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ON IMPLEMENTING VOICE OVER IP ON UNIVERSITY OF INDONESIA WIDE AREA NETWORK AND INDONESIAN HIGHER EDUCATION NETWORK INFRASTRUCTURE

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ABSTRACT

Electronic-based learning environments (ELE) are being increasingly used at all levels of the educational system at the University of Indonesia. With the improvement of infrastructure and integrated applications to manage academic and administrative matters of the University of Indonesia, the whole stakeholders of the University has increasingly participating to use the facilities to become member of the open sourcing and informing society in the world. The use of the state of the art resources such as Global Distance Learning Network, Teleconference facility, Voice over IP, computer and other pervasive equipment such as laptop, PDA, and smart phone’s have been witnessed at the University of Indonesia. It has been used to support the university stakeholder’s continuous learning effort using global resources available through the social networking environment using the Internet.

Information and Communication Technology (ICT) infrastructure is the backbone of the University’s data, voice, video and all traffic of communications. The advancement of the infrastructure will affect the development of the university. In order to provide a world class learning environment, the infrastructure provided must be able to support ‘any time, any place’ learning paradigm in addition to the conventional brick and chalk method.

Indonesia higher education network (INHERENT) was started in the year 2006 to facilitate the interconnection, by providing the Intranet for higher education institution in Indonesia. Each university can build their own facility and then later on share their achievement to other universities. This paper focuses on the idea of implementing an integrated ICT infrastructure development to support the use of electronic numbering for the members of INHERENT. We also provide the design of the infrastructure and step by step methods to enable the provision of a unique number for INHERENT Voice over IP (VoIP) service.

This paper examines the phenomenon of the introduction of the state of the art learning environment at UI and other universities in Indonesia, i.e. VoIP. We describe the design of implementing University and inter-university wide Voice over IP infrastructure through Indonesia’s Higher Education Research Network (INHERENT), as an effort to build up a Next Generation Network application and services. It can be expected that the socialization and wider deployment of the VoIP system among the INHERENT administrator and users will lead to a more efficient and cheap way of communication through Internet Protocol Services.

Key words: Electronic based learning environment, Next Generation Network, Voice over IP, ENUM, ITAD, DNS.

I. INTRODUCTION

Information and Communication Technology becomes one of the primary requirements on building and running most of business, including the education business. The current trend shows that some institutions combine data and communication services within one management. Furthermore some organizations already use the same infrastructure in the process of authentication and authorization of all services and application. For example Lightweight Directory Access Protocol (LDAP) is used to facilitate the authentication and authorization the access of any services within university of Indonesia. Although the use of the same infrastructure for authentication and authorization has been implemented, most of organizations use a different identification between information services and communication services. For example, the use of identification as awaludin@ui.edu for email service and 601009@ui.edu as a VoIP identification. This condition occurred due to the need of interconnection ability between VoIP and existing public telecommunication infrastructures, such as number-based Public Switched Telephone Network (PSTN) and Public Land Mobile Network (PLMN).

The establishment of Indonesia higher education and research network (INHERENT)
triggered new development of ICT infrastructure and services for universities in Indonesia. The needs to integrate application and services among the universities become apparent. For example in voice over IP service development, which can be used to interconnect the existing voice communication infrastructure of the INHERENT member institutions?

VoIP infrastructure integration can be built with two methods, bilateral or multilateral. Bilateral integration means interconnecting the VoIP network through definition of each peer in configuration file, i.e. address and port service. Multilateral integration methods mean that the interconnection between all networks is established in hierarchical manner. In this method interconnection to all networks is through one node reference. There are some proprietary and open-source solutions to address the issue of integration and global accessibility.

![INHERENT Topology 2008](image)

This paper focuses in searching for a Domain Name System based solution and integrated infrastructure design of INHERENT. The digit sequence number is just for the purpose of uniqueness. Figure 1 shows the current topology of the INHERENT, as per March 2008.

2. Background

2.1. NGN Based Infrastructure Modeling

NGN is a service-oriented network that integrates voice, video and data service. NGN system architecture is divided into four layers, as follows [Huawei06]:

- Layer 4 (Service Layer): provides value-added services and operation support based on established calls.
- Layer 3 (Network Control): provides a real-time call control and connection control function.
- Layer 2 (Core Switch): provides an integrated transmission platform with high reliability, Quality of Service assurance and large capacity
- Layer 1 (Edge Access): connects subscriber and terminal to the network by variety of means and convert original information format to a suitable one and transmitted over the network.

![VoIP Network Topology University of Indonesia](image)

NGN system architectures is used as a reference to develop and integrat the service infrastructure of voice, video, data and application in INHERENT network. Some university such as University of Indonesia, Bogor Agricultural University, Bandung Institute of Technology, and Gadjah Mada University have already used an integrated voice and data services within their infrastructure. Figure 2 shows the VoIP network topology at the University of Indonesia.

2.2. Global Identification of Services

Public switch telephone network (PSTN) uses an international numbering system modeling for services. The system is based on ITU-T recommendation called E.164. E.164 defines the format of telephones number which contains a maximum of 15 digits and uses a plus sign (+) as the prefix.

NGN based communication infrastructure and service uses Internet Protocol (IP) as backbone and interconnect all component in edge access, network control and service layer to provide the voice, video and data services. This condition requires a translation and integration between E.164-based numbering already been used within the existing telecommunication infrastructure to Internet protocol based addressing.

In the Internet, a node or a computer is identified by the use of 32-bit addressing represented in decimal for IPv4, or 128-bit addressing...
represented in hexadecimal (IPv6). For example, to provide a web service to the Internet user, University of Indonesia web servers use an IP address of 152.118.24.11 (IPv4) and 2001:0:0:0:0:0:0:0 (IPv6). The use of decimal numbering (IPv4) or hexadecimal numbering (IPv6) implies a unique addressing in the IP networks to interconnection of a large number of nodes globally. However, the IP addressing is easy by the users of Internet due to the fact that it doesn’t represent or mean any information about the service or the organization information.

2.3. DNS and NAPTR

Domain Name System (DNS RFC 1034 and 1035) is developed for the ease of access to the services in the Internet. With the use of this system, users will no longer required to know of the Internet node by IP address decimal digit or hexadecimal number, but rather by the use of the name that represents the service or the organization. For example, University of Indonesia’s web server named www.uie.ac.id, represents its web service (www) and the organization (uie.ac.id). The DNS records subsequently map the information within DNS database and distribute this database across the Internet through the name server (Albiez6).

The mapping between IP address and names is one of the features of DNS. Other features include classification by DNS records and the use of the so-called implied mapping authority pointer (NAPTR) is the latest type of record that supports regular expression based rewriting (RFC 2915). This feature contributes DNS for wider applications and services, and also addresses the issue of convergence between IP-based services infrastructure and L.164 numbering-based services infrastructure, by the use of ENUM or ITAD.

2.4. ENUM

Telephone Number Mapping (ENUM or E.164) from Telephone Number Mapping, RFC 3761) is a suite of protocols to unify the telephone numbering system E.164 with the Internet addressing system DNS by using an induced lookup method, to obtain NAPTR records. The records are stored at a DNS database. Currently, the public root domain for ENUM is e164.arpa and widely used by most operators to interconnect PSTN network to IP network (Hexen6, Xnate6).

ENUM uses DNS to map E.164 numbers to Uniform Resource Identifier (URI). The following steps should be conducted:
  1. Remove all punctuation separating the digits of the phone number and add a plus sign before the country code. This converts the phone number "(+1)408-555-1234" to the string "+14085551234.") The result is referred as ENUM’s Application Unique String (AUS), which will be used later.
  2. Remove the plus sign and reverse the order of the digits in the number. (This converts the string "+14085551234" to the string "21215550341").
  3. Insert periods after each digit in the string and append "@e164.arpa." The result is the domain name to be looked up. (This converts the string "21215550341" to the domain name 2.1.2.1.5.5.5.0.0.4.1.e164.arpa.)

2.5. ITAD and ISDN

Internet telephony administrative domain (ITAD, RFC 3219) is a telephone numbering system intended to be used by organizations for providing internet telephony routing for their users. The use of ITAD number requires IANA approval. ISDN (ITAD Subscriber Number) provides a method for inter-domain routing with an ISDN addressing. An ISDN is formed by assigning a domain-local subscriber number to an ITAD (Internet Telephony Administrative Domain) number, using an internis as the delimiting. For example, subscriber 19999 in ITAD 848 allocated for University of Indonesia would have ISDN 19999*848. As of March 2008, ITAD has been assigned to 506 domains in 46 countries.

ISDN uses DNS to map E.164 numbers to L.164. The steps should be performed:
  1. Remove all punctuation separating the digits of the phone number and add a plus sign before the country code. This converts the phone number "+14085551234." The result is referred to as ENUM’s Application Unique String (AUS), which will be used later.
  2. Reverse the order of the digits in the number. (This converts the string "+14085551234" to the string "21215550341").
  3. Insert periods after each digit in the string and append "@e164.arpa." The result is the domain name to be looked up. (This converts the string "21215550341" to the domain name 2.1.2.1.5.5.5.0.0.4.1.e164.arpa.)
The impact of the use of DNS for interworking between VoIP networks is the delay caused by DNS mechanism for domain lookup. Further more the design of the VoIP service integration focuses on the use of ENUM as a DNS solution for URI lookup, and uses a “e164.inherent.diki” as a root domain.

The reason of selecting ENUM and “e164.inherent.diki” as a root are:
- ISN is still in the research stage, and has not yet widely used by Internet users.
- To prepare the infrastructure that has the ability of convergence.
- The use of “e164.inherent.diki” is due to the unclear policy of use of “2.6.164.arpa” root domain in Indonesia. As March 2008 ENUM deployment is still in a “test-bed” state.

![VoIP interconnection through ENUM](image)

Figure 3. VoIP interconnection through ENUM

4. IMPLEMENTATION

We propose the use of ENUM solution with private ENUM root domain e164.inherent-diki.net for the integration of VoIP service between INHERENT members. At least 6 universities is ready to joint this activity (VoIP integration through ENUM), i.e. University of Indonesia (UI), Bandung Institute of Technology (ITB), Gadjah Mada University (UGM), Bogor Institute of Agriculture (IPB), Surabaya Institute of Technology (ITS), Brawijaya University (UB).

4.1. Implementation Step

The following is the propose interconnection scenario, as can be seen in Figure 4:

1. Sub-zone definition and delegation of zone e164.inherent-diki.net to universities that join the test-bed activity.

2. Zone implementation at the running DNS server or at VoIP server that run named services. The second option is preferable due to testing activities that might disturb the operational services.

3. NAPTR lookup test between zones/sub-zones.

4. NAPTR lookup features activation within VoIP server or softswitch.

5. Basic call test on various devices on edge-access layer.

6. Further test and integration for email and Instant Messaging service.

![Implementation Phase](image)

Figure 4. Implementation Phase

4.2. Zone Delegation

Zone delegation scenario is designed by assigning a unique digit for each university to be seen in Table 1. The digit sequence number is just for the purpose of unique identification.

<table>
<thead>
<tr>
<th>ENUM</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1.e164.inherent-diki.net</td>
<td>DIKTI (Directorate of Higher Education, Ministry of National Education)</td>
</tr>
<tr>
<td>1.0.e164.inherent-diki.net</td>
<td>Universitas Indonesia</td>
</tr>
<tr>
<td>2.0.1.e164.inherent-diki.net</td>
<td>Universitas Gadjah Mada</td>
</tr>
<tr>
<td>3.0.1.e164.inherent-diki.net</td>
<td>Institute Teknologi Bandung</td>
</tr>
<tr>
<td>4.0.1.e164.inherent-diki.net</td>
<td>Institute Teknologi Surabaya</td>
</tr>
<tr>
<td>5.0.1.e164.inherent-diki.net</td>
<td>Institute Pertanian</td>
</tr>
</tbody>
</table>

Category: Engineering
<table>
<thead>
<tr>
<th>dikti.net</th>
<th>Bogor</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0.1.164.inherent-dikti.net</td>
<td>Universitas Brawijaya</td>
</tr>
<tr>
<td>7.0.1.164.inherent-dikti.net</td>
<td>Universitas Diponegoro</td>
</tr>
</tbody>
</table>

Table 1. The zone allocation of e164.inherent-dikti.net

4.3. DNS Server Relationship

The requirement of root domain at ENUM infrastructures is facilitated by providing a e164.inherent-dikti.net zones. On March 2008, ns.e164.ui.edu is serves as the DNS master for e164.inherent-dikti.net, which maintain its sub-zones, such as 1.0.1.164.inherent-dikti.net for University of Indonesia. Organization that uses a sub-domain of zone e164.inherent-dikti.net will set its DNS server as a slave, refer to the master/slave relationship with master DNS server of e164.inherent-dikti.net zone. In this case the ns.e164.ui.edu DNS server. The possibility to become a master of its maintained sub-domain is always open and provided by request. For example ns.e164.ugm.ac.id (UGM DNS server for ENUM) can become a master for 2.0.1.164.inherent-dikti.net.

Securing the DNS database is provided by implementing access control list (ACL) within DNS configuration that limits who can query and update DNS databases of each zone in the e164.inherent-dikti.net. This limitation is required due to the open platform feature in Internet network interconnection.

The definition of SRV record within the main and the operational DNS server is required as a mechanism of VoIP service lookup within each organization or domain. For example at the University of Indonesia, the VoIP service defined by the port 5060 is served by a machine called sip.ui.edu.

NAPTR record definition is provided within each machines or computer which serves the ENUM zone, which map the DNS names to URI for services like SIP or Jabber. For example the NAPTR record of 9.9.9.9.1.10.1.e164.inherent-dikti.net is added to DNS configuration within ns.e164.ui.edu DNS server. This entry along with URI information maps the lookup of domain name 9.9.9.9.1.10.1.e164.inherent-dikti to URI of sip:19999@ui.edu.

4.4. Implementation Verification

The implementation of ENUM within the VoIP infrastructure required VoIP server or softswitch to have the ability to process ENUM information. The same requirement also exists to VoIP subscriber terminal. At VoIP server this feature is activated by loading ENUM’s module and adding an ENUM root domain definition.

Success indicator of implementing ENUM feature within VoIP infrastructure is verified by establishing a call to one of VoIP subscriber that ENUM is ready within the INHERENT network. For example, the call establishment to VoIP subscriber of sip:19999@ui.edu by calling a number +6111999 from INHERENT networks.

4.5 Related Work

The implementation of VoIP across university wide area network and the Intraad of the Higher Education Research networks is highly related to the integration of a single sign on system using Lightweight Directory Access Protocol (LDAP) and IPv6 integration. Further work on the multileaf network implementation, video conference management, as well as Internet Messenger (IM) service integration is some activities which could be conducted subsequently.

5. CONCLUSION

The ability to expand the network and deploy new applications within the existing infrastructure is the expectation of all universities in order to provide a strong education system. The integration of VoIP network becomes a model for the service-integration between universities in the INHERENT network. Scalability and global accessibility becomes the main issue in the integration of VoIP network infrastructure in INHERENT. One solution to address the issue is using ENUM. ENUM solution implements the integration of VoIP network and services between universities of INHERENT members.

Further activity required to answer and analyze the following issues:

- The security of VoIP service infrastructure.
- IM interconnection based on SIP and Jabber, and its global interconnectivity.
- Allocation and implementation of public enum (2.6.164.arpa) from Department of Post and Telecommunication, to answer the needs of global accessibility.

REFERENCES

[Wallingford05] Theodore Wallingford, Switching to VoIP, O'Reilly, June 2005


