Expert Systems with Applications 38 (2011) 736–742

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

A new intelligent system for senior executives to maintain remote control of their company

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ARTICLE INFO

Keywords:
Mobile enterprise
Multi-agent
Intelligent system
Remote control

ABSTRACT

The mobile-enterprise concept has emerged as an innovation with the increasing use of personal digital assistant (PDA) on wireless data networks. To realize the concept, simply use the PDA to search for information is not enough, where an intelligent paradigm is required to deal with the request for information as well as the command execution in a distributed information system. This paper proposes a mobile-enterprise multi-agent paradigm (MMAP) which is an agent-based intelligent solution provider developed for small to medium enterprises (SMEs) in order to increase their flexibility and competitiveness in the market. The system is driven by intelligent software agents. Their design and prototype implementation are demonstrated in this paper.

1. Introduction

In today's competitive climate, being responsive to key customers' requirements in information, services, decisions and creative collaboration can make the difference between success and failure. Nowadays, most of the popular enterprise mobility solutions are limited to wireless connections (Palm, Inc., 2000) or information retrieval from a website or from a database (Brans, 2003).

There is yet the lack of an effective holistic platform for accommodating all the activities required for the extraction of information, collating them into a form meaningful to the requesters and presenting them in a format that matches the exact requirement of the executives on the move.

The provision of such capability requires the support of an intelligent system in the organization which is being proposed here in the form of a paradigm called 'mobile-enterprise multi-agent paradigm' (MMAP). The paradigm is not only a wireless platform for wireless data retrieval from the Intranet, but also involves the design and implementation of a multi-agent system for enterprise operational management.

In order to achieve the intended effects, the activities to be addressed within the MMAP involve the following areas:

- The issues and the mechanisms involved in the collection of real-time information from various departments of a company.
- The collation of this real-time data into a Linux database for access by other analytical and scheduling applications from different platforms.
- The formulation of an object paradigm for smooth mapping of physical operations into logical schematics for design of the above applications.
- The development of interfaces for wireless PDA access into the real-time and batch information within the company.

2. Related work

2.1. Overview

Agents possess several important characteristics in terms of information system design, including proactivity, uncertainty management, autonomy, social abilities (Lea, Gupta, & Yu, 2005). Research on intelligent multi-agent based systems and their application is on the rise (Cil, Alpturk, & Yazgan, 2005; Lea et al., 2005; Petit-Roze & Grislin-Le Strugeon, 2006; Sheremetov, Contreras, & Valencia, 2003; Symeonidis, Kehagias, & Mitkas, 2003).

Petit-Roze and Grislin-Le Strugeon (2006) proposed a multi-agent personalized information system (MAPIS) that aims to give specific and customized responses to individual user requests. Although the search and solver agents can handle data with some intelligence, this system is not designed for mobile platform and is not comprehensive enough to accomplish a large task. A prototype multi-agent enterprise resource planning (MAERP) system is proposed that utilizes the characteristics and capabilities of software agents to achieve enterprise wide integration (Lea et al., 2005). The design of coordination agents and data collection agents in this architecture can be advisable to our new paradigm. In addition, an intelligent policy recommendation multi-agent system (IPRA) is proposed that introduces adaptive intelligence as an add-on for ERP software customization (Symeonidis et al., 2003). The system

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doi:10.1016/j.eswa.2010.07.027

can be thought of as a recommendation engine, which takes advantage of knowledge gained through the use of data mining techniques, and incorporates it into the resulting company selling policy. The system increases its intelligence by the use of agent technology and data mining techniques though its paradigm is not suitable for our objectives because its main concern is on decision support and it is not fit for mobile clients. Moreover, a software system called InteliTeam is developed based on a web-based collaborative system framework (Cil et al., 2005). The software provides online mapping, online queries, and online analysis functions for users. Although the methods for data gathering and problem structuring are advisable, the system cannot satisfy real-time requirements and its interfaces are not based on mobile devices. There is also an agent-based intelligent infrastructure of contingency management system (CMS) using knowledge source concept and agent technology as an agglutinating center of the system (Sheremetov et al., 2003). This infrastructure supports information collection from distributed heterogeneous databases, integration with enterprise legacy software systems, logistics planning, and monitoring of contingency situations in an open and dynamic agent environment. Coalition formation techniques with fuzzy knowledge acquisition have been developed in the system. Since this system is designed for contingency management, the whole infrastructure cannot be adapted to the mobile-enterprise concept though the methodologies that CMS used for data collection from distributed databases are useful as references for building up a new data acquisition module for our system.

2.2. Summary

During the recent years, many efforts have been made to develop various enterprise management information systems. At the same time, PDA incorporation with cellular wireless data networks has been a more and more matured technology, which can be integrated with management systems to develop a brand-new concept – "mobile enterprise". However, currently developed systems have their own limitations. In our investigation, a few of multi-agent systems lack control function, or can not be updated in real-time though they can perform certain tasks intelligently.

Although these new technologies have empowered mobile-enterprise management, they are not complete solutions for mobilizing an enterprise because their paradigms were originated from different backgrounds and were designed for their respective purposes. Thus, the above systems can only be important references for part of an innovative intelligent object paradigm for monitoring and control of mobile enterprises to cater for the future trend in wireless management information system especially for SMEs.

3. Proposed paradigm

We propose an intelligent mobile-enterprise multi-agent paradigm (MMAP), which is a multi-agent system for enterprise operation management. Its main functions include: (1) interpret the questions posted, and retrieve information from the appropriate source, then automatically formulate the information into the appropriate answer; (2) execute the instructions given by automatically retrieved information, determine who in the company should take action and distribute the instructions together with the required information. The architecture is described in simple terms as shown in Fig. 1.

Each department may have an individual database management system (DBMS), thus making it easier to be managed.

Intelligent agents, software that are proposed to act on behalf of human beings to perform laborious information gathering tasks, such as locating and accessing information from heterogeneous information sources, resolving inconsistencies and filtering away unwanted information, integrating information and adapting over time to their users' requests and the shape of the information delivery (Tyndale, 2002). In order to assemble all of the above functions, our approach is to distribute the functions to distinct agents in order to increase the flexibility and the adaptability of the systems. In this way, the MAS design for processing information is at the core of our system.

Since the data/information in an organization is probably stored in an environment within the total control of the respective department for easy trading and update, it is appropriate that information be stored in distributed database and be managed by their respective agents that look after data acquisition as well.

When an enquiry comes in, the information needed for answer would normally have to come from several distributed database and hence a separate query agent is required to interpret the enquiry and identify from which database the respective information would come from and then issue the requests for information to the appropriate data collection agent accordingly. Since the data collection agent collects the data and manages their store into the respective database, it has intimate knowledge of the database that it searches and hence will have first-hand knowledge of whether the data is available or not. Therefore, we divide the functions for enquiry handling into two agents, one is query agent, which is designed for information processing, and the other is data collection agent, which is for databases management.

Data collection agents should possess specific domain knowledge needed to carry out its tasks. The "intelligence" in the data collection agents identifies invalid data and missing values so that the data is complete and applicable when being returned to the other agents. Query agents should have the ability to monitor, communicate, and collaborate with other agents, react to various requests, as well as assign tasks to proper data collection agents.

The MMAP consists of six major components:

(1) The data acquisition module (DAM)
- real-time raw data capture
- resolve inconsistencies in the retrieved data
- filter away irrelevant or unwanted data
- communicate with DCA by presenting data in a standard format

(2) The data collection agent (DCA)
- communicate with DAM to receive data input from the DAM
- storing data in the proper format in DSM
  - reformatting data
  - locating
- MES or ERP database mapping
- searching the relevant information from its associated DSM
- communicate with QA and respond to the query agent's request
  - semantic analysis
  - collating information, filling query form

(3) The data storage module (DSM)
The DSM is a dedicated database designed to store data specific to its related department or function such as finance or warehouse.

(4) The query agent (QA)
- analyze the questions asked by the end users
  - communicate with WCP
  - semantic analysis