Operational Planning using Web-Based Interfaces to a Coloured Petri Net Simulator of Influence Nets

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Abstract

We present an environment for web-based simulation of influence nets to be used for operational planning. Previous work in this field has shown how influence nets, which are used for probabilistic modelling, can be extended with time and then translated into a coloured Petri net to do temporal evaluation of plans. Simulating the coloured Petri net model in a web environment is easy for a subject matter expert to use the simulator for planning without knowing the underlying coloured Petri net formalism and tools. This paper discusses the use of influence nets for operational planning, a simulator for influence nets implemented using coloured Petri nets, and the architecture of the complete web-site which can be used for operational planning.

Keywords: Operational planning, Courses of action, Effects based operations, Influence nets, Coloured Petri nets, Web-based simulation.

1 Introduction

Planning an operation to achieve objectives can be a very complex task. A plan may depend on interplay between several different complex events, where only some of the events are controllable. In many cases, plans are developed to try to compel an adversary to take actions or make decisions that the adversary is not pre-disposed to make.

The operational planning method presented in this paper has been motivated by a concept called effects based operations (EBO). EBO is the notion of selecting actions based on their collective contribution to desired and undesired effects. The set of selected actions is called a course of action (COA). To support EBO, at least two problems must be addressed. The first is to relate effects to actionable events. In this problem, we need to define the set of desired and undesired effects on the adversary. From these effects we work backwards, from effects to causes, and identify actions which we believe to have impact on the effects. Finally, we arrive at the actions that we have at our disposal for achieving the effects. In the second problem, called the COA problem, we must select from the set of all possible actions those subsets that will yield, with high probability, the effects we wish to achieve, and with low probability the undesirable effects. Then, taking into consideration constraints associated with specific actions or combinations of actions, the selected actions must be sequenced and timed phased. This timing of the actions is important to be able to know in which order and when the controllable actions should be done to obtain the best possible conditions for a successful operation. The result is a set of alternative COAs. These COAs are then evaluated against requirements to determine the COA that provides the best likelihood of causing the desired effects to occur and the undesired effects to not happen.

Probabilistic models like, e.g., Bayesian influence nets (Jensen 1996) and influence nets (Rosen & Smith 1996), can be used to model a situation to determine which actions to take to optimise the outcome of an operation. However, these models do not include the temporal aspect of the planning.

Previous research on influence nets is presented in, e.g., (Wagenhals, Shin & Levis 1998) and has demonstrated how timing information can be added to influence nets by translating the influence net and a timing profile to a coloured Petri net (CP-net or CPN). This CP-net can then be simulated both to estimate the probability of a successful operation, and to evaluate a plan for timing the operation. The translation from the influence net and the timing profile to the CPN model is done completely automatically, i.e., the places, transitions, and declarations of the CPN model are generated without user interaction. In this paper we will refer to a CP-net generated using this method as a \textit{fixed CPN model}.

The influence net formalism has been extended slightly to include so-called logical gates. An influence net with logical gates together with timing information is in the following called a \textit{timed influence net with logic} (TINL).

Recent work, presented in (Lindstrøm & Haider 2001), has developed a \textit{generic CPN model} that is able to simulate any TINL. In other words, a \textit{TINL CPN simulator} has been implemented. The advantage of the generic CPN model is that time is saved during the translation, because a new CPN model does not need to be generated each time a new TINL needs to be examined as it had to when generating fixed CPN models. Instead, the generic CPN model within the TINL CPN simulator is initialised with appropriate tokens to reflect the concrete TINL. One issue of concern was that the simulation time for the generic TINL CPN simulator would be much longer due to the complex colour sets and potential large number of tokens in places required by the generic CPN model. Experiments presented in this paper has shown that using a more effective CPN simulator has overcome this problem.

It is essential that tool support is available to and usable by (1) the team of intelligence analysts and other subject matter experts (SMEs) responsible for analysing a situation in terms of actions and effects...