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Let your TOES do the walking at the University of Michigan

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The University of Michigan
Ann Arbor, Michigan

Enrollment: 36,500 (Ann Arbor Campus)
Public Four Year Institution
providing academic excellence in undergraduate, graduate, and doctoral programs

The University of Michigan's Transcript Order Entry System (TOES) automates the transcript order and delivery process, allowing students and alumni to order transcripts remotely via the Web and have their transcript delivered via EDI/SPEEDE to its destination on that same day. This paper will discuss the creativity and teamwork required to create this system, the various technologies utilized to support the application, and various issues related to federal law, University policy, data security, and data integrity. Special attention will be given to the innovative working relationships, the introduction of new technologies, the creative use of legacy technologies, as well as the rapid prototyping development philosophy employed.
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About the University of Michigan

Founded in 1817, the University of Michigan is one of the nation’s top-ranked public universities and top twenty-five academic institutions in the country. Nineteen schools and colleges on the Ann Arbor campus, plus campuses in Flint and Dearborn, comprise the University. There are 26 libraries, more than 500 clubs and organizations, 23 Big Ten sports and 36,500 students who came from all 50 states and more than 150 different countries, enrolled in over 160 degree programs. Among the 9,873 graduates for the academic year of 1995-1996, 5413 received undergraduate degrees, 1647 received master or Ph.D. degrees, and the rest are professional degree holders. These numbers have remained constant in the last ten years, contributing to the University’s large alumni population. Decision making on most academic policies is decentralized among the faculties from each of the schools or colleges. Major administrative, financial, and university-wide policies are decided by the President and other administrative officers, who report to the eight-member Board of Regents, elected directly by the citizens of the state of Michigan. Financial Report of 1996 fiscal year showed a tuition revenue of approximately $452 million, $300 million state appropriations and over $70 million from various other funding sources.

The “Dream” for an Automated Transcript Production Process

As the University of Michigan writes a new chapter in it’s history of excellence in the area of Administrative Computing and moves further toward a fully distributed computing environment, the Transcript Order Entry System (TOES) was designed and developed with a blend of both present and future technology infrastructure to accomplish that goal.

1992 marked a major advancement in the history of the University of Michigan’s Administrative Computing: the completion of the Academic Record Project, a project that brought all of the student academic information into an electronic form, stored on a IBM/IMS mainframe system. This made it possible for the development of a system that automatically prints transcripts for students and alumni of the University of Michigan. This system advancement provided significant savings in the time required for the production of transcripts. It provided a clearer, more professional look to the University of Michigan transcripts in comparison to the photocopy image of archived paper records.

These past accomplishments have set the ground work for the next phase which was to begin with the development of TOES. Our dream for TOES was to:

- develop a paper-less system from beginning to end.
- provide easy access to our students and alumni; anytime, anywhere.
- reduce costs and improve quality of our services to students and other units within the University.
- fully automate the transcript production and transcript request tracking processes.

The TOES project sought to leverage as much of the past institutional technological investment as possible. The TOES application was approached from the requester’s point of view. A solution was desired that would allow the requester to order a transcript in a manner independent of geography and
time. The desired solution would eliminate the need for paper documents, while preserving (and enhancing) the current validation and verification processes. While it is always tempting (at least for the technologist) to dream of a “better world”, our desire for a quick implementation with a minimum investment caused us to explore our current environment. We were able to take advantage of several previous initiatives:

- The Registrar’s Office had previously collaborated with the Information Technology Department (ITD) to develop a system that automated the process of compiling both the official and unofficial transcript. This data resides on a legacy system in a hierarchical database. This legacy system, an IBM Mainframe running MVS and IMS, has historically limited access to non-staff members of the university community due to security requirements.
- ITD had deployed a distributed authentication mechanism for distributed applications, called Uniqname\(^1\), which is based on the Kerberos\(^2\) work from MIT. Over the past five years, members of the university community have been provided with a Uniqname and password. This authentication mechanism has historically been limited to support our student based services.
- ITD had deployed several remote data access systems using database technology from Oracle.
- ITD and the Registrar’s office collaborated to provide student access to student data that resided on the Legacy system. This was accomplished using the Mandarin\(^3\) technology, which limited access to proprietary clients that required Macintosh computers. This application, called Wolverine Access\(^4\), took advantage of the existing Uniqname support and pushed the Kerberos support out to the Legacy System.
- The ITD “Web Team” introduced an alternative client to the Wolverine Access application: Secure Socket Layer (SSL) compliant Web Browser (e.g., Netscape, Internet Explorer). By taking advantage of the secure network channel available through the use of SSL and using a UNIX workstation as a trusted gateway, a student was now able to access student data via a Web client, by allowing the Web Server on the trusted gateway to act as a Uniqname proxy for the student.

The “Old” Transcript Production Process

The University of Michigan Ann Arbor campus responds to nearly 100,000 requests a year to produce copies of student transcripts. The prior transcript ordering process was essentially the same one used during the era of archived paper records. Fifteen full time employees plus 6 seasonal employees were dedicated to handle the work load. The old process involved mailing in or handing in a paper transcript request with a hand written signature to the Office of the Registrar or the Student Service Centers for processing. Signatures received in the mail, by fax or drop-off box sites were unverified. The handling of such paper requests created procedural requirements that included cash handling, coding, tracking, manually filing, and document retrieval at all points in the process. This manual process was time consuming and allowed many errors to occur. Occasionally records were lost or mis-filed. Any error in delivery of this information had devastating effects for the student, such as missed employment.

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1 A short sequence of characters (three to eight) that serves as a unique campus-wide name or identity for a user of computer services at U-M.
2 A widely-used secret-key network authentication service which relies on exchanges of several encryption keys known only to the appropriate parties to protect information sent across an open network.
3 A project, initiated at Cornell University, to access the mainframe legacy data using client/server technology.
4 Wolverine Access is the University’s Web based service that allows students and alumni of the University of Michigan to access their records directly from the administrative mainframe database.
opportunity and missed deadlines for admission to graduate programs. The old process prevented taking advantage of electronic data storage, retrieval, and transmission delivered by the Academic Record Project in 1992. Figure 1 illustrates the “flow” of the “old” tedious process with it’s many undesirable features.

Given the increasing mobility of our students and alumni, their emerging expectations of distributed computing, and the growth in transcript orders, it was determined that a more efficient model for delivering transcripts was necessary. We wanted to provide a process that was easier to use, anytime and anywhere, while increasing service and reducing our staffing requirements.

The Team for TOES

Traditionally, central offices at the University of Michigan relied entirely on the Information Technology Division (ITD) for all its technology and project management. In 1993, this started to change:

- The Office of the Registrar installed a Local Area Network and purchased personal computers for all staff, replacing the dumb terminals used to access the mainframe computer.
- The Office of the Registrar initiated a project to install an Interactive Voice Response (IVR) system for registration. The office was responsible for all aspects of the project and sub-contracted some components to ITD.
- The Office of the Registrar implemented Universal Algorithm’s Schedule 25 and 25E products for classroom scheduling and customized a friendly user interface as a front end to the system.
- Academic Affairs started to invest in technical staff in order to provide leadership in the planning, development, and implementation of technology in support of the core business of the University. The Office of the Registrar filled a new Director of Information and Network Systems position. This position is responsible for managing all student systems (including Financial Aid, Admissions, Records, and Student Accounts). The office also staffed several more systems analyst and programmer analyst positions and has its own network administrator.

The Office of the Registrar had truly embraced client/server technology. The office was taking ownership of the “client” side of the development. Obviously these dynamics changed the traditional role of Information Technology Division staff. Changing roles of staff across organizational boundaries were a source of strength for the various teams and the resulting systems. Organizational and technical barriers were overcome at an amazing speed and with positive results.

As with previous projects, one of the challenges of the TOES project was managing the integration of technical staff across organizational boundaries. Traditionally, there was a “high wall” that separated the mainframe world from the workstation and client world. The development staff for the legacy applications had well-defined processes from twenty years of successfully delivering mainframe solutions. The development staff for the workstation and client systems had fewer formal procedures to consider. The legacy systems had an elaborate change control mechanism to support PL/1 and COBOL application deployment on the mainframe. The workstation and client groups managed their own application deployment. The legacy developers were conditioned to move cautiously through a rigorous multiphase development methodology, while the workstation and client developers were used to employing rapid prototyping development techniques.

The result was two distinct cultures possessing two different approaches to developing and deploying applications. The technical requirements of the TOES project required contributions from both groups. The business requirements demanded a low cost yet high-quality solution. In order to satisfy these requirements, we chose to build a project team blending all the areas and utilizing the strengths of all to
circumvent the historical boundaries. Client development was done by both the Registrar’s Office developers and ITD staff. Mainframe development was supported by proficient PL/1 developers. Web server and Oracle server development were by a skilled UNIX programmer, an Oracle wizard and a technical visionary.

As with all projects, we lost some team members and gained new ones. Rebuilding the team and keeping pace with the timeline became a large challenge. Two seasoned project leaders left the project early in the second phase. A new project leader joined the staff and had to come up to speed quickly with new technology and team dynamics.

The Development of TOES - Fulfillment of our Dream

Early involvement with other critical areas of the University was essential. System architecture and security documentation were prepared at the beginning of the project which the University General Counsel’s Office and the Provost’s Office reviewed and subsequently approved. The database administrators responsible for allocating the Oracle server were notified of the TOES timeline to facilitate technical support and to fulfill critical database space requirements.

With our combined team of Registrar’s Office developers and ITD developers we were able to produce quick turn around of desired changes. The TOES system is the aggregation of several phases of development. Each phase had specific objectives of inherent value that increased when combined with the succeeding phase. The TOES System Architecture Overview is shown in Figure 2.

Phase 1 - Visual Basic Client & Mainframe Data for EDI/SPEEDE Transmission

Phase 1 (Figure 3) focused on:

- the local implementation of EDI/SPEEDE - a nation wide project that enabled institutions to exchange student academic records electronically in a standard format known as ANSI/X.12 standard.
- transcript order entry and order processing by Registrar’s Office clerks and the storage of all the order information in the database.
- order information retrieval and updating for tracking and reporting purposes.

This required that mainframe application programs be written to:

1) receive request information, such as ID number, from the Office of the Registrar client workstation,
2) send mainframe transcript data stream, in an Office of the Registrar specified format, back to the client,
3) print a paper transcript at a secured designated location, and
4) encrypt and decrypt data at appropriate points in the process.

On the client side, desktop application needed to be developed to:

1) allow the authorized clerks to enter student identifying information, transcript requirement, and order destination information and store the information to the database,
2) retrieve and update order information within the application itself and produce various reports,
3) map between the transcript data stream to the EDI (Electronic Data Interchange) standard format for EDI translation and transmission, and
4) communicate with the corresponding encryption and decryption routines on the mainframe server.

Microsoft’s Visual Basic and Seagate’s Crystal Report were chosen as the desktop development tools because they are user friendly and very closely integrated with each other. Another advantage of Visual Basic is that it has the capability of using third party Dynamic Link Libraries (DLL).

At this stage of the project, the Registrar’s Office decided to use a desktop database (MS Access) as the data repository to support the rapid prototyping development need. The intent was to automate the internal operations of the office. Using the inherent encryption capabilities of Kerberos, ITD helped to develop the corresponding encryption and decryption routines to provide data privacy. This allowed sensitive information to be sent across a public network without compromising an individual’s right to privacy. The technical detail of the client application interaction with mainframe server is further explained in Figure 4.

The EDI component was accomplished by implementing Supply Tech’s STX product on the Registrar’s Office EDI Server (Figure 5). The University of Texas at Austin subsequently established a national EDI Server which provided routing service. This solved many difficulties concerning automated data transfer and data encryption among “trading partners” (other schools, colleges, and universities). The University of Michigan is a subscriber to that routing service thereby achieving automation, a high level of secure data transmission, and increased access to many trading partners.

**Phase 2 - WWW Interface for Students and Alumni and Oracle Server Migration**

In the midst of the TOES development, the Web explosion overtook the university community. A ubiquitous client interface had emerged which students and alumni were beginning to exploit to do many things formally (formerly??) supported by specialized clients. Students were now checking their grades, changing their addresses, and accessing a variety of other functions using Web clients. Extending this interface to support ordering transcripts was, in retrospect, a natural extension to this service. The Registrar’s Office was also exploring the option of adding more resilience to their transcript order database. It was an opportune time to extend the TOES system, support Web clients, and transition to a more scaleable database.

The implementation of this phase of TOES also involved the interpretation of the Family Educational Rights and Privacy Act (FERPA). FERPA requires that a student’s written consent accompany the release of confidential student data to third parties. The question of whether written consent is equivalent to a handwritten signature is one that every institution is struggling to resolve. For example, The Michigan Freedom of Information Act defines “writing” and “written” in a manner that explicitly includes electronic documents as “writing”. The idea of requiring a handwritten signature as a matter of security is only valid if one has a way of verifying the signature. The Department of Education has recognized the need to broaden the concept of written consent and has issued a formal response to the Assistant Vice President and Registrar of Cornell University who raised this issue.

An invitation to examine the security and risk of the TOES process was extended to the University Internal Audit department just before the move to production was to begin. The team worked closely with the University auditors to examine and test each individual component of the system. The team enhanced and updated the system architecture and security documentation which were prepared at the early stage of the development. TOES was secure from beginning to end and throughout the whole process.

The TOES system has extremely powerful security safeguards built in. The positive identification of the user, order confirmation, together with data encryption, provides a high level of security and a guaranteed privacy of data that would be impossible with any paper based system.
A requester must be currently enrolled or be an alumni who has a University of Michigan Uniqname and Kerberos password. The requester can access the system from our public computing sites, any computer using Point to Point Protocol (PPP) dial-up connections, or from any Internet Service Provider. To establish a session, a combination of Netscape security between client and Web server, SSL and Kerberos authentication between Web server and Kerberos server is used. After successful authentication, a Kerberos ticket is granted by the Kerberos server and the requester is allowed to proceed.

The Wolverine Access Web server then sends the requester’s Uniqname in encrypted form to the mainframe IMS database to check if the requester has a financial hold indicated on their record. If a hold credit exists, the hold credit date, amount, and source department will be displayed along with a list of the phone numbers of the source departments. The requester is not allowed to proceed until all hold credits have been resolved.

The requester enters all the order information such as destination address, number of copies to each destination, and type of transcript. Whenever the current session has been idle for five minutes, re-authentication occurs. Re-authentication is again required before order information is stored to the Oracle database. An informational message is displayed to inform the requester that this Kerberos authentication constitutes their written permission, and unless given, all their order information is ignored.

Successfully re-authenticating results in the order information being encrypted and passed to the Oracle database server, where the order information is decrypted and stored in an Oracle database. Successful completion triggers an email confirmation to the requester along with a printable order confirmation displayed on the screen.

Each business day the authorized Registrar’s Office operators retrieve all the unprocessed orders stored in the Oracle database using client application. The operators too must be authenticated to Kerberos server in order to access the client part of the system. There are two types of output: a paper transcript or an EDI transcript. The paper transcripts are printed at printers located in secured areas of the Transcript and Certification Department or the Student Services Center. Transcript data files are downloaded to the Registrar’s Office EDI server for translation and transmission. Before an EDI transcript file is transmitted, it is encrypted by Pretty Good Privacy (PGP) using University of Michigan’s private key and the University of Texas’ public key. The encrypted transcript file is then transmitted to the University of Texas EDI server over the Internet. Acknowledgments from the University of Texas EDI server and trading partners are received and reconciled with all the EDI transmissions on the same business day. All discrepancies are reported and further investigated.

**The Cost of TOES**

The first phase of the project, incorporating the EDI implementation and the Office of the Registrar’s order entry system, took 1 year and 1.5 FTE (full time equivalents) to develop. The second phase of the project, involving the Web interface and Oracle port from MS Access, required an additional .5 FTE and took 8 months to complete. Total costs of Registrar Office staff and ITD recharges totals around $100,000. Since most of the other technologies were leveraged from existing systems and software, very little additional money were expended to complete the system.

In addition to development time, operational staff from the Transcript and Certification department participated in requirements definition and testing activities. We found this number difficult to estimate given the methodology used. Users were involved in short bursts at various intervals along the way.

The TOES project team will never be able to accurately define the total cost of the TOES development. Existing technologies were leveraged and the overall cost of the effort was significantly lower than
expected. Incorporating new technologies as they became available increased our costs but also increased our chance for success.

**Lessons Learned**

- Project management and planning cannot be ignored. For example, scope definition is very important. In addition to speeding up software development, a rapid prototyping methodology can also speed up scope creep which can lengthen the timeline without a valid review until after the fact.
- Do not get too caught up in the technologies. Use what is available and find creative ways to make it work. Build to allow for change so one can take advantage of new technologies as appropriate.
- Teamwork can make it work.
- Communication and trust is critical with new development approaches.
- Get the right skills on the team. Set high goals and strive to achieve them.
- Be ready, flexible and positive to the customer’s constantly changing requirements. The success of delivering a system depends on the ability to react quickly to customer’s needs.
- Examine and update system architecture as the project progresses. Respond to the changing environments and technologies and be able to come up with different strategies and solutions quickly.

**Finale**

The TOES client application has been installed on about 30 Registrar’s Office Windows 95 workstations across the campus, making it possible for the authorized staff to perform various tasks like order entry, order processing, order tracking and statistical reporting at different locations of the Student Services Center. The TOES Web front-end is accessed daily by hundreds of students and alumni anywhere, any time.

The combination of Kerberos authentication, encryption of data, and the confirmation of orders provides a level of security and a guarantee of privacy far exceeding the old order collection process. It also provides much greater positive identification of the requester than an unverified signature.

The long-term savings in operating costs, the staff, and the promises of better services for students, alumni, and the university community justifies the commitment of the resources contributed by various parts of the University. Teamwork was the only way this project could have achieved such success. All team members performed to the best of their abilities, and the University upper management supported the team throughout the whole project.

While the University of Michigan continues to evolve to the computing environment of the twenty-first century, we will continue to face new challenges and continue with our endeavor. Our journey has just begun …
Figure 2
TOES System Architecture Overview
Figure 3
Transcript Order Entry System
Phase 1: Transcript Order Entry and EDI/SPEEDE

DSC Mainframe
- Regular IMS Transactions (TSPRINT, RPRINT Clones)
- IMS Message (USERID=TH2080IP, SIN, LTERM)
- SCDB/UCDB SA TABLES

MANDARIN SERVER
- Mandarin Transactions
- PROBE Name & Input Parameters
- Processing Message & Transcript Data

RO LAN Server:
- Transcript Data
- Transcript Order Manager Database

SPEEDE PC:
- EDI Translation (XMAP)
- EDI Data Encryption (PGP)
- EDI Transmission (STX)

UMCE Kerberos Server:
- Operator Authentication
- Kerberos Ticket
- Operator Uniqname

RO LAN

Institution A
- Internet

Institution B
- Internet

Institution C
- Internet

UNIV OF TEXAS Transcript Server

Official Transcripts
- Error Reports
- Marker Pages

Unofficial Transcripts
- Error Reports

MFS Cx-80 Lterm Print

TCP/IP

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Figure 4
Client/Server Infrastructure Using Project Mandarin Technology
for Retrieving Transcript Data

- Transcript Data File
- Transcript Order Manager (TOM)
- Database

TCP/IP

Kerberos Ticket

Operator Username

Kerberos Driver

TOES
Client Application

PROBE 17: TSMSG

PROBE 18: TSDATA

TCP/IP

RO LAN File Server:
- Transcript Data File
- Transcript Order Manager (TOM)
- Database

* New Implementation of Project Mandarin at the University of Michigan
Figure 5
EDI Translation and Transmission Process
(Using Supply Tech's XMAP and STX products)

1) STX imports all the transcripts downloaded during the day to XMAP
2) XMAP translates transcript data into EDI format
3) STX appends trading partner header information
4) STX calls PGP program to encrypt EDI file
5) STX transmits encrypted EDI file to University of Texas EDI Server
6) STX receives acknowledgement
7) STX generates transmission report