ORIGINAL CONTRIBUTION

Development of the Internet-Based Total Health Care Management System Using Electronic Mail

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In order to develop the distributed database management system for total health care management on the Internet (the world wide computer network) as an infrastructure, a new distributed type network-based database management system using the electronic mail (e-mail) system was reported in this paper.   The basic architecture of this system is as follows ; (1) the history management server stores only the consultation record of about 100,000-population, (2) it also indicates the medical consultation records and health care histories (when, where, and summary of medical procedures) of the each person when it is required, (3) the facility management system stores the raw data of each person and sends it when the patient or doctor makes a request through the history management server.   A model system was built using the e-mail system in an Internet environment on a UNIX* workstation as an experiment.   The performance of this model was considered to be adequate for practical use since the basic facilities can be easily set up.   *J Epidemiol*, 1995 ; 5 : 131-140.

health care, medical record, distributed database, electronic mail, Internet

Recently, it is an important concern how to exchange the personal medical information among the medical facilities and health care facilities in Japan.   The expansion of the elder population requires the medical follow up for the long term of patients with their chronic disorders such as hypertension, diabetes mellitus and ischemic heart diseases. In the long term of chronic disorders, the patient does not always keep consulting to the single doctor.   The patients usually consult to the two or three doctors because of the doctors' specialties.   On the other hand, almost all the aged people are required to have an annual physical examination and initial diagnosis of "adult disease" disorders including the malignant disorders[1].   The progress of health check for adult diseases extended the life span of the nations.   However, the connections between the health care facilities and medical facilities are not tight yet. Comparing the past medical records and the health check results of the patient would make it easier for the doctors to establish a better initial diagnosis and follow up with a therapeutic treatment.   As shown in Figure 1, the health

records are stored at the health center where the individual took the annual examination and the medical records of each patient are stored at each medical facility in Japan. The benefits of total health care without any barriers between medical facilities need to be updated as an infrastructure.

Recently, the multimedia communications and computer networking established itself as state of the art worldwide[2,3].   The world wide computer network system, the Internet, is spreading rapidly all over the world and enables a large variety of data transport protocols (Internet Protocols) among remote computer terminals.   In the USA, some medical and preventive medical information exchanging trials, named total health security plan[4], are also making progress.   To standardize the data among the each clinical and chemical analyst, the standard data format for exchange between medical facilities called "HL-7" was established in 1994[5].   These American trial decisions are nation-wide medical recordings.
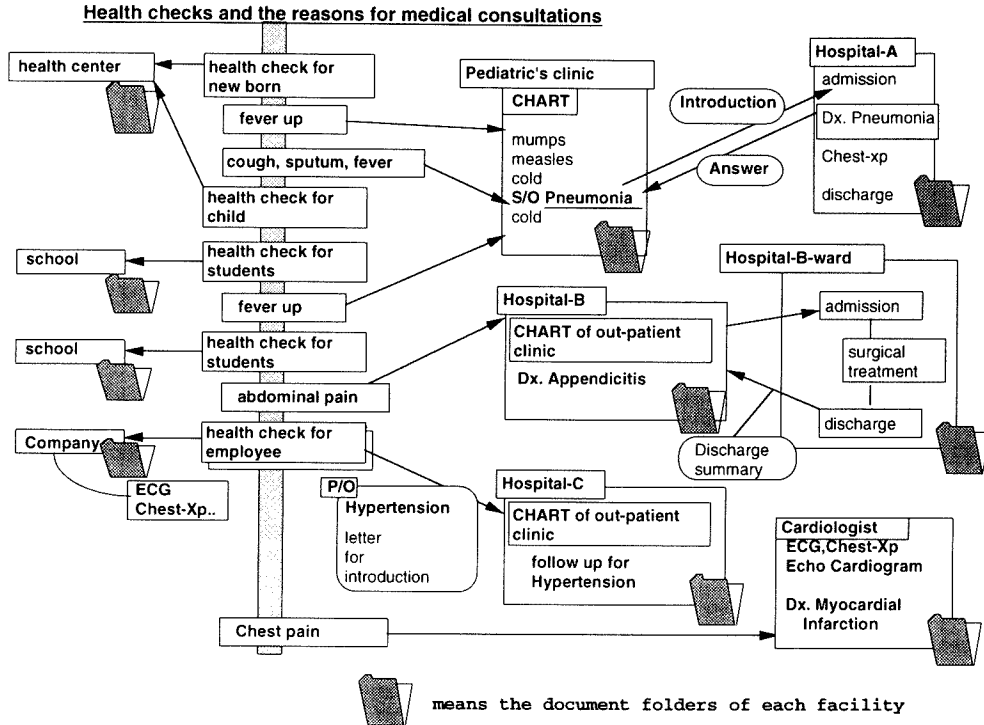
In the epidemiological field, Ostbye et al. reported the

Health checks and the reasons for medical consultations

Figure 1. State of medical recording in Japan. Allows mean the information exchanging between the facilities. The "folder like symbol" means the document folders in each facility. The medical records and the results of health checks are stored into the document folders in each facility. In each facility, the health check results and medical records are made by self-seeking manners. Thus it is difficult to refer those data at the emergency.

development of an epidemiological network system in Europe using the Internet[6]. Development of a network based health care recording and survey system in the near feature would be a logical choice.

To develop the new distributed type database model for total health care management, a network-based distributed database management system using the e-mail system[7] as an initial model was tried in our previous reports[8-10]. In this report, the possibility of network-based total health care using Internet technology was studied.

METHODS

System architecture

As shown in Figure 2, this model system was constructed as the network-based and distributed database management system. The fundamental procedure of network connection among each server and terminals was TCP/IP (Transmission Protocol/Internet Protocol). This model system consists of three subsystems such as History Management Server (HMS), Facility's Management Server (FMS) and Terminal. The HMS is assumed to preside at the suitable position of the medical network segment on

the Internet, for example, the prefecture health and sanitary office. The FMS is assumed to preside in every medical facility such as health care facilities, health center ("Hokensyo" in Japanese), a company's health organizing office, schools, medical clinics and hospitals. The HMS and FMS are the application programs on UNIX workstations. The terminals are the usual TCP/IP network terminals such as X-window[11] terminals on UNIX workstations, MS-Windows* terminals on usual IBM-PC** personal computers and Macintosh*** terminals on Apple computers.

These three subsystems act the each quota part of the procedure for database maintenance and searching the data.

Procedures for database management

The procedure for database management is shown in Figure 3. Each person has his own ID number on this

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* MS-Windows is a registered trademark of Microsoft Corporation.
** IBM-PC is a registered trademark of IBM.
*** Macintosh is a registered trademark of Apple Computer Co. Ltd.
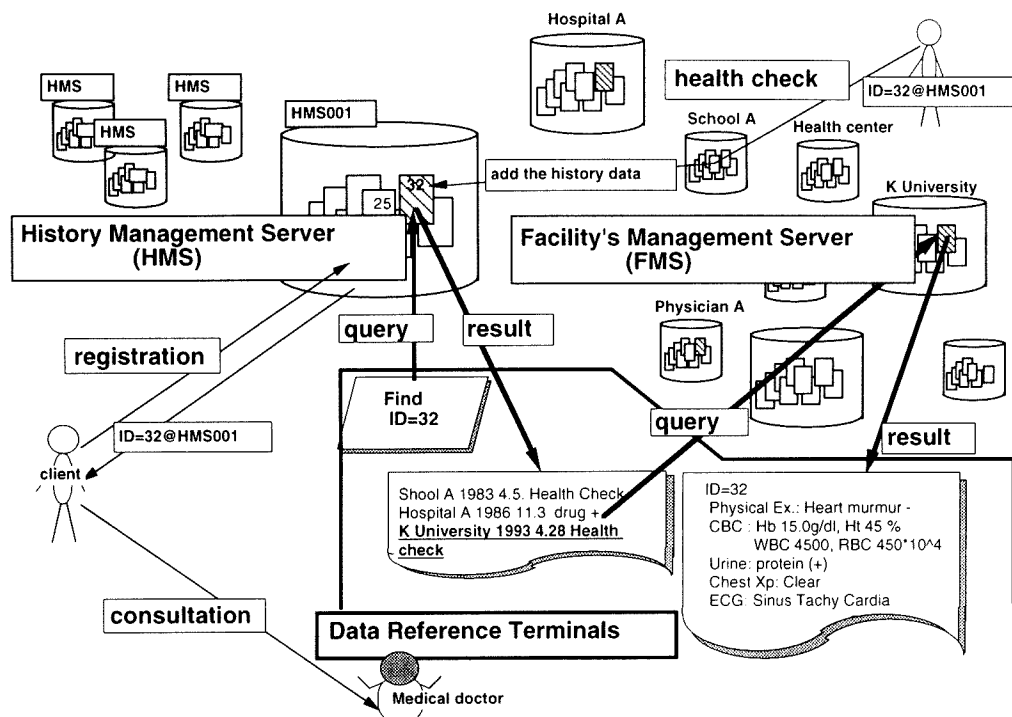
Figure 2. System architecture. HMS means the history management server. FMS means the facility's management server. This figure indicates the basic architecture of this system. When the user (for example, medical doctor) wants to scan the history of the patient (ID number = 32 @ HMS001), he sends the query e-mail to the HMS. The HMS sends the history record file to him. After selecting the history record, he send the request e-mail with the searching ID number as a subject header to the correspond FMS. The FMS send the patient's (ID number = 32 @ HMS001) raw data file to the doctor. The HMS does not store the raw data file of each person, but stores the history records of consultation about the medical and healthcare management.

system. At the first time, he accesses to any medical facilities, the FMS sends the mail for registration to the HMS. The HMS works automatically and sends the assigned ID number for him. The I.D. number is consisted of 2 parts ; serial numbers on the HMS and the HMS's address on the Internet. This ID number is used as the serial number of this system for all of his life. Even if he would move the different area covered by a different HMS he uses the same ID number as before. So the HMS maintains the personal history data of each person forever. Each member's history record includes a "date" and "time" of consultation, the medical facility's e-mail address, and reason for the consultation. For example, "1994/04/25, 13 : 00 Annual Health check at XXXXX health care facility", "1994/05/30, 08 : 15, Medical consultation at YYYYY clinic" and "1994/06/20, 02 : 20, Admission at ZZZZZ hospital". The HMS sends the history data file automatically searched for request from the terminals.

The raw data of each person such as the results of health check, physical examination records and blood check result are stored as the plain text files. The image data files from every imaging procedure in medicine are stored

in each facility's FMS data storage or in the image data storage servers on facility's LAN (local area network) as a standard UNIX image data-formatted file using the JPEG or GIF formats as the compression protocol. This data are stored as the objective data files on each member's directory. The FMS sends each objective data for the requirement from the trusted terminals using a plain text mail.

Implementation

In this model system, the procedures of database management such as registration of new members, assign of ID number, adding the history data into the identical file on HMS and so on are mediated by e-mail. The terminals send the e-mail to the appropriate server to execute the each procedure with the POP (post office protocol[12]) through the POP server on each facility's LAN. On the Internet, everyone can easily get the POP client programs (the programs to send and receive the e-mail with using POP) for UNIX workstation ("MH"), MS-Windows ("Eudra") for Windows) and Macintosh ("Eudra" for Macintosh). Especially the POP client programs of MS-Windows and
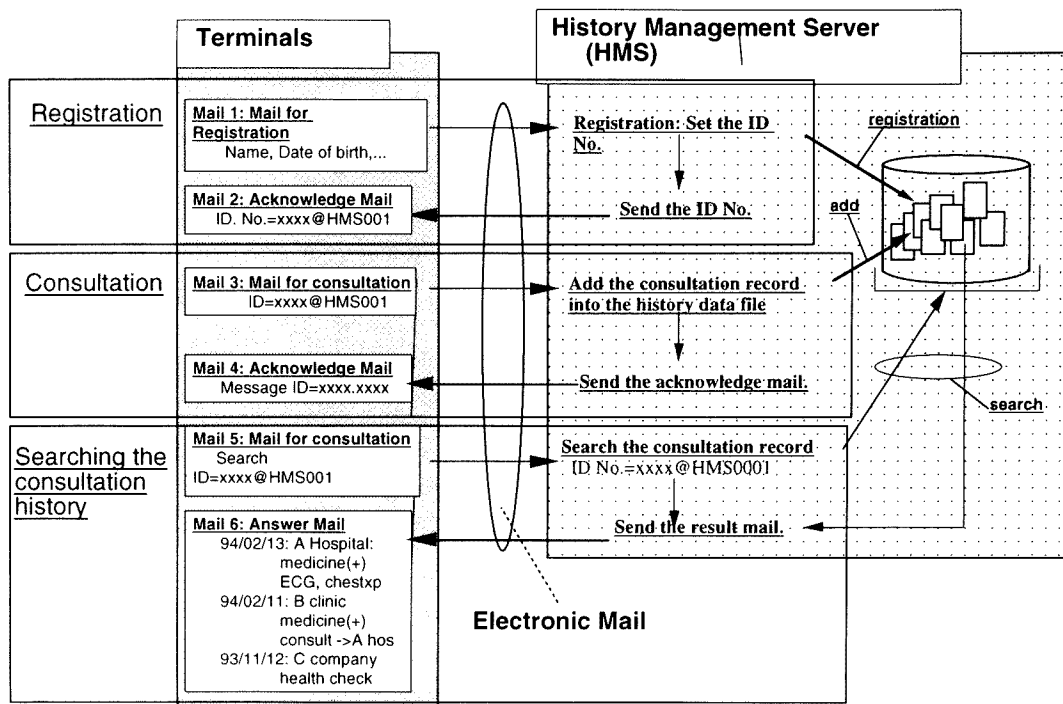
Figure 3. The relations between the each process on the terminals and the procedures on the HMS. The procedures for the database management are classified into 3 steps : Registration. Recording the consultation record into the HMS, Searching the history data. The allows to the right indicates the E-mail from each terminal for sending the registration, recording and searching queues to the HMS, and to the left means from the HMS to the terminal for the answers and acknowledges.

Macintosh are the one of the most popular programs on the Internet. The POP clients send and receive the e-mail with using the post-office box manner on the POP server working on the UNIX workstation. The UNIX system can execute the programs with the multi-user and multi-task mode. So the same UNIX workstation can execute the FMS program and POP server of the facility.

The data are updated with the manners as follows : (1) The information clerk of the facility sends the e-mail of query to the HMS corresponded to his/her ID number for getting his/her history data file when the person will come to the medical facility. (2) The same e-mail expresses the consultation record for the HMS. (3) After updating the history data as mentioned above, the HMS sends the history file to the delegate POP server's address of the facility with scanning the header part of the e-mail automatically. (4) After waiting some time, the person enters into the doctor's office. Until that the history management file is presented on the doctor's terminal. (5) If the doctor requires to see his/her raw data, the doctor sends the request e-mail to the corresponded FMS. The FMS automatically sends the raw data file to the participated e-mail address of the doctor. (6) After the examination and medical procedure, the medical records are stored into

the medical chart file of the patient on the FMS data storage.

RESULTS

Experimental implementation of the model system

Figure 4 shows the experimental test-bed for implementation of this model system. The HMS and the FMS were written by Perl script language[13] on UNIX workstation A (SPARC* station ELC by Sun Microsystems, Inc, CA, USA) with Sun OS 4.1.1[14] on one of the LAN (Network A : assumed to be the Facility in which the HMS locates.) connected to the Kyoto University Integrated-information Network System (KUINS). The POP server program (popper ver. 2.6) was also available on the UNIX workstation A. The e-mail transport program was sendmail.mx (ver. 5.6+Japanese Patch by the WIDE project)[15]. The UNIX workstation B connected to the different LAN segment of KUINS (Network B : assumed to be the far remote network from the network A.) This workstation enabled the POP service for the POP clients on segment B.

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* SPARC station and Sun-OS are the registered trademark of Sun Microsystems Inc.
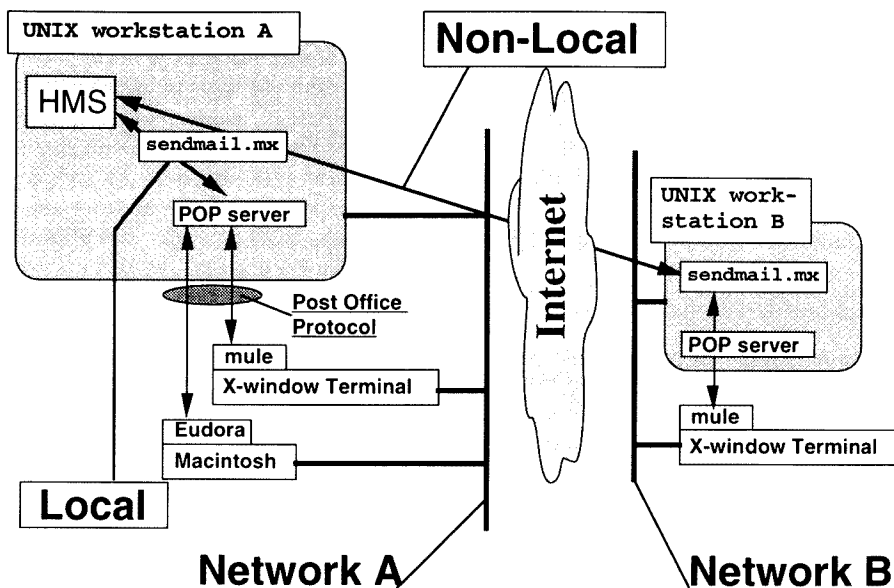
Figure 4. Model network System. The model network system were implemented on the usual Internet segments as an experiment. On this testbed (the experimental environment), the facility A and facility B was assumed. "Local" assumed the local condition that the requests and answer mail are exchanged in closed Local area Network (Facility A : such as the history management center for medical recording). "Non-Local" means the condition for exchanging the requests answers across the usual Internet.

Figure 5. Registration. A screen sample of the data registration to the history management server with portable personal computer terminal (Macintosh 145B with Eudra1.3.3J).

The data reference terminals were Macintosh personal computers (Power Book 145 B, Macintosh LCII and Macintosh Quadra 840 by Apple Computer Co. LTD with Mac-OS Ver. 7.1-J) using Eudora-J Ver. 1.383 as the POP client program for sending the e-mail to the corresponded host. Using the POP client program (mh-e, with mule ver. 2.01) on the usual X-window[11] terminal, it was also able to send and receive the e-mail through the POP server.

Figures 5, 6, 7 show the screen samples of data terminals,

Macintosh 145B, with Eudra-J (1.383-J5.). As shown in Figure 5, a user (such as a doctor, for example) of this system obtains the sheet of the data format by e-mail (the left side window), and he makes the receipt-formatted mail on the another window. After making the initial data file of the client (the person to be registered) on the other window (the right upper window), the doctor sends the e-mail to the HMS through the POP server. Receiving the e-mail form the terminal, the HMS decides the ID number
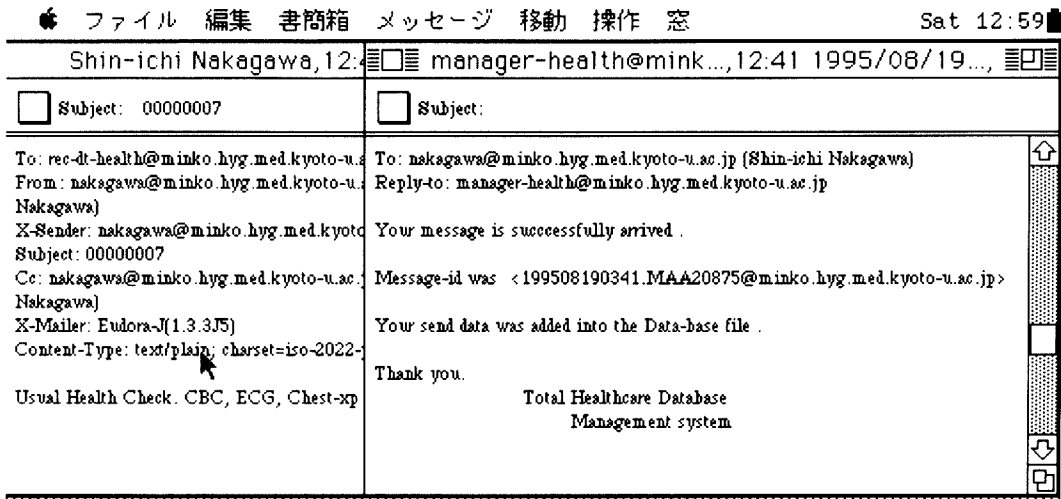

Figure 6. Data addition. A screen sample of the data addition to the history management server with portable personal computer terminal.
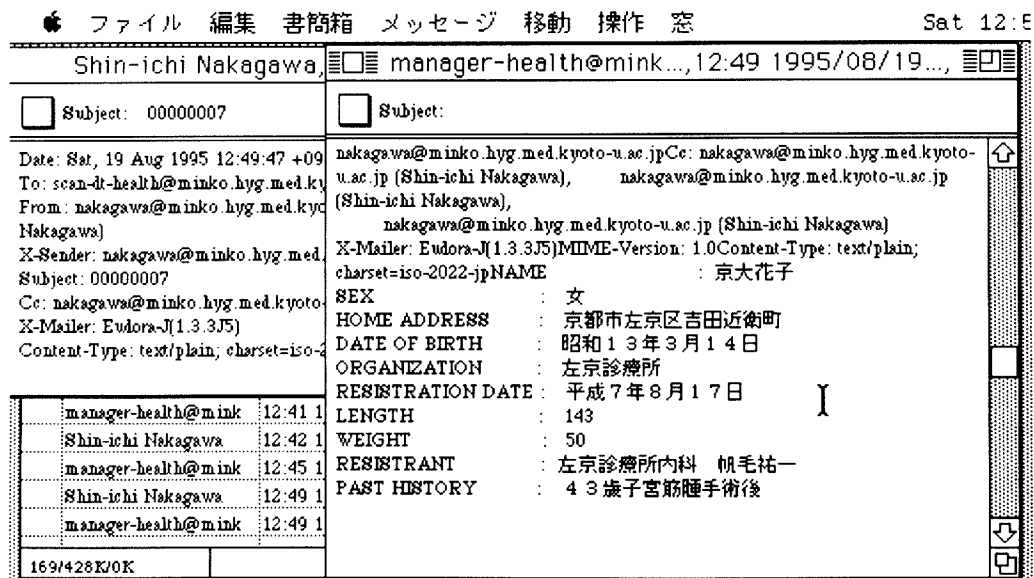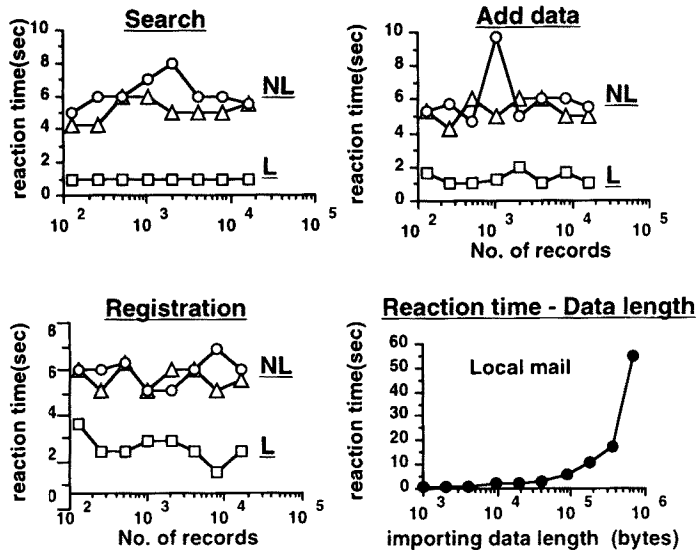

Figure 7. Searching. A screen sample of the data searching on the history management server with portable personal computer terminal.

Figure 8. Performance of model system. Result of measurement the interval between the cue and response with increasing the number of records (items) on a single directory at the HMS. The character "L" means the measured with the local condition, and the character "NL" means the non-local condition.

of the client and sends the notification mail of his ID number to the sender (the right lower window). Figure 6 shows the sample operation of making an addition to the individual history file on the HMS. The user makes the data for the client about the consultation (the left side window), and sends the data to the HMS. After processing the receiving data, the HMS sends the notification to the sender (the right side window). Figure 7 shows the sample operation of data scanning on the HMS. The user sends the e-mail whose subject part is filled with the searching key (this case the 00000007 ; the left upper window). The HMS sends the participated data file of the client.

Estimation of the performance

The performance of the HMS was estimated by measureing the reaction time, the interval between the time sending cue to the HMS and getting the answer from the HMS. The reaction time was calculated from the e-mail header's time stamps between the cue and the answer mail of each function. For example, data search, registration of a new member and addition of data to each member's data file with sending the test mails including 1 K byte ascii data, etc. To investigate the effect of the increasing the number of stored records on the HMS, the same intervals were measured at the condition of 128, 256, 512, 1,024, 2,048, 4,096, 8,192, 16,384 member's files on a single directory of the HMS.

The effect of the network distance for each procedure was also investigated with exchanging the between "Local Mail" (L) and "Non Local Mail" (NL) conditions on the assumption that the data exchanging among the far-remote medical and health care facilities are on the Internet at the same conditions.

Figure 8 shows the performance of this system. Almost all the reaction times for each action are less than 5 seconds. The reaction performance is almost constant regardless of the number of stored items on the server (even if the server stored over 1×10^4 items). Therefore, the History Management System's performance is suggested almost enough for a plain text base data transfer. The effect of the importing data length into the HMS was also investigated with sending the 1,024, 2,048, 4,096, 8,192, 16,384, 32,768, 65,536, 131,072, 262,144 and 524,288 bytes length data at the condition that the HMS stores 16,384 cases on the single directory. As shown in Figure 8 (the right lower part), the throughput rate for the variable length recording into the server was also measured. When the data length was less than 50 K bytes, the reaction time was less than 5 seconds. Exceeding 50 K bytes of data length, the performance decreases sharply.

DISCUSSION

Table 1 shows the summary of the trials of the network-based medical recording in Japan. However, there is no effective system for rapid data searching of a patient's history, drug allergy information and clinical records stored in other medical facilities. To solve these problems, several people have tried to develop a system using a large main frame computer[16,17]. Their basic architecture is a hierarchy-system in which all the identical raw data are stored in the top data storage system. In this system, the peripheral terminals in each medical facility work only to collect the patients' raw data and offer them to the upper systems.

The Japanese welfare administration has been trying to build a computer network system called WISH, which

Table 1. Trials for medical information exchanging in Japan.

WISH : Wide-area Information-exchange System for Health and Welfare administration.
　　　Since 1991 Mar.
　　　Minisry of Health and Welfare administration < — VAN — > Public Health Center Exchange the Informations for public health

Himeji city medical doctors society computer network system.
　　　Since 1987 Dec.
　　　Medical doctor's clinics < — > Medical doctor's society Server Computer Information for First Aid and browsing the health care data with personal computer.

UMIN : University Medical Information Network.
　　　Since 1988
　　　1988-1994 : Network with N1 protocol
　　　　　　(links between main frames)
　　　1994-　　 : Network service with TCP/IP started.

Trials for Information Exchange with IC cards.
　　　Some trials are working. Ex. 1991. Mar : Awaji Island in Hyogo pref.
　　　Each patient's IC Card stores the patient's own medical information.

Jpmed network news.
　　　Since 1995 Feb. Trial for nation wide network news exchaning among the medical sites in Japan using NNTP (Network News Transport Protocol on the Internet) by sigmed@north. ad. jp. mailing list.

depends on the commercial VAN connecting every health care offices and the Ministry of Health and Welfare[18]. This system is too difficult to implement at the nation wide level because of its high cost. In fact, the needs of medical cooperation among the several medical facilities to solve every patient's medical problems are minimal in the small scale communities (100,000 people or less). This is because in normal day-to-day scenarios, there is very low demand to send or retrieve the information of a patient who lives very far away. Thus the network-based distributed system is a better solution.

Figure 9 shows the proposed integrated recording environment for the total health care, in an assumption that one HMS manages a 100,000-population community (almost the same scale as usual cities in this country). Because the most of patients and people do not step over the border of the city for medical consultation into the medical facilities actually. Everyone has the home-doctors in a neighbor area from his own house. The queries across the cities would not arise frequently. So one HMS maintains the history record of the inhabitants of city-size community. In Japan, there are approximately 10 hospitals and 100 clinics in a 100,000-population community. Each hospital has 5-6 out-departments everyday. One doctor at an out-department or clinic is able to examine 10-12 patients per hour. The examination times for each patient are 4-5 minutes[19]. In our model, the maximum traffic of the HMS would be assumed to be the 100-150 requests for the patient history at the beginning of the out-department. Because it is assumed that the requests for query of the patient's history would be sent simultaneously from the each terminal at the beginning of

the each out-department and clinic every morning. The frequencies of collisions for sending the query would be getting lower with course of time because the processing time of each terminal for medical procedure would be random. Therefore, the network traffic in our model would not cause any difficulties.

In 1993, Kakehashi and his research group reported the result of the survey for the medical network needs of doctors in Hiroshima city of Japan[20]. They reported the most of the doctors' opinions were that the implementation of the medical computer network was too early stage. One of the cause they pointed out was the difficulty of learning the computer operations as the extra work for the surplus of their working hours. The authors also reported the difficulty of the LAN setting and implementation on the UNIX operating system, and proposed the various trials of easy implementations using the personal computer terminal[9]. Recently in the hospitals, UNIX workstations are used as the front-end for CT (computer associated tomography) machines, MRI (magnetic resonance imaging) systems, CRI (computer associated Roentgen Image) systems. In the near feature, these UNIX terminals would become to be the usual terminals in hospitals and connected to the Internet, and which would share the stored data for our system requests with e-mail. The implementation of our system would not be so difficult because it depends on the standard UNIX and IP. Thus, it is not difficult to establish the systems using this model in the mean of the hardware environment since the UNIX workstations are used only for processing or storing the image data files.

Kaihara et al. tried to build the hospital information

service using the X-windows based medical information systems in Tokyo University Hospital in 1993[21,22]. His group is trying to build a network system named UMIN, which enables access to the patient's medical records among the medical university hospitals in this country. Tatsumi built the multimedia anatomical data reference system in 1993[23]. Yamamoto built the electronic mail protocol based news data transport system as a prototype for the medical information exchange in 1993[24]. In 1994, Yoshihara et al. implemented the experimental Local area model named PALM at the Miyazaki Medical College Hospital[25,26].

Recently the protocols for multimedia communication on the Internet become the standard method named the Hypertext Transfer Protocol (HTTP) by Tim Berners Lee in CERN as an Internet draft[27,28]. After release of the proposals of HTTP, many programs for HTTP server-client model implementations were released in 1993-1994[29]. Thus the many HTTP servers were made on the Internet and serve the various multimedia databases in the world. In Japan, several medical HTTP servers were built and started as an experiment.

Table 2 shows the lists of the Japanese medical HTTP servers. The authors are trying to develop this system to support the Multimedia Mail extensions[30], which enable a gateway between the electronic mail system and Hypertext Transfer Protocols.

The Internet has still many problems to be resolved yet. One of the most important problem is "How to make the safe environment for exchanging the precious personal

Table 2. Medical multimedia information service servers in Japan at Dec. 1994.

Japanese National Cancer center.
  Since 1993. Gopher service for cancer researching information.
  gopher : //gan.ncc.go.jp/, http : //www.ncc.go.jp/
Osaka Medical College
  Since 1993. http : //www.osaka-med.ac.jp/
Dept. of Medical Information faculty of Medicine Tokyo University (UMIN).
  Since 1994. http : //cc.umin.u-tokyo.ac.jp./
Dept. of Social Medicine Graduate School of medicine Kyoto University.
  Since 1994. http : //minko.hyg.med.kyoto-u.ac.jp/
Kyoto University Hospital.
  Since 1994. http : //www.kuhp.kyoto-u.ac.jp/
Fujita Health University.
  Since 1994. http : //pathy.fujita-hu.ac.jp./
Nagoya University School of Medicine.
  Since 1994. http : //www.med.nagoya-u.ac.jp/
Ehime University School of Medicine Dept. of Anesthesiology and Resuscitology
  Since 1994. http : //mwsl.m.ehime-u.ac.jp./

information on the wide area network". The problem how to make the safe network environments are called generally "Secure". The implementation of Linn's Privacy Enhancement for Internet Electronic Mail protocol[31], which encodes the electronic mail as a secret mail data using the open cryptmatism mechanism, and which our
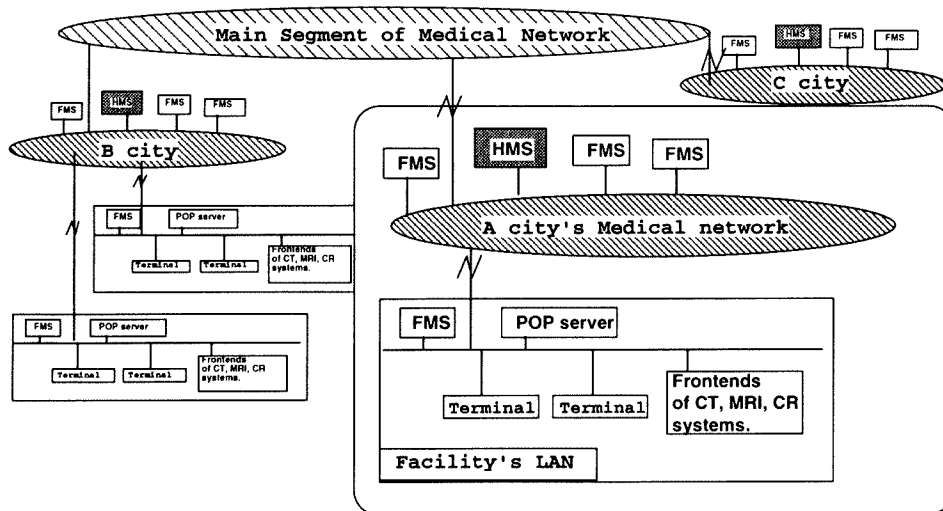
Figure 9. Proposed network environment for total health care management. This figure is the proposed network environment for total health care database management and medical records with network. Each ellipse means the unit of network. In this figure, the A, B and C city's medical network indicate as the one ellipse. The network of the cities communicate each other through the main segment. The medical network of each city includes has the HMS and connects the various facilities in the city, each facility has the FMS.

system can use without any difficulties, makes it possible to achieve a high level of security. The another implementation called PGP (Pretty Good Privacy) program for Electronic mail encording with a cryptmatism manner was implemented at 1994 in the USA[32]. When these programs and protocols would be implemented with easy user interface, everyone can send the e-mail safely. These programs are tested on the all over the Internet and getting to be the higher level.

In Japan, the medical information network that enables the border-less communication among medical facilities with using Internet protocol does not exist. Actually, there are many difficulties not only about the pure technical and financial problems for establishing the medical Internet in this country, but also the other problems such as the problem for medical records' ownership and ethical problems. In these opinions, "the medical" is the most special field for exchanging the personal information on wide area network. So, the problems, "How to make secure" and "How to establish the more safe network environment" are important and difficult to resolve. However, the network objective medicine is the most major current topics in recent years all over the world. Thus, it is suggested that the special researches by the epidemiologists based on the opinions of the social medicine are expected.

ACKNOWLEDGEMENTS

REFERENCES

1. The Japan Foundation of Welfare Statistics. Annual Report for Public Health in Japan, 1993.
2. Tanenbaum A. Computer Networks, 2nd ed. Prentice-Hall, Inc., 1988 : 320-366.
3. Norman HJ. LAN/WAN Optimization Techniques, Artech House, Boston, London, 1989.
4. Gore A, Clinton B. Total Health Security Plan, White House Blue Book. 1994.
5. McDougall M, Carlson D, Quinn K. version 2.2 Health Level 7 Standard Documents., 1994.
6. Ostbye T, Bojan F, Rennert G, Hurlen P, Garner B. Establishing an international computer network for research and teaching in public health and epidemiology. European Journal of Epidemiology. 1991 ; 7(1) : 34-38.
7. Crocker D. Standard for the format of arpa Internet text messages, RFC822. 1982.
8. Nakagawa S, Kimura M, Yokoi K, Itokawa Y, Kasahara Y, Sato T, Kimura I. Development of a database management system for general health care management with using electronic mail system., Proceedings of the 21st jus UNIX Sympo-

9. Nakagawa S, Kimura M, Chou H, Yamamoto A, Sakamoto T, Itokawa Y, Kasahara Y, Sato T, Kimura I. Development of a network model for the total health care management on multi-vender environment. IEEE COMSOC Multimedia '94 Proceedings, 1994 : 5-1-1-5-1-5.
10. Nakagawa S, Kimura M, Chou H, Yamamoto A, Sakamoto T, Kasahara Y, Sato T, Kimura I. Total Health Care Management with Internet. Proceedings of the 23rd jus UNIX Symposium, 1994 : 13-18.
11. MIT X Consortium. X Window System, Version 11, Release 5 Relesenotes, 1992.
12. Rose M. Post Office Protocol. RFC1081, 1988.
13. Larry W, Schwarz RL. Programming perl, O'Reilly & Associates, Inc, 1993.
14. Sun Microsystems. Sun-OS administration manual. Sun Microsystems Inc, 1992.
15. Bryan Costales, Eric Allan, Neil Rickert, Sendmail, O'Reilly & Associates Inc, 1993.
16. Komori M, Nakano Y, Minato K, Kimura I, Okajima K, Takahashi T, Abe M, Konishi J, Satoh, K. Present status and performance of PACS at Kyoto University Hospital, Comput. Methods Programs Biomed, 1990 ; 36, 2-3 : 77-84.
17. Takizawa M, Sone S, Imai S, Sakai F, Imai Y, Maruyama A. Practical mini- PACS based on a hybrid video and digital network, Comput. Methods Programs Biomed, 1990 ; 36(2-3) : 119-124.
18. Fukushima Y, Kitazawa J, Sotoyama S, Inoue Y, Harita T. Outline of the Wide-Area Information Exchange System for Health and Welfare Administration. Supplement to Journal of Epidemiology, 1993 : 171-172.
19. The Japan Foundation of Welfare Statistics, Annual Report for Public Health in Japan, 1994.
20. Kakehashi M, Tsuru S, Seo A, Yoshinaga F. Current and future perspectives of medical information network systems for community health using computers and IC card. Japanese Journal of Public health, 1993 ; 40(6) : 427-439.
21. Kaihara S. Workstation network system which enables international exchange of characters and images at the University of Tokyo Hospital. Int J Bio-Med Comput, 1994 ; 34, 1-4 : 357-361.
22. Kaihara S, Ohe K, Sakurai T, Kiuchi T. HIS and research, Hospital Information Systems : Scope-Design-Architecture. Proceedings of the IMIA Working Conference, 1992 ; xv+303 : 97-101.
23. Tatsumi H. System development for data deposit and retrieval of the JAA using the Internet, Kaibogaku Zasshi-Journal of Anatomy. 1993 ; 68(5) : 564-570.
24. Yamamoto R. Mednews protocol, MedNews, 1992.
25. Yoshihara H, Araki K, Koga Y. Medical image database distributed by personal computer LAN, 1994, Japanese Journal of Medical Informatics, in press.
26. Yoshihara H. PHOENIX/PALM Status quo and future prospects of the total hospital information system of a Japanese medical college. Journal of Medical Systems, 1994, in press.
27. Lee BT. Hypertext Transfer Protocol, Internet draft, 1993.
28. Lee BT. Hypertext Markup Language, Internet draft, 1993.
29. WWW project, WWW Daemon user guide, NCSA httpd documents, 1991.
30. Borenstein N, Freed N. MIME, RFC 1993 : 1521-1522.
31. Linn J. Privacy Enhancement for Internet electronic Mail, RFC 1993 : 1421-1424.
32. Garfinkel S. PGP. O'Reilly & Associates, Inc., 1993.