

## Intelligent Agent based Business Intelligence

Samo Bobek<sup>1</sup> and Igor Perko

University of Maribor, Faculty of Economics and Business, Razlagova ulica14, SI-2000 Maribor, Slovenia

Business intelligence (BI) actively supports management activities in gaining insight into their company results and processes, using tools and technologies such as data warehouse, on line analytical processing, data mining, advanced reporting etc. To make qualified decisions managers combine information arriving from BI applications with disperse information about global economic state, their customers, partners and competitors. Often decisions, based on information from sources outside the BI system are taken. This behavior generates usually undocumented and hence hard to explain decision deviations of information and suggestions, arising from BI applications.

Agent technology shows great potentials in advancing BI, resolving complex communication, integration and analysis problems. While the popularity and application of the agent technology has grown over the recent years, the field is currently marked by unique and innovative approaches and architectures for solving the complex communication, integration and analysis problems. It shows best potentials in linking disperse systems, creating new standardised communication and reasoning paths. We synthesized research in the field of BI and agent-based systems, and built a model proposing three prospective fields for using intelligent agents in the field of BI – intelligent data acquisition, intelligent modelling, and intelligent information brokerage for mediating information flow between users and disperse information sources. Proposed potentials are discussed within a case of implementation of intelligent agent-based systems in customer credit rating in a Bank.

**Key words** Business intelligence; Decision Support systems; Intelligent Agents; Multi agent systems; Data Acquisition; Data integration; Data Delivery

### 1. Introduction

The field of Business Intelligence (BI) has evolved over the years and its importance in business use is well established. Some issues have gradually matured, while new ones require research attention [1].

Business intelligence actively supports managers' activities in gaining insight into their company results and processes, using tools and technologies such as Data warehouse, ETL processes, Data mining, advanced reporting etc. All these tools are great in handling structured data in an organized environment, but have limited capabilities in handling data that isn't organized and doesn't necessarily originate from well defined source.

While the popularity and application of the agent technology has grown over the recent years, the field is currently marked by unique and innovative approaches and architectures for solving the complex communication, integration and analysis problems [2].

There is currently a lack of a unifying framework that synthesizes literatures in the two relevant streams business intelligence (e.g., DSS, MIS, MSS, etc.) and Agent-Based Systems (ABS). The goal of our paper is to contribute in solving this gap. We find that the agent-based systems paradigm, with its new approaches and suitable mechanisms, could solve some major issues in BI to achieve the goal providing insight into whole business environment breaking the limitations of data, currently stored in structured form. We explore potentials of agent-based systems in a case of customer credit rating as this part of BI is especially external oriented. Therefore we assume to discover potentials in use of agent-based systems. The paper is organized as follows. In Section 2, we discuss the tasks and components of BI and display a BI data framework. In Section 3, we discuss the concept of agents, intelligent agents, multi-agent systems, and present number of factors, pointing to the usage of agents. In Section 4, we synthesize the BI and ABS literatures, and develop a framework for usage of ABS in a customer credit rating instance.

---

<sup>1</sup> Corresponding author: e-mail: Samo.Bobek@uni-mb.si, Phone: +386 22290251

## 2. Business intelligence

Business intelligence has many definitions and many names. It replaced terms such as decision support and management information systems [3-11]. In context of this paper BI is defined as a system that combines data acquisition, data storage, data delivery and knowledge management, using analytical tools to deliver quality information to decision makers. According to Langseth proactive BI has some essential components [10, 11]:

- Real time data warehousing
- Data mining
- Automated anomaly and exception detection
- Proactive alerting with automatic recipient determination,
- Seamless follow-through workflow
- Automatic learning and refinement,
- Support of collaboration
- Data visualization

Achievements in delivery technology and multiplicity of available communication channels are excellent, though data can be converted into information only by knowing its significance for managers in time of its delivery. Therefore manager's needs as well as the potential information, carried by data must be well known.

## 3. Intelligent agents

Agent-based systems belong to the most vibrant and important areas of research and development to have emerged in information technology in the 1990s [12]. Because of the lively extensive spreading of directions in research no publicly accepted solid definitions of agent-based systems and their elements – agents is provided. Hence, in context of this paper we will use some general definitions:

Software agent is software that acts as an agent for another as in a relationship of agency. When several agents act they may form a multi-agent system [13].

Intelligent Agent (IA) refers to a software agent that exhibits some form of artificial intelligence. According to Wooldridge [14, 15] intelligent agents are defined as agents, capable of flexible autonomous action to meet their design objectives. They must involve:

- Reactivity: to perceive and respond in a timely fashion to changes occurring in their environment in order to satisfy their design objectives. The agent's goals and/or assumptions that form the basis for a procedure that is currently executed may be affected by a changed environment and a different set of actions may have to be performed.
- Pro-activeness: ability to exhibit goal-directed behavior by taking the initiative, responding to changes in their environment in order to satisfy their design objectives.
- Sociability: capability of interacting with other agents (software and humans) through negotiation and/or cooperation to satisfy their design objectives.

In context of intelligent agents other properties are also mentioned:

- Self-analysis: ability to analyze and explain its behavior and detect error and success.
- Learning, adapting and improving through interaction with the environment.

Multi-Agent System (MAS) is a system composed of several agents, capable of mutual interaction. The interaction can be in the form of message passing, requesting, negotiating or producing changes in their common environment. MAS can manifest self-organization and complex behaviors even when the individual strategies of all their agents are simple [16]. In order to achieve full functionality of MAS, agents must include some concepts, described by Padghan [17]:

- Actions: ways the agent can operate on the environment,
- Percepts: ability to accumulate relevant information from the environment,
- Events: ability to collect relevant information about a change (percepts are subset of events),
- Goals: following objectives to be accomplished (should be consistent),
- Beliefs: handling accumulated information about the environment,

- Plans: Using means for achieving goals,
- Messages: necessary for agents to interact,
- Protocols: specification of interaction – rules.

To determine why agents are useful, we must first understand how agent's and MAS features translate into properties of information systems. The usefulness of agent's features depends on their application; therefore it is important to understand how agent's and MAS relate to application types and application areas [17, 14]. There are number of factors, pointing to the usage of agents:

- Open, dynamic uncertain or complex environment: In such environments, agents' properties such as flexibility, autonomy learning and robustness are required.
- Agents are natural metaphor: Many environments are organized as societies of agents, cooperating, competing with one another or assisting the user to work on a problem.
- Distribution of data, control or expertise: Their use is suitable in distributed system, where it is hard to achieve centralized solutions. Distributed systems act as semi-autonomous components.
- Mediation between diverse technologies for instance adding to legacy system a new layer, providing them with functionalities.

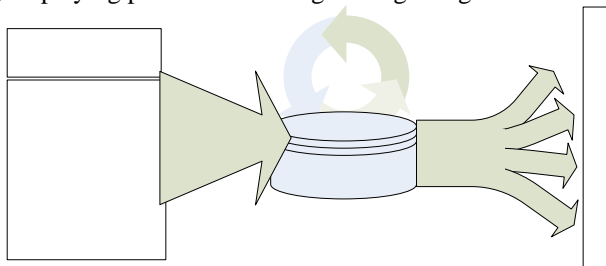
Michael Luck [12] recognizes some emerging trends and drivers in using agent-based technology:

- Semantic Web: to define data on web so it can be used by machines for automated processing,
- Web Services and Service Oriented Computing: with its structure, almost ideal for supporting agent interactions in multi agent systems,
- Peer-to-Peer connects users, using wide array of technologies, agents can help achieve higher standard of robustness, ease of deployment and maintenance,
- Grid Computing enables integrated, collaborative use of high end computer systems managed by multiple organizations. They often require resource sharing across organizational boundaries,
- Ambient Intelligence combines omnipresent computing, communication and intelligent user interfaces,
- Self-managing Systems and Autonomic Computing with minimum of human interference to increase productivity while minimizing complexity for users,
- Complex Systems: conceptualizing real systems as compromising interacting autonomous entities in order to build realistic computer simulations.

#### 4. A framework for intelligent agent based Business intelligence

Combining the process, described in BI data framework and the properties of agent-based technologies, we assume three areas of intelligent agent potentials in BI. Intelligent agents based BI framework is presented in

Figure 1, displaying potentials of using intelligent agents in BI.



**Figure 1** Model for using ABS in BI

Our assumption is that intelligent agents can be used for:

**Intelligent Acquisition:** for collecting mainly unstructured data from internal and distributed sources with use of agents recognizing information in semi-structured documents and autonomously researching possible sources of information.

**Intelligent modeling:** for creating environment simulation models for predicting future states of models, using ABS, handling on data, events and intelligent rules.

**Intelligent delivery:** for proactive delivery of selected information to appropriate users over the right communicating channel. This can be done using the brokerage agents, capable of identifying importance and correlation of information and autonomously deciding on used means for information delivery.

Further more intelligent agents can be used to facilitate intelligent collaboration.

Bellow we will discuss mentioned potentials using a case of customer credit rating in a bank.

Credit risk evaluations are crucial for financial institutions due to high risk associated with improper credit decisions [18]. This is why many different techniques, also known as credit scoring models, have been developed by the banks and researchers in order to solve the problem involved during evaluation process [19]. Most commonly there are two main objectives of credit scoring models: probability for repayment of complete debts, which classifies the customer in one of the groups and the amount of money customer can successfully repay. In general there are several issues in creating a customer credit ranking evaluation: Gathering quality customer data with intelligent acquisition, building successful, intelligent models, simulating future customer states and, at last, timely delivery of any relevant information concerning customer credit ranking changes.

**Intelligent acquisition:** Customer financial data, held in relational databases, normally accessed by classification models, contains delayed consequences of customer actions, performed in the past. If proactive reaction is expected; data about customer actions must be acquired from its origins, usually from distributed sources, at the time of its creation.

**Intelligent modelling:** Research was being done in using artificial intelligence tools such as Neuron networks for creating successful models with high correlation with actual credit scoring [19-22]. Their usage was though never widely accepted. Two possible reasons could be suggested: models that do not reflect the whole complexity of the real world were proposed, combined with the lack of explanatory means of the provided results. It is hard to decide on a suggestion, which can not be properly explained.

Important and often neglected characteristic of social models is a fact that customers are connected in a network of formal and informal relations. Therefore change in one player can affect a whole group of customers, carrying different consequences. The challenge is to create a model, capable of handling regulated, structured data, enhanced with unstructured data, derived from various sources such as news, investment records, customer plans and realizations etc. We argue that such a simulation can only be handled with use of agent-based systems [23, 24], where customers are simulated by intelligent agents, actively responding to changes in their environment. Up to now solutions of simulating complex systems still haven't reached the stage of development enabling their wide usage and can therefore be used primarily for research purposes.

**Intelligent delivery:** Usually credit ranking commissions meet on a regular basis where full credit reports are discussed and decisions are taken. This approach has two back drafts: it is time consuming for several senior and middle management, on the other hand very important issues, requesting immediate response, are often put in a queue and consequently not getting the response time, they ought to. Information delivery should combine: carrying the right information, using the right channel to the right user, last, but not least in the right time [25]. This is why really good assistant is so highly valued. Using intelligent agents with ability to proactively respond to exceptional events, to decide which information is to be delivered first, to be able to answer to user requests for additional information could upgrade the process of customer decision taking on a new level.

## 5. Conclusions

BI and intelligent agents have emerged as different research areas which are in recent research attempts often linked. While BI is successfully used in providing information from structured sources it often fails in providing information from distributed sources where information is placed in unstructured documents. Beside that there are other unsolved problems within existed BI frameworks. We are persuaded that some of them could be solved with integration of intelligent agents in BI.

In order to determine potentials of intelligent agents we propose a model presenting three prospective fields of intelligent agent usage. Intelligent Acquisition of data shows great potentials in using intelligent

agents for collecting mainly unstructured data from internal and distributed sources. Social simulation models, using ABS could greatly improve the prediction capabilities of currently involved models. The research of complex social simulation models using AI is very promising but there is still a lack of applied models and unified frameworks. Intelligent delivery of selected information to appropriate users, using the right communicating channels is a task where intelligent brokerage agents, capable of identifying importance and correlation of information and autonomously deciding on used means for information delivery could be used.

The discussed case of intelligent agent-based systems in customer credit rating in a bank showed that involving ABS is possible in all three potential fields. Furthermore it could greatly improve results of a customer credit rating system.

In our future we intend to deeply research three mentioned areas of intelligent agent potentials. We would like to build prototypes with different functionalities which could help us elaborate proposed framework and will allow us to test it within different business cases. We intend to start with intelligent agent based support system for customer credit rating and than to proceed to other business cases.

## References

- [1]. I. Perko & S. Bobek. Issues in Management support system development. International Institute for Advanced Studies in Systems Research and Cybernetic IIAS 2005. (2005), IIAS .
- [2]. R. Kishore, H. Zhang, & R. Ramesh. Enterprise integration using the agent paradigm: foundations of multi-agent-based integrative business information systems. Decision Support Systems In Press, (2005).
- [3]. Microstrategy. The 5 Styles of Business Intelligence: Industrial-Strength Business Intelligence. (2004).
- [4]. H. Morris. Analytic applications and decision -centric BI. DM Review **14**, 6, (2004). pp. 44-50.
- [5]. B. Moncla. Corporate performance management: turning strategy, into action. DM Review **14**, 5, (2004). pp. 21.
- [6]. S. Atre & D. Malhotra. Real-time analysis and data integration for BI. DM Review **14**, 2, (2004).pp. 18-20.
- [7]. P. Fingar. Business Process Management -The\_Next\_Generation. www.bpmg.org (2005).
- [8]. A. Gary. Don't Stop Thinking About Tomorrow The Key to Planning Your Business Intelligence Infrastructure Business intelligence, data warehousing and analytics. DMReview (2005).
- [9]. S. Negash. Business intelligence. Communications of the AIS **13** (2004).pp. 177-195.
- [10]. S. Bobek, S. Sternad, & I. Perko. Business Performance Models in Management Information Systems: Information Quality issues. International Institute for Advanced Studies in Systems Research and Cybernetic (IIAS 2005). (2005), IIAS.
- [11]. J. Langseth & N. Vivarat. Why proactive Business intelligence is a Hallmark of the Real-Time Enterprise: Outward Bound. Intelligent Enterprise (2005).
- [12]. M. Luck, P. McBurney, O. Shehory, & Willmott Steve. Agent Technology roadmap. (2005).
- [13]. Wikipedia. Software agents. [http://en.wikipedia.org/wiki/Software\\_agents](http://en.wikipedia.org/wiki/Software_agents) (2005).
- [14]. M. Wooldridge. An Introduction To Multiagent Systems. (2002).West Sussex, Wiley.
- [15]. I. S. Rudowsky. Intelligent Agents. Communications of the AIS **14** (2004). pp. 175-290.
- [16]. Wikipedia. Multi-agent system. [http://en.wikipedia.org/wiki/Multi-agent\\_system](http://en.wikipedia.org/wiki/Multi-agent_system) (2005).
- [17]. L. Padghan & M. Winikopff. Developing intelligent agent systems. (2004), Wiley.
- [18]. M. Romih. Kreditno tveganje in zahteve za uvedbo IRB metodologije za merjenje kreditnega tveganja v poslovnih banki. (2005), EF Ljubljana.
- [19]. T. S. Lee, C. C. Chiu, Y. C. Chou, & C. J. Lu. Mining the customer credit using classification and regression tree and multivariate adaptive regression splines. Computational Statistics & Data Analysis **50**, (2006).
- [20]. Y. M. Huang, C. M. Hung, & H. C. Jiau. Evaluation of neural networks and data mining methods on a credit assessment task for class imbalance problem. Nonlinear Analysis: Real World Applications In Press, (2006).
- [21]. D. J. Hand & M. J. Crowder. Measuring customer quality in retail banking. Statistical Modeling: An International Journal **5**, 2, (2005), Arnold Publishers. pp. 145-158.
- [22]. H. Xiaohua. A Data Mining Approach for Retailing Bank Customer Attrition Analysis. Applied Intelligence **22**, 1, (2005), Springer Science+Business Media B.V., Formerly Kluwer Academic Publishers pp. 47-60.
- [23]. M. Mohammadian. Intelligent Agents for Data Mining and Information Retrieval. (2004).London, Idea Group.
- [24]. N. Baxter, N. Collings, & I. Adjali. Agent-Based Modelling Intelligent Customer Relationship Management. BT Technology Journal **21**, 2, (2003), Springer Science+Business Media. pp. 126-132.
- [25]. R. Kishore, H. Zhang, & R. Ramesh. Enterprise integration using the agent paradigm: foundations of multi-agent-based integrative business information systems. Decision Support Systems In Press, (2005).