Heterogeneous Network Framework Architecture – A Survey

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Abstract— The **objective of this paper is to analyze heterogeneous network framework for providing seamless connectivity and data transfer between various network technologies. This framework provides QoS seamless heterogeneous network architecture. Due to increasing popularity of mobile wireless network, we face the challenge of combining a diverse number of wireless networks. The heterogeneous network of wireless communication is expected to integrate potentially a large number of heterogeneous wireless technologies which could be considered a huge step forward towards a universal seamless access. One of the main challenges for seamless mobility is the availability of reliable horizontal (intra system) and vertical (inter system) handoff schemes. Efficient handoff schemes enhance quality of service and provide flawless mobility. The heterogeneous network is ubiquitous. It means that, the Ubiquitous data service has ability to provide access to information, voice and multimedia sessions everywhere, anytime, and anywhere.**

Keywords- Heterogeneous networks; seamless; vertical handoffs; horizontal handoffs; ubiquitous; wireless network; QoS

I. INTRODUCTION

A heterogeneous network is understood as a combination of various network technologies (wired and/or wireless) put together for efficient data connectivity across the network. Heterogeneous network environments illustrate the integration and coexistence of a variety of wireless access technologies with different protocol stacks and supporting a number of applications and services with different QoS requirements to be provisioned to network resources with different degree of multi-mode capabilities to access the available networks **[1].** To make use of multiple broad band transport technologies and to support generalized mobility.

The requirement of Heterogeneous Networks arises from the need of an efficient coexistence of latest and legacy technologies. For example, the new emerging technologies like HSDPA & WiMax will have to coexist with legacy technologies like GSM, GPRS. A heterogeneous network also includes telecommunication networks viz. 3GPP-standardised UTRAN and GERAN along with non-cellular access networks like WLAN 802.11.

To understand the heterogeneous network architecture, let's understand what is network architecture? Network architecture is the combination of network topology and the involved protocols responsible for various applications and services. It is comprised of the factors like network capacity and network capability.

A simple definition of network capacity can be – the amount of traffic a network can handle at any given instance. The capability of a network determines the services that the network is able to offer and it clearly depends on the capacity. Network capacity and capability depend on the network architecture.

II. STUDY ANALYSIS- CHALLENGES OF HN

Heterogeneous networking faces many challenges in several areas. At the lowest levels, many new access technologies including 3G, WiMax and Ultra Wide Band (UWB) will be supported on heterogeneous networking devices. The expansion of the layer 2 provides something as a balance by a reduction in the network layer as core networks. It uses IP packets to make services easy such as telephony, data and multimedia.

One of the major capabilities of the heterogeneous network framework is **handover**. Such handover is an important factor to ensure proficient handling of the data packet at all layers which in turn should satisfied the prime objective of seamless data transfer even when the network resources may be mobile.

QoS is another major issue in heterogeneous networking environment. Since diverse wireless network contain changeable QoS as a result vertical handover also affect the point of attachment as well as QoS of the connection as observe by supplementary entities in the protocol stack. This also affects the delivery of effective performance of network and transport services; as a result the system must be reacting to modifiable in QoS in the available channels. To minimize the system effects on the applications, it considers the dealing with QoS changes as well as what can be done by the system via upper layer. On the other hand, upcoming applications are expected be proficient (via facilitate by system) to structure them to make use of QoS changes in wireless networks.

A new classes of application can be built further which will facilitate new features such as personalization, personal area networks and location based services.

In order to address the above mentioned issues there is a requirement of a **framework** that has an answer to the key challenges of heterogeneous networking for mobile devices. A map supports one to plan a journey, same as a frame work is necessary to move forward in the new area.

III. Conceptual Framework for Heterogeneous networks - Layering

The OSI reference model is the well accepted framework in data communication which is developed by the CCITT. It indicates the functions of the layers to provide a framework for exchanging data between networked applications.

The OSI model cannot be the leading model for heterogeneous networking. There are some reasons for that which describe as below:

1) In the OSI model, first three lower layers are important with the movement of packets between networks. The upper layers of the OSI model are considered to deal with end-to-end issues between application processes. In heterogeneous networks, this type of separation between networking and end-to-end issues is not able to support constantly. There are several reasons for this.

The basic role of network layer in OSI model is used to simply forward packets to their significant destination. But in heterogeneous network framework, network layer must also support new functions.

A vertical handover function is the most important. The vertical handover requires frequent and near communication between the mobile host and the network which cannot be simply integrated into the OSI model.

The vertical handover also involves the reconfiguration of certain parameters in the network, such as allowing for the reservation of resources to ensure quality of service in the receiving network. This reality is difficult in OSI structure model.

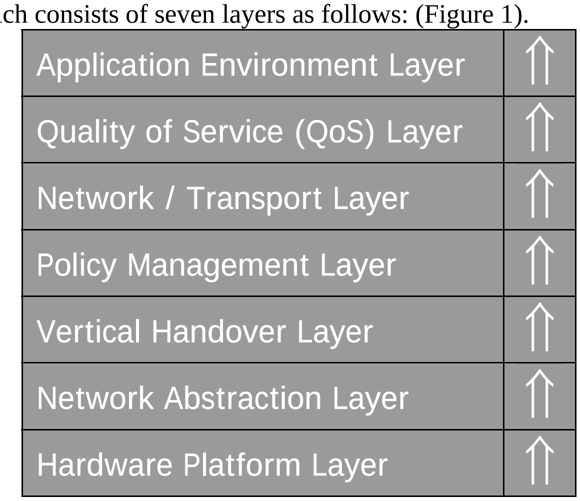
2) The characteristics of the networks at the edge which is not very divers from the core network, as a result of scrutiny the OSI model works very well. The beginning stage of Internet holding the Ethernet or Token ring system were contain wired networks, which works with megabits per second among endpoint. The core network and end systems had chosen dissimilar evolutionary ways, due to changes of network trends. With the use of MPLS and single-mode fiber optics technologies, core networks become more faster. The peripheral systems are rapidly becoming dominated by the appearance of wireless technologies that have very different characteristics in terms of latency, bandwidth, and availability and error distribution properties.

The OSI model acts as a conceptual framework and indicates that it must be updated. This type of approach specifies the hierarchy of functionalities but does not provide the detailed interfaces between them. The hierarchy order is most important. For example, the functionality of vertical handover is above the transport layer.

Due to the increase in the complexity and number of tasks in heterogeneous networking, successful implementation of seamless interoperability requires the introduction of a new level of intelligence to components at the network, device and application levels. Some of these new features include network component reconfigurability, policy management during vertical handovers and QoS management.

For the exchange of information between network components of heterogeneous networks, there is a need for a reference model which is similar to the OSI model and will clearly define the functions of all layers.

We analyze the new heterogeneous framework **[3]** which consists of seven layers as follows: (Figure 1).



[Figure 1. Heterogeneous Network Framework]

In model, vertical handover, with input in turn from policy management, is placed *below* the network transport layer. Likewise, the application and the network transport modules separates quality of service via its own specific layer.

An authenticity, policy management and vertical handover functionality very well incorporated into single module. To full fill the upper layers framework, the framework should be followed by not only the upper layers it self but also further below layers. Accordingly, the QoS layer would provide great utility to network abstraction layer. In terms of implementation, to highlight the needs of clear conceptual separation, it is determined that possibilities for vertical integration and trans-layer interfacing.

a) **Hardware Platform Layer:** This is the lowest layer. To support wireless networks, which hardware components and technologies essential is the function of it. It defines characteristics like the electromagnetic spectrum required for a given technology, the different modulation techniques that may be used, as well as the MAC (Media Access Control) algorithms for acquiring and reserving channels. It is predictable that individual systems may be totally contrary with each other, so that the layer is ordered of vertical sub-layers, which represents a particular network technology. For e.g. 3G, WLAN, WiMax, etc.

b) **Network Abstraction Layer:** This layer provides a common interface for supporting the different network technologies present at the lower layer. It is responsible for controlling and maintaining networks on the MN (mobile node).

c) **Vertical Handover Layer:** This is the key component of heterogeneous networking [4]. This layer is mainly responsible for the specification of mechanisms including for vertical handovers. It supports both **network-controlled** (decide when and how the handover will occur. It has mechanisms in the network that maintain all relevant information on the mobile host, including its location relative to different networks, their signal strengths at the mobile node's location and its direction and speed. It is not scalable approach. If new wireless network are added then the information about all the networks to which the host is current attached becomes difficult to maintain.) And **client-controlled** handovers (it is controlled by the mobile device. It is very advantageous as compared to the network controlled. Mobile node will maintain the latest information about network interface, which makes it better stage to decide when the handover should be happen. The mobile node will also have knowledge of its other higher level issues as well as its TCP connections. This factor makes the decision to conduct a vertical handover.

d) **Policy Management Layer:** This layer evaluates the circumstances when a handover should occur. It consists of a set of rules which evaluate the relevant parameters and their values to make a decision about a handover. The mobile host is also associated with other parameters like coverage and signal strength, the status of the network and the status of any transport connections,

There are mainly two types of policy management: reactive and proactive.

A reactive policy depends on network abstraction layer which has knowledge about the presence or absence of networks as the hetnet device changes its location. The literature [5] describes almost all the policy management systems. For example, POLIMAND, including the most recent PROTON [6] have been reactive.

A proactive policy will acquire and work as a source of information about coverage and signal strength, before the mobile actually reaches a given location. A proactive policy is the **Time Before Vertical Handover or TBVH** which work as a key factor. As TBVH already knows that, the higher layer protocol stack makes maximum use of channels which may be unavailable in short period of time.

e) **Network Transport Layer:** This layer observes the routing, addressing and transport problems in secondary networks.

f) **Quality-of-Service (QoS) Layer:** This layer supports both upward and downward QoS. Its task is to ensure that the QoS offered to applications can be maintained at an acceptable level during the lifetime of a connection.

g) **Application Environments Layer:** This layer specifies mechanisms and routines that assist in building applications which can use all the layers of the framework.

IV. NETWORK ARCHITECTURE OVERVIEW

A network's architecture describes its overall structure in terms of physical and logical entities and their mutual relationships. The term network architecture consists of physical network elements, their interconnections (i.e., the network topology and the transmission technology being used) as well as the protocols that govern how information is exchanged. Network architectures can be subdivided into two categories **- logical and physical.**

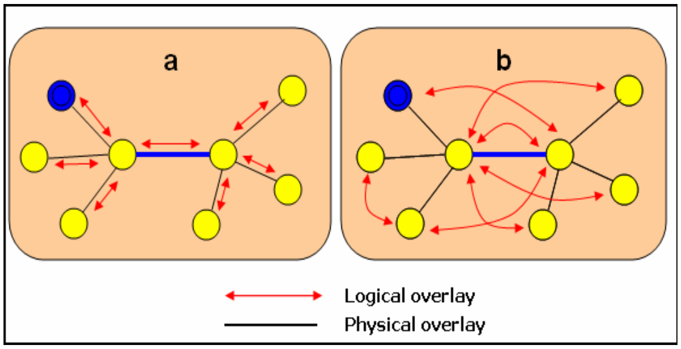
Logical network architectures

The logical network architecture is a logical structure completely separate from the physical network. Logical topologies can be built at any level even at the transport or at the application level. They can be static or dynamically reconfigurable.

For example, Peer to peer networks (P2P networks) has become visible which is example of application level logical network architectures **[1].**

In this type of networks clients automatically detect network connectivity between members of the P2P network and establish their own view of the world, i.e., they create a logical overlay to the physical topology. This logical topology is now used as a basis for routing, which can lead to a large degree of inefficiency.

In below figure both examples depicted to visualize this.

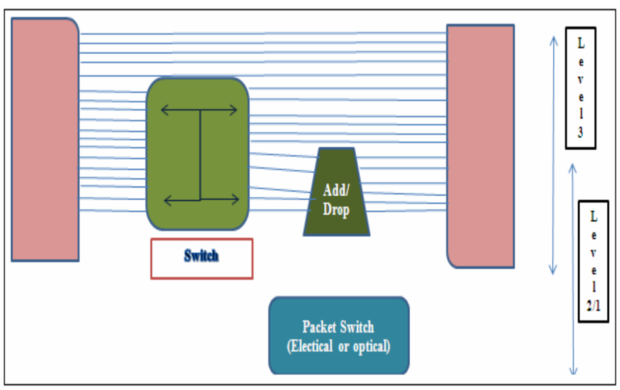


[Figure 2. Logical versus Physical Architecture]

The Figure 2(a) shows a logical topology which matches the physical one, whereas in Figure 2(b) there is a mismatch. In Figure 2(b) broadcast from the blue node would require 6 times the capacity on the blue link compared to Figure 2(a). This is due to the fact that the peer-to-peer protocol has a view of the network, which differs fundamentally from the network's physical topology.

<u>Physical network architectures</u>

Physical network architectures are defined by the physical properties of the network. One example is an optical network with a WDM overlay. From the [7] we discuss the below Figure 3, shows how physically a node can have properties that make it belong to several technologies, e.g., WDM, and optical packets switching [2]. Such a node can handle resources with varying granularity, e.g., fiber, wavelength and optical packet / burst.



[Figure 3. Network node Structure]

V. HETEROGENEOUS NETWORK ARCHITECTURE

When network architecture migrates from one existing network architecture to another one, new equipment must be introduced.

A step by step migration strategy required to complete the size of networks which implies that, at all times the network will consist of a combination development. This combination development ranging from electrical routers to all optical packet and wavelength switches.

It is important to find a suitable architecture in which a new technology (e.g., all optical switches) can be introduced gradually/progressively and hence enable a seamless migration.

A. Single- versus multi technology architectures

A network can be single technology/protocols in many levels such as IP level. A network architecture based upon one single technology has the advantage of easier maintenance. That's why the widespread use of IP is the main argument. However, a single technology probably cannot provide the optimal solution in all circumstances. In any case, it is a given fact that most of today's telecommunications networks are multi technology networks. Three main reasons are describe as below:

1. Interconnection

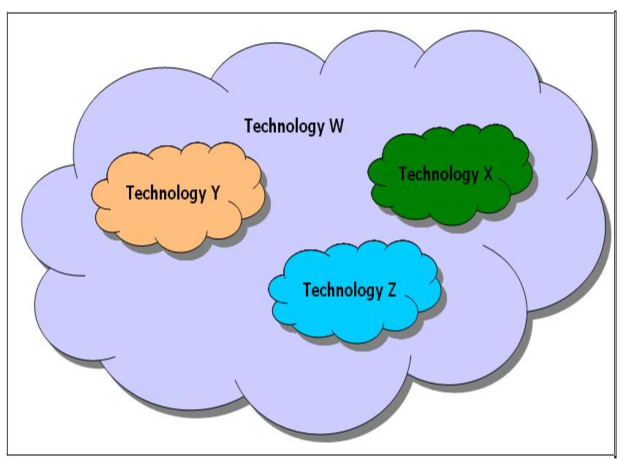
The networks are themselves interconnected networks of different operators. Each operator has full control over its own domain (and adopt a single technology, if possible), but has no control over what technology its neighbor is using.

2. Size

Some networks are very large. Each technology has its advantages. Therefore different technologies can be optimal in different circumstances & environments, and thus an operator can decide to use the optimal technology solutions in the different areas.

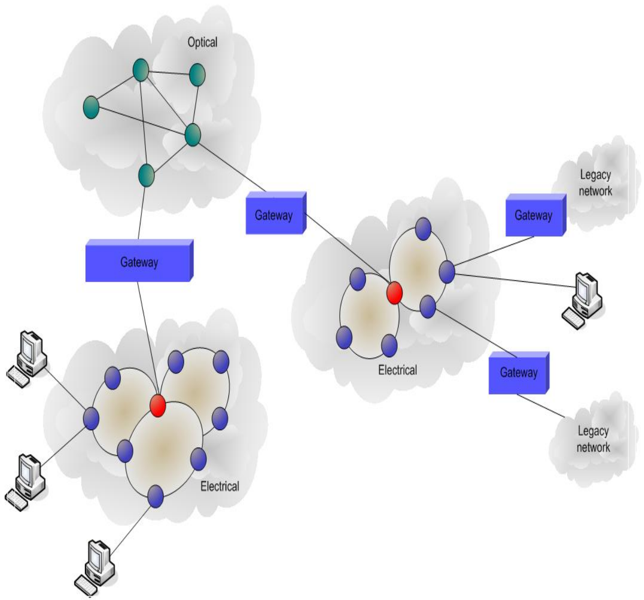
3. Upgrade

The upgrade of large networks is done gradually and during the upgrade phase, multiple technologies are present in the network. This can also occur due to competition in standardization.



[Figure 4. A mixed-technology network. Due to network evolution new technologies are popping up as "islands" within the network.]

In multi technology network environment, it is clear cut to group all network nodes into domains such that, within each domain there is only single technology equipment. This is shown in Figure 5. The gateways are used to work as adaptation devices, between network domains.



[Figure 5. Structure of a Heterogeneous Network]

A partitioning plays a vital role in a network which finds a way to interconnect the network domains thus the entire network remains fully connected. Therefore, this leads to requirement of traffic adaptation between the areas as reasons follows:

a) **Bit rate difference:** Different technologies support different bit rates. Given below table describe the network frame ranges:

Type	Ranges (bit rate)
Ethernet	100 Mbps or 1 Gbps
Standard Telecommunication	622 Mbps, 2.5 Gbps

When the bit rate changes from electrical switches which running 2.5 Gbps to optical switches which running 10/40 Gbps the adaptation/alteration will be required in core network.

b) **Packet size variation:** The limitation of switching speed is packets per second. It means that, as changes from lower to higher bit rate domain occurs, the size of the packets and the timely duration of the packets is unchanged, in terms of bits, increases with the bit rate. For example, if two optical domains using the same switching technology but with different bit rate. The packets in one domain will contain four times several bits because of bit rate increases by a factor of four. Another example is where the bit rate is kept constant but the timely duration is increased. The technologies used, e.g., packet switching and fast circuit switching can mandate such a duration increase.

c) **Packet length constraints:** The domains might use fixed or variable length packets.

d) **Transport characteristics:** Diverse technologies will most expect to hold different transport characteristics for e.g., packet delay/loss.

e) **Traffic grooming:** It is very valuable to merge traffic stream, when entering a new area. To make more efficient use of network resources, two or more streams with same destination network can be combined.

f) **Addressing schemes.** Network administrators usually administer their own pool of addresses. Hence for global interconnection either administration or translation at domain boundaries is required.

VI. Analysis of Table

Table -1 Comparison between wired and wireless transmission technology

	WIRED		WIRELESS		
CAPACITY	Much higher than wireless		Limited to the frequency used		
TOPOLOGY	Point-to-Point		Broadcast		
RELIABILITY	Reliable		Unreliable		
MOBILITY	Fixed		Mobile		
	STANDARD	DATA RATE	STANDARD	DATA RATE	
		Max.		Max.	Typical
	10/100/1000 Ethernet	1 Gbps	802.11 a	54 Mbps	22 Mbps
			802.11 b	11 Mbps	4 Mbps
	Optical Ethernet	2.5 Gbps	802.11 g	54 Mbps	20 Mbps
			802.11 n	300-450 Mbps	50-150 Mbps

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CONCLUSION

The critical issues for existing networks as well as future networks are high capacity, transparency (signal format, protocol independence), End-to-end QoS support, Flexibility etc to manage dynamically the performance parameters. The utilization capacity of optical networks is to be enhancing from the existing level of utility are achieved. Though wireless networks offer low transmission capacity but do provide flexibility in terms of user mobility particularly for the mobile, wireless access networks.

An adaptation unit serves as an interface between optical networks and Ethernet network domains running at the same bit rate for the traffic handling. The traffic handling trade-off considered is delay and bandwidth utilization. To optimize for efficiency or delay for combining packets then, bandwidth resources usage is completely optimal.

The analyzed heterogeneous network framework fulfills all the requirements which can be efficiently utilized by combining different technologies like with diverse characteristics for the heterogeneous networks. It also provides seamless and interoperable architecture.

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