Use of Ontologies to Support the Situation Room Metaphor as an Auction Engine for Corporate Information and Knowledge Exchange

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Abstract
In this paper, we present a methodology for modelling corporate interactions using the concept of the situation room as a supporting paradigm. Such an approach enables a way to model interactions of a rather idiosyncratic nature, in this instance a closed corporate auction market that is concerned with the exchange and valuation of intangible goods, namely information per see. Work presented in this paper forms part of a wider research in defining a methodological framework for Situation Room Analysis (SRA), and its deployment for complex auctions systems study. Using this approach we propose the use of ontologies as a powerful means to support the implementation of multi-party collaboration and decision-making activities that build on the paradigm of a Situation Room (SR). The approach is characterized as top-down in that the SR paradigm is conceptualized through three related models: the Situation Room Model (SRM), the Information Management Model (IMM) and the Situation Analysis Model (SAM). The ontology-based approach includes the semantic features of the exchanged auction-related information thus offering the integration of the SRA framework with existing corporate decision-making grids.

Keywords: ontologies, multi-party decision making, auction engines

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SETTING THE STAGE: SITUATION ROOM ESSENTIALS

Work presented in this paper forms part of a wider research in defining a methodological framework for Situation Room Analysis (SRA), and its deployment for complex auction systems study for intangible goods as in this case of corporate information and knowledge. In our approach, we propose the use of ontologies as a powerful means to support the implementation of multi-party collaboration and decision-making activities that build on the paradigm of a Situation Room (SR). The latter term, upon which we base the development of a specialized auction engine, is broadly used in the context of military operations and has specific semantical connotations. Like all systems of notation and semantics, Situation Room Analysis can never be anything but a model; it is a map to a territory, whose validity may be evaluated by reference to that under-lying reality in the ‘real world’.

After a set of brief introductory positioning statements, we relate our work with the world of ontologies and provide some insight to the way of using SRA in the context of a
corporate auction market. An implementation using Web services is then presented, accompanied with some representative services and a basic ‘reference’ scenario and concludes with an experimental finding regarding the model’s behaviour in a set of simulated example cases.

Historically speaking, a Situation Room is considered as the intelligence analysis centre used to stay abreast of the latest intelligence reports and updates. Such intelligence allows an army’s or an army unit’s senior officers to make informed command decisions and/or stay current on news throughout the federation of other units and beyond. Within this aim, i.e. the multi-party collaboration and decision-making activities from within the Situation Room Analysis framework, it is easy to see that the latter should be data-driven. In this respect we can consider the case of, for example, a company planning to create a virtual market response Situation Room to improve how it collects and assesses information regarding its own and/or competitors’ products. Such an approach would enable stakeholders to obtain important data in a more timely and effective manner.

For strategic decisions senior management need information about, among others, markets, customers and technology development in their industry as well as changing economic circumstances. Bovet and Martha (2000), for example, argue that decision support systems have a critical role to play in supporting longer term, strategic decisions across highly interdependent ‘value networks’. However, such information systems have rarely satisfied this information requirement and Ward and Peppard (2002) suggest that the main reasons for this include the paucity of external information included in the systems, the rawness of the data and the data’s lack of context. This latter point, in particular underlines the requirement for knowledge as opposed to just information (Hulpic 2002; Skyrme 1999). In the context of customer information Dhar and Sundarajan (1999) discuss the problem of maximizing information liquidity, which they define as the rate at which organizations are able to transform the inherent information in a data set into an economically valuable action and useable knowledge. While not restricted to only maximising customer information, the proposed approach to the closed auction market discussed in this paper is concerned with realising such benefits.

The use of SRA for auction systems builds and extends on our previous work with this methodological framework as presented in (Koumpis 1997) and (Koumpis and Roberts 2003), which put emphasis on the idiosyncratic characteristics of the ICT sector such as innovation, technological change, transfer of technology and technology diffusion. The latter require the development of a design space where different scenarios will be subject to in vitro assessment and evaluation. The employment of the framework may take place during any phase of the life cycle of an ICT service or product, i.e. from the early design phases up to the phase of its launching into the market.

In this respect, a promising approach to cope with the definition of an SRA-based auction engine exploits semantic indexing techniques. The latter, though not new, is a sophisticated indexing schema, which allows us to support the kinds of operations necessary in an efficient way based on ontologies in terms of taxonomic information with additional links that represent associated properties. As we see later in the paper, Web services are used as a means for organizing the interactions among the SR auction participants, and the latter may assign their tasks (e.g. look up, identify and classify, relevance check) to them. In this respect, SRA-based auction services can be divided into three general groups:

1. information retrieval services;
2. cooperation services; and
3. transaction-related services.

Use of ontologies

There is an increasing interest in ontologies for a variety of content-based tasks, including conceptual indexing, context sense disambiguation and cross-system information retrieval. A relevant contribution in this direction is represented by ontologies with domain specific coverage, which are a crucial topic for the development of concrete application systems. According to Hahn (2003), semantic web technologies and management tools can be used to link the particular entities of a distributed model. More specifically, two integration concepts have been used:

1. file-based, where the information is stored in an XML representation enriched with meta-information expressed in RDF (Resource Description Framework); and
2. online, where tools can provide the information online with an interface implemented as a Web service.

The employed indexing scheme is based on ontologies: taxonomic information with additional links that represent associated properties. While some ontologies represent very general knowledge, others specifically target a particular domain (Ankolekar et al. 2001). We first need to define a mapping between the attributes used in the auction engine and the terminology represented in the ontology. Users (are expected to) employ terms defined in ontology when generating respective bids. Ontologies can also provide a way to group records of a database in a semantically meaningful way. This type of semantic grouping can be used to optimize bid performance. We anticipate that SR participants will frequently access data using groupings
defined in a particular ontology; this ontology can be used to create indices that will allow SR participants to retrieve data grouped by ontological concepts from the auction engine.

In order to use ontologies for indexing we have to establish links between the data in the auction engine and the concepts in the ontology. All pairs of attributes and values in the database are mapped to concepts in the auction engine ontology. (Throughout this paper the simplifying assumption is made that data is stored in a universal relation. This is not a necessary condition, but simplifies the discussion of the basic ideas.) This mapping requires the use of a data dictionary to translate database attribute value pairs to ontology concepts. An example is given in Figure 1. The solid links are ontological links and the dashed links are indexing links. The table at the bottom represents the attribute-value pairs. To access them, an Attribute Editor has been implemented and used to select attributes and/or values for a particular concept of the ontology. Selecting an existing attribute and value will automatically update the corresponding concept box to the type of the value already present. (For example, if a concept-valued attribute is selected, clicking on a value field and then on a concept in the Editor selects that concept as the new value of the attribute. This enables convenient selection of a concept within the ontology as the value of an attribute.)

The integration of ontologies into corporate legacy information and knowledge sharing systems is of growing interest as they can increase the efficiencies of the way a company uses existing information and knowledge (re)sources. For instance, in the case of a company that uses a traditional division of their activities into different cost or profit or value centres, each centre is related to different tasks and the aims it is expected to fulfil relate to different elements of the corporate objectives (see Figure 2). To address this, each department or business unit uses a particular ontology, which provides the communication means for assisting coordination of its core business.

Such a local ontology may vary greatly from centre to centre. For example, the introduction of a new product relates to profitability aspects for the Finance Dept and invokes the possibility of stopping any further production and selling of older products that have reached their maturity in the market. It also raises questions related to campaigning, competitors’ attitude, etc. for the Marketing Dept, as well as minimization of production costs and waste for the Production Dept. From the

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**Figure 1.** Use of ontologies for indexing data/information entities used for SRA
above, it is clear that there is need for a treatment of the semantics for each different notion as this appears at the local ontology level; this is the role that can be assigned to the Global Ontology, which affects the entire corporate process grid and, as expected, the employed auction engine. The relationship between the several local ontologies and the one global ontology is managed through the mapping. Uschold (2000) recognizes that if both local and global ontologies coexist there is the need to know how much of each local ontology needs to be mapped. He identifies two cases where there are either very few ontologies, where each need to be mapped into all the others, or, alternatively, the situation where there could be many ontologies, but relatively few need to be mapped to one another. Aumann and Heifetz (2001) claim that ‘in interactive contexts such as games and economies, it is important to take account not only of what the players believe about substantive matters (such as payoffs), but also of what they believe about the beliefs of other players.’ To a lesser extent, there was also concern about the players’ uncertainty about the strategies available to others, and about their own payoffs.

Before going into a deeper level of analysis for the use of ontologies in our framework, we provide some background information on modelling aspects of the Situation Room Analysis framework. We also discuss some basic auction engine services it is expected to provide to SR participants, and for which the use of ontologies is considered as a contributing factor to overall efficiency.

MODELLING ASPECTS OF THE SITUATION ROOM

This section includes some additional information on the models pertaining to the SR concept. Our goal is to support high-level corporate operations, by means of defining the Situation Room Analysis as a powerful
vehicle to support this need. The main entities for defining the basics of Situation Room Analysis are related with:

- the concept of the Situation Room per se;
- the managed information within the SR; and
- the main items of the conducted auctions, which relate to intangible goods such as corporate information and knowledge.

In regard to all three of them three corresponding models are defined, namely:

1. The Situation Room Model (SRM);
2. The Information Management Model (IMM); and
3. The Situation Analysis Model (SAM)

They all concern descriptive conceptualizations of entities and activities, annotated with the interactions and possible relationships among them, which results in a super-model namely the Situation Room Analysis. Furthermore, we elaborate on this by providing the specifications for setting up the implementation of this to an IT framework using emerging technologies (XML, software agents, Semantic Web and ontology technologies) and established system design approaches (UML).

In both modelling and interpreting the impact of information in the context of the virtual network the research is also informed by game theory and transaction cost theory (Casson 1991; Friedman 1991).

Table 1 provides a description of the supported actions on a given auction entity as this is realized within the Information Management Model of the SRA framework.

As seen from Table 1, the central notion for an information entity within the Information Management Model is linking it to other entities available within the corporate auction market. Another important notion is that of ‘placeholders’ in which a specific entity will be input. These may either be predefined if we expect specific entities to populate them, or realized ad hoc. Such ad hoc creation of a placeholder often takes place under time and resource pressure and therefore its results are usually suboptimal. For this reason it is essential that placeholders are reconsidered on a periodic schedule and – if needed – adapted, renamed or consolidated with others.

In regard to the placeholders the same actions hold as for the information entity. There is, however, an exception and this is for the creation of a new placeholder. The reason for this is that while a piece of information has arrived and we recognize its existence, a placeholder is an artificial artefact for the construction of which we are solely responsible.

A further important aspect of the Information Management Model relates to the ability to represent all actions performed or attributed to particular information entities. In this respect, what is actually needed is a

<table>
<thead>
<tr>
<th>No</th>
<th>Identifier</th>
<th>Action type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RM</td>
<td>Remove</td>
<td>It is removed as if it never came under consideration within a set structure under use in the Situation Room. A more recommended practice is to justify reasons for its irrelevance and ignore it (see below). However, as long as logging of events throughout the corporate auction market is taking place, tracing back to this state is possible.</td>
</tr>
<tr>
<td>2</td>
<td>IGN</td>
<td>Ignore</td>
<td>It exists but is not used for any current inferences made within a set structure under use in the Situation Room. This is the case of trying to simplify a problem by ignoring (temporally or permanently) a set of information regarding specific aspects of the subject under consideration.</td>
</tr>
<tr>
<td>3</td>
<td>LN</td>
<td>Link</td>
<td>With some other piece of information within a set structure under use in the Situation Room. How? By means of choosing one of the supported link types.</td>
</tr>
<tr>
<td>3a</td>
<td>LN_TO</td>
<td>As above</td>
<td>Link as related to with a unidirectional link to another information entity.</td>
</tr>
<tr>
<td>3b</td>
<td>LN_FROM</td>
<td>As above</td>
<td>Link as related to with a unidirectional link from another information entity.</td>
</tr>
<tr>
<td>3c</td>
<td>LN_BOTH</td>
<td>As above</td>
<td>Link as related to with a unidirectional link for both information entities.</td>
</tr>
<tr>
<td>3d</td>
<td>LN_ONL</td>
<td>As above</td>
<td>Link ‘only’ to the other information entity without any further pre-defined relationship between them.</td>
</tr>
<tr>
<td>3e</td>
<td>CUST_LN</td>
<td>As above</td>
<td>This type enables user defined link types to be created by means of enabling users of the system to develop their own link categories, which may be domain- or user-specific and which may vary among each of the users or usage types.</td>
</tr>
<tr>
<td>3f</td>
<td>LN_LN</td>
<td>As above</td>
<td>This forms an important type of linkage as it provides the means to link a specific link with another link.</td>
</tr>
<tr>
<td>4</td>
<td>ADD</td>
<td>Add it</td>
<td>It concerns the insertion of a particular information entity to a set structure under use in the Situation Room.</td>
</tr>
<tr>
<td>5</td>
<td>CRT</td>
<td>Create</td>
<td>Creation of a new placeholder.</td>
</tr>
</tbody>
</table>
‘device’ that guards some conditions and performs some actions when the conditions are true. This idea is not new in Computer Science theory and practice where it is expressed by well-known metaphors like demons in AI and triggers in databases, and it has been widely used in several modelling languages and development environments (see for instance (Ceri and Widom 1996)). Our notion of a linker element (in brief: linker) realizes this idea in a slightly different fashion. While normally, the condition is defined by a universal predicate, which means that the guard needs to observe the whole, or a large part of a database to find any place where the condition is true, our linker works locally, as it guards only its own operands.

According to our approach the linker is the only way:

- to express relationships among information entities within the corporate auction market, be they passive or active relationships. Thus, we use the same notion for describing both static information entities and actions to them. The uniformity allows treating actions in the same way as static links, i.e. we can add and delete actions in the same way as we add and delete static relationships during a database transaction.
- to define actions on information entities. In this respect, any action that takes place within the SR to enrich or explain an information entity is simply linked to the previous state of the entity, providing also the last inherently proprietary characteristic of that last action.

Implementation of ontologies within the SRA framework

Our approach builds on the adoption of a service-oriented architecture that encompasses the simplicity and scalability of the Web services model (see Figure 3). Besides the simplicity of implementation, the advantage of modularity also enables the ‘repackaging’ of any existing SRA services into new, composite services. This increases the added value of the framework and should encourage companies to invest in its usage and population with new auction data. Preliminary developments that we have been experimenting with took place across a set of network nodes emulating the conditions of a realistic Situation Room.

As a result of this, we identify the need for introducing semantics in our approach as:

- synonyms of situations in various corporate contexts; and
- equivalent situation types in various corporate contexts.

They are also needed for:

- synonyms of situations in the same corporate context; and
- equivalent situation types in the same corporate context.

It is in this respect that there is a need to support semantic level processing for the collaborative SRA services to be delivered through the underlying application. For this, the technical goal is to provide a transparent system architecture. This will act as a dispatcher between cross-Cost/Profit/Value centres that will automatically handle the inconsistencies among the different situations and coordinate inter Cost/Profit/Value centre auction management at the process level.

Based on the above, it is clear that we need declarative forms of scripting complex web services, which would also enable composition of scenarios that represent real-world coordination among the different members of the SR, also taking into account temporal and synchronization aspects.

Ankolekar et al. (2001) describe DAML-S, a DAML+OIL ontology, designed by the DARPA Agent Markup Language (DAML) Services Coalition, to specify the capabilities of Web Services. DAML+OIL provides a semantic and further expressive power to the Extensible Markup Language (XML) and the Resource Description Framework (RDF). Furthermore, DAML-S provides service descriptions in three conceptual areas:

1. the profile, which describes what the service does;
2. the process model, which depicts how the service works; and
3. the grounding which states how the particular service is used.

SRA-BASED AUCTION IMPLEMENTATION

Features that one would expect to support an auction engine are, among others:

- user registration and authentication;
- Adding items for auction along with any other relevant information by the users;
- bidding on the items by the users;
• categorizing the auction items; and
• tracking by the user on sale and bid.

The prototype that we developed for verifying the adequacy of the Situation Room Analysis framework offers a deployment-ready platform for integrating auction features in a corporate Intranet.

A basic scenario of use is as follows. To get things started the Situation Room chairman (usually a senior corporate board member or the Chief Knowledge Officer) specifies the particular SR auction rules, enters all the SR participants’ details and sets the deadline for the first rounds of bids to be processed.

In order to achieve this it is necessary to support all the members of the Situation Room in having access to a core set of information, either by means of accessing a common documents repository or by using the operational corporate document management system appropriately adapted to support instant access to SRA topics.

Passwords are then sent to each SR session member, so that they can enter their particular bids via their own secure area. At the end of each round of bids the SRA auction engine is expected to verify the results with respect to the highest bidders. As the application domain concerns mainly corporate decision-making, the bidding process may be related with the valuation of some newly arrived information and data, or with the examination of some past event.

After each round of bids all SR members receive a notification confirming their latest bidding status. The SR chairman then sets the deadline for the next round of bids and the process is repeated until each SR member has a complete response to the items subject to decision.

When all SR members have responded to the particular thematic list they were given at the beginning, the SRA auction ends.

Our rationale for using Web services is that applications based on various programming languages, object models, and platforms can efficiently and elegantly interact with one another. Furthermore, the rationale for using ontologies relates to the fact that these are considered to be a well-established approach for modeling specific domain knowledge. It is after they prepare the correct model information and make it easily available that the synthesis of ontologies and Web services can more effectively automate the work, because it requires the sort of comprehension and complex decision making traditionally performed manually.

On the SRA-based auction system architecture

From the viewpoint of the architecture of the SRA-based auction system, Web services are used as a means for organizing the interactions among SR participants, and the latter may assign their tasks (e.g. look up, identify and classify, relevance check) to them. In this respect, SRA-based auction services can be divided into three general groups:

1. **Information retrieval services**: a particular Web service is designed to support its ‘owner’ in finding data or locating documents within the corporate Intranet environment. It searches structured (e.g. auction profile) and semi-structured (e.g. auction-related support documentation) data, extracts information, processes it and filters it. Such a service is expected to ‘know’ the desires and interests of its ‘owner’ or its ‘invoker’. It knows where to look for this data and needs no assistance by the user. The autonomy is the main reason why someone should use such a service.

2. **Cooperation services**: these are used to solve more complex problems. The cooperation Web service interacts and cooperates with other Web services, its environmental resources and the users. Generally the cooperation service is more intelligent than the information retrieval service because the ability of collaboration demands complex algorithms and functions. (Imagine for instance an SRA-based auction for a subject that needs involvement of experts from two different disciplines; in the simple case where no cooperation services exist, no initiative for a joint action could be taken.)

3. **Transaction-related services**: which are used in the distributed SRA-based auction environment and are mainly assigned responsibility of carrying out valuation transactions to/from the participating (sub-)systems or applications with a defined level of security. It is easy to understand that this third level of services can be treated as a black box, without causing any loss of the generality of the provided solution.

A final aspect is the number of human users – the SR members – to populate such a system. If just a few people participate in the SRA sessions, the resulting outcome is of marginal benefit with respect to the costs related for establishing and operating the system. The appropriateness of the proposed approach, therefore, lends itself to the case of larger organizations where there is a need to support multi-party decision-making with use of asynchronous session-based interactions. The individual SR members would be asked then to ‘solve’ parts of a global valuation problem and coordinate their (individual) results appropriately through an auction process.

For instance, it is a totally different exercise to employ a thematic relevance check procedure for an amount of 10,000 documents with an average of circa 15 separate thematic keywords in each one of them, than it is to use it for a base of 1,000 documents with a complicated (nested) average of 15 keyword items for each document. Similar limitations to the appropriateness of the solution apply for the amount of involved parties.
Figure 4 provides an estimate of the gross system performance based on a simulation we have run for a set of more than 4,600 different cases. It should be noted that the reliability for the border values is rather low (<1.7), signifying a possibly reduced adequacy of the approach for such ‘extreme’ cases. For determining gross performance we used the weighted average sum of parameters including, among others, user recall, connectedness of thematic items, retrievability and relevance. From the trace results, we see that higher numbers indicate better performance as it is also the ‘natural’ expectation, though it is apparent that the performance peak exhibits abnormalities; e.g. for 10 themes and 100 users the system behaviour is close to this shown for 10,000 users, while there is a decline in performance in between for 1,000 users. This anomaly is easier to understand when we look back to the correlation among the different parameters that have been considered but further discussion and exploration of these aspects is beyond the scope of this particular paper.

To validate the model’s appeal, a series of sessions were jointly held in Thessaloniki, Greece with the Greek Innovation Relay Centre Help-Forward (www.help-forward.gr) where we had invited an audience of 23 companies. The main aim was to expose them to the concept of Situation Room Analysis and have them participating in various assessment exercises, in which the participants were able to conceptualize problems and situations faced within their daily routine, and for which the learning process is extremely demanding. We also identified during this workshop that companies do not feel ‘framed’ or constrained by labels such as ‘Knowledge Management’ or ‘multi-party collaborative decision-making’, and in this respect they are open to using methods and adopting solutions that will really help them in their business.

Finally, from a set of focus group sessions we held with industry practitioners, it became evident that though people might have always been using ontologies empirically for both representing and solving day-to-day problems, the corporate users that we have worked with seem to be needing a guided approach in doing so, and in this respect SRA fulfils a real need.

CONCLUSIONS

The fast growth of innovations in the past 20 years (coming mainly from the service and engineering disciplines) exposes companies and their shareholders to varied risks and different types of risk that may be difficult to quantify. Though extended report-centric infrastructures have been established (with companies investing several thousands of euros on them on an annual basis) these often result in extensive yet largely meaningless statements enumerating every possible risk yet still exhibit insufficient specific risk disclosures.

The problem with the way it is often currently done by companies is that it is not an integral part of a wider development process. It is more of a pre-development process where a model of how the business works is produced independently of the developers. From the developers’ perspective such a model has no relevance as a development artefact. The challenge is to produce modelling artefacts that are an integral part of the development process and that automatically generate supporting applications, as well as the respective application protocols. The concept of Situation Room Analysis (SRA) is proposed as a means of achieving this level of integration, thus closing the gap between the (envisaged) functionality and the (supporting) semantics of any particular corporate auctioning process and especially the one related with intangible goods such as information and knowledge. Activities related to both the preparatory actions needed for establishing a session within the SR as well as for organizing information management and processing within it, can make apparent the fact that there are plenty of infinite regress problems and that we need to disaggregate the concept.

![SRA performance indicators](image-url)

**Figure 4.** Simulation-based estimation of SRA-based auction performance
of information before we can get a better understanding of the arguments.

In the paper we have proposed the usage of an ontology-based approach that includes the semantic features of the exchanged decision-making information thus improving the quality of integration of the SRA framework with existing corporate decision-making auction markets. Our approach was verified building representative applications by means of Web services and the DAML-S language. Furthermore, in our SR family-specific modelling approach, the particular models as well as their instantiations are made up of elements representing notions that are part of the corporate requirements.

Note
‘Utility function’ is a technical term not of engineers but of economists. It means ‘that which is maximized’. Economic planners are rather like physical engineers in that they strive to optimize something.

References