Towards Agent-based 'Smart' Collaboration in Enterprise Networks

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Abstract*—International competition and dynamically changing customer demands lead SME's to join dynamically formed, 'smart' enterprise networks aiming to increase their competitiveness and market share. Supporting such networks with decision making related to collaborations and providing adaptive user interfaces are key challenges. In this paper, we use furniture manufacturing SME's as a case study and we provide an overview of our ongoing work on e-Furn, an agent-based system for supporting 'smart' collaboration in enterprise networks. We outline two main features of the proposed approach: a) assisting users in typical collaboration decisions, such as product bundling and task outsourcing, and b) providing users with dynamically adaptive user interfaces.

***Keywords*—smart business networks; agent-based enterprise collaboration; intelligent recommendation systems; data mining**

I. INTRODUCTION

Small and Medium Enterprises (SMEs) currently face many challenges in maintaining competitiveness in the markets they operate in. The globalization of economy and the removal of duty barriers resulted in global supply chains [25], increasing thus pressure on wage intensive enterprises, such as manufacturing SMEs. Traditional effectiveness and efficiency improvements are no longer sufficient in the global race against competitors from Eastern Europe, India, and China. Therefore, several SMEs initiate outsourcing and/or off-shoring activities attempting to maintain their competitiveness. Furthermore, an efficient response to competition from multinational companies has often been joining suitable SME collaborative networks.

Virtual Organizations (VOs) can be a potential solution to this problem but they admittedly suffer from trust related problems. Therefore, VO members are commonly selected from a closed pool of known network partners [3, 5]. Smart Business Networks (SBNs) [20] are one step beyond VOs and they emphasise dynamic network operations enabled by state of the art information and communication technologies.

Such enterprise networks have certain characteristics, the prominent ones being their dynamic nature and flexibility in participation. For these reasons they are termed 'smart'. In SBNs members act solely towards achieving their personal goals and maximizing their individual benefit. This contrasts other forms of enterprise networks and virtual organizations where there is a different sense of membership and members aim to increase their individual benefit by acting towards the benefit of the whole organisation.

The dynamic nature of SBNs makes the use of software agents mandatory to develop software for supporting their operations. Agents offer flexibility and interoperability while they can provide both decentralised and inherently adaptive coordination and control. Furthermore, to better support the regularly changing business network competencies, it is necessary to utilise both service-oriented and agent-driven system architecture.

In this paper we present an overview of e-Furn, an agent-based system aiming to support 'smart' networking in furniture manufacturing SMEs. The context 'smart' networking in furniture SMEs and the core SBN concepts, together with agent and web service technologies that can be used to support SBNs, are briefly discussed in Section 2. Section 3 provides an overview of the e-Furn system, while Section 4 presents an outline of the approach that e-Furn follows to provide intelligent recommendations. In Section 5 the adaptive user interface design process followed in e-Furn is outlined, followed by a description of an exemplar e-Furn usage scenario discussed in Section 6. Finally, Section 7 briefly presents related work and Section 8 closes the paper.

II. CONTEXT AND BACKGROUND

The global financial crisis which has recently hit EU markets has forced many furniture manufacturing SMEs to reduce the range of their products and their production capacity in an attempt to reduce costs. Furthermore, the fierce international competition and the sophisticated customer requirements have in many occasions led furniture manufacturers to specialise in small product ranges where they have the experience to demonstrate excellence and to achieve highest product quality. However, this specialisation that emerged in furniture industry has often certain drawbacks. For example, despite having diverse preferences and varying requirements customers generally prefer to purchase complete solutions and the lack of variety shown by furniture manufacturing SMEs results in customers heading for larger stores with higher product range capable to accommodate their needs. In other cases, knowledgeable

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customers have done extensive market research, using the internet for instance, and they have specific product requirements that furniture manufacturing SMEs can not meet directly.

A. *Smart Business Network Concepts*

To address such problems furniture manufacturing SMEs traditionally tended to form partnerships and alliances and offer both own and partner products to customers aiming to mitigate the narrow product range and complex customer requirements problems [4].

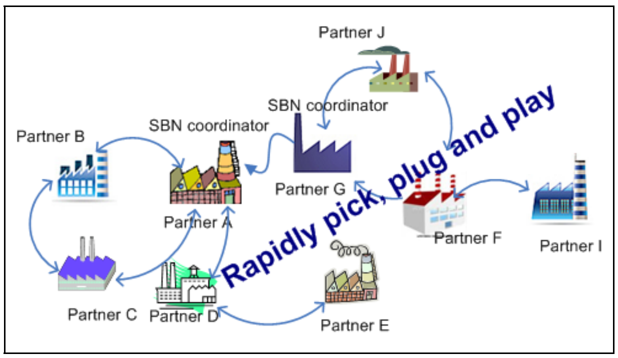

Figure 1. Smart Business Network

This approach has worked quite well in the past where customer demands were rather stable and product ranges were more or less fixed or rarely changing. Today, however, this is not the case due to the above mentioned reasons. We argue that the solution to this problem would be to provide the technological means for furniture manufacturing SMEs to rapidly join dynamically formed business networks and within them form 'smart' collaborations acting rationally to promote their goals while benefiting from the overall network context and collaboration infrastructure.

An SBN [20] is a collection of dynamically connected enterprises linked to each other with information and communication technologies, and acting 'smarter' than any individual business can (see Fig. 1). Such networks are characterised as 'smart' because of sophisticated products, services and experiences they provide to their members, as well as due to multiple possibilities they offer to network members to collaborate, innovate and organise themselves.

The key characteristic of SBNs is that they have the ability to "rapidly pick, plug, and play" business processes and re-configure them dynamically to meet changing objectives, such as fulfilling varying customer orders and reacting to unexpected situations such as emergencies. The words, "rapidly pick, plug, and play", reflect the main abilities that SBN members have: to quickly connect and disconnect from the network, to select and execute business processes across the network, and to establish decision rules and embedded logic within the network [20].

B. *Service-Orientation and Software Agents*

There are a number of approaches that can be applied to design software architectures satisfying the aforementioned requirements. E-Furn follows the SOA (Service-Oriented Architecture) approach enriched with using software agents. SOA can be viewed as an abstract software architecture in which all functions are realised as *services* [18]. Services are capable of being remotely invoked by external users and by other services, they encapsulate application logic with a uniformly defined interface, and they are commonly made publicly available via discovery mechanisms [23]. SOAs do not inherently provide any support for rational (semi-) automated selections, as would be needed to directly support VO creation for instance. This issue can be addressed by enriching SOAs with software agents.

SOAs are commonly, but not necessarily, implemented as Web Services (WS) leading to the issue of combining agents and WS [10]. The main efforts for integration of agents and WS focus on masking services for redirection, aggregation, integration and administration [9]. Although the evolution of Multi-Agent Systems (MAS) and WS has been completely different, both technologies have pursued common goals such as providing dynamic, open and service oriented architectures. To solve their differences and to provide interoperation possibilities, various approaches aiming to facilitate this interoperation have evolved, such as WSIG [9], WD2JADE [19] and ESWA [21]. These efforts can be classified in three categories [2]. Firstly, WS can provide the most basic level functionality while agents can supply higher-level functions by using, combining and choreographing WS to achieve added-value functions [19]. Alternatively, communication in WS and agents may become equivalent, so that there is no distinction between them (an approach commonly referred to as 'agents in web service wrappers') [21]. Finally, both concepts can remain separate creating a heterogeneous service space and interoperating through gateways and translation processes [9]. In e-Furn we view agents as web-service orchestrators and choreographers invoking WS, legacy systems and other resources, such as databases, as needed.

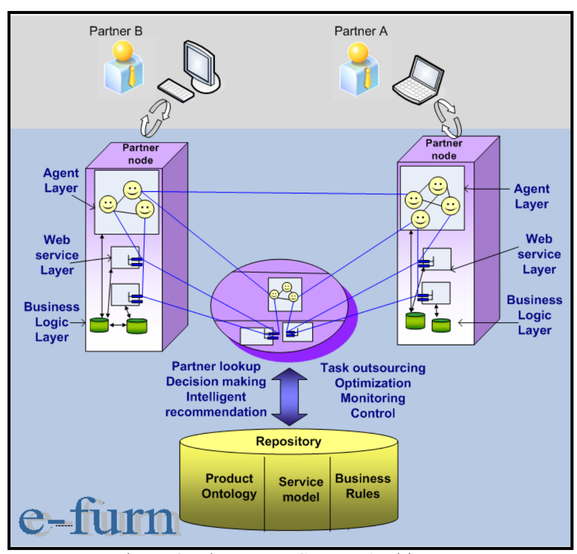

Figure 2. The e-Furn System Architecture

III. THE E-FURN SYSTEM

The e-Furn system (see Fig. 2) follows the principle of separation of concerns, considering different software architectural layers: the Business Logic layer comprising legacy systems and other information resources, and the WS and the Agent layers corresponding to WS and agents respectively. The functionality of all three layers is combined to produce overall 'smart' business networking functionality. The system is viewed as a grid of distributed interconnecting partner nodes that are all linked with each other. One of the nodes plays the role of the *main e-Furn node* and acts as coordinator of other nodes, for example by intermediating to establish communication for new partner nodes joining the network, and by resolving conflicts that may arise. To establish communication, new partner nodes get in contact with the main e-Furn node and after necessary authorisations they obtain access to the partner details, such as addresses and available services. e–Furn is considered to be an open system based on software agents as described in [5, 8]. The main architectural elements of the e-Furn system are:

Software Agents: Agents interconnect users with other main functional system components such as WS. Each external actor to the system, for example service providers, service users and system administrators, is associated with a software agent acting on her behalf, interconnecting the actor with the rest of the system and providing assistance. In the current version of e-Furn three main types of agents are distinguished: agents that act on behalf of service owners (e.g. 'Provider Agent'), agents that act on behalf of service consumers (e.g. 'Salesman Agent' and 'Monitor Agent'), and agents that perform management and administration tasks (e.g. 'Discovery Agent', 'Selection Agent' and 'Broker Agent'). Agents acting on behalf of service owners manage access to services and ensure that contracts are fulfilled. On the other side, management agents have a double function: to balance the system workload and to help in solving conflicts. Finally, agents that act on behalf of service consumers have to locate services, agree on contracts, and track and resolve the interoperability mismatches.

Agent roles: Agent behaviour is modelled using roles. At run-time each agent decides on what roles to play depending on the goal it pursues. Some roles are mandatory since they are characteristic of a particular agent type. Thus, for example, agents aimed for overseeing and coordinating overall system operation should play the 'Global Monitor' and the 'Platform Manager' roles. Both factors, the actual implementation of these roles and the agent election of the roles to take, eventually determine the agent behaviour. Roles for the e-Furn agents have been identified using the methodological steps discussed in [16] and [26] but the detailed presentation of e-Furn agent roles is outside the scope of this paper.

Ontologies: e-Furn utilises various data repositories containing the knowledge that is necessary to carry out its operations. These repositories can be either local or external to the system. Knowledge in e-Furn is represented by means of ontologies as well as rules. Ontologies are used in agent communication and in WS semantic annotation enabling interoperation and dynamic service composition.

Web services: The SOA paradigm facilitates on demand linkage of users and computational resources. Services are designed to support interoperable machine-to-machine interaction over a network and they provide interfaces allowing clients to invoke them independently of physical device, operating system or application used.

Business rules: The SBN operation is governed by a set of organisational policies and business rules. These are stored in a central rule-base and members can also make copies. Furthermore, partners can also have local rules governing their participation in the network. Agent behaviours are affected both by global as well as by local business rules during system operation.

Repository: Central to e-Furn is the concept of main information repository. However, the repository is not stored in a centralised database but instead it is updated dynamically based on partners' local knowledge bases, system usage history and partner availability. Any calculations regarding system operations are done based on the snapshot of e-Furn repository as was determined at the particular time.

Intelligence assistance: E-Furn aims at supporting business networking operations and therefore e-Furn users are expected to be enterprise employees such as salesmen administrators and possibly other personnel involved in networked business processes. Enterprise customers do not interact with the e-Furn system directly. e-Furn users receive intelligent assistance in their daily operations. Representative examples of such assistance are recommendations for product bundling and manufacturing task outsourcing. More details about this assistance are provided in Section IV.

Adaptive user interfaces: e-Furn users interact with the system via polymorphic user interfaces that adapt dynamically to user preferences and to system operation results. The motivation and design approach of e-Furn user interfaces is briefly discussed in Section V.

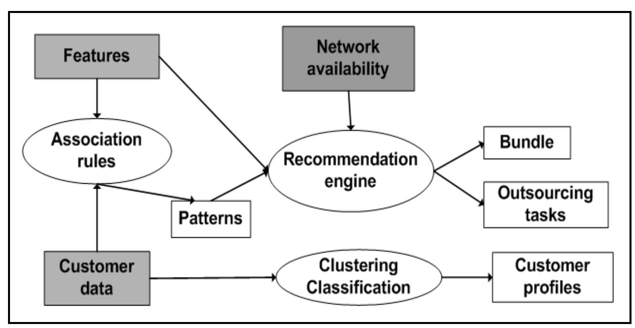

Figure 3. Intelligent Recommendations in e-Furn

IV. INTELLIGENT RECOMMENDATIONS

The e-Furn system uses innovative intelligent methods to provide recommendations to users, e.g. salesmen or other employess, of each e-Furn member enterprise (see Fig. 3). For example, it can formulate and recommend *product bundles* considering an initial set of furniture features, furniture types available from partners on the network, and historical customer and sales data. Similar methods are applied to recommend *outsourcing manufacturing tasks* to other e-Furn members based on resource availability, price, and previous collaboration data.

The details of the approach are as follows: e-Furn maintains a repository of product features, such as colour, style and utility, which is updated dynamically. In addition to individual product characteristics, the repository includes information concerning possible product relationships. For example, typical product relationships are common product combinations, such as a set of chairs along with a dinner table and a set of kitchen furniture along with a fridge and freezer.

These feature combinations can include matching schemes in terms of style, colour, utility and spatial collocation. The exact values of these features are specified dynamically, for example via agent negotiation, before they are fed into **recommendation algorithms**.

However, what makes this system component truly intelligent is the utilisation of **association rule mining** which uses sales data from the customer database and furniture features from the respective feature database to extract sales and configuration *patterns* [7, 11, 28]. For instance, the system can identify items that sell together, such as sofas and TV tables. It subsequently estimates the best selling price for this bundle, considering numerous additional parameters, such as customer details, customer sales history and profit expectations.

Another important system feature is the processing of customer data and modifying recommendations based on customer classification results. Customer data are initially populated using empirical information supplied by human experts. These initial data concern furniture suitability for various business and domestic purposes, settings and budgets. Customer data are subsequently enriched during system usage and eventually a number of customer profile types are evolutionary constructed using data mining. The approach involves formulating clusters, (i.e. groups) of customers [29]. These clusters indicate similarity across a number of dimensions, including demographic, marketing, and even subjective factors. Clusters are then inspected by experts to formally determine classes of customers, which in term can be used in customer **classification** [22, 27] and customer profile formation [24]. Recommendations are then produced taking into account customer classes when such information is available.

In addition, e-Furn maintains information in the repository concerning services, e.g. manufacturing tasks, which e-Furn partners can undertake within a subcontracting collaboration. This information is also updated dynamically, for example a partner can modify the types of services that offers at any time, and the price of offered services is finalised by agent negotiation. Based on product manufacturing requirements and on internal and external availability of manufacturing services availability, e-Furn recommends whether related manufacturing tasks should be completed in house or be outsourced to other partners. To this purpose, a list of necessary tasks is produced and appropriate reservation recommendations are made.

V. ADAPTIVE USER INTERFACES

The user interface is the channel through which a user communicates with the e-Furn system, drives the system's flexibility and usability. As suggested in [1] and subsequently in [17], in order to build adaptation in an interface three important issues need to be considered: (i) users do not remain the same over time, through interacting with the system user's online learning model changes according to their knowledge and experience thus, updates of either the user model or the system design are vital; (ii) fixed interfaces can not be the solution to all types of systems, variety of skills and preferences will eventually lead to user interfaces that are better suited to some users than to others; (iii) user interfaces can become easier to use and more efficient and usable if adaptivity is considered [13]. Considering these criteria in the case of e-Furn we have concluded that an adaptive user interface is appropriate:

- Users of the system are salesmen experts in the domain at hand but not necessarily expert computer users. Their interaction with the system as well as gradual knowledge of the domain will lead to greater experience in use and thus adaptation will assist to better suit their varying requirements.
- E-Furn assists in dynamic creation of product bundles based on the customers' needs. A fixed interface can not be the case since the presentation of the products, and all related information and possibilities, needs to be customised based on the product bundle recommended by the system.
- Past studies have shown that usability can be affected when designing adaptive agent-based systems. Still, studies need to take place in the future to test e-Furn in real situations.

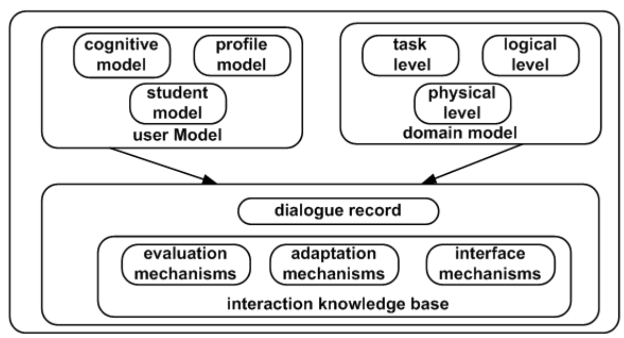

Figure 4. Adaptive Human-Computer System (from [1])

Having decided to use adaptive user interface for e-Furn the next step was to decide which design process would be followed. In [1] a high-level architecture for the design of adaptive human-computer systems is proposed (see Fig. 4). Based on that architecture the elements of three models had to be decided for the e-Furn adaptive user interface system:

- User model: psychological data and profile data elements need to be specified, for example the users' browsing habits (amount of time spent browsing specific pages).
- Domain model: defines the scope of the e-Furn system. Elements regarding the intentional level, the conceptual level and the physical level need to be specified, for example what does the user hope to achieve through browsing; what a web page is and how do the different hyperlinks related; how would

the actual menus, buttons, icons look like. Both the user and domain model are in the conceptual level and thus information could not be easily coded through interaction rather certain information needs to be known in advance, such as the user profile.

- Interaction model: the dialogue record, adaptation mechanisms inference mechanisms and evaluation mechanisms elements need to be collected. The interaction model uses information collected from users' interaction with the system. This information can be: pages visited, links selected; page suggestions through the e-Furn system containing furniture; use of heuristic page summarisation system in order to extract keywords from pages and thus form product bundles based on past experience; evaluations on suggestions by measuring how often the user views the suggested pages containing product bundles.

A detailed description of the above models is outside the scope of this paper.

VI. AN EXEMPLAR USAGE SCENARIO

Consider a furniture manufacturing enterprise E1 which produces and sells kitchen furniture. A customer walks in the exhibition of E1 and inquires about certain types of furniture, such as kitchen tables and fitments. After interaction with a seller the customer concentrates on a particular type of wooden kitchen fitments and a kitchen table. The customer states that her existing dining room suite is an old family heirloom. Therefore, she prefers the kitchen furniture to have similar furnish and the kitchen table to have a similar byzantine-like fretwork if possible. She then requests a quote for a set of furniture of that type.

After interacting with the customer, the seller is convinced that the customer has already obtained a competitive quote for at least the kitchen fitments from elsewhere. In search for a better alternative, the seller logs on to e-Furn and immediately sees a familiar interface. Behind the interface lurks the seller's personal assistant agent, which customizes the seller's interface according to the seller's personal preferences indicated previously. By selecting appropriate menu options, the seller requests information about the types of kitchen fitments that company E1 produces. The seller's agent response displays E1's kitchen fitness product range, together with technical specifications and prices. At the same time, additional menu options are enabled, for example leading to information about how kitchen fitments can be combined with other types of furniture.

The seller subsequently shows the customer more details about the selected kitchen fitment and the respective prices for different sizes. However, the customer does not seem enthused and she inquires again about the compatibility of these fitments with her existing dining room suite.

The seller then instructs e-Furn to inquire E1's network of collaborators about the particular kitchen table and the desired type of fretwork and to also suggest any other options that might be attractive to the customer. The agent A1, hidden behind the seller's user interface in e-Furn, contacts the respective agents of E1's network members but it receives a negative answer since no one can undertake such type of fretwork. The agent subsequently contacts the agents of all enterprises registered in e-Furn and finally receives a positive answer from agent A2 belonging to the enterprise E2. A1 interacts with A2 using a predefined negotiation protocol and achieves a price reduction. Subsequently, A1 invokes e-Furn's recommendation module and receives the suggestion that a good alternative option would be to offer the kitchen fitment and kitchen table together with kitchen chairs capable of receiving a fretwork. Given the fretwork eligibility requirement, A1 first checks for compatible kitchen chair types in the E1's product range but it finds nothing. Subsequently, it contacts agents of all other enterprises registered in e-Furn and receives responses from agents A2 and A3, corresponding to enterprises E2 and E3 respectively, and negotiates the respective prices. Finally, A1 invokes the recommendation module of e-Furn, which recommends two alternatives for producing a quote. The first alternative involves offering a bundle of kitchen fitment and kitchen table from E1 having a fretwork done by E2. The second alternative involves a bundle which additionally includes four kitchen chairs of the type offered from E3, also having a fretwork done by E2. At this point A1 modifies seller's user interface so that the two alternatives and the respective prices are clearly shown. Furthermore, additional menu options leading to more information about that type of kitchen chairs are displayed.

The seller quickly examines the two alternatives and presents them to the customer. Subsequently, seeing that the customer is inclined towards the second alternative but still indecisive, the seller decides to offer a slight additional reduction to the second bundle. Finally, the customer agrees and the seller updates e-Furn accordingly.

VII. RELATED WORK

There currently many internet applications that allow customers purchase product bundles and compare products from different suppliers, e.g. [14, 15]. However, they target end customers, and there is no interaction between different parties to define the exact features and prices of bundle items. Instead, e-Furn targets SMEs and aims to facilitate SME networking operations and execution of networked business processes in a dynamic manner. For example, in e-Furn product prices are always updated by negotiation before product bundling and they can be different for each partner, while in comparator applications product prices are fixed and they can change only by initiative of the respective supplier.

In [12] an approach involving using WS orchestration technology to realise adaptable and configurable business networks is described, and evaluated in a case study involving transforming a static supply chain network to a "loosely coupled" dynamic business network. However, the approach does not support choreography of services nor does it provide any intelligent assistance to network partners.

Collins, Ketter and Gini in [6] show how intelligent agents can support organisational decision-makers in making multi-attribute decisions in highly dynamic environments. They present an architecture that enables automatically connecting, disconnecting and communicating with the appropriate actors in the network. However, that architecture does not provide the same functionality as e-Furn, e.g. there is no support for product bundling and task outsourcing, and it is not based on the same technologies, such as WS.

VIII. Concluding Remarks

The e-Furn system is being developed to assist furniture manufacturing SMEs in participating in 'smart' business networks. E-Furn is based on combined use of agents and web services and its main futures include providing intelligent assistance and adaptive interfaces to users.

However, there are many issues relevant with providing robust and effective technological support for SBN operations in general, and furniture manufacturing SBNs in particular, that are still open. In the near future we plan to elaborate further on issues concerning provision of intelligent assistance to furniture manufacturing SBN members, such as product bundling recommendations and task outsourcing optimisation.

References

[1] D. Benyon and D. Murray, "Applying user modeling to human-computer interaction design," Artificial Intelligence Review, vol. 7, no. 3, 1993, pp. 199-225; doi: 10.1007/BF00849555.

[2] I. Blacoe and D. Portabella, Guidelines for the integration of agent-based services and web-based services, 2005.

[3] B. Blau, J. Kramer, T. Conte and C.v. Dinther, "Service Value Networks," Proc. 2009 IEEE Conference on Commerce and Enterprise Computing, IEEE Computer Society Press, 2009, pp. 194-201. doi: 10.1109/CEC.2009.64

[4] L.M. Camarinha-Matos, "Collaborative Networks In Industry Trends and Foundations " Digital Enterprise Technology, P. F. C. a. P. G. Maropoulos, ed., Springer US, 2007, pp. 45-56.

[5] C. Carrascosa, A. Giret, V. Julian, M. Rebollo, E. Argente and V. Botti, "Service Oriented MAS: An open architecture," Book Service Oriented MAS: An open architecture, Series Service Oriented MAS: An open architecture, ed., Editor ed.^eds., IEEE Press, 2009, pp. 1291–1292.

[6] J. Collins, W. Ketter and M. Gini, "Flexible Decision Support in a DynamicBusiness Network," The Network Experience — New value from smart business network, Springer Berlin Heidelberg, 2009, pp. 233-248.

[7] L. Dong and C. Tjortjis, "Experiences of Using a Quantitative Approach for Mining Association Rules," Intelligent Data Engineering and Automated Learning2690/2003, Springer Berlin / Heidelberg, 2003, pp. 693–700.

[8] A. Giret, V. Julian, M. Rebollo, E. Argente, C. Carrascosa and V. Botti, "An Open Architecture for Service-Oriented Virtual Organizations," Book An Open Architecture for Service-Oriented Virtual Organizations, Series An Open Architecture for Service-Oriented Virtual Organizations, ed., Editor ed.^eds., Springer-Verlag., 2009, pp. 23-33.

[9] D. Greenwood and M. Calisti, "Engineering Web service - agent integration," Proc. Systems, Man and Cybernetics, 2004 IEEE International Conference on, 2004, pp. 1918-1925 vol.1912. doi.

[10] D. Greenwood, M. Lyell, A. Mallya and H. Suguri, "The IEEE FIPA approach to integrating software agents and web services," Book The IEEE FIPA approach to integrating software agents and web services, Series The IEEE FIPA approach to integrating software agents and web services, ed., Editor ed.^eds., ACM, 2007, pp. 1-7.

[11] J. Han, M. Kamber and J. Pei, Data Mining: Concepts and Techniques (2nd edition), Morgan Kaufmann, 2006, p.800.

[12] J.V. Hillegersberg, R. Boeke and W.-J.V.D. Heuvel, "The Potential of Webservices to Enable Smart Business Networks in Smart Business Networks," Information Technology, vol. 19, no. 4, 2004, pp. 228–233; doi: 10.1057/palgrave.jit.2000027.

[13] K. Höök, "Steps to take before intelligent user interfaces become real," Interacting with Computers, vol. 12, no. 4, 2000, pp. 409-426; doi: 10.1016/S0953-5438(99)00006-5.

[14] http://www.amazon.com/.

[15] http://www.ciao.co.uk/.

[16] A. Karageorgos, N. Mehandjiev and S. Thompson, "RAMASD: a semi-automatic method for designing agent organisations," Knowl. Eng. Rev., vol. 17, no. 4, 2002, pp. 331-358; doi: 10.1017/S0269888903000572.

[17] R.J. Keeble and R.D. Macredie, "Assistant agents for the world wide web intelligent interface design challenges," Interacting with Computers, vol. 12, no. 4, 2000, pp. 357-381; doi: 10.1016/S0953-5438(99)00004-1.

[18] A. McAfee, "Will Web Services Really Transform Collaboration?," MIT Sloan Management Review, vol. 46, no. 2, 2005, pp. 78-84.

[19] X. Nguyen, R. Kowalczyk, M. Chhetri and A. Grant, "WS2JADE: A Tool for Run-time Deployment and Control of Web Services as JADE Agent Services," Software Agent-Based Applications, Platforms and Development Kits, 2005, pp. 223-251.

[20] E.v.H. Peter Vervest, Louis-François Pau and Kenneth Preiss, Smart Business Networks Springer Berlin Heidelberg, 2005.

[21] E. Ramírez and R. Brena, "Integrating agent technologies into enterprice systems Using Web Services," Enterprise Information Systems VII, 2006, pp. 223-227.

[22] L. Rokach and O. Maimon, "Top-down induction of decision trees classifiers - a survey," IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, vol. 35, no. 4, 2005, pp. 476 - 487 doi: 10.1109/TSMCC.2004.843247

[23] C. Schroth and T. Janner, "Web 2.0 and SOA: Converging Concepts Enabling the Internet of Services," Book Web 2.0 and SOA: Converging Concepts Enabling the Internet of Services, Series Web 2.0 and SOA: Converging Concepts Enabling the Internet of Services 9, ed., Editor ed.^eds., 2007, pp. 36-41.

[24] R.I. Scott, S. Svinterikou, C. Tjortjis and J.A. Keane, "Experiences of using Data Mining in a Banking Application," Proc. 2nd WSES/IEEE/IMACS -Int'l Conf. Circuits, Systems Computers ((IMACS CSC'98), 1998, pp. 343-346. doi: 10.1.1.55.2093.

[25] A.J. Stentoft, D. Torben and H. Anders, "Key Success Factors for ICT-System Implementation in SME's," The Network Experience, 2009, pp. 249-266.

[26] M. Stuit and N.B. Szirbik, "Towards agent-based modeling and verification of collaboration business processes: an approach centered on interactions and behaviors," International journal of cooperative information systems; doi: 10.1142/S0218843009002063.

[27] C. Tjortjis and J. Keane, "T3: A Classification Algorithm for Data Mining," Intelligent Data Engineering and Automated Learning — IDEAL 20022412/2002, G. Goos, et al., eds., Springer Berlin / Heidelberg, 2002, pp. 1-10.

[28] C. Wang and C. Tjortjis, "PRICES: An Efficient Algorithm for Mining Association Rules," Intelligent Data Engineering and Automated Learning – IDEAL 2004, Lecture Notes in Computer Science Volume 3177/2004, Springer Berlin / Heidelberg, 2004, pp. 352-358.

[29] I.H. Witten and E. Frank, Data Mining: Practical Machine Learning Tools and Techniques (2nd Edition), Morgan Kaufmann, 2005, p. 525.