A Probabilistic Multi-agent Scheduler Implemented in JXTA

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Abstract. Multi-agent technology and constraint satisfaction techniques can be effectively combined and utilized to solve many real-world problems. This paper presents a multi-agent system based on Probabilistic Interval Algebra (PIA) networks to solve distributed scheduling problems. An IA network is a graph where nodes represent intervals and directed edges are labelled with temporal interval relations. A PIA network has probabilities associated with the relations on the edges that are used to capture preferences. The proposed multi-agent system consists of PIA-Agents that are connected via edges to form a network. Each PIA-Agent has ownership and control over a PIA network. A prototype is implemented using JXTA and demonstrated on a university domain to show how the PIA-Agents work together and coordinate their activities to recommend a temporal schedule which is a globally consistent solution which attempts to maximize the desires of each individual PIA-Agent.

Keywords: Allen's temporal relations, CSP, agents, temporal reasoning, JXTA.

1 Introduction

Recently, researchers have combined the intelligent agent and CSP paradigms into single systems. For example, researchers in [2] have analyzed and discussed possible ways of integrating CSP and agent techniques. Other researchers [7] used agents to solve distributed versions of a CSP. Liu and his co-workers [6] presented a multi-agent oriented method for solving CSPs. In their method, distributed agents represent variables and a two-dimensional grid-like environment in which the agents inhabit corresponds to the domains of the variables.

We use Allen's [1] temporal representation approach which is based on intervals and the 13 possible binary relations between them as shown in Table 1. The relations are before (b), meets (m), overlaps (o), during (d), starts (s), finishes (f), and equals (=). Each relation has an inverse. The inverse symbol for b is bi and similarly for the others: mi, oi, di, si, and fi. The inverse of equals is equals. A relation between two intervals is restricted to a disjunction of the basic relations, which is represented as a set. For example, (A m B) V (A o B) is written as A {m,o} B. The relation between two intervals is allowed to be any subset of I = {b, bi, m, mi, o, oi, d, di, s, si, f, fi, =} including I itself.

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An IA (Interval Algebra) network is a graph where each node represents an interval. Directed edges in the network are labelled with subsets of I. By convention, edges labelled with I are not shown. An IA network is consistent (or satisfiable) if each interval in the network can be mapped to a real interval such that all the constraints on the edges hold (i.e., one disjunct on each edge is true).

An IA network is a binary constraint satisfaction problem (CSP) with infinite domains. The intervals are the variables. The domain of each variable is the set of pairs of reals of the form (x,y) where x <y. The constraint between two variables i and j is the label on the edge (i,j) in the IA network.

Table 1. Allen's interval relations

Relation	Symbol	Example
X before Y	b	XXX YYY
X meets Y	m	XXXYYY
X overlaps Y	o	XXXX YYYY
X during Y	d	XXX YYYYYYY
X starts Y	s	XXX YYYYYYY
X finishes Y	f	XXX YYYYYYY
X equals Y	=	XXX YYY

A Probabilistic IA network (PIA network) is an IA network with probabilities associated with each interval relation. For example, if we prefer to read the newspaper during breakfast instead of before, we could have: "read newspaper" {d(0.9), b(0.1)} "breakfast".

Directed edges in the network are labelled with subsets of I, and each relation in the subset is assigned a probability. The probabilities on an edge sum to 1. By convention, we list the labels in a set by decreasing order of probability. A PIA network is consistent (or satisfiable) if one disjunct on each edge is true. The probability of a solution is defined to be the product of the probability on each of its edges. Given two solutions, we prefer the one with higher probability. Our proposed system attempts to generate a solution with maximum probability.

A PIA-Agent is an agent which has ownership and control over a PIA network. A node in one PIA-Agent's PIA network can be connected by an edge to a node in another PIA-Agent's network. The individual PIA-Agent networks along with their interconnecting edges, is called a PIA-Agent network. For example, Figure 1 shows a 5 PIA-Agent network that includes a professor, student, secretary, spouse and director. Each node in the network represents a real world event in the PIA-Agent's daily life.