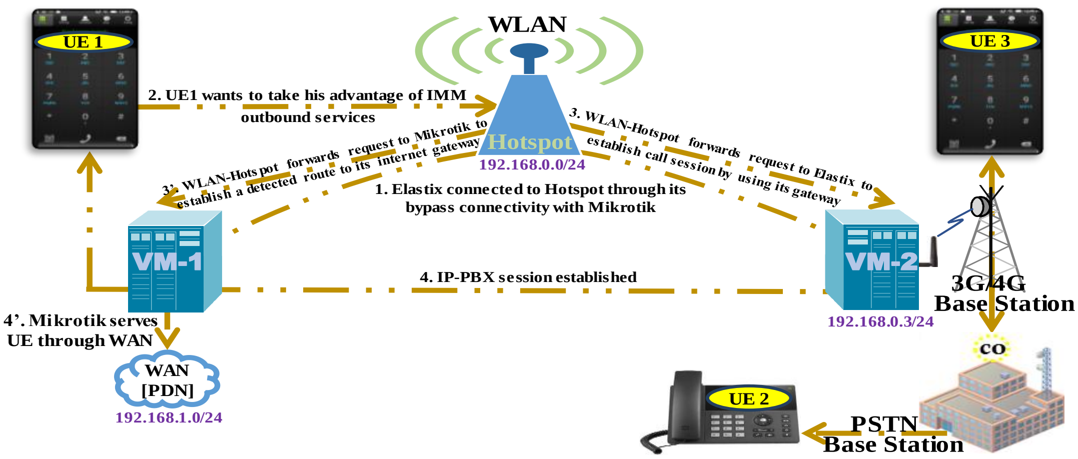

Fig. 5. IMM outbound services.

As shown in Fig. 4, both UE-1, UE-2 have the ability to use IMM inbound services (Services that are provided within IMM coverage area without the need to use communication interfaces for other existing networks).

UE-1 can perform VOIP call with UE-2 within IMM WLAN Domain.

As shown in Fig. 5, UE-1 has the ability to use IMM outbound services (Services that are provided within IMM coverage area with the need to use communication interfaces for other existing networks). UE1 can contact UE2 by using Elastix PSTN interface, and can contact UE3 by using Elastix GSM interface, also can access to Internet via his connectivity with Mikrotik Public Data Network (PDN).

In IMM smart community, the user does not need more than a device that has WLAN interface to direct communicate with IMM services station to have a complete package of existing services as well as any forthcoming smart services/applications.

IMM test-bed architecture achieves its goals from the success of VM-1 to serve UE-1 to access the Internet that is provided via the VM-1 capabilities, and from the success of VM-2 to serve UE-1 by establishing IP-PBX session between itself and UE-2 for making wireless VOIP call within IMM WLAN Domain, also from the success of the VM-2 to serve UE-1 by establishing IP-PBX session for making external PSTN-call between it and UE-2 that existing out of IMM WLAN Domain, finally from the success of the VM-2 to serve UE-1 by establishing IP-PBX session for making external GSM-call between it and UE-3 that is existing out of IMM WLAN Domain.

IV. Performance Metrics

Considering the previous scenarios, there are many important performance metrics such as: Data Rate, Capacity, Utilization, Packet Delivery Ratio and Throughput which are defined in [15]-[17].

1. Data Rate is the speed with which bits of data pass through a transmission-media.
2. Capacity is the maximum number of bits/second a network element can accommodate.
3. Utilization (U) is the percentage of capacity currently being consumed by aggregated traffic on a link or path.

$$U = \frac{Traffic}{Capacity} = \frac{Packets / Second * Bytes / Packet * 8Bit / Byte}{Bits / Seconds} \quad (1)$$

4. Packet Delivery Ratio (PDR) is the ratio between the number of packets received at destination (N_R) and the number of packets sent from source (N_S). It represents the maximum utilization that the network can have.

$$PDR = \frac{\sum N_R}{\sum N_S} * 100 \quad (2)$$

5. Throughput (∅) is the amount of data that is successfully delivered to destination via the network per second.

$$\emptyset = PDR * Data\ Rate \quad (3)$$

Fig. 6, presents the change of throughput along network within a period of time (47second) to download (5MB) file at (i, ii), while at (iii, iv) the percentage ratio of the number of transferred packets per second in both two cases is presented: user equipment moving around (pedestrian) the service station and user equipment close to the service station.

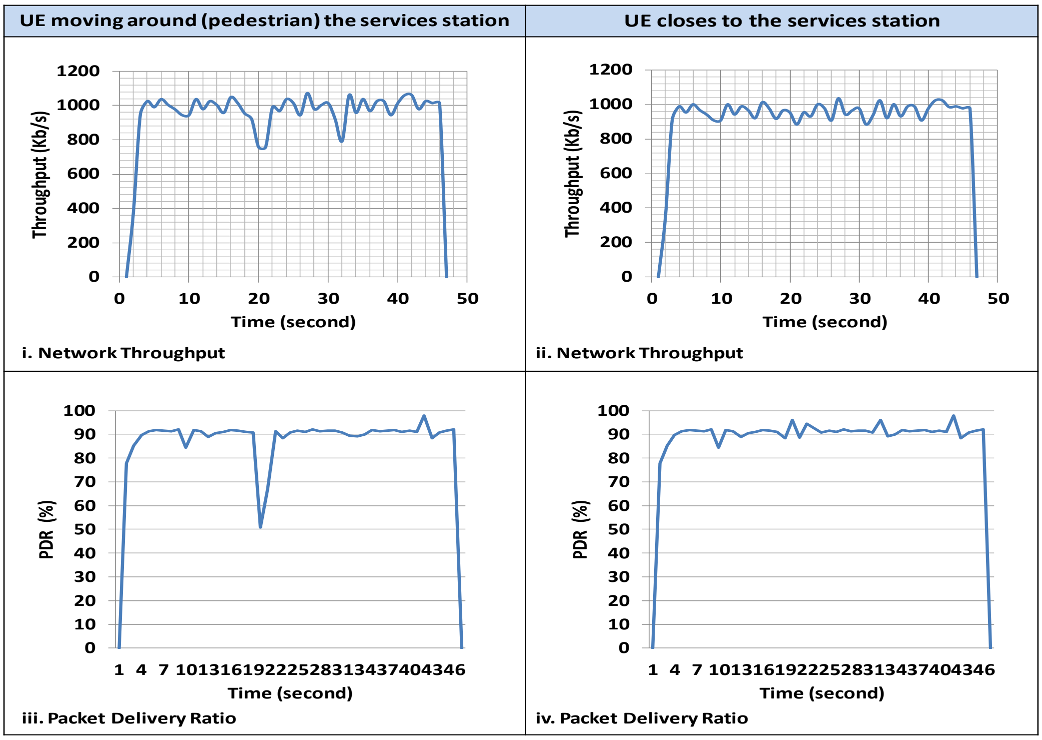

Fig. 6. IMM network performance metrics.

V. Conclusions

This paper proposes a novel unified communication system able to scale up depending on available resources and the target market.

Also, this paper evaluates the proposed IMM test-bed performance through different testing scenarios.

The potential impact of the proposed IMM is the cost of planning new projects at recent places and users' expenses may be decreased, that led to satisfy both Operator /Provider companies and their clients. Also, IMM has several environmental impacts likes scaling down both the emitted carbon footprint/electromagnetic radiations that comes from the existing base stations via saving the energy consumption.

In addition, IMM will deliver all existing/forthcoming smart services/applications to their clients over their existing devices that have WLAN interface and few adopted software.

Finally, IMM may be considered as one of the proposed prototypes for SDN/NFV deployment techniques.

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