An Object Oriented Framework for Integration of Social Science and Natural Resource Management Tools

Fernanda Zermoglio, John Corbett and Stewart Collis
Mud Springs Geographers Inc.
18 South Main, Suite 718
Temple, Texas, 76501
(fernanda@mudsprings.com).

Delivering information to decision makers is often a bottleneck in turning research results into effective decisions and policies. Information technology in social science research is maturing to provide more sophisticated tools for analyzing, visualizing, managing, and disseminating information. Successful integration and dissemination is dependent on creating flexible and scalable software frameworks that provide both complex analysis tools for advanced users and deliver information to a wider audience. Social science studies are increasingly linked to a specific geographic location (e.g., GPS coordinate) or region (an agro-ecological zone or a political region) and organization of this complex socio-economic data requires a sound data management scheme. Geographic Information Systems (GIS) technology is a logical basis for such a Spatial Decision Support System (SDSS). The principal goal of these systems is to store and manage information for any research project, model, or study in a systematic way that is both useful to researchers and accessible to those other than researchers or technicians.

AWhere™-ACT represents an implementation of an SDSS providing effective analysis and information delivery tools to decision makers who are not GIS specialists. Using object oriented methodologies and Component Object Model (COM) technology AWhere™-ACT provides a scalable framework for efficient integration with other systems (for example, demographic models, epidemiological models and weather generators) and databases (such as geo-referenced documents and remotely sensed time series data). The AWhere™-ACT components (as can all COM compliant objects) can be reassembled into specific applications to meet tailored needs or can be incorporated piecemeal into wholly separate applications. This versatility and flexibility without intellectual property compromise, offers a highly effective and efficient mechanism to share scientific advances and contribute to decision makers information synthesis needs.

Geographic Information Systems (GIS) are an established technology in the environmental management and research arena. However, adoption by non-specialists has not been widespread. The software system AWhere™-ACT[1] brings GIS a step closer to the decision maker whilst providing a sophisticated underlying structure that experts can use for modeling purposes. AWhere™-ACT is a spatial decision support system built using object oriented techniques to manage, analyze, visualize and disseminate information to a broad range of users. The stand-alone software framework for AWhere™-ACT contains data specific modules, which utilize, where appropriate, the same underlying object oriented structure. This approach has proven to be a successful implementation of an information delivery tool that can help users make better policy decisions related to agriculture and natural resource management.

One underlying principle in promoting effective use of any spatial information system is the concept of a *foundation database*. There are volumes of data available to decision makers from various sources, many of which are available via the Internet for free or at minimal cost. This however is of little use to a non-technician who neither has the time to track down such data sources or the expertise to reformat, re-project and load them into appropriate spatial information system tools. As such, an effective spatial decision support tool must come with pre-packaged data that allows at least initial analyses to be done, with no need to seek external data sources. As a user becomes more proficient, or requires more detailed information, the ability to add custom data sets must also be provided. Simply providing data management tools will not address the need of non-GIS specialists. AWhere™-ACT comes packaged with extensive databases, and each layer is thoroughly documented with metadata if further information is required. Databases delivered using AWhere™-ACT have predominately been eastern and southern African countries including Kenya, Ethiopia, Zimbabwe and Botswana and more recently parts of the United States and Mexico. The thematic groupings of data layers are diverse and include climatic, infrastructure, ecological, topographic,

[1] ACT is an acronym for Almanac Characterization Tool.

demographic and hydrographic layers. To manage the diverse nature of these layers an object oriented data model was developed. This design is key to delivering such a variety of information in a usable form.
Essential to the creation of a decision support system that will ultimately have an impact is the framework used to deliver the tools to end-users. This framework must provide a simple interface to end-users but have the potential to provide for the needs of more advanced users. The AWhere™-ACT Shell addresses these issues by utilizing COM technology to package applications and data models in a user friendly graphical user interface (GUI) (client or presentation layer) and provides advanced level access to the underlying components and objects (business and database layers).

To reach a largely non-technical audience the AWhere™-ACT client interface is modeled on the Microsoft Outlook™ interface for familiarity and function (Figure 1). The listbar on the left contains a set of "bars" that represent a separate COM applications or modules. Within each bar is a collection of items that refer to a function within each module. This design has the advantage of delivering a variety of applications to end users with a consistent interface. Interface design considerations are essential for application and information delivery and end user acceptance. There are also significant advantages to using a COM software framework to deliver multiple applications that relate to the interaction between these modules.

Using COM the many common features of the individual AWhere™-ACT applications such as toolbars, listbars, and map controls are handled by the AWhere™ Shell (Figure 3). This allows efficiencies in memory and implementation but also provides a common interface design. More importantly, the object models and data models underlying each individual application can interact with one another. This allows new modules to take advantage of the work previously done in existing modules and leads to faster development. This is an enormous advantage for developers who have the capacity to develop custom modules or stand alone applications using the AWhere™-ACT components.

For users who do not have the capacity or time to develop custom COM based modules for the AWhere™ Shell there is an intermediate yet powerful option available. Incorporating Visual Basic for Applications (VBA) in the shell interface provides an interface to the underlying object models of the applications delivered in the shell. This allows programmatic access to the shell's object models in much the same way Microsoft Access or Microsoft Word can be customized by a user with some programming skills. This offers a powerful tool that allows scientists and researchers to concentrate on developing their own temporal models rather than developing data management tools and data models.

COM (Component Object Model) technology enables great efficiencies in software development. Programmers may integrate existing components (e.g., a graph control) into their applications instead of building them from scratch, thus saving an enormous amount of work. There are thousands of robust, commercial COM controls available, and AWhere™-ACT takes full advantage of these (e.g., map, graph and toolbars). Most COM development tools (Visual Basic, Visual C++ etc.) also allow custom building of COM controls. Hence the flexibility of sharing certain components of an application with other developers is open to all developers. For example, AWhere™-ACT consists of a suite of custom built controls that other developers can access and incorporate into their applications. The ReportWhere module of the AWhere™-ACT suite is a stand-alone control that could be compiled as a separate application or integrated into other applications. There is license protection on these components, so the original developers can maintain control and knowledge of who is using their tools (an asset for version control). COM technology opens up enormous cost efficiencies for software development and opportunities for truly integrated collaboration and are the basis for the development of AWhere™-ACT Shell

In order to take advantage of the benefits object oriented programming and COM technology offers AWhere™-ACT uses a three-tier architecture. Three-tiered architecture is an industry standard that provides a framework for logical components of software to interact and enables flexibility in managing changes and updates in system components. The three tiers consist of the database layer, business layer and presentation layer or *client*. A major advantage of this approach is that if the rules (and subsequently the code) of one tier ever change, the programmer need only modify or replace that layer; there is no need to migrate the changes to the other layers [Sarang, 1999]. At all three levels, object models underlie the components at each layer to help organize code and provide structured models with methods and properties to allow communication between layers and to other applications. Where appropriate

the AWhere™-ACT Shell modules are built on a common data model (e.g. AWhere, CensusWhere and SoilWhere share a common data model).

AWhere™-ACT demonstrates a tool that integrates GIS functionality and aspatial tools and applications. AWhere™ Shell is an object-oriented framework for integrating independently developed applications and providing a common user-friendly interface that can be customized to meet user's needs. Lueng [1997] also points out that "A SDSS without knowledge is a tool of no intelligence and minimal usage. The success of a SDSS in general and knowledge-based spatial information system in particular lies on it's level of intelligence". Whilst the intelligence relevant to environmental analysis and modeling underlying AWhere™-ACT have not been described in detail here [Corbett et al., 2000], the framework presented sets the stage for integration of knowledge and information systems. With the computing power available to researchers and developers, the modeling world sees many diverse and very specific applications. While it is unlikely that a single model or tool will resolve all possible concerns of decision-makers, tools like AWhere™-ACT can provide a common foundation from which to begin more specific investigation.

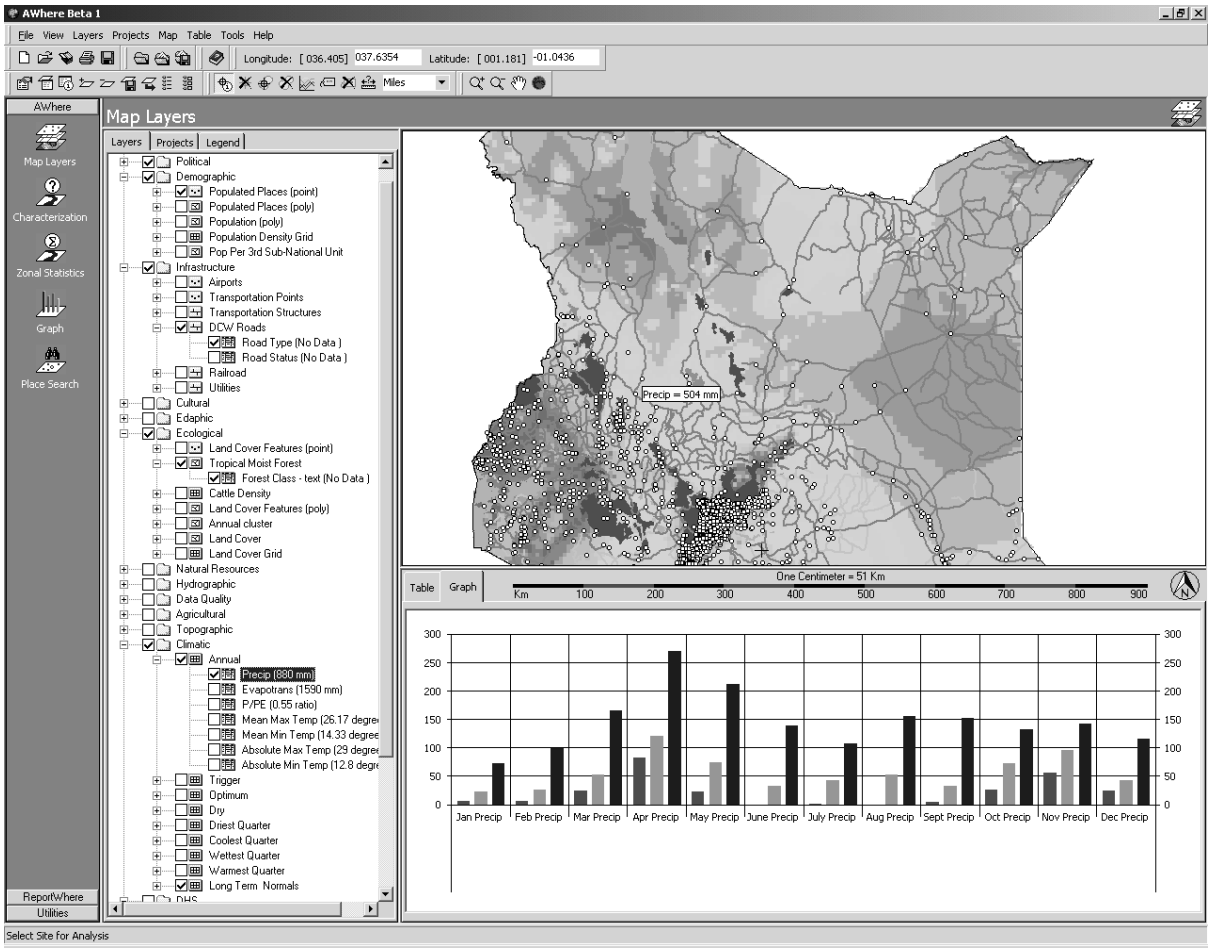

Figure 1. AWhere™-ACT interface.

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