Decision Theoretic Resource Management for Intelligent Environments

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The Problem: A useful intelligent environment requires that all its fundamental resources be used effectively. Collections of these resources constitute services, which can be requested by software agents operating in the environment. The challenge is to fulfill as many service requests as possible, in the best way possible, while minimizing the number of conflicts.

Motivation: Natural human-computer interaction in an intelligent environment requires a rich multi-modal interface. Ideally, the environment should allow user interaction via speech, gesture, movement, and other means. Similarly, the environment should speak and give visual responses, at the very least. Achieving such interaction abilities is complicated, involving many distinct hardware and software components. For example, in order to hear and respond to a user's question, the environment must have a microphone, audio input controller, natural language interpreter, textual question answering system, speech synthesizer, audio output controller, and speakers. Increasing the interaction complexity increases the number of components required and possible interactions among them. Clearly, without an effective means of managing these components, their use quickly becomes infeasible.

Additionally, as the variety of available devices and services rapidly increases, it becomes difficult to design software systems that use them effectively. The resource manager provides an additional abstraction level, enabling the software components to function without knowledge of the particular resources in an environment.

Previous Work: Rascal, the existing resource management system in the Intelligent Room, seeks to solve many of the same problems[2]. However, it fails to provide a sufficient representation for agents' preferences. There are also several smaller issues that limit is use in an intelligent environment. Although other existing systems accomplish a small subset of this project's goals, none provide an integrated solution.

Approach: First, the resource manager must know how requests can be fulfilled (i.e. which particular resources are required to fulfill a particular request). For example, Figure 1 shows the resource requirements for a DVD movie request.

Given a set of current and potential future requests as well as a set of resources, the system seeks to find the globally optimal assignment. This approach requires knowledge of how well a particular set of resources satisfies a request and the relative importance of each request to the system as a whole[1]. In economic terms, we look at utilities of each requesting agent and the global utility, with the global utility being computed directly from the utilities of each agent.

Impact: Having such a functional resource management system dramatically increases the effectiveness of software agents and the ease of their design. As new devices are developed and placed into an intelligent environment, existing software agents can make use of them right away. The system also allows individual software agents to be designed to maximize their own utility, without regard to the utility of the system as a whole.

Future Work: There are many potential methods for making utility calculations. Once the system has been fully implemented, work on evaluating these various methods will begin. Also, several alternative resource representation schemes look promising, so identification and evaluation work will be done there, as well.

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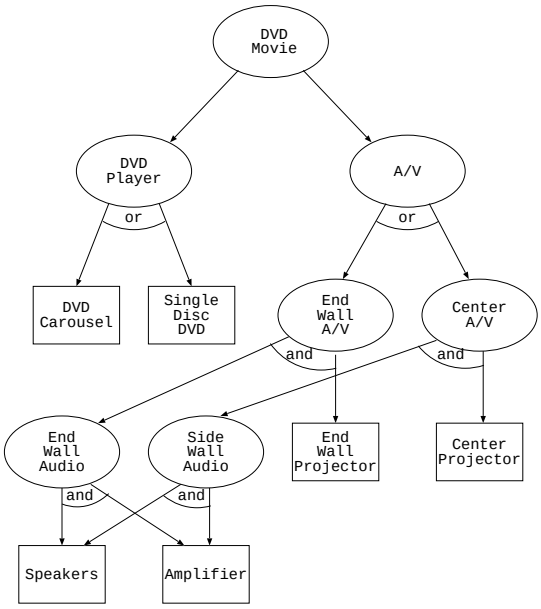

Figure 1: The DVD movie service requires the DVD and A/V service. The DVD service selects one of the two DVD players, and the A/V service selects either the end wall or center A/V services. These A/V services, in turn, need a projector and an audio service. Finally, the audio services use the speakers and amplifier. Note that services can use other services, but every branch of the tree terminates in a device.

Oxygen partnership.

References:

[1] J. Doyle and R. H. Thomason. Background to Qualitative Decision Theory. *AI Magazine*, 1999.

[2] K. Gajos. Rascal: A Resource Manager For Multi Agent Systems in Smart Spaces. In *Second International Workshop of Central and Eastern Europe on Multi-Agent Systems*.