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Expanding the Security Dimension of Surety

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Expanding the Security Dimension of Surety

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Abstract

A small effort was conducted at Sandia National Laboratories to explore the use of a number of modern analytic technologies in the assessment of terrorist actions and to predict trends. This work focuses on Bayesian networks as a means of capturing correlations between groups, tactics, and targets. The data that was used as a test of the methodology was obtained by using a special parsing algorithm written in JAVA to create records in a database from information articles captured electronically. As a vulnerability assessment technique the approach proved very useful. The technology also proved to be a valuable development medium because of the ability to integrate blocks of information into a deployed network rather than waiting to fully deploy only after all relevant information has been assembled.

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Abstract. A small effort was conducted at Sandia National Laboratories to explore the use of a number of modern analytic technologies in the assessment of terrorist actions and to predict trends. This work focuses on Bayesian networks as a means of capturing correlations between groups, tactics, and targets. The data that was used as a test of the methodology was obtained by using a special parsing algorithm written in JAVA to create records in a database from information articles captured electronically. As a vulnerability assessment technique the approach proved very useful. The technology also proved to be a valuable development medium because of the ability to integrate blocks of information into a deployed network rather than waiting to fully deploy only after all relevant information has been assembled.

Introduction

Objectives of the Effort

The objective of the concept described in this document was an effort to hybridize a number of artificial life technologies to explore the predictive capabilities of such a union. Terrorism like other areas of tactical operations is evolving as a result of pressures being imposed by international efforts. The computational technologies of artificial life offer a potential approach for terrorism prediction that has not been tried before. The idea is to use Bayesian networks to capture the characteristics of terrorist cells and use genetic programming principles to explore the evolution of these characteristics over time. The evolved tactics could then be used to assess the vulnerabilities of "terrorist targets" using agent based simulations.

A number of complementary efforts exist which employ these newer analytic technologies. Small unit tactics are being researched using agent based modeling. Machine intelligence is being explored using Bayesian networks and machine design is being approached using genetic programming principles. Genetic programming methodologies have also been integrated into agent simulations in efforts to evolve optimal behavior of some agent level function.

The sections to follow will touch on genetic and agent based programming and the application of the technologies to this area of research. The section on Bayesian networks will go into detail to demonstrate the applicability of the technology as applied to the problems of terrorist prediction. The model and algorithms used in the study will follow the discussion of the fundamentals.

Genetic Programming (GP)

Genetic programming, like genetic algorithms, can trace its roots to Darwinian biology. Genetic programming attempts to automatically create computer programs from some high level description of a problem. The objective is to "breed" computer programs through a process of natural selection. The approach consists of creating a program which is tested against a fitness criteria, a reproduction or selection process and a series of genetic operators that force the automatically generated programs to change. Programs reproduce or are selected for survival into the next generation based on probability distributions reflecting the level of fitness of the algorithm. Change in the evolving programs is achieved through the application of a series of genetic operators including; mutation, crossover, and a special architecture-altering operator. This last operator is not common to the classic set of genetic algorithm operators.

Mutation involves the paring and regrowth of a functional sub-tree. This operator is employed with a low probability. The crossover operator, which is a high probability operator, randomly selects branches of two genetically created programs and splices branches from one tree onto the others root structure. The architecture altering operators are involved in defining "subroutines", argument sets, loops, recursions and memory. These operators provide an automatic mechanism for structuring the program.

The basic idea for using the GP technology was to explore changes in doctrine or terrorist behavior. Instead of creating an operator set from which algorithms were defined, the operator set would consist of actions or series of actions a terrorist might employ to defeat the defensive systems associated with a target. This technology coupled to agent simulations were intended to assess the vulnerability of next generation terrorist targets through a Monti-Carlo type game theoretic application.

Agent Based Simulations

Agent programming is a paradigm of algorithm development that extends object oriented programming to include, the "environment", perceptions of the environment, and an ability to reason and respond to stimuli encountered in this environment. Object models encapsulate state and state transition functionality or methods. State transitions are typically triggered by some "incoming message" which results in a method being fired. Agents while including these characteristics employs a capability for deciding which state transition method to execute.

Agents are talked about in terms of behavior which is a more sophisticated form of method. Behavior includes a level of awareness about its relationship to the environment and the ability to choose appropriate behavior. The "awareness" consists of a recognition of its current state, the state of its environment, a set of objectives, and an internal representation of the closed system. The agent assesses its state relative to a desired state, based on the internal representation including objectives and selects from a set of actions. The action selected is the one most suitable for causing the state transition to some desired state. This decision or selection function provides agents with varying degrees of autonomy.

A final characteristic that can be incorporated into agents is the ability to create new state transition functionality. It is possible to provide an agent with a genetic programming type capability in which it uses evolutionary principles to evolve new functionality. This new functionality is designed to drive the system closer to the goal or objective based on the agents internal model of the closed system. The agents internal representation is used to define the fitness function for use with the GP algorithms. These capabilities combine to provide a powerful computational environment for assessing complex multi-dimensional problems, such as terrorist actions.

Bayesian Networks

The bulk of this research effort was an exploration of the use of Bayesian networks for use in defining baseline terrorist behavior. In addition it was assessed as a means for capturing and implementing that behavior into an agent simulation to define vulnerabilities and trends in terrorist behavior. The technology has its roots in

Bayesian probability theory (Pearl, 1988) in which the probability distributions are not "a priori" known. The methodology is based on sets of prior distributions which may possess varying levels of knowledge and sophistication and an update mechanism to improve these distributions as information is gathered through experiment, observation, analysis, or expert opinion.

Bayesian network calculus begins with the idea of conditional probabilities. Conditional probabilities are simply stated: *given a state B, the probability of state A is x.* Mathematically this is written in equation 1.

$$P(A|B) = x \qquad \textit{Eqn. 1}$$

The basic probability calculus rule is given in the next expression which leads to Bayes rule in equation 3.

$$P(A|B)P(B) = P(A, B) \qquad \textit{Eqn. 2}$$

$$P(B|A) = \frac{P(A|B)P(B)}{P(A)} \qquad \textit{Eqn. 3}$$

Bayesian networks (Jensen, 1996; Pearl, 1988) extend the fundamentals of Bayesian statistics to include a representation of information in formal directed graphs. The nodes in these graphs represent system variables with a finite number of mutually exclusive states. Therefore a variable "A" with states a_i can be expresses as follows with associated constraints delineated in Equation 4.

$$P(A) = (x_1, x_2, \ldots, x_n) \qquad x_i \geq 0 \qquad \sum_i^n x_i = 1.0 \qquad \textit{Eqn. 4}$$

The arcs depicted in network diagrams represent the causal relationship between the system variables. Within the context of a network, a variable may have more than one parent. The resultant probability of a variable existing in a state, is conditioned on the states of the parent nodes. Parent nodes are defined to be variable lying on the source side of the directed arcs in a diagram. The conditional probability for a variable, "A", with parent variables, $B_1, \ldots, B_n$, is represented in equation 5.

$$P(A|B_1, \ldots, B_n) \qquad \textit{Eqn. 5}$$

The complexity of using this technology is defining the tables that correlate states and probabilities for the expressions represented by equation 5. Our interest is in the joint probability distribution of the system. Given that conditional independencies hold for the network, the chain rule may be applied and the joint probability distributions may be defined as follows.

$$U = \{B_1, \ldots, B_m\} \qquad P(U) = \prod_i P(B_i | pa(B_i)) \qquad \textit{Eqn. 6}$$

$pa(B_i)$ represents the parents of the variable B_i and U represents the set of variables comprising the Bayesian network.

The advantage of the approach is the basic Bayesian nature of the problem in which information may be incorporated into the network as it becomes available. The distributions do not have to be known beforehand. Two papers by Spiegelhalter et. al. (Spiegelhalter, 1990; Spiegelhalter, 1993) provide a nice description of using data, sometimes sparse, to refine Bayesian network models.

Bayesian Modeling.

Bayesian networks are the outgrowth of the failure of expert rule based systems to replicate the functions of domain experts. Expert systems are attempts to model the behavior of domain experts in computer algorithms. Early expert systems were rule based using classic *if-then* rules on discrete pieces of information. Rule based systems attempted to capture decisions in blocks of *if-then* rules and use an inference engine to determine actions given a set of evidence. Limitations of this technology involve the representation of uncertainty associated with the information, handling conflicting rule sets, and allowing for data refinement. Fuzzy logic mitigates problems with conflicting rules and some aspects of information uncertainty but does not provide effective data refinement methods.

Unlike expert systems Bayesian networks are designed to model a domain. Execution of these models provide support function for the domain expert who must deal with complex issues and systems. Bayesian models are dynamic from a perspective that information may be appended to prior information allowing for continuous refinement of the information. Bayesian networks are not dynamic from a causality perspective. As new relationships between variables emerge they will not be represented in the network. Bayesian networks have been used for medical diagnoses, for computer vision, meteorological prediction, and information processing.

Model Building (Variables, causality, data). One of the principle areas of effort associated with the construction of a Bayesian network involves the identification of the hypothesis variable(s) and the information variables. Hypothesis variables might represent a disease being diagnosed, or the state of a complex system. Information variables consist of the indirect observables that must be used to infer a hypothesis. Causality is the characteristic of one variable affecting a second variable. In a directed acyclic graph, the arrow connecting two nodes dictates the influence ordinality. The information delineating the degree of influence is defined in sets of conditional probability tables and represent information captured in expressions such as equation 5.

The third type of variable is a mediating variable and is used for convenience. They are intended to ease the acquisition of conditional probabilities. These variables are used to collapse information into blocks were fidelity is unnecessary.

Netica. The tool used in these studies was a product of Norsys Inc. called Netica. Netica is a Windows 95/98 program for working with belief networks and influence diagrams. It has a user interface for drawing the networks. The relationships between variables may be entered interactively as individual probabilities, in the form of equations, or obtained from flat data files with varying degrees of missing data.

Netica can use the networks to perform various kinds of inference. Given a new case Netica will find the appropriate values or probabilities for all the unknown variables, even under conditions of limited data. Netica can also use influence diagrams to find optimal decisions, maximizing the expected values of utility variables

A number of transforms are possible in Netica. Variables that are no longer of interest or have been found to have limited utility may be removed without changing the overall relationships between the remaining variables or requiring re-initialization. Probabilistic models may be postulated and tested by modifying links, or by removing and adding causal relationships. The capabilities of the Netica and Bayesian networks in general lend themselves to extensive "what-if" type analyses.

Terrorism Background

It is interesting to note the degree of debate concerning the definitions of terrorism. Not only can nations not agree on a definition, but government agencies can not agree on a definition. From a national perspective the difficulty is that "one mans freedom fighter is the another mans terrorist". The legal definition of terrorism (Jones, 1997) is defined by Title 22 of the US Code section 2656f(d): "The term terrorism means premeditated, politically motivated violence perpetrated against noncombatant targets by sub-national groups or clandestine agents usually intended to influence an audience". Clearly a definition that is useless in the current environment. By this definition Kobahr Towers, the World Trade Center, or the Tokyo subway attack are not terrorist acts.

It appears that much of this attention diverting debate is founded on political concerns rather than on the legitimate concerns of organizations to protect its citizens, its assets or its liberties. The structure and terminology of the definition supports an agency's desire to assume responsibility. The previous definition would support the Justice Department's bid to be the responsible agency, a more international flavor would put State in charge. As a citizen, I am concerned about being gassed, blown apart, or killed so some news program's ratings will increase.

Volumes of articles and texts have been written on the subject of terrorism and the psychology of terrorism. A significant fraction of the information discovered in government publications is a restatement of public policy concerning responses to terrorist acts. In this first discussion I provide general observations of terrorism, a later section will explore the impacts of nuclear, chemical / biological terrorism within the context of the "megaterrorist".

The dynamics of terrorism is changing from the actions and events seen in the 60's and 70's, the time of political activism and terrorist actions directed against governments and the symbols of government. The motive of acts perpetrated were predominantly politically motivated and seemed to be a tool for gathering attention or establishing a forum for articulating opinion. Since then there appears to be a continuing slide into violence, a shift in motivation and a change in the perpetrating agent. If we look at terrorism past and present is appears that terrorism can be categorized based on a number of generic principles. Political, revenge, religious, crime, and as a "fifth element" for a state entity.

Trends.

The original intent was to use agent techniques to identify trends in terrorism, to predict the form it make take and then begin to develop countermeasures. From what we find in the literature and from the data, the trends are rather obvious. The Defense Science Board study (DSB 1997) identified the need for analytic tools for use in risk assessment and threat mitigation. As a result of the obvious trends, activities of this effort were modified to explore the possibilities of using Bayesian techniques to support intelligence gathering, and performing vulnerability assessments.

The trend being observed is a trend toward greater violence, greater anonymity, greater acceptance as a nation state's tactical option, and a tool of subterfuge by criminals. We also see terrorism taking on aspects of a business, there are more free-lancers than before and there is a significant financial aspect to successful terrorist organizations.

The a significant trend in terrorism is the shift to one of the many flavors of religious terrorism (Hoffman, 1998; Cetron, 1994). This is significant because in the minds of these groups the self imposed constraints that existed in political terrorism have been abrogated by the belief that acts being committed, are some how justified by a particular god. In some cases that justification extends to a belief that non believers must be eliminated, in order for the sect to survive or to fulfil some prophesy. Also significant in this trend is the idea that these terrorists"...execute their terrorist acts for no audience but themselves" (Ranstorp, 1996), making detection and interdiction more difficult.

The dangerous aspect of this form of terrorism was articulated in a quote attributed to Hussein Mussawi, a hezbollah terrorist (Cetron 1994), "We are not fighting so that the enemy recognizes us and offers us something, We are fighting to wipe out the enemy". Another difficulty with religious terrorists are prophetic interpretations of scripture. The millennium seems to be a watershed era with many believing that in the next millennium they will somehow be granted power to rule, some sects such as AUM in Japan felt they needed to hasten this event. We also find that with religious based terrorism, there appears to be a greater longevity due in part to a larger reserve of public support to draw on (Laqueur, 1996).

A troubling trend has been the symbiotic relationship that exists between terrorists and the media. Terrorist have come to be expert "spin doctors" or public relations specialists, orchestrating acts that will draw the most attention possible. The media on the other hand are continually on the prowl for the most sensational story they can find. With the global expanse of the news media, acts perpetrated by small groups can quickly gain world attention. An expert in terrorism, Brian Jenkins has been quoted as saying ". Terrorism is theater and terrorists can now play to a global audience".

A serious aspect of this symbiosis is that fact that groups must perpetrate more and more violent or heinous acts in order to capture the attention of the media in order to make the headlines. The media needs the attention grabbing headlines to improve "ratings" so the most violent act makes the news effectively creating a spiral of increasing violence.

In Sper's thesis on terrorist organization, (Sper, 1995) she identified a dynamic of terrorism that I found interesting. In her thesis she points out that terrorist groups are dedicated to action, not rhetoric, as a result there is a balance that must be maintained between operations and individual survival. Once formed the group must perpetrate acts of violence in order to survive. She points out in her conclusions that terrorism can not succeed resulting in an internal discontent that must be offset by leaders of that group. Attempts to offset this failure requires more action and greater violence making the groups more vulnerable, beginning a downward spiral leading ultimately to its demise. While hopeful on the surface the underlying fact is that the initiation of a terrorist action must, because of the dynamics, continue and increase its acts of violence in an attempt retain supporters and to overcome the failures of the organization.

While governments have always used various means to influence the actions of other governments the demise of the Soviet empire and the emergence of a single superpower(?) has driven home the fact that conventional means of confrontation is suicidal in most situations. As a result, terrorist acts has emerged as a legitimate means of engagement against a superior power. The added benefit of these tactics is the potential difficulty in identifying an action with some nation state. State sponsored terrorism is designed more to affect policy rather than obtaining publicity. Similarly the acts are likely to be more violent because of fewer constraints that would be self imposed on some group trying to obtain public support.

Operating in parallel with this trend in legitimizing state sponsored terrorism is the emergence of "guns for hire". Individuals such as Carlos or the Japanese Red Army (JRA) have sold their services to different groups and governments. In the case of the JRA amassing a serious fortune. The combination of state sponsorship and free-lance terrorists creates a very formidable adversary. With state sponsorship comes state technologies, logistics and training sites. Independent operations may not be able to afford the latest in weapons or possess knowledge of the latest technologies but governments do.

A new form of terrorist is the one connected with crime. In the past much of the violence was perpetrated against different factions in organized crime, what we are beginning to see is the use of terror by organizations in order to maximize profit, protecting their organization or to intimidate governments (Cetron, 1994). This has manifesting itself, particularly, in the narcotics trades. Different from past criminal acts of intimidation, is the indiscriminate use of terrorist tactics.

In order to defeat an adversary it is important to understand him, to understand his capabilities, and his identity (Carter 1998). The problem with terrorism, is that achieving these objectives is not easy, it must begin with learning from the past. The remainder of this report attempts to define a method for capturing these lessons from the past and develop methods for addressing future treats.

Terrorism Model

The terrorism model depicted in figure 1 represents a very basic, data sparse representation. This model captures four basic issues; the potential target, the potential tactics that would be used, the weapons that might be employed and the terrorist group that might be involved with the act. A fifth factor is the date and location significance parameter. This model permits a very crude analysis of who and what might be attacked, as well as when and by whom. If this basic model can be expanded and additional discriminating variables added to the network the tool can be used in sifting through forensic evidence as well as performing vulnerability analyses on potential targets.

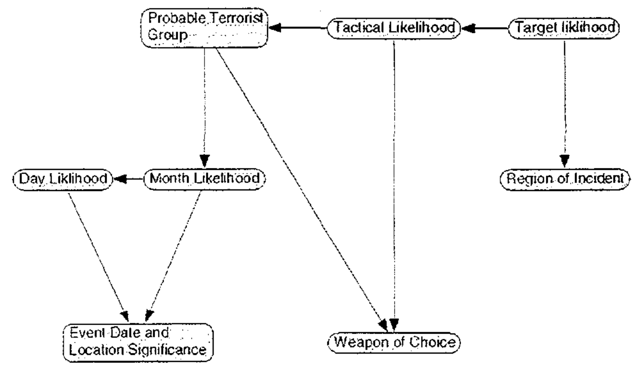

Figure 1. Baseline Bayesian network terrorism model.

The variables in this display are representative of the information found in the State Department's "Patterns of Global Terrorism". The exception is the node that is called "Event Date and Location Significance". This node was added to capture a tendency for some terrorist group to schedule events on dates or in locations of historical or religious significance. For example the embassy bombings in Africa occurred on a date that Osama Bin Laden deemed were the dates that "infidels" first set foot in Saudi Arabia during the Gulf War. The interesting aspect of the technology is the fundamental Bayesian aspects of the technology. As data is generated or otherwise identified it can be incorporated into the network resulting in the modification of the posterior probabilities distributions.

The data generated for this node was somewhat arbitrary for purposes of this analysis but could be developed by a core of historians scanning scriptures or monitoring news reports and correlating that with statements being made by known and suspected terrorists. This could then be integrated into the network to help identify a perpetrating group and to identify dates of potential significant. E.g. right wing terrorists seem to view Hitters birthday as significant and /or the attack on the Dividian complex in Waco.

Once a model is defined, distribution information must be gathered for use in populating the conditional probability distributions associated with nodes (variables) and the causal relationships of the network. This data can be any combination of experiment, expert opinion, or data gathered from information sources such as intelligence organizations, or the news media. The data populating the bulk of the model in figure 1 came from the State department reports found on the internet. After we have identified and loaded the data the Bayesian tool is used to "compile" the network which then provides us with a tool for entering evidence, performing what-if analyses or simply looking for dominant characteristics. The next edited figure shows the results of a compilation of the network defined in figure 1.

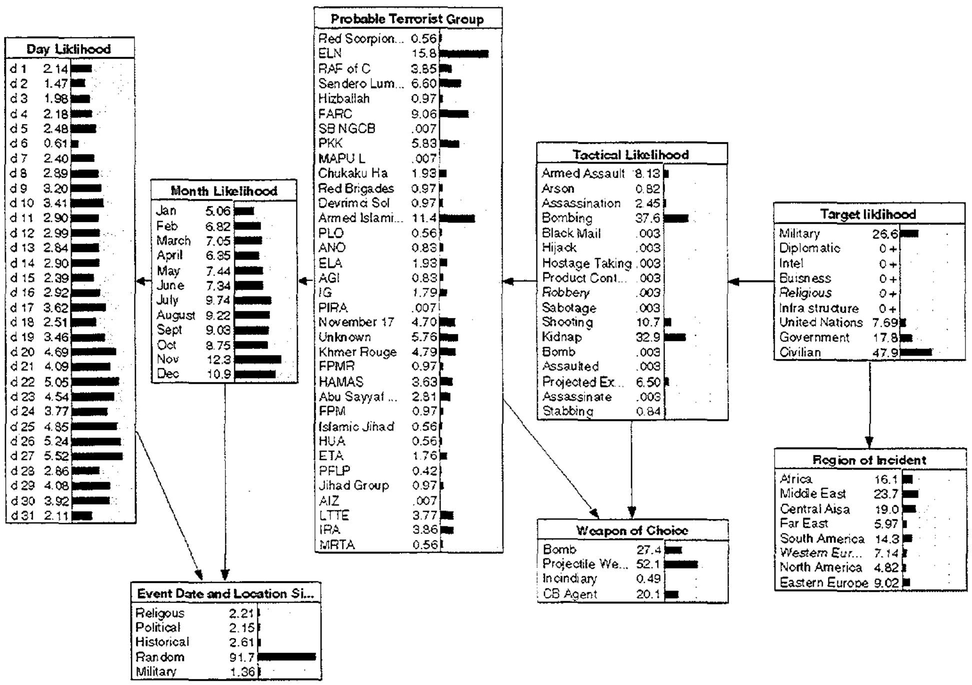

Figure 2. Compilation of the terrorist model shown in figure 1.

What we see from this graphic is a distribution over the state for each variable. Based on the data loaded into the Bayesian network we see a relatively uniform distribution of terrorist events in time, i.e. no month of day preferences. In terms of tactic employed there is a tendency to perpetrate some kind of bombing or conduct a kidnapping. We also see that nearly half of the attacks were directed against civilian targets. Additionally, we can assess group activism and global hot spots.

The nature of the Bayesian network, as it is implemented in Netica, or the Hugin model, is to permit extensive what-if type analyses. The introduction of evidence into the networks permits an analyst to explore the impact of data / information on hypothesis variables in the network. In the next couple of paragraphs a few what-if type issues are demonstrated.

This collection of information in figure 2 is interesting but could be obtained through more conventional methods. Where this approach begins to provide added benefit is when there is accumulating evidence of an action being planned. As an example, the next figure represents a situation in which there are indications that the Provisional Irish Republican Army may be planning some kind of action. By entering that as evidence in the Bayesian network The distributions change reflecting the additional evidence that was entered and the state of knowledge that results.

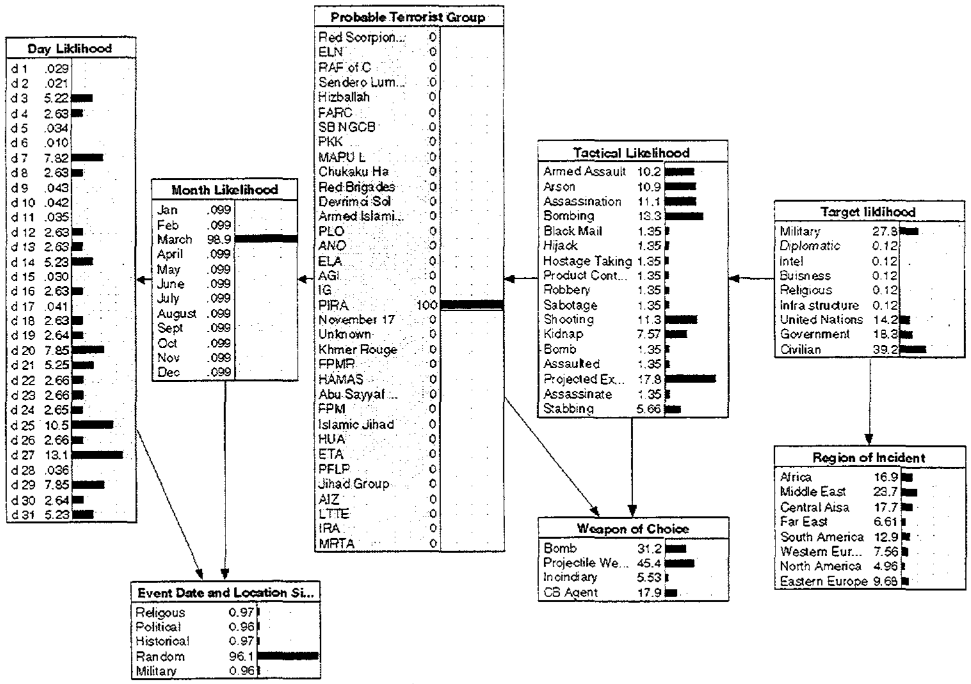

Figure 3. Entering evidence that the perpetrating group is likely to be the PIRA.

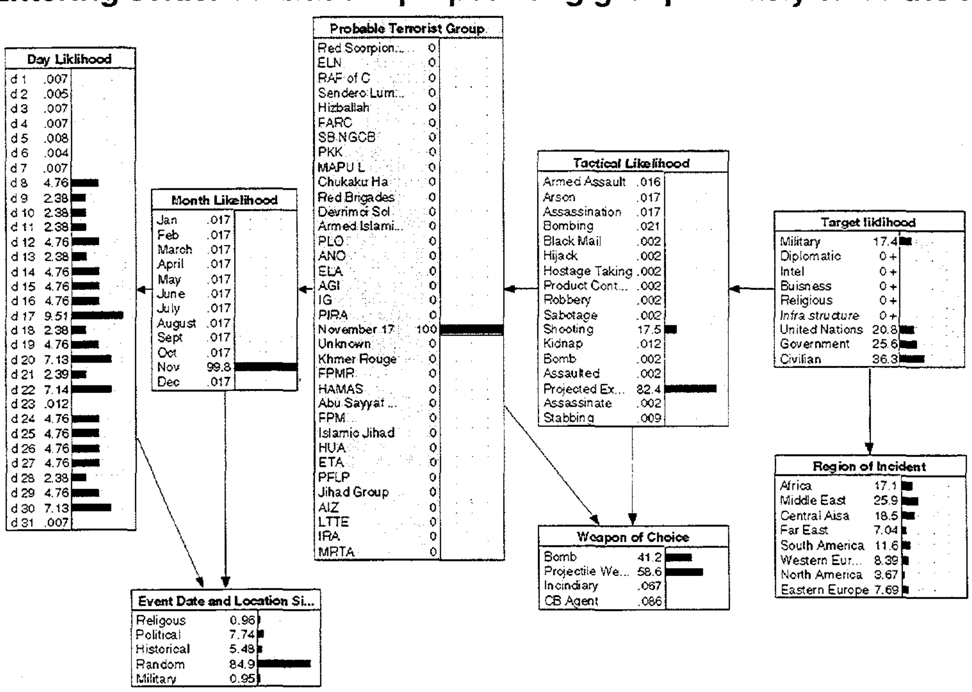

Figure 4. Evidence that the perpetrating group may be the November 17 movement.

What is interesting when using this technique is the patterns that emerge. For example in this case the data in the database indicates that the PIRA has a tendency to stage attacks in the month of March. Targets are likely to be civilian and the day in March is likely to be random. This finding may be a function of my limited input of Irish history. The situation in figure 5 reflects a situation in which there is evidence that the November 17th Movement is preparing for some type of action. The figure shows that the likelihood is that event will occur during the month of November and it will be some sort of rocket attack. The target will potentially be civilian, 36% or government, 25%.

The last example asks the question, if an attack were to occur in North America what is the potential target? The findings are that the target is likely to be military and it is likely to be a bombing incident. The timing is uniform implying that the incident could occur at any time, and that there are no real strong indicators for who would likely perpetrate the act of terror.

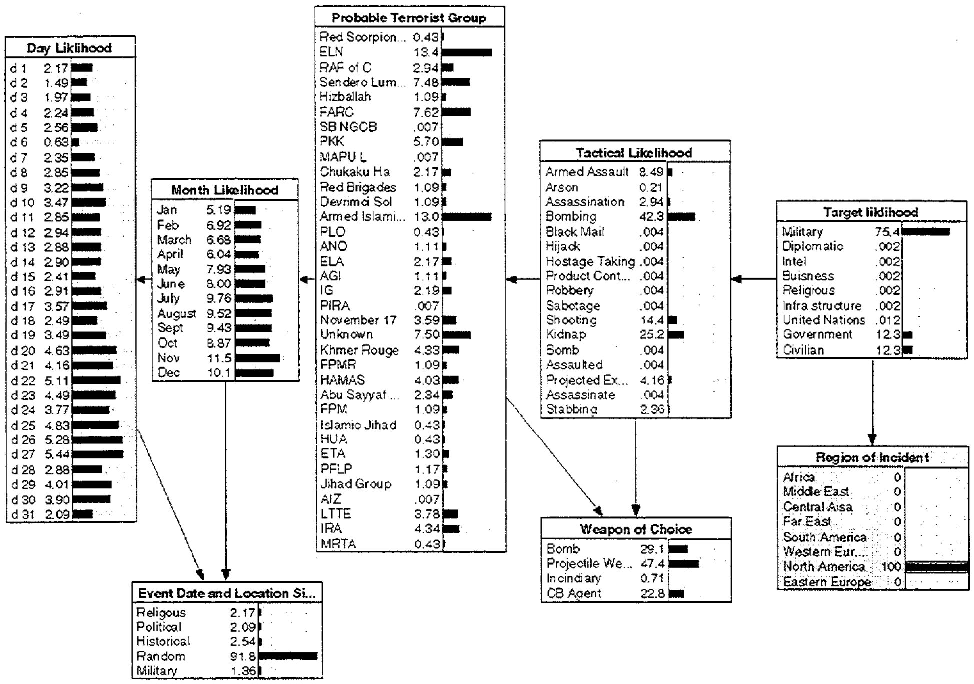

Figure 5. Exploring the type and target of an attack in North America.

What we have seen, is that even this very simple representation can provide interesting what-if analyses for a vulnerability analyst. Expanding the model provides additional fidelity and could move this methodology into a forensic regime. In this case, databases that reflect the method of bomb construction based on past occurrences could provide indicators or evidence for the group that might have instigated an attack. The information gleaned might also be used to flag the sale of special materials that a particular group likes to use in its bomb construction.

In this simple model, I have extended the model beyond what exists in the database in two ways. The first was the addition of the significance variable. This aids in vulnerability assessment by identifying target dates that may hold some special significance to some group trying to "make a statement". The second modification was defining the correlation between tactic and the type of weapon to be employed. Table 1 is a depiction of that block of information.

Table 1: Correlation between tactic and weapons utilization.

Tactic	Weap
Armed_Assault	Projectile_Weapon
Armed_Assault	Bomb
Armed_Assault	Knife
Arson	Incidary
Assassination	Bomb
Assassination	Projectile_Weapon
Assassination	CB_Agent
Bombing	Bomb
Bombing	CB_Agent
Black_Mail	CB_Agent
Black_Mail	Bomb
Hijack	Bomb
Hijack	Incidary
Hijack	Projectile_Weapon
Hostage_Taking	Projectile_Weapon
Product_Contaminati on	CB_Agent
Robbery	Projectile_Weapon
Sabotage	*
Shooting	Projectile_Weapon
Kidnap	Projectile_Weapon
Projected_Explosive	Projectile_Weapon
Projected_Explosive	Bomb
Stabbing	Knife

Basically, a "weapons expert" was tasked with defining the probability of a weapon being used in assaults, bombings, kidnappings, etc. This was entered as a separate piece of information into the Bayesian tool. This very fundamental piece of information was constructed in a flat file and then loaded into the Bayesian network as part of its "learning" function.

It is very easy to focus on a piece of information needed to test a model and load that into the network. In this case the weapons information was loaded in two phases, I first decoupled the *group* from the *weapons* choice, I then loaded the data and re-linked *group* to *weapon*. This approach was taken because I had no weapons preference data for the groups. This effectively permits the "weapons expert" information to be common to all groups and to be used as the prior distribution in the Bayesian updating algorithms. As information is acquired the probability tables will begin to diverge from that of the expert due to the Bayesian updating approach. The methodology provides a very robust approach for loading and interrogating new information into the network.

The basic model depicted up to this point can be modified or allowed to evolve without invalidating prior efforts. In the basic model of figure 1 we have allowed the lower left variable to be added to account for terrorist acts which might represent a correlations between specific dates and events that have political or religious significance. The model is also extensible into the model represented in the next figure. This model is based on a model construction approach and attempts to capture terrorist behavior from a theoretical perspective. It considers the social, and political dynamics of terrorism and defines the causality of descriptive variables, external to the databases. Data must be constructed or compiled and then processed by the Bayesian tool to populate the probability tables used in the model.

The next figure is one extension of the model depicted in figure 1. It extends the relations and variables associated with terrorism. The important aspect of this building approach is that data and linkages do not have to be discarded as we develop better understandings of the problem.

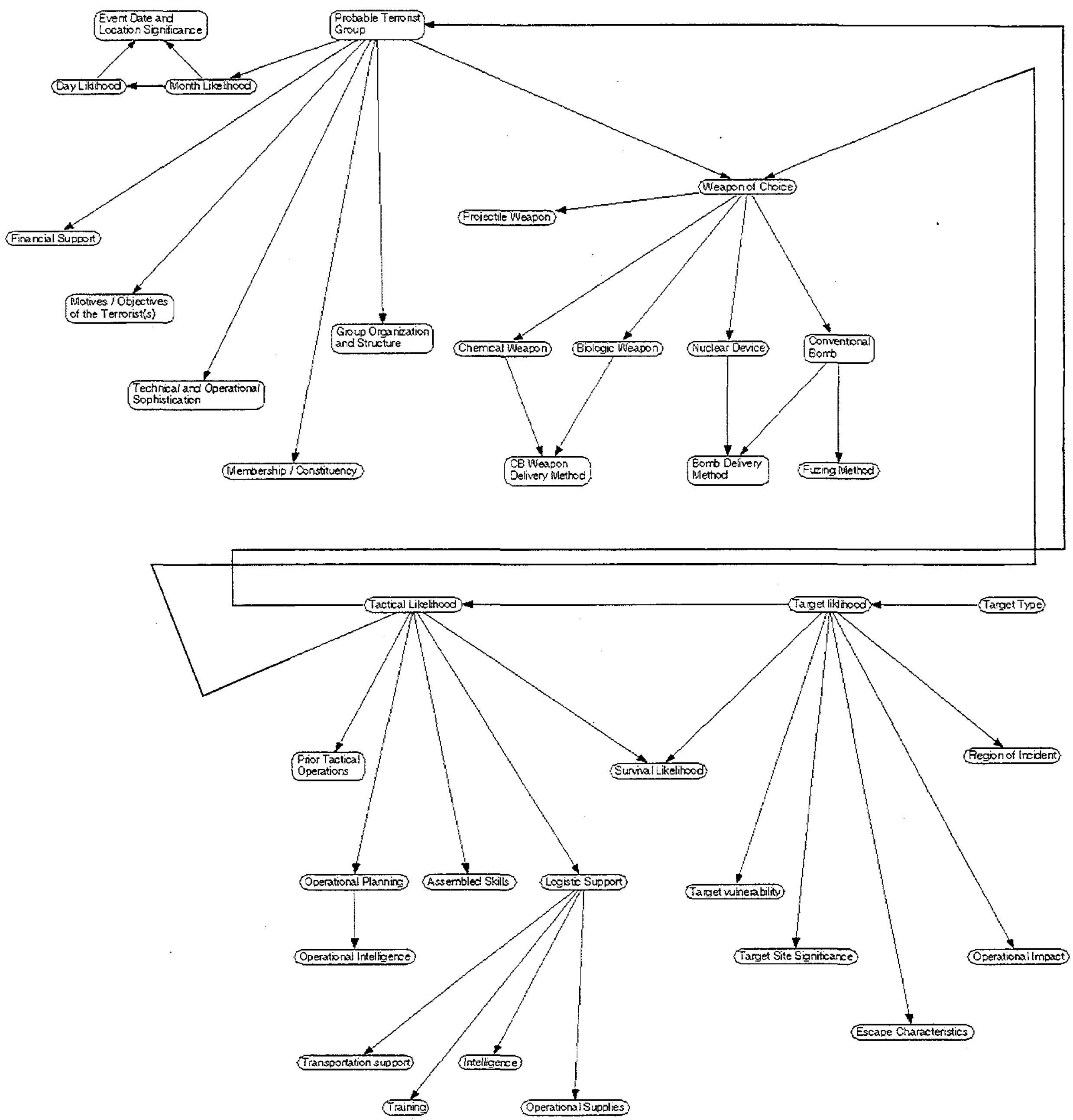

Figure 6. Expanded terrorism model founded on literature analyses.

The model depicted in figure 6 expanded the four basic variables, "*Probable Terrorist Group*", "*Tactical Likelihood*", "*Target Likelihood*", and "*Weapon Of Choice*" found in figure 1. Detail was added to "*Weapon Of Choice*" to provide a more comprehensive view of the type and scale of the potential threats. This detail would permit a vulnerability analyst to formulate better plans for mitigating an event or providing better target vulnerability assessments. The added detail would provide the designers of a embassy compound, for example, information that could be used in risk assessments associated with the design of ventilating systems to mitigate gas attacks or the geometry of window openings to mitigate or divert shock wave propagation.

The "*Tactical Likelihood*" variable expansion provides higher fidelity information that can be used to assess the mode of attack. Knowing for example that the group does not have the logistics support needed to perpetrate a chemical attack can prevent the dilution of effort needed to safeguard a facility or person.

The "*Target Likelihood*" variable expansion provides a framework for conduction detailed threat analyses. Small unit tactics can be run against classes of targets in order to build vulnerability databases that would be loaded into the network. With this information a high fidelity risk assessment might be performed on assets of US interest in order to assess the probability of an attack against the facility. Also, by knowing the vulnerability and potential attack plan, intelligence gathering can concentrate on searching for the "signature" that would indicate a particular asset may be attacked.

Parsing Algorithms

The most difficult aspect of this effort was in part a result on a misconception of developing a turn-key product that could be placed into service at the completion of the study. I did not have access to electronic databases possessing data of sufficient depth to be useful to test the mathematics. To ameliorate this problem I developed a small Java routine that will parse electronic articles, searching for specific keywords that represent states of the variables in the models. There are many indexing algorithms that search files for keywords but do not have the ability to create a structured database. The principle source of information for the parsing algorithms was the State Departments "Patterns of Global Terrorism". While sparse in incident and detail they did provide sufficient data to test the Bayesian approaches.

As we have seen in the Terrorism models, variables define characteristics or observables in the problem while states represent the possible "levels" that a variable may possess. The parsing algorithm attempts to find a particular state for each variable and then add a vector to a database for the incident being scanned. The state is searched based on state name, or an arbitrary number of aliases. The input screen for the algorithm is presented in appendix B. The Setup screen allows a user to define a directory to be searched at which point a list of files is presented and a selection of files is made by the user. The user also must define the database file name and the number of variables that will constitute each vector in the database.

At this stage two options have been enabled the first is a purely interactive options while the second is an automatic option. For the manual setup each variable is defined and the search strings for each state of that variable are defined. The problem is that for large searches this method is prone to typographical errors. As a result a second method was enabled which allows a user to construct a dataset with all search parameters defined in a flat file. For example the database that was generated and displayed in appendix A had over 75 states associated with the variable "Group". The data file used in this automatic setup is presented in Table 3 of appendix B.

The second screen of the algorithm was simply a monitoring screen to watch the progress of the parsing and database creating function. A code listing is included in appendix C.

Simulated data

In an effort to discover a method for validating the use of Bayesian methodologies on this terrorism problem I found that I could use beta distributions to approximate the high fidelity data that should reside in detailed terrorism databases. Beta distributions have a nice set of conditions that lend themselves to be used for approximating discrete state oriented data. A functional form for a Beta distributions is given in the next equation.

$$F(x) = x^b \cdot (1-x)^c \qquad \text{Eqn. 7}$$

A nice feature of this distribution is that the mean value is defined by;

$$\mu = \frac{b}{(b+c)} \qquad \text{Eqn. 8}$$

S-plus is a statistical package that I used to generate random data from a beta distribution generator. That data was filter by performing a series of binary operations to create a discrete distribution over the number of states for a variable. This permitted me to explore a number of cases in which the causality associated with a Bayesian network was unknown.

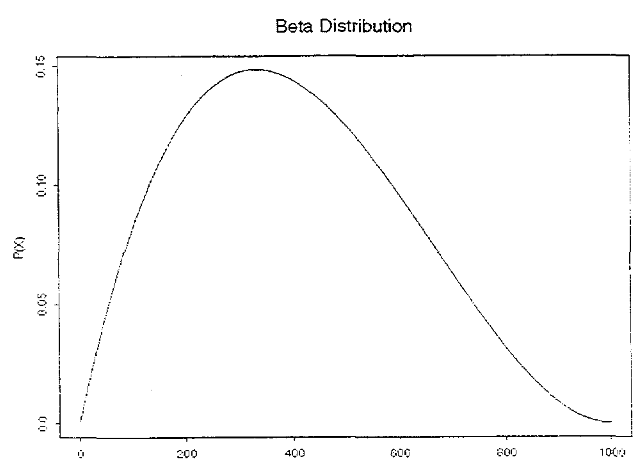

Figure 7. Beta distribution with shape factors set to 1 and 2.

Assume we have a variable being modeled that possess 10 possible states, and we want the mean to be the third state of the ten. We generate a histogram using S-plus and then perform the following scaling.

$$K = \frac{(k \cdot 9 + 0.5)}{Int(1)} + 1 \qquad \text{Eqn. 9}$$

A histogram plot of this result is displayed in the next figure. These indices are then used to identify which state to load to a database that will be used to approximate data for a variable in the Bayesian network.

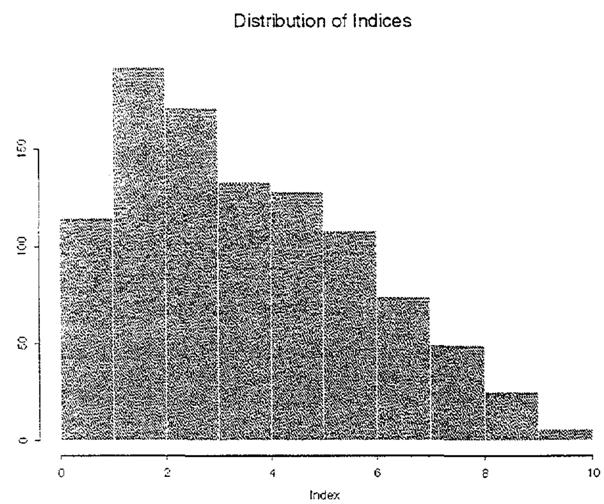

Figure 8. Plot of indices using shape factors a=1, and b=2.

A View Of The "Megaterrorist" World

LTC Jones (Jones, 1997) describes an entity called a metaterrorist as someone with global associations, educated, with a sophisticated organizational structure, technically well versed and well financed. He uses surrogates, seeks anonymity, and will attack anywhere in the world with technologies to maximize effect. Another aspect of this form of terrorism is the potential use of former STASI or KGB sleeper agents which may be located in the US and Western Europe. The bottom line is that this may be the most significant change in the character and sophistication of future terrorism.

WMD. A topic explored in the literature concerns the potential for the use of weapons of mass destruction (WMD) including nuclear, chemical and biological weapons. In Marr's thesis (Marrs, 1994) he explores the potential of nuclear weapons being used in some future terrorist act. He argues that the common perception is that nuclear terrorism is not possible because of the complexity of design or that they are inconsistent with terrorist goals. What we have seen already is that in a number of situations, a nuclear option may fit the goals perfectly.

He points out that the post cold war environment is potentially more conducive to proliferation, a fact that is obvious from recent world events in central Asia. The fall of the Soviet Empire has added the additional problems of many weapons existing in a nation that is dangerously short of economic capital, that lacks the control over the criminal elements and has many unemployed highly educated scientists that have the ability to design nuclear devices. There have already been incidents of the German government seizing black market uranium sales, to date all have been con jobs. There have also been indications that some groups have actively attempted to acquire a nuclear capability, AUM being one of these groups.

Another potential reason we may see this development is the state sponsors of terrorism. This may be a means of achieving some degree of military parity with the US. The clandestine placement of a single device in a US city would have far reaching consequences in terms of policy and public sentiment. It is unclear that such an act would be beneficial to an adversary's aims is unclear.

The other dimension of WMD is the chemical and biological aspect LeHardy (LeHardy, 1997) explores two cases of the use of WMD, the AUM sect in Tokyo, and the Rajneesh incident in Oregon and begins the exploration of the concepts of deterrence from a terrorist perspective. The point is that the WMD threshold has been crossed and it has taken lives, not as many had the events been better prepared and executed. Col. Birdsong (Birdsong, 1997) pointed out that the purity of the sarin attack in Tokyo was substandard even by AUM's standards, had it been half as pure as sarin found in military stockpiles the death toll would have reached 5000 in 5 minutes. Chemical agents often have dual uses which make their detection in early development difficult. methl parathion, an insecticide, is in the same family as sarin.

The appeal of WMD is not necessarily the killing potential, although it can be significant, is the strategic, operational, psychological and political effects it can create. As indicated in Birdsong and again by Bray (Bray, 1998), 100 Kg of anthrax spores spread from a simple crop duster over a metropolitan area like New York city could create 1,000,000 to 3,000,000 deaths. This is on the scale of a full-up nuclear device.

A final concern is the possible future of genetically engineered biological agents. While the benefits of genetic engineering have enormous potential, the threat this technology posses is also significant. Genetically engineered diseases that the human species has no defense against is a possibility. The race that must be started is the race to define a genetic "vaccine" that can defend against broad classes of unknown agents created in a laboratory (McCulloch, 1997).

Target Vulnerability Analysis. The utility of performing the agent based target vulnerability analysis was lessened as a result of the trends in international as well as aspects of domestic terrorism. Weapons of mass destruction appear to be on the near horizon. Identifying targets and assessing vulnerability takes on a different dimension as a result. WMD do not possess a targeting algorithm in the classical sense. While a bomb needs to be placed in the vicinity of the intended target, WMD are not similarly constrained. Attacking a target with CB agent might entail dispersing from neighboring structures or via an attack vector that may preserve the attackers anonymity.

Conclusions

There are a number of things that can be learned from this small effort, principle among these is the potential uses of the technology in the effort to assess the vulnerability of US assets to terrorist actions. Bayesian networks allow the analyst to bring together information from a number of disciplines and explore traditional as well as new relationships of that information. The simple model that was examined in this effort provided an environment to explore these causal relationships of variables in an effort to garner a better understanding of terrorism.

The completeness of the databases used to populate a Bayesian network aids in the fidelity and accuracy of the information being sought. The technology permits multifaceted information to be used in a complementary manner. The opinion of weapons experts can be coupled to detailed forensic evidence, sociology, as well as intelligence gathered in the field to provide a predictive tool for doing vulnerability assessments.

The original intent was to use agent based analytical techniques in conjunction with Bayesian networks to evolve patterns of terrorism that might emerge in the near future. The literature searches needed to populate the baseline terrorism models provided insights on these trends that mitigated the sophisticated analytical requirements for predicting trends. The effort did uncover a very interesting capability of Bayesian networks for being used in risk or vulnerability assessments. The simple examples demonstrated the potential of this technology for performing vulnerability assessments. This capability can be significantly expanded through a series of concentrated efforts in specialized fields and integrating the results of the efforts into a Bayesian network.

One area that could greatly aid in these assessments is the utilization of small unit tactical models to identify tactics that could defeat the defenses of the targeted asset. Use of a computational environment such as ISSAC or SWarrior, could be used to statistically determine the difficulties of defeating a potential target's defenses. Coupling this information with an enhanced tactical database could provide a very respectable threat awareness capability for use by security elements. High value targets could perform assessments identifying the limited sets of tactics that could be employed and potentially identifying the groups most likely to initiate the tactic. With that information and information characterizing group patterns a "signature" might be identified and monitored.

A great deal more work could be expended in developing a working terrorist assessment tool, including specialists with special operations skills, organizational dynamists, sociologists, historians, and weapons experts. The technology will probably not be as useful in the area of WMD for the reason that targets take on a different character than that of an embassy or apartment complex. Vulnerability assessments in this regime depend more on the information gathering and interdiction capabilities. The strength of the method is the fact that the tool can be deployed in a graded manner. Complete sets of information are not required before useful information can be obtained from a Bayesian tool.

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APPENDIX A **State Department Inspired Database**

The database that follows is a compilation of US State Department terrorism significant events. The table was generated by the parsing algorithm created for this effort. A description of the algorithm can be found in the next appendix, along with appropriate data files. The " * " found in various locations indicates a lack of specific variable information.

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
Jan	d_9	CY1992	Central_Aisa	United_Nations	Shooting	*	Killed
March	d_18	CY1992	Far_East	Government	Kidnap	Red_Scorpion_Group	*
Nov	d_30	CY1992	South_America	*	Kidnap	ELN	*
March	d_21	CY1992	South_America	*	Kidnap	RAF_of_C	*
Feb	d_11	CY1992	South_America	*	*	Sendero_Luminoso	Killed
March	d_7	CY1992	Central_Aisa	*	Bombing	*	*
March	d_29	CY1992	South_America	*	Bombing	Hizballah	*
March	d_20	CY1992	Middle_East	*	Armed_Assault	*	*
March	d_27	CY1992	South_America	*	Bombing	FARC	Killed
April	d_22	CY1992	*	*	*	*	*
April	d_23	CY1992	Central_Aisa	Civilian	Bombing	*	*
May	d_20	CY1992	Central_Aisa	*	Armed_Assault	*	Wounded
June	d_10	CY1992	South_America	Civilian	Shooting	*	Wounded
June	d_14	CY1992	Central_Aisa	*	*	*	Killed
July	d_4	CY1992	Western_Europe	*	Bombing	*	*
July	d_19	CY1992	Middle_East	*	*	*	Killed
July	d_8	CY1992	Middle_East	Military	Projected_Expl	*	Wounded
July	d_15	CY1992	Middle_East	*	Armed_Assault	*	*
July	d_17	CY1992	Middle_East	United_Nations	Assassination	*	*
July	d_20	CY1992	Middle_East	Military	Bombing	*	*
July	d_21	CY1992	South_America	*	Bombing	Sendero_Luminoso	Wounded
July	d_24	CY1992	South_America	*	Bombing	*	Wounded
August	d_4	CY1992	Western_Europe	*	Stabbing	*	Killed
August	d_26	CY1992	Africa	*	Bombing	*	*
Sept	d_10	CY1992	South_America	Civilian	*	SB_NGCB	Wounded
Sept	d_9	CY1992	Central_Aisa	*	Armed_Assault	PKK	*
Sept	d_17	CY1992	Central_Aisa	*	Assassination	*	*
Oct	d_2	CY1992	South_America	*	Assassination	Sendero_Luminoso	*
Oct	d_12	CY1992	North_America	Military	Stabbing	*	Wounded
Oct	d_21	CY1992	Middle_East	Civilian	Armed_Assault	*	Killed
Oct	d_23	CY1992	South_America	Military	Kidnap	FARC	Killed
Nov	d_16	CY1992	Middle_East	United_Nations	Bombing	*	Killed
Dec	d_7	CY1992	Middle_East	*	Shooting	*	Killed
Dec	d_25	CY1992	Africa	Military	Bombing	*	Wounded

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
Dec	d_28	CY1992	South_America	*	Bombing	Sendero_Luminoso	Wounded
Dec	d_29	CY1992	Africa	Military	Bombing	*	Killed
Jan	d_9	CY1998	Middle_East	*	Kidnap	*	*
June	d_24	CY1998	Eastern_Europe	*	Kidnap	*	*
Jan	d_14	CY1998	Middle_East	*	*	*	*
Jan	d_21	CY1998	Middle_East	*	*	*	*
Jan	d_25	CY1998	Central_Aisa	*	Armed_Assault	*	*
Feb	d_8	CY1998	Western_Europe	*	Kidnap	*	*
Feb	d_25	CY1998	Middle_East	Civilian	Kidnap	*	*
Feb	d_31	CY1998	Eastern_Europe	Military	*	*	Killed
Feb	d_19	CY1998	Middle_East	*	Kidnap	*	*
May	d_21	CY1998	Central_Aisa	*	Shooting	*	Killed
March	d_25	CY1998	Africa	*	Kidnap	*	*
March	d_14	CY1998	South_America	Civilian	Kidnap	RAF_of_C	*
Sept	d_21	CY1998	South_America	*	Kidnap	FARC	*
March	d_27	CY1998	*	*	Kidnap	*	*
June	d_27	CY1998	Africa	*	Kidnap	FARC	Killed
March	d_25	CY1998	South_America	*	Bombing	*	Wounded
April	d_10	CY1998	*	*	*	Armed_Islamic_Group	Killed
May	d_4	CY1998	Africa	Civilian	*	*	Wounded
April	d_12	CY1998	Central_Aisa	Civilian	Bombing	PKK	Wounded
April	d_24	CY1998	Africa	*	*	*	*
April	d_21	CY1998	Far_East	Government	Armed_Assault	Khmer_Rouge	Wounded
April	d_29	CY1998	Central_Aisa	*	Armed_Assault	*	*
April	d_23	CY1998	South_America	*	Kidnap	*	*
April	d_24	CY1998	Africa	*	Kidnap	*	Killed
April	d_23	CY1998	Middle_East	*	Kidnap	*	*
April	d_26	CY1998	North_America	*	Bombing	*	Killed
July	d_25	CY1998	South_America	*	Kidnap	PLO	*
April	*	CY1998	Africa	*	Kidnap	*	*
May	d_1	CY1998	Central_Aisa	*	Bombing	*	*
May	d_4	CY1998	Central_Aisa	*	*	*	Killed
May	d_5	CY1998	Central_Aisa	*	*	*	Killed
May	d_6	CY1998	Central_Aisa	*	*	*	Killed
May	d_16	CY1998	Central_Aisa	*	Kidnap	*	Killed
May	d_19	CY1998	Africa	United_Nations	Armed_Assault	*	Wounded
May	d_22	CY1998	Africa	Government	*	*	*
May	d_23	CY1998	Central_Aisa	*	Bombing	*	Wounded
June	d_26	CY1998	South_America	*	Kidnap	FARC	*

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
May	d_27	CY1998	South_America	*	Bombing	ELN	*
June	d_19	CY1998	Central_Aisa	Military	Bombing	*	*
June	d_3	CY1998	Central_Aisa	Civilian	Kidnap	PKK	*
June	d_23	CY1998	Central_Aisa	*	Bombing	*	Wounded
June	d_21	CY1998	Middle_East	Civilian	Kidnap	*	Killed
June	d_25	CY1998	Central_Aisa	*	Armed_Assault	*	*
June	d_21	CY1998	North_America	*	*	Unknown	*
June	d_23	CY1998	Central_Aisa	*	Bombing	*	*
July	d_25	CY1998	Africa	*	Kidnap	FARC	*
June	d_28	CY1998	Central_Aisa	*	Bombing	*	Killed
July	d_8	CY1998	Africa	United_Nations	Projected_Expl	*	Killed
July	d_14	CY1998	South_America	*	Kidnap	FARC	*
July	d_17	CY1998	Central_Aisa	Government	Projected_Expl	*	*
July	d_28	CY1998	South_America	Civilian	Kidnap	*	*
July	d_20	CY1998	Eastern_Europe	Military	*	*	Killed
July	d_22	CY1998	Middle_East	*	*	ANO	*
July	d_24	CY1998	Central_Aisa	Military	Bombing	*	*
July	d_25	CY1998	Eastern_Europe	*	Shooting	*	Killed
July	d_26	CY1998	Central_Aisa	*	Bombing	*	*
July	d_28	CY1998	Central_Aisa	*	Shooting	*	Killed
August	d_1	CY1998	Western_Europe	Military	Bombing	IRA	*
August	d_26	CY1998	Central_Aisa	*	Projected_Expl	*	Wounded
August	d_13	CY1998	Africa	Government	Bombing	*	*
August	d_10	CY1998	Central_Aisa	*	Projected_Expl	*	*
August	d_19	CY1998	*	Military	*	Unknown	*
August	d_21	CY1998	Central_Aisa	Civilian	Bombing	LTTE	*
August	d_29	CY1998	Western_Europe	*	Bombing	IRA	*
August	d_25	CY1998	Africa	Civilian	Projected_Expl	*	*
August	d_29	CY1998	*	*	Arson	*	*
Sept	d_15	CY1998	Central_Aisa	Civilian	*	*	*
Sept	d_30	CY1998	Far_East	*	Projected_Expl	Abu_Sayyaf_Group	*
Dec	d_23	CY1998	Far_East	*	Kidnap	Abu_Sayyaf_Group	*
Sept	d_21	CY1998	Eastern_Europe	Military	*	*	Wounded
Sept	d_22	CY1998	Central_Aisa	Civilian	Kidnap	FARC	Wounded
Sept	d_29	CY1998	South_America	*	Bombing	*	*
Dec	d_20	CY1998	Eastern_Europe	*	Kidnap	*	*
Oct	d_5	CY1998	South_America	*	Kidnap	*	*
Oct	d_10	CY1998	Central_Aisa	*	Bombing	*	*
Oct	d_13	CY1998	Central_Aisa	*	Projected_Expl	*	*

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
Oct	d_9	CY1998	Central_Aisa	*	*	*	Wounded
Oct	d_20	CY1998	South_America	*	Kidnap	*	*
Oct	d_19	CY1998	South_America	Civilian	Bombing	ELN	*
Oct	d_26	CY1999	South_America	*	*	ELN	*
Oct	d_29	CY1998	Middle_East	*	Kidnap	*	*
Nov	d_18	CY1998	Africa	*	Armed_Assault	*	Wounded
Nov	d_14	CY1998	Central_Aisa	*	Projected_Expl	*	Wounded
Nov	d_21	CY1999	Africa	*	Kidnap	*	*
Nov	d_17	CY1998	Central_Aisa	Civilian	Projected_Expl	November_17	Wounded
Nov	d_24	CY1998	Middle_East	*	Bombing	*	Killed
Nov	d_25	CY1998	Central_Aisa	*	Projected_Expl	*	*
Nov	d_30	CY1998	Africa	Military	Armed_Assault	*	Wounded
Dec	d_8	CY1998	South_America	*	Kidnap	ELN	*
Dec	d_30	CY1998	Middle_East	Civilian	Kidnap	*	*
Dec	d_7	CY1998	Western_Europe	*	*	*	*
Dec	d_8	CY1998	South_America	*	Kidnap	FARC	*
Dec	d_20	CY1998	Central_Aisa	United_Nations	Projected_Expl	*	Wounded
Dec	d_23	CY1998	Central_Aisa	Government	*	*	*
Dec	d_26	CY1999	Africa	Government	Shooting	*	*
Dec	d_29	CY1998	North_America	Civilian	Kidnap	Islamic_Jihad	Killed
Jan	d_22	CY1993	South_America	Civilian	Bombing	*	Killed
Jan	d_24	CY1993	Central_Aisa	*	Bombing	*	Killed
Jan	d_30	CY1993	Central_Aisa	*	Projected_Expl	*	*
Jan	d_28	CY1993	South_America	*	Bombing	*	*
Dec	d_31	CY1993	South_America	*	Kidnap	FARC	*
Feb	d_4	CY1993	Middle_East	Civilian	Bombing	*	*
Dec	d_23	CY1993	South_America	*	Kidnap	ELN	*
Feb	d_26	CY1993	North_America	*	Bombing	*	Killed
Feb	d_26	CY1993	North_America	*	Bombing	*	Killed
March	d_3	CY1993	Eastern_Europe	*	Bombing	*	*
March	d_7	CY1993	Western_Europe	*	*	*	*
March	d_25	CY1993	South_America	*	Kidnap	*	*
March	d_16	CY1993	Western_Europe	*	Shooting	*	Killed
March	d_22	CY1993	Middle_East	Government	Shooting	*	Killed
April	d_15	CY1993	Central_Aisa	Government	Assassination	*	*
April	d_20	CY1993	Middle_East	*	Assassination	*	Wounded
May	d_13	CY1993	South_America	*	*	MAPU_L	*
May	d_19	CY1993	South_America	*	Bombing	Sendero_Luminoso	*
June	d_8	CY1993	Middle_East	Civilian	Bombing	*	Killed

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
June	d_22	CY1993	Middle_East	Civilian	Bombing	*	Killed
June	d_30	CY1993	Western_Europe	Government	*	PKK	*
June	d_28	CY1993	Central_Aisa	Civilian	*	PKK	*
July	d_1	CY1993	Far_East	Military	*	*	*
July	d_9	CY1993	Far_East	United_Nations	Bombing	Chukaku_Ha	*
July	d_7	CY1993	South_America	Civilian	*	Sendero_Luminoso	*
July	d_7	CY1993	Far_East	*	*	*	*
Oct	d_19	CY1993	Central_Aisa	Civilian	Kidnap	PKK	*
July	d_25	CY1993	Central_Aisa	*	Bombing	*	Wounded
July	d_27	CY1993	South_America	Civilian	Bombing	*	*
August	d_18	CY1993	Central_Aisa	Civilian	*	*	*
August	d_18	CY1993	Middle_East	*	Bombing	*	Killed
Sept	d_25	CY1993	Central_Aisa	*	Kidnap	*	*
August	d_28	CY1993	Central_Aisa	*	Assassination	*	*
Sept	d_2	CY1993	Western_Europe	Military	*	Red_Brigades	*
Sept	d_9	CY1993	South_America	*	Bombing	Devrimci_Sol	*
Sept	d_20	CY1993	Africa	*	Kidnap	*	*
Sept	d_26	CY1993	Middle_East	United_Nations	Bombing	*	*
Oct	d_11	CY1993	Western_Europe	*	Shooting	*	Wounded
Oct	d_16	CY1993	Africa	Military	Shooting	*	Killed
Oct	d_26	CY1993	Africa	*	Kidnap	Armed_Islamic_Group	*
Oct	d_30	CY1993	Africa	*	Kidnap	Armed_Islamic_Group	*
Oct	d_24	CY1993	Western_Europe	*	*	PLO	*
Oct	d_28	CY1993	Africa	*	*	*	Killed
Oct	d_25	CY1993	South_America	Civilian	Bombing	*	Killed
Oct	d_29	CY1993	Western_Europe	*	*	*	Wounded
Nov	d_20	CY1993	Western_Europe	Government	*	PKK	Killed
Nov	d_8	CY1993	Central_Aisa	*	*	Hizballah	Wounded
Nov	d_14	CY1993	Far_East	*	Kidnap	*	*
Nov	d_20	CY1993	South_America	*	Bombing	*	*
Nov	d_25	CY1993	Middle_East	*	*	*	Killed
Nov	d_29	CY1993	Middle_East	*	Shooting	*	Wounded
Dec	d_2	CY1993	Africa	*	Shooting	*	Killed
Dec	d_4	CY1993	Africa	*	Shooting	*	Wounded
Dec	d_5	CY1993	Africa	*	Shooting	*	Killed
Dec	d_7	CY1993	Africa	*	Shooting	*	Killed
Dec	d_7	CY1993	Africa	*	Shooting	*	Killed
Dec	d_12	CY1993	Middle_East	*	*	*	Killed
Dec	d_11	CY1993	Middle_East	Civilian	Kidnap	*	*

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
Dec	d_13	CY1993	Middle_East	*	Bombing	*	Killed
Dec	d_16	CY1993	Africa	*	Armed_Assault	Armed_Islamic_Group	Killed
Dec	d_27	CY1993	Middle_East	Civilian	Bombing	*	Wounded
Dec	d_29	CY1993	Africa	*	*	*	*
Jan	d_4	CY1994	Central_Aisa	*	*	*	*
Jan	d_9	CY1994	Central_Aisa	*	*	*	Wounded
Jan	d_10	CY1994	Western_Europe	*	Bombing	Red_Brigades	*
Jan	d_11	CY1994	South_America	*	Bombing	Sendero_Luminoso	*
Jan	d_14	CY1994	South_America	*	Kidnap	ELN	*
Jan	d_29	CY1994	Middle_East	Government	Shooting	ANO	Killed
Feb	d_2	CY1994	Eastern_Europe	*	*	*	*
Feb	d_3	CY1994	Western_Europe	Military	Bombing	ELA	Wounded
Feb	d_19	CY1994	Middle_East	*	*	AGI	Wounded
Feb	d_23	CY1994	Middle_East	Civilian	Bombing	IG	Wounded
March	d_4	CY1994	Middle_East	Civilian	*	IG	Wounded
March	*	CY1994	Western_Europe	*	*	PIRA	*
March	d_13	CY1994	Middle_East	*	Projected_Expl	*	*
March	d_24	CY1994	Central_Aisa	Civilian	Bombing	*	Wounded
March	d_27	CY1994	Central_Aisa	Civilian	Bombing	PKK	*
March	d_29	CY1994	Middle_East	United_Nations	*	*	Wounded
April	d_1	CY1994	South_America	*	Kidnap	RAF_of_C	*
April	d_17	CY1994	Central_Aisa	Civilian	Bombing	*	Killed
April	d_3	CY1994	Middle_East	*	*	*	Killed
April	d_8	CY1994	Central_Aisa	Civilian	Bombing	*	*
Nov	d_17	CY1994	Western_Europe	*	*	November_17	*
April	d_13	CY1994	Middle_East	*	*	*	*
April	d_27	CY1994	Africa	*	Bombing	*	*
May	d_8	CY1994	Africa	Civilian	Shooting	Armed_Islamic_Group	Killed
Nov	d_17	CY1994	Western_Europe	*	Projected_Expl	November_17	*
May	d_29	CY1994	Middle_East	*	Shooting	Unknown	Killed
June	d_17	CY1994	Africa	*	*	*	*
June	d_10	CY1994	Central_Aisa	Civilian	*	PKK	Killed
June	d_22	CY1994	Central_Aisa	*	*	*	Wounded
June	d_24	CY1994	Western_Europe	*	Bombing	ELA	*
July	d_4	CY1994	Western_Europe	*	*	*	Killed
July	d_11	CY1994	Western_Europe	Civilian	Bombing	*	*
July	d_18	CY1994	South_America	*	Bombing	*	Wounded
July	d_21	CY1994	South_America	Civilian	*	*	*
July	d_23	CY1994	North_America	*	Stabbing	Unknown	Wounded

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
July	d_26	CY1994	Far_East	*	Armed_Assault	Khmer_Rouge	*
July	d_27	CY1994	Western_Europe	*	Bombing	*	Wounded
August	d_3	CY1994	Africa	*	Armed_Assault	Armed_Islamic_Group	Killed
August	d_22	CY1994	Central_Aisa	*	Kidnap	PKK	*
August	d_12	CY1994	Central_Aisa	Government	Bombing	PKK	Wounded
August	d_18	CY1994	South_America	*	Bombing	FPMR	*
August	d_26	CY1994	Africa	*	Kidnap	*	*
August	d_30	CY1994	Far_East	*	*	*	*
Sept	d_23	CY1994	South_America	*	Kidnap	RAF_of_C	*
Sept	d_27	CY1994	Middle_East	Civilian	*	IG	Killed
Oct	d_14	CY1994	North_America	*	Armed_Assault	HAMAS	Killed
Oct	d_30	CY1994	Africa	Military	Armed_Assault	Armed_Islamic_Group	*
Oct	d_23	CY1994	Middle_East	Civilian	Shooting	IG	Killed
Dec	d_11	CY1994	Far_East	*	Bombing	Abu_Sayyaf_Group	Killed
Dec	d_12	CY1994	Central_Aisa	*	Bombing	*	Wounded
Dec	d_26	CY1994	Africa	Civilian	*	Armed_Islamic_Group	Killed
Dec	d_25	CY1994	Middle_East	*	*	HAMAS	Wounded
Dec	d_27	CY1994	Africa	*	*	Armed_Islamic_Group	*
Jan	d_8	CY1995	Africa	Civilian	*	Armed_Islamic_Group	Killed
Jan	d_12	CY1995	Middle_East	Civilian	*	AGI	*
Jan	d_15	CY1995	Far_East	Civilian	Projected_Expl	Khmer_Rouge	Killed
Jan	d_18	CY1995	South_America	*	Kidnap	*	*
Jan	d_18	CY1995	Africa	*	Kidnap	*	*
Jan	d_22	CY1995	Africa	*	Shooting	*	Killed
Jan	d_24	CY1995	Western_Europe	*	Shooting	*	Killed
Jan	d_25	CY1995	Africa	*	*	*	*
Jan	d_26	CY1995	South_America	*	Kidnap	ELN	Killed
Jan	d_31	CY1995	South_America	*	Kidnap	*	*
Feb	d_14	CY1995	Central_Aisa	*	Shooting	*	Killed
Feb	d_24	CY1995	Middle_East	*	Shooting	*	Wounded
Feb	d_27	CY1995	Western_Europe	Government	*	*	*
Feb	d_28	CY1995	South_America	*	*	*	*
March	d_3	CY1995	Africa	*	*	Armed_Islamic_Group	*
March	d_8	CY1995	Central_Aisa	*	*	*	Wounded
March	d_27	CY1995	Middle_East	*	*	*	*
March	d_31	CY1995	Middle_East	Civilian	*	Hizballah	Killed
April	d_5	CY1995	South_America	*	Bombing	FPM	*
April	d_9	CY1995	North_America	*	*	Islamic_Jihad	*
April	d_9	CY1995	Eastern_Europe	Military	Armed_Assault	*	*

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
April	d_19	CY1995	South_America	*	Kidnap	ELN	Killed
April	d_21	CY1995	Central_Aisa	*	Bombing	*	Killed
April	d_22	CY1995	Western_Europe	*	Shooting	*	*
April	d_29	CY1995	Africa	*	*	*	Killed
May	d_5	CY1995	Africa	Civilian	Armed_Assault	Armed_Islamic_Group	Killed
May	d_5	CY1995	Middle_East	*	*	Hizballah	Wounded
May	d_7	CY1995	Africa	Military	*	*	Killed
May	d_15	CY1995	South_America	*	*	Sendero_Luminoso	*
May	d_22	CY1995	South_America	*	*	*	*
May	d_23	CY1995	Africa	*	*	*	*
May	d_30	CY1995	Africa	Civilian	Bombing	Sendero_Luminoso	*
May	d_31	CY1995	South_America	*	Kidnap	ELN	*
June	d_5	CY1995	South_America	Government	Kidnap	*	*
June	d_7	CY1995	Africa	*	Shooting	Armed_Islamic_Group	Killed
August	d_24	CY1995	South_America	*	*	Unknown	*
July	d_25	CY1995	Central_Aisa	*	Kidnap	*	*
June	d_26	CY1995	Africa	Military	Shooting	AGI	Killed
July	d_3	CY1995	Western_Europe	*	*	*	*
August	d_13	CY1995	Central_Aisa	Government	Kidnap	HUA	Killed
July	d_11	CY1995	Western_Europe	*	Assassination	Armed_Islamic_Group	*
July	d_17	CY1995	Central_Aisa	Civilian	Kidnap	*	*
July	d_25	CY1995	Western_Europe	*	Bombing	*	Wounded
August	d_5	CY1995	Western_Europe	*	Bombing	*	*
August	d_10	CY1995	Western_Europe	*	*	*	*
August	d_19	CY1995	South_America	Government	Kidnap	*	*
August	d_25	CY1995	Western_Europe	*	Bombing	*	Wounded
August	d_20	CY1995	Western_Europe	*	*	*	*
August	d_21	CY1995	North_America	Military	Bombing	HAMAS	Wounded
August	d_24	CY1995	Central_Aisa	*	Bombing	*	*
August	d_27	CY1995	Western_Europe	*	Arson	ETA	*
Sept	d_22	CY1995	South_America	*	Kidnap	*	*
Sept	d_1	CY1995	South_America	*	*	RAF_of_C	*
Sept	d_2	CY1995	Africa	*	Shooting	Armed_Islamic_Group	Killed
Sept	d_3	CY1995	Africa	*	Shooting	Armed_Islamic_Group	Killed
Sept	d_5	CY1995	Middle_East	*	Stabbing	PFLP	Wounded
Sept	d_20	CY1995	Western_Europe	Civilian	Arson	*	*
Sept	d_10	CY1995	Central_Aisa	*	Bombing	*	Wounded
Sept	d_13	CY1995	Eastern_Europe	*	Projected_Expl	*	*
Sept	d_20	CY1995	Western_Europe	*	*	*	*

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
Sept	d_21	CY1995	Western_Europe	*	*	*	*
Oct	d_13	CY1995	South_America	*	Bombing	*	Wounded
Oct	d_29	CY1995	Eastern_Europe	*	Bombing	*	*
Oct	d_20	CY1995	Central_Aisa	*	Bombing	*	*
Oct	d_27	CY1995	Africa	Military	Kidnap	*	Killed
Nov	d_8	CY1995	Middle_East	*	*	*	*
Nov	d_9	CY1995	Africa	*	*	Armed_Islamic_Group	*
Nov	d_10	CY1995	Western_Europe	*	*	Unknown	*
Nov	d_13	CY1995	North_America	Military	Bombing	*	Killed
Nov	d_15	CY1995	Western_Europe	*	Shooting	*	Killed
Nov	d_19	CY1995	Far_East	Military	Bombing	Chukaku_Ha	*
Nov	d_19	CY1995	Central_Aisa	*	Bombing	Jihad_Group	*
Nov	d_22	CY1995	Central_Aisa	*	Bombing	*	Wounded
Nov	d_30	CY1995	Africa	*	Shooting	Armed_Islamic_Group	Killed
Dec	d_9	CY1995	Western_Europe	Government	*	ETA	*
Dec	d_10	CY1995	South_America	*	Kidnap	FARC	Killed
Dec	d_11	CY1995	Western_Europe	United_Nations	*	*	Wounded
Dec	d_16	CY1995	Western_Europe	*	*	ETA	Wounded
Dec	d_23	CY1995	Western_Europe	*	Bombing	*	*
Dec	d_27	CY1995	*	*	*	AIZ	*
Dec	d_31	CY1995	Far_East	Government	Kidnap	*	*
Dec	d_30	CY1995	Western_Europe	*	Bombing	Armed_Islamic_Group	*
Jan	d_1	CY1996	Middle_East	United_Nations	*	*	*
May	d_26	CY1996	Far_East	Military	*	*	*
Jan	d_19	CY1996	Eastern_Europe	*	*	*	Killed
March	d_20	CY1996	Africa	Civilian	Bombing	*	Wounded
Jan	d_22	CY1996	South_America	*	Kidnap	RAF_of_C	*
Jan	d_29	CY1996	Middle_East	Civilian	Kidnap	*	*
Jan	d_31	CY1996	Central_Aisa	Civilian	Bombing	LTTE	Wounded
Feb	d_6	CY1996	South_America	*	Kidnap	ELN	*
Feb	d_9	CY1996	Western_Europe	*	Bombing	IRA	Wounded
Feb	d_11	CY1996	Middle_East	Civilian	Bombing	*	*
Nov	d_17	CY1996	Western_Europe	Government	Projected_Expl	November_17	*
Feb	d_16	CY1996	South_America	*	Kidnap	ELN	*
Feb	d_17	CY1996	South_America	*	*	ELN	Killed
April	d_20	CY1996	Central_Aisa	*	*	*	*
Feb	d_26	CY1996	North_America	*	Bombing	HAMAS	*
March	d_19	CY1996	Middle_East	*	*	HAMAS	*
March	d_20	CY1996	North_America	*	*	Islamic_Jihad	*

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
March	d_14	CY1996	Middle_East	*	*	*	*
March	d_23	CY1996	South_America	Civilian	*	ELN	Killed
March	d_26	CY1996	Far_East	Military	*	Khmer_Rouge	Killed
May	d_27	CY1996	Africa	*	Kidnap	Armed_Islamic_Group	Killed
March	d_31	CY1996	South_America	*	Kidnap	*	Killed
April	d_18	CY1996	Middle_East	Civilian	*	IG	*
April	d_24	CY1996	Eastern_Europe	*	Bombing	*	*
May	d_5	CY1996	Central_Aisa	*	*	*	Killed
May	d_9	CY1996	Far_East	*	Kidnap	Khmer_Rouge	*
May	d_13	CY1996	Middle_East	*	*	HAMAS	Wounded
May	d_16	CY1996	South_America	Government	Bombing	Sendero_Luminoso	*
May	d_28	CY1996	Western_Europe	*	Bombing	*	Killed
May	d_31	CY1996	South_America	*	Kidnap	*	*
June	d_4	CY1996	Eastern_Europe	*	Shooting	*	Killed
June	d_10	CY1996	South_America	*	*	ELN	Killed
June	d_9	CY1996	Middle_East	*	*	PFLP	*
June	d_15	CY1996	Western_Europe	Civilian	Bombing	IRA	Wounded
June	d_25	CY1996	North_America	Military	Bombing	*	Wounded
June	d_27	CY1996	Eastern_Europe	*	Bombing	*	*
July	d_8	CY1996	Africa	*	*	*	Wounded
July	d_12	CY1996	Western_Europe	*	Kidnap	*	*
July	d_14	CY1996	South_America	*	Kidnap	ELN	*
July	d_20	CY1996	Western_Europe	*	Bombing	ETA	Wounded
July	d_24	CY1996	Central_Aisa	*	*	*	*
July	d_26	CY1996	Eastern_Europe	Military	Shooting	*	Wounded
August	d_1	CY1996	Africa	*	Bombing	Armed_Islamic_Group	*
August	d_17	CY1996	Eastern_Europe	Civilian	Bombing	*	Killed
August	d_9	CY1996	South_America	*	Kidnap	*	*
August	d_10	CY1996	South_America	*	Kidnap	ELN	*
August	d_11	CY1996	Africa	Military	*	*	Killed
August	d_14	CY1996	Central_Aisa	*	Kidnap	ELN	*
August	d_15	CY1996	Eastern_Europe	*	*	*	Wounded
August	d_28	CY1996	Africa	*	Kidnap	*	*
August	d_21	CY1996	South_America	Civilian	Kidnap	*	*
August	d_25	CY1996	Middle_East	*	Shooting	*	Wounded
August	d_27	CY1996	Western_Europe	*	Shooting	*	*
Sept	d_11	CY1996	Middle_East	Government	*	*	*
Sept	d_13	CY1996	Middle_East	Government	Kidnap	*	*
Sept	d_14	CY1996	South_America	Military	*	ELN	Wounded

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
Oct	d_1	CY1996	Eastern_Europe	*	Armed_Assault	*	Killed
Oct	d_5	CY1996	Africa	*	Shooting	*	Killed
Oct	d_10	CY1996	South_America	*	Kidnap	ELN	*
Oct	d_16	CY1996	Africa	*	Shooting	Unknown	Killed
Nov	d_26	CY1996	Far_East	Government	*	Khmer_Rouge	*
Oct	d_24	CY1996	Africa	*	Armed_Assault	*	Wounded
Oct	d_26	CY1996	South_America	Military	Assassination	ELN	Killed
Dec	d_9	CY1996	Africa	*	Kidnap	*	*
Nov	d_12	CY1996	Middle_East	*	*	*	*
Nov	d_15	CY1996	Africa	*	*	*	*
Nov	d_22	CY1996	Central_Aisa	Civilian	*	November_17	*
Dec	d_3	CY1996	Western_Europe	*	Bombing	*	Wounded
Dec	d_28	CY1996	Eastern_Europe	United_Nations	Armed_Assault	*	*
Dec	d_11	CY1996	South_America	*	Kidnap	RAF_of_C	Killed
Dec	d_17	CY1996	Eastern_Europe	Government	Kidnap	MRTA	Wounded
Dec	d_23	CY1996	Eastern_Europe	Military	*	*	*
Dec	d_27	CY1996	Africa	Civilian	*	Unknown	Killed
Dec	d_31	CY1996	Middle_East	*	*	*	*
Jan	d_2	CY1997	Eastern_Europe	*	Shooting	*	Killed
Jan	*	CY1997	Western_Europe	*	Bombing	*	*
May	d_4	CY1997	Eastern_Europe	Military	Bombing	*	Wounded
Jan	d_5	CY1997	Africa	*	Bombing	*	*
Jan	d_18	CY1997	Africa	*	Shooting	*	Killed
Jan	d_19	CY1997	Eastern_Europe	*	Kidnap	*	*
Jan	d_20	CY1997	Eastern_Europe	*	*	*	*
Jan	d_21	CY1997	Middle_East	Government	Kidnap	*	*
Jan	d_23	CY1997	Eastern_Europe	Military	Shooting	*	Killed
Feb	d_2	CY1997	Africa	*	Shooting	*	Killed
Feb	d_17	CY1997	Eastern_Europe	Military	Kidnap	*	Killed
Feb	*	CY1997	Eastern_Europe	*	Kidnap	*	*
March	d_7	CY1997	South_America	Military	Kidnap	RAF_of_C	Killed
Feb	d_8	CY1997	Africa	Government	Kidnap	*	*
Feb	d_11	CY1997	Africa	Civilian	*	*	Wounded
Feb	d_12	CY1997	South_America	*	Kidnap	*	*
Feb	d_22	CY1997	South_America	*	Kidnap	FARC	*
Feb	d_22	CY1997	South_America	*	Kidnap	*	*
Feb	d_20	CY1997	Central_Aisa	*	Kidnap	ELN	Killed
Feb	d_21	CY1997	Eastern_Europe	*	*	*	Killed
Feb	d_22	CY1997	Eastern_Europe	Military	*	*	Wounded

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
April	d_23	CY1997	Eastern_Europe	*	Kidnap	*	*
Feb	d_23	CY1997	South_America	Civilian	*	*	Wounded
Feb	d_24	CY1997	South_America	*	Kidnap	ELN	*
March	d_12	CY1997	Middle_East	Civilian	Kidnap	*	*
Nov	d_16	CY1997	South_America	*	Kidnap	FARC	*
March	d_21	CY1997	Western_Europe	*	*	*	*
March	d_27	CY1997	Africa	*	*	*	*
March	d_25	CY1997	Western_Europe	*	*	PKK	*
April	d_27	CY1997	Middle_East	Civilian	Kidnap	*	Killed
March	d_29	CY1997	South_America	*	Kidnap	*	*
March	d_30	CY1997	Far_East	*	*	Unknown	Wounded
April	d_1	CY1997	South_America	*	*	ELN	Killed
April	d_3	CY1997	Africa	*	*	*	*
April	d_27	CY1997	South_America	Civilian	Bombing	FARC	*
April	d_23	CY1997	Eastern_Europe	Civilian	*	*	*
April	d_22	CY1997	Far_East	*	Armed_Assault	Khmer_Rouge	Wounded
April	d_27	CY1997	Far_East	*	Armed_Assault	Khmer_Rouge	Wounded
April	d_28	CY1997	Eastern_Europe	*	Kidnap	*	*
Oct	d_15	CY1997	South_America	*	Kidnap	ELN	*
May	d_16	CY1997	South_America	*	Kidnap	ELN	Killed
June	d_13	CY1997	Middle_East	*	Arson	*	*
June	d_17	CY1997	Eastern_Europe	*	*	*	Wounded
June	d_22	CY1997	Africa	*	*	Armed_Islamic_Group	Killed
July	d_27	CY1997	South_America	Civilian	Kidnap	ELN	*
July	d_1	CY1997	Central_Aisa	*	Kidnap	LTTE	*
July	d_6	CY1997	Middle_East	*	Arson	*	*
July	d_12	CY1997	Central_Aisa	Civilian	*	LTTE	*
Sept	d_12	CY1997	North_America	Military	Bombing	Unknown	Wounded
July	d_19	CY1997	South_America	*	Kidnap	ELN	*
July	d_30	CY1997	South_America	*	Kidnap	*	*
July	d_26	CY1997	Middle_East	Civilian	Kidnap	Unknown	*
July	d_30	CY1997	South_America	Military	Bombing	ELN	Wounded
August	d_10	CY1997	Middle_East	Civilian	Kidnap	*	*
August	d_7	CY1997	South_America	*	Armed_Assault	*	*
August	d_15	CY1997	Middle_East	Civilian	Kidnap	*	*
August	d_14	CY1997	Middle_East	Civilian	Kidnap	*	*
August	d_30	CY1997	South_America	*	Kidnap	ELN	*
Sept	d_12	CY1997	North_America	Military	Bombing	HAMAS	Killed
Sept	d_26	CY1997	Central_Aisa	Civilian	Armed_Assault	LTTE	Killed

Table 2: US state Department's "Patterns of Global Terrorism" based table

Month	Day	Year	Location	Target	Tactic	Group	Result
Sept	d_16	CY1997	Eastern_Europe	Military	Kidnap	*	*
Sept	d_18	CY1997	Middle_East	Civilian	Armed_Assault	*	Wounded
Sept	d_22	CY1997	Middle_East	Military	Shooting	Unknown	Wounded
Oct	d_1	CY1997	Central_Aisa	*	*	*	*
Oct	d_16	CY1997	Central_Aisa	*	Kidnap	PKK	*
Oct	d_30	CY1997	Central_Aisa	Civilian	Kidnap	LTTE	Wounded
Oct	d_22	CY1997	Middle_East	Government	Kidnap	*	*
Nov	d_28	CY1997	South_America	Military	Kidnap	ELN	*
Nov	d_27	CY1997	Far_East	*	Kidnap	*	*
Oct	d_29	CY1997	Africa	Government	*	*	*
Oct	d_30	CY1997	North_America	Government	Kidnap	*	*
Oct	d_31	CY1997	Africa	*	*	Unknown	*
Nov	d_11	CY1997	South_America	*	Kidnap	Unknown	*
Nov	d_12	CY1997	Central_Aisa	Civilian	Kidnap	FARC	*
Nov	d_26	CY1997	Middle_East	Civilian	Shooting	November_17	Killed
Nov	d_29	CY1997	Eastern_Europe	*	Kidnap	*	*
Nov	d_20	CY1997	Middle_East	*	Shooting	Unknown	Killed
Nov	d_24	CY1997	Africa	United_Nations	Kidnap	*	*
Nov	d_22	CY1997	Africa	*	*	*	Killed
Nov	d_27	CY1997	North_America	*	Kidnap	*	*
Dec	d_10	CY1997	Central_Aisa	Civilian	Bombing	*	*
Dec	d_18	CY1997	Africa	*	Kidnap	*	*
Dec	d_17	CY1997	*	*	Kidnap	*	*
Dec	d_18	CY1997	South_America	*	Kidnap	ELN	*
Dec	d_23	CY1997	Central_Aisa	*	*	*	Wounded

APPENDIX B Parsing Algorithm.

The parsing algorithm had to reflect the structure of information being sought in terrorist modeling effort. That structure consisted of a set of states with an associated variable. The search would scan for a state name or alias and if found store the state descriptor at the appropriate location in a record to be added to the database. The parsing algorithm was structured to handle two situations. The first case was a fully interactive version that allowed a researcher to enter all variables and associated states and the second option read variables and states from a flat file. This second method became the preferred option for this problem as it enhanced the developmental aspects of the search and the number of states associated with terrorist groups would have made manual entry prone to typographical errors.

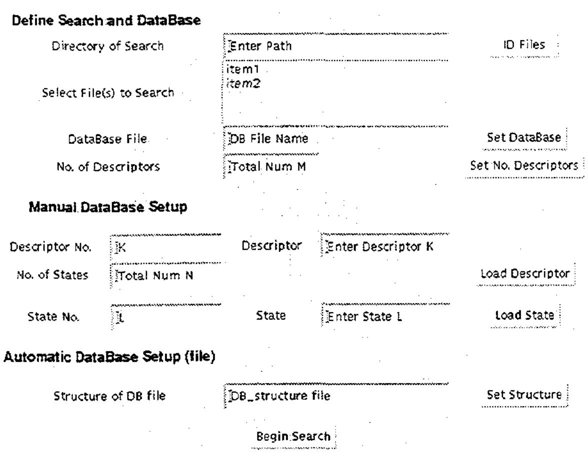

Figure 9. Setup screen for the parsing function.

The JAVA code representative of the parsing algorithm is presented in Appendix C. Screen shots of the code are presented in figures 9 and 10, followed by the input dataset used in this effort.

This next shot represents a view of the parsing algorithm, during the execution of the code.

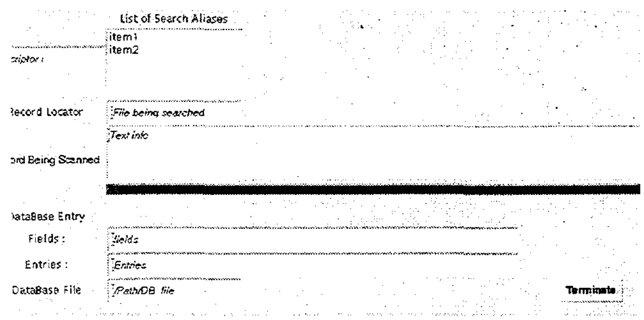

Figure 10. Execution screen that displays parsing actions.

The amount of information that had to be entered to perform the parsing on the US State Departments information reports necessitated a flat file input implementation. The data used for parsing these data sources is presented in the table below.

Table 3: Input data set for terrorism parsing algorithm.

Variable	State
Month	Jan:January, Feb:February, March, April, May, June, July, August, Sept:September, Oct:October, Nov:November, Dec:December
Day	_1:1 , _2:2 , _3:3 , _4:4 , _5:5 , _6:6 , _7:7 , _8:8 , _9:9 , _10:10 , _11:11 , _12:12 , _13:13 , _14:14 , _15:15 , _16:16 , _17:17 , _18:18 , _19:19 , _20:20 , _21:21 , _22:22 , _23:23 , _24:24 , _25:25 , _26:26 , _27:27 , _28:28 , _29:29 , _30:30 , _31:31
Year	CY1990:1990, CY1991:1991, CY1992:1992, CY1993:1993, CY1994:1994, CY1995:1995, CY1996:1996, CY1997:1997, CY1998:1998, CY1999:1999

Table 3: Input data set for terrorism parsing algorithm.

Variable	State
Location	Middle East:Iraq:Israel:Jerusalem:West Bank:Egypt:Jordan:Yemen:Lebanon:Bahrain:Gaza Strip:Saudi Arabia, North America:United States:U.S.:America:US:Mexico:Cuba, Western Europe:Germany:Austria:Norway:Switzerland:Spain:France:Italy:Ireland:Greece:United Kingdom:UK:Netherlands, South America:Panama:Chile:Colombia:Argentina:Costa Rica:Peru:Honduras:Nicaragua:Ecuador:Venezuela, Far East:Japan:Philippines:Cambodia:Indonesia, Central Aisa:Sri Lanka:Iran:Kuwait:Pakistan:India:Turkey:Afghanastan, Africa:Rwanda:Moroco:Somalia:Ethiopia:Kenya:South Africa:Algeria:Uganda:Sierra Leone:Angola:Sudan:Eritrea:Nigeria, Eastern Europe:Yugoslavia:Azerbaijan:Georgia:Russia:Croatia:Poland:Tajikistan:Bosnia:Herzegovina
Target	United Nations:UN, Government:diplomatic:embassay:ambassador:official, Civilian:hotel:plant:pipeline:ship:airplane:flight:refinery:bridge:rail:railroad:nightclub:tourist:tourists:priests, Military:base:soldier:soldiers:convoy:barracks:depot
Tactic	Shooting:shot:shoot:gunfire:automatic weapon:handgun, Bombing:bomb:bombed:explosion:truck bomb:truck-bomb, Kidnap:Kidnapped:kidnapping:hostage, Armed_Assault:Assaulted:attacked, Projected Explosive:Grenade:rocket:RPG:motar, Assassination:Assassinate:assassinated, Stabbing:Knifed:stabbed, WMD:chemical agent:biological agent:bio agent:chem bio:nerve gas, Arson:Arsonists:Arsonist, Contamination:contaminate:Poision:adulterate
Group	Osama Bin Laden, Unknown, ANO:Abu Nidal Organization, Abu Sayyaf Group:ASG, AGI:Al-Gama'at al-Islamiyya, Al-Jihad, ABB:Alex Boncayao Brigade, AIIB:Anti-Imperialist International Brigade, Arab Revolutionary Brigades, Arab Revolutionary Council, Armed Islamic Group, Aum Shinrikyo, AUM:Aum Supreme Truth, ETA:Basque Fatherland and Liberty, Black September, DFLP:Democratic Front for the Liberation of Palestine, Dev Sol, Devrimci Sol:Revolutionary Left, DHKP_C, Ellalan Force, Euzkadi:Euzkadi Ta Askatasuna, Fatah_RC:Fatah Revolutionary Council, FACT:Federation of Associations of Canadian Tamils, HAMAS:Islamic Resistance Movement, HUA:Harakat ul-Ansar, Hizballah:Party of God, IRA:Irish Republican Army, IG:The Islamic Group, Islamic Jihad, IG for the LP:Islamic Jihad for the Liberation of Palestine, Jamaat:Jamaat ul-Fuqra, JRA:Japanese Red Army, Jihad Group, Kach, Kahane Chai, Khmer Rouge, PKK:Kurdistan Workers Party, LTTE:The Liberation Tigers of Tamil Eelam, FPMR:Manuel Rodriguez Patriotic Front, MEK_MKO:The Mujahedin-e Khalq Organization:MEK:MKO, MEK:Muslim Iranian Students Society:MEK, ELN_Columbia:National Liberation Army, NLA:The National Liberation Army of Iran:MEK, New Jihad Group, NPA:New People's Army, Org of Oppressed:Organization of the Oppressed on Earth, PLF:Palestine Liberation Front, PIJ:Palestinian Islamic Jihad, PDK:Party of Democratic Kampuchea, PMOI:The People's Mujahedin of Iran, PFLP:Popular Front for the Liberation of Palestine, PFLP-GC:Popular Front for the Liberation of Palestine-General Command, PIRA:Provisional Irish Republican Army, FARC:The Provos, RAF of C:Revolutionary Armed Forces of Colombia, RJO:Revolutionary Justice Organization, November 17:17 November:Revolutionary Organization 17 November, ROSM:Revolutionary Organization of Socialist Muslims, DHKP_C:Revolutionary People's Liberation Party/Front, ELA:Revolutionary People's Struggle, Sendero Luminoso:Shining Path:SL, Sikh Terrorism, Talaa:Talaa'al-Fateh, MRTA:Tupac Amaru Revolutionary Movement, Vanguards of Conquest, WTA:World Tamil Association, WTM:World Tamil Movement, October_3rd Org:3rd October Organization, May_15 Org:15 May Organization, Asifa:Al-'Asifa, Al_Fatah:Al-Fatah , Algerian Terrorism, ASALA:Armenian Secret Army for the Liberation of Armenia, Chukaku_Ha:Chukaku-Ha:Nucleus or Middle Core Faction, Force 17, FRPL:Lautaro Popular Rebel Forces, Lautaro Youth Movement:MJL, FPM:Morazanist Patriotic Front, ELN:National Liberation Army:Nestor Paz Zamora Commission:CNPZ, The Orly Group, PLO:Palestine Liberation Organization, PFLP_SC:Popular Front for the Liberation of Palestine-Special Command, PSF:Popular Struggle Front, Puka Inti:Sol Rojo:Red Sun, Red Army Faction:RAF, Red Brigades:BR, Sol Rojo, EGTK:Tupac Katari Guerrilla Army, MAPU_L:United Popular Action Movement, Red Scorpion Group, SB_NGCB:Simon Bolivar National Guerrilla Coordinating Board, AIZ:Anti-Imperialist Cell
Consequence	Wounded:injured:wounding, Killed:kill

The colons (:) in the file are characters triggering an alias representation, and the comma (,) seperateds states for each variable being sought.

APPENDIX C **Java code for the Parsing algorithms.**

The lists that follow are code listings for the essential part of the parsing algorithm developed for this project. The two files included consist of the "main program" and the file containing the functionality of the parsing algorithm. The three other files comprising the routine are not included since they were created by the Java Workshop (JWS) tool and do not directly relate to the parsing code.

Main Program

```
/**
 * This file was automatically generated.  Do not manually modify this file.
 *
 * Runtime vendor: SunSoft, Inc.
 * Runtime version: 1.0
 *
 * Visual vendor: SunSoft, Inc.
 * Visual version: 1.0
 */



import sunsoft.jws.visual.rt.base.Group;
import sunsoft.jws.visual.rt.base.MainHelper;
import java.applet.Applet;

/**
 * Generated Main class
 *
 * @version 1.20, 05/21/96
 */
public class DB_BuildMain extends Applet {
  /**
   * Helper class for the generated main class.  This variable is only
   * used when we are running as an applet.
   */
  private MainHelper helper;

  /**
   * Called when application is run from the command line.
   */
  public static void main(String args[]) {
    MainHelper helper = new MainHelper();
    helper.checkVersion(1.0);

    Group group = new DB_Build();
    helper.main(group, args);
  }

  /**
   * Called when the applet is loaded.
   */
  public void init() {
    helper = new MainHelper();
    helper.checkVersion(1.0);

    Group group = new DB_Build();
    helper.init(this, group);
  }

  /**
```

```
 * Called whenever the applet's page is visited.
 */
public void start(){
  helper.start();
}

/**
 * Called by the browser when the user leaves the page.
 */
public void stop() {
  helper.stop();
}

/**
 * Called by the browser when the applet should be destroyed.
 */
public void destroy() {
  helper.destroy();
}
}
```

DataBase Build Class

```
/**
 * This is a template.  You may modify this file.
 *
 * Runtime vendor: SunSoft, Inc.
 * Runtime version: 1.0
 *
 * Visual vendor: SunSoft, Inc.
 * Visual version: 1.0
 */


import sunsoft.jws.visual.rt.base.*;
import sunsoft.jws.visual.rt.type.*;
import sunsoft.jws.visual.rt.shadow.java.awt.*;
import java.awt.*;
import java.io.*;

import java.util.*;

public class DB_Build extends Group {
 int Desc_max=0;
 int St_max=0;
 int total_descriptors, total_states;
 String dir_Item, file_Item, db_Item;
 String Descript[];
 String States[][];
 String[] fnames;

 private DataInputStream is = null;
 private DB_BuildRoot gui;
 private FileWriter DBout ;

 /**
  * Sample method call ordering during a group's lifetime:
  *
  * Constructor
  * initRoot
  * initGroup
  * (setOnGroup and getOnGroup may be called at any time in any
  *  order after initGroup has been called)
  * createGroup
  * showGroup/hideGroup + startGroup/stopGroup
  * destroyGroup
  */

 /**
  * All the attributes used by the group must be defined in the
  * constructor.  setOnGroup is called at initialization for all
  * the attributes.  If the attribute has not been set prior to
  * initialization, setOnGroup is called with the default value.
  */
```

```
public DB_Build() {
  /**
   * Define the group's custom attributes here.
   *
   * For example:
   *
   * attributes.add("customString", "java.lang.String",
   *      "Default String", 0);
   */

  /**
   * This method defines the attributes that will be forwarded to
   * the main child (either a window or a panel).  All attributes
   * defined by this method are marked with the FORWARD flag.
   */
  addForwardedAttributes();
}

/**
 * initRoot must be overridden in group subclasses to initialize
 * the shadow tree.  The return value must be the root of the
 * newly initialized shadow tree.
 */
protected Root initRoot() {
  /**
   * Initialize the gui components
   */
  gui = new DB_BuildRoot(this);

  /**
   * This method registers an attribute manager with the group, such
   * that attributes marked with the FORWARD flag will be sent to
   * this attribute manager.
   */
  addAttributeForward(gui.getMainChild());

  return gui;
}

/**
 * initGroup is called during initialization.  It is called just after
 * initRoot is called, but before the sub-groups are initialized and
 * before the attributes are sent to the setOnGroup method.
 *
 * initGroup is only called once in the lifetime of the Group.
 * This is because groups cannot be uninitialized.  Anything that
 * needs to be cleaned up should be created in createGroup instead
 * of initGroup, and then can be cleaned up in destroyGroup.
 * createGroup and destroyGroup may be called multiple times during
 * the lifetime of a group.
 */
protected void initGroup() { }
```

```
/**
 * showGroup may be overridden by group subclasses that want
 * to know when the group becomes visible. It is called just before
 * the group becomes visible. The group will already be initialized
 * and created at this point.
 */
protected void showGroup() { }

/**
 * hideGroup may be overridden by group subclasses that want
 * to know when the group becomes non-visible. It is called just
 * before the group becomes non-visible.
 */
protected void hideGroup() { }

/**
 * createGroup is called during group creation. Groups can be
 * created and destroyed multiple times during their lifetime.
 * Anything that is created in createGroup should be cleaned up
 * in destroyGroup. createGroup is called just after the group
 * has been created. Anything that needs to be done before the
 * group is created should be done in initGroup.
 */
protected void createGroup() { }

/**
 * destroyGroup is called during the destroy operation. Groups can
 * be created and destroyed multiple times during their lifetime.
 * Anything that has been created in createGroup should be cleaned up
 * in destroyGroup. destroyGroup is called just before the group
 * is destroyed.
 */
protected void destroyGroup() { }

/**
 * This method may be overridden by group subclasses that want
 * to be informed when the application is starting. This method is
 * only called after the entire application has been initialized and
 * created.
 *
 * For applets, startGroup is called whenever start is called on the
 * applet.
 */
protected void startGroup() { }

/**
 * This method may be overridden by group subclasses that want
 * to be informed when the application is stopping. This method
 * will be called before a destroy is done.
 *
 * For applets, stopGroup is called whenever stop is called on the
```

```
 * applet.
 */
protected void stopGroup() { }

/**
 * "getOnGroup" may be overridden by sub-groups that
 * store attribute values themselves, and do not depend on the
 * group superclass to store them.  This method should be overridden
 * instead of "get".  Any attributes handled in setOnGroup where
 * super.setOnGroup is not called must also be handled in getOnGroup.
 *
 * The default implementation of getOnGroup retrieves the value
 * from the attribute table.
 *
 * The reason that "getOnGroup" should be overridden instead
 * of "get" is that "getOnGroup" is guaranteed not to be called
 * until the group class is initialized.  This means that initRoot
 * will always be called before any calls to getOnGroup are made.
 *
 * Also, this method is only for attributes that are defined in the
 * sub-groups.  It is not called for forwarded attributes.
 */
protected Object getOnGroup(String key) {
  return super.getOnGroup(key);
}

/**
 * "setOnGroup" may be overridden by sub-groups that
 * want notification when attributes are changed.  This method
 * should be overridden instead of "set".  Any attributes handled
 * in setOnGroup where super.setOnGroup is not called must also be
 * handled in getOnGroup.
 *
 * The default implementation of setOnGroup puts the value
 * in the attribute table.
 *
 * The reason that "setOnGroup" should be overridden instead
 * of "set" is that "setOnGroup" is guaranteed not to be called
 * until the group class is initialized.  This means that initRoot
 * will always be called before any calls to setOnGroup are made.
 *
 * During initialization, "setOnGroup" will be called for all
 * the group's attributes even if they have not be changed from
 * the default value.  But for attributes that have the DEFAULT
 * flag set, "setOnGroup" will only be called if the value
 * of the attribute has changed from the default.
 *
 * Also, this method is only called when attributes defined in the
 * sub-groups are updated.  It is not called for forwarded attributes.
 */
protected void setOnGroup(String key, Object value) {
  super.setOnGroup(key, value);
```

```
}

/**
 * handleMessage may be overridden by subclasses that want to act
 * on messages that are sent to the group. Typically, messages are
 * either AWT events that have been translated to messages, or they
 * are messages that have been sent by other groups.
 * super.handleMessage should be called for any messages that aren't
 * handled. If super.handleMessage is not called, then handleEvent
 * will not be called.
 *
 * The default implementation of handleMessage returns "true". This
 * means that no events will be passed up the group tree, unless a
 * subclass overrides this method to return "false". AWT events are
 * not propagated regardless of the return value from handleEvent.
 *
 * If you want a message to go to the parent group, override
 * handleMessage to return false for that message.
 *
 * If you want an AWT event to go to the parent group, you need to
 * call postMessageToParent() with the event message.
 */
public boolean handleMessage(Message msg) {
  return super.handleMessage(msg);
}

/**
 * handleEvent may be overridden by subclasses that want to get
 * notified when AWT events that are sent by the gui components.
 * The return value should be true for handled events, and
 * super.handleEvent should be called for unhandled events.
 * If super.handleEvent is not called, then the specific event
 * handling methods will not be called.
 *
 * The message's target is set to the shadow that sent the event.
 * The event's target is set to the AWT component that sent the event.
 *
 *
 * The following specific event handling methods may also be overridden:
 *
 * public boolean mouseDown(Message msg, Event evt, int x, int y);
 * public boolean mouseDrag(Message msg, Event evt, int x, int y);
 * public boolean mouseUp(Message msg, Event evt, int x, int y);
 * public boolean mouseMove(Message msg, Event evt, int x, int y);
 * public boolean mouseEnter(Message msg, Event evt, int x, int y);
 * public boolean mouseExit(Message msg, Event evt, int x, int y);
 * public boolean keyDown(Message msg, Event evt, int key);
 * public boolean keyUp(Message msg, Event evt, int key);
 * public boolean action(Message msg, Event evt, Object what);
 * public boolean gotFocus(Message msg, Event evt, Object what);
 * public boolean lostFocus(Message msg, Event evt, Object what);
 */
```

```
 public boolean handleEvent(Message msg, Event evt) {
  return super.handleEvent(msg, evt);
 }

/**
  Identify the directory in which the files to be parsed reside
**/
 public void ID_File_search(Message msg, Event evt) {
  dir_Item = (String)gui.DoS_val.get("text");
  System.out.println( "Directory : "+dir_Item );

  Scan_Dir();
  gui.list1.set( "items", fnames );
  return;
  }

 public void Scan_Dir( ) {
  File f = new File( dir_Item );
  if( !f.isDirectory() )
System.out.println( dir_Item+" is not a directory");

  fnames = f.list();
  int len = fnames.length;
  return;
  }

/**
  Select from a scrolling list the files to include in the parsed database
**/
 public void PickFile_Action(Message msg, Event evt) {
  fnames = (String[])gui.list1.get( "selectedItems" );
  System.out.print( "files selected : " );
  for( int k=0;k<fnames.length; k++ )
System.out.print( fnames[k]+" ");
  System.out.println(" :");
  return;
  }

/**
  High level action that sets the database
**/
 public void Set_DataBase(Message msg, Event evt) {
  db_Item = (String)gui.DBFile_val.get("text");
  System.out.println( "DataBase : "+db_Item );
  /* Open the database file for write operations */
try
  {
  DBout = new FileWriter(dir_Item+"/"+db_Item);
  }
catch ( IOException e )
  {
  System.out.println( "Problem with database allocation" );
```

```
  }
   return;
  }

/**
  High level manual action that sets the number of decsriptors
  to be included in the database
**/
 public void Set_No_Desc(Message msg, Event evt) {
  String tmp = (String) gui.NoD_val.get("text");
  Integer CVT;
  total_descriptors = CVT.parseInt( tmp ) ;
  System.out.print( "Num of Descriptors = "+total_descriptors+ "\n");

  Descript = new String[ total_descriptors ];
  States = new String[ total_descriptors ][];
  gui.Des_i_val.set( "text", CVT.toString(Desc_max+1) );
  return;
  }

/**
  Upon entry of a descriptor and the number of states
  associated with the descriptor, stores the information
**/
 public void Load_Action(Message msg, Event evt) {
  Integer CVT;
  St_max = 0;
  gui.St_num.set( "text", CVT.toString(St_max+1) );
  String tmp = (String) gui.Desc_val.get("text");
  Descript[Desc_max]= tmp;
  System.out.print( "Descriptor : "+tmp+"  ");
  tmp = (String) gui.NoSA_val.get("text");
  total_states = CVT.parseInt( tmp ) ;
  System.out.print( "Num of States = "+total_states+"\n");

  States[Desc_max] = new String[ total_states ];

  Desc_max +=1;
  gui.Des_i_val.set( "text", CVT.toString(Desc_max+1) );
  gui.State_val.set( "text", "Enter State L+" );
  return;
  }

/**
  Load and store the states associated with a descriptor.
**/
 public void Load_St_Action(Message msg, Event evt) {
  Integer CVT;

  String tmp = (String) gui.State_val.get("text");
  StringTokenizer words = new StringTokenizer( tmp );
  int nToken = words.countTokens();
```

```
   System.out.println( "State : "+tmp+" --> No. of Tokens : "+nToken );
   States[Desc_max-1][St_max] = tmp ;
   St_max+=1;
   if( St_max < total_states )
{
   gui.State_val.set( "text", "Enter State L+" );
gui.St_num.set( "text", CVT.toString(St_max+1) );
}
   else
{
   gui.State_val.set( "text", "States Complete" );
gui.St_num.set( "text", CVT.toString( 0 ) );
gui.Desc_val.set( "text", "Enter Descriptor K+" );
gui.NoSA_val.set( "text", "Total States" );
}
   return;
   }

/**
   Load DB structure from a file.
**/
  public void Set_DB_Struct(Message msg, Event evt) {
   String Item = (String)gui.DB_Struc.get("text");
   File file = new File(dir_Item, Item );
   System.out.println( "DataBase Structure: "+Item );
   /*  Open the database structure file */
try {
   open( file );
   try {
   String line = (String)readLine();
   while (line != null)
{
StringTokenizer Desc_St = new StringTokenizer( line, ",\n
" );
int mx_val= Desc_St.countTokens();
Descript[Desc_max]= Desc_St.nextToken();
States[Desc_max] = new String[ mx_val-1 ];
for( int k0=0; k0<mx_val-1; k0++ )
   States[Desc_max][k0]= Desc_St.nextToken();
Desc_max += 1;
line = (String)readLine();
}
   }
   catch ( IOException e ) {
System.out.println( "Problem with the string reads" );  }
   }
catch ( FileNotFoundException e) {
   System.err.println( "DB Structure File opening is messing up" );}

   return;
   }
```

```
/**
  Generic search initiator.
**/
 public void Search_Action(Message msg, Event evt) {
  System.out.println( "Begin Search Operations");
  gui.RL_val.set("text",file_Item);
  gui.DB_File_val.set("text",db_Item);
  for( int k=0; k<Desc_max; k++ )
{
gui.Srch_desc.set("text",Descript[k]);
gui.Key_list.set("items",States[k]);
}
  String TmpList="" ;
  for( int k1=0; k1<Desc_max; k1++)
{
TmpList= (String) TmpList+" "+Descript[k1];
}
  gui.Field_val.set( "text", TmpList );
  Build_DB( TmpList );
  /* Parsing operations begin in next call */
  Process_Search();

  return;
  }

/**
  Search operations function.
**/
 public void Process_Search( ) {
  String ck, tmp="";
  String TmpList[];
  TmpList = new String[ Desc_max ] ;
  for( int k=0;k<fnames.length; k++ )
  {
  File file = new File(dir_Item, fnames[k]);
  gui.RL_val.set("text", fnames[k]);
try {
  open( file );

  /* Now begin to read in the records from the file */

  try {
  String line = (String)readLine();
  while (line != null)
{
String TmpHold="";
gui.RecSearch_val.set( "text",line);

TmpList= Parse_Rec( line );

line = (String)readLine();
for( int k3=0; k3<Desc_max; k3++ )
```

```
   TmpHold = (String) TmpHold+TmpList[k3];
gui.Entries_val.set( "text",TmpHold );
   /* dump findings to the database */
Build_DB( TmpHold );
}
   }
   catch ( IOException e ) {
System.out.println( "Problem with the string reads" ); }
   }
   catch ( FileNotFoundException e) {
   System.err.println( "File opening during search is messing up" ); }
   }
   return;
   }

/**
   Permute and Parse the record read into core in Process_Search.
**/
   public String[] Parse_Rec(String s) {
   String ck="", ck0="", val="" ;
   String Hold[];
   String TmpList[];
   TmpList = new String[ Desc_max ] ;
   for( int k0=0; k0<Desc_max; k0++ )
TmpList[k0]= (String)" * ";

   StringTokenizer words = new StringTokenizer( s, " ,;\n
" );
   int Nrec = words.countTokens();
   Hold = new String[ Nrec+10 ];
   for( int k4=0; k4< Nrec; k4++ )
Hold[k4]= words.nextToken();
  /* Next loop on descriptors, and each state of the descriptor
to check for equivalence */
   for( int k1=0; k1<Desc_max; k1++ )
for( int k2=0; k2<States[k1].length; k2++ )
   {
  /* First break the state into alias search keywords */
   StringTokenizer Alias = new StringTokenizer( States[k1][k2], ":" );
   int nAlias = Alias.countTokens();
   for( int z3=0; z3<nAlias; z3++ )
   {
  /* Setup the equivalent multi-word state */
   StringTokenizer Nstate = new StringTokenizer( Alias.nextToken() );
   int nToken = Nstate.countTokens();
   ck= (String)Nstate.nextToken();
   if( nToken>1 )
for( int k3=1; k3< nToken; k3++ )
   ck= (String)ck+"_"+Nstate.nextToken();
   if( z3<=0 )
ck0= (String)ck;
   for( int k4=Nrec; k4<Nrec+nToken; k4++ )
```

```
Hold[k4]= (String)" ";
  /* Begin the search conbinatoric against state(i) of descriptor(j)  */
   for( int z0=0; z0<Nrec; z0++ )
{
val= (String)Hold[z0];
if( nToken>1 )
   for( int z1=1; z1<nToken; z1++ )
val= (String)val+"_"+Hold[z0+z1];
if( ck.equalsIgnoreCase( val ) )
   TmpList[k1] = (String)" "+ck0+" ";
}
   }
   }
   return TmpList;
   }

/**
   Dump info to a database.
**/
   public void Build_DB(String s) {
try
   {
   DBout.write( s+"\n" );
   }
catch (IOException e)
   {
   System.err.println("Data dump error\n") ;
   }
   return;
   }

/**
   Open a file to read.
**/
   public void open(File f) throws FileNotFoundException {
try {
   if (is != null)
is.close();
} catch (Exception e) {
   // do nothing
}
FileInputStream fis = new FileInputStream(f);
is = new DataInputStream(fis);
   }

   public boolean returnsStrings() {
return true;
   }

   /** Actually reads a line.**/
   public Object readLine() throws IOException {
String line = is.readLine();
```

```
if (line == null) {
   is = null;
   return null;
}

return line;
   }

/**
   Termination command that closes the DB file.
**/
 public void Terminate_Action(Message msg, Event evt) {
   System.out.println( "Search Operations Complete");
try
   {
   DBout.close();
   }
catch ( IOException e )
   {
   System.out.println( "Problem closing database" );
   }
   return;
   }

}
```

Distribution:

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