KEEL Technology for 'Intelligent' Policies

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Objective: Demonstrate the feasibility of a 'dynamic' graphical language to describe policies that can be executed by devices or software applications with the added benefit of allowing those policies to be audited by humans.

Research: Compsim has invented a new technology that fits in the Artificial Intelligence space. That technology, called KEEL for Knowledge Enhanced Electronic Logic, competes with Artificial Neural Nets and Fuzzy Logic as a fundamental cognitive solution to "soft" problems. We term these "soft" problems as those where the information needs to be interpreted and fused to address real-time, multi-dimensional inter-related situations.

The assumption is that future combat systems will include devices and software applications that will take on the responsibilities that have previously been delegated to humans. These responsibilities will include the operation of autonomous devices that will seek goals and perform operations based on policies. These policies will describe modes of operation or how to respond to certain circumstances.

We suggest that the human verbal and written language is insufficient to describe policies because of the granularity of the language. While humans get around this issue because they are recognized to operate in a loosely-coupled, somewhat controlled manner, machines built by humans are not offered the same latitude. Machines and software applications MUST perform according to auditable rules (policies). Mathematical formulas may be successful in describing situations in explicit detail, but we would suggest that the dynamic nature of the problems that we will be asking these devices and software applications to perform are too complex to effectively describe with mathematical formulas. This is why the field of artificial intelligence has been developed (artificial neural nets / fuzzy logic / etc.).

Compsim has developed a graphical language that we feel can describe 'policies' in a way that can be executed by devices and software applications. This language is one that creates explicit solutions to these complex problems without the use of textual descriptions of text based formulas. Compsim has also developed an architecture for executing these policies.

Compsim proposes to investigate the feasibility of using the KEEL graphical language to define operational policies. The objective is to define policies that can be audited by humans, thus providing a mechanism for review and extension, should that become necessary.

Compsim suggests that any time one is dealing with significant political situations or situations where human life might be endangered one must utilize a technology that can create completely explainable and auditable solutions. Neural net based solutions are automatically excluded, since they are not based on rules, only recognized patterns. A failure in training can cause disastrous results. Fuzzy logic, while it is based on rules, obscures those rules through a fuzzification process that is as much art as it is science. A solution that cannot explicitly be explained cannot be effectively corrected if necessary. Bayesian logic (Bayesian Belief Networks) is another potential technology that can be applied to this type of application. The focus on probability and statistics may work well in some relatively static situations. However, in dynamic situations, it is unlikely that statistics will be sufficient to accurately describe the problem / solution.

When we talk about policies in this context, we are defining *how* data will be interpreted. This means that the definition of the rules must be such that they define how to respond to non-linear situations. We are also talking about the need to solve complex multi-dimensional problems. These are difficult to describe with the human verbal / written language. Examples of these types of problems are: How to perform a maneuver; How to allocate resources; How to evaluate a target given the environment…

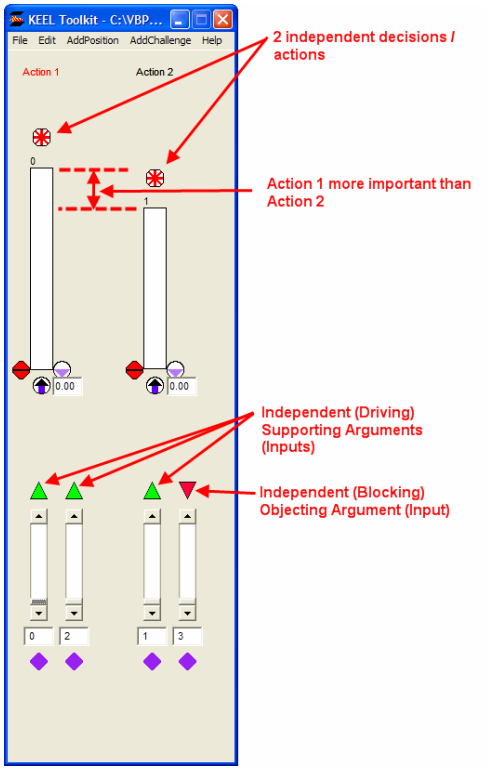
In some cases, policies are used to define how to perform a general operation. These policies must be able to be modified by a higher authority. Some of the policies will be developed with a consideration of costs. For example a UAV may be assigned a policy that balances target value against risk. The situation may occur where new intelligence is received that suggests the target may have a higher value than perceived by the UAV. This could be because of specific new knowledge of the target or because of the impact of the target on associated entities (such as friendly forces or dependent functions that could make the target more or less valuable).

Alternative 1:

Compsim proposes to work with the Air Force Office of Scientific Research to select a policy of specific interest for feasibility testing of the KEEL graphical language. Subsequently, the policy will be integrated into a test environment where it would be jointly tested. Compsim will test the feasibility of creating a policy that can be tuned by the user.

Alternative 2:

Alternatively, Compsim will create a policy that describes a decision to go to war. This will provide an abstract model suitable for evaluating any country's capabilities and drivers. Feasibility will be established if it can effectively demonstrate the reasoning that will take place under different situations.

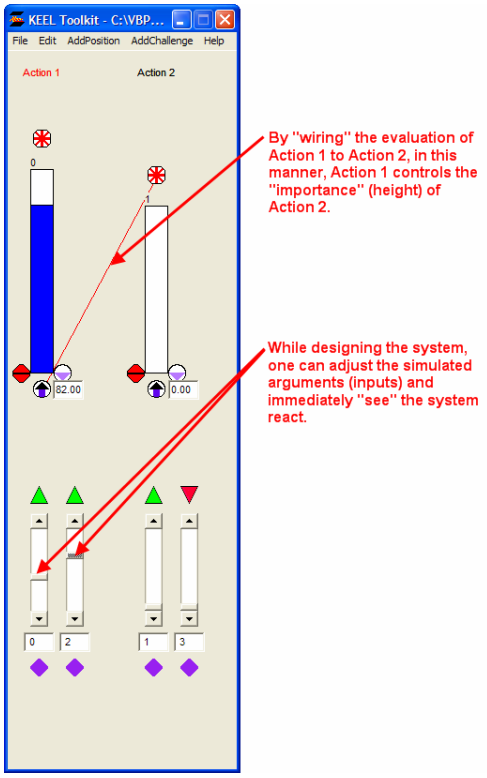


Brief overview of the KEEL Graphical Language:

The image at the right shows the KEEL graphical language. This is KEEL source code.

The image at the right shows two independent actions: one driven by two supporting arguments and the other by one supporting argument and one objecting argument.

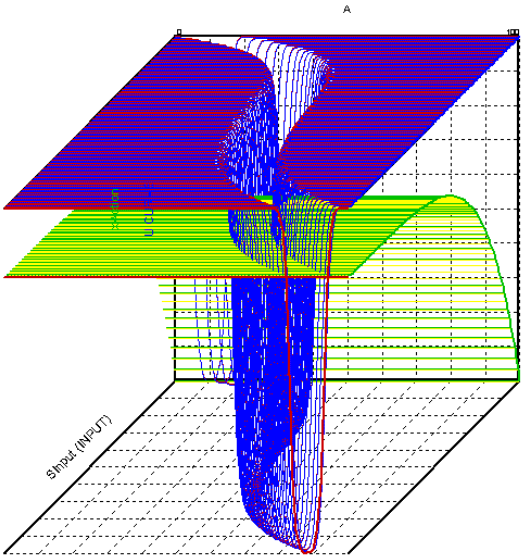
This situation shows that Action 1 is more important than Action 2 based on the height of the vertical bars at the top of the window.



This shows the impact of suggesting that the evaluation of Action 1 will control the importance of Action 2.

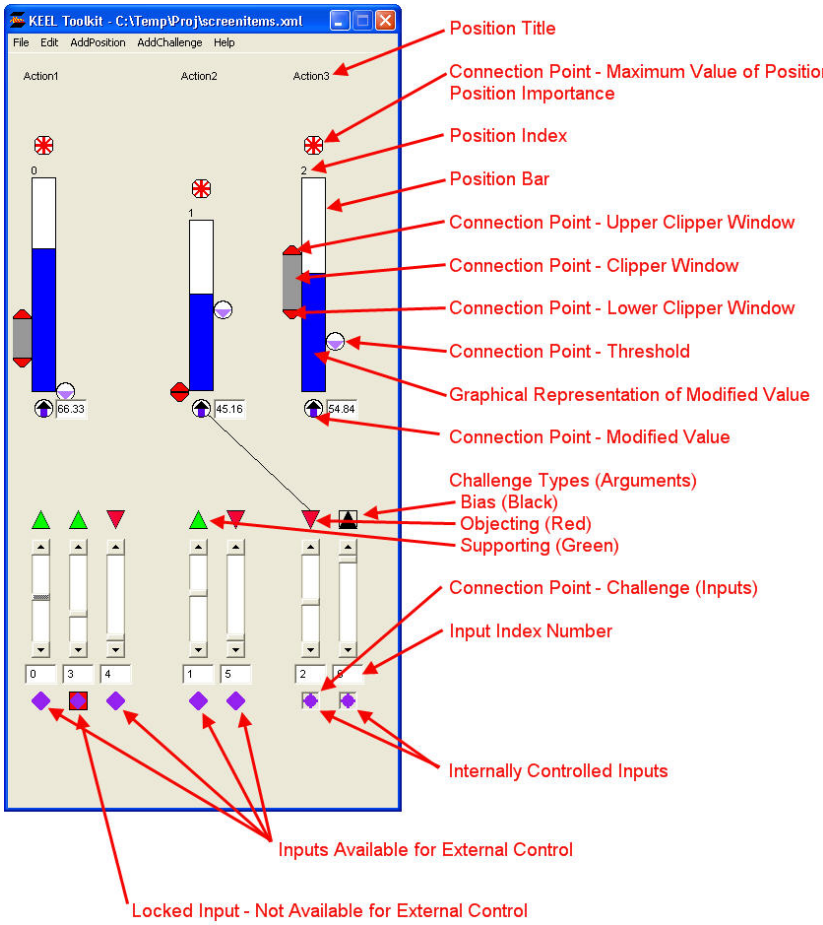
Because the KEEL graphical language is "dynamic", adjusting the inputs will be immediately shown by changing the importance of the dependent Action 2.

Labels are assigned to inputs and outputs. These allow "humans" to interpret the relationships. The resulting KEEL Engine (encapsulation of the design) does not used text, except to comment the code.



These simple structures allow the designer to address complex non-linear relationships without resorting to text based code. The resulting design can be automatically translated to conventional languages like: C, Java, Microsoft C#, Microsoft Visual Basic, Microsoft Visual Basic .NET, Macromedia Flash, Macromedia Flash Object format and PLC Structured Text.

The following image shows "most" of the components of the language. The "thresholds" allow the creation of "events". The clipper components allow the system to consider time and space relationships.



We believe that only a graphical language can effectively describe the relationships that must be managed in complex policy decisions. And only allowing the actions of devices executing these policies to be audited, can one effectively manage them.

Deliverable:

The initial research will attempt to describe "policies" using the KEEL graphical language representation model that can be used by humans (where there needs to be a process for explicitly describing how information items were evaluated) or by devices and software applications (where their actions need to be explained and audited). The policies will be available for analysis by stimulating the graphical language and viewing the connections (wiring) between information items. It will also be available for analysis by graphing relationships and testing in simulated applications, should that be appropriate. It will also include a demonstration of how "devices" can be audited once they are deployed in real-world environments.

Summary:

Compsim is the inventor of KEEL technology and has developed a US patent portfolio around it. Compsim is the only company capable of exposing these concepts in a timely manner. We know of no other approach that offers a similar "dynamic graphical language" to address non-linear inter-related problem domains with completely explainable auditable solutions. When policies are executed by devices, they must be audited to insure proper operation.

KEEL technology is an extension of Compsim's Argument Mapping solution (Compsim Management Tools) which addresses business and organizational decision-making. This patented decision-making method focuses on relatively static business decisions. KEEL extends this model with the graphical language and solutions to *dynamic* "web" structured problems rather than "tree" structured problems.

References:

Paper and presentation at the IEEE High Assurance Systems Engineering Conference in 2004
Paper and presentation at Phoenix Challenge – Warfighters Conference in 2004
Other papers and demonstrations available on Compsim's web site:
http://www.compsim.com

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