Clarity: The Synergy of WWW Technology and Enterprise Application Systems

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Abstract

The continuing decline in the percentage of public funding for higher education is forcing institutions like the University of Minnesota to place greater reliance on tuition revenue, the creation of new revenue streams, cost containment, and improving productivity to survive. In addition, the institutional strategy to drive decision-making to the lowest possible level in the organization requires easily understood management information to be delivered to the same levels. These needs demand both new business and technical solutions. The development of Clarity, a WWW-based departmental decision support system developed to supply those needs offers not only an affordable desk-top solution appropriate for small institutions but also a scalable solution for large institutions seeking to improve the functionality of aging legacy systems or provide cost effective management reporting tools. This presentation will demonstrate the strategic solutions developed at the University of Minnesota including development strategies and front and back-end hardware and software- and a demonstration of the most recent advances in reporting and user functionality.
Overview - The University of Minnesota

The University of Minnesota, with its four campuses, is one of the most comprehensive universities in the country and ranks among the top 20 universities in the United States. It is both the state land-grant university, with a strong tradition of education and public service, and a major research institution, with scholars of national and international reputation. The Twin Cities campus, the largest of the four campuses, is located in the heart of a major metropolitan area and is comprised of 19 colleges offering 157 bachelor’s, 202 master’s, 5 professional and 116 doctoral degrees. Other important parts of the University include the Supercomputer Institute in Minneapolis, and agricultural experiment stations at Rosemount, Crookston, Grand Rapids, Morris, Lamberton, and Waseca. Through the Minnesota Extension Service, the University is present in each of Minnesota’s 87 counties.

The University of Minnesota has set a goal of becoming one of the top public institutions in the country. The 1993 Gourman Report ranked the University’s undergraduate program seventh among all U.S. public universities and 22nd among all U.S. public and private universities. Its graduate programs ranked sixth among U.S. public universities and 14th among all U.S. public and private universities. Six undergraduate programs and eight graduate programs ranked number one, and all six of the health sciences professional schools on the Twin Cities campus were ranked in the top ten among U.S. public universities. Given the continuing decline in the percentage of public funding for higher education and the resulting demand for greater value and accountability, it will require new management solutions to maintain and enhance these standings.

This paper supports the presentation of Clarity, a web based decision support system developed at the University of Minnesota. Issues that will be discussed include:

- Issues facing higher education institutions that led to the creation of this system
- Need for informational landscapes that are diversified and integrate the potential of the Web
- Business and technological solutions underlying the development of Clarity at the University of Minnesota.
Higher Education Operational Issues

To surmount the formidable external challenges that include increasing competition for resources, both financial and human, universities must develop effective strategies for managing institutions of higher education. One of the first responses to economic pressure is typically an increased effort to communicate and justify achievements in order to maintain or increase support and funding from external constituencies. A subsequent strategy often focuses greater reliance on tuition revenue and the creation of new or alternative revenue streams. While this direction may have longer term potential, we believe the ability for colleges and universities to survive and flourish in the next millennium will require significant improvements in the strategic use of existing resources and large gains in the understanding and management of costs.

As universities, colleges and departments grapple with dramatic changes in their current environment and search for a management paradigm sensitive to the special needs of higher education there are significant internal barriers to be surmounted:

- The expansion of management and budgetary strategies that drive decision-making to the lowest level in educational institutions
- Aging legacy systems organized around traditional functional and informational silos
- Organizational operating data difficult to access by staff and decision makers
- Transactional data substituted for management information with minimal strategic analysis provided to decision makers
- Limited understanding about what information should be considered in making critical financial and operational decisions
- Financial and management expertise insufficient to address financial and competitive risks
- Increased competition for resources and students
- Financial strategies focused primarily on increasing revenues absent critical information and strategies to manage costs
- High internal organizational barriers that are resistant to interdisciplinary problem solving
- Deeply held perceptions that good education and good management are mutually exclusive
Diversified and Integrated Information Landscapes

If emerging higher education management paradigms are to be ultimately successful, institutional information architectures will need to reflect the strategic plan. If management decisions are pushed to the lowest level in organizations, information must follow.

Decision-makers will increasingly need greater quantity, quality, and accessibility of information to support institutional strategic planning and operations. A critical part of this challenge will require transforming massive amounts of operating data into strategic management information and educating decision makers about how to best interpret and use it.

If institutions and their information organizations are to achieve the information/decision environment needed to support achievement of their objectives, they need to step back and reexamine their information landscape and strategies and ask the following questions:

- Do they expect enterprise/client server applications to meet all enterprise needs?
- Does a vision exist for integration, coordination or synergy between Web and Client Server applications?
- Is there a middle ground between the enterprise system/data and multiple desktop departmental information systems?
- Are internal organizational structures built around traditional functional and informational silos?
- Is the emphasis on transactional information rather than analysis and process?
- Is the medium for delivering information responsive to both user and data needs and preferences?
- Is there a strong organizational advocate for management information needs as opposed to transactional information needs?

A strategic alternative to the traditional information landscape is one in which enterprise systems serve as an anchor to diverse information architecture that includes data warehouses, data marts, and enterprise and local Web-based applications. This approach capitalizes on the respective strengths of multiple systems and technologies and in the process provides value-added benefits, reduced risk, reduced costs, and higher satisfaction.

Better information means better decisions. Strategic planning and operational decisions in higher education are complex and often involve multiple domains of information including financial, student and human resources. One solution to
many of the problems cited above is to provide an environment that is as rich in information quality as it is in technology via the development of advanced decision support systems designed to acknowledge and address existing organizational weaknesses.

Just as teachers and researchers are finding the cutting edge of scholarship in interdisciplinary collaborations, university administrators are facing problems that demand new business and technology solutions that exploit the potential synergy of institutional research, financial, managerial, and technological expertise.

What drives the need for an interdisciplinary approach?

• Optimal decisions require information from multiple varied areas including curricular, financial, student and human resources,

• Information must be integrated, intuitive and readily accessible to support daily decisions,

• Information systems must be designed to recognize and supplement the existing skills and needs of staff and administrators.

• Information system design must combine first hand knowledge of collegiate and departmental operating practices with aggressive leveraging of technology.

• Return on investments in administrative systems requires aggressive leveraging of technology be coupled with proactive and innovative personal contact, training and support

To make something seem easy is often the hardest task of all and achieving an integrated, intuitive information solution is no exception to this rule. Too often institutional information residing in enterprise systems or traditional data warehouses is not optimized for management purposes and typically reflects separate transactional systems (e.g. registration, payroll, accounting, etc.). Even where institutions seek to solve this problem through the purchase of the current generation of “integrated” enterprise administrative application suites, the benefits they offer can not be fully achieved when implementation strategies mirror the legacy system data silos they replace.

Web-based decision support solutions offer an unparalleled ability to distribute information throughout an organization in a powerful and elegant format. However, the technological power of Web applications alone cannot guarantee that the information delivered will be intuitive, integrated, and reconcilable. For every opportunity provided by the rapid explosion of creativity, access and opportunity on the web, the challenge is how to harness its power and integrate it with existing technologies.

The University of Minnesota Information Landscape
The University of Minnesota is one of many universities addressing aging legacy systems and non-compliant Year 2000 issues by replacing its Human Resources/Payroll and Student systems. Systems replacement inevitably raises the question of how to integrate and coordinate existing web based student, financial and departmental decision support systems and the current enterprise financial system into an overall information strategy. This represents a challenge on two levels: data and technology. On the technology side the issue of the respective roles and strategies for the use of Web based and client-server applications is inevitably raised. Is the Web a “passing fad” or a legitimate part of the enterprise information strategy? A voice for the “monolithic concept” declares that one system should meet all needs in order to be successful. The substantial costs associated with the systems replacement gives the issues of cost and value-added benefits a high profile. On the data side, ownership of the data, recognizing the needs of non-transactional users and realizing the promise of truly integrated data are under discussion.

Figure 1: The University of Minnesota Information Landscape, and Figure 2: Information Landscape Integration illustrate both the current and potential possibilities available to the university. It is a landscape that is anchored by enterprise transaction systems and supplemented with Intranet, Extranet and Internet Web applications designed to meet multiple user needs. It is a landscape that meets transactional and reporting/analysis needs through both client/server and Web delivery systems. It is a landscape that responds to the demographics of its users as seen in Figure 3: Information Systems Demographics and Figure 4: Interface Overlap and reduces costs by utilizing web-based delivery systems for occasional users and client-server applications to high volume transactional users or functional experts. It is a landscape that capitalizes on the Web to fill specialized niches such as self-service and decision support functionality. It is a landscape that envisions workflow as a three-dimensional process as shown in Figure 5: Workflow in a Multi-System Information Landscape. It is an information landscape that minimizes costs by utilizing multiple technological solutions closely synchronized to individual application objectives rather than adapting a single technological approach to meet all needs. It is a dynamic landscape that is constantly changing and reshaping itself to take advantage of emerging technology.

At its best, Clarity is one part of this diversified information architecture, with a clear and defined business vision, utilizing an innovative technology solution to deliver high value added functionality at low cost.

**Clarity: The Business Solution**

Because better information means better decisions, the business solution focused on identifying the critical information needed to support the business and planning needs of university administrators in colleges and departments. Although the university had spent a considerable amount of effort on benchmarks or critical measures, these institutional level performance indicators have limited utility for deans and department heads – the administrators who make the daily
operating decisions that ultimately drive the institutional outcomes. This situation is not uncommon in higher education; benchmarks are developed as a result of external demands while the recognition for operational performance measures for allocating resources and managing the vast array of enterprises that typically comprise universities has been much slower to develop.

In building a decision support system, it was critical to transcend alternative solutions previously recognized as insufficient or ineffective. Decision support had to be more than data reporting. Whereas data reporting meets necessary functions such as compliance reports, or unit profiles, it typically does not lend itself to supporting operational decisions. For example, historical enrollment patterns for a college does not allow an assessment of instructional capacity but is often the index provided.

One of the key factors in Clarity’s approach to decision support is that solutions are needs driven rather than data-driven. As Figure 6. Process Flow Model for Clarity Decision Support indicates, Clarity begins with the decision, identifies the critical information needed to support the decision, gathers the data which underlies that information, and builds a report that arrays the data into information lending itself to the decision. In instructional resource management where multiple related decisions are required, a conceptual framework has been built so that reports are delivered within a broad context maximizing decision support. Through this process, the result is intuitive to decision-makers and the utility of the reports is not limited to trained analytical or financial staff.

By drawing on the extensive business-case experience of the Clarity team members, initial reports are developed and refined by subsequent feedback from focus groups and end-users.

Another key factor in Clarity’s approach to decision support is that solutions are integrated. Higher education decision needs are complex; often a decision requires multiple types of varied information. For example, decisions regarding new faculty hires typically would require financial, human resource, and student information. Given the potential long-term commitment of such a decision, operating with only isolated information may be undesirable.

Integration means more than providing multiple reports of varied information, but rather merging these separate pieces into a coherent whole. Due to the historical creation of transactional silos of data at the university, it is not unusual that reports driven from these silos do not reconcile. Decision support must ensure that the information provided overcomes these problems and reflects collegiate and departmental reality. How this is accomplished within Clarity will be detailed below.

The value of any information system is the extent to which it is used and promotes process change. In addition to making Clarity intuitive, integrated, and reconcilable, it had to be made accessible and responsive to user needs. By choosing a strategy of rebuilding the foundation of Clarity as key technological
advances occur, users are assured to have maximal performance, flexibility and power - powerful incentives to remain active customers. One of best examples of this strategy is that college deans have remained active users and advocates for Clarity.

**Clarity: The Technical Solution, Issues, and Evolution**

The technical solution centered on recruiting a small team of highly motivated staff with both departmental and technical backgrounds to leverage existing and emerging technology aggressively. Within this setting, the Clarity project created an environment where business staff understand technology and technology staff understand the business case.

The evolution of the scope of the Clarity project in regard to user, data, and report expansion is detailed in Figure 7: Clarity Data Expansion, Figure 8: Expansion of Clarity Functionality, and Figure 9: Functional Issues. The initial scope of this project began within a single college on the Twin Cities campus of the University of Minnesota and included only financial data. This reflected in part that the financial data was the cleanest institutional data and it would later serve as the underpinning for instructional cost and revenue management.

Due to limited resources and the lack of web applications as a viable option, a desktop solution using Microsoft Access® was chosen and implemented in the spring of 1995. Implementation of this solution, however, was intense and updates of data so unwieldy that by fall of 1995, Clarity had become a client server solution. Due to the breadth of tightly integrated products including Microsoft Windows®, and Microsoft Office® and Windows NT® Server, Microsoft was a clear choice as the technology provider.

The client server solution, however, has inherent shortcomings. Desktop installations still were unwieldy as adequate ODBC (Open Database Connectivity) had to be maintained on an individual user basis. Still more fundamental were the platform-specific limitations of a client server solution.

At the same time, administrative reorganization in 1995 led to Clarity being expanded from a single college to all five colleges under the Provost for Arts, Sciences, and Engineering. This growth in size dramatically increased the amount of financial data required – from about $70 million to $250 million in annual expenditures. Due to the scalability of the Microsoft products, optimal response time and performance was maintained with this new increased base, within the introduction of Microsoft SQL® after some reconfigurations within NT®.

Web functionality in general, and Microsoft web programming tools specifically (IIS®) were growing in power, flexibility, and integration with SQL® and NT®. A new strategy of delivering decision support was chosen with parallel options: client server tools for power users and web tools for the casual users. Quickly it
was discovered, however, that users unanimously preferred the look and feel of the web application despite the fact that there was greater functionality on the desktop. With increasing power and functionality being made available on the web, a critical decision was made to switch exclusively to a web based application by the summer of 1996.

During 1996, Clarity underwent several changes as the web foundation was rebuilt with new emerging tools. Utilizing Microsoft ActiveX® and Microsoft Server Page® allowed users to get the most recent information while minimizing technological management costs. For example, if Clarity were using outdated static web page technology the site would require the management of over 10 million web pages rather than a dozen templates. Changes, whether in data updates, report content, or visual output can readily be developed and maintained.

Starting in 1997, tuition management reports were developed in Clarity in response to a new university wide change in budgeting that held colleges and departments responsible for their tuition revenue. Data for the entire University of Minnesota System was used in these reports – with annual tuition revenue of $192 million. Reports were built to report tuition revenue from the highest (institutional total) to the lowest level (a single term course).

Administrative reorganizations in 1997 resulted in Clarity being included in the portfolio of the Executive Vice President and Provost at the University of Minnesota with budget authority over 25 units totaling $1 billion in annual expenditures. Current plans call for Clarity to serve all campuses and units within the University System. The scalability provided by the use of Microsoft Windows®, NT Server®, SQL Server®, Active Server Pages®, and other Microsoft Web-based tools will support the expansion of this system to an enterprise level— even in a $2 billion organization.

At the same time that expansion in size and user base is being implemented, Clarity continues to grow in complexity of report content. Work has already begun on instructor activity reports – part of the instructional management module – which will provide course and student information by instructor for the entire University of Minnesota system.

**Clarity Technical Tools**

The Microsoft products used within Clarity are detailed in *Figure 10: Microsoft Products Used* and *Figure 11: Clarity Tools and Upgrades*. On the back-end, Clarity utilizes the power of the Microsoft BackOffice® server family. SQL Server 6.5® is used to store and deliver Clarity’s data, Clarity’s back end consists of two Windows NT-based servers, each equipped with four 9GB hard drives, 196 MB of RAM, and four Pentium® 133 processors.
On the front-end, *Clarity* provides Macintosh and both Windows 3.x and Windows 95/97 users with the same interface. Internet Information Server 3.0® and Active Server Pages® specifically, have allowed *Clarity’s* development to become truly cross-platform.

Data Integration, Report Content and Evolution

Decision-makers throughout higher education need significant advances in the quantity, quality, and accessibility of information to support institutional strategic planning and operations. Although Web-based solutions offer the ability to distribute information throughout an organization in a powerful and elegant format, the technological power of the Web alone cannot guarantee that the information delivered to support management decisions will be intuitive, integrated, and reconcilable. That is, higher education will not realize the full benefits of recent advances in technology if decision support systems continue to mimic the data silos that exist with transactional information. Advanced decision support must provide an environment that is as rich in information quality as it is in technology.

At the University of Minnesota, transactional information is extracted from the production systems and stored within the data warehouse. Each of the production systems, however, has a unique organizational code and structure. For example, the numbering system and roll-up structures for courses into departments, colleges and campuses may not resemble the structures for payroll or financial accounts. Although tables of data within a production system (e.g. registration and admissions information within student production data) can be easily merged, data across systems require significant effort. This is not uncommon in data warehouses and with the existence of translation tables, data can be eventually integrated for decision support. Without integration in the data warehouse, however, this translation must occur at the desktops of each end user. This often leads to multiple interpretations of integration and conflicting reports, or end users do not attempt to achieve data integration. Both of these outcomes are unacceptable for decision support.

*Clarity* utilizes a data mart approach. The emergence of data marts is becoming more common in higher education as well as in the corporate world. By extracting a subset of data and optimizing for reporting, performance and power can be greatly enhanced over a warehouse or at a fraction of the cost to achieve comparable performance. In addition, data marts allow the existence of data not present in the warehouse (e.g. additional years of data or external data). Within the *Clarity* data mart, data integration from multiple production systems is achieved – via translation tables – and each end user gets the same data. With an integrated data warehouse, less integration would need to occur in the data mart, however, the enhanced reporting performance offered necessitates its use.

*Clarity* has taken a modular approach in report content functionality, that is, reports to support management decisions are grouped in four major areas: finances, human resources, assets and instruction. Within this framework, stand-
alone reports can first be created and later joined to integrate information across various decision areas. In addition, users who function within one content area can more easily navigate to their needed information.

*Clarity* first began with financial data and over time space and indirect cost recovery – for sponsored research grant activity – data have been added. In addition, data to support instructional resource management decisions has also begun.

Decision support for instructional resource management is a key component of *Clarity*. Instruction is one of the basic missions of any higher education institution and instructional costs are a large component of institutional expenditures. Instructional resource decisions are complex and personnel investments are often long term. Furthermore, at the University of Minnesota, increased incentives have been created to manage instructional costs and revenues.

Because of the multiple and varied factors involved in instructional resource management, a conceptual model was created to allow users to better utilize reports within the broader decision support domain. *Figure 12: Instructional Resource Management Conceptual Framework* illustrates the conceptual framework utilized in *Clarity*.

Within instructional decision support, the first reports designed to assist in the management of tuition revenue included enrollments, student credit hours and tuition data aggregated from a single course offering to a course, department, college, campus and system total. Other reports demonstrated the cross-college activity of students and courses, that is, the interdependence of colleges in affecting tuition revenue based upon enrollment management and course access strategies. Based upon these reports, deans representing the three main undergraduate admitting colleges at the University of Minnesota Twin Cities campus have joined together and developed a common strategy regarding new student recruitment.

Instructor activity reports are currently under development. These reports will assist deans and department heads in maximizing curricular coverage with existing resources. Other decision supports planned include tuition mapped to instructors to allow resource planning for faculty retirement replacement and return on investment modeling for various pedagogical models of instruction. Enrollment management, scholarship management, and curricular management reports are currently under design to begin looking at issues such as tuition elasticity, and instructional capacity.

Alternative applications of the *Clarity* solution

Although built within the context of higher education, the *Clarity* solution can be applied in many settings. It is applicable to environments where:
• Multiple sources of information located in disparate sites or platforms are needed on the desktop

• The life or improve the functionality of aging legacy systems needs to be extended

• Substantially lower cost and more responsive alternatives to legacy systems for providing management decision support are sought

• Management information solutions easily scaleable for organizational size and complexity are needed
Figure 1: The University of Minnesota Information Landscape
Figure 2: Information Landscape Integration

Web-Based Integrated Decision Support Applications

Web-Based Functionally Specialized Applications

Web-Based External Sources of Data
Figure 3: Information Landscape Integration

- **Occasional Users**
- **Functional Experts**
  - External
  - Internal
  - Functional User
  - Power User
  - IT User
Figure 4: Interface Overlap

Occasional User

HRMS, Financial, Student

Functional Expert
Figure 5: Workflow in a Multi-System Landscape
Figure 6: Process Flow Model for Clarity Decision Support
Figure 7: Clarity Data Expansion

- **Spring 95**
- **Fall 95**
- **Spring 96 Winter 96**
- **Fall 97**
- **Fall 97**
- **Spring 98**

Financial Expands to $2 billion, 4 million transactions. Curriculum Data System-wide

- 9000 Instructor Activity Data Added
- Financial data expands to $1 billion annual, 2 million transactions
- $192 System-wide tuition added
- Multi Year Financial Data
- Financial expands to $250,000,000 & 1,000,000 transactions
- Financial only $60 m annual 500,000

**Dates:**
- Spring 95
- Fall 95
- Spring 96 Winter 96
- Fall 97
- Fall 97
- Spring 98
Figure 8: Expansion of Clarity Functionality

- **Desktop Application**
- **Spring 95**
- **Fall 95**
- **Spring 96**
- **Summer 96**
- **Winter 96**
- **Fall 97**

**Client Server Application**
- **Web Only, Dynamic Pages, Drill-down levels, Drill Across Years, Virtual Desktop (Bookmarks, Links)**
- **Expanded Functionality & Content**
- **Dual Dynamic Data Navigation, Pull Down Menus,**
- **Query Capability, Pivot Tables, Dynamic Graphs & Spreadsheets, To-Do Lists, Expanded Content**
Figure 9: Functional Issues

- **Capacity & Scalability (Performance, Optimization)**
- Data Replication, Data Updates, Data Integration, Browser Degradation, Peoplesoft Integration

- **Data Integration (Student/Financial)**
- Increased Web Functionality (Pivot Tables, Graphs, Spreadsheets, Browser Degradation)

- **Limited Web Functionality, Browser Degradation, Expanded Data Demands**

- **Dual Environment (Data/Programming)**
- User Web Pref., Limited Web Functionality

- **Desktop Installation**, **ODBC Connectivity**

- **Desktop Installation, Implementation Updates**

- **Spring 95**, **Fall 95**, **Spring 96**, **Summer 96**, **Winter 96**, **Fall 97**
<table>
<thead>
<tr>
<th>Product</th>
<th>Version</th>
<th>Figure 10: Microsoft Products Used</th>
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<tr>
<td>Windows NT Server 4.0</td>
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<td>Visual InterDev™</td>
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<td>ActiveX™</td>
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Figure 11: Clarity Tools and Upgrades

- **Spring 95:** Access Interface, SQL 6.0
- **Fall 95:** Access Interface, SQL 6.0, NT 4.0
- **Spring 96:** Active Server Pages, Visual Studio, Active X Components, Erwin Data Modeling
- **Summer 96:** SQL 6.5, NT 4.0, IIS 3.0, IE Browser, IDC/HTX
- **Winter 96:** NT 5.0 Beta, IIS 4.0, SMS, IE 4.0, Exchange Server 5.0, Windows
- **Fall 97:** No Server Environment
Figure 12+: Instructional Resource Management Conceptual Framework

- **Demand**
  - Enrollment Management
  - Curricular Management
  - Scholarship Management

- **Fiscality**
  - Instructional Cost Management
  - Tuition Revenue Management

- **Productivity**
  - Courseload Management
  - Instructor Management