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An integrated decision support environment for organisational decision making

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Abstract. Traditional decision support systems are based on the paradigm of a single decision maker working at a stand-alone computer or terminal who has a specific decision to make with a specific goal in mind. Organisational decision support systems aim to support decision makers at all levels of an organisation (from executive, middle management managers to operators), who have a variety of decisions to make, with different priorities, often in a distributed environment. Such systems are designed and developed with extra functionality to meet the challenge. This paper proposes an Integrated Decision Support Environment (IDSE) for organisational decision making. The IDSE is designed and developed based on distributed client/server networking, with a combination of tight and loose integration approaches for information exchange and communication. The prototype of the IDSE demonstrates a good balance between flexibility and reliability.

Keywords. Hybrid integration approach, decision support environment, organisational decision making, flexibility and reliability

1. Introduction

Over last several decades decision support systems (DSS) have experienced a paradigm shift from a stand-alone system that supports a single decision maker to make a specific decision through group decision support systems (GDSS) to organisational decision support systems (ODSS), through which distributed decision makers interact with one another and their decisions are co-ordinated towards mutually defined goals, i.e. the goals of organisations. Organisational decision making is a demanding task because the decisions that need to be made involve all aspects of an organisation including their products, technologies and personnel management. When considering the impact from the whole supply chain and global market such as end customers, material providers and product retailers, organisational decision making is further complicated. Due to the nature of organisational decision making in terms of its complexity, dynamics, multiple

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goals and often opaqueness, various types of decisions need to be made at different times and in different organisational units. Further they can be well–structured, semi-structured, ill-structured or unstructured [1]. These decisions can be also made at different levels of organisation such as strategic, tactical or operational. Therefore, decision support for organisational decision making is a big challenge, which has motivated broad interest in research on ODSS in recent years [2]. This paper proposes a novel framework of an Integrated Decision Support Environment (IDSE) aiming to meet the new challenges of organisational decision making, in dynamic situations, through a hybrid integration approach. The paper is organised as follows: Section 2 gives an overview of related work. The concept of the IDSE is proposed in Section 3, followed by Section 4 focussing on the integration strategies that enable IDSE functionality. Section 5 discusses further issues and draws conclusions.

2. Related work

A decision support environment distinguishes itself from a decision support system, and other information systems, by the feature of functionality reconfiguration. IDSE is a decision support environment that can provide flexible functions according to the changes of decision settings for varied applications. Most traditional decision support systems provide fixed functions despite their success in many application areas [3-5]. Other information systems such as EDP (Electronic Data Processing), MS/OP (Management Science and Operations Research) and MIS (Management Information Systems) have made contributions to decision support from the perspectives of data/information provision and management, but they also do not address the changing nature of decision making and provide corresponding solutions [6]. One stream of research attempted to address this issue was the proposal of DSS generators [7-8]. The DSS generators can assemble necessary capabilities from a set of DSS tools (new technology, new languages, new hardware and software) to configure specific DSS faster and easier to develop models, data and user interfaces that are customised to the application's requirements. The IDSE however goes one step further, which can integrate capabilities from a set of systems to configure a computer environment for varied decisions under varied situations, including decision making on ill-structured and non-structured decision problems.

IDSE is designed and developed based on the ODSS concept and therefore differs from a GDSS (Group Decision Support Systems) and EIS (Executive Information Systems). GDSS and EIS (now called Enterprise Information Systems) were both developed as complementary to but more powerful support tools than traditional DSS, in the sense that GDSS can provide brainstorming, idea evaluation and communication facilities to support team problem solving [9-11], and EIS extended the scope of DSS from personal or small group use to the corporate level and can provide a wide variety of information such as critical success metrics, key information indicators, reports with the ability to drilldown to underlying detail, budget information, plans and objectives, competitive information, news and more [12-14]. ODSS were developed based on the advances in GDSS and EIS, but had its focus on organisational decision making. It provides a mechanism for a large, geographically dispersed, decentralised organisation to allow individual managers to make decisions within their own domains while maintaining consistency with the decisions made by other managers and organisational goals. In short, it provides distributed decision support to distributed decision making on varied applications. Carter et al [2] summarised the difference of an ODSS from a traditional DSS in five aspects including purposes, politics, approach to building, focus on functions and components. This paper will focus on its technical side and discuss IDSE from system integration viewpoint (i.e. the components and relationships between components) and explore how the system integration approach will provide new strengths to ODSS.

The characteristics of the IDSE lie in two dimensions, as summarised in Figure 1: firstly its flexibility of functionality, and secondly its capability to support organisational rather than individual or team (group) decision making.

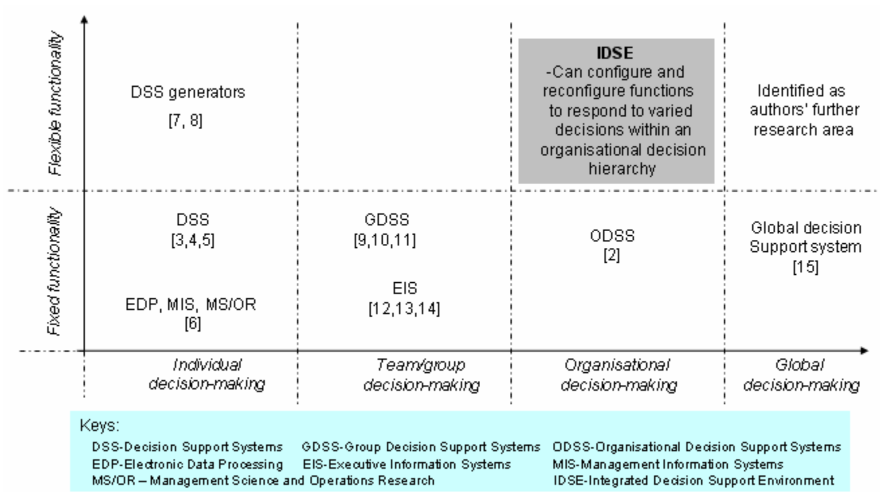

Figure 1. IDSE position relative to DSS and other information systems

3. Framework of the Integrated Decision Support Environment

The basic paradigm for a traditional DSS is that it consists of three major components: a model base management system (MBMS) with a model base, a database management system (DBMS) with a database, and a user interface (UI) dialog system that manages the interaction between the user, and the model base and the database. Due to the limitation of the functions provided by the three components and the "hardwiring" between the components, a DSS is destined to support specific applications with specific decisions under specific settings for specific users (decision makers), as illustrated in Figure 2(a). In an ODSS, these three basic components are still often the same as those of a traditional DSS, although there may be differences on how the components are designed and used.

To support organisational decision making, with varied applications that deal with varied decisions under varied settings for varied users (decision makers), an ODSS requires additional elements and functions. For example, network for communication. More importantly, it requires flexible but reliable mechanisms that allow agile configuration of the system components to provide support to the varied applications.

This is realised through a hybrid integration approach within IDSE, as shown in the Figure 2(b). The three components (i.e. the UI, the DBMS and the MBMS) comprise the basic components of the IDSE. The three basic components provide constant and fundamental support to applications (represented by a straight through symbol in the Figure 2(b)). IDSE has four additional components: a DM (decision management) component, an RR (resource reasoning) component, a CPM (change prediction and management) component, and a CW (collaborative working) component. Their support to applications is flexible based on the configuration of the components (represented by a switch symbol in the Figure 2(b)). This section will discuss the key additional components of IDSE and their relationships, and Section 4 will discuss the integration issue in detail.

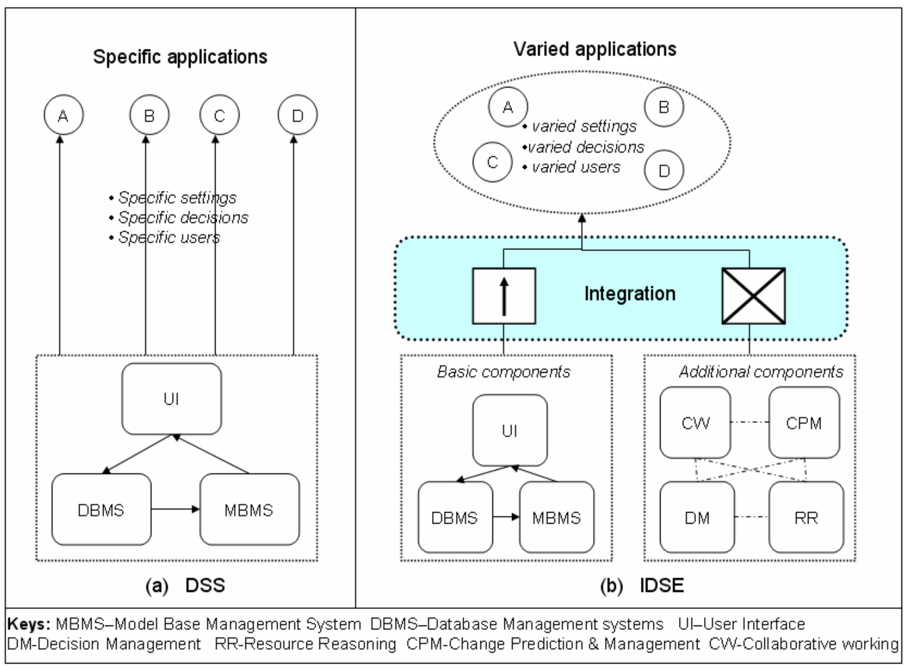

Figure 2. How an IDSE differs from a traditional DSS

3.1 The relationships between the three basic components

Figure 3 shows how the three subsystems (the MBMS, the DBMS and the UI) identified as basic components of IDSE work together to support decision makers (users). Decision makers initiate the communication with the IDSE and provide necessary inputs. The UI subsystem then talks to the MBMS to answer user queries, performs relevant sensitivity (what-if) and other analytical tasks. In the meantime, it talks to the DBMS to access data as required. The DBMS also provides direct data and information support to the MBMS. The solid arrows in the Figure 3 show that direct data and information access and sharing occur between the components. The direction of the arrows represents information flow. The close relationship between the three basic components implies that a tight integration approach would be appropriate in this case (to be discussed in Section 4 in detail).

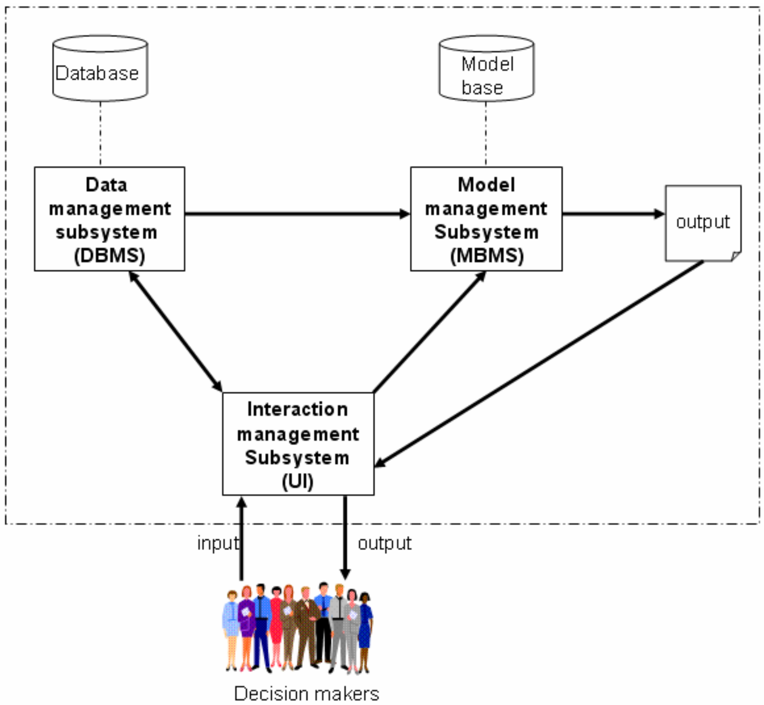

Figure 3. Three basic components of IDSE

3.2 IDSE additional components and their relationships

Efficient and effective organisational decision making depends not only on the decision maker making good judgement on resources that are required for the decision tasks, but also on good management of decision hierarchy where decision makers position in, and decision maker's interaction and collaboration with fellow decision makers. Especially when decision makers try to make changes of the decisions, how the consequences will propagate along the decision hierarchy. Based on the above considerations, four key additional components have been identified for the IDSE: a decision management (DM) component, a resource reasoning (RR) component, a change prediction and management (CPM) component and a collaborative working (CW) component. The DM component is designed to manage decision hierarchies and dependencies in an organisation as well as COA (Course of Action) planning. The RR component provides IDSE with the capability to search for the right resources including facilities and human resources across organisation units for decision tasks. This is developed from state-of-the-art ontology mapping techniques and a well-developed resource knowledge repository. The major function of the CPM component is to provide the IDSE with the capability of assessing any changes of decisions and their consequence propagation along hierarchies and organisational units before a change is carried out. Finally, the CW component provides interactive and collaborative capability to team decision making in an organisation when mutual decision goals (i.e. the organisational goals) are defined but decision preferences vary for different decision makers at different organisational levels. While these four components have their distinguished functions, the specification of the dependencies between the components allows them to communicate and to interact with each other, and to invoke and call services from each other when necessary. Figure 4 illustrates the relationships between the four components represented with SysML [16]. In the component diagram, the directions of the arrows show the information flow from one component to another, and the labels attached to the arrows show the nature of the messages that are communicated between the components.

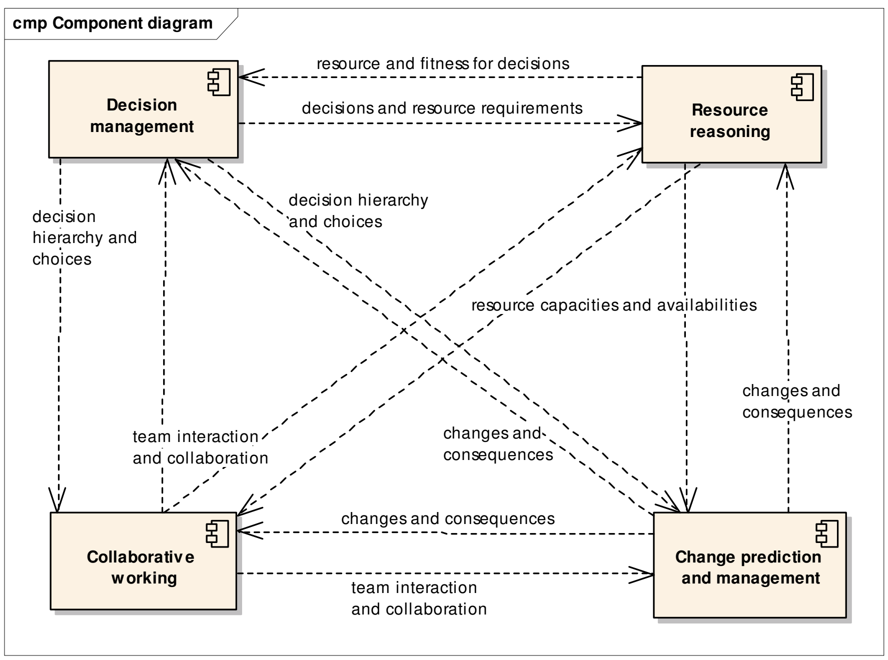

Figure 4. Relationships between the four components

3.3 IDSE communication mechanisms

This section discusses three communication mechanisms that enable distributed decision making across dispersed organisation units and determine IDSE performance: communication standard XML and remote procedure call XML-RPC, Java Networking Model and port mapping, and secure communication mechanisms.

3.3.1 Communication standard XML and XML-RPC

Communication standards are necessary because they provide a mutual "language" for IDSE components to "understand" each other's request and response. XML (eXtensible Mark-up Language) [17] has been used as a standard for IDSE communication because of its purity (pure data without side factors), popularity and user-friendliness. When IDSE components communicate over network using HTTP, XML-RPC (Remote Procedure Call) is used as the remote call protocol. An XML-RPC message is an HTTP-POST request. The body of the request is in XML. A procedure executes on the server and the value it returns is also formatted in XML.

The basic construct of an XML-RPC protocol for IDSE is shown in Figure 5, viewed with XMLSpy. Four elements as the first level children of *<IDSEMethodCall>* are important to communication: a *<sender>*, a *<receiver>*, a *<methodName>* and a number of *<param>*. The definition of the *<sender>* and *<receiver>* ensures that the message is communicated between the right components (from the right source to the right target). *<functionName>* element indicates the nature of the function (the reason to call a method), e.g. to report an error when something goes wrong. The details of the error then are described in *<params>*.

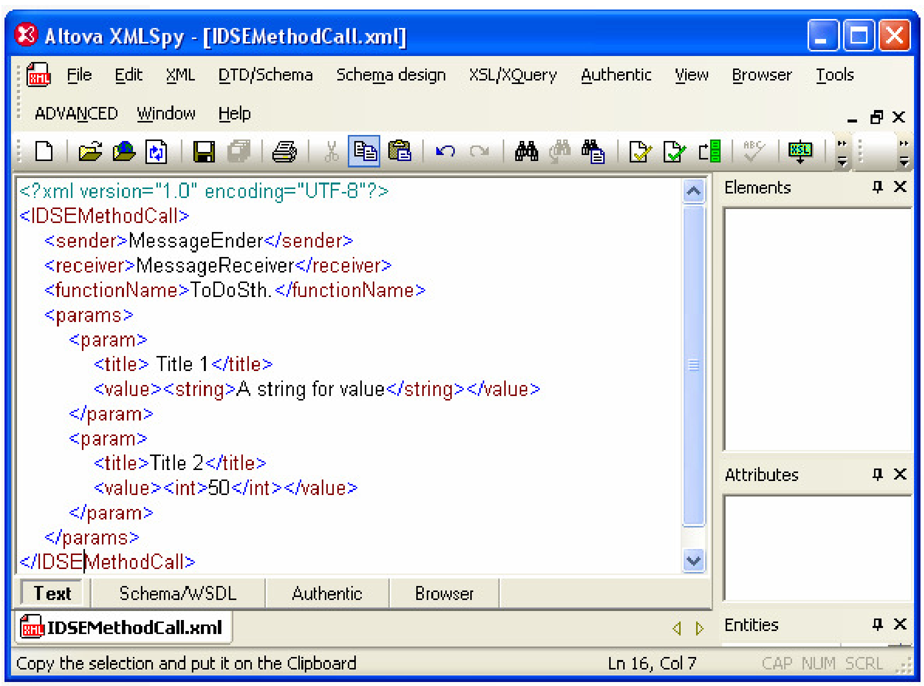

Figure 5. Construct of XML-RPC communication protocol for IDSE

3.3.2 Java Networking Model and port mapping

The IDSE employs a client/ server architecture on network, communication between different components will need the identification of the IP address and the port number.

The following figure 6 illustrates the Java Networking Model. The server assigns a port number. When a client requests a connection, the server opens the socket connection with an *accept()* method. The client then is able to establish a connection with the host on the assigned port. Thus, a communication channel is created with both server and client knowing where the communication is from and where to go for a particular purpose. To avoid communication chaos and maintain consistency, specific port numbers are assigned to all defined components of the IDSE.

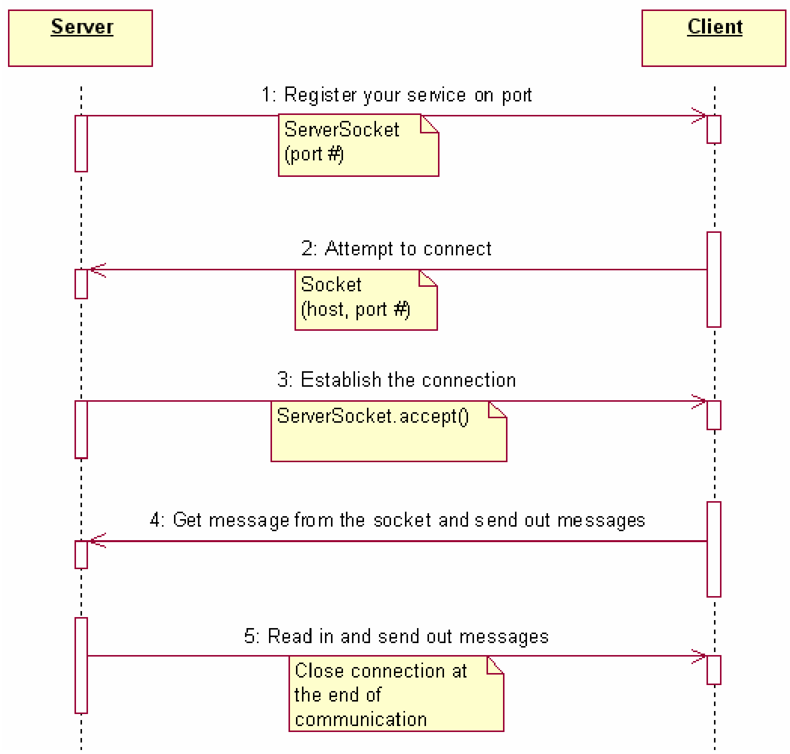

Figure 6. Java Networking Model with UML

3.3.3 Secure network communication mechanisms

Any information not transmitted through a secure channel on a network is subject to unseen eavesdropping. If security of information is an issue, then it is essential precautions be taken to provide secure communication between IDSE components. Java Secure Socket Extension (JSSE) has been identified and implemented for IDSE first prototype to meet the above requirements (Other methods could be incorporated as required). There are three key steps in secure data and information transmission from a Sender to a Receiver, as shown in Figure 7. These are encryption, decryption and authentication.

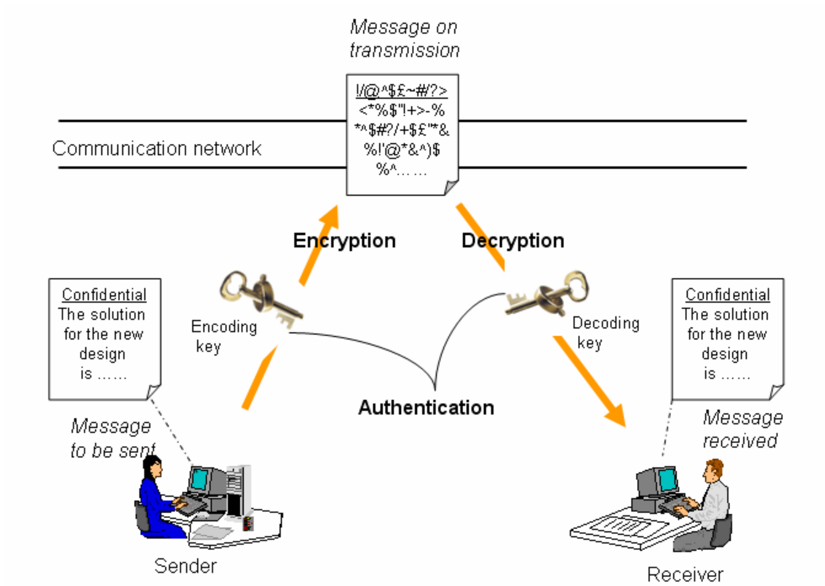

Figure 7. JSSE secure communication for IDSE

Encryption is the process of encoding messages before they enter the network, then decoding them at the receiving end of the transfer, so that receivers can interpret them [18]. The process works because if you scramble messages before you send them, eavesdroppers who might intercept them cannot decipher them without the decoding key. Some authentication mechanisms and software tools have been available for the key management such as self-signed certification and third-party certification. If you encrypt a message using your private key, you have "signed" it. A receiver can verify that the message came from you by using your public key to decode it. Third-party authority certificate is able to handle the issue with more sophisticated solutions. Secure Socket Layer (SSL), developed by Netscape, is currently a popular public-key encryption method used on the Internet and is implemented within IDSE.

4. A hybrid integration approach for the IDSE

Section 3 has discussed the basic components, additional components and the communication mechanisms for IDSE. This section will discuss a hybrid integration approach that binds all the components to the communication network to form the IDSE, which works as a coherent software environment to provide reliable and flexible support to organisational decision making. This is an evolution of the authors' previous research on a hybrid integration approach for distributed design co-ordination [19].

The hybrid integration approach taken to develop the IDSE is a combination of tight integration (through integration standards) and loose integration (through integration middleware). Specifically, the integration of the three basic components is undertaken through a tight approach, and the integration of additional components is undertaken through the loose integration approach. The difference between the tight integration (also called coupling) and loose integration (also called cohesion) within the IDSE is that tight integration binds components (such as DBMS and MBMS) together in such a way that they are dependent on each other, sharing data, methods and interfaces. In contrast to tight integration, loose integration is the "act or state of sticking together" or "the logical agreement" [20]. Cohesively integrated components (such as DM, RR, CPM and CW) are independent from one another. Changes to any source and target components should not affect the others directly. In this case, information is still shared between components but without worrying about changes to the components, leveraging some type of middleware layer to move information between components, and make adjustments for differences in component semantics. The tradeoffs have been considered in the IDSE through a combination use of integration middleware for cohesion and integration standards for tight coupling, as shown in Figure 8.

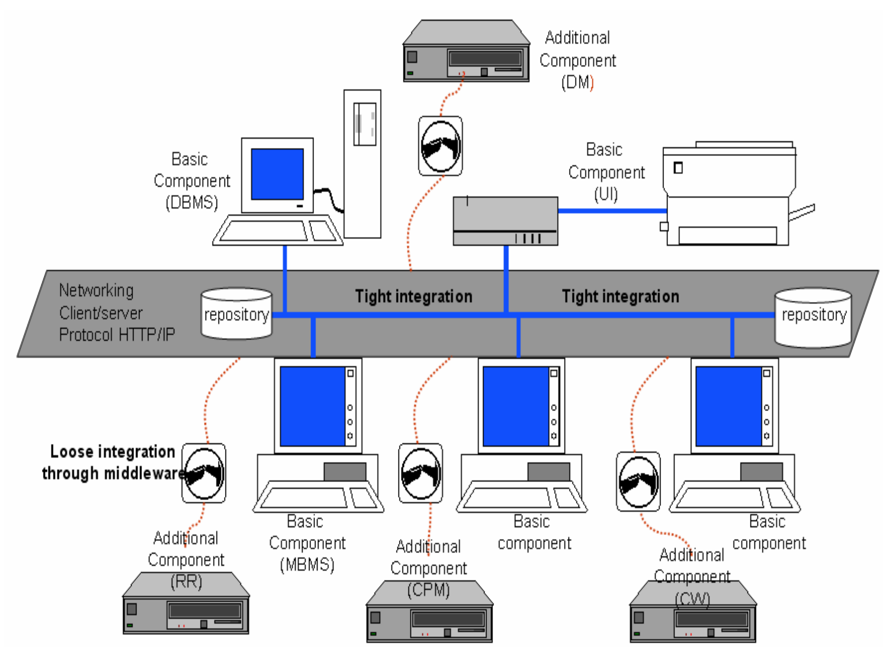

Figure 8. Tight and loose integration for IDSE

The advantage of having a combination of tight and loose integration within the IDSE is that the balance between reliability and flexibility is maintained. Through the loose integration with middleware, components such as DM, RR, CPM and CW can be added to, changed or removed from IDSE without typically requiring changes to any of the other components according to the varied application requirements in the organisational decision making domain. Integration middleware (a special piece of software in the case of IDSE) thus provides the technology infrastructure of most-cohesive integration solution. It is able to account for the differences between components, accommodating differences in application semantics within a middle-tier process. Despite the flexibility provided by the integration middleware, common decision making processes are to be reused within IDSE, therefore tight integration through standards such as XML and XML-RPC provides high speed and method sharing with great reliability. The disadvantage of having the hybrid integration approach is its complexity of implementation. In the future, IDSE will look into exploration of Web Service as an integration standard, and Java EE (Java Enterprise Edition platform) will be investigated as the new integration broker for IDSE.

5. Discussion and conclusions

This paper has proposed an Integration Decision Support Environment based on a study of DSS evolution and challenges of decision making in modern organisations. The key features of the IDSE which distinguishes itself from a traditional DSS can be summarised as:

(1) IDSE can support varied applications, i.e. varied decisions under varied situations for varied decision makers. Traditional DSS normally support specific applications with specific decisions under specific situations for a single decision maker working on a stand-alone computer.

(2) IDSE consists of more functional components than a traditional DSS. In addition to the basic components of a database management system, a model base management system and a user interaction system, the IDSE also has a decision management component, a resource reasoning component, a change prediction and management component, and a collaborative working component. These components empower IDSE with extra functionality that can manage decision hierarchy, reason the right resources for decisions based on ontology mapping, predict changes and propagation path, as well as team interaction and collaboration.

(3) The combined use of a tight integration and loose integration approach within IDSE provides good balance between the integration reliability and flexibility.

Further work will be research on new additional components to expand IDSE functionality to support global decision making [15, 21]. In the meantime, exploration on new integration mechanisms including Web Service and Java EE technology will be undertaken to enable global communication.

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