A Framework for IoT Objects Management based on Future Internet IoT-IMS Communication Platform

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Abstract— **In recent years, with the continuing growth and development in mobile communication technologies, the number of mobile devices and network connected equipment is increasing quickly. Objects/Things in daily life are given the capability to achieve environment sensing and network connectivity. Internet of Things is the best usage and application of mobile computing and ubiquitous service. There are more and more possible applications while things can communicate with each other. However, there are lacks of rules or specifications for things naming. A framework for IoT object management and naming is proposed based on the future internet IoT-IMS communication platform. The communications to Internet of Things (IoT) objects can be easily accomplished through the proposed IoT-IMS (IP Multimedia Subsystem) URI (Uniform Resource Identifier). The framework is implemented by integrating with previous future internet IoT-IMS communication.**

Keywords-IP multimedia subsystem; Internet of Things; IMS-URI; Cloud Computing.

I. INTRODUCTION

Internet and mobile communications has become more and more popular; network has been a necessary part in daily life. In recent years, people start to discuss future internet and Internet of Things (IoT). The major concept of IoT is trying to make objects could communicate with each other. That makes the number of internet connected devices would increase soon. In order to achieve the IoT world, the relationship between objects/things should be considered and the number of internet connected devices would rapid increase. The operation and management for various things is going to be a major task in core network. For migrating to IoT from the current environments, the task to integrate the huge heterogeneous architecture is important. In that such large network, the communication quality between objects/things should be improved.

In our previous research, IP Multimedia Subsystem (IMS) is considered to integrate with objects/things in Internet of Thing world. The reason is that IMS supports different switching mode such as circuit switching and packet switching in telecommunication, many heterogeneous access network and various multimedia services. The services are enhanced to be delivered in different core network or access network. The optimized IMS with features of cloud computing, which is called future internet IoT-IMS communication platform is proposed before [1-2].

The previous research integrates cloud computing to IoT-IMS platform, the computing or storage resources can be managed and deployed automatically in virtualized environment. According to different requirements of IMS element, the computing power and service capability would be adjusted and allocated by the proposed self-adapted script. Besides, the operator could also manually configure the resource allocation according core network status in order to further improve the communication efficiency. The communication quality and service capability in large objects/things in IoT can be kept by the following tasks: (1) allocate more computing resource from resource pool with scalability and elasticity, (2) monitor the whole performance metrics of the IoT-IMS communication platform in real-time.

This rest of the paper is organized as follows. In Section 2, the related works and technological background are reviewed and discussed. In Section 3, the naming delivery agent architecture and the working flow are proposed and illustrated. Our implement results are shown in Section 4. Finally, the conclusions and future works are discussed in section 5.

II. RELATED WORKS

The Future Internet, Internet of Thing, IMS and the Future Internet IoT-IMS communication platform which plays an important role in innovative mobile and internet services in ubiquitous computing are first illustrated. Then, the major framework for IoT objects management is proposed in next section.

A. Future Internet

The development of Future Internet is a very popular research issue. The status of Future Internet is still under discussion. The basic concept of Future Internet is to integrate various data and network communication technologies. It would be given the capability to achieve self-organization and the capability plays an important role in the evolution progress.

According to the Cluster of European Research Projects (CERP-IOT) technique report [3], future internet is defined as a dynamic global network infrastructure. It should be able to achieve self-configuration according the specifications and can be integrated with many virtual objects and physical objects. The future internet should be composed of the following items: (1) standardized communication protocols, (2) Internet of Things, (3) Internet of Media, (4) Internet of Services and (5) Internet of Enterprises. In addition, IoS is defined as a software component and could be delivered through various access network and internet. IoM is going to handle the scalable video coding (SVC) and 3D image processing and achieve the challenge of dynamic adaptive network configuration. Currently, the network architecture,

978-0-7695-4974-3/13 $26.00 © 2013 IEEE
DOI 10.1109/IMIS.2013.98

protocols and applications are under discussion, research and development. In these emerging issues, IoT and cloud computing have become the hottest research topic, which are also our major objective in this research.

B. Internet of Things

Internet of Things (IoT) is regard as a RFID technology, which was proposed by MIT Auto-ID center in 1999. International Telecommunication Union (ITU) also released the report [4] in 2005. The IoT technology enables novel dynamic technologies such as intelligent middleware, connection between real/physical world, virtual cyber world and digital world. By these technologies, the wireless sensor could be adapted in IoT architecture such as shown in figure 1.

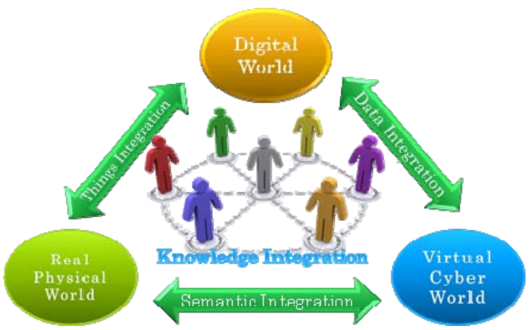

Figure 1. IoT Symbiotic Interaction

The original IoT concept belongs to the era of network communication. By the revolution trend of information technology and communication technology, various and innovative technologies are necessary in IoT to achieve the objective in future internet. The basic concept of IoT is shown in figure 2. In IoT world, the users can use any service in anytime, at anyplace, through any network and any device to communicate with anyone. The application and service can be used in daily life [3].

Figure 2. Features of Internet of Thing (IoT)

RFID is a mature technique, which is also play an important role in IoT world. By combing the current RFID and sensor network could achieve many applications such as delivering information through cognitive intelligent sensor, smart home devices and vehicular network. For instance, the eCall project [5-7], which is an accident alarm and notification system in European Union. The eCall system integrates the alarm system into vehicular. For instance, if the vehicular is upside down or it's supplemental inflatable restraint system (air bag) has trigged. The system would notify the event time, location and car license number to emergency center through GPS navigation module and data network such as GPRS or UMTS, and then tell the police and EMT to handle the accident. Whole the system is form a large communication network by integrating with cloud computing, manageable service, suitable adjustment, remote control and policy decision.

C. IP Muleimedia Subsystem

The architecture of IMS is as shown in figure 3 [8] that can be divided into three tiers: the Media/Transport plane, Control/Signaling plane and Service/Application plane.

The Media/Transport plane is a referral to a wide range of different access technologies. Basing on IP transport layer, users go through Wireless LAN, GPRS (General Packet Radio Service) or UMTS to acquire connectivity. Once connected to IMS, users can access a variety of multimedia services.

There is a set of IMS core components in Control/Signaling plane – CSCFs (Call Session Control Functions), which includes Proxy-CSCF (P-CSCF), Interrogating-CSCF (I-CSCF) and Serving-CSCF (S-CSCF). CSCF is the main component responsible to the SIP based voice and multimedia session control, including the application layer registration and location information exchange with HSS (Home Subscriber Server). P-CSCF is the first contact point for UE (User Equipment). The UE can obtain the P-CSCF's IP address after registering with the access network. S-CSCF is mainly responsible for Call Service and Session Control. I-CSCF is the first connecting point when requests enter the serving network. I-CSCF is responsible for inquiring with HSS about the user's information and relevant location. I-CSCF has implemented the Topology Hiding Inter-work Gateway (THIG) function to improve security and privacy. The SIP signaling will be processed and routed to the destination through this plane.

In the Service/Application plane, there are various application servers. The application servers provide users a wide range of IMS service. Operators can use the standard IMS architecture to build up their application servers.

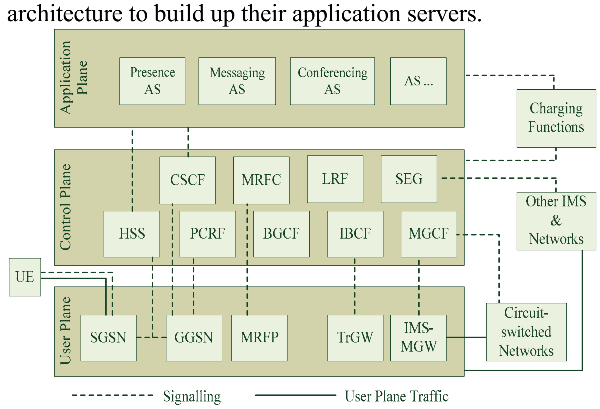

Figure 3. Layered Architecture of IP Multimedia Subsystem

D. Future Internet IoT-IMS Communication Platform

Current Internet cannot satisfy the service requirement in the future. Thus, the Future Internet IoT-IMS Communication Platform is proposed [1-2]. The IMS is defined as the major architecture and then integrates with cloud computing and standardized software architecture. In the platform, the core elements in IMS are virtualized into resource pool and can be managed wit with scalability and elasticity. Basically, the Infrastructure as a Service (IaaS) is enabled in the platform. The main system framework is adapted with cloud computing to handle the huge data traffic, deliver messages and deliver content. The resource pool and the communication must be optimized with IMS and cloud computing in order to support a lot of objects/things in IoT. First, the VMware ESXi is selected as the virtualization hypervisor. Then the OpenIMS [9] core is deployed upon the hypervisor. In our platform, there are 8 I-CSCFs, 8 P-CSCFs, 8 S-CSCFs and 8 HSSs. The logical topology of the communication platform is shown in figure 4.

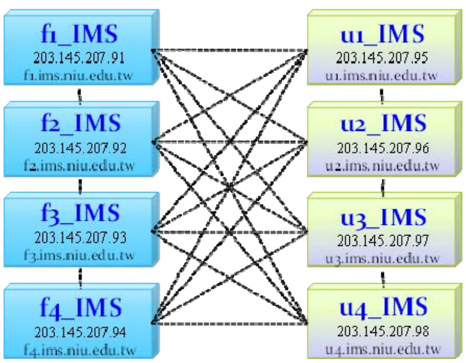

Figure 4. The architecure of virtuzlied IoT-IMS communication platform.

Finally, huge data traffic in IoT environment can be processed well with the features of data center or communication platform such as virtualization, flexible, scalable and efficient by using the proposed architecture, which means that the management and monitor to IMS can achieve better traffic sharing and load balancing.

III. Naming Delivery Agent

The framework is proposed based on IoT-IMS communication platform. The communication messages between UAS and UAC are implemented by eXosip library [10], which is a SIP socket API. Then, the query message is delivered through UDP protocol and the module would query the mapped SBO code. Finally, the response message would be returned to UAC. The UAC could communicate with the objects/things in real-time. The IoT-IMS URI module is shown in figure 5.

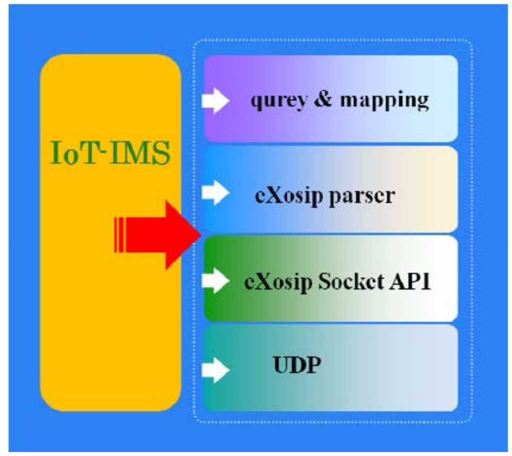

Figure 5. IoT-IMS URI module

In order to get message from sensors quickly, which means that the message could be delivered from object to UAC as soon as possible, the UAC would trigger a SIP message to query UAS. To support the task in the proposed agent, users use UAC to send SIP message to query UAS. At this time, the UAS would receive the message and parse it. The corresponding object would have the mapped IMS-URI; the IMS-URI would be extracted from the SIP message and be used to query the message or recording through SBO code. After getting the data from object, the result would return to UAS, then the UAC forwards result to UAC. Finally, the user can get the desired message from the specific object/thing. The system architecture is shown in figure 6.

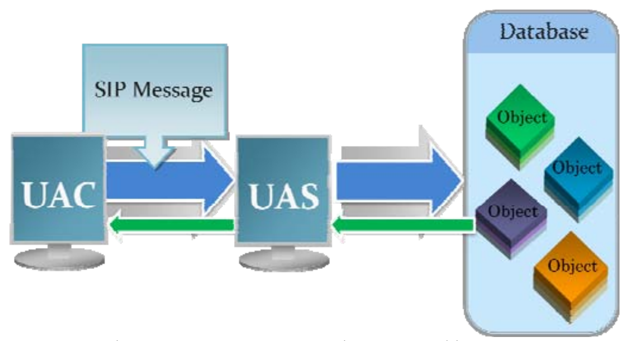

Figure 6. IoT-IMS URI naming agent architecture

The working flow of naming delivery agent system is shown as figure 7. There are two parts in this system – UAC and UAS. UAS establishes a socket and listens on the specific port. UAC sends the query message to UAS if the UAC wants to get the data of specific object. If UAS receive message, it would parse the message and extract the corresponding IoT-IMS URI to database. From the corresponding URI, the SBO code can be found in the database. Then, the result would be return to UAC. User can know the detailed information of object/thing with a specific IoT-IMS URI.

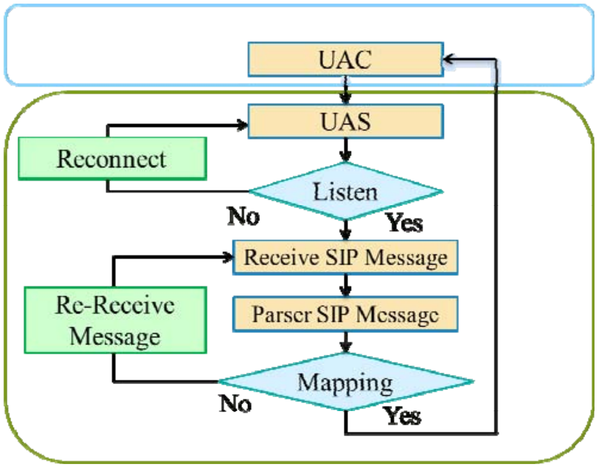

Figure 7. Working flow in IoT-IMS URI naming agent architecture

The data in object would be retrieved by the record and mapping in database. The primary relationship would be established by two physical keys. Then, the both record in database is connected through the two tables. The mapping method is shown in figure 8. The sample mapping table of SBO code and IoT-IMS URI is shown in figure 9.

Id	uid	SIP URI
1	2	temp@ims.niu.edu.tw
2	3	light@ims.niu.edu.tw

id	Data (SBO code)
2	025709
3	025B02

Figure 8. IoT-IMS URI and SBO code mapping

```
SBO = URI  made...
025B02  temp@ims.niu.edu.tw
025709  light@ims.niu.edu.tw
025C06  humidity@ims.niu.edu.tw
```

Figure 9. Snapshot of SBO code and URI of IoT object mapping.

IV. Implementation Results

In this framework implementation, IPv6 is considered in the testing environment. As shown in figure 10, UAC could send its query message to find the sensor.

```
1.humidity
2.light
3.temp
select:2
eXosip_message_build_request successfully
eXosip_message_send_request successfully
receive a MESSAGE sip message
```

Figure 10. API for UAC to select the object.

From the packet, UAS would parse the message from UAC, get the source address and destination address. Figure 11 shows the source address of UAC - <sip: fish@2001:e10:1440:ffff:20c:29ff:fe5d:ba52> and destination address - <sip: light@2001:e10:1440:ffff:20c:29ff:fe3e:975c >. Also, the IoT object, which the UAC would like to communicate, is the light object.

```
eXosip_message_build_request successfully
eXosip_message_send_request successfully
listening...
Get Message...
******parser content******
To: <sip: light@2001:e10:1440:ffff:20c:29ff:fe3e:975c>
Request-URI User:light
Request-URI Host:2001:e10:1440:ffff:20c:29ff:fe3e:975c
Schmem:sip
Sip version:SIP/2.0
Line-based text data:text/plain

From: <sip: fish@2001:e10:1440:ffff:20c:29ff:fe5d:ba52>
Scheme: sip
Message body: Hi! I'm fish~
Content-Length: 13
Sequence Number: 20
Method: MESSAGE
Call ID: 634807014
Sip version: SIP/2.0
max-forwards:70
*****parser content end*****
```

Figure 11. UAS prase the message

As shown in figure 12, the mapped value of SBO Code in database can be parsed by the SIP-URI form the packet. Then, the data message would transmit to UAC. From the above figure, the SBO data is 025709.

```
Get SIP-URI:light@ims.niu.edu.tw

Find the mapping SBO Data:025709
```

Figure 12. Snapshot of SBO code and data mapping

Finally, the data value of specific SBO code, which means a specific object, is put in message body of SIP MESSAGE. Then, the content is delivered to UAC. From the UAC parse result, the message 025709 is mapped with UAS. The object message is shown in figure 13.

```
******parser content******
To: <sip: fish@2001:e10:1440:ffff:20c:29ff:fe17:299a>
Request-URI User:fish
Request-URI Host:2001:e10:1440:ffff:20c:29ff:fe17:299a
Schmem:sip
Sip version:SIP/2.0
Line-based text data:text/plain

From: <sip: green@2001:e10:1440:ffff:20c:29ff:fe98:4a1a>
Scheme: sip
Message body: 025709
Content-Length: 6
Sequence Number: 20
Method: MESSAGE
Call ID: 354493757
Sip version: SIP/2.0
max-forwards:70
*****parser content end
```

Figure 13. Data returned to UAC

The packets between user agent server and user agent client are inspected through Wireshark [11]. The sensed data of humidity in option one is selected from the object. From the captured packet, the data is delivered in SIP message with MESSAGE method and encapsulated in IPv6 UDP packet. The detailed packet is shown in figure 14.

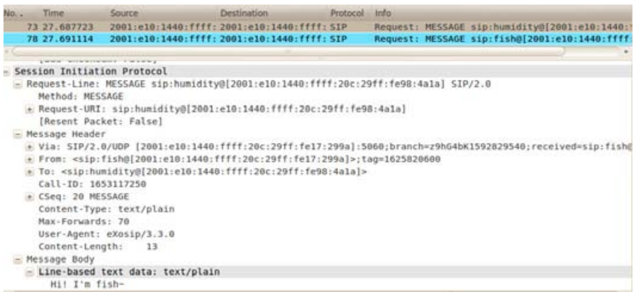

Figure 14. Packet inspection at Uuser Agent Server

As shown in figure 15, after the UAC receives the packet, the value of sensed data from object can be obtained in real time through the proposed IoT-IMS URI naming agent.

Figure 15. Packet inspection at User Agent Client

V. CONCLUSIONS AND FUTURE WORKS

This paper continues the research result in future internet IoT-IMS communication platform. In IPv6 environment, a management framework for object naming, communication is proposed, which is based on IMS. Through the communication framework, the relationship between IMS-URI and IoT object is established, which is called IoT-IMS URI. The SIP method – "MESSAGE" is used to communicate with object between IoT environment and IMS environment. By the standardized naming and addressing rules, the translation and communication is simplified. In the future, the communication cost, efficiency, response time will be measured to evaluate the performance of our communication platform and management framework.

ACKNOWLEDGMENT

This research was partly funded by the National Science Council of the R.O.C. under grants NSC 101-2219-E-197-002.

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