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Newly Proposed Framework for Addressing Heterogeneity in Technologies, QoS, Security, and Applications (AHTQSA) In IP Networks

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ABSTRACT

This paper is aiming to develop a global framework to address the issue of heterogeneity in computer networks. This work is an extension of [A New Historical Based Policing Algorithm for IP Networks] that proposes a new policing algorithm; called Historical Based Token Bucket (HTB) algorithm. The HTB algorithm reduces the losses by on average 72% and 99% less than the Class-Based (CB) algorithm for different types of video and voice respectively, whereas the HTB algorithm increases the delay by about 4% and 9% more than the CB algorithm for different types of video and voice respectively. This paper investigates the possible components that constitute a successful operation cycle for Service Provisioning in IP Networks and develop a new Global Framework to address the heterogeneity characteristic of this complex system. The newly Global Framework, AHTQSA, is divided into three parts: Customers, Service Selector, and Service Provider. Customers are representing the service requirements and evaluation of the provided services either through the Quality of Experience (QoE) and the monitoring tools which should be provided by the service selector. The Service Selector consists of six Ontologies which represent the overall operation cycle starting from selecting to obtaining the services. The Service Provider component that consists mainly from six interfaces that interact directly with the Service Selector and Customer to complete the operation cycle for Services provisioning.

Keywords: Framework, Heterogeneity, Service Level Agreement, Quality of Service, Quality of Experience.

1. INTRODUCTION

Three technologies have been emerged and have a great impact of the characteristics of IP Networks, which are cloud computing, Internet of Things (IoT), and Smart Cities [1]. IoT is driven by technological advances, not by the applications or user needs whereas Smart Cities originated to solve the problems in modern cities [2]. By 2020, things as many as 50 billion are estimated to be connected to the Internet as indicated in figure 3 [1,3] or more [4]. There are similar terms/technologies that have the same functionality and meaning of IoT such as RFID [5], M2M (Machine-to-Machine), WSN (Wireless Sensor Network), USN (Ubiquitous Sensor Network), IoE (Internet of Everything), and WoT (Web of Things) [1]. Sensor Networks represent as the enabler of IoT [6]. Examples of IoT are [7]: Smart Environment Monitoring, Smart Manufacturing, Smart Health, Smart Living, Smart Building, Smart Transport and Mobility. In addition to, not only mobile and computer devices are connected to Internet but many types of devices and systems such as cars, televisions, sound systems, lighting equipment and other are connected to Internet [1]. Therefore, the essential layers in Cloud Computing Model have been extended to include a new layer named Everything as a service (XaaS) [8][9].

More than half of the World's population now lives in urban areas [10,11,12]. Examples of IoT are [7]: Smart Environment Monitoring, Smart Manufacturing, Smart Health, Smart Living, Smart Building, Smart Transport and Mobility. The structure of IoT consists of Human, Thing, and Service as indicated in figure 1 [1]. Figure 2 represents the connectivity among object that support IoT and the data center [13].

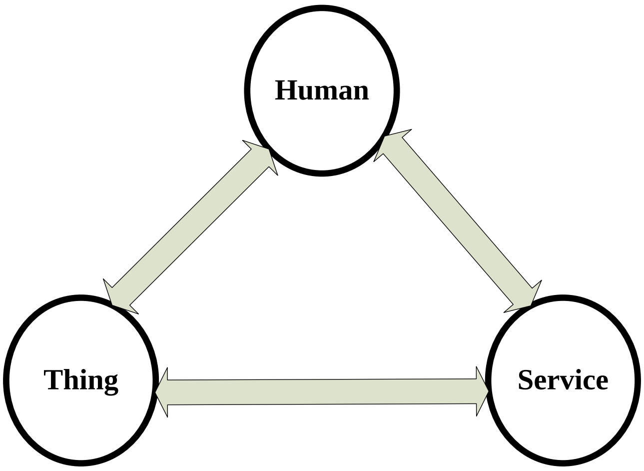

Fig 1: Structure of IoT

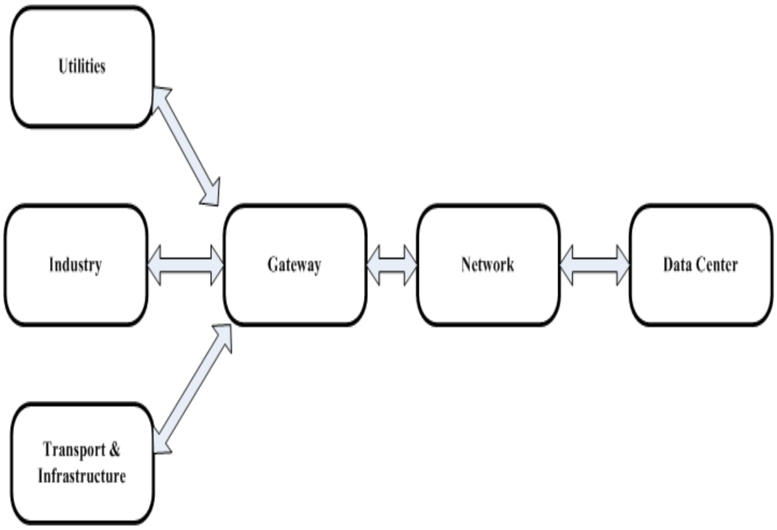

Fig 2. Industrial IoT from Edge to Cloud Source

Ubiquitous sensing enabled by Wireless Sensor Network (WSN) technologies cuts across many areas of modern day living [14]. The growing in number of devices in a communicating-actuating network creates the Internet of Things (IoT) [14]. The IoT paradigm depends on intelligent and self-configuring nodes (things) interconnected in a dynamic and global network infrastructure whereas Cloud computing has virtually unlimited capabilities in terms of storage and processing power [5]. Smart Cities have six characteristics: smart economy, smart people, smart governance, smart mobility, smart environment and smart living [15].

There is a type of merging between IoT objects and cloud computing and this merging leads to the need to resource management component [16]. The trend of The Internet of Things (IoT) envisions a multitude of heterogeneous objects and interactions with the physical environment [23]. The IoT represented in real-world by services and provided through plethora of heterogeneous objects [23]. Paper [23] indicates the entity, resource and service models for the IoT domain. One of the important features that are provided by semantic models for the IoT is the handling of interoperability in data and service levels [23].

The proposed framework will focus on heterogeneity challenges that results in the emerging of new technological trends such as cloud computing, IoT, Smart Cities. The heterogeneity is presented in multiple areas. Also in the proposed framework will take care of heterogeneity on: network systems, and services. Network systems are represented in three categories: Cloud Computing, IoT, and Smart Cities.

By definition, IoT allows people and things to be connected anytime, anyplace, with anything and anyone, ideally using any path/network and any service [17]. IoT is primarily driven by technological advances, not by the applications or user needs [17] whereas, SC [2] originated to solve the problems in modern cities.

For the time being, cloud computing facilitates the using of infrastructure, platform, software...etc. as services [18]. Everything as a service (XaaS) [19] is a category of models. This paper is organized as follows. Section 2 deals with related works. Problem statement is given in section 3. The details of the proposed framework are given in section 4. Section 5 presents the conclusion and future work.

2. RELATED WORK

Heterogeneity is One of the Obstacles that face IoT [20]. To fix this issue, [20] proposes a cognitive management framework. In this model changes are represented using cognition and proximity [20] focuses mainly on four axes: to hide heterogeneity of connected objects, ensure resilience of dynamic service provisioning, assess proximity between IoT applications and "useful" objects, and use cognitive technologies [20]. The cognitive framework uses semantics and virtualization to address heterogeneity issue [20]. In [20] cognition is represented in three levels to achieve self-management and self-configuration, in addition to that this framework considers security and privacy using authentication and access control. In [20], a security framework is presented that comprises mechanisms to achieve intrusion detection and reaction. One of the goals of this framework is to identify and classify heterogeneous network vulnerabilities using vulnerability ontology.

There are multiple types of approaches to apply QoS on network traffic according to the characteristic of each type of traffic. There are two main schemes for applying QoS on IP networks which are: Integrated Service (IS) and Differentiated Service (DiffServ). The Integrated Service (IS) has two types of services: guaranteed and predictive [21] and it works with multicast and unicast. The main components in the IS are "resource reservation" and "admission control". Traffic conditioners are usually located within DiffServ boundary nodes [36]. Figure 3 illustrates the traffic conditioners; the classifier selects packets in a traffic stream based on the content of some portion of the packet header.

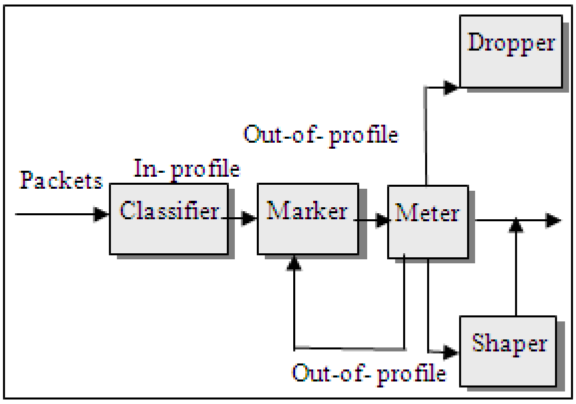

Fig 3. The QoS Components in the IP router

There are multiple types of QoS attributes and policies that ca be applied at different network layer. In layer 2, Class of Service (CoS) as an example, can be added to frame header to prioritize the traffic. In layer 3, Differentiated Service Code Point (DSCP) as an example, can be added to mark traffic and apply policy according to the traffic category requirements. Also, QoS policies can be applied on routing protocol to determine the feasible paths [22]

For the time being, there are different types of Web services: RPC, SOA, and RESTful Web services [24]. One of the methods to handle heterogeneity is the SOA which has a great applied field as consolidating to be used in new applications [24]. Before applying the requirements of the customer SLA, there is a need to have a method for discover the available services. Then there will be a negotiation of Service of Level Agreements (SLA) to state the terms for the service [24] then a monitor service to ensure the achievement of the provided services for the customers [24].

Application can be classified into Real-Time and Elastic. Elastic can be categorized: Interactive Burst, Interactive Bulk, and Asynchronous. Real-Time can be categorized into Tolerant and Intolerant [25]

An SLA is defined as a contract between the service provider and customer that specifies the QoS level that can be expected [26]. [26] focused on managing and controlling of the QoS level provided to customers using a mathematical model named utility mode. The utility model developed by [26] to represent the aspects of SLA for multimedia using the microeconomics theory. Interoperability is an important touchstone due to the reenactment of Internet and cloud technologies [27]. The four deployment models: public, private, community and hybrid and three services models

(SaaS, PaaS, IaaS) standardized in 2011 by NIST [28]. One of the lock-in aspects that is caused by Interoperability issue in Cloud computing environment [28].

Paper [29] introduce our approach “Web service QoS (WS-QoS)” that enables an efficient, dynamic, and QoS-aware selection and monitoring of Web services [29]. WS-QoS ontology is using XML and representing QoS requirements for Web Services [29]. Paper [30] presents a new framework for specifying and monitoring Service Level Agreements (SLA) for Web Services [30] and it is applicable as well to any inter-domain management scenario [30].

The Service-Oriented Architecture (SOA) consists of: service registry, service provider and customer [30]. As indicate in Fig. 4 [31]

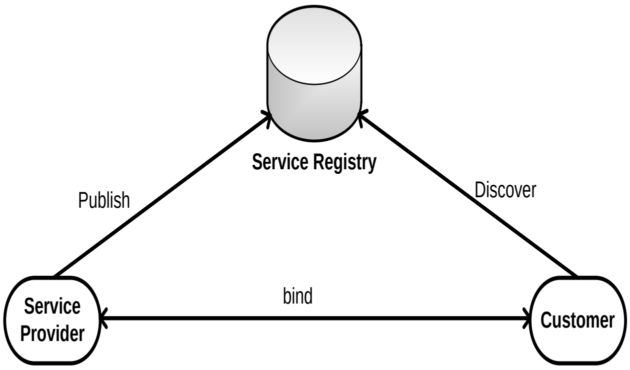

Fig 4. Service-Oriented Architecture

Internet of Content, in which, Content is any type and volume of media. Content may be pre-recorded, cached or live, static or dynamic, monolithic or modular [32].

This paper [33] proposes a new policing algorithm; called Historical Based Token Bucket (HTB) algorithm to study the impact of deploying HTB algorithm on real time traffic from the delay and losses point of view. The studied experiment is based on capturing and measuring different voice and video Internet traffic by using Wireshark measurement tool [35] then classifying the traffic into different classes depend on their characteristic by using the HTB developed tool which is based on the application port number. The HTB algorithm uses a single token bucket algorithm, traffic should be transmitted based on the presence of tokens in this bucket, each token represents a given number of bytes, which is assumed to be one byte in our implementation, and the bucket can hold up to Bc tokens. Traffic is allowed to transmit up to its peak burst rate if there are adequate tokens in the bucket and if the burst threshold is configured appropriately as shown in figure 5 [33].

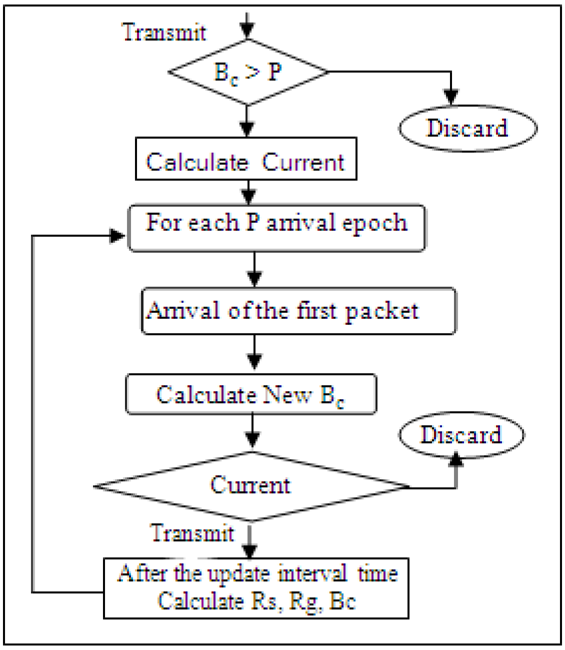

Fig 5. The Historical Based Token Bucket Algorithm.

The results the HTB algorithm reduces the losses by on average 72% and 99% less than the CB algorithm for different types of video and voice respectively, whereas the HTB algorithm increases the delay by about 4% and 9% more than the CB algorithm for different types of video and voice respectively. QoS is a mechanism to assure that the traffic which traverse the Internet such as audio and video data; will have minimum delay, loss and high throughput. To implement the QoS policies, the network hardware as the routers should have the capability for traffic conditioners. Traffic conditioners mean classifiers, meters, markers, shapers, and droppers [34].

This paper proposes a dynamic QoS approach for both the customers and the ISPs that provide a good utilization for their bandwidth. The paper also compares the proposed algorithm with the well known Cisco policing algorithm which is known as CB. The experimental results have lead to two conclusions, firstly, the losses in HTB algorithm is less than the CB algorithm by on average 84.7% in case of Al-Jazeera video stream, 99.9% in case of El-Hayat video stream and 30.4% in case of US Fighting video stream whereas, the delay in HTB algorithm is more than the CB algorithm by 5.5% in case of Al-Jazeera video stream, 3.7% in case of El-Hayat video stream and the US Fighting video stream. The HTB algorithm reduces the losses up to 100% in case of BBC RADIO3 voice stream, 99.7% in case of BBC RADIO5 voice stream and the Jungle DNP Radio voice stream whereas, the delay in HTB algorithm is more than the CB algorithm by 6.2% in case of BBC RADIO3 voice stream, 7.4% in case of BBC RADIO5 voice stream and 20% in case of Jungle DNP Radio voice stream. Also it should be mentioned that the HTB algorithm does not require more processing than the CB and it an adaptive algorithm that can be suitable for several types of Internet traffic.

3. PROBLEM STATEMENT

We believe in the right to obtain an acceptable level of services that run on IP networks in our developing countries which have 2 billion of Internet users from 3.2 billion (62.5 %) accoring to ICT facts n Figures in 2015. To provide a specific level of agreement, traffic is pass through different systems and to gurantee the service alog this path, there is a need to control the resouces using dynamic mechanisms to be able to be adapted according to the status of the systems. These systems consist of different components such as Traffic Identificatio, QoS, SLA, Monitoring, and Security. The characteristics of these componets inroduce a complex system.

4. AHTQSA GLOBAL FRAMEWORK

To provide SLA in Internet networking, multiple components are needed to be deployed and there are interactions among these components. The variations of these components, the features that control each components, and the probability invloved in the inferred results in specific component in some components create a complex system to achieve a the successful operation for the SLA. The Adaptive HTQSA framwork is adapted to handle the operation of these heterogeneities in this complex system. Figure 6 indicates the overall component of the AHTQSA framework.

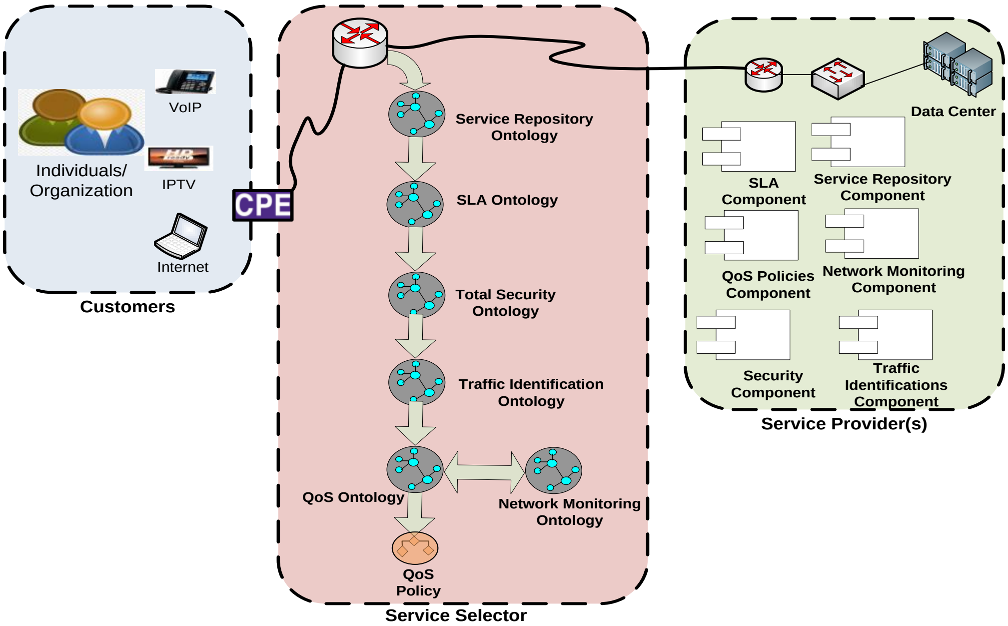

Fig 6. Global Framework for AHTQSA

A. Overview

The partners of this system are: the service providers, Service Selector, content developer, and the customer. The following sections explains: the components, and the operation of the Adaptive HTQSA. The definiton of the used terminology are:

- Customer:the user that requests the service. User may be an individual or corporate entity
- Service Selector: this is an independent entity that are responsbile for:
  - monitor the status of the service provider and execuation of the SLA among customers and service provider
  - ensure and sustain the success operation of the SLA between customer and service provider
  - select the most apporopraite Service Provider for the customer request
- Service Provider that have the service and its responsibilities are:
  - Publishing their available services
  - Integrate their monitroing system with the Service Selector

B. Components

AHTQSA global framework consists of main six Ontologies: Traffic Identification, QoS, SLA, Security, Service Reporistory and Moniroting

- Traffic Identifications Ontology
  - Domain

    It includes different identification methods as indicated in Figures 7 and 8 which are categorized into two essentail groups:
    - online classification for known attacks
    - offline classification for abnormal attacks
  - Answered Questions
    - What are the causes of the abnormal attacks
    - Do the Service Provider apply the required security methods?
    - The target users
      - Customer
    - Developer
      - Service Provider and Service Selector
    - Operation

      This ontology wil include the different concpets that represents the categories of applications and they will be classified into two main categries known and unknow classes then using of machine learning algoritthms to put each type of traffic on its correct class.
- Security Ontology
  - Domain: the relations of concepts that are used by security methods to provide protection on nework system including
    - Type of attacks
    - Detection engines
    - The behavaiour in case of abnormal attacks
  - Answered Questions
    - What are best method to detect the attacks
    - Handling abnormal attacks
    - The status of security attacks on specific customer
  - The target users
    - The service provider
  - Developer

- The Service Selector and the Service Provider

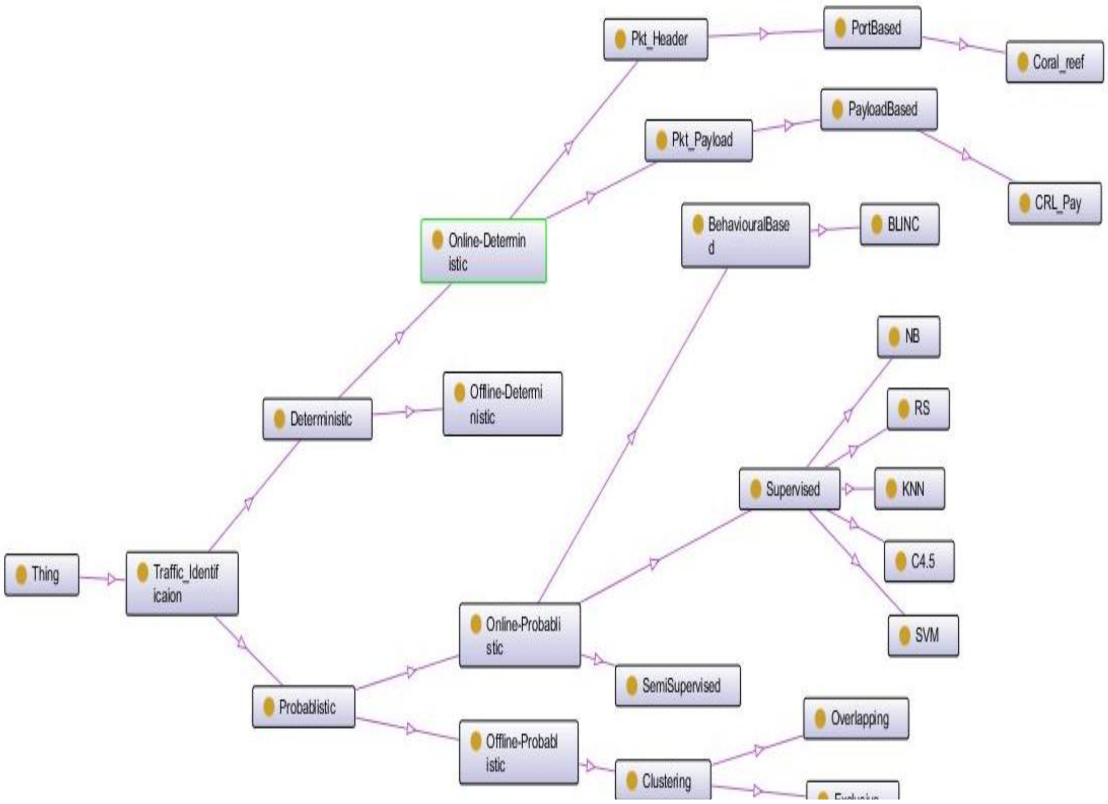

Fig 7: A Sample of Traffic Identificaion Ontoloy Structure

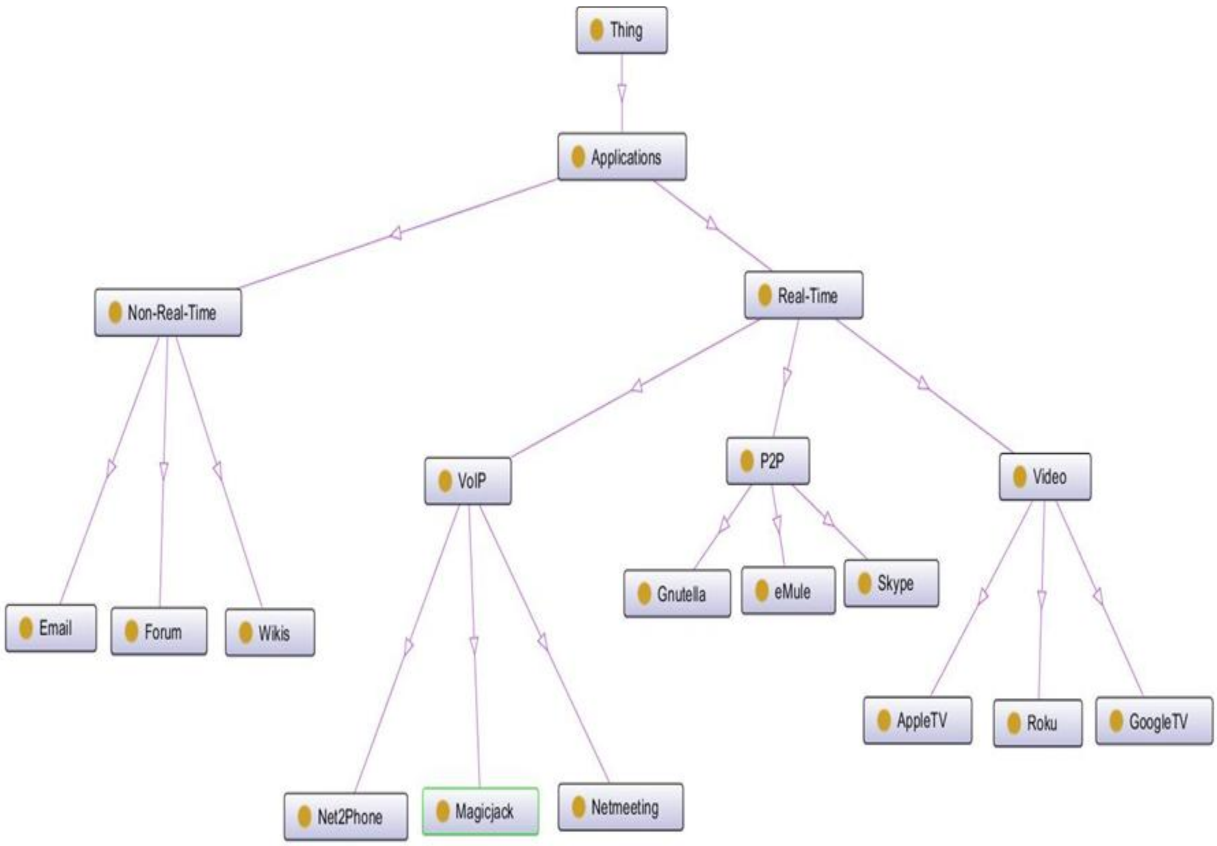

Fig 8. A Sample of Application Characteristics Ontoloy Structure

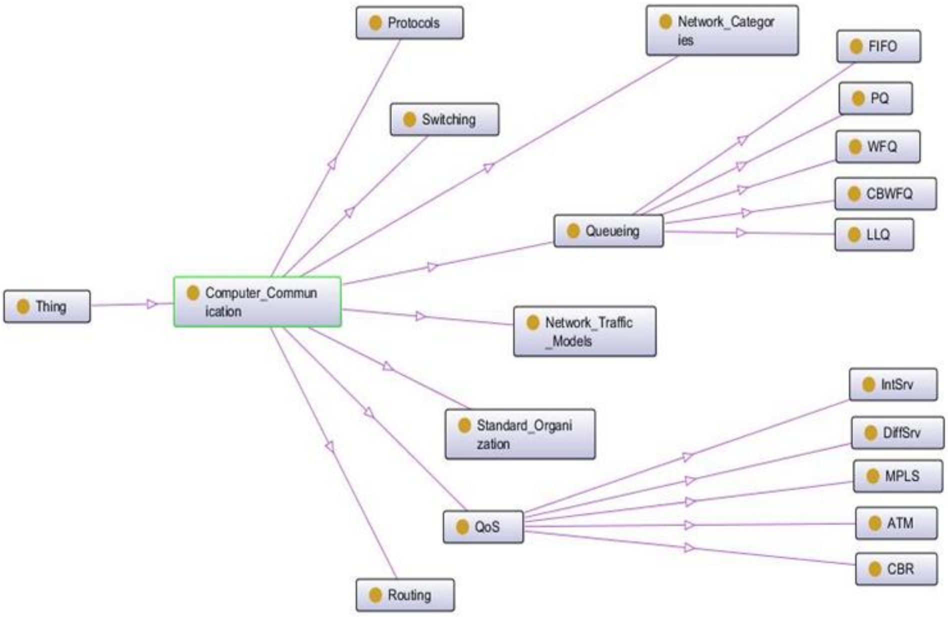

Fig 9. A Sample of QoS Ontoloy Structure

- QoS Ontology
  - Domain
    It includes different QoS policies as shown on Figure 9 that can be applied to guarantee the SLA among the service provider and the customer
  - Answered Questions
    - Is it QoS achievable?
  - The target users
    - Service Provider
  - Developer
    - Service Selector and Service Provider
- Traffic Monitoring Ontology
  - Domain
    The scope of this ontology is to identify the different collections methods for network data that represent the status of the network and ensure the achievement of the Service Level Agreement
  - Answered Questions
    During service provider selection process, it address the abilitiy for the provider to achieve the SLA
  - The target users
    The customer will use it to ensure the achievment of its services
    The service selector will use this component
  - Developer
    Service Selector, and Service Provider

C. Case Study

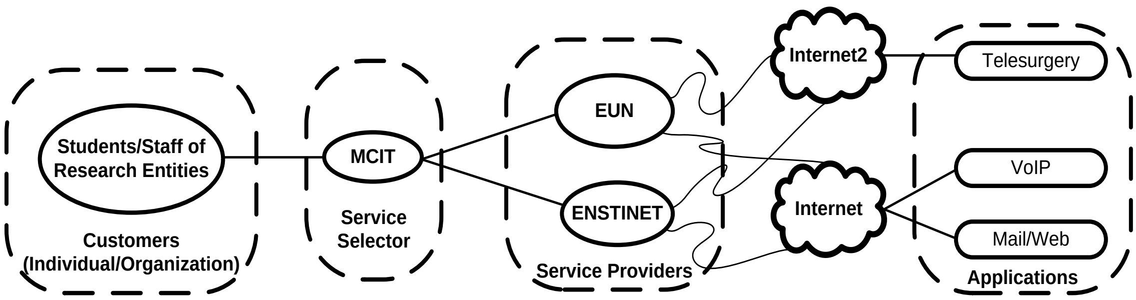

Fig 10. Case Study for Research Entities in Egypt

This case study is concerned with research community that have different deployment scenarios for either research and normal activities. These activities have a dynamic characteristics and run over Internet and Internet2 IP networks. The problem to be addressed in this case are: how to have a dynamic assignment for SLA for these applications and how to have a fully controlled operation cycle to ensure the required SLA over complex system. The case study consists of three stack holders as shown in Figure 10: Customer, Service Selector, and Service Providers. The first, Customers are assumed to be the staff and students in Egyptian universities and they are act both roles individual which represent staff and students and organization which represents faculties and research entities. The second, Service Selector is assumed to be the Ministry of Communication and Information Technology (MCIT) as it is considered as it has sufficient capabilities for selecting among different providers and measuring the SLA.

The third, Service Provider are assumed to be the Egyptian Universities Network (EUN) and Egyptian National Scientific & Technical Information Network (ENSTINET). There three categories of applications that will be used are: telemedicine application for telesurgery over Internet2, VoIP SIP Phone application, and Mail Application. Telesurgery application needs: SLA which has the following attribute: throughput that shouldn't be less than 10 Mbps for example and a delay that shouldn't exceed 330 ms [37]. Internet2 may be one of the technologies that suits telesurgery. VoIP application is sensitive to delay and packet losses according to many references as [38], the delay shouldn't exceed 150 ms and the 5 percent for packet loss and due to the different compression techniques these QoS attributes may subjected to changes. The third type of application is the mail and it doesn't have a specific QoS requirements. Each type of the three application will have its own SLA. Monitoring and Security Ontologies components are needed for all types of SLA as they have a great impact for obtaining the services with the required efficiency and confidentially.

CONCLUSION AND FUTURE WORK

Although, several research efforts have been developed for providing Internet services with a specific SLA, it remains a challenge for the research community to have a global framework over IP network, particularly, Internet to achieve the expected QoE for the customers. The main characteristic that run lead to this challenge is the complexity of the system and the main problem to be addressed in this complex system is the Heterogeneity. The Global Framework, AHTQSA, has been developed to address the heterogeneity issue in this complex system. The necessity of such frameworks has a greater motivation for developing countries than the developed countries because the individual or organization are in urgent need to rationalize the cost of the service and obtain the need SLA. AHTQSA Global Framework consists of three parts: Customers, Service Selector, and Service Provider. Customers are representing the service requirements and evaluation of the provided services either through the QoE and the monitoring tools which should be provided by the service selector. The Service Selector consists of 6 Ontologies which represent the overall operation cycle starting from selecting to obtaining the services. The Service Provider component that consists mainly from 6 interfaces that interact directly with the Service Selector and Customer to complete the operation cycle for Services provisioning. There is a need for both Customer Validation and System Verification Methods to ensure the correctness of the Service Provisioning process.

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