Journal of Engineering and Development, Vol. 17, No.2, 2013, ISSN 1813- 7822

Design and Implementation of Internet Protocol Based Geolocation System

Muayad Khalil Murtadha

Assistance Lecturer

Computer Center/University of Baghdad

Abstract

Determining the geographic location of an Internet Protocol (IP) devices based on its IP addresses is a challenging matter because of wide network topologies and many protocols used to interconnect these devices. On the other hand, the Internet Protocol does not contain any geographic information; they contain routing information, therefore some geolocation techniques should be developed to solve this matter. Today, finding the geographic location of an IP address becomes more important for many applications like local aware applications and restricted content delivery based on IP location. This work presents the design and implementation of IP location determination system which has been developed using the network of Computer center of University of Baghdad. In this system, a network entity called a Location Information Server (LIS) is defined to exist within the access network used to provide location information to IP devices operating within the access network. The designed system provides solutions that meet the requirements for determining the location of Private IP address inside Local Area Network (LAN), also, it describes the geographic location of Public IP address on the Internet.

Keywords: Internet Protocol, IP Geolocation, Location Determination, Locaion Information, Geographic location

تصميم و تنفيذ نظام تحديد المواقع الجغرافية مبني على استخدام بروتوكول الانترنت

مدرس مساعد مؤيد خليل مرتضى

مركز الحاسبة الالكترونية / جامعة بغداد

الخلاصة

تحديد الموقع الجغرافي للاجهزة التي تعمل على بروتوكول الانترنيت (Internet Protocol) مبنية على تحديد الموقع الجغرافي لعنوان بروتوكول الانترنيت (IP address) هو مسألة تحدي بسبب سعة البنية للشبكات واستخدام عدة انواع من البروتوكولات لربط هذة الاجهزة. من جهة اخرى، بوتوكول الانترنيت لا يحتوي على اي معلومات جغرافية، بل يحتوي على معلومات التوجيه، لذلك بعض تقنيات تحديد الموقع الجغرافي ينبغي ان تطور لحل هذه المسألة. اليوم، ايجاد الموقع الجغرافي لعنوان بروتوكول الانترنيت اصبح اكثر اهمية للعديد من التطبيقات مثل تطبيقات المعلومات المحلية للمستخدم وفرض القيود على توصيل المحتوى مبنية على الموقع الجغرافي لعنوان بروتوكول الانترنيت. هذا العمل يعرض تصميم وبناء نظام تحديد الموقع لعنوان بوتوكول الانترنيت والذي طور باستخدام الشبكة الموجودة في مركز الحاسبة الالكترونية في جامعة بغداد. في هذا العمل تم تعريف كيان يسمى خادم معلومات المواقع (Location Information Server) ليوضع على الشبكة لتوفير معلومات الموقع الى الاجهزة التي تعمل بوسطة بوتوكول الانترنيت ضمن الشبكة. النظام المصمم يوفر الحلول التي تلبي متطلبات تحديد الموقع لعناوين بروتوكول الانترنيت الخاصة (Private IP address) في الشبكة المحلية (Local Area Network) ، وكذلك يوضح تحديد الموقع الجغرافي لعنوان بروتوكول الانترنيت العمومي (Public IP address) على شبكة الانترنيت.

1. Introduction

Determining the geographical position of an Internet Protocol (IP) devices or IP users has been an open issue since Internet became available for everyone and everywhere, but because this has not been a critical need, it was more like an academic problem than a real concern that had to be solved. But lately, more and more critical services are available in the global network based on IP geolocations, where location information is a valuable customization for many websites. Therefore, finding the geographic location of an IP address becomes important technique for many new applications over the Internet.

IP Geolocations can be defined as the mapping of Internet Protocol (IP) address to real word geographic location of a Network connected or Internet connected to a computing device or mobile device. IP Geolocation involves in mapping IP address to country, region, city, latitude/longitude, Internet Service Provider (ISP) and domain name among other useful things.

Many applications and benefit may be enabled by knowing the geographical locations of IP device. Such as locality-aware applications include local weather forecast, the choice of language to display on web pages, targeted advertisement, page hit account in different

places, restricted content delivery according to local policies, local events, and local time zone adaptation could be accomplished without user interaction. Locality-aware peer selection will also help point to point applications in bringing better user experience as well as reducing networking traffic such as IP phones that uses Voice over IP (VoIP) technology and video conference systems that uses H323 and SIP protocols. Also, Web services such as Google.com, Amazon.com could partition their users based on geography [1].

This paper describes the design and implementation of IP location determination system to an office that has an enterprise local network and also has many connections to Internet; therefore several techniques for applying this technology to an application are presented. To view the proposed system, this paper is organized as follows: **Section 2** presents the related work in geolocation of IP address, section 3 discusses the location determination system architecture, while **section 4** describes the design and implementation of IP location determination system which divided into two parts, part one deals with IP location determination system for local enterprise network, and part 2 explains the implementation of IP geolocation for global networks or Internet, and finally section 5 shows the conclusions and outlines the future work.

2. Related Work

Today, any enterprise network and/or Internet has become the base for a collection of many resources and applications that may use by a wide number of users with different utilization. So, offering the ability for users to get information based on geographic location can decrease search time and increase visibility of local establishments, taking into account that determining geographic location based on IP address offers localization services and brings user communities without need for Global Positioning System (GPS) receivers.

One important thing here is that geographic location is outside the scope of the Internet protocol, where IP addresses do not contain any geographic information. Therefore, there is need to develop some protocols and techniques that deals with this problem. These protocols or techniques should provide the geographic location of IP users with some accuracy bound and taking the time to getting the location into account. Some notes are presented and summarized for some available works for IP location determination which is available from the survey.

Some works based on measuring time delay between computing devices or hosts using some available tools like *Ping latencies* to measure propagation delay, or by advanced using *Traceroute Paths* to measure processing delay [2][3]. This techniques based on assumption that the geographic distance between the hosts is a function of the time delay between them. Therefore using triangulation method with few hosts of known locations, it should be possible to determine approximate location of the IP address. The difficulty with measuring time delay as well as lack of good estimation function depends on the ability of translating milliseconds into kilometers. This is because there are many different links between hosts which may be optical links, satellite links, wireless links or standard Ethernet links. Each of them has different propagation delay.

Another works use the technique that infers information from domain name system host name and the IP address of the target device to reach to the nearest network nodes, routers or servers that may provide some geolocation information **[1][3]**. While other works use the assumption that is similar IP addresses from one subnet should be close to each other. Therefore knowing the location of few computing devices, servers or hosts from a pool, such as from the web form, can be assumed it is true for the whole subnet. All of the above techniques have limited accuracy and need to more improvement works **[5]**.

3. IP Location System Architecture

The location determination service in any networks may be dividing into three critical functions that can be use to dealing with the location of arbitrary IP devices. These functions are as follows: *location measurement, location determination* and *location acquisition*. A *location measurement* is a datum that can be used to locate a device. A location server uses measurements to determine location, and a location measurement can be used as a key into a location database, or as input to an algorithm. *Location determination* is the act of using measurements taken from the access network to calculate or compute the physical location of a device. The computations may be relatively simple or complex depending on the type of access network, such as looking up switch and port values in a database for wired Ethernet networks, and such as computing location based on angle of arrival or time of arrival of radio

signals for wireless networks. Location determination is, by its very nature, a process that is dependent on the context of the access network. *Location acquisition* is the act of obtaining location information once location has been determined. Location information is acquired by accessing a network service, a location server, and is done without requiring specific knowledge about the type of access network [6]. **Figure 1** show how the entities in the network-based location architecture participate in each of these functions.

In this architecture, a network entity called a Location Information Server (LIS) is defined to exist within the access network. The primary function of the LIS is to provide location information to IP devices operating within the access network or to properly authorized applications requesting location through a reference mechanism. It should be noted here that "IP device" is used to refer to the IP network entity whose location is being determined.

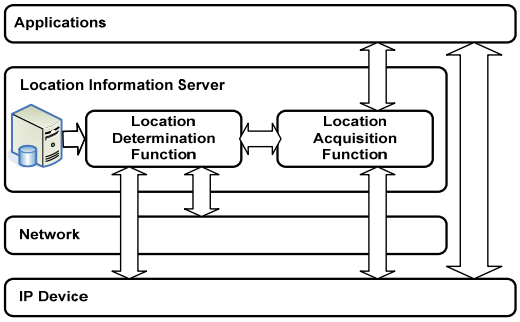

Figure 1: Location Determination System Architecture

The access network can be large or small, flat or hierarchical, wired or wireless and the list goes on and on. There is no standard for what constitutes an enterprise network; consequently the technologies and mechanisms that are needed to determine location also vary from network to network. A network entity called Access Location Entity (ALE) is defined to provide location measurements, and located at the very edges of the network where it has access to the necessary information about network attachments. The ALE is a generic label applied to a class of components that provide location measurements. The specific functions that ALE provides depend on the type of access network, but they all have the common property of being responsible for providing location measurements**. Figure 2** shows how ALEs from different types of access networks can report to a single LIS. The LIS needs to understand each of these networks, but the LIS hides this complexity by providing the same interface to its clients, irrespective of the type of access network. Note that each ALE monitors a particular network sector and multiple ALEs may be required at different points of

the network to provide sufficient information to determine location. The LIS is responsible for collating information from multiple ALEs [6].

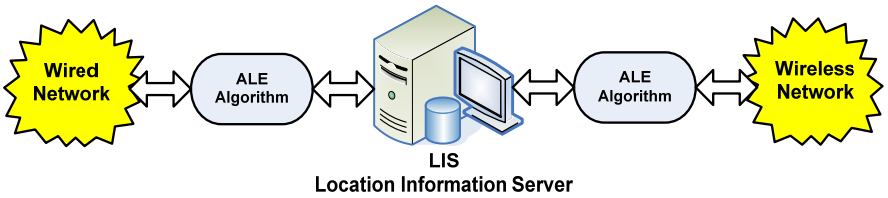

Figure 2: Different Types of ALEs fot Different Access Networks

It is useful to realize that at any point along the location determination chain, one piece of information is known and the other is required. The Flexible LIS-ALE Protocol (FLAP) used for communication between the LIS and ALE was developed. The FLAP Protocol was designed to provide a framework for reporting location measurements. FLAP protocol names the known component *terminal* information, that is, the information identifies a particular terminal. The unknown part relates to how the terminal accesses the network. This is called *access* information. The ALE is responsible for providing access information when given terminal information. For example, if ALE in an Ethernet switch is queried, it can provide a link between a MAC address and/or IP address (terminal information) and a switch and port (access information). The distinction between terminal and access information is a simplification that can be thought of as a key-value pair. The link between these values is provided by the ALE. FLAP protocol provides a framework for reporting this link between terminal and access information. Also FLAP is defined as a protocol framework that provides bidirectional, asynchronous communication between two entities, in this case, a LIS and ALE, therefore in the spirit of keeping all configuration data centralized, the LIS initiates the FLAP connection. The only configuration that may be required at the ALE is that which permits the authentication of the LIS.

4. The Design and Implementation of IP-Based Location Determination System

Generally, based on IP addressing assignment, we can assume that the computer network in any organization may consist from two sides, one deal with the internal Local Area Network (LAN) of the organization that has internal IP access with *Private IP Addresses*. These private IP addresses will be hidden for other networks or for Internet because of firewalls and routers may isolate internal local network from outside word. The other side works with Internet which has external IP access with *Public IP Addresses* on Internet. The proposed system should be design to cover these two sides. Therefore the

system may be works with enterprise LAN to determine the private IP address location in any place on the organization, and also have the ability to works with Internet to determine the external IP address geolocation.

The implementation of the system requires an organization works with these two sides of network, and this organization may have a clear network structure and many computing devices connected to one local network. Therefore, the proposed system uses the computer network of the Computer Center of University of Baghdad at aljaderiya campus, where the Computer Center has an organized network planning, with modern network devices used and because the availability of wire maps schematics of the network.

The Computer Center has more than 14 laboratories, each laboratory have at least 20 computers arranged as 5 rows by 4 columns and two of them arranged as U shape with one row and two columns, **figure 3** shows the computers arrangement in some laboratories. Each laboratory has its own network that connect there computers using managed switch, like Cisco catalyst 2500, and all switches are connected to one main switch. A Microsoft Windows server platform with routing capabilities was installed on hardware model type HP Proliant ML380 server is used to operate as Location Information Server (LIS) that manages the location determination operation. **Figure 4** presents the network structure of Computer Center with IP addressing scheme.

(a) Laboratory Number (3) **(b)** Laboratory Number (14)

Figure 3: Computer Laboratories in Computer Center at University of Baghdad

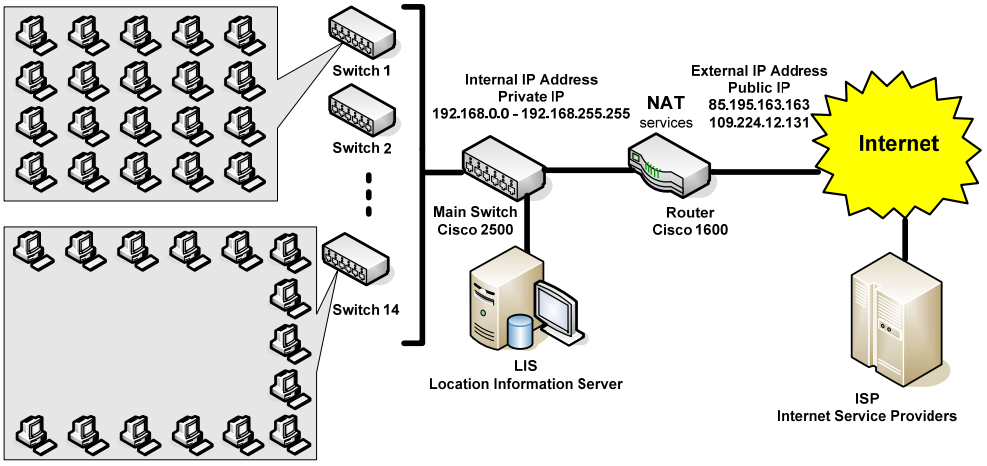

Figure 4: The Network Structure of Computer Center with IP Addressing Scheme

4.1. Internal IP Location Determination

This section deals determining the location of IP address inside local network. In fact, this is may be useful function at Computer Center which provides many international certifications to improve the administration of the online tests on each laboratory and on each computer on the specified laboratory, for example on line tests of IC3 certification should done only at laboratory 4, so if the IP address of the computer of the test on any other laboratory, the exam may be closed.

The ALE algorithm for Ethernet wired network should be use to determine the geographical location of IP devices. The ALE operation for Ethernet network depends mainly on layer 2 switches and many of the switches available are smart switches which they support an interface that allows the switch configuration to be set and the performance of the switch to be monitored remotely. One of the most important information that a managed switch keeps is a current list of all MAC addresses connected to each port on the switch. They do that by listening in on the incoming traffic to examine the source MAC addresses of the incoming frames on its ports. The MAC address-to-port mappings are stored in a MAC database. This MAC database is often called *MAC address table* or *Content-Addressable-Memory* (CAM) table. The MAC entry is created after switch initialization and stay in the MAC address table up to the age time. If any device does not transmit another frame to the switch before age time expires, that entry will not be refreshed and removed from MAC address table. Therefore the MAC address table remembering the most active devices in the network and also the aging time accommodates devices when moves. Aging allows the switch to forget an entry about a device that has been removed. If a device is moved from one port to another, the switch will

immediately learn the new location of the device as soon as that device begins to transmit frames to switch on the new port.

When the ALE now accessing the MAC address table of a particular switch, it is possible for ALE to see all client hardware (MAC) addresses connected to the switch and what physical interface (port) they are connected on. This MAC addresses information can then be used by the LIS to determine where a particular device is. The LIS will do this by maintaining a "wire map" database that relates switch ports to location, typically, the office location that is at the other end of the Ethernet cable and that is plugged into a specific switch port. One important thing here is that how to represent the location of IP device inside office. The best way is to specify the room number or laboratory number and then indicates in which row and column that the computer is located. Based on IP addressing assignments the location of private IP address in the local network can be measure in different ways:

4.1.1 Location Determination Based on Static IP Assignments

In this way a static IP address is assigned to each computer or IP device in the network to become a part of the network, but the communication between computers or IP devices can occur through Network Interface Card (NIC) or network card, and each card have a hardware address known as MAC address burned into the network card itself. When there is a communication from on computer to another, we are familiar with IP addresses of these systems, but in fact the computers use the physical address or the MAC address to send and receive data.

One way to implement the location determination system is by building a database in the LIS that contains the static IP address (assigned to each computer) to the MAC address corresponding to that IP address. In this way the IP-to-MAC address mapping is provided to the ALE from the LIS. The LIS now receives FLAP messages from the ALE periodically providing switch-port-MAC mappings that the LIS keeps in a dynamic table, as shown in **figure 5**, this then allows the LIS to map IP address to location by following the chain of IP to MAC, MAC to switch and port, and then switch and port to location using the wire map database.

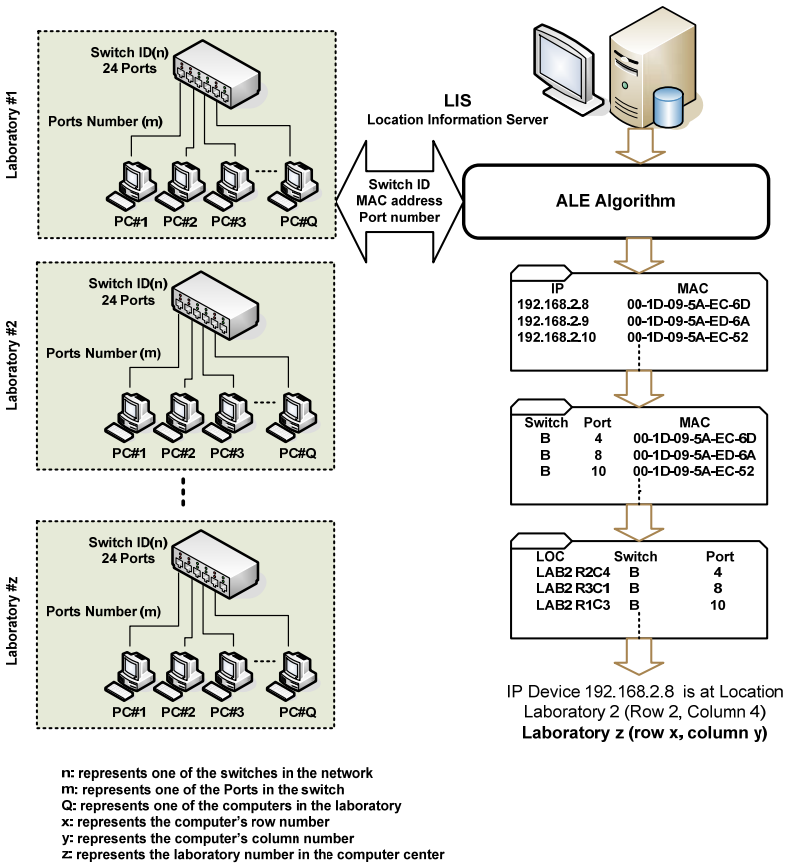

Figure 5: Location Determination Using IP to MAC,MAC to Switch and Switch to Port Chain

In this way we need to manually enter the IP-to-MAC addresses database into the LIS. The problem here is that the change in any IP addresses assignment to any computer must also known and changed in the LIS database Therefore this is becoming less and less common use in large networks especially when there are many subnets in the network, because the manual building of IP-to-MAC addresses database leads to many difficulties to the static IP addresses administration and performs complex operation in the LIS.

One way to overcome this problem is to use the Address Resolution Protocol (ARP) which designed to provide a mapping from logical IP addresses to the physical MAC addresses. Address resolution is the process of resolving addresses or converting from one type of address to another. In the case of ARP, the logical address or network (layer-3 address) is being converted to the MAC address or physical (layer-2 address).

The router of the network keeps the information of IP address to MAC address mapping in the ARP table or ARP cache. Now the ALE can request the ARP table from the router, as shown in the **figure 6**, to determine the MAC address corresponding the IP address required, and then performs the chain of MAC to switch, switch to port, port to location in the LIS database to determine the location of the computer location or IP device location. Flow chart in **figure 7** describes the location determination implementation based on static IP assignments with ARP table used.

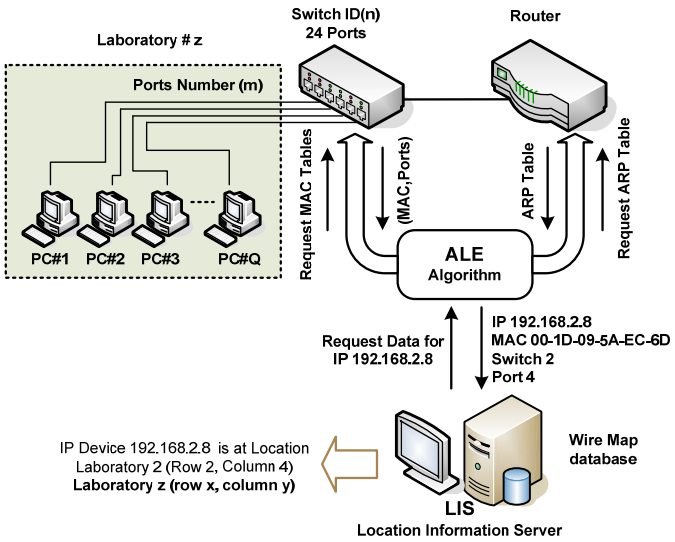

Figure 6: Static IP Assignments Using ARP Table Location Determination System

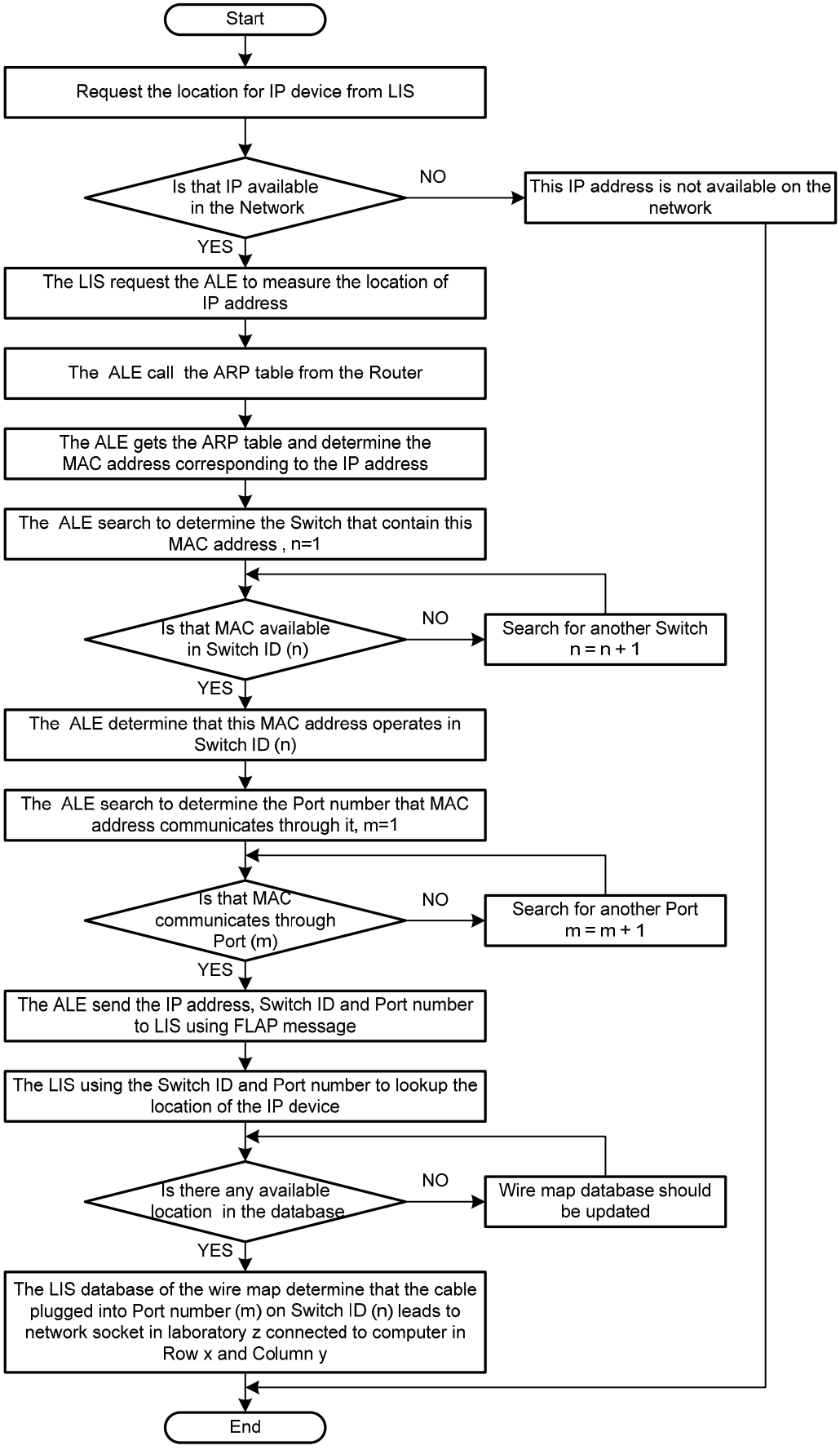

Figure 7: Flowchart Explains Static IP Assignments Location Determination System

4.1.2 Location Determination Based on Dynamic IP Assignments

Configuring IP addressing on a large TCP/IP-based network may be complex, especially if machines are moved from one network to another frequently. The Dynamic Host Configuration Protocol (DHCP) can help with the workload of configuring systems on a network by assigning addresses to systems on boot-up automatically.

The process of dynamically assigning IP addresses is managed via a DHCP server. The DHCP server is configured with a set of usable IP addresses, called a scope. The scope can also include the subnet mask, IP addresses of the default gateway, DNS servers, WINS servers, and other necessary addresses. When a computer comes online and is set up to use a DHCP server, it requests an IP address by transmitting a broadcast request packet looking for any DHCP servers on the network (known as DHCP Discovery). The DHCP server responds with an offer containing an IP address that the client can lease (known as the DHCP Offer). The client then accepts the offer by sending a request message for that address from the DHCP server (known as the DHCP Request), and then the server responds with an acknowledgment to the client that it has that address and additional settings for the lease time (known as the DHCP ACK). The DHCP server marks the IP address in its database as being in use so that it is not assigned again. Several Microsoft Windows server platforms having the DHCP server capabilities, and also many routers and firewalls today comes with DHCP services. Therefore, the DHCP protocol can be easily install and configured in the networks and the setting of host computers is simple.

In the location determination systems the use of DHCP protocol gives an important step to improving the system to become more dynamics where the DHCP server can provides the information of IP address to MAC address mappings as shown in the **figure 8**. Flow chart in **figure 9** describes the location determination implementation based on dynamic IP assignments. This chart presents that the ALE can request the DHCP server to determine the MAC address corresponding the IP address required, and then performs the chain of MAC to switch, switch to port, port to location in the LIS database to determine the location of the computer or IP device.

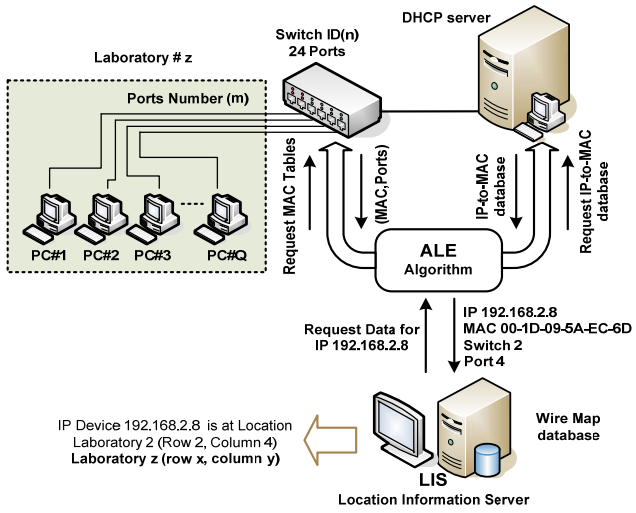

Figure 8: Dynamic IP Assignments Location Determination System

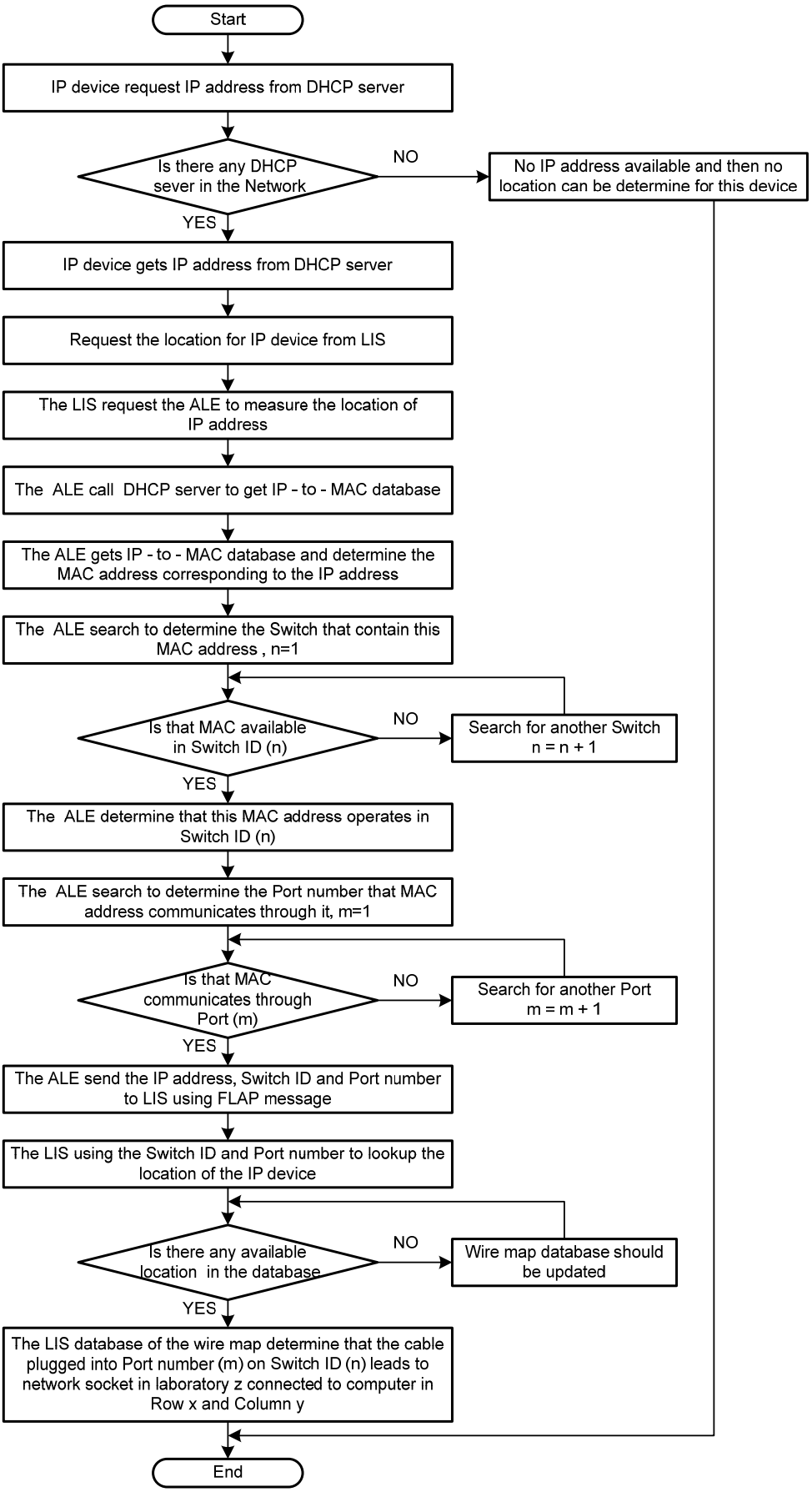

Figure 9: Flowchart Explains Dynamic IP Assignments Location Determination System

4.1.3 Location Determination Based on Domain Name Assignments

The Domain Name System (DNS) is a hierarchical system of user-friendly names that can be used to locate computers and other resources on your local network or on the Internet. This style of name, known as a Fully Qualified Domain Name (FQDN), must be converted to an IP address before communication can occur. DNS server exists as the solution to resolve the names of computers (FQDN) to IP addresses. The DNS can be implemented using Microsoft Windows Server platforms which are built on the same standards of Internet.

For the location determination system, the ALE can request the DNS server to get the IP address for the name space of the specified computer. as shown in the **figure 10**, where the DNS server use the DNS revolvers of type A records which contain the forward lookup of computer host name to IP address. ALE then request DHCP server to determine the MAC address corresponding that IP address, and then performs the other parts of location determination system. Flow chart in **figure 11** describes the location determination implementation based on DNS assignments.

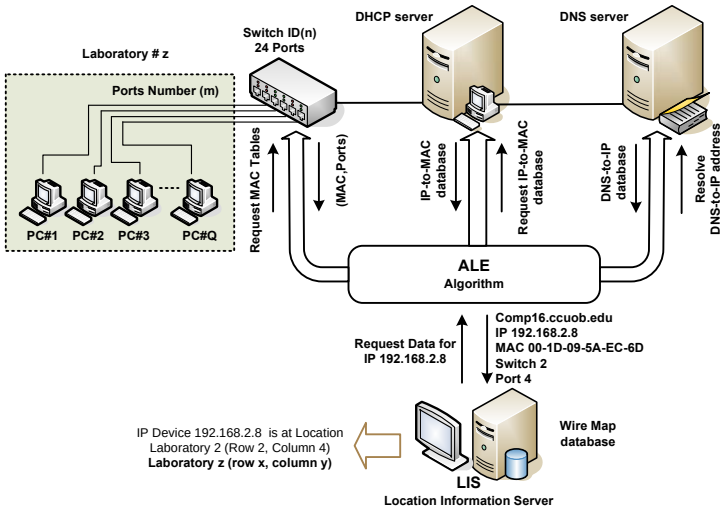

Figure 10: Domain Name System Based Location Determination System

4.2. External IP Location Determination

This section describes the implementation of gelocation system for public IP address, or IP address on the Internet. The IP location determination over Internet (or the Internet geolocation) is a technique of determining the physical location of the Internet user by determining the latitude/longitude of IP device and by interfacing to geographical maps to locate the country, city, nation, ISP and other things. This technique provides many useful applications such that to identify where the web visitors are coming from, where the potential

customers are, display different languages and reduce credit card fraud based on geographical location, also used to fight against illegal spammers and hackers to locate the source of the problem.

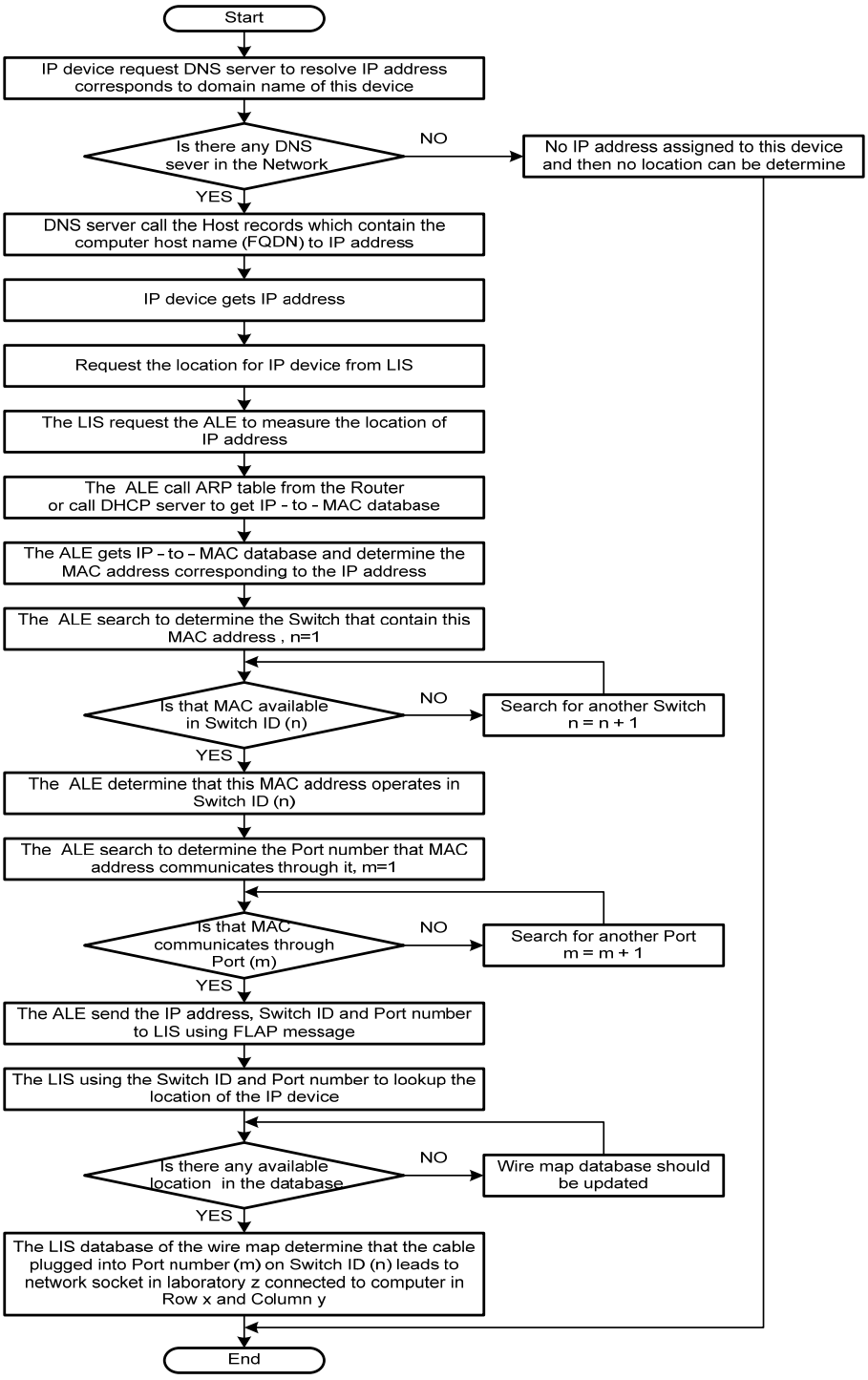

Figure 11: Flowchart Explains Domain Name System Based Location Determination System

Most networks today are connected to the Internet, and having an Internet connection presents a number of security concerns. For example, the server connected directly to the Internet may be subject to be hacked. Network Address Translation (NAT) is a network service that is responsible for translating internal IP addresses from computers inside the network to a public address used by the NAT service, which hiding the internal network addresses. **Figure 4** displays a typical NAT configuration in the home router of Computer Center network. Notice that the NAT server has two network interfaces: the internal interface (*Local Area Interface LAN Interface*) connected to local network and the external interface (*Wide Area Interface WAN Interface*) connected to Internet. The internal interface has a *Private IP address* of the internal network (192.168.0.1), this will be the default gateway address of all other systems on the network because the NAT server is the way off the network, whereas the external interface uses an external *Public IP address* (85.195.163.163) or other IP address provided by ISP. The router then may perform DHCP protocol or Point to Point protocol to provide Internet connections to computers in local network.

To determine the IP address geolocation, it must be first determine the public IP address of the network, if this IP address is not given by ISP, we can use the web report from the *www.whatismyip.com* web site which gives the pubic IP address of the network, and then it is possible to determine the location of this IP address. Today, there are a growing number of companies maintain license databases which map IP addresses to geographic locations and there are a number of commercially available geolocation databases and their pricing and accuracy may vary depending on the services. The most common databases are those provide by IPligence, IP2location and Maxmind. Each of them provides different types of databases that depend on the services and accuracy. **Table 1** present a comparison between these databases depending on its applications and the information which provided. The table shows that the Maxmind database may provides more applications than the other two types.

On the other hand, each database may have many products, for example IP2location provides 20 different databases or products, while the IPligence provides three different products with different services and applications as shown in the **table 2**, where the price of the database or the product depends on the information contained in the database. It is clear that the IPligence MAX gives better performance and accuracy from other types because it provides the city and the latitude/longitude localizations which lead to better accuracy.

On the Internet, there are some of database servers that provide free IP geolocation determination with limited accuracy. These database servers use one of the localization databases described above. For example, some geolocation servers provide IP to country or IP to city locations, which gives direct IP address to geographic map on the Internet, which can be used to determine the geographical location of the IP device, such as shown in **figures 12**, 13, 14 that show the public IP address of computer center on the geographic map for two ISPs.

Table 1 :A Comparison Between Maxmind, IP2location and IPligence databases

	Maxmind	IP2location	IPligence
Continent			√
Country	√	√	√
State/Region	√	√	√
City	√	√	√
Zip Code	√	√	
Latitude	√	√	√
Longitude	√	√	√
ISP	√	√	√
Organization	√	√	√
Organization Type	√		
Network Speed	√	√	
Network Type			
Domain	√	√	
Area Code	√	√	
Metro Code	√		
Weather Station		√	
Time Zone		√	√
Proxy	√		
Subscription	Monthly	Annual	Annual

Table 2: IPligence Products Databases of IP address to Geolocation

Product Name	IP From/IP To	Country Code	Country	Continent Code	Continent	Time Zone	Owner	Region Code	Region	County	City	Latitude / Longitude
Lite	√	√	√	√	√							
Basic	√	√	√	√	√	√	√	√	√			
MAX	√	√	√	√	√	√	√	√	√	√	√	√

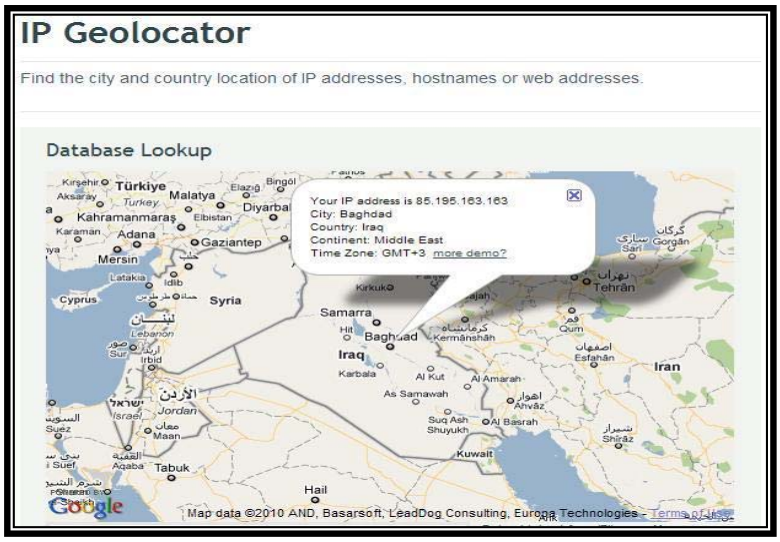

Figure 12:Public IP Address Geolocation for ISP#1 using *www.IPligence.com* Server

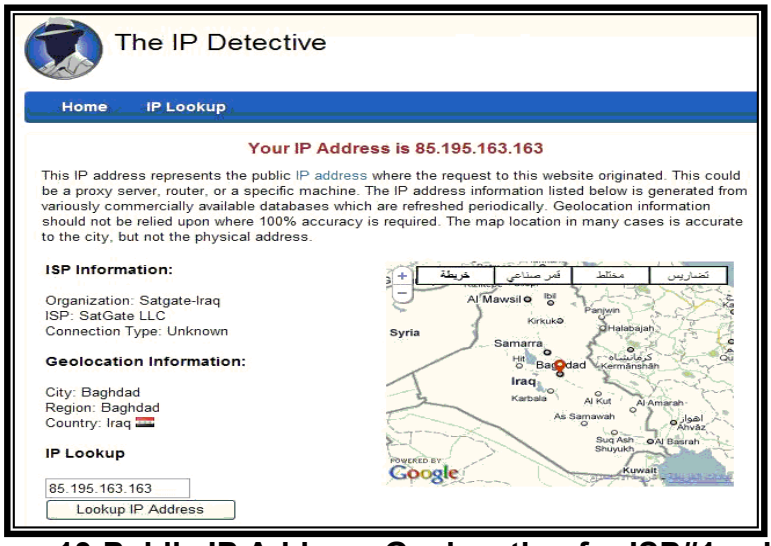

Figure 13:Public IP Address Geolocation for ISP#1 using *www.theipdetective.com* Server

Figure 14:Public IP Address Geolocation for ISP#2 using *www.whatismyipaddress.com* Server

In fact, it is difficult to measure the performance of the geolocation databases using *ping* command because the difficulty of getting good time delay measurement as well as the lack of good estimation function which depends on the ability of transferring milliseconds into kilometers. This is because there are many different links between the user and the ISP. These links may be optical fiber with gigabits, satellite links with few megabits, wireless links with more than 100 megabits and standard Ethernet wire which depends on the category type. Each one of the links has different versions with different speeds, and so, each one has different propagation delay. On the other hand, there is another important factor which is the load balance (number of users per given bandwidth) also effects the network speed and then leads to more time delay when using more users per given bandwidth. Therefore it is better to use tools provided by specialized servers deals with this issue on the Internet, for example the tools provided by *whatismyipaddress.com* and *topwebhosts.org* to measure the accuracy of IP geolocation databases. Table 3 shows the user reported accuracy of the geolocation services over 90 days for the IP geolocations databases described above. Also, table 4 presents a performance comparison of several services for free IP gelocation databases described for private IP address of ISP#2 in computer center that have been obtained after several tests.

Table 3: Summary of The Reported Accuracy of Geolocation Services over 90 Days Using Tools Provided by *whatismyipaddress.com* and *topwebhosts.org*

Distance	Maxmind	IP2location	IPligence
0-2 km	34%	33%	32%
2-10 km	13%	14%	13%
10-25 km	7%	5%	5%
25-50 km	5%	5%	5%
50-100 km	6%	5%	5%
100-250 km	7%	7%	6%
250-500 km	6%	7%	6%
500-1000 km	6%	7%	6%

Table 4: The Performance Comparison Between Several Geolocation Databases of ISP#2

	Maxmind	IP2location	IPligence
Continent			Middle East
Country	Iraq	Iraq	Iraq
State/Region	Baghdad	Baghdad	Baghdad
City	Baghdad	Baghdad	Baghdad
Latitude	33	33.3406	33.72434
Longitude	44	44.4009	44.90136
Organization	Earthlink Ltd.		
ISP	Earthlink Ltd. Communication and Internet Services	Earthlink Ltd. Communication and Internet Services	Earthlink Ltd. Communication and Internet Services
Connection	Broadband	DSL	Broadband
Time Zone		GMT+3	GMT+3

The latitude/longitude of the computer center building at aljaderiya campus obtained from Google earth is (latitude: 33.6529, longitude: 44.7623), comparing this with values in the test comparison in table 4 shows that the IPligence may provide better performance and accuracy from the other two databases. The important note here is that the accuracy and the information provided by these free database servers differ from one to another depending on the database version used, the services and the tools used in the location determination. For example the *www.theipdetective.com/tools* may gives more accurate IP address geolocation of private IP address (85.195.163.163) which is the IP address given by ISP#1 in computer center of University of Baghdad at aljaderiya campus when using the tools provided, as shown in figure 15, . Also there are some databases provides DNS name to IP address and then to geographic location. For example we can determine the location of the web site server of University of Baghdad (*www.uobaghdad.edu.iq*) as shown in figure 16, which gives the IP address of the server and their location. The best database servers that give this application those provide by *www.ipadress.com/whois* (one litter d) and *cqcunter.com/whois* .

The high accuracy databases are fee databases as those provides by IPligence, IP2location and Maxmind with IP address to geolocation update for one year or more depending on the type of products and services required. Most of these databases can be easily integrated into web application and connected to the LIS of the desired system. The venders of these databases offer many Application Programming Interfaces (APIs) and provide codes in many languages such as ASP, PHP, .NET and java programming that can used to retrieve geolocation data from the database server. For example IP2location offers these codes over the web site *www.IP2location.com*.

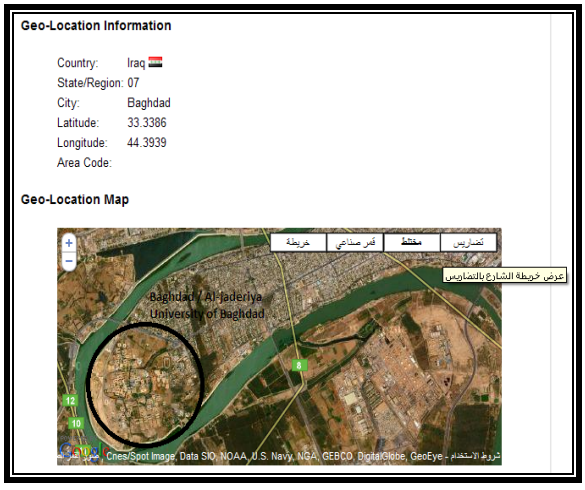

Figure 15: Public IP Address Advanced Geolocation using *www.theipdetective.com/tools*

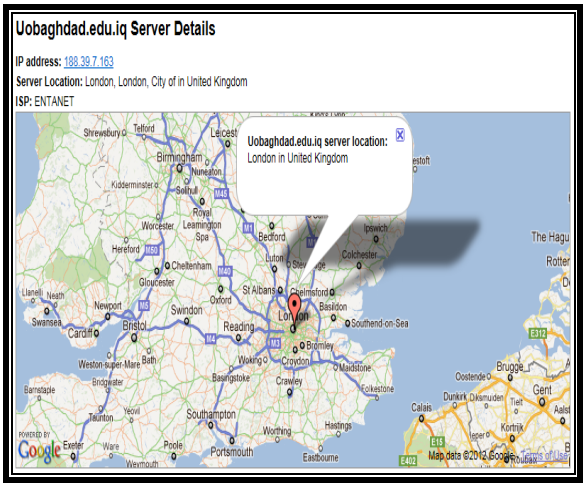

Figure 16: IP Geolocation of the Web Site Server of *www.uobaghdad.edu.iq*

5. Conclusions

The design and implementation of the IP address location determination system is described, where it has been developed and tested in Computer Center at University of Baghdad. This system works by classifying the network of Computer Center into two sides, one deal with internal network with private IP addresses and the other side deals with external connection to Internet with public IP addresses. The requirements and techniques to design the location determination system for each side were described.

The main important issue is to define a LIS which was used to control and administrate the location determination technique, where it appears that the centralized LIS server is important to the management of the location services that deals with many types of access networks with different protocol technologies. Also the ALE is organized to deals with location measurement which placed in front of each access network, where the complexity and size of ALE depends on the type of access network which can be a small software component in a network device or complex hardware that reads network packets to acquire measurements.

The location determination of private IP address in local network can be measured in three different techniques based on the IP addressing assignment. By the implementation tests of these three techniques its found that the static IP assignment using ARP protocol may be easily to implement, but it is complex to manage static IP addresses especially in large networks because each IP address change in any device requires update of database in LIS and therefore its better to use the DHCP protocol which may gives better IP addressing management when computers move from one location to another. The best technique was based on DNS system which provides more configuration capabilities to the network especially when integrated with DHCP protocol. But also this technique has some drawback where it suffers from a problem when moving from one DNS zone at one organization to another DNS zone at office for example.

The geolocation of public IP address on the Internet can be determined using one of the commercially available databases which provided by specialized companies. The most known that we check are those provided by Maxmind, IP2location and IPligence where each one of them provides different types of services, applications and product versions. The comparison

tests of these geolocation databases shows that the IPligence may provide better performance and accuracy than the others when using the available free versions of them. Also, it is found that the accuracy depends on the information provided by the database of the geolocation servers which were differ from one provider to another depending on the database version used and the services and the tools used in the location determination. These databases require periodically updating to maintaining any change in IP address locations.

Most of these databases can be easily integrated into web application and connected to the LIS of the desired system. Therefore, when connecting the local LIS to one of public IP to geolocation database and merging them, we may get a complete IP address location determination system.

References

1. Troy Ronda and Nilton Bila, "**Appono: A Geolocator for the Internet**", Technical Report, University of Toronto, 2007.

2. Bamba Gueye, Artur Ziviani, Mark Crovella and Serge Fidida, " **Constraint-Based Geolocation of Internet Hosts**", Proceedings of 4th ACM SIGCOMM Conference on Internet Measurement, pp:288-293, New York, 2004.

3. V. Padmanabhan, L. Subramanian, "**An investigation of geographic mapping techniques for Internet hosts**", Proceedings of the 2001 Conference on Applications, technologies, Architechure and Protocols for Computer Communication, pp: 173-185, New York, 2001.

4. K. Nowwicki and T. Sikorski, "**Geo-location of Commune of an IP User**", Proceedings of the First International Conference on Information Technology, (2 pages), Poland, 2008.

5. C. Guo, Y. Liu, W. Shen, H. Wang, Q. Yu and Y. Zhang, " **Mining the Web and Internet for Accurate IP Address Geolocations**", IEEE Communication Society, pp:2841-2845, 2009.

6. Martin Dawson, James Winterbottom and Martin Thomson,"**IP Location**", McGraw Hill, 2007.