FEATURE ARTICLE

# The Superiority of M-Technology for a Hospital Information System: II

## Comparison of System Performance between Ingres and Open M

*by Hee Sun Jeon, Yun Sik Kwak, Hune Cho, Hyung Soo Kim and Soo Yon Jang*


### Abstract

Ajou University Hospital is a 900-bed tertiary care teaching hospital with approximately 140 medical staff, 200 house staff and 450 registered nurses. An average of 850 in-patients and approximately 2,000 outpatients are treated daily. There is also a 36-bed Emergency Care Unit, which is the major trauma referral center in the region. To support the above clinical activities, ATOM-1 (Ajou Total Medical Information System-1) open distributed system was developed in November of 1990 and was implemented in June of 1994 when the hospital was newly opened. System hardware consists of 23 Unisys Servers (U6000/65x19 and U6000/85x4), 300 PCs, 170 workstations, and 240 printers. The network is connected to an FDDI backbone and uses TCP/IP, Ingres/Net, and 5 bridge routers. The client hardware is SUN (SPARC Classic). The client user interface is SUN Motif (OSF/Motif). The software was written in Windows/4GL and C for the client and Vision, C, COBOL (MF) for the servers. The DBMS is Ingres v.6.4 and the operating system is UNIX SVR4. The applications include an order communication system for all physician orders, admission, discharge, transfer, scheduling, patient registration, pathology, laboratory, blood bank, pharmacy, dietetics, x-ray, nuclear medicine, physiological function tests, accounts receivable, billing, medical record tracking, physical therapy, radiation therapy and nursing. Total investments include hardware costs of $6 million and software development costs of $4 million.

User satisfaction with the system was high. However, there were serious drawbacks such as high overhead costs for the servers and relatively slow data processing compared to that of the M DBMS. Server shadowing is not possible and consequently the hardware cost has been very high.

Therefore, it was decided in early 1995 to convert the Ingres-based ATOM-1 to an Open M-based downsized system, without changing the system architecture, in order to lower the hardware cost and to improve system performance. The entire system, with the exception of outpatient order entry, was converted to Open M-based in November of 1996. The outpatient order entry has been on a SUN SPARC C workstation which cannot be ported to Open M at present. In the meantime, material and inventory management and cost analysis systems using Open M have been developed and implemented. Therefore, there has been a unique opportunity to compare the performance of Ingres and Open M as the database management system for the hospital information system. The outcome was remarkable in that Open M was shown to be an average of 50 times faster in data processing time in a simulated condition but 8 times faster in real time processing. The server memory and CPU requirement was one third that of Ingres.

In conclusion, a client/server-based open distributed hospital information system with Open M shows superior performance over Ingres.


### 1. Introduction

Ajou University Hospital is a 900-bed tertiary care teaching hospital, which has been established to support patient care, medical research and training of medical nursing and medical technology students, interns, residents and fellows. The hospital was opened in June of 1994. There are approximately 140 medical staff, 200 house staff, and 450 registered nurses working for 850 inpatients and approximately 2,000 outpatients daily. This is the major referral medical center in Kyunggi Province, immediately outside of Seoul, supporting a population of about 5 million.

The ATOM-1 (Ajou Total Medical Information System-1) development project was conceived in

November of 1990. Implementation began in June of 1994.

The database management system in use at the time was Ingres v.6.4, with 23 Unisys servers, 170 SUN (SPARC Classic) workstation-clients, 300 IBM-compatible PCs and 240 printers. The network is attached to an FDDI backbone, 5 bridge routers, and run with TCP/IP and Ingres Net.

The order entry, admission, discharge, transfer, scheduling, insurance reimbursement, patient registration, pathology, laboratory, blood bank, pharmacy, x-ray, nuclear medicine, dietetics, special function test laboratories, accounts receivable, billing, medical record tracking, physical therapy, radiation therapy and nursing modules are included in the hospital information system.

However, the Ingres-based system showed very high overhead cost for the servers. The data processing time was relatively slow and downtime was observed due to maintenance.

Therefore, we decided to convert the Ingres system to Open M. This conversion project was started in July of 1995. We successfully migrated the software programs supporting diagnostic radiology, dietetics, medical record tracking, and special function laboratories activities in February of 1996. The rest, with the exception of outpatient order entry, was converted to Open M in November of 1996. For the outpatient order entry, a SUN SPARC C was used as the client to which Open M cannot be ported at present.

In the meantime, material and inventory management, cost analysis and insurance reimbursement using Open M were developed and implemented in August of 1996. For the M Technology system, ISM was used as the programming language and database management system.

This paper briefly describes the background of developing the ATOM-1 together with the M conversion to develop ATOM-2. We also had a unique opportunity to compare the performance of the data processing time between Ingres and M Technology.

In those two systems, the hardware and network backbone were the same except for the database programming languages and communication tools, namely Ingres Net and M Net.

This paper was presented previously at the 23rd M Technology Association-Japan annual meeting.

## 2. Philosophy of Ingres-Based System Development

The hospital information system development team was formed while construction of the hospital was under way.

The philosophy of system development by the medical center's top management was as follows:

-Implement an order communication system (OSC) for all physician and nursing orders

-Implement an open-distributed hospital information system and;

-Develop an infrastructure for future hospital information systems.

On the basis of these, the following system development objectives were formulated. For the technical aspect: a distributed open client/server hospital information system should be developed; an OCS for all orders should be developed; and an interface for connecting equipment should be developed.

For the business aspect: hospital services provided to patients should be improved; hospital employee's productivity should be increased and quality of health care should be improved.

For the OCS: physicians should use the system for ordering; GUI-based OCS should be developed to make ordering easier; a group order system should be developed; test results and order status reviews should be available; system response time should be faster; and nursing staff should be liberated from clerical tasks.

## 3. Development costs for the Ingres-Based System

The total personnel costs were $4 million for 1,300

man-months. The total hardware cost was $6 million, which included the servers, network and peripheral devices.

# 4. Ingres-Based System Platform and System Configuration

## *4.1 System Platform (See Table 1 below.)*

## *4.2 System Configuration (Figure 1)*

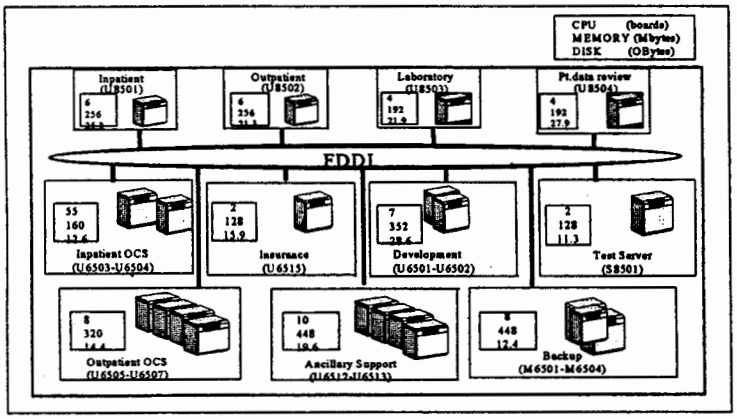



Fig 1. Ingres System Configuration

The servers and peripheral devices were connected through an FDDI backbone with 5 Bridge routers. The system consisted of 23 Unisys servers (U6000/85x4, U6000/65x19, 300 PCs, 170 workstations, and 240 printers). The total server random access memory (RAM) equalled 3,000MB and disk capacity equalled 250GB.

# 5. Strong Points of Ingres-Based System

## *5.1 Technical Aspect*

-Open distributed systems can easily be expanded and future technology can be used without changing the current system[2,3].
-Client/Server systems increase system efficiency.
-Store and forward is used to communicate between servers for transactions.
-Automated devices are interfaced and bar-coded labels are effectively utilized.
-GUI provides advantages to physician ordering mechanism.

## *5.2 Business Aspect*

-Physicians and nurses can order directly through OCS.
-Nursing package automatically communicates with ordering information(DB).
-OCS information communicates with patient's administrative package so patient waiting time is minimized.
-Reimbursement requests are more accurate and faster.

# 6. Weak Points of Ingres-Based System

## *6.1 Technical Aspect*

-System cost is too high due to relatively slow transaction and response time. The system frequently deadlocks.

| | Client | Server |
|---|---|---|
| User Interface | SUN Motif (OSF/motif) | |
| Language & Tool | Windows/4GL, C | Vision, C, COBOL (MF) |
| Application | All OCS entry | All ancillary support |
| | Review Reports | Order status review |
| | | Patient registration |
| Database | Ingres v6.4 | |
| Network | TCP/IP, Ingres/Net | |
| O/S | UNIX (SVR 4) | |
| Hardware | SUN (SPARC Classic) | |
| | Unisys (U6000/65, U6000/85) | |

Table 1. System Platform

| | |
|---|---|
| DBMS | :ISM |
| Program | :Visual BASIC 4.0, STDM |
| Network | :M Net |
| Hardware | :Same as Ingres system |
| Network Backbone | :Same as Ingres system |
| Entire system development and implementation | :July 1995 - Nov 1996 |
| Cost | |
| DB | $400,000 |
| Personnel | $2,353,000 |
| Total | $2,753,000 |

Table 2. System with M Technology Migration Plan

-Server and disk shadowing and mirroring are not easily accomplished. Therefore, there is approximately 1.5% of downtime for system maintenance.

## 7. M-Technology-Based System Development

M-Technology has been chosen to improve the system performance and eliminate the weaknesses of the Ingres-based system. The existing hardware, network and peripheral devices should not be altered and open distributed client/server architecture should be supported by the new DBMS.

Migration of the Ingres system to an M system should be accomplished with a minimum of work disruption. The migration was carefully planned and executed gradually. This M system development started in July of 1995 and the software packages for the diagnostic radiology, special function laboratories, dietetics and medical record tracking were implemented in February of 1996. The material and inventory management, insurance reimbursement, and cost analysis systems were implemented in July and August of 1996. The remainder, except outpatient OCS, was implemented in November of 1996. The outpatient OCS has been using SUN (SPARC C) workstations which cannot be ported by ISM at present.

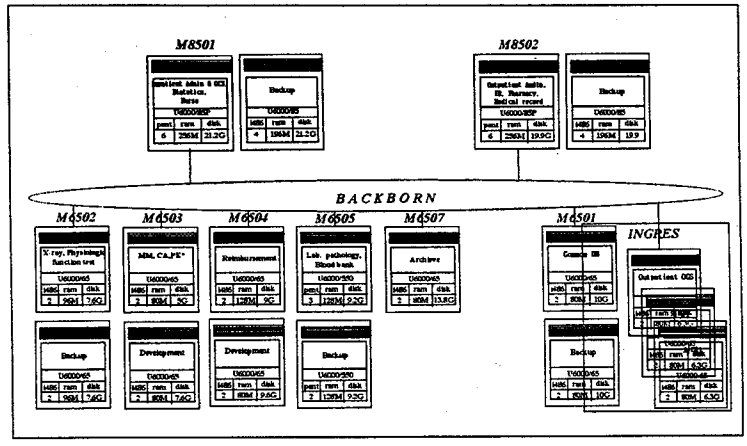
| Program Development Tools | | |
|---|---|---|
| Pure M | : | System programming |
| BLBX | : | Data access routine for integrity |
| McGen | : | M code generator |
| DD | : | Data Dictionary |
| MQ | : | Data query tool |
| M Net | : | Communication |

Backup and replication system development
-System and database backup
-Transaction unit replication
-Simplification of data recovery procedure using journal file

Table 3. Development of System with ISM

The details of the migration plan (Table 2), development tools (Table 3), and the system architecture (Figure 2) are as follows. The client was changed to a Pentium PC using Windows 95 v.4.0. The system server total RAM was 1,104MB with 866MB backup and a total disk capacity of 95.7GB with an 85.1GB backup.

## 8. Comparison of Response Time and Hardware Resource Requirements between Ingres and M-Technology-Based Systems.




*MM: Material management, CA:Cost analysis, PE:Physical examination
Fig 2. M-Technology System Configuration

The system response time of a simple bulk test was an average of 105 times faster with M Technology than with Ingres, and the application test was an average of 2.6 times faster with M Technology. In the real environment, M Technology was an average of 8 times faster for ordering activities; 2 times faster for diagnostic test results review; and more than 10 times faster for patient administration functions (Tables 4, 5, 6 and 7). M Technology required only 1/3 the hardware capacity that was required by the Ingres system. (Tables 4, 5, 8).

| | Benchmark | Ingres | M | Times Faster in M | Average |
|---|---|---|---|---|---|
| *Simple Bulk Test* | | | | | |
| Count | Query | | | | |
| | Insert | 417.5 | 3.5 | 119.2 | |
| | Update | 524.7 | 5.2 | 99.9 | |
| | Delete | 394.0 | 5.2 | 75.7 | |
| | Insert | 3,444.5 | 27.2 | 126.6 | |
| | Update | 4,201.5 | 33.2 | 126.5 | |
| | Delete | 3,222.4 | 38.5 | 83.7 | 105.2 |
| *Application Test* | | | | | |
| Order Entry | | 3.3 | 1.2 | 2.8 | |
| Radiology Accession | | 3.7 | 1.0 | 3.7 | |
| Code Master Entry | | 1.7 | 1.5 | 1.1 | |
| Deletion of Lab Test | | 2.0 | 1.5 | 1.3 | |
| Radiology Test List | | 28.7 | 4.0 | 7.1 | 2.9 |
| | | | | | 53.9 |

Table 4. Comparison of response time Ingres vs M Technology-based systems (Unit: sec)

| | | Ingres | M | Rate(%) |
|---|---|---|---|---|
| *System* | | | | |
| Resource | CPU Number | 3 | 1 | |
| | Memory (MB) | 384 | 128 | 33.33 |
| | Disk (GB) | 27.3 | 10.5 | 38.46 |
| Utilization | CPU IDLE (%) | 33.35 | 37.6 | 112.74 |
| | Free Memory (MB) | 2.51 | 3.61 | 143.82 |
| | Disk Util (%) | 51.16 | 55.75 | 108.97 |
| No of Users | Log-In | 107 | 102 | 95.33 |
| | DB Session | 141.12 | | 8.51 |
| *Database* | | | | |
| Disk Usage | Engine | 710 | 92 | 12.96 |
| (MB) | Data | 675 | 614 | 90.96 |
| | | x3 capacity necessary | | |

Table 5. Comparison of hardware resources between Ingres and M Technology based systems for radiology, medical records, dietetics, and special function labs.

| Function | Ingres | M | Times Faster in M |
|---|---|---|---|
| Form Loading | 120 | 15 | 8 |
| Patient Selection | 6 | 1 | 6 |
| Order Review | 5/8 orders | <1/8 orders | -8 |
| Order Entry | 6/8 orders | <1/8 orders | 6 |
| Lab Order Review | 5 | 5 | 1 |
| Lab Results Review | 2 | 1 | 2 |
| Pathology Order Review | 2 | 1 | 2 |
| Pathology Reports Review | 1 | 1 | 1 |
| Radiology Order Review | 2 | 0.5 | 4 |
| Radiology Reports Review | 1 | 0.5 | 2 |

Table 6. Comparison of Transaction Time of Order Entry and Results Review in Real Environment

| Function | Ingres | M | Times Faster in M |
|---|---|---|---|
| Admission & Discharge Review | 2 | 1 | 2.0 |
| Hospital Daily Transaction Summary | 21,400 | 4,500 | 7.2 |
| Discharge Billing Summary | 90-1800 | 5 - 20 | 18 - 90 |
| Inpatient List | 1200 | 300 | 4.0 |
| Patient Order and Procedure List | 420 | 100 | 4.2 |
| Accounts Receivable Daily Report | 420 | 50 | 8.4 |
| Outpatient Reimbursement Monthly Request | 68,400 | 14,400 | 4.8 |
| Inpatient Reimbursement Monthly Request | 79,200 | 2,400 | 33.0 |

Table 7. Comparison of Transaction Time of Patient Administration Activities in Real Environment

| | Ingres | M | M/Ingres Ratio |
|---|---|---|---|
| Random Access memory | 3,000MB | 1,104MB ( 866GB Backup) | 0.37 |
| Disk | 250GB | 96GB (85GB Backup) | 0.38 |

Table 8. Comparison of Total Capacity of Random Access Memory and Disk Storage

## 9. Conclusions

The opportunity presented itself to compare the performance of a hospital information system under both Ingres and M Technology (ISM). The hardware environment used in both systems was identical.

The following conclusions have been made:

1. M Technology required only 1/3 of the server and disk capacity to handle approximately the same number of transactions as that of the Ingres DBMS.

2. M Technology showed much faster transaction and data processing speed, being 5 times faster in the case of GUI and 5 to 100 times faster depending on the nature of the applications.

3. M Technology minimized system downtime because of fewer hardware requirements allowing for hardware backup systems. **M**

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## References

1. Kwak, Y., Jeon, H., Cho, H., Kim, H., and Jang, S. "The Superiority of M Technology for the Hospital Information System." 23rd *MTA-Japan Annual Meeting* abstract. (1996): 30.

2. Scherrer, J., Louis, C., and Borst, F. "DIOGENE2, a Distributed Hospital Information System with an Emphasis on its Medical Information Content." Yearbook of Med. Info. Schattauer, Stuttgart. (1995): 86-95.

3. Tolchin, S. "Overview of an Architectural Approach to the Development of the Johns Hopkins Hospital Distributed Clinical Information System." Journal of Medical Systems. (1986): 321-328.

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## Calendar

MTA Europe Annual Meeting
Wednesday, October 29, 1997
The Palace Hotel, Brussels
* Please note that this date is one week later than originally announced.

MDC Meeting
September 24-27, 1997
Allerton Hotel, Chicago
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