A Network
for Research and Development Commmunities in Japan
-JUNET-

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ABSTRACT

JUNET is a computer network for research and development communities in Japan which started to work in October 1984. It connects universities and major research laboratories in Japan, and the physical links currently used are public telephone lines. The applications on the network are electronic mail and bulletin board. Special efforts has been made to support naming, message exchange with Japanese characters, administrations, and interconnection with existing research purpose networks in the world.

This paper describes a brief history, current status, software, addressing, administrations, and interconnection of *JUNET*.

1. Introduction

JUNET started working in October 1984 to provide a network-based research environment for research communities in Japan. There has been a computer network called *N-1* for similar purposes in Japan connecting several mainframes at major Japanese national universities[Ishida85]. JUNET is a volunteer network to provide network communication environments to researchers including who are unable to access *N-1* network, that is to say, users of small systems like workstations and mini computers. JUNET thus connects local area networks at research institutes in Japan by public telephone lines using the UUCP protocol[Nowitz78], and it also provides users with the means of the worldwide communications via international telephone lines.

1.1. Purpose of JUNET

In Japan, there have been strong demands for a computer network where computer scientists can communicate with each other and exchange various research information. Such a network, without a doubt, improves qualities of research and development environment at universities and research laboratories.

Recent improvements on various communication media require improvements on design of distributed environment. To achieve such an environment based on computer communications, a computer network which can be used for experimental purposes of researches on distributed processing has to be existing.

From the above issues, the purposes of JUNET are as follows;

(1) to provide communication environments for research and development communities in Japan in order to exchange research information,

(2) to provide communication environment to exchange information with research and development communities in the world,

(3) to provide testing environment for researches on widely distributed computers, network interconnection, and network gateway functions.

1.2. History of JUNET

There are some historical reasons which have prevented Japanese research and development communities from establishing a network for them. One of such a reason is that there have been not so many good computers for communication in the communities. Another example of such a reason may be that there used to be more restrictions in using the telephone lines than there are now. Since 1983, UNIX† has become popular in Japanese research and development communities, and this has encouraged the communities to start a simple network such as the one using UUCP protocol over public telephone lines.

JUNET is founded when a gateway in Tokyo Institute of Technology started to poll Keio University's gateway, both running UNIX operating system, in October 1984. The skeleton of JUNET has thus been established including University of Tokyo's VAX-11 one week later. Applications used that time were electronic mails and electronic news.

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† UNIX is a trademark of Bell Laboratories.

At the time the three universities started the network, researches specificaly required in Japanese environment, such as Japanese language interface for communication applications, Japanese character code standard, and interconnection to existing research and development networks, were started to take place. The domain addressing over UUCP network was introduced in May 1985 with a system to generate the address conversion software. At the same time, transmission rates of modems were switched to 1200bps at major sites in JUNET.

As for the internetworking between JUNET and other foreign networks, Kokusai Denshin Denwa Co., Ltd. (KDD), an international telephone and telegraph company, started investigating the USENET message qualities in July, 1983. After one year investigations, KDD decided to establish reliable links with USENET in September, 1984. In January, 1985, an active international link to USENET was set up, for the first time, with Centrum voor Wiskunde en Informatica, the Netherlands. Since then, several foreign gateways in USENET have been linked with this JUNET gateway. Some are located in Europe and the others in the United States.

1.3. Current Status of JUNET

JUNET currently connects 70 systems in 24 institutes. The UUCP protocol over telephone lines is used for all of the links among institutes. Most of the links are dial-up lines using 1200bps or 2400bps modems, although some 300bps modems still exist. For 300bps, 1200bps, and 2400bps modems, CCITT V21, V22, and V22bis are used respectively in Japan.

Institutes of the network are universities, research laboratories of computer software/hardware companies, and research laboratories of telephone companies. Users of the network are registered at gateways of each of the institutes in order to provide name server functions described later. All the functions are administrated by administrators at each of the institutes on totally volunteer basis.

2. Overview of JUNET

2.1. Machines and Operating Systems

Systems in JUNET are divided into two groups; gateways at institutes and others. A gateway machine has one or more links to gateways at other institutes while a machine other than gateways has a link to the gateway of the institute which it is in. As described above, links among gateways are UUCP links over public telephone lines, but local area connections within institutes are varied in their types; public, leased, and private telephone lines, hardwired serial lines, Ethernet, Chaosnet, and so on. The variations in machines and operating systems also widely spread in JUNET. The following table shows machines and their operating systems in JUNET nodes.

Table 1. Machines and Operating Systems in JUNET

Machines	*Operating Systems*
DEC System-2060	TOPS-20
DUAL	UNIPLUS
IBM-PC/IX	VENIX
NEC PC9801	PC-UX (System III)
SUN-1	4.2BSD
SUN-2	4.2BSD
Symbolics 3600	Zetalisp†
LMI Lambda	Zetalisp and 4.1 BSD Unix
Toshiba UX-300F	System III
MicroVAX	Ultrix-32m (4.2 BSD)
PDP-11/44	2.9BSD.
VAX-11/730	4.2BSD
VAX-11/750	4.2BSD
VAX-11/780	VMS V3.4
VAX-11/780	4.2BSD

2.2. Functions of JUNET

There are several application functions available in *JUNET*. Electronic mails and electronic news are the major applications among them. Since use of Japanese language in messages is the strong demand of users in the network, multi-languages are supported in text messages for both applications. Existence of Japanese character codes in messages involves some confusing problem at a system which have no functions to handle the Japanese codes. To avoid this problem, special considerations are made in a message header, yet keeping the international text message format standard[Crocker82].

Addressing and naming are handled by a JUNET naming system. This system provides:

- hierarchical domain-based addressing,
- name server functions,
- and automatic naming database management.

JUNET is connected to several foreign systems. The Major gateway is a system called *kddlab*. Through such gateways, systems in JUNET are connected to USENET. Conversions of addresses and formats from JUNET standard to USENET standard including the character code issues are done on the responsibility of these gateways.

3. Technical Discussions on JUNET

3.1. JUNET Domain Addressing

Naming or addressing strategy of distributed resources is one of the most important issues in distributed environment. Two kinds of basic concepts can be considered in addressing for a network like JUNET;

† LISP machines are connected via Chaosnet to VAX systems, and messages are delivered using Chaosnet mail system.

absolute addressing and relative addressing. In general, the absolute addressing provides transparent and general addresses to the whole environment but the database for the address tends to be large if it is managed in a centralized manner, while in the relative addressing, like the one used in UUCP network, functions to convert addresses are distributed to each of the system, and general names can not be provided.

The concept of domain[Mockapetr83] is introduced to provide a practical way for the absolute addressing by combining a small group of addresses into a name. When the domain concept is used in a hierarchical manner, it avoids functions of managements from being too centralized by setting efficient levels in the hierarchy. In JUNET, hierarchical domains are used for its addressing scheme for the following reasons:

- JUNET is a volunteer-based network to interconnect local area networks in various institutes. This means administration efforts should be distributed to each of the institutes. Therefore, the distribution of management functions employed by the hierarchical domain method is efficient in JUNET environment.
- Since the JUNET is still in its developing phase and physical connections are changing frequently, transparency in addressing is strongly required. The domain strategy reduces operations by its distributed management functions when a physical link is added or changed, yet providing absolute addressing.
- Each of the domain names is corresponding to a name of an organization, a department, or a system. This provides the most natural name space for users in the real world.
- The hierarchical structure of domains provides extensibility of naming methods. For example, an organization can construct lower level domains in its will without changing any other databases in other domains.

In the hierarchy of JUNET domain structure, a domain called *junet* is the top domain. The second level domains are called *sub-domains,* and each of them represents a name of an institute or an organization. Lower level domains than the sub-domains are determined at each of the sub-domains. In any cases, the lowest level domains are names of hosts. The names of sub-domains usually are names well known to the society, but such names sometimes differ in intra/inter national environment. Therefore, one or more names can be registered as synonyms for a sub-domain name to help users to address with general knowledge on the name of organizations. Table 2 shows the examples of sub-domain names and their synonyms in JUNET.

There are one name server in each of the domains which handles definitions and deletions of names using a database dedicated to that domain. A name server of a domain thus has a database to define names of lower level domains adjacent to the domain, or names of resources, such as user names, if it is the lowest level domain. The knowledge of each name server is used in retrieving information of resource names and in delivering messages. The domain structure of JUNET is illustrated in Figure 1.

Table 2. Example sub-domain names and their synonyms

Domain names, Synonyms	*Institute names*
ascii	ASCII
csk	CSK
dec-j	DEC Japan
fujitsu	FUJITSU
icot	ICOT
ipa	IPA
jsd	JSD
kddlabs	KDD Labs
keio	Keio University
nec	NEC
nagano	Nagano University
ntt	NTTMECL
ricoh	RICOH
shizuoka	University of Shizuoka
sophia	Sophia University
sra	SRA
titan,tokodai	Tokyo Institute of Technology
tsuda	Tsuda University
u-tokyo,todai	University of Tokyo
u-kyoto,kyodai	Kyoto University
u-osaka,handai	Osaka University
toshiba	TOSHIBA
ulis	University of Library and Information Science
unix-pacific	AT&T Unix Pacific

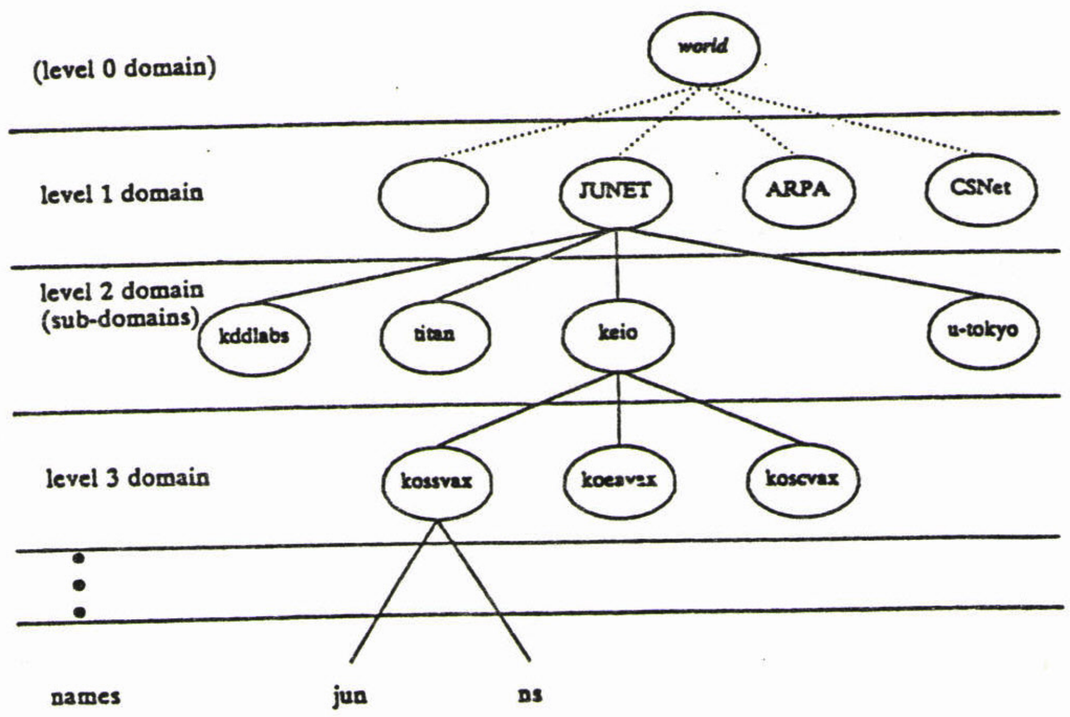

Figure 1. Domain Structure of JUNET

Note that this is a logical naming structure and physical links may be established in completely different structure.

3.1.1. Addressing Scheme

The general notation for the addresses or the names in JUNET is represented using at-sign (@) and period (.) as delimiters:

$$name@domain_n.domain_{n-1}.\cdots.domain_2.domain_1$$

Here, $1 \cdots n$ represent a level of a domain in the n leveled hierarchy. Since the top level domain is called *junet*, a user name *ns* on a host called *kossvax* in Keio University whose sub-domain name is *keio* is represented as follows for example when no lower level domains are set in the sub-domain:

ns@kossvax.keio.junet

Apparently, the *.junet* part can be omitted in JUNET, and *.keio.junet* can be omitted in the *keio* domain.

Nicknames or synonyms of user names in a sub-domain are recommended to be registered in the sub-domain name server. These names are usually taken from a user's first name and last name delimited by a period both capitalized. With this convention, the real name of a user *ns* , 'Nobuo Saito' can be used in the following format:

Nobuo.Saito@keio.junet

or,

Nobuo.Saito@keio

This corresponds to the general knowledge about the user that 'Professor Nobuo Saito of Keio University'.

3.1.2. Routing Scheme

A message is delivered to a system where the name server of the destination domain is existing. Transmission of a message is directly achieved when the name server of the source domain knows a direct physical path to the system where the name server of the destination is. Otherwise the message is passed to a name server of an upper level domain. A message to non-existing domain is thus passed toward the top level domain and finally reached to the top domain in the worst case, then an erroneous return is occurred there. Thus, to make the message transmission efficient, the sub-domain gateways are recommended to make the number of hops to the top domain name server small, as well as to have links for sub-domains where heavy traffic is expected.

3.1.3. Design and Implementation

The message delivery system with the JUNET addressing functions is implemented in UNIX 4.2BSD. The message delivery is done by a modified version of sendmail[Allman83] whose rule is generated by a rule generating system of JUNET. The rules are described based on the following policies:

- Connections among sub-domains are UUCP links.
- Connections within a sub-domain can be either UUCP link, SMTP[Postel82] over Ethernet, or other kinds of links.
- Systems which are not running the addressing system of JUNET can be connected as one of the lowest level domain where functions of the higher level domain can not be working.
- Traditional UUCP notations (*a!b!c*) can be used anywhere.

Since the production rules of the JUNET sendmail system is differed site by site, the rules have to be generated at each site. To keep the consistency in the rules over JUNET sites, a generation system to generate the necessary rules is designed and implemented. The system reads a simple description file, generates the sendmail rules, and initializes the domain database. This database is accessed by the modified version of the sendmail system. The structure of the JUNET addressing system is shown in Figure 2.

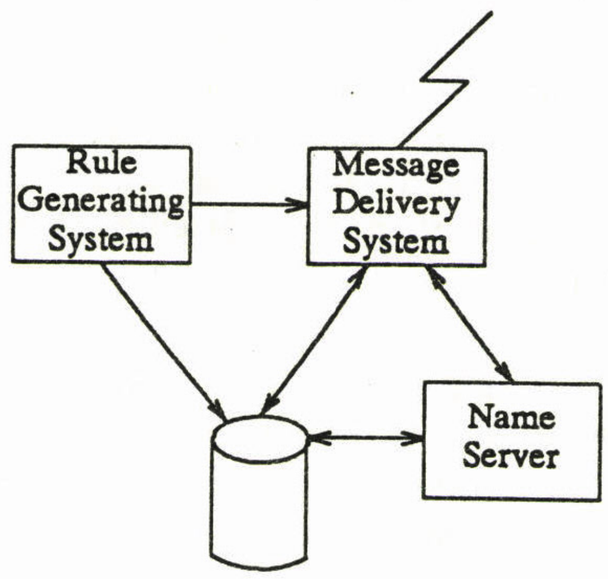

Figure 2. Structure of JUNET Addressing System

In the description file, informations about the system is described under in the entries shown below:

entry tag	*information*
$make	whether this system is a gateway of a domain or not.
$name	a full name of a domain where this system belongs to, and its synonyms if any.
$site	a name of a system to which this system has a direct link, followed by a list of domain names which should be solved at the specified system.
$link	a system name which is directly connected to this system and is the entry point of the shortest path toward the system where the top domain name server exists.

The domain database contains relations between a physical link to a system and domain names which should be solved at that system. This is initialized in the generation operation, but not necessarily be the completed at the initialization time since the database is periodically updated automatically by a special message from the top domain. In other words, the initialized database is used as it is until the first update message arrives. Other than the sendmail, the *rmail* command which receives messages through UUCP links was modified to handle JUNET addresses efficiently.

3.2. Japanese Processing

To satisfy the strong demands for Japanese character handling in the environment of JUNET, special considerations have to be paid to the communication software. The following two issues are considered according to the average environments of JUNET systems:

(1) There are several kinds of character codes which are actually used in operating systems as internal codes to represent Japanese characters including Kanji characters. Among them, there is the JIS Kanji code which is a 16-bit code set whose information is contains in two 7bit bytes. A sequence of the code is surrounded by a shift-in/shift-out pair when used in ASCII text. To avoid the complicated operations of switching modes when seeking such a byte stream according to the shift-in/out codes, some Kanji codes use two 8bit bytes to represent one Kanji character utilizing the the most significant bit for distinguishing the Kanji characters from ASCII characters.

(2) Two kinds of terminals are used by JUNET users. ASCII terminals which display only ascii characters, and ASCII/JIS terminals which can display both JIS Kanji codes and ASCII codes.

Since there are several Kanji codes used as described in (1), setting a standard of code set used in JUNET is necessary. We have selected the JIS Kanji code as the standard because it is the standard for peripherals and it consists of two 7bit codes. This allows the system to use the sign-bit for parity checking without compacting, and also allows systems to use some software which has functions of tricky usage of these bits: tty driver of UNIX operating system is masking these bits, and some text editor which is possibly used as a filter of text messages in the network uses the bits in special purposes.

When the JIS Kanji code set is used in ASCII text, the mode switching is done by the escape sequence as shown in Figure 3. Most of the existing software based on 7bit ASCII code can be used for the sequence without change except that they have to accept the escape ASCII character which sometimes is removed in some communication software to avoid confusing problems of accepting object codes as text messages. When an operating system uses different Kanji character set other than JIS Kanji code, responsibility of conversion from the JIS Kanji codes to its internal code is in that system.

Figure 3. JIS Kanji sequence in ASCII text

To avoid breaking the screen image by transmitting the escape sequence to the pure ASCII terminals, we have set a convention in the header of text message format. Since we have two ways to represent Japanese language, Kanji representation and Romaji representation which is a phonetic representation of Japanese language using English alphabet, there are three possible formats in the 'Subject:' field of the header as shown in Figure 4.

```
Subject: Next Meeting (In English)

        Next Meeting will be postponed to next Friday.


Subject: Next Meeting (In Japanese/Romaji)

        Jikai no kaigou ha raisyuu no kinyou-bi ni enki shimasu.


Subject: Next Meeting (In Japanese/Kanji)

        次回の会合は、来週の金曜日に延期します。
```

Figure 4. 'Subject:' field including types of code.

This helps a user at an ASCII terminal to refuse to show the contents of Kanji coded messages, then he/she might move to another terminal or print the message to a JIS Kanji printer in order to see the contents.

4. International Gateway for USENET

JUNET is a network in Japan, distant from the central USENET sites in the world. This geological isolation causes many problems, which may not be serious in other networks.

The first issue is that this isolation makes the frequency of human transfers between the JUNET sites and the sites in other major computer networks less often, which means JUNET users usually do not have enough information on foreign network configurations. Because of this reason, the routing task of each message should be done on the responsibility of the gateway, which has the information on foreign networks as its databases. The several conventions have to be introduced in address mapping between a JUNET format and foreign network formats, and in sharing the foreign network information among the users.

The second issue is to reduce the communication cost between JUNET and foreign networks. The JUNET gateway has to prevent the name server from sending queries to foreign resolvers as far as possible by means of having the foreign network databases. Frequent queries are expensive under the JUNET environments.

The third issue is to prevent a message with an invalid address from being delivered to the foreign networks. Such invalid messages will increase the load of international links and also the transmission costs without this restriction. Finally, the methods to maintain the network databases are to be investigated under the current JUNET environments.

4.1. Setting Up Procedure for International Gateway

A network which is designed for information exchange on a variety of research areas, such as JUNET, will be more useful if it has gateways to link other similar networks in the world. For this purpose, KDD joined USENET with the following steps.

(1) Local Testing:
On July 6, 1983, KDD received the tape of B news programs [Horton83] from Mr. M. Horton of AT&T Bell Labs. and started examining the software on the local machines.

(2) Examining the Quality of Messages:
Since October 4, 1983, KDD has been receiving USENET log tapes from Professor K. Chon of KAIST (Korea Advanced Institute of Science and Technology), which were initially made at *mcvax* (Centrum voor Wiskunde en Informatica) in the Netherlands, and have been investigating the contents of the tapes.

(3) Setting up Online Links:
KDD started setting up the online links with foreign sites in October, 1984. At first, several tests were made between *kddlab*, a gateway in KDD, and *kaist*. Then several links have been set up with *mcvax*, *ukc* (University of Kent), *ihnp4* (AT&T Bell Labs.), *hplabs* (Hewlett-Packard Labs.), etc. The gateway *kddlab* polls these sites at least once a day even though *kddlab* does not have any message queues for them. Thus, *kddlab* can send/receive mails to/from EUNET (European Unix Network), UK (The United Kingdom), ATT (AT&T) and USENET sites in North America with one hop. KDD currently uses international telephone lines with V.22 modems for the foreign gateways and is planning to change some of these links to X.25. Messages for other networks, such as SDN (System Development Network), ACSnet (the Australian Computer Science Network)[Lauder85] etc., can be delivered to their destinations through 2 hops. The current USENET international network configurations around JUNET are shown in Figure 5, where an ellipse and a rectangle represent each network and a gateway respectively.

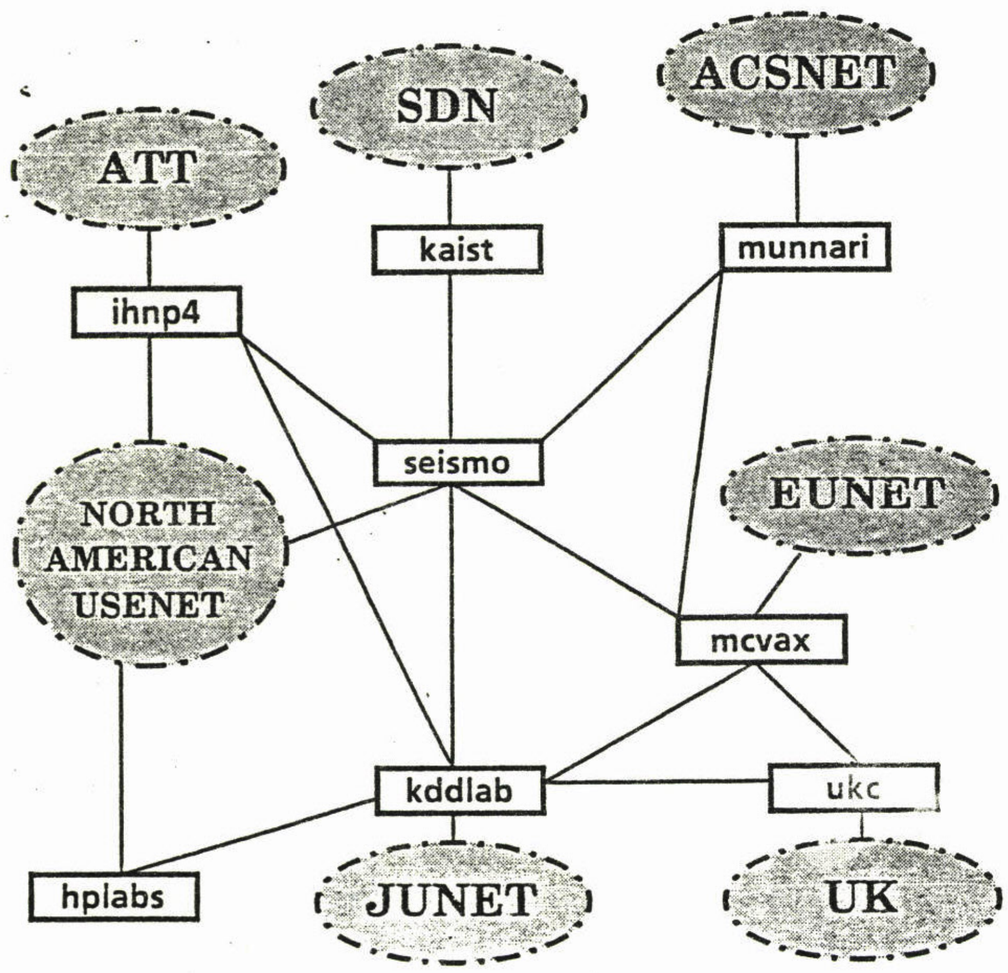

Figure 5. Network Interconnections around JUNET

Currently, most of the mails from JUNET to foreign networks are passed down to a node *kddlab* and sent to destinations after the appropriate paths being generated at this site.

4.2. Administration of JUNET

In contrast with the current JUNET environments, many of the nodes in USENET currently have different network address formats. In USENET, a user has to construct a full path considering every network address notation used on that path. On the other hand, newcomers in electronic mail systems usually do not have enough information on the whole network address syntax to send or to receive mails and news. As the result, a lot of messages are illegally addressed by such users. In the experiences at the gateway, a user was observed to try to send a message to a destination with 43 different (and illegal) paths. We have noticed that such tries for an international connection are extremely expensive and have to be avoided by some administrative methods.

This might be solved to some extent when the domain addressing is used at most of the USENET sites. However, since many of the JUNET users require active communications with foreign networks, this problem has to be solved under the current conditions.

According to the JUNET domain addressing concept, foreign networks are considered that they are in the top level domain as shown in 3.1.1. This provides a uniform addressing environment to JUNET users. To attain this environment, a JUNET gateway must have conversion functions between a JUNET style of address format and other address formats such as the one used in the UUCP world.

The current routing scheme at the JUNET gateway is as follows:

(1) All of the incoming messages through international links will be delivered to JUNET users. Either of a UUCP source route path, like *kddlab!site!user*, or a JUNET address, like *kddlab!user@site.junet*, is accepted and mapped into a JUNET standard notation.

(2) As for outgoing messages from JUNET to overseas networks some restrictions are made at the gateway for efficiency, monetary cost of the gateway system, and for convenience of the users.

As for the outgoing messages, source routing is not permitted. It is the international gateway, not each message sender, who does determine the actual route for a message. The gateway selects the best path according to the cost and reliability of each link. A message sender has to specify the destination address as shown in 3.1.1. Any destination site name must be in the directory database of the JUNET gateway in the corresponding domain.

In spite of the above restriction, a special consideration has to be made for an outgoing message which is replied to a message from a system in a foreign net-

work. Conversions of sender addresses into the JUNET standard formats are almost impossible since the overhead of managing the database becomes very large. This implies a destination address automatically generated by 'reply' sub-command of a mailer at a JUNET site will be in a source routing format. Thus, such a replied message has to be allowed to be delivered. In order to achieve this, the gateway has to discriminate replied messages from originated messages.

In order to use international links, users in JUNET have to be registered at the gateway. Without this registration, a user is not permitted to send a message through an international link. In this case, the user is notified and recommended for the registration.

For the registration, a user simply has to send a message containing the following information to *member@kddlab.kddlabs.junet*: **a full Name, organization, postal address, JUNET address, destination addresses** in the source path format which are trivial to be legal and are necessary for the user.

There are two advantages in this registration mechanism: One is to reduces the load and cost at the gateway which are caused by badly addressed messages, another is to share information of the addresses which are registered in the registration message described above.

Currently, the valid top level domain names are *junet, eunet, acsnet, uk, att* and *uucp*. The name of *uucp* is reserved for the sites in North America. That is to say, in spite that these networks are sub domains of UUCP domain, these networks are treated as one of the top domains in the JUNET strategy. Major networks other than the UUCP network are also considered as top level domains.

For example, an outgoing mail with *user@site.uk* will be expanded into *ukc!user@site* at the JUNET gateway. Since a real domain name itself is sometimes hard to remember, its nicknames or synonyms are provided for convenience. For example, *europe* is a synonym for *eunet,* and *australia* for *acsnet* or *oz.*

Special care is taken at the gateway to handle a mail with an invalid address. Many of the USENET sites are starting to use domain addressing, where much of the routing task for the foreign networks is usually done at each domain server[Crocker82] [Mockapetr83] [Mockapetr83....] [Postel84] [Postel84..]. Under this situation, each message address will be interpreted or solved at some domain server, and hence a user does not have to specify an exact source path but a domain address form. However, it is expensive to have a foreign domain sever solve each unknown address when it is not valid and the transmission cost is not neglectable. Queries to foreign name servers as described in RFC883[Mockapetr83.....] to resolve user addresses are very expensive for intercontinental gateways. This is exactly our case, and hence this kind of approaches were abandoned. An intercontinental gateway must have a more intelligent name server than other gateways will have.

From this point of view, the following philosophy is taken for a JUNET international gateway.

(1) Reject a message to a foreign domain if it is determined as an invalid address by referring to the directory database.

(2) Gather the foreign network address information to keep this directory database as complete as possible.

For the same reason, the gateway restricts the users of these international links to the registered members. This reduces the possibility that a novice sends through international links a lot of messages with incorrect addresses, which are returned back to Japan. Registering has another advantage that it decreases the possibility for unrestricted many persons to use the networks. Hence this makes the characteristics of the networks clearer. the gateway keeps the networks not used for any commercial or business purposes in this stage as far as possible.

4.3. Procedures for Creating a Knowledge Base for Addressing

The JUNET gateway system consists of a mail receiver, the 4.2BSD sendmail[Allman83], a rerouter, a mail transmitter, a foreign site database, a JUNET user directory, and several database maintenance programs (Figure 6).

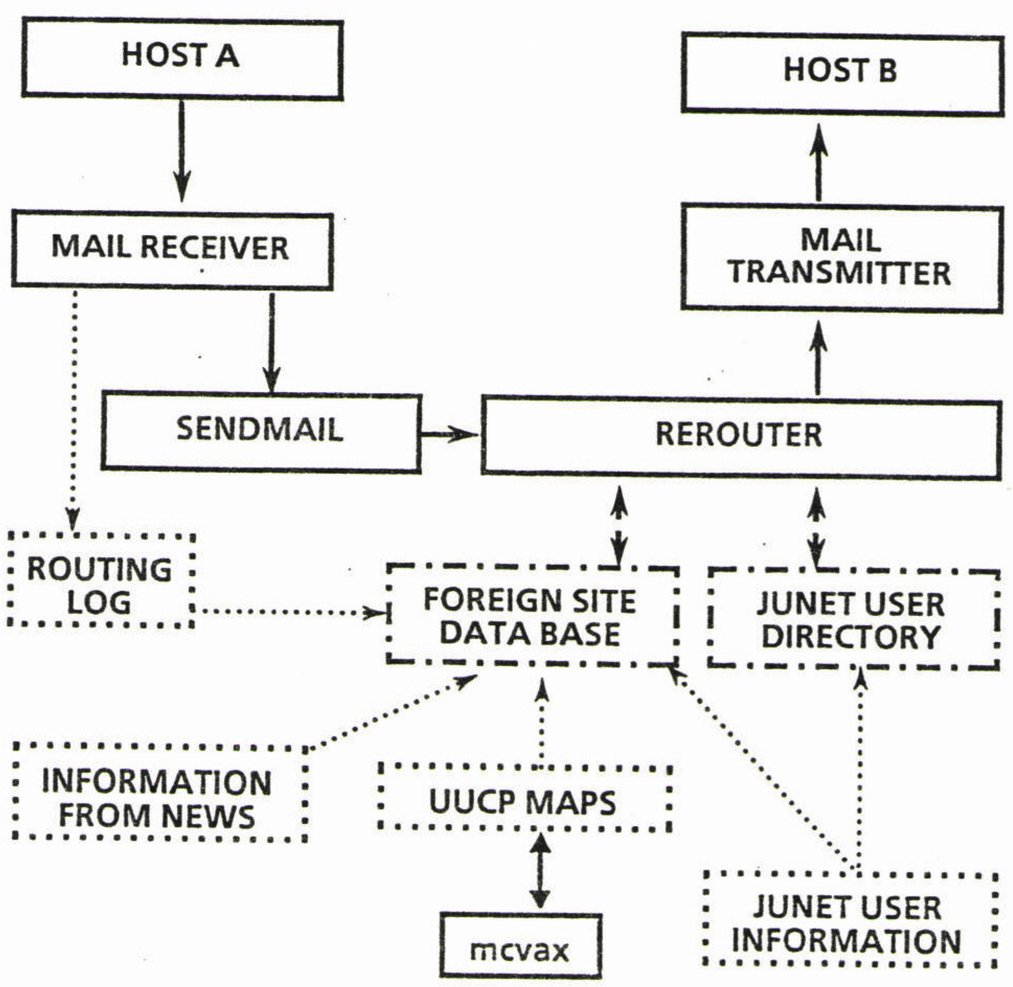

Figure 6. Structure of JUNET Gateway System

The overall algorithm taken at the JUNET gateway system is as follows; the mail receiver extracts the sender and receiver addresses from every received message, and puts them into the routing log file, which is used by a rerouter to determine whether or not the mail is a reply message to a previously routed mail. Then this mail is passed to 4.2BSD sendmail system to resolve the path for that message. At the sendmail program, the

sender and receiver addresses are analyzed into canonical forms, and then passed to the rerouter. The rerouter (an extension of 'rerouter'[Beertema84]) decides the feasibility of routing the message. If that is sent from a foreign country, or if the originator is a registered JUNET user and the destination address is stored in a foreign site database, it is just passed to the corresponding mailers through a mail transmitter. A message from a JUNET site has to have a JUNET domain address except a reply to a previously routed mail from a foreign network. Otherwise the message is sent back to the sender for the confirmation. So the gateway adopts a philosophy of not sending a doubtful message.

There are four kinds of sources to create or to maintain the address databases. The first source is the UUCP MAPs which are maintained between *kddlab* and *mcvax* through copying the maps to each other on demand basis. This serves as the main information source on foreign sites, and is guaranteed not to have a conflict. The second one is the JUNET user information, as explained above. Since the configurations of world networks are changing, it will be very difficult to keep the information of the first source complete, and hence this source must serve as its complement. The third one is the routing log at this gateway. Since the receiver and sender addresses of each message from a foreign site are stored as a routing log, it presents more up-to-date address information on the networks. These addresses are stored as a dynamic foreign user directory. The last one is the information read through the news, and this information is merged into a foreign site directory database together with the first 3 sources.

4.4. Services Available at the Gateway

The services provided by this gateway, other than mails, are news and directory guidances. Other services such as file transfers are not supported right now. These are under consideration. As a gateway for news, *kddlab* daily receives the news of the fa newsgroups from *hplabs*, and sends/receives the news of the net newsgroups to/from *mcvax*.

As for directory guidances, two types of guidance methods are available. The directory information of each host has been individually maintained in the UUCP environments. Hence, it is generally difficult to get the information on some specific site. There have been some attempts to solve this problem by means of creating the site directory database in the networks. The typical programs are 'path,' 'netdir,' etc., which are derivatives of 'rerouter'[Beertema84]. The basic principle taken in these programs consists of the following steps:

(i) create the site directory database based on some news or the site maps received from the nearest sites,

(ii) prepare new commands to consult this database.

A keyword to fetch some site information is usually a site name itself. A basic assumption in these programs is that users in the networks have a lot of experience to communicate with each other:

(a) They know the node name and the user name of the destination.

(b) The unknown information is the path to the destination.

These approaches are too complicated for a novice since these conditions are not often satisfied when he uses a mail system. He may not know the site name but the organization, and may not know who to contact nor how to use the commands provided by that mail system. The current UNIX mail systems contain many commands to send or to receive a mail, which may confuses a novice or makes it difficult for him to understand the entire mail system. The mail commands must be appropriately reorganized.

From this point of view, KDD has developed a menu-driven user interface called 'Mail Assistant.' The main motive to develop this mail program is to provide a uniform and integrated mail interface for a novice. The structure of the menus is shown in Figure 7.

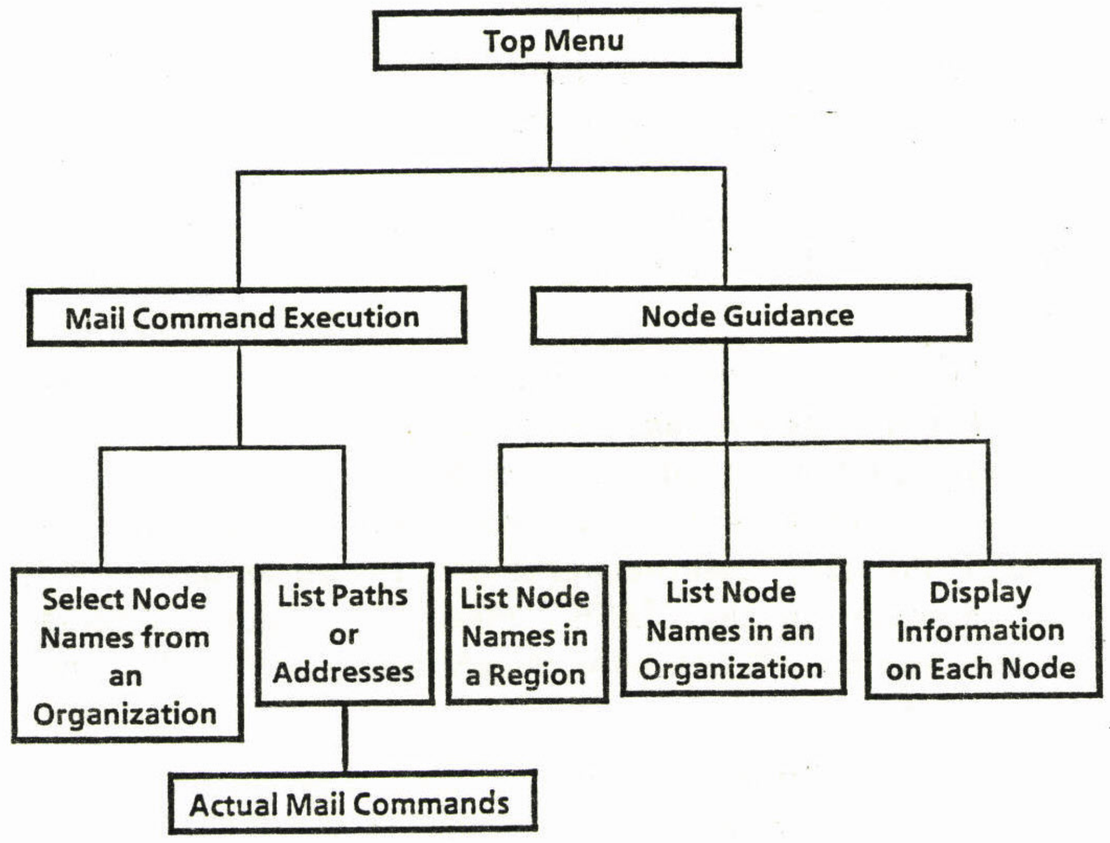

Figure 7. The Hierarchy of Menus

In this system, a user can

(1) get the list of nodes in each organization or each region, where regions may be geological (such as Oregon) or may be domains like SDN, EUNET, etc.,

(2) display the node information (node names, organizations, administrators, etc.)

(3) fetch the addresses in the JUNET domain addressing format, or the shortest source routing path or 5 alternatives to the destination site, and

(4) execute a mail command to send a message to the selected destinations.

The entire process to input commands are guided by hierarchically organized menus. At each menu, a user is informed what he should input to get the path to the destination without considering the actual network configurations. This makes it much easier for a novice to join the networks. It is possible to fetch a site infor-

mation with specifying its node name, its organization name or its synonyms. The later reduces the amount of each user's task to search a node name in the site directory list when he only knows the organization name of the destination.

The current version does not have a database on the user names in the worldwide networks. This is because only node names are currently available in the USENET environments. However even without that database, the user interface to post messages into the networks has been drastically improved. Mail Assistant hides the details of address formats from a user, and provides a uniform interface to the networks. This uniform environment to send a mail enables each user to specify more reliable addresses, and thus reduces the anxiety to send messages with incorrect addresses.

The Mail Assistant Program provides a user with a necessary information, under the assumption that a site has a compete USENET directory database. It is, however, often very difficult to keep each directory database up to date without any conflict under the USENET environments. Hence it is not desirable for each JUNET site to maintain such kind of databases for its mail system. To help a JUNET user of a small computer to know the appropriate information on his destination, the 'netdir' program, which was originally given by Mr. Piet Beertema of *mcvax*, has been extended at KDD to extract a site information. A site information can be extracted with various keys such as its organization name or the abbreviations as well as a node name. These keys should be specified in a subject line of a mail header. Thus it is much easier to fetch appropriate node addresses than before. Instead of informing a source path to the destination, the reply includes its address in the JUNET style.

5. Conclusion

The number of systems in JUNET has been increasing rapidly since it was started working in October 1984. Through studies of existing networks, the hierarchical domain addressing scheme was employed in JUNET. This provides users with clear and transparent addressing notations not only for messages exchanged within JUNET, but also for the ones exchanged with users in foreign networks.

The actual work for the addressing and routing of JUNET is achieved by the modifications of *sendmail* software and the rules, together with some other software. These programs provide an environment where the logical naming definitions and physical routing issues are clearly separated so that reliability, efficiency, extensibility, and flexibility of communication in the network are simultaneously achieved.

Internationalization of computer software is one of the most important issues in computer science, and some works have been achieved in JUNET communication software. In JUNET, electronic mail and news software are designed to enable 16bit Japanese character handlings, based on the standard JIS Kanji code.

Since Japan is a country floating in the Pacific Ocean, any of international communications are expensive. This, as well as the fact that the domain addressing is used in JUNET, requires special considerations and functions at international gateways: a registration system is employed for the international links to reduce unnecessary traffics and to make the conversion of addresses efficient.

Distribution of administration loads to each of the institutes is important as a volunteer based network. The hirarchical domain addressing scheme certainly contributes to this issue. Concentrating conversion loads, which are required for international messages, to the gateway systems also lightens the address mapping problems at most of the sites but the gateway sites.

These discussions leads the following issues which we are currently studying for the JUNET project:

- Use of data links, such as a packet switching network using X.25 protocols, which are more reliable, faster and more efficient than the public telephone lines we are using now. Although public telephone lines will still be used for its high availability.
- In the current system for message deliveries, the overheads caused by erroneous messages are large. This can be reduced by some mechanisms which handle name serving and message delivery functions dynamically based on distributed database technologies.
- As for network interconnections, various problems have to be solved. This can not be achieved without international cooperations among networks which are contributing to research and development communities in the world.

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