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Creating A New University Through Object Oriented Enterprise Modeling: A Study of Communications Knowledge Management & Distributed Cognition

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ABSTRACT

Enterprise based object oriented (OO) and Unified Modeling Language (UML) modeling makes it possible to build the needed visual environments to organize people, technologies and activities (Arias, 1999d). In our modeling approach, the focus is on "things and relationships between things" described in commonly used terms. The modeling software bridges the so-called "semantic gap" between the people and the computer language (Booch, Rumbaugh & Jacobson, 1999).

An object can be a product, a process, a person, a team, a company, an application or the inter-relationship between other objects. Objects can be pictured on the screen as maps formed by personalized "icons" with their relationships. Once a "map" of objects has been produced, users can navigate and visualize very complex relationships. Objects can hold data, such as cost, schedule data, weight and other relevant information (Zack & Serino, 1996). Another important property of an Object is its ability to perform work scripted in "methods." Thus an Object can be given the capability to perform functions, such as performing computations, gathering data from other computers, showing video of servicing a part or accessing a 3D-CAD drawing for viewing. This "active model" is much more than a map for navigation in an abstract process model (Arias, 1999a). It becomes the actual work environment for individuals and teams. It creates an occasioned environment for learning, assessing issues and impacts, communication, configuration management and control and more. In short, it is the user interface or " control center" from where to manage the organization (whether it be an institution of higher education or a corporation).

UML technology allows us to model a complex enterprise, while OO technology builds on the former and generates complex applications. The point at which these two technologies meet becomes the intersection that enables planners and stakeholders to develop a new paradigm for looking not only at their organization, but also at precisely what their contributions are to the overall enterprise (Arias, 1998).

In this paper we will present the use and design of object oriented enterprise computer models (OO) for the purposes of creating and/or transforming organizations. We will also provide proof of concept on how OO contributes to the reshaping of relationships

among people and their organizations and, also, how OO can transform the processes of discovery, learning, research and communication through emerging forms of distributed cognition (Arias & Bellman, 1995).

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This paper is grounded in our work, which supports recent advances in the application of OO (object oriented enterprise computer modeling) for the creation of new and transforming universities (Arias, 1998; 1999a, 1999b and 1999d). Our thinking is grounded in direct experiences while grappling with issues related to transforming a large portion of the largest military base in the world (Fort Ord) into a State university (California State University, Monterey Bay). We were simultaneously involved in re-engineering massive infrastructure, the political negotiations of thousands of acres of "prime real estate," munitions searches, toxic waste clean-up (number one in the nation for several years), physical plant, remodeling, environmental studies, and much more (Arias, 1996).

At the same time, at the university wide level we were responding to numerous publics, all clamoring for a "new paradigm for looking" at higher education (Broad, 1997; Consortium for Educational Technology for University Systems, 1997). Pioneer planners found themselves in the indelible position of having to "brand-new" and "renew" at the same time (Arias, 1997). Our challenge as related to this paper became how to document our activities in an object oriented enterprise computer model (OO) and how to operationalize the model over time for the purposes of strategic planning. Although our research remains a "work in progress," we (in the social and behavioral sciences) continue to collaborate with corporate partners in implementing OO modeling approaches and strategies in a manner that is not only providing new breakthroughs in on-line teaching, learning, research and assessment, but also providing unique insight to faculty personal electronic pedagogies, small group research, and distributed cognition. Our goal is to capture the planning and implementation behavior of the university as "enterprise" and provide a OO model for continual renewal of innovative curricula and learning experiences, designed to prepare students for the rapidly changing professional development needs of the 21st century (Senge, 1990).

During the first phase of the university we (university founders) met with and surveyed thousands of individuals in the state and nationally. They represented various sectors of life, from corporations, to government, to non-profit organizations. We also selected these individuals by virtue of their experiences in "developing world-class workforces" (Sperling & Tucher, 1996) . Contacts were established based on our expanding social network research. Through this experience it became self-evident that we were experiencing a *cultural shift in higher education*. We found that the majority of colleges and universities in this state and nation were founded during times when their publics were not focused on accountability and quality. They were founded during periods of what corporate America would refer to as eras of "protected markets." Our new university was to be founded during a time when the citizenry of the State of California was demanding that we be "end-user driven" and able to serve students in "open markets" (as opposed to "protected markets"). Realizing this cultural shift, we asked the question "What if the purpose of this university were teaching?" (Western Interstate Commission for Higher Education, 1995). Hence, we made the "teaching of students" our highest priority; we were, in fact, an institution whose goal it became to be "end-use driven." (Peculiar as it may sound, we found that most traditional universities have gotten away from a focus on teaching.) We have made teaching our highest priority while, at the same time, strapping-on the challenge of technological infusion for the purposes of enhancing teaching and learning. This focus on teaching has become the "driver" to all our planning and is visually apparent in our OO model, most especially in terms of understanding how every unit in the university serves the student by making teaching our highest priority vis-a-vis our powerful Vision Statement, as it states "The university will develop a culture of innovation in its overall conceptual design and organization, and will utilize new and varied pedagogical and instructional approaches including distance education." (Similarly, although the new University of California, Merced has as its' central question "What research questions might we raise in order to build our new university?" the point is that key questions must first be raised in order to determine the focus of a new university, and this becomes the premise by which to design an OO supported model.)

This point is not to be taken lightly as we (in the Social and Behavioral Sciences Center) are providing a new paradigm for capturing the instructional process, understanding the process, analyzing it, and evolving it through the utilization of advanced OO tools on a daily basis. The manner in which we have and continue to align our personnel and resources has contributed to early original breakthroughs and success that provide an integrated, consistent environment in which we capture, analyze, design, and implement new and experimental instructional strategies and processes as well as the technical applications that support them (Manville, 1996).

Moreover, it is this type of strategic planning and implementation that encourages new forms of personal electronic pedagogy and distributed cognition. In other words, Professors are embracing their on-line instructional materials in new ways, in group ways (Arias, 1997; Lipnack & Stamps, 1997). They are distributing their materials on-line and also re-shaping materials they capture on-line for their own instructional purposes and re-sharing these over and over again with their colleagues (Arias & Bellman, 1994; Gunneson, 1997). This distribution-assimilation-redistribution behavior, encourages both individual and group reconceptualizations of similar materials. This behavior has enhanced interdisciplinary thinking and allows us to examine the nature of distributed

cognition. Moreover, object oriented tools allow us to place all "enterprise" knowledge into effect, while examining how to focus on teaching and how to fully realize knowledge as "capital" (Arias & Bellman, 1991).

Such advances create unprecedented opportunities for the application of OO in institutions of higher education, as well as in any setting that is "organizational". At the same time OO can provide rapid and efficient access to enormous amounts of knowledge and information, strategic transformation, and new abilities for visually processing data and for studying more complex systems than has been possible before (Tapscott, 1996). Object oriented computer modeling can also be used for increasing, in fundamental ways, understanding of learning, knowledge acquisition, and intelligence in living and engineered systems (Ryan, 1996).

We are collaborating with our corporate partners to design OO based computer models that enable planners to envision new pathways to sustain and/or renew existing institution culture for the purposes of envisioning sustainable transformation and scalability. Put differently, a focus on sustainable transformation allows us to build a visual model of a complex enterprise, while a focus on scalability allows us to utilize object oriented enterprise modeling technology to generate complex applications. The point at which these two foci meet becomes the intersection that enables planners and stakeholders to develop a new paradigm for looking not only at their organization, but also at precisely what their contributions are to the overall enterprise and where there are gaps (Arias, 1999a). The gaps are visual and thus almost impossible to misunderstand to the average person by the organization.

Similarly, much like corporations, most institutions of higher education today are experiencing the problem of how to sustain vitality in the internal culture and organization in an institution (Daniel, 1996; Davis, 1994). They are also experiencing the problem of truly articulating the current state of their institution, as well as "marrying" both current reality and vision for the future, while at the same time scaling-up for growth and innovative opportunities. New technologies that could be used to capture and represent these realities are emerging every day: object-oriented technology, component-based technology, and client-server technology. They are all, in different ways, very powerful paradigms for capturing, representing and implementing highly complex business processes or systems (Metes, Gundry & Bradish, 1998). Yet, as we found in the creation of a new university, these technologies are very complex to use and are not yet mature. In fact, there currently are no real standards for OO because the technologies themselves are still evolving. The creation (design and implementation of academic programs) at the newly established California State University, Monterey Bay provides an excellent *use-case* (albeit, real application) of how object oriented enterprise computer models (OO) were applied, and later, how they became central to strategic planning of the Social and Behavioral Sciences Center (Arias, 1999a). In addition, it has become quite apparent that OO technologies have guided Center planning in such a way so as to allow faculty and staff in the social and behavioral sciences to become university wide visionaries and innovative implementers in the areas of distributed and distance learning as well as research on small group on line teaching, learning, research and assessment. Planning of this nature has allowed us to make "intentional" major contributions for evolving processes in campus wide initiatives for infusing technology into distance education curricula and student service and for integrating major new software

applications (a la Banner CT), especially in terms of how to apply our mode for measuring student outcomes.

There are basically three issues here. First, there is a need for an organic form that *helps institutions of higher education analyze, and evolve, their processes* in a technology-independent manner. This will help them form a clearer understanding of their goals and reach consensus on their processes for how to get there. That understanding (albeit, knowledge) will then help planners and stakeholders alike, align and focus the administration of the institution and its employees and, so, create a dynamic environment. The second issue is how to best *leverage new and powerful technologies* with minimum risk and without the steep learning curve that is typically associated with them. More times than not a new campus wide software is infused in a setting that demands a good deal of peoples time in daily work-life for extended durations. Like hundreds of other institutions, we too are undergoing the transition to Banner CT software as a campus wide application. While setting up training modules the "Banner people" are not shy when it comes to sending the message to the administration that they will need fifty per cent of key individuals' time for more than a year to implement specified modules. And the third issue is *how these advances will reshape relationships among people and organizations and transform the processes of discovery, teaching, learning, research, communications and distributed cognition.* In the Social and Behavioral Sciences Center, we have made the leap into this arena, by design, and have determined that OO is one of the most powerful solutions that "captures" all three of these issues and also provides true continuity from "concept to reality" in a dynamic (multiperspectival), and collaborative (multidimensional) way.

Today's most innovative and successful academics see the need for addressing the three issues we have outlined above (Daniel, 1996). They know *serving students first* means satisfying their rapidly changing needs. For many institutions of higher education, this means creating distance education degree programs and other learning experiences. But doing so in a traditional structure, where resources have been allocated over time focused on the priorities derived from another era, is a tremendous challenge facing American higher education today (Sperling & Tucher, 1996). Through our experiences and early successes, we have made a commitment to object oriented enterprise modeling (OO) solutions a powerful collaborative approach with minimum risks and maximum potential.

Working within a new university setting, it did not take us long to determine that, as academic innovators, we must continually anticipate and instantly respond to rapidly changing conditions. In order to remain vibrant, we must be sure we remain flexible and not frozen into one way of doing work nor one paradigm for looking. Most State institutions of higher education are notorious for creating stagnant bureaucracies. They assume that achieving success in their institution is about how to build software efficiently – not how to run the institution effectively (Consortium for Educational Technology for University Systems, 1997). Most new and existing universities are entering into "mega deals" for the acquisition of major software in order to save money and "transform" their institutions. (The California State University System is a classic example of this as they recently attempted to leverage "efficiency" software and hardware from conglomerate corporations as a means of building a common software infrastructure throughout all twenty-three of its member institutions.)

Software corporations are powerfully convincing when it comes to articulating how their product will make the academic business process run more efficiently. In every case of which we are aware, software marketeers claim to have "all the efficient solutions." Again, this is the traditional and costly approach to the business process design. Our research sees this issue as a point of departure and, as a result, presents OO as a common sense vision of the solution – a solution that has been formed from not only creating and transforming a new university, but also through years of field experience from an array of settings (Arias & Bellman, 1995; Arias, 1997).

Systems Perspectives

Our unique visual methodology and tools are invaluable resources for the concurrent design of distance-distributed education, IT educational networks, software/courseware development and the administration of programs across academic institutions. In most collaborative educational and research environments, teams must rely on paper based support processes and tools. However, complex systems can no longer be effectively represented on paper; communications of complex relationships and dynamic behaviors require software. The uses of visual software representations are now standard for mechanical design, but the use of models in the management of product development is still mostly in the paper stage. Academic institution management situations are complex, and it is difficult to readily evaluate alternative decisions that depend on relationships between process requirements, schedule, risks and educational outcomes. Such evaluations require many different experts working together, often on an "ad-hoc" basis. Isolated software tools support each task, yet the integration of the work to communicate for action is difficult (Arias & Bellman, 1995).

The enterprise based object oriented (OO) and unified modeling language (UML) modeling makes it possible to build the needed visual environments (Booch, Grady, Rumbaugh & Jacobson, 1999). In our modeling approach, the focus is on "things and relationships between things" described in commonly used terms. The modeling software bridges the so-called "semantic gap" between the people and the computer language. An object can be a product, course, schedule, process, a person, a department/center, school, an application or the inter-relationship between other objects. Objects can be pictured on the screen as maps formed by personalized "icons" with their relationships. Once a "map" of objects has been produced, users can navigate and visualize very complex relationships. Objects can hold data, such as cost, schedule data, weight and other relevant information.

An important property of an object is its ability to perform work scripted in "methods," such as performing computations, gathering data from other computers, showing video, or accessing a drawing for viewing. Whether working locally or at a distance the "active model" is more than a map for navigation in an abstract process model. It becomes the actual work environment for individuals and teams; especially while "working together apart" (Grenier & Metes, 1992). It is an environment for learning, assessing issues and impacts, communication, configuration management, assessment, control and more. In short, it is the user interface or academic administrative control panel from which to manage the university.

Our approach allows the management of distributed academic programs using this kind of processes perspective. Process integration is represented as active maps that allow

dynamic behavior to be communicated through simulation. Faculty and administrators are now able to describe work both in abstract forms and to simultaneously perform the actual process in the model. *Over time object oriented enterprise modeling will eliminate the need for abstract inactive process modeling.*

Object Oriented (OO) Enterprise Modeling and Distributed Cognition

Object oriented modeling (OO) methodologies have steadily grown since Smalltalk to more than fifty methods in the mid 1990s. In 1997, many of these approaches were combined into a standard called UML, or the Unified Modeling Language. Although this standardization has prompted a growing number of companies to develop UML-based technologies, there are a number of contrasting approaches that contain unique logical approaches to problems and modeling methods. These differences are significant for the emergence of different forms of distributed collaborative work and distributed cognition (Arias & Bellman, 1995; Arias, 1997; Osherson & Smith 1990).

The application of object oriented enterprise models to the development of the new California State University, Monterey Bay have become a research use-case for comparing the logic of several different methods and kinds of distributed cognition and activity systems they respectively generate in different types of implementation environments (from analyzing chaos during the first two years of the creation of the university to the development of electronic portfolios for student learning plans, and all relational work and planning activities). In one area of research, we are analyzing the types of object logic and ontologies used for software application developments, businesses, and technology enterprise modeling and computer supported collaborative research, instruction, engineering and/or simply group work. This has been a primary tool for research which contrasts major types of OO technologies to display their methods, use-cases and patterns relevant to these different implementation environments. When work environments are viewed as patterns of human behavior in this way, the emerging vision becomes one from "concept to code". Hence, the act of OO modeling attunes the researcher so that he/she comes to the understanding that basically "anything" can be "modeled out," from the design of a new university to the values and beliefs of a culture.

In the Social and Behavioral Sciences Center at California State University, Monterey Bay, our ongoing research analyzes these advanced technologies and their resulting distributed cognitive systems in terms of communication knowledge management. We perform research in the virtual research setting for analysis of computer supported collaborative research, teaching, and learning, and the corporate setting for analysis of Integrated Product Development Teams in Concurrent Engineering for manufacturing systems, Middle ware systems design, Business Process Modeling and BPR, Business and IT Architecture alignment and planning, and computer supported collaborative work in standards and product development.

Object Oriented (OO) Distributed Intelligence for Concurrent Engineering and Integrated Product Development (IPD)

Integrated Product Development (IPD) and concurrent engineering has redefined the nature of distributed work, teaching, learning, research, and both individual and distributed cognition (Arias & Bellman, 1995; Lipnack & Stamps, 1997). Today collaborators can participate in IPD based on their ability and knowledge independent of physical availability. This virtual IPD environment provides the opportunity to design not just the product (whether they be on-line materials for instruction or the design of a speech processing chip) but the systems of which it is a part. Through virtual IPD, the range and availability of stakeholders to take part in product development is greatly expanded. For example, an aerospace program can now concurrently design an aircraft as well as the larger transportation systems of which it is part. Using new visualization software, all members of IPD teams are able to have a shared systems relational view of approximately two million parts (including engineering design plans, mission statements, goals, contracts, etc.), their relation to thirty-thousand employees (who perform all assembly activities from design to riveting the wings), and the creation of one aircraft in relation to the other similar aircraft being produced. The peculiarity here is that, even after following the same plans for building and replicating the aircraft and while utilizing the self-same assembly plans, no two aircraft are ever the same. Moreover, no one knows how to systematically improve on the quality of any single aircraft or the total systems assembly business process. The traditional approach (which is typically resource driven) has always focused on improving the parts over system, that is, without a systems view of the relation between people, technology and work activities. Relatedly, we were advised by a high level executive at the N.A.S.A. Space Center that, due to recent and massive lay-offs, they did not have a "systems view" of how to reach the moon. This is an engineering as well as social peculiarity that object oriented enterprise modeling technology is especially designed to address.

Today as more and more institutions of higher education are being planned and/or are transforming themselves there is a need to account for every step of change along the way. What if, for example, a change in the transformation process is made, and it doesn't work? Or, say it does work. How will we know how to do it again, elsewhere in the organization?

Universities have traditionally created infrastructure to support everything from physical plant, to IT, to housing, to business and finance, to course inventory and its relation to space. But rarely is there a *shared systems relational view that can be visually processed by all stakeholders* (from, say, State representatives, to physical/IT planner, to faculty, to students). Utilizing OO technologies, we ask, "How can we model out the value chain of the university?" Or, a related question might be "If we make a change and it doesn't work, how is it documented?" We also raise questions that enable us to model cognitive forms, like, "What are the common assumptions or shared meanings about common truths and how are they inter-related in a discipline?" It is these sorts of questions that aid us in most effectively transforming knowledge assets from several different disciplines into a more robust paradigm for looking at the unity of knowledge. We may in effect turn these *knowledge assets into effective research capabilities* for planning innovative interdisciplinary academic programs and more (Manville, 1996). The point is that people, technology and work activities differentiate. Object oriented enterprise modeling simply becomes a common sense tool for modeling how things are "unified" in a "relational way" (Arias, 1999a).

Efficiency Object Oriented Enterprise Models

When you begin to view organizations from the paradigm of "efficiency models," you see the uncanny resemblance of behavioral work activities associated with the business of running universities and corporations. Both are, in fact, focused on "product programs" within distributed organizations that involve the simultaneous development of product and processes. This is certainly the case in start-up settings. While creating California State University, Monterey Bay, we often say "It's like designing the bicycle while riding it down the hill" (Arias, 1996).

This is precisely why start-up and/or transforming organizations often experience chaos. In the new university setting, we most often encountered problems that single individuals in isolation could not fully grasp, yet they felt responsible for activities for which they were not directly responsible. For instance, part of our founding principles at the new university included demonstrating that we could be entrepreneurial and, at the same time, build an efficient model. This was interpreted by many (with very little information to go by) within the context of also raising thirty percent of our annual budget, which was part of the negotiation for starting the campus. The behavioral response from faculty and staff alike was, naturally, to write an abundance of grants in order to gain the "overhead" garnered from those grants. But it soon became apparent that the "overhead" on, say, Federal grants only brought in up to eight per cent of the total grant. This activity was not adding up to thirty per cent of a forty-million dollar annual budget.

Likewise, another major assumption was that we would adapt new technologies and utilize them for distance education. Many people in our campus community took this to mean that we were becoming a "high tech campus with fully realized distance and distributed educational abilities. The majority of the units saw this as their personal responsibility and began to act out their contributions to this effort in isolation. They began to purchase hardware for distance education purposes that was being duplicated elsewhere on campus. Even the University Police unit set up an interactive televised fixed systems (ITFS) connected to a satellite dish for "pulling down" telecourses from state supported counterparts for the purposes of teaching their personnel through distance education. Ironically, they were the first to set up such a system on this campus, did so in isolation, and designed it in such a way so that faculty, staff and students could not have access; it is located in a "secured area." (A similar analog can be drawn to the fact that the University Police followed a similar pattern for setting up a costly gymnasium "for police personnel only.") Most felt that distance education meant that everyone must "get on line" and do so immediately or they would be perceived as "outcasts" and reviewed accordingly. To say the least, this was certainly not the case, but again, the point is that people responded in isolation to one another and did not have shared meanings surrounding these important initiatives. This phenomenon, coupled with a rapidly expanding environment, created a *culture of rapid concurrent development* without iterative feedback.

These are use-cases of how we must necessitate the integration of several perspectives, concurrent development and iterative feedback. Cognitive Science and AI studies on multi-agent activities illustrate how the supplied knowledge of any single expert constrains other collaborators by introducing innovative enablers and new constraints on decision options (Johnson-Laired, 1988). During collaboration inputs from these different knowledge sources form a web of constraint which shapes the problem representation in its operation context. This combination of concurrency with constraint satisfaction significantly expedites problem resolution and likewise greatly facilitates successful integrated product development (Arias, 1997).

For the past several years our research has focused on the connectivity between concurrent engineering (CE) and enterprise integration, as integrated product development (IPD), and how they are transforming manufacturing processes, work activities and the ways organizations think (Arias & Bellman, 1990; 1993; 1994; and, 1995). Our research maintains that, as the web of activities around product development change, so do the ways work processes are conceptualized. These shifts benefit organizations through more effective product life cycle, cost reductions and performance improvement. They necessitate the integration of multiple perspectives across organizations and the recognition of different theories of activity held by different cohorts throughout the enterprise. They require managers to allow IPD teams, using new communication technologies and visualization software, to evolve into new corporate cultures and adjust organizational infrastructure, resulting in agile organizations (Metes, Gundry & Bradish, 1998). Research of this nature informs us how it is that we may also grapple with improving teaching, learning, research and assessment at the university level. But at the same time we recognize that this represents a paradigm shift in terms of how we "do" teaching and transform the personal electronic pedagogies of professors, as well as the nature in which students learn and perform research.

New Object Oriented concepts and tools make it possible to build a visual environment. Members of an organization are often "star struck" by how OO shows where they are (as individuals) in the "universe" of their organization and how what they do is "relational" to everything else in their organization. (This is a very different depiction than the stagnant and traditional one dimensional organizational chart.) Imagine working at an organization for many years and, for the first time, actually being able to visualize where you are in an organization and, at the same time, to see how what others are doing is related and/or directly influenced by what you do.

Relatedly, we are collaborating with students on the development of electronic portfolios that are designed within an object oriented enterprise model. Fact is, student's electronic portfolios are actually at the core of the university wide model, hence, everything in the "universe of the university" is "related" to serving student needs (see Figure ___). This will encourage students to add to "data containers" how their previous work was articulated when they first entered into the university, how they will be processed while in attendance, and possible pathways to graduation. Even more fascinating is how the OO model actually "webs" everything they do at the university to everything else (everything from the Vision Statement, to meeting the requirements of the curriculum, to how the student is advised, to assessment activities and connectivity to on line learning experiences as well). We drew "relational webs" between the activities and plans of the

individual student, and such things as the university's Vision Statement. This sort of design certainly places things into perspective for the student.

Professors are also proffering the idea of using OO models for constructing electronic portfolios for review, tenure and promotion. Academic units may opt to use similar active models for preparing academic program review reports. Hence, I am suggesting that OO can be the most effective model for also visually presenting the connectivity between planning and institutional development for accreditation and more. This is similar to what is required to support technical work in the increasingly complex context of managing a corporation. In the object oriented approach, the focus is on things and relationships between things as described in commonly used terms. In traditional software, terms in daily use are converted into software jargon that can only be understood by programmers. Object oriented systems are able to bridge the so-called "semantic gap" between the people and the computer language (Zack & Serino, 1996).

A new paradigm for managing large, distributed, international and intercultural organizations has now emerged from this process (Arias & Bellman, 1993; Tapscott, 1996). The IPD and CE process has significantly increased stakeholders and multiplied the volume and types of interactions between them. Today, a product program is both a learning system and a communications network. Support for new organizational structures and program management leads to virtual organizations utilizing multimedia electronic teleconferencing, automated program management tools and new forms of computer supported collaborative work (CSCW).

Object Oriented Enterprise Modeling (OO) Logic for Computer Supported Collaborative Work (CSCW) for Ontology and Standards Development

The use of OO logic in models is also being applied in work on Web systems development for electronic commerce and other distributed programs. These efforts require the formulation of ontologies and standards across industries and national boundaries (Arias, 1997). The types of knowledge about standards being explored today are the subject of many different distributed collaborative efforts. These involve establishing objectives such as: CBL or Common Business Library as sets of XML DTDs, Channel Definition Formats, Electronic Data Interchange, ICE or Information Content and Exchange protocols, KQML or Knowledge Query and Manipulation Language, XML Namespaces, OBI or Open Buying on the Internet standards, OFX or Open Financial Exchange, OTP or Open Trading Protocol, Process Specification and Process Interchange Languages, Simple Workflow Access Protocols, Universal Data Element Frameworks, Web Interface Definition Languages, XMI Metadata interchange and more. (Elsewhere, but not in this paper, we will describe how the OO framework is able to protect corporate/institutional knowledge assets and corporate/institutional rights while it promotes distributed cognition among market competitors.)

Because of the enormous complexity of the distributed work involved, most of these initiatives are seldom integrated and often overlap and replicate each other's efforts. To be effective, this distributed knowledge work requires collaboration across the other related standards groups for constructing a viable framework. Such a framework must be relevant to all of major electronic commerce areas: business-to-business commerce,

business-to-consumer commerce, enterprise computing, education and research. In this part of the paper, we will discuss the creation of such working enterprise frameworks and expand on our previous work based on an examination of how they promote collaborative work and distributed cognition (Arias & Bellman,1995).

The framework is dynamic by adapting to environmental changes and in enabling users to ask "what if" and other types of enterprise-specific questions to measure the systemic effects of different future scenarios from different views of electronic commerce. It provides for different types of queries about both the as-is framework and the potential and/or real implications of the introduction of new technologies, effects of new or changes in economic and governmental policies and corporate strategies and emerging markets.

Each of the electronic standards initiative projects entail the organization, distillation and collective action on information among global businesses, many of whom are in market competition with one another. In order to facilitate work, it is necessary to obtain information that, on the one hand, protects corporate knowledge assets while distilling the information into a form that enables collective discussion, agreement and eventual action. This involves creating processes to link diverse and complex data structures and knowledge processes, as well as collating and interpreting them into a framework for collaborative and collective action. It entails working with proprietary information in such a manner that corporate rights are maintained while transforming and disseminating knowledge across industries and discipline domains.

The object oriented enterprise modeling (OO) framework developed with unified modeling language (UML) object oriented logic focuses on both business and IT architectures to effectively model the processes and dynamics of distributed Intelligence. In this manner the OO framework addresses the computational aspects of distributed intelligence by optimizing through dynamic models task allocation, interactions between work groups, activity groups, consortia and other organizations addressing standards and processes relevant to electronic commerce. This defines and improves group processes and facilitates organizational representation and collective learning. It also provides for more consistent management of numerous efforts by strategically aligning their contributions and work and by providing for more effective group cognition.

On The Application of Object Oriented (OO) Modeling at a New University

A fascinating application of related OO logic is how at California State University, Monterey Bay we take the Vision Statement so seriously we designed a model around its founding principles (to include "relational" webs to people, activities, plans, policies, academic programs and requirements, space and much more). When we query the OO model, it reveals the relations between people, things (plans, initiatives, policies, university learning requirements, major learning outcomes), as well as work activities (from student academic advising to instruction) to the parts of the Vision Statement they serve. Thus, when a new employee joins the Social and Behavioral Sciences Center for instance, we can orient them in such a way so as to not only bring them up-to-date not only on the "state of the university," but also demonstrate the relations their personal work activity has to the Center and the rest of the organization (literally). More

importantly, by analyzing the "gaps" in work activities, the new employee can visually process howthey will be making a contribution to the organization from the start. It gets new employees "on the same page" (as we say) and gets them focused on their new job; it assists them in organizing their personal "bench work". We can also provide a visual orientation to stakeholders just outside our immediate work activity and use the model to clarify our planning processes.

In a new university setting where some five hundred plus employees are brought into the setting in a period of forty-eight months, the impact of such a model on the distributed cognitive process in an organization with a common goal, and shared meanings, values, beliefs and vision, is immeasurable. Object oriented models show an "endless" number of relations between people, technology and activities no matter how different (albeit, distant) they appear to be from each other; as long as they are within the same enterprise, a relationship may be drawn.

As we referred to earlier, California State University, Monterey Bay is in the midst of both planning and implementing the educational programs that will give life and substance to the learning community at this new university. In response to both student needs and external deadlines, this process involves a broad array of university faculty, administrators, staff, and students, as well as external stakeholders in the community and state, working on a variety of educational planning tasks in a fast-paced, rapidly expanding, and highly decentralized fashion that is both "brand-newing" and "renewing" programs. In order to strategically remain on the "same page" with all stakeholders, we have experimented with object oriented enterprise modeling to allow planners to construct a elaborate model of our "business" processes from vision to deployment. In other words, our model has given us the ability to visually process how one's "benchmark" is "relational" to everything in the institution from the Vision Statement to the design of technological infrastructure, the academic program, the bench work of the individual faculty member, to the learning plan and graduation pathway of the student and much more. In short, object oriented enterprise modeling gives planners as well as all stakeholders a new "paradigm for looking" at the institution; in addition, it assists leaders in adapting to a changing future in very much the same way vibrant corporations are building business process frameworks. The key benefits of OO for smart companies are much like those for institutions of higher education and are pointed out by The Delphi Group (1998) as follows:

- Minimize distortion of business strategy from vision to implementation
- Speed deployment of business strategy
- Maximize the agility and integrity of ongoing business process change.

As they further state (1998), "These three benefits all speak to the principle problem faced by companies in today's highly volatile markets – speeding the time required to get from 'Concept to Code.' (Think of concept as the articulation of a strategy and code as the implementation of that strategy.)." This is certainly true in the creation of a new university, and especially the case for the infusement of distance/distributed educational programs that institutions of higher education are now moving towards at an unprecedented pace.

The California State University, Monterey Bay OO model enables administrators, faculty, staff, students and other relevant stakeholders to visually understand the program elements in relationship to all others at every level. Our model is a multi-level active model, which capture all personnel, roles, relationships, organizations, processes, stakeholders and global environments relating to the development, as well as ongoing transformation, of this new university. We refer to the model as a "communication knowledge model" because it communicates activities or enterprises in interrelated knowledge dimensions through aspects and views. Using the model faculty, and staff in the Social and Behavioral Sciences have been able to configure any proposed or real change at any level in the institution to understand, measure and control effects throughout the entire system. Then, once we understand with all relevant objects represented, we are able to represent the system in the Universal Modeling Language (UML) to generate applications for all parts of the higher education life-cycle, from student enrollment, administration, financial management, course management, student assessment, credit articulation and graduation/matriculation, life-planning. We have recently discovered how powerful a tool an OO model can be in such things as an outcomes-based educational environment, or for organizing (i.e., documenting and visually processing) electronic student portfolios as related to their capstones; faculty can also use the model for organizing their work when they are up for retention, tenure and/or promotion. OO models are also an excellent tool for strategic alignment across universities, especially in the case of accreditation or renewal efforts. OO designs allow stakeholders to visualize the goals not being met by gaps in the model and relationships between goals, objectives, and processes, by linking vision, goals, objectives and critical success factors. Then these can be reconciled by visually reasoning through the model.

Our modeling approach, OO, is a significant advance in problem solving and decision support. It permits visual reasoning about systems otherwise not available in text and algebraic driven reports and analyses. In so doing, it has profound implications for the effective management of institutional transformation of highly complex and complicated systems. It captures all components at multiple levels within a university, program or project. This enables the configuration and analysis of any change and accurately measures direct and shadow costs and effects across the entire institution.

In the case of our new university, it became apparent that the only way to organize people in a very chaotic setting was to move them to a point at which they are all thinking in a very similar fashion. Thus, our model design had to be based on the principles of our powerful Vision Statement. The model was to become "vision oriented." Today, OO tools have been combined with other advanced tools to deepen the understanding of not only the university as a whole, but more specifically, academic planning in the Social and Behavioral Sciences Center. Our goal is to utilize OO tools to provide clarity on how to graduate with a degree in the social and behavioral sciences and to demonstrate through a visual model how all units in the university either do or do not serve that goal. As above, in the case(s) where related units are not serving our goal, we find a "gap". Through gap analysis, we discover areas that need our attention. At the same time, we build into the model electronic pathways to social and behavioral science, as well as to other knowledge bases.

We start by applying the work of one of our professors while utilizing GIS (geo-spatial information science) technology to literally view the physical plant of the university, while at the same time capturing numerous digital video images from the air (about twenty-thousand feet above the ground) this is known as a virtual "fly-by" (see Figure ___.) This allows us to create a gross view of the land-mass and physical lay-out of buildings, streets, and more (Lao, 1999). In addition, we are adding to the model information about the square footage located in each building. This enables us to recreate virtual "grey space" which replicates the real space in a virtual environment. We refer to this as "gross level modeling". At another level (less gross) we "drill down" into, say, the administration building. In OO we view the administration building as a "container." In this "container" we store as much information about the university as we choose, and we do the same for each building or unit. We added our Vision Statement in the center of all administrative units (see Figure ___). By placing major administrative units surrounding the Vision Statement, we are able to travel from point-to-point in the model, "drill-down" and discover extensive knowledge bases held in numerous containers throughout the model of the university. Again, our objective is to design not only a visual model, but one that also has contained, within its units, extensive data sets that are "relational" and can be queried to produce an endless number of web-relational diagrams (that are multiperspectival and multidimensional as well). Data in one container may be calculated against data in other containers, and the results will provide planners with "what if scenarios." For instance, if we wanted to know the relation between the types of courses and which part of the Vision Statement they serve, this would become visually apparent in the model and so, too, would the gaps in terms of the parts not being served.

When we move to the level of strategic planning in the OO model and select "containers,"we discover points that store historical documents about the earliest developmental stages of the university. These documents are linked to either other documents or to other points in the model. Following these relational points you may choose to focus on other major areas such as Academic Affairs. "Drilling down" into the Academic Affairs "container" allows one to view academic majors, major learning outcomes, university learning requirements, individual learning plans, and, when queried, the web-relations between which goals they serve will be displayed (see Figure ___). At this level you move to a more micro-level of analysis and "drill-down" into the academic centers at the university and find that there are institutes, and faculty and respective syllabi linked via key words to the university learning requirements and major learning outcomes they serve. Again, every aspect of the design model has complementary foci to the overall mission of the center (see Figure ___). Again, containers found at this level contain information for experiencing (for learning), analyzing (for researching, but not manipulating), and processing (conducting computations) to generate "what if scenarios" and to compute possible realities.

Especially in the start-up enterprise, you will find that several times per week an "accountable party" has a problem to solve. What this means in relation to the object oriented model is that through the model we can now tie problems within the organization to envision how things operate. At the same time, the vision, principles and goals of the organization become the guiding principles. You begin to visualize how your personal activity within the organization contributes to the vision through tiered-phased goals. Hence, you see the connection between your "bench work" as a *strategic planning extension*. As a case in point, in the Social & Behavioral Sciences Center we

have tied the personal electronic pedagogical approaches of the faculty to every part of our powerful vision statement. That is, we have demonstrated how our center planning activities relate directly to the principles in the vision statement vis-à-vis point-to-point relational linkages from each faculty member's respective syllabi and course materials, to major learning outcomes, how students are assessed, and how students are advised through graduation. Additionally, while we (as a new university) see our charge as the "university of the 21st century" designing an academic program that is outcomes-based, our Social & Behavioral Sciences Center has designed an academic program that takes full advantage of the enormous technological infrastructure we have in place in order to meet our initiatives in distance education, improving our relations with local community colleges and creating assessment protocol in an outcomes-based educational model.

In terms of the latter, through the use of OO technology the Social and Behavioral Sciences Center (SBSC) is able to come to a thorough understanding of "how things work" at the university wide level. Taking this strategic view into account, along with the vision statement and recently stated initiatives (found in the CSUMB Plan 2002) which state as its highest priority that we will create and implement a distance education academic program, the SBSC has used OO to plan accordingly. We have made unique contributions, for example, in the area of student out-comes assessment and to incorporation of recent major software acquisitions. We have as a goal to implement a fully software system running on both a relational database engine and hardware capable of expanding the university's needs for assessment and student advising. A priority during the implementation is to create this system based upon a university wide information system (a la Banner CT). The challenge is to customize the Banner CT software (that is Oracle based) to meet the needs for the university wide plans for academic assessment, while at the same time taking full advantage of the information system as it is being implemented at the university. This will have a major impact university wide inasmuch as this will provide advising tools that will be more effective in offering high quality information on resources and possibilities available at the university and other sources.

In sum, our vision of OO is predicated on a broad view of the university as "enterprise" and allows one to perform everything from a virtual fly-by of the university, to navigation through academic programs and how they relate to major learning outcomes, university learning requirements, student assessment, individual learning plans, student capstones, outcomes-based assessment, life-planning and much more.

The real challenge for university administrators and corporate managers is to design a model that captures how it is their organizations can be naturally adaptive and evolve to be a more agile system, while at the same time fully realizing the potential of virtual IPD and OO technologies for knowledge management and infusion (Metes, Gundry & Bradish, 1998).

We've learned that the OO model will provide universities with a *visual model,* giving them a systems perspective view of the academic enterprise at every level (theoretically every perspective and every dimension). A novice user who is able to quickly gain ability with the tool can quickly begin to model and configure change within an enterprise. More advanced users have access to more customized level languages which enable them to tailor the tool both in design and function to meet any educational requirement (Booch,

Grady & Rumbaugh, 1999). The basic knowledge of the model and our education specific templates are the result of organizational enterprise research from our many successful engagements.

Managing Complex & Transforming Academic System Environments

In the case of the creation of California State University Monterey Bay, we have become particularly effective in the process modeling of complex academic systems, especially in "modeling-out" new and renewing institutional change. We are able to model all component subsystems and capture alternate perspectives and conflicting processes. We identify and connect multiple elements and agents within an enterprise or social system, locate how they interact at each level within and between hierarchies of aggregates, and all of the specific ways they relate to the goals, visions, laws, norms of the organization or culture. This permits the identification of sources of inter cultural and organizational culture conflicts. We capture agents and their interactions within the most complicated system and interfaces with simulation models of system complexity. These models contain alternative possible trends or scenarios based upon any number of simulated runs comparing relationships between possible intervening, uncontrollable and unpredictable variables. Each of these trend scenarios are configured to observe how they would each respectively affect each agent and its relationships with other agents and aggregates within the system. This enables academic institutions to develop long range strategic plans or policies, and to make just-in-time adjustments to their as-is environments to take best advantage of projected changes in the global environment.

Again, this work is central to the focus on the SBSC program as we can demonstrate several prototypes of academic models and how specific applications can be developed for a range of transformational purposes from administration to course content delivery over widely distributed global distance educational networks.

In the 21st century the most viable institutions will be those that are able to quickly and continually change and improve their operational processes and utilize new technologies and knowledge, while reducing cost and time investments and, at the same time "scaling-up" in order to adapt new modes of operation (like employees that telecommute, distance/distributed education and/or on line corporate training, group work at a distance, etc.). In effect the operational paradigm for the success of the institution/company of the 21st century will be the ability to continually reinvent themselves without disruption or loss of productivity.

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