An Agent-Based Expert System To Support Water Mains Rehabilitation Decision Making

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Extended Abstract

The development of an efficient strategy to support rehabilitation of water mains is becoming increasingly complex as water distribution companies have to respond swiftly not only to external regulatory agencies but also to internal investment policies. The decision when to renovate or reline water mains involves a set of complex and interrelated factors some of which relate to the aging pipe infrastructure, others include customer complaints, and hydraulic performance and water quality. If the investment strategy took into account all recorded data, over 28,000 possible combinations should be considered (Dean, 1993). To make effective use of this wealth of recorded data the water industry needs an intelligent system that can combine formal reasoning with expert heuristics to analyse the complex relationships in the data warehouse and assist the process of decision making.

In this paper we describe an on-going study undertaken by an inter-disciplinary research team whose aim is to develop an intelligent knowledge-processing framework to support water engineers in planning their investment strategy. The domain is an ideal application of expert systems, but given the complexity of the decision making process requiring differing areas of expertise and continually changing external pressures it was felt that an agent based approach to the problem is a more suitable approach. The research addresses the value of agents collaborating together and sharing their expertise to recommend an effective and consistent investment strategy. The following issues are being investigated:

1. How can we represent, in an agent based architecture, the dynamic interaction of the various expertise required to support the water engineers?
2. How much autonomy should each agent be endowed?
3. How de we capture the local and global recommendations proposed by these agents?
4. How can common problem solving be effectively incorporated among agents?

This paper addresses mainly the first two issues. The first section gives a brief overview of the domain application. The next section defines the concept of agent within our research project and describes our knowledge processing framework which consists of a set of *collaborative agents*, each representing different kinds of *knowledge* and tasks, and *reasoning* together to provide an effective investment strategy plan (Figure 1). The role of each agent is then outlined. For example, the *APredictor* agent applies its statistical knowledge about corrosion trends to develop a predictive model of the pipe life expectancy. The task of the *AStrategy* agent is to apply the reasoning strategy elicited from expert engineers and propose an investment strategy. Other agents perform supporting roles to these agents; for example, the *ADatamining* agent will interact with existing water information systems to scan the database for problem cases and relay them to another agent, the *AHot-Spot*, which will identify the nature of these problems and then dispatch the diagnosis to the *AStrategy* agent. Each agent must also possess knowledge of abilities and roles of other agents so as to co-ordinate their activities. Finally, the paper reports on the development of two prototype agents, the A*Predictor* and the A*Strategy* agents embedded in Pipe LIfe Span Predictor

system (PLIP) and South West Water Information Management system (SWWIM). PLIP is an agent whose main role is to predict the life expectancy of a given water main pipe based on statistical survey of 4367 pipe samples which analysed corrosion trends and tuberculation rates for different pipe materials, pipe diameters, pipe ages, water types and soil types (Bancroft, 1996; Dean, 1984, Dean, 1993: Edwards, 1996). SWIMM is the strategy agent which emulates water expert consultants and recommends a rehabilitation strategy based on a set of nine parameters, such as the water quality, customer complaints, population density, water quality, etc. This agent is endowed with some degree of flexibility to produce a multiple ranking process to assist engineers in prioritising the rehabilitation programme (Davis, 1987; Sharp, 1998).

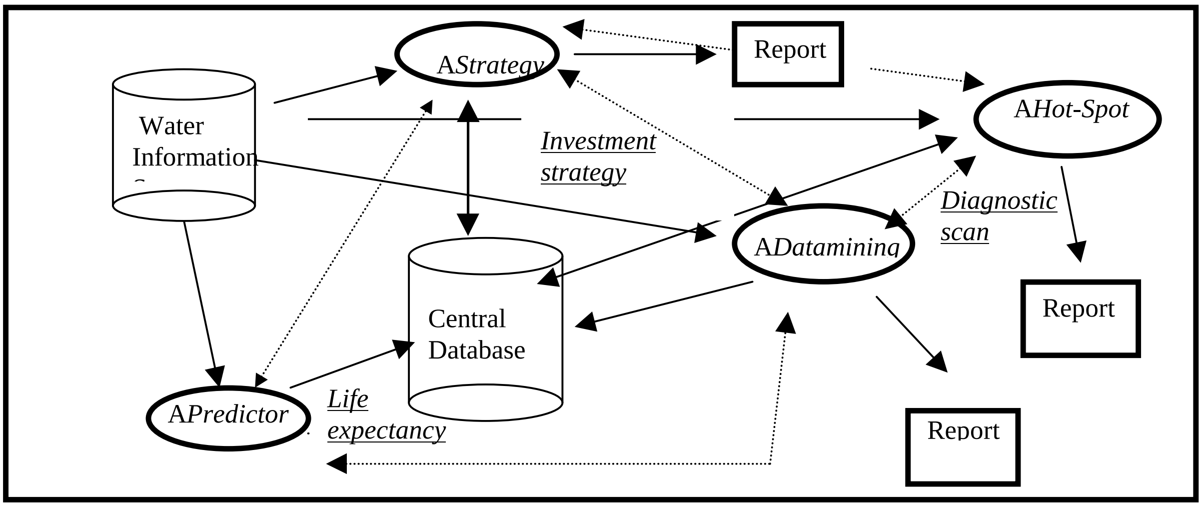

Figure 1. A top-level view of our intelligent knowledge processing framework

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