Web-based Knowledge Management of Demilitarization

Technology Trees

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Abstract

This thesis examines the design, development and deployment of a global-scale dynamic web-based knowledge management system and evaluates the issues encountered during the underlying research.

Industries which deal with the design engineering of products over their complete life cycle generate a vast amount of information. This knowledge, taken to be synonymous with information, pertains to the components, equipment and processes needed to effectively manage the products at all points of the life cycle. The continual growth of this knowledge requires a dynamic management system which will support the dissemination of knowledge while providing access to a global user-base. The main focus of this research is the creation of a tool benefiting the maintenance and delivery of information, in a user-friendly graphical format, while providing flexible knowledge dissemination.

Visualization of information is a useful tool for education and training in industry. An interactive application was created to provide an intuitive coupling of the information with the end user. Most areas of industry implement tools or methodologies which allow for a better understanding and access of pertinent information. This thesis outlines the development and implementation of visual, interactive tools for knowledge management to provide structured information to a global user base dealing with the end of life cycle of a product family.

The Defense Ammunition Center (DAC) in McAlester Oklahoma required an additional informational management system for the technologies used in ammunition disposal and to assist in the training of personnel worldwide. Previously, DAC used a
universal PowerPoint template which was much like a flowchart. Each chart was adapted for specific items by the reuse of changing path lines, lines following the steps of demilitarization, to indicate appropriate process paths for the demilitarization of munitions. These hierarchy structures are referred to as Technology Trees. This method of documentation was static and did not allow for access of additional information. This research work developed a web-based, dynamic method to deliver required information in a multimedia form. The interactive informational data portal described in this paper allows users to navigate through applicable technology paths for a particular ammunition family from disassembly to handling of waste streams. This user-friendly system has information that is quickly and easily accessible by all installations.

This thesis presents the design and implementation of a knowledge management system created for the DAC. The functionality of the web-based system allows both viewing of information and easy managing of all database information. The system developed can also be adapted to train and manage other information for various institutions. A web-based database editor was also developed to allow the transfer of the technology tree structures for ammunition disposal from hard copy to an interactive user format through the use of server-based scripts and a database management system.

Any particular information technology structure can be viewed in a graphical format over the web through the use of Macromedia Flash. The Flash application displays the parts and processes implemented in the demilitarization of munitions, diagramed in a tree-type flow chart so that the disposition of the item can be easily understood. The system also allows users to get additional information about each part
or how it can be disposed. The technology structures can be created and edited from either web forms or directly from the dynamic Flash interface which allows the administrator to see the information that they are adding or changing. This application shows how a graphically orientated information interface can deliver information effectively to users around the world.

This research has produced a successful web-based, dynamic and interactive, knowledge management system which was developed with optimal use of available resources. This system improves the human-computer interface by its employment of information visualization and use of multimedia. The tool developed through this research has become implemented at the DAC and currently benefiting a global user-base.
Chapter One: Dynamic Web-Based Knowledge Management

There is a trend in information management to use a single interface for global distribution of large quantities of data via the computer networks such as the Internet. Visualization of this information is an area of research which is growing based on its possible benefits [1]. Web portals allow access of multiple information sources to web users across the globe. The same system can also be used for industrial or corporate intranets and educational institutions [2]. Computer supported work systems link humans with information via a computer system. These applications are currently successful in providing knowledge to the global user base and have become increasingly more appealing over the later part of the twentieth century. However, problems do arise with global industries when information sharing is needed and this thesis will address one of those problems, dynamically viewing information in a graphical format.

One important global institution, the Defense Department, has approximately 2,200 systems to track its transactions and operations [3]. Problems arise due to the fact that these systems were built at different times with different standards and utilities making collaboration an obstacle. Treasury Department Commissioner Richard Gregg stated, “We have bought every piece of hardware and software in existence, and in some cases we have both of them two or three times, because no one wants to share [3].” This identifies the government’s need for online applications which do not require additional financial recourses to use among groups and users in various locations.
1.1 Knowledge Management

Knowledge management is a concept which continues to serve a strong role in today’s information age. Its use as a strategy of consulting companies has had many incarnations since the early part of the 20th century, starting with Taylor’s ‘scientific management’ [4]. This system then went on to become a widespread engineering technique after the development of time and motion studies which were spawned from Taylor’s concepts [5]. Today the term “knowledge management” has become a buzz-word taken to mean a utopian harmony between information and how the information is put to use. For this research knowledge management can be broadly defined as a collection of processes that govern the creation, dissemination, and utilization of knowledge [6]. This definition has been selected as it adequately encompasses the requirements necessary for the project which is described in this paper.

In this research, knowledge is taken to be synonymous with information. Wilson postulated that this is an incorrect unification with the following argument [7]. He stipulates that knowledge involves the mental processes of comprehension, understanding and learning that occur in the mind and only in the mind; regardless of interaction with the world outside the mind, and interaction with others [7]. He defines information to consist of any data gathered from the outside world. Wilson’s declaration is unsound since information we gather from the outside world is based on the classifications, categorizations and interpretations mankind has placed on our environment. The innumerable objects created by mankind are products of the mind.
and any information gathered from the outside world are products of perception. This makes knowledge a “group-mind” based conglomeration of both scientific and subjective evaluation of the environment, whether natural or unnatural, and information is a symbiotic feedback of that knowledge. Knowledge is a primary resource for successful operations and the achievement of goals [8]. Therefore it is recognized that this valuable information must be captured and placed in some form of system which allows for access, updating, and the evaluation of the knowledge providing some type of benefit.

Benefits of knowledge management include the analysis of information, sharing of information between individuals and groups, and other functionalities of the system such as the following. These systems can assist in benchmarking and pinpointing weaknesses, or other target areas, while allowing for adaptability to suit the changing environment. When attempting to accomplish any goal, the more knowledge which can be obtained pertaining to the reaching of that goal will be inversely proportional to effectiveness of achieving that goal. This instinctive idea parallels the design paradox postulated by Ullman pertaining to product engineering (Figure 1.1) [10]. Realizing the impact this information has and the rewards which can be obtained when the information is put to optimal use, it becomes clear that the design of a knowledge management system is critical to reaching the potential of the industries, institutions, or individuals who make use of the system. With today’s available technology, computer supported work systems have become exceptional methods for knowledge management.
1.2 Architecture of the Knowledge Management System

Architecture, as used in this context, relates to the broad decisions that must be made by an organization as it creates its information support system [11]. The goal behind optimization of the architecture is to unify a system so that all aspects are efficiently connected. The project outlined in this thesis required the implementation of a large-scale dynamic web-based management system for knowledge sharing, information evaluation and user education.

The end user, the Defense Ammunition Center, requires a system to couple the products which they handle, types of ammunition, with the methods used in the demilitarization of those ammunition types. These methods encompass a range of parameters. The equipment used and resources required for demilitarization must be
examine and linked to the specific ammunition items for which they are intended to be used. Results stemming from the methods must be considered and documented pertaining to the end products. These end products consist of reusable or recyclable items or waste streams. Waste produced from demilitarization is of particular scrutiny from an environmental point of view due to the nature of the components of military ammunition. Responsibility lies with the demilitarization community to not only account for what is produced from the processing of munitions, but to institute an evolving system to improve munitions processing.

It is the charge of this research to design, develop, and deploy a knowledge management system which will suit the user’s needs. The system must allow for the input of information from a wide-spread user base. This data management alone must be optimal in its ability to accept the most pertinent information and allow for efficient input and manipulation of said knowledge. Data must be structured such that proper relationships are maintained and the connections between the information can be evaluated. The information must be delivered to users in the most effective manner available. Distribution of the information must promote interactivity between the user and the knowledge.

1.3 Components of the Knowledge Management System

Generally, if data is properly stored using traditional databases, online applications can be used to present and manipulate the data. Web-based applications can be created to suit the needs of a client and can be adapted to evolve by a system
designer. Information management applications are needed in both industrial and education sectors to deliver knowledge to individuals and institutions. The tools developed for education and information relation continue to expand depending on the needs and requirements. With database driven systems, the knowledge is maintained while the application interface, and the application functionalities, can be changed without the need of re-compiling the stored information.

Delivery of electronic media over the Internet provides an immense outlet for information sharing, especially for institutions with widely dispersed personnel that require the information or training. Use of the Internet for information distribution is viable since 87% of U.S. workers have broadband access [12].

1.3.1 Web-based applications

Web-based applications have experienced a tremendous growth in the last ten years and have the advantage of being cross-platform tools, which will extend to the largest possible audience base [13]. The increase in use and development of these applications is due to a range of benefits which they offer over standalone applications, as well as the ability for larger range of individuals to create these tools with little resource demands. This is appealing to any institution by providing significant time and cost savings.

Local computer applications require an installation to a local machine which make distribution more difficult and often produce obstacles pertaining to an institution’s procedures associated with introducing new software into their network. If applications can be accessed through the client’s Internet browser, then there will
be no need for downloads of additional components making deployment of these web-based tools easy when compared to locally executable software. This also makes maintenance of the application easier. Changes to the software are instant because it exists in a single location on a web server. All users access the same version of the application and the privileges given to those users can be controlled by an administrator.

Flexibility is a key aspect of these online programs as they can be scaled and manipulated in real time. New capabilities can be added or changes can be instituted to suit a user or customer needs. This allows for a more dynamic feedback system between the applications users and its developers.

1.3.2 Centralized Information Database

Content is stored in central location allowing for superior maintainability while providing many desirable benefits. Numerous users can contribute to and manipulate the data from various locations. This connectivity is not possible using independent satellite data sources. Data corruption is also avoided and users are always working with the most recent collaborative information. In addition, security is more insurable due to the fact the database, and the scripts which utilize the data, are kept in secure locations which can be monitored and updated. A representation of the relationship between users, computer scripts, and data is depicted in Figure 1.2.
The most impressive asset of online applications that utilize centralized data is the ability for users to access the system from anywhere with only a personal computer and an Internet connection. With the advancements in wireless technology, mobile connectivity has allowed for an unparalleled convenience of access. Web-based applications can be not only more convenient but also more intuitive. The interfaces can be customized based on user preferences providing a more effective relationship between a client and the tool. The information contained in the database is also routinely backed-up to avoid total loss. It is necessary to realize centralized databases allow for a single point of failure for the entire system.
Chapter Two: Literature Survey

It can be argued that at its most basic form, knowledge management has been used in one form or another for centuries [15]. The systems of gathering, relating, and sharing knowledge have progressed and been incorporated into modern industry since the beginning of the twentieth century. Most notably with the work of Fredrick Taylor, whose role as plant manager led him to seek the most efficient way to conduct operations in the steel industry [16]. His scientific approach utilized available technologies to study and promote labor capacity. From the early twentieth century on, various systems have been developed to evaluate and improve the functionality of numerous user entities. The methods incorporated into these management systems have continuously developed with respect to the available resources.

Today, with the benefits afforded by the Internet and computer technologies, information management is entering a new frontier with yet unexplored possibilities. It has been debated that online information visualization is either a failed experiment or a future revolution. While many systems have not lived up to expectations, the future does hold great potential. This area is a relatively new field and most critics of the premise have commented that there is a serious lack of information visualization applications [1]. These systems do not reflect the possibilities proposed by proponents of online knowledge management systems.
2.1 Knowledge Management and the World Wide Web

From the Web of Science web-site, journal papers which included the term ‘knowledge management’ in the title increased dramatically from 1995 to 2002 [7]. The growth is evident when compared to the use of the term prior to this exponential rise (Figure 2.1.) The constant use of the term prior to the year 1995 parallels the mainstream introduction and increasing use of the Internet. It is evident from Table 1 that the increasing use of the Internet has proportionally led to the increase of knowledge management systems. This realization, coupled with the technological focus of these papers, suggests that modern knowledge management is being researched symbiotically with the advent of technologies which promote information sharing.

Figure 2.1: Occurrences of Knowledge Management Focused Papers [7]
Table 2.1: Internet Users in the United States, 1994 – 2001 [7]

<table>
<thead>
<tr>
<th>Date</th>
<th>Percentage of Population (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov-94</td>
<td>12.77</td>
</tr>
<tr>
<td>Oct-97</td>
<td>22.07</td>
</tr>
<tr>
<td>Dec-98</td>
<td>33.84</td>
</tr>
<tr>
<td>Aug-00</td>
<td>46.4</td>
</tr>
<tr>
<td>Sep-01</td>
<td>54.66</td>
</tr>
</tbody>
</table>

2.2 Leading Case Studies of Web-Based Knowledge Management

Web sites, such as Amazon.com (Figure 2.2), utilize web-based applications which recall information from databases so that users can efficiently find information about products [17]. These sites, or portals, manage multiple types of media and information to be accessed by a user anywhere thorough any platform. Web-based applications are developed to deliver knowledge and educate users in intuitive and time efficient ways. Web-portals tend to follow a fairly standard format. Assessment of some documented cases where a knowledge management system was developed for the Internet will show what is currently offered by the mature web tools.
2.2.1 Knowledge Portal at Cisco

Cisco Systems, Inc. is the worldwide leader in networking for the Internet. The foundation of the Internet and most networks around the world is Cisco’s Internet Protocol-Based networking solutions. Internet Protocol (IP) is the basic language to communicate over private networks and the Internet [18]. The company has always worked to create solutions for transporting data, voice and video and is recognized as a pioneer in creating internet tools.

When Cisco wanted to rapidly expand their Service and Support Advocacy Group by sharing the knowledge of experienced managers with little strain on resources, the company partnered with VisionCor to create and institute a knowledge portal to accomplish this goal [19]. The three main initiatives of the project were to
minimize time-to-proficiency, maximize sharing of knowledge assets, and foster ongoing learning and communication.

VisionCor’s Integrated Knowledge Architecture is an object-oriented approach to organizing content based on usage. Knowledge is grouped into smaller pieces, called knowledge objects, and significant relationships are built to unite these objects. This allows users to locate critical information more efficiently. The result of the venture was a successful portal which provided intuitive user control of a vast amount of employee training information.

VisionCor’s tool is not revolutionary in the presentation of its data and does not implement dynamically linking a user with a computer application. It does however do a good job of representing how an object orientated approach to information control can produce a powerful web-based information system. This case shows how with little resource demand, a large group can be provided access to vital information thus improving company efficiency.

2.2.2 MITOS Greek Financial Market Tool

This self-described integrated web-based system for information management identifies a key problem with information explosion. Without controlling the information structure, knowledge access and integrity are hindered. The emphasis of the project was the adage that information is only valuable to the extent that it is accessible, easily retrieved and structured [20].

MITOS was designed to handle the vast information explosion of the Greek financial market. The system was designed to utilize advanced information
representation with text centered web-based displays. The system combined techniques from the areas of Information Filtering, Natural Language Processing and Information Extraction [20]. Efficiency is evident in the system designers’ approach to utilize existing information to be integrated within the MITOS tool.

This case study exemplifies two major aspects necessary to developing a successful web-based information management system. The data structure and accessibility must be easy while being consistent to provide sound information to the users. Also, the system should be able to incorporate existing information eliminating redundancy of re-creating information. This is outlined in the MITOS computer architecture schematic in Figure 2.3.

![MITOS Computer Architecture](image)

Figure 2.3: MITOS Computer Architecture [20]
What is found wanting in the online MITOS knowledge management system is the object orientated access of information in a graphical format. A graphical representation of knowledge is essential when the information is inherently of a dependant structure, like the DAC Technology Trees, which relate sub-components of a specific ammunition type with the demilitarization processes. A study of a current system of knowledge management utilizing graphical display of related data is provided in the following section.

2.2.3 Ancestry.com

Connection or linking of information as will be used in DAC demilitarization processes is utilized at Ancestry.com (Figure 2.4), which maintains and displays genealogy trees for their clients [21]. The elements of a genealogy tree are similar to those associated with the information trees documenting the demilitarization of ammunition. Information about the components of the trees is stored while maintaining relational integrity. Information about each element of the tree, in this case information about a member of a family, is grouped in an object oriented manner and can be accessed by navigation through the tree. After gathering the necessary data, accessible information from this site consists of lines of text, pictures, or hyperlinks.
The Ancestry.com web-site provides a similar example of an available system to relate data visually, but less advanced or innovative, to the research outlined in this paper. While the system is capable of utilizing database records and displaying them graphically online, the application leaves much to be desired in the way of user interactivity. This tool displays data in a text centered tree structure. The details of the specific knowledge management system desired by the DAC are discussed in the next section.

### 2.4 Technology Trees Used at the Defense Ammunition Center

The Defense Ammunition Center (DAC) is located in McAlester Oklahoma and is part of the United States Army Joint Munitions Command. This command stores, maintains, accounts for, issues and reconstitutes equipment and materiel for
the U.S. Army. DAC serves to provide the military services with timely ammunition training, demilitarization technology, explosives safety, engineering, career management, and technical assistance through logistics support [22]. The DAC has an online information management system, MIDAS, which provides a vast amount of knowledge pertaining to the components of military ammunition [24]. Ammunition is grouped in families and each family may contain numerous sub-group families, as shown in Figure 2.5. Technology Trees document the demilitarization process involved in the end-of-life cycle of specific ammunition in a family.

Figure 2.5: Portion of 81 mm HE Mortar Bomb Breakdown (circles indicate end step)
2.4.1 Current Technology Trees

Demilitarization processes, as well as the research and development of demilitarization technologies, for the Army’s conventional ammunition are handled at the DAC facility. Each type of ammunition belongs to a family and each family has a unique disassembly structure with multiple methods of handling each step in the deconstruction and recovery processes. The large collection of information arising from the demilitarization of ammunition requires a medium to relate that information to other user groups.

The current method of generating Technology Trees at the DAC involves a static template which contains all the available processes for ammunition demilitarization, and generalized components, in a flow chart layout. The breakdown of munitions and the processes used are represented by colored path lines on the universal chart. Path lines are re-orientated on the universal sheet to indicate the demilitarization of different types of ammunition. These generated structures are referred to as Technology Trees (Figure 2.6).
With the variety of munitions being handled at the DAC, as well as other installations for worldwide distribution and demilitarization, the number of Technology Trees has reached just below 300 in number and continue to grow. Trees must be created to document the demilitarization for each applicable process for every family of munitions. Currently the creation of a Technology Tree results only in a PowerPoint file or hard copy paper document which can be shared but relates little information. There are several drawbacks to the trees as they are, but when
comparing them to what is possible with online applications the need to move this information from paper to a digital medium becomes apparent.

PowerPoint Technology Trees must be created for each method of demilitarization for each type of ammunition. This creates a sizable amount of computer files which must be individually maintained. The current trees are difficult to understand for those who do not deal with them frequently. When looking at a tree it is often unclear which components of the ammunition are being referred to and which paths they follow. This is due to the fact the templates are universal and static so each chart is not uniquely created and allows no relation to additional information. A computer based system allows each chart to have a simple and unique format. Path lines run on top of one another as well as loop from one area to another due to the fact that the tree charts were created from the universal template, making them unclear. The charts do not offer additional information about specific parts and processes or other particular circumstances for individual munitions due to the use of a universal chart. An interactive application would allow for users to not only clearly see the available demilitarization methods due to an improved information layout without size constrictions, but would add many other benefits including interactive access, data evaluation and global distribution.

2.4.2 Online Knowledge Management of Technology Trees

The intended primary functions of the online Technology Trees are to educate and inform individuals and institutions of all the pertinent information for the demilitarization of a particular type of ammunition. With the currently implemented
system the dissemination of this information is not possible. Management, relation, and sharing of the information related to ammunition demilitarization needs to be addressed by modern means.

The web-based system developed for the DAC utilizes Active Server Pages and Macromedia Flash to provide a powerful online database editing system which is geared specifically towards efficient Technology Tree building, viewing and evaluation. To couple stored database information with an online graphical interface, Macromedia Flash was used which allows dynamic and interactive application for obtaining information [23]. This approach provides a secure database which utilizes only the necessary information. The information in the database can be accessed and manipulated through the web-based interface which is scalable to accommodate new functionality and expanding needs of the client. The data and application can also be integrated with other systems. Details about the database, ASP scripts and Flash implementation are given in the following sections.
Chapter Three: Online Technology Tree System

3.1 Design of a Web-Based System for Ammunition Technology Trees

One objective of this research is to develop an application to provide all the necessary information for the demilitarization of military ammunition, allow for management of that knowledge, and to educate users of the available disassembly procedures. The web-based application needs to serve both as a way to input and recall information that will be utilized by demilitarization groups. This knowledge management system must also be maintainable and effective for providing useful information to multiple users at various locations.

The success of the application depends on its ability to accommodate many different users on a global scale. These users have different needs which must be provided by the tool. Information needs to be put into the database which is used to present the trees in an interactive format. The application must be dynamic to handle the tree data which varies significantly from one another in size, structure and information. Before discussing the two main aspects of the application, data input and information display, the users of the application are determined.
3.2 Application Users

Application users fall into three groups with privileges depending on their classification. The three user types are administrator, manager, and user. Application users consist of individuals at installations, facilities, and other institutions which need to create or access information to assist in or assess demilitarization of ammunition. Users login to the web application from the main screen (Figure 3.1). The users profile is pulled from the database and the tool allows the user access to functionalities for which they are approved. Also, these three user types may work with the “central database” or a separate “satellite” database. The user architecture is expressed in Figure 3.2.
3.2.1 Administrators

Administrators input and manage all the information needed to create or modify a technology tree. An administrator determines what goes into the database. They can also create new user accounts of any classification. Currently, administrators consist of Defense Ammunition Center personnel and individuals selected by the DAC to input data in the early stages of this project. An administrator may create new application access accounts, with any level of authorization for any facility using the tool. This is beneficial in granting others access to the site. The same system is used for the Munitions Items Disposition Action System Database (MIDAS) web-site, an authoritative central repository for data development efforts.
providing information needed for the conventional ammunition demilitarization program to individuals who request access to use the web information tool.

3.2.2 Managers

A manager account is facility specific. After trees containing all available methods of demilitarization are created by an administrator, they are made available to other users who may wish to use the trees to not only see what is possible but also to examine particular methods of ammunition processing. Facilities may use the trees to define and analyze the demilitarization processes implemented at their facility. They are able to view available trees and specify the “paths” which are used for demilitarization of the particular munitions at the installation. This information is stored in the database and is only available to the manager account for which the “paths” were specified. The facility specific methods can be recalled and modified by the manager.

Managers may also wish to examine other available procedures for various benefits, including analysis, determination where improvements can be made or decisions regarding technology development. A manager can create new user accounts for the facility for which they are designated. In addition, a manager can not create an application account for the level above them, administrator.

3.2.3 Basic Viewing User

A basic user may only view the information and not update, change or modify it. These users could consist of government officials or other parties which need to
know how munitions are being handled, what is possible, and promote thinking
toward what efforts need to be made to improve the current demilitarization methods.
The basic user does not have any privileges to change the information which is
presented by the application, but they still have access to interactive viewing of the
trees and other information and media which is connected with the trees.

3.2.4 Satellite Users

There is a need for trees to be created for future munitions which do not
currently have demilitarization process outlines. Also, it may be required that users
create new trees, or manipulate older trees, but are not allowed to access the
Technology Trees which are contained in the central database. These users have
administrative privileges over their own set of trees in a separate database. If they
would like to make use of a Technology Tree from the central database, it may be
imported. Trees from the satellite users may be incorporated into the central
database, but only after approval from an administrator account with rights to the
central database. This system is currently implemented by many institutions
including the Defense Ammunition Center.

Satellite users characterize munitions, a procedure of quality checking, which
involves documenting data such as weight and composition for each ammunition
component. When administrators at the DAC are satisfied with what is submitted, it
is then added to the central MIDAS database and made available for online access.
3.3 Application Information Management

The need to transfer information from the current static outlines, shown in Figure 2.6, of technology trees to online databases which can be called upon for dynamic tree generation and user interactivity lead to information input function development. In order to make use of the knowledge associated with the end-of-life cycles of military ammunition, the information must be documented and available in a format which allows for recall and utilization of the data. The best way to accomplish this is through a database [17]. When the information is contained in this manner, it allows authorized users to input and recall the data from any Internet browser via the web-based application (Figure 3.3).

Figure 3.3: Application Main Toolbar
3.3.1 Creating New Trees

From the main menu, users with administrative rights have numerous functionalities available to allow for data entry to the database. Initially, a new Technology Tree will need to be created. When a new technology tree needs to be added, the administrator can select the “New Tree” function from the Technology Tree pull down menu. The family of ammunition for which the tree is being created could be specified from either the national stock number (NSN), DODIC, or a nomenclatural MIDAS name. This would allow for system flexibility while providing a way of insuring technology trees are created for a proper family and that the family does not have multiple trees. Once a tree is created, an administrator can begin to populate the database information (Figure 3.4).

![Figure 3.4: Creation of a New Technology Trees](image)
3.3.2 Editing Trees

Under the Technology Tree pull down, the “Edit Tree” option brings up the information as it appears in the database Table (Figure 3.5). Each row of data represents a node, the building blocks of Technology Trees. These rows can contain any type of data which could aid in delivering demilitarization information to users, including the name, weight, type of node, location of additional media, and other information. Currently, the system allows for the input of the new data name, type, the process it belongs to, its availability and node specific information. Currently, this is all that is needed to describe a Technology Tree. If further information is desired it can be added to each tree or referenced from another location or application. Information management functions are also assigned to each row. An administrator would perform the desired action on the node that requires editing. This is needed to insure the trees are built in the proper manner.

![Figure 3.5: Technology Tree Editor](image)
3.3.3 Tree Integrity

The main focus of the information management is to maintain a virtual tree structure. Addition, deletion and other forms of information manipulation have been carefully designed to maintain a structural integrity. Technology trees are built by adding on to existing information developing a hierarchy. From one element, or node, another can be added. This is a parent-child relationship necessary to keep information in a structured order which can later be used to create the interactive trees. Any changes made must redefine the effect of the tree structure. An example is shown in Figure 3.6 where a node is removed from an existing tree branch.

![Figure 3.6: Depiction of Node Deletion from Tree Structure](image)

Information redundancy in a database is something which should be avoided when designing a database [25]. Redundant information adds no benefit and can lead
to corruption of data. At the very least, redundancy requires the programmer to needlessly accommodate the unneeded information. With this in mind a minimal amount of information is stored for each row, or node, of data in a tree.

Each node has an identification number which is unique within that tree. Additionally, each node has a parent identification number. This simplistic approach is efficient and effective. Each node has only one parent. The alternative is to document all the children of each node. This creates a database field which will vary undesirably making data manipulation increasingly difficult. The administrator has no control over the identification numbers for the nodes of a Technology Trees. The parent numbers are also generated based upon which node an editing operation was performed. However; administrators may realize that the information they have in one location of a tree actually belongs in another. In order to allow for administrators to move nodes and branches which have already been created around the tree, a change parent function was added to the editing functionality.

New individual nodes can be added to or between other nodes (Figure 3.7). For fast information input by an administrator, options are available to continue building upon the path they are working on or to return to the updated Table. The same applies to deletion where the parent-child relationship must be maintained. In cases where entire branches of information need to be removed, a recursive delete function removes the data node and any node related below that one. The information contained in the database for a particular node can also be edited.
3.3.4 Tree Building

The large size of these trees coupled with the generalities between trees and tree elements led to the development of application features which assist in tree building. When dealing with a large amount of data in a single system, it is necessary to maintain continuity among the trees. Also, an administrator would find it undesirable to input the massive amount of information repetitively typing or designating the same information for each node. With this in mind, a library feature was developed for the Technology Tree application (Figure 3.8). This library is crucial for management of all engineering information to be used among the hundreds of Technology Trees.

Figure 3.7: Addition of Nodes to Tree Structure
The library is a Table in the database which contains the node information for each node used in building technology trees. The notes field can grow to several pages long when defining a component or process involved in demilitarization. The library can be added to or edited as needed. With the library in place, administrators do not even need a keyboard to generate Technology Trees. Node elements can simply be pulled from the library and inserted in the desired tree by two clicks of a mouse. This feature helps to ensure continuity, which is a requirement of the Technology Tree application, and also helps to make the tool more user-friendly.

Expanding on the idea of maintaining continuity and improving usability, additional methods of data entry were generated. As evident from the static Technology Trees discussed earlier in this paper, trees have recurring branches. If a tree already contains a branch, or string, of nodes which would apply to another Technology Tree, it can be duplicated and saved as a template. By selecting the key
node, the top node of the desired portion of the tree to be reused, every node below
the key node, the children of the key node and so on, can be saved and given a unique
template name. With the template now designated it can be placed in any other tree.
This amounts to the formation of complex branches with a single database operation.

Often with the Technology Trees, and with flow charts, a node will have
several options below it which are similar in structure. Maybe, the only difference is
that the verbiage has changed for a single part of the string. Here the administrator
does not need to create a template. A duplicate branch function was created to make
an identical branch which provides a different option for a single node. This function
not only aids in usability, but works with the same resources used for the template
feature, meaning it makes dual use of existing application programming.

Even further progression of making the process of tree building easier
intuitively lead to the desire to copy an entire tree. Many of the ammunition families
share similar trees. Keep in mind that families of ammunition consist of hierarchies
themselves which are expansions of a general tree to account for differences between
some more specific types of ammunition within that family. An example is the major
family, HP.
Table 3.1: HP MIDAS Family Definitions [26]

<table>
<thead>
<tr>
<th>Major Family</th>
<th>Sub-Group Family</th>
<th>1st Sub Level Family</th>
<th>2nd Sub Level Family</th>
<th>DEFINITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td></td>
<td></td>
<td></td>
<td>HE Projectiles and Warheads. Includes all projectiles, warheads, mortars, or similar items that do not have a cartridge case, propellant, or rocket motor associated, and that contain a high explosive filler.</td>
</tr>
<tr>
<td>HPC</td>
<td></td>
<td>HPCL</td>
<td></td>
<td>HE Projectiles with cast loaded projectiles, 155mm, 175mm and 8&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>HPCLR</td>
<td>8&quot; and 175mm, non-RAP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HPCM</td>
<td></td>
<td>Miscellaneous HE projectiles and warheads with cast loaded explosives. Predominately 2.75&quot; and 5&quot; rocket warheads and various projectiles derived from cartridge breakdown projects.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HPCS</td>
<td></td>
<td>155mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>HPCSR</td>
<td>155mm RAP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HE projectiles with press loaded explosives. Predominately Navy 5&quot; projectiles.</td>
</tr>
</tbody>
</table>

HP is MIDAS nomenclature for the high explosive projectile. Within the HP family there are sub-groups and further sub-groups depending on how specific the ammunition is. These changes can be related to the munitions size, components, or use. New munitions may also be created in the future which fall into this major family but vary from the other sub-families. Therefore, after creation of a complete major family tree, the Technology Tree can be copied and used for a sub-group family. The tree may vary from its final form but it can be manipulated to suit the needs of the tree. This is advantageous when compared to creating each tree from scratch.

Once a technology tree has been completely and correctly inputted into the system it is finalized. Changes made by the administrator to the information after finalization is documented. The information which was edited, the administrator who made the changes and the point in time when the changes were made is kept in
database Tables referenced to the ammunition family the changes were made. Records of these changes are maintained for two main reasons, ISO certification requires documentation of information management during auditing, and keeping records of changes to information also allows for backtracking and correction of changes which need to be undone. Complete deletion of a technology tree, using the delete function on the main menu, will create a backup copy and allow for a new tree to be generated for that ammunition family.

3.4 Application Information Display

Information visualization is a rapidly growing field that is emerging from research in human-computer interaction [27]. One of the most difficult problems associated with information visualization is the limited amount of screen space available to show a changing and unknown amount of information [28]. What is needed is a robust graphic interface which can take raw data, and dynamically generate intuitive tree structures which can relate all the necessary information without overwhelming the user.

3.4.1 Graphical Technology Trees

The selection of the “View Tree” feature on the main menu, or the quick link button from the tree editing Table, allows any user to select a technology tree for viewing. A web interface, built with Macromedia Flash, was developed for this purpose. Flash provided the necessary authoring environment which combines scripts, computer code, and animated graphics, which allowed for the dynamic
delivery of information to the user in a graphical representation [29]. The application was created to be tree independent. This only means that all that changes from tree to tree is the initial data which is pulled from the database. However; the technology tree structures, which are user interactive for information access, displayed may vary significantly.

After selecting the tree, the entire tree is displayed, beginning in the upper-left corner of the screen, or stage (Figure 3.9). The tree expands along the positive x axis and down, the positive y axis when working with Macromedia Flash. Clicking on a node will result redrawing of the tree with the related child nodes a level below. This allows a user to work through the specific part of the tree they wish to view without having to handle the bulk of the entire tree.
Figure 3.9: HCCL Technology Tree

Drawing the tree with each data element in its correct location requires a recursive program which actually draws the tree from top to bottom. This is a result of how data is stored for the trees. Each node has a single parent making dissemination of its structure a process counter to the top-down format of the desired tree drawing. A dynamic approach to tree generation was needed due to the variances from tree to tree, the program must be able to depict any possible tree structure. The tree must also be displayed in a clear manner. Each node can have different branches below it. Therefore, the drawing algorithm works with levels and columns, similar to the rows and columns of a spreadsheet or database. The Flash component determines
if the space has already been used or if it is available to place nodes when constructing the branch system. In order to avoid confusion branches from one node are not placed above branches from another. This is not optimal in utilizing screen space but it is optimal in providing clarity of how the tree is laid out and is in itself, aside from all other benefits of the application, a vast improvement over the former incarnation of Technology Tree.

### 3.4.2 Nodes: The Building Blocks of Technology Trees

The Flash tree has great adaptability to represent the information and differences among each node. Icons, colors, and other variances in graphics are used to deliver a good amount of information at a glance while using only a single node. When a terminal node is reached, it becomes red. This means that the end of the branch has been reached. Other colors have significance as well. If a technology is not currently available or is in an emerging stage, the node will be semi-transparent or orange, respectively.

Nodes, from left to right, feature an icon to indicate whether it is a part or a process performed on the munitions and the name of the node. The use of icons can expand to include as many as are needed to represent differences between nodes. For example, looking at Figure 3.10 the carbon filtrate process included in the tree is conceivably a viable option but has never been used for this particular family. Therefore the node has an italic red “T” attached to its upper left corner to denote that more testing is needed before this option can be used. This information is valuable to
those in the demilitarization community to see what is possible and examine holes in the demilitarization of ammunition as a whole and at an individual tree layer.

![Figure 3.10: A Carbon Filtrate Process Node](image)

3.4.2 Technology Trees Information Access

In addition, the tree nodes have additional functionality and information access associated with them. Two buttons are featured on right side of the node. Clicking the top button, labeled “I”, will bring up a menu with access to various information such as, cost, weight, technical drawings, 3D animations and other forms of data and media (Figure 3.11). Technical drawings, which are already present in the demilitarization system, can be linked to the nodes. This makes cross media access easy for even inexperienced users. The benefits of 3D animations for education and information relation has been well realized [30].
Vector-based animations are effective forms of media which can be utilized to provide online education to application users (Figure 3.12). The Vector-based system utilizes client machines to create web media which is scalable and consist of a small file size. Engineering CAD models can be utilized to create these animations or they can be created with a 3-D animation software package. These animations couple images with sound to more efficiently relay information than plain text, audio, or images. The more senses which can be involved with information sharing, the more effective the tool can be for. Animations can be stored in a server-folder and referenced by nodes in the database. Models of the item or process involved in demilitarization can be created and manipulated in any way necessary to present a
virtual illustration which can completely describe specific details of a technology tree node. As these animations are vector based, like the Flash Technology Tree, the files are relatively small and are ideal for Internet relay.

![Figure 3.12: Screenshots of Animations](image)

The information tool can also bring up path specific information reports beginning with the first node of the tree and ending with the selected node (Figure 3.13). This has tremendous potential for demilitarization evaluation and optimization. It allows for calculations to be made based on the choices made in navigating the tree structure which are analogous to the decisions made in real-life demilitarization of munitions. When coupled with the necessary data, this method can be utilized to perform a number of various knowledge analyses.
3.4.3 Graphical Technology Tree Editor

The bottom button brings up an edit window. If a user has administrative privileges, then information input and management can also be performed from the Flash graphical interface. This insures for proper data placement. When dealing with a large amount of structured data, it can be difficult to visualize the information structure from a Table which mimics a database. Therefore, it is necessary the
graphical interface provide administrators with all the functionality of the external Technology Tree editor.

All of the information management features available from outside the graphical interface, excluding tree creation and deletion, are available within it (Figure 3.14). The Flash menus call Active server pages on the web-server which update the database with the changed information. Editing of any information currently contained in a technology tree is updated instantly both in the database and on the client’s browser. Other changes, which alter parent-child relationships, require a refresh to see the changes.

Figure 3.14: Graphical Technology Tree Editor Forms
3.4.6 Technology Tree Control and Navigation

A floating control menu allows the user to manipulate the graphical representation of the stored information. This menu allows for movement around the stage and zooming in and out. Due to limitations of screen size and the unlimited size of technology trees led to the additional functionality of grab and drag navigation. Displaying all of the nodes of a technology tree or clearing the nodes on the stage is also possible from the navigational menu. Buttons on the menu will generate process-specific tree structures. Certain processes are closed loops where all waste is reconstituted while an open loop generates waste. In the old paper-based system, these process-specific trees required individual technology trees for an ammunition family. Now all trees can be quickly and dynamically generated with the use of the Flash application. Two printing features are contained on the menu. A user can either print just the tree structure which is visible on the screen, or they can print the entire technology tree.
Chapter Four: Application Components

4.1 Computer Architecture

The scripts for the HTML ASP pages, and the actions called upon them by the user through use of the application, are kept and maintained on the server. The server also contains the data, in both a MySQL database and file folders. The web-connected client computer views the application though a web browser. The client computer also handles the SWF files which are accessed. The function structure is depicted in Figure 4.1.

![Application System Structure](image)

Figure 4.1: Application System Structure
4.2 Active Server Pages

A web server runs an HTTPD (Hyper Text Transfer Protocol Daemon) program [31] which provides quick, simple, and non-intrusive methods of servicing a website. The connection between a server and a client, the individual users, is temporary and must be reestablished for every data transfer. Web pages are viewed with browsers which are typically, Windows Internet Explorer and Netscape. A browser is needed to access pages on the World Wide Web. Hypertext Markup Language (HTML) is a set of special codes referred to as "tags," which instruct a web browser how to display a hypertext document. Scripting languages can be used within HTML pages to create the functions of an application.

Active server pages (ASP) were developed by Microsoft and are an open, compile-free application environment in which you can combine HTML, scripts, and reusable ActiveX server components to create dynamic web-based business solutions [32]. Active Server Pages enables server-side scripting for IIS with native support for both VBScript and Jscript. ASP was utilized for this application due to its ease of use, versatility, and speed.

4.3 SQL Database

A database management system is a collection of data. The database is organized with Tables which contain data pertaining to a specific group. These Tables can be related to one another and used to store information, which can be retrieved and manipulated by statements contained in web page coding. Today, some
of the most popular databases include Oracle, SyBase, MySQL and Microsoft Access. The Windows operating systems on the computers at the Defense Ammunition Center, as well as most other facilities, have Access and it is currently used for the MIDAS application. The drawback to Access is it was not designed for large amounts of data to be stored and managed [33]. Implementation of this system on the scale indicated will require the use of a more robust data management system in the future.

Keeping in mind that one of the benefits of this application is that it requires no additional recourses to implement, MySQL was selected because it is a free database management system.

### 4.4 Database Management

IBM developed Structured Query Language (SQL) in the late 1970’s and is currently the standard language used for database communication [34]. SQL statements are used which allow the user to define and manipulate the data in the database. Data retrieval, and other editing tasks such as adding, deleting of data and updating of data, is performed through SQL statements. Open Data Base Connectivity (ODBC) is an Application Programming Interface (API) which allows a program access to a database. Regardless of the database type being used, all calls made to the ODBC API. This application currently uses Microsoft Access as a database, but could easily be shifted to any other since SQL and ODBC work with all databases.
4.5 Macromedia Flash

Flash MX, developed by Macromedia, is a useful animation and web graphic creation tool which was used to develop the interactive-graphical interface of this application. Flash is currently an effective way to add functionality to a web site [35]. Once considered an animated graphics tool, Macromedia now promotes Flash as a full-fledged development platform for creating what Macromedia calls "rich Internet applications." Nearly every commercial Web site uses Flash, as do many of the Web's most effective ads [36]. Web developers have found it to be ideal for offering attractive and usable tools to clients. Flash offers cross-platform consistency and ease of distribution couple to deliver a runtime technology which in capable hands can produce interesting and agile applications. The uses of Flash have evolved and spread to cover a broad spectrum. While the general public might only be familiar with Flash from games, advertisements, and motion graphics on the Internet, the multitude of task oriented applications which have been created with the tool is quickly increasing [36].

The realization that Flash is an advantageous platform for web content is something which the developing community continues to recognize with each passing release of the software. Recently, the capabilities of Flash have been widely broadened by the further development of the tool. Flash’s scripting language, ActionScript, provides a scripter with highly sophisticated interface and application design [35]. A major focus was placed on the development of ActionScript. Through the efforts of many engineers a plethora of new capabilities are available to
ActionScript programmers. Graphically rich and interactive user interfaces are now created to deliver sophisticated web applications.

Flash animation and interactivity are created, in the Windows world, in Flash-format files with the extension .fla. These files are published to be used with web pages and have the file extension .swf. These SWF files are viewed on client machines through a Flash Player. Flash player is a component of Windows Internet Explorer and most users will not need to download additional software to use and learn from the online application. The Flash files are executed on the client machine which frees the server from being responsible for running the application for multiple users.
Chapter Five: Implementation

5.1 Defense Ammunition Center Use of Technology Trees

Technology trees for hundreds of ammunition families have been completed and used. In the coming year, it is planned that database-based technology trees for all current ammunition families will be created will be implemented at the Defense Ammunition Center and made available to the demilitarization community. Also, addition methods of modifying existing databases will be evaluated to avoid unnecessary information logging. Once the application is brought on-line, authorized individuals will be able to access the system and learn from the information it delivers. Potentially the tool will provide various methods of evaluation including comparison and evaluation of what processes are available and being used for the demilitarization of particular munitions, as well as the costs and hours involved in those processes at multiple facilities allowing for optimization.

5.2 Nationwide Installation and Contractor Use of Technology Trees

Currently several government installations are using the application to develop technology trees for various munitions. The use of this system in such a manner facilitates development of the tool. Implementation of the system among these separate entities has led to successful creation and deployment of the satellite information feeding functionality. Most importantly this aspect of the project has reinforced the strong need for a consistent information library and the template system. When you have to deal with many users and complicated elements of
engineering, you can not rely on different individuals to produce similar technology
trees. Therefore, a primary focus of tool development will be creating these
knowledge objects to be used within the system.

While the system is available to any authorized user, there are issues which
arise when dealing with a wide user-base. Mainly the variation of hardware is a
variable which effects application development. When dealing with graphical
information displays it must be taken into consideration that what a user sees will
depend on the hardware they are viewing the information with. The actual size of the
trees may vary to extremes but the physical size of the application display must be set
to function on both new computer monitors and older displays with varying
resolutions.

Differences between computer hardware also require more efficiency in the
coding and balancing between the server and client side operations. When
considering the diversity of processing power among users, it must be recognized that
computations requiring high amounts of processing are better handled by the server as
it with be powerful enough to accommodate the needs of the application.

5.3 Worldwide Use of Technology Trees

Ammunition demilitarization is a global industry. The DAC, other facilities,
and contractors provide services to many nations. Employees of the demilitarization
community often travel to various locations to provide their knowledge to others.
Now, several are needed in Iraq to assist in demolition of captured enemy
ammunition. As much as 400 tons of this ammunition has been processed in a single month during the country’s liberation [37].

Trees have been developed for the Israelis to provide detailed ammunition disposal information. As use of the system becomes more prevalent the global user base will increase. This leads to the need of distribution of the information maintained and generated by the application. In cases where users do not have computer access, or only little information is needed to be delivered other methods of knowledge deployment are necessary. Options of sharing technology trees, outside of the online tool, include printing of trees or portions of trees to paper copies. Trees may also be saved as .pdf files and sent via email.
Chapter Six: Conclusion

6.1 Summary

The goal of the new Technology Tree management system for the DAC was to allow access to all information available for ammunition demilitarization and to educate users of the correct disassembly procedures. The application developed for the DAC provides a high level of functionality. Being web-based it is accessible from any Internet connected computer. The method of content generation is efficient due to the availability of database editing in both the web forms and Flash interface. The necessary hierarchal relationship of information is handled by the application making Technology Tree generation easy for the administrator. The Flash interface allows for outstanding information access in an intuitive format. This application exemplifies how a graphical interface can be implemented to aid in education and information sharing in industry. The system design is adaptable for other types of information management for education.

These types of relational evaluations are precisely what knowledge management systems strive to achieve. Not only is information now a functional entity, but the system fosters improvement. When properly instituted the assets provided by the technology trees will be significant when compared to the data which is maintained in the system. Capabilities like this are crucial to propelling a knowledge management system beyond what is currently available with web applications which only provide improved access of information to users.
6.2 Accomplishments

This research has produced a successful web-based, dynamic, knowledge management system. The efforts of this project conclude that the success of any information system is the structure of the information and its ability to evolve. The dynamic system created by way of this research is capable of providing this, where the previous static system was not. This tool improves the working relationship between end-users and computers through the development of the interactive graphical interface. The employment of information visualization and use of multimedia, show that successfully tools can be created with increased functionality and deliverability of information dissemination with little cost. The tool developed through this research has become implemented at the DAC and currently benefiting a global user-base.

The application successfully accommodates users who have a variety of different needs and supports a wider range of user behaviors. The information drawn from the database is presented an interactive format making for intuitive access from a centralized location. This is achieved with the application by dynamically manipulating data, which varies significantly in size, structure and information. The user is provided with a visual representation which can then be used to access needed information and other functionalities of the system.

Graphical representation of structured information is successfully accomplished through the use of Macromedia Flash, providing an interactive interface for access and management of information. This approach provides a secure
database of consistent and current knowledge utilizing minimal storage. The accomplishments of this graphically orientated data interface show that knowledge visualization is method of information management with substantial benefits. Accessible information is accessed and manipulated through the web-based interface which is scalable to accommodate future functionality. The research produced a data management tool which can be integrated with other systems and will also be able to evolve over time.

6.3 The Future of the Project

Currently the project is being used by the Defense Ammunition Center and several facilities in the demilitarization community to further develop Technology Trees. The functionality of the knowledge management system will continue to increase as various possibilities are realized and requirements emerge. The system will be integrated with other information delivery applications. Integration with the existing MIDAS web-based information system is planned for the near future as well as incorporation of the system with a demilitarization optimizer.

With all these user types and the need to provide interactivity between them, a super administrative user is needed to manage all accounts and the more advanced database operations. This user will have control over all other user accounts and databases. The super administrator is needed due to the changes among multiple sub-user groups and the management of shared system-wide information.

Additional media and information which does not exist will be created. The systems library and template knowledge objects will be added too.
and creation of demilitarization templates has been an ongoing process and user input
is vital to their generation. Animations will be developed to be linked to the
technology trees. As the use of the tool for employee education becomes more
prevalent, the resources provided to those employees will continue to evolve and
expand.

Methods of knowledge use will continue to be developed. What information
is efficiently generated and available to the user will increase as new options are
desired. The system will progress towards a position of evaluation. The tool created
from this research will provide methods of demilitarization analysis. Virtual
DEMWAR reports will be generated. These reports outline the ammunition and
methods used in its demilitarization. New functionalities will be developed to create
these reports dynamically for workload projections. The capabilities will be
specifically geared towards producing costs and relaying end products from a
workload. The tool will also be added to for determination of the effects particular
methods of demilitarization have on the environmental.

The options of accessing and sharing the information contained and generated
by the application will be expanded upon. Access of the system from handheld
computers, including PDAs, for education in the field is currently in the planning
stage.
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