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An Intelligent Data Integration Approach for Collaborative Project Management in Virtual Enterprises

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Abstract

The increasing globalization and flexibility required by companies has generated new issues in the last decade related to the managing of large scale projects and to the cooperation of enterprises within geographically distributed networks. ICT support systems are required to help enterprises share information, guarantee data-consistency and establish synchronized and collaborative processes.

In this paper we present a collaborative project management system that integrates data coming from aerospace industries with a main goal: to facilitate the activity of assembling, integration and the verification of a multi-enterprise project. The main achievement of the system from a data management perspective is to avoid inconsistencies generated by updates at the sources' level and minimizes data replications. The developed system is composed of a collaborative project management component supported by a web interface, a multi-agent data integration system, which supports information sharing and querying, and web-services that ensure the interoperability of the software components.

The system was developed by the University of Modena and Reggio Emilia, Gruppo Formula S.p.A. and tested by Alenia Spazio S.p.A. within the EU WINK Project (Web-linked Integration of Network based Knowledge—IST-2000-28221).

Keywords: data integration, virtual enterprise, project management, software agents, web-services

1. Introduction

The increasing globalization and flexibility required by companies in the last decade generated new issues relating to the management of large scale projects and the cooperation between enterprises within geographically distributed networks. ICT support systems aim to allow enterprises to be able to share information, by guaranteeing data-consistency and establishing synchronized and collaborative processes.

These issues become very critical when talking about the aerospace industry, and in particular the production of scientific satellites and in-orbit infrastructures. within this context, we found very specific management issues compared to the traditional One-of-a-Kind Production models. Many critical factors are actually combined together: absolute reliability of materials, components, equipments and final assembled outputs, unique production processes and products, huge investments and high risks related to the ROI (Return On Investment) factor and strict time constraints.

For this reason the development of sophisticated and accurate procedures to analyse production requirements, verification and testing, and an accurate management of enormous quantities of technical documentation is required.

Moreover, the high quality of final products can only be assured by acquiring components from highly specialized companies: for this reason, it is very rare that the entire space project (called space program) is carried out within the scope of a single organisation, and often the prime contractor (typically a large company with adequate know-how) outsources specific components or activities to smaller firms through various forms of subcontracting. When this happens relations between main contractors and subcontractors are strategic and must be supported by adequate collaboration practices.

Finally, strict time constraints and huge investments require that all the activities within the entire product life-cycle (design, manufacturing, verification and testing, pre-launch operations) be planned and monitored precisely, by adopting project management tools capable of taking into account several factors including resource and product availability, budget and time constraints, personnel skills and availability.

Traditionally, all these issues have been dealt with by devoted information systems able to address only a subset of them. The integration of the different management tools and information sources has been increasingly perceived as being necessary for several reasons, the first being the fast technological evolution: in fact, the overall product life-cycle has shortened and quite often, during a space program, the time elapsing between the design and the launch phases is so long that some of the involved technologies become obsolete in the meantime. Secondly, new collaboration paradigms such as Collaborative Project Management, Supply Chain Management and Knowledge Management are definitely mature enough to support the overall process and must be accompanied by adequate information systems [10, 16]. Finally, the availability on the market of new technologies (XML for the exchange of data among different systems, SOAP for the interoperability among different software platforms, mobile agents for accessing remote systems resources) allows the possibility of a powerful and potentially easier interoperability than in the past.

In this paper we present a planning and collaborative management infrastructure for complex distributed organizations working as virtual enterprises on large scale projects. Other research projects and applications were developed for the integration of different databases, with the purpose of creating a complete information system for a "global" ERP system. Usually, the integration process is manually achieved and the databases are replicated into a new database without a strict updating policy.

Our system however focuses on two main goals: avoiding inconsistencies generated by updates at the sources' level and minimizing data replications. In this way we are able to support enterprises collaboration for a specific joint project. In particular, we use a semi-automatic integration methodology following a semantic approach that uses Description Logics-techniques [3], clustering techniques, and the ODM-ODMG [9] extended data model to represent extracted and integrated information [1, 7]. The system builds a

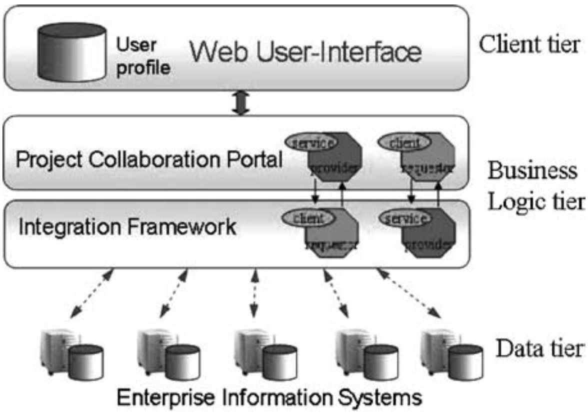

Figure 1 General WINK architecture.

virtual integrated view of the databases of the enterprises involved. Data resides on each enterprise information system (i.e. data is always updated), only their schemata are integrated into a global virtual view. Finally a multi-agent mediator-based system supports distributed queries over the Global Virtual View [4]. On the top of this data management framework, we provide a business logic component to manage the planning and the collaboration among different enterprises. We tested the system in a real world scenario in the aerospace industries courtesy of Alenia Spazio SpA, the Italian leader within the aerospace industry.

The proposed system, WINK, was developed within the EU WINK Project (Web-linked Integration of Network based Knowledge—IST-2000-28221) and is based on a three-tiered architecture (see Figure 1), exploiting integrated data coming from several data sources to provide the users with a set of tools, which increase the capability of managing large projects. In particular, the client tier supports operations such as alert firing, activity scheduling, project planning and visibility management, with a customized and integrated web interface. The business logic tier then includes a project collaboration infrastructure which supports monitoring, the execution and planning of a project as a multi-agent data integration component, which supports information sharing and querying; web-services, which ensure the whole interoperability of the software components. Gruppo Formula SpA, an Italian ERP software development leader, provided the project collaboration infrastructure, while the multi-agent mediator system was developed by the DBGROUP research database group of University of Modena and Reggio Emilia (http://www.dbgroup.unimo.it). Finally the data tier is the operational data source.

The paper is organized as follows: in Section 2, we give an overview of the case-study and the benefits offered by using WINK. In Section 3 we describe the general WINK architecture, then in Sections 4 and 5 we illustrate the main components of the architecture. In Section 6, the 'system at work' is shown thanks to a real world scenario. Finally, in Section 7 we present related works and in Section 8 sketches out some conclusions and future work.

2. Case study and expected benefits

The activity of Alenia Spazio's Assembling Integration and Verification (AIV) Department is based on well known aerospace industry standard procedures defined by the ECSS (European Cooperation for Space Standardisation). An exhaustive description of the standards adopted in the Verification and Testing phase in the aerospace industry can be found in two standard documents:

- ECSS-E10-02-A (17 November 1998): This standard establishes the requirements for the Verification of a space system and it specifies the fundamental concepts of the verification process, the criteria for defining the verification strategy and the rules for the implementation of the verification programme;
- ECSS-E10-03-A (03 January 2002): This standard provides standard environmental and performance test requirements for a space system and its constituents, defines the test requirements for products and systems that are generally applicable to all projects, defines the documentation associated with testing activities covering each stage of verification by testing, as defined by ECSS-E-10-02, for a space system from development to post-landing.

Starting from these requirements, the life cycle of an Alenia space program (i.e. the plan related to design, manufacturing, assembling and launch of a scientific satellite or an International Space Station module) can be subdivided in the following main phases:

- *Phase A*: It is the embryonic phase of a spatial programme, when the customer specification are acquired and the project scope is defined;
- *Phase B*: In this phase subcontractors are selected and the detailed project requirements are specified within the definition of the overall requirement tree. The requirement tree is a hierarchical requirement organization in which, every requirement which has a mother requirement from which it descends from is defined; each subcontractor has the responsibility for a specific branch of the requirement tree, the applicable set of requirements is called requirement specification. Further, we have a specification tree which is hierarchically subdivided into levels (e.g. system, subsystem and equipment);
- *Phase C/D*: In this phase, components are designed starting from the system level down to the equipment level following the requirements defined during Phase B. The Assembly and Test phases follow a bottom-up order, implementing integration rules starting from the equipments up to the system level. After the definition of the best testing and verification strategy has been found, different tests on the materials and components are carried out and the related non-conformances are dealt with on the basis of the requirements defined during Phase B. Assembling and manufacturing activities can go on only if the testing and verification activities have had positive outcomes;
- *Phase E*: This phase corresponds to the final launch campaign.

ProductID	SPEC_NUMBER	SPEC_TITLE	DOC_NUM	OC_TYP	HEADER	PHASE_ID	MOD_MARKER
GOESCRS5006	GO-ESC-RS-5006	Operations Interface Requirements Document	PRA-RP-AI-0002	REP		QUAL	cmorino,814,14:43
GORSESASY0002	GO-RS-ESA-SY-0002	System Requirement Document	GO-RP-AI-0012	REP		QUAL	sdellacr,710,14:45
GORSESASY0002	GO-RS-ESA-SY-0002	System Requirement Document	GO-RP-AI-0010	REP		QUAL	sdellacr,710,14:45
GORSESASY0002	GO-RS-ESA-SY-0002	System Requirement Document	GO-RP-AI-0003	REP		QUAL	sdellacr,710,14:45
GORSESASY0002	GO-RS-ESA-SY-0002	System Requirement Document	GO-RP-AI-0001	REP		QUAL	sdellacr,710,14:45
GORSESA							5
GORSESA							5
GORSESA							5
GORSESA							5
GORSESA							5
GOSRAI0C							1
GOSRAI0C							1
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ProductTree	REQ_ID	HEADER	TEXT
CUPOLA	10.0	PRODUCT ASSURANCE REQUIREMENTS	Product Assurance requirements for the EGSE are specified in dedicated document (refer to AD[4]).
CUPOLA	10.0-R2	Level 0 and Level 1a and 1b payload data processing	The contractor shall assume that the following products have to be provided: - Level 0: Time-ordered raw data downlinked from the satellite - Level 1a: Time series of payload data with calibration data attached including satellite ancillary data - L
CUPOLA	10.0-R3	Level 0 and Level 1a and 1b payload data processing	The contractor shall specify for the products, listed in req. 10-R2 - the algorithms required to generate the products (Detailed Processing Model DPM) with the requested accuracy as per Chapter 7. - the detailed product specification (Input Output Da
CUPOLA	10.0-R4	Level 0 and Level 1a and 1b payload data processing	Based on the algorithm and product specifications, the contractor shall develop a GOCE system simulator prototype including three self-standing modules namely: - The forward module simulating the gravity field at the orbits altitudes and the GPS and
CUPOLA	10.0-R5	Level 0 and Level 1a and 1b payload data processing	document describing the HW and SW environment needed to run the simulators and indicating the needed resources like memory and CPU processing times.
CUPOLA	10.1.b	VERIFICATION METHODS	The different verification operations shall be carried out at different level of assembly. The verification program shall ensure the coherence and the complementary of all these verification steps in order to ascertain that the full verification proces
CUPOLA	10.2	ANALYSIS AND TESTING	
CUPOLA	10.2.1	Verification philosophy	Testing of MGSE shall be kept to a minimum (proof loading, proof pressure, leakage for pressurized items, shock damping system, water tightness, functional performance) and where possible be replaced by analysis and calculation. Nevertheless any MGSE i
CUPOLA	10.2.2	Stress Analysis	A stress analysis shall be carried out on each item used to handle/transport flight hardware using the specified load cases (all welded joints shall be analyzed considering the 0.7 as added value of safety design, all bolts to bolts joints shall be con
CUPOLA	10.2.4	Thermal Analysis	A complete thermal analysis shall be carried out for TTA, TSC and GTSC.
CUPOLA	10.2.5.1	General MGSE Items	
CUPOLA	10.2.5.1.1	Proof Test	A mass dummy shall be utilized by the subcontractor. This shall be capable of simulating the mass, centre of gravity & interface of the flight hardware in all test configurations. Proof load testing shall be carried out each delivered MGSE Item, at 2 t
CUPOLA	10.2.5.1.2	Functional Performance Test	The Mass Dummy at 1 times the Safe Working Load shall be used to verify the performance & function of each MGSE Item.

Figure 2 Product and requirement tree of CUPOLA project.

The Testing and Verification phase (part of the C/D Phase) represents the core of the project: on one hand most of the components and the related manufacturing and testing procedures are unique and, on the other side, high levels of quality must be guaranteed.

At the beginning of the project (Phase A), the AIV manager builds a product tree (see Figure 2) according to the program requirements. The product tree can be then divided into sub-trees, each assigned to some external enterprise. An external enterprise will be considered a contractor or a sub-contractor depending on its responsibility and budget amount. The AIV Department examines the project requirements and organizes them in a hierarchical tree where the lower levels typically contain the needed equipment, the intermediate levels represent the assembled components and the root level is the overall system perspective.

In this way, the best verification procedures matching the requirements are defined. These activities are supported by different information systems from different enterprises, and involve many complex and distributed processes:

- Project scheduling systems for Gantt definition;
- Project accounting systems for the definition of project costs, budget and final balance;
- Resource planning systems for personnel allocation capable of matching the right skills and the right activities according to time and cost constraints;
- Requirement management systems usually rely on dedicated databases due to the complexity of the product and the high value of the materials;
- Document management system to manage Non-Conformance Reports (NCRs) which are usually stored on dedicated databases;
- Supply Chain Management system.

Starting from the requirement tree, the best-practise procedures and the project budget, goals and constraints, the AIV manager defines a weekly General Schedule (GS). An AIV GS associated to a specific space programme has an average duration of about 4 or 5 years and usually involves 20–40 people. The testing and verification activities corresponding to the various requirements assigned to an Alenia Spazio subcontractor are carried out by itself.

The GS is then transformed into a Detailed Schedule (DS), which holds a more operative function and usually has a short-medium term objectives. Due to strict time constraints, especially when launch date approaches, and the need in terms of reliability for materials, components and assembled equipment, the AIV Department requires daily management meetings, where the accomplished verification activities are analyzed and a detailed plan for carrying out the next step is formulated. In particular any non-conformities encountered are classified, the appropriate corrective actions are defined and the related documentation (Non Conformity Report—NCR) is archived. The GS must be up to date and must be continuously updated during the Assembly and Test phase. The daily meeting, chaired by the AIV manager, represents an important step that reworks all the information coming from the various IT systems combined with the additional information of the various people involved. This activity is very expensive in terms of employed resources and, to some extent, can lead to inefficiencies and ineffectiveness in the process itself. AIV activities have to take into account several vertical processes that are most likely managed with different information systems, therefore additional efforts have to be made in order to harmonize all data needed for activity monitoring (see Figure 3).

In addition, AIV processes involve the participation of External Companies such as Customer, Subcontractors/Suppliers and External Facilities. The customer (e.g. ESA or NASA) is present during the various tests. The customer is informed about the NCR's and shares the development risks according to the established contract.

The Subcontractors have to demonstrate to Alenia Spazio (which often is the PRIME contractor) that the requirements they receive are met. A Subcontractor is involved when a NCR related to his provided component is managed. He is responsible for defining the plan of a component repair or substitution. Some time suppliers e.g. for the Ground Support Equipment (Electrical e.g. LABEN, Mechanical and Fluidic) can be managed directly by the AIV Team.

The WINK system tries to facilitate the management of subcontractors network, daily-meeting information and project management by providing the aforementioned

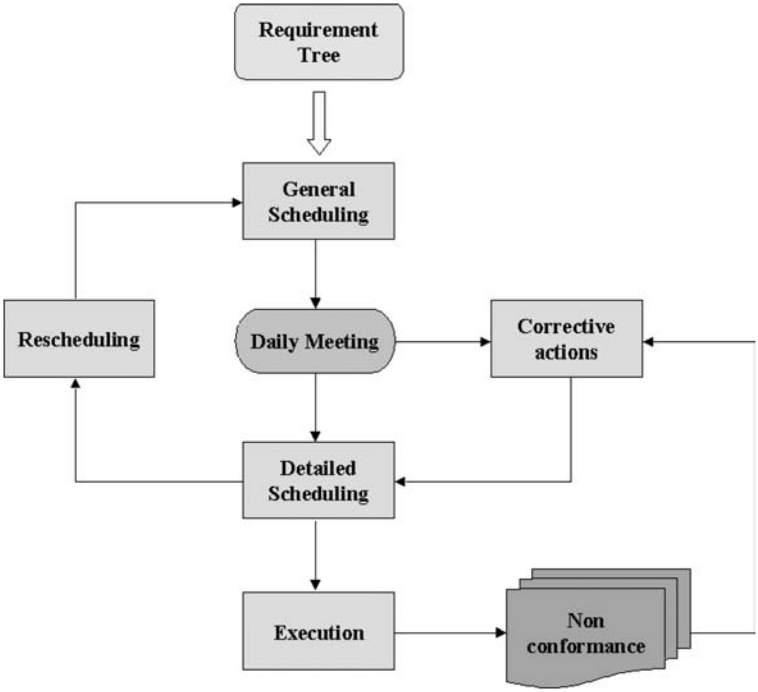

Figure 3 AIV activity flow.

semi-automatic data-integration capability. From the AIV perspective some foreseen benefits of the system are the reduction of number and duration of activity verification meetings, re-scheduling simplification, employee travel reduction, performance monitoring improvement, resource allocation (with real-time visibility on intranet) improvement, reduction of testing time and costs related to AIV management.

2.1. Available information systems

In this paragraph the most important information systems and the software supporting the management process the AIV department are described as follows:

- Many enterprise tasks are supported by the **SAP R/3** ERP system. The AIV manager uses information coming from the following SAP modules:
    - Material Management (MM)—manages all the purchase processes;
    - Asset Accounting (AA)—manages all the data related to the company assets;
    - Financial (FI)—manages all company accounting processes;

  - Controlling (CO)—manages all the operations carried out at Cost Centre level with all the relative information as manpower hours, cost planning, actual costs monitoring, mapping between structural/outsourcing costs and Cost Centres.

- **NCR Data Base:** The Non-Conformance Management Database (NCR DB) is a centralized database accessible to all participants (Alenia Spazio employees and Partners) involved in Alenia Spazio space programs. The general purpose of the application is to record, report, review and allows analysis of non-conforming items regarding satellites or manned systems such as components, software problems, and operational non-conformances and anomalies. The NCR DB allows:

  - The workflow of NCR documents, disposition and corrective action documents, preventive action and lessons learnt
  - The printing and review of documents (e.g.: NCR status list)
  - Statistics and graphics

Each step of the workflow is controlled by the application and one or more electronic signatures of the actors involved in the workflow authorize each phase. The application has been developed in a Lotus Notes 4.6 environment and is accessible in the Internet by authorized users;

- **AIV DB** stores data relating to product trees, project requirements and project activities. This source is under the direct control of the AIV manager and has been implemented using Oracle 8i;
- **STORAGE DB** is an Alenia Spazio proprietary software developed in MS-ACCESS and running on PC's. It allows Alenia Spazio to manage all of its needs involving use of the logistic department of the AIV/AIT branch, tracing data of all the physical items and boxes present inside the integration facility and also tracing all the intervention requests arisen to the logistic team. A control system by means of different passwords ensures the correctness of the flow;
- **PDM WindChill** Product Data Management (PDM) is a strategic suite for Alenia Spazio. It's a stand-alone and enterprise system, which builds a bridge between two different parts of the business: engineering and manufacturing. The PDM system is still in a start up stage. At the moment, the first prototype of the system has been developed and it is in the test phase. With this first version of PDM you can perform the following activities: define the access control policy, set-up the environment for every new program, store documents, create a high-level product structure and manage various workflows for documentation processing and change management;
- **AIV Schedule:** The AIV Schedule is generated using Microsoft Project and it reports the milestones, the activities, the relevant durations and the links between activities.

WINK objectives and benefits

The WINK system improves AIV business processes by adopting more effective business models, which integrates the management of processes, and related available stand-alone systems in an integrated web based environment.

In particular, the AIV processes may be improved w.r.t. the following points are taken:

- *Entire AIV project life cycle support in the Phase C/D*: The entire AIV project life cycle, from the overall design to the actual data registering, could be supported by a unique system;
- *Reduction of the checkpoint frequency*: The daily meetings represent the core of the AIV activities. However the meetings require a large effort in terms of personnel since they require the involvement of many people in the same place that are not often directly interested in a specific daily meeting topic. This is necessary as different people hold a partial view of the business processes and the meeting is an instrument enabling a global view. Through WINK, a web-based information push notification system has been implemented. In this way the right people at the right time will be involved in the AIV verification activity, while others, that are not required to be present at the meeting, are simply informed about the work in progress;
- *Collaboration among people belonging to different ALENIA sites or business units*: The AIV activity involves people belonging to different ALENIA sites or business units driven by a predefined workflow (for instance an internal logistic order request, acceptance and closure) or people requiring an interaction (for instance the collaborative definition of a project schedule). Moreover the visibility of the distributed resource availability and allocation to the different project activities is important in order to improve resource planning and in general, the overall and detailed activity planning;
- *Collaboration with customer, subcontractors/suppliers and external facilities*: Usually several components of the final output to be assembled in ALENIA sites have to be manufactured by ALENIA subcontractors. This fact has an impact on the AIV activity, firstly because the verification of the requirement corresponding to the component supplied by these subcontractors must be carried out by the subcontractors themselves, secondly because delays or problems in the subcontractors verification activity can generate delays in the AIV scheduled activity;

Finally, in the "traditional" process model many applications are involved in the different life cycle phases (see Figure 3) and often they have to manage similar sets of data. These systems have been integrated and the acquisition of data among them has been automated in the following areas:

Integration of the NCR management with the project activity plan: The management of the NCR is traditionally not integrated with the project activity plan. Indeed, as described above, a non-conformance can generate a rescheduling, therefore WINK is proving very helpful, providing an integrated approach for managing the NCRs and linking them to the related project activities;

Integration of the logistics data management with the project activity planning: Traditional project-planning tools do not allow effective material planning. In assembling activities material planning is relevant in order to allow a better overall project scheduling, budgeting and cost control. Moreover, some project activities are conditioned by logistics data as well as material availability or production/delivery lead times. WINK provides a bridge between the logistics data management and the activity plan by means of an integrated environment;

Integrated cost control system: In the "traditional" process model the activity planning, the resource planning and the related cost control are carried out on different systems. Indeed MS Project is used for obtaining the GS and DS, an Excel sheet is used for defining the detailed resource planning and Main 21 is used for cost budgeting and controlling purposes. WINK provides an integrated approach allowing activity scheduling, resource (people or equipment) and material planning with related cost budgeting, planning and monitoring on the same system;

Configurable alert and workflow automation system: The retrieval of relevant information at the right time on the right system is a very critical aspect. in a distributed context involving different and heterogeneous information systems like that offered by the AIV "traditional" process model. WINK provides an integrated environment with a fully configurable alert system, which is triggered according to the events being managed such as non-conformance reporting, extra budgeting, milestones and contacting the right people in a timely fashion. WINK simultaneously provides a fully configurable workflow automation system allowing people to perform activities by accessing the system. It is thus possible to negotiate activity schedules, resource assignments, internal or external resource or material orders.

3. WINK architecture

The WINK architecture, shown in Figure 4, is based on a three-tier model. The client tier makes a Web User Interface available on which information is collected and presented as a customized web interface. The data tier manages the interactions with data provided by the Enterprise Information Systems. The business logic tier combines the capabilities of two separated modules, the Project Collaboration Portal and the Integration Framework. In particular, the first module supports business logic for the monitoring, execution and planning of a project—the resource management, information on non-conformities and alerts as well as document organization. The Integration Framework collects the data required by the implemented business processes in a very dynamic way, by virtually integrating information coming from heterogeneous and possibly distributed data sources.

The Integration Framework achieves this is achieved by using MIKS, an agent-based system [4], which allows highly flexible and configurable data integration. In this way, the business logic tier of WINK system is continuously fed by updated data for each of the implemented business processes.

In the following sections, the Project Collaboration Portal and the Integration Framework modules are described in detail. Here we focus on the problem of the interoperability

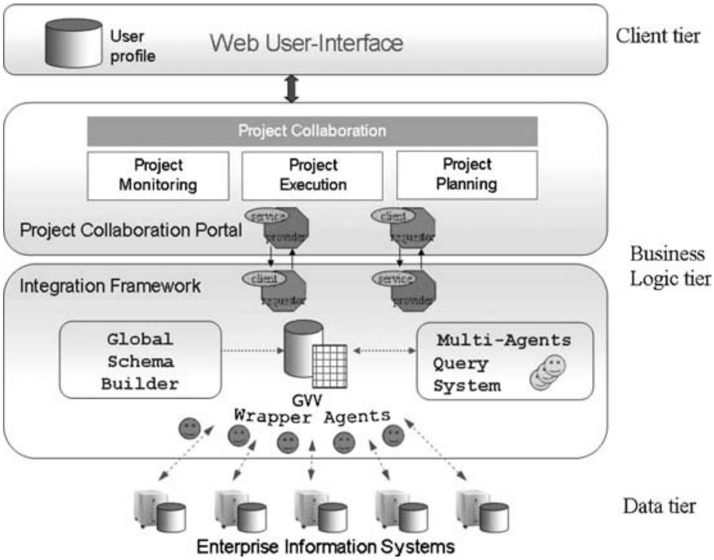

Figure 4 The detailed WINK architecture.

of heterogeneous software platforms that arise in the WINK project. A communication managing system is needed within the business tier, where the Project Collaboration Portal and the Integration Framework reside on different sites and on different platforms. The Project Collaborative Portal has been implemented with Microsoft technology (ASP pages and DCOM objects) while the Integration Framework is a JAVA compliant system including agent and CORBA technologies for managing internal communication. In order to solve the interoperability issues, we chose to adopt web services, thanks to their flexibility and easy development features. Technologically speaking, web services do not add any feature to the previously developed techniques (like CORBA or RPC) in distributing data management applications, but they provide an easier and less expensive mean, based on the W3C standards used to connect systems. The connection is achieved by using WSDL, the Web Service Description Language, a proposed standard that provides a model and an XML format to describe web services. WSDL allows the separation of the description of the abstract functionality offered by a service, from concrete details of a service description (e.g. "how" and "where" the functionality is offered) [17]. Web services allow applications to interact with each other by using SOAP, that provides the definition of the XML-based information, which can be used for exchanging structured and typed information between peers in a decentralized, distributed environment [18].

The interoperability between the Project Collaboration Portal and the Information Framework is assured by a set of web services built on the SOAP protocol that guarantee the data flow within the WINK system.

4. The project collaboration portal

The Project Collaboration Portal (PCP) addresses issues related to the decentralisation of project and production activities with the related concentration on the core business in the specific industrial sector of the One-of-a-kind Production (e.g.: industrial equipment, ship building, aerospace).

The PCP is composed of four modules: the Project Collaboration module, the Planning module, the Execution module, and the Monitoring module As depicted in the WINK architecture (Figure 4). The *Project Collaboration* module allows visibility of data presentations in aggregate and detailed views, searching, filtering and reports printing facilities and links between different data for each node or actor according to their visibility rights. A documental system has been developed that permits a large number of documents related to each data object (Products, Bills Of Material, Project scheduling and so on) to be managed at a distributed level. Moreover a smart configurable workflow automation system has been developed to allow interactions between users in order to negotiate specific aspects (orders, activity or phase duration and so on) in the entire project life cycle phases (planning, execution, monitoring).

The *Project Planning* module allows us to define two transversal project structures called respectively *Extended Project Organisational Structure* and *Activity Plan*. The *Extended Project Organisational Structure* describes the temporary, multi-site and multi-company hierarchical organization that has been created to carry out a particular project, while the *Activity Plan* describes the project in terms of operational phases and activities. This module supports the management of activity plans directly inserted via the WINK user web-interface, as well as those generated by other applications (such as MS Project and Windchill).

The *Project Execution* module allows us to track project steps in terms of consumed resources, exception management, and performance (time and costs) to identify deviations from the plan and provide alerts if the project exceeds budget, according to the rules defined for the WINK Alert System.

Finally the *Project Monitoring* module provides reports of all relevant data information by means of OLAP functionalities and printable reports.

4.1. Day-by-day activity

The core part of *the Project Execution* is the day to day activity of the AIV group, that is supported by the WINK system. The main activities of this process are shown in Figure 5, where the action and information flows are depicted. While AIV day to day activity involves different organizational positions and people, the whole coordination is controlled by the AIV manager, who manages and is given a view of the events that are taking place.

The first step of the process is the checking of the material arrivals and status of orders linked to the open AIV activities. Within Alenia Spazio, data is managed in two disconnected systems: Storage DB and SAP. Storage DB manages the item availability and the material requests and arrivals, while SAP manages the material orders from Alenia Spazio

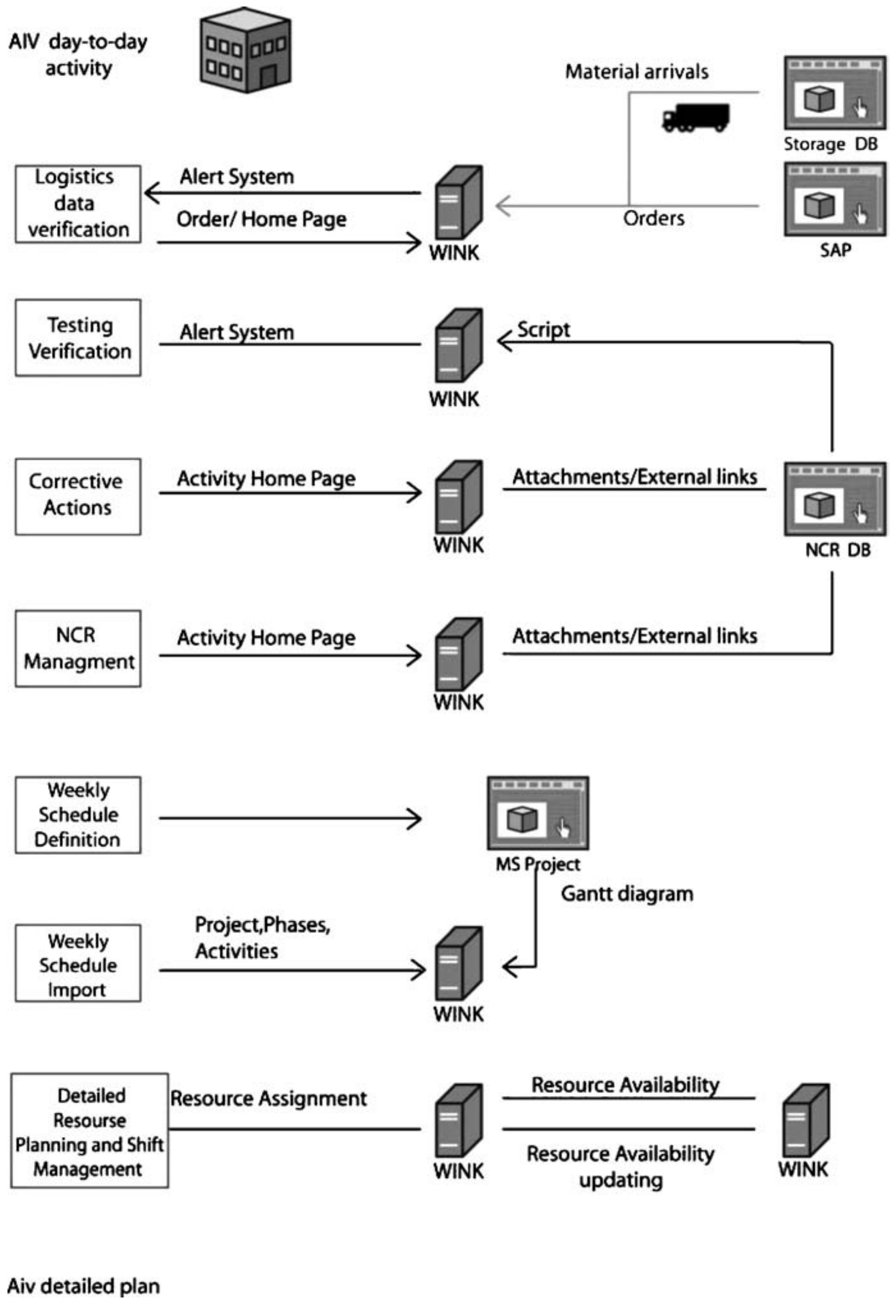

Figure 5 The AIV day-by-day activities.

to external suppliers. WINK links these data, correlating them to the appropriate operational activities.

Together with the previous step ("Logistics data verification"), the Testing Verification activities and their progress are carried out and corrective actions can be planned planned and the related non-conformances are managed and reported on NCRs. WINK links this information and documentation held in the NCR DB integrating them with the operational activity plan. In particular the NCR DB originates an event for the WINK alert system that notifies the AIV manager of the opening of new NCRs, enabling him or her to link the specific NCRs to the appropriate operational activities. In this way the WINK alert system, on the basis of the people assigned to those activities, could notify them of the opening of a new NCR assuring that the right people are informed about the incoming NCRs at the right time.

On the basis of all the information provided and integrated by WINK (logistic data, testing and non conformance feedbacks, operational plan, resource availability, accounting data and so on) the AIV manager can define the AIV weekly schedule and the related detailed resource planning.

The detailed schedule is defined in the same way as the General Schedule, i.e. by defining the Gantt diagram with MS Project and importing it into WINK via an Import/Export feature. Detailed resource planning is carried out through the assignment of the actual available resource to the specific Detailed Schedule activities, with the support of a graphical resource availability calendar provided by WINK.

WINK allows us to link Detailed Schedules to the General Schedule activity or phase that it derives from. In this way it is possible to maintain coherence between general and detailed scheduling, even when being them recognizably separated inside WINK. This ensures a better managing of the rescheduling processes. Also the WINK Alert System can be configured to notify us about the appropriate information in the AIV manager at the right time, whenever a certain event occurs.

5. The integration framework

The Integration Framework consists of a web service architecture that encapsulates a multi-agent mediator-based system. The mediator provides an integrated access to the Enterprise Information System, exploiting the functionalities previously developed within the MOMIS [1] and MIKS [4] systems.

5.1. Integration process

The proposed Integration Framework relies on a semantic approach based on the conceptual schema- or metadata- of the information sources, to perform intelligent Integration of Information.

The methodology follows a GAV approach [12], which results in a Global Schema, which provides a reconciled, integrated and virtual view of the underlying sources, called Global

Virtual View (GVV). The GVV is composed of a set of (global) classes that represent the information contained in the sources being used, together with the mappings establishing the connection among the elements of the global schema and those of the source schemas.[1]

Within the framework, a common language ODL_I^3 is a subset of the corresponding ODL-ODMG language—according to the proposal for a standard mediator language developed by the I^3-POB working group, augmented by primitives to perform integration. In particular, ODL_I^3 can express inter- and intra-source intentional and extensional relationships among classes, mapping tables (to establish a connection among the Global and the local View), integrity constraints and some further operators to handle heterogeneity.

ODL_I^3 relationship types are the following:

- `syn` (synonym of) is a relationship defined between two terms t_i and t_j (where $t_i \neq t_j$) that are synonyms in every source involved. For example, you can use t_i and t_j in every source to denote a single concept.
- `bt` (broader terms) is a relationship defined between two terms t_i and t_j, where t_i has a broader, more general meaning than t_j. bt relationships are not symmetric. The opposite of `bt` is `nt` (narrower terms).
- `rt` (related terms) is a relationship defined between two terms t_i and t_j that are generally used together in the same context in the considered sources.

To accomplish the integration process, the Global Schema Builder component exploits the Common Thesaurus which is generated using lexical knowledge derived from WordNet [13], schema derived relationships and integration knowledge inferred by exploiting description logics techniques.

Affinity coefficients giving a measure of the level of matching among the concepts in the data sources are computed based on the relationships in the Common Thesaurus. Then, a threshold-based hierarchical clustering technique is used to classify concepts into groups of different levels of affinity. Finally, the designer selects (or unifies/separates) the clusters providing a unified Global Virtual View (GVV) of the integrated domain.

The GVV in expressed in ODL_I^3 and may be exported in XML/RDF/OWL in order to guarantee interoperability with other open integration systems.

5.2. A multi-agenst query system for supporting global query execution

The GVV gives users an integrated view over data that are scattered over different places and applications. An external application interacts with the Integration Framework for posing queries to the GVV in OQL query language by means of web services,

Like other semantic approaches, the global querying phase consists of three steps [5]:

- semantic optimization;
- query plan execution;
- fusion of local, partial answers.

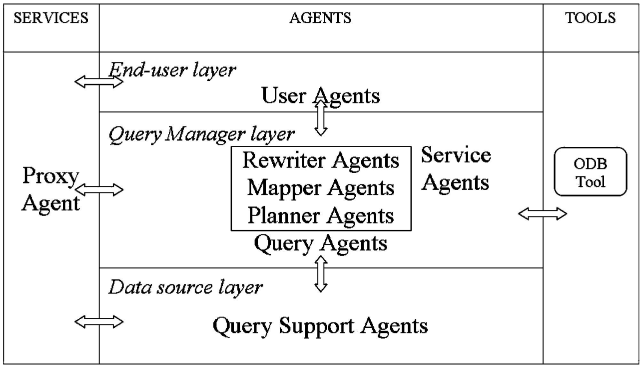

Figure 6 The Multi Agent Query System.

We have designed and implemented a Multi-Agent System (MAS) for supporting the whole phase of global query execution. The system has been built using the JADE environment (http://jade.cselt.it), a FIPA-compliant development tool (http://www.fipa.org). Agents perform activities for manipulating global queries to create queries at a lower level of abstraction (local queries) that are then executable on data sources. Local answers have then to be synthesized into a global answer. Notice that, while the integration process is essentially a one-way bottom-up information flow starting from the source contents and ending up with the generation of a GVV, the querying phase is a two-way process: top-down when users submit queries over the GVV, and bottom-up when local answer are made available and have to be merged to compose the global answer.

Figure 6 illustrates the organization of agents. The agents that carry out global query decomposition and partial answer merging (globally called *Service Agents*) and the agents responsible for query execution at the local level (*Query Agents*) are grouped in the Query Manager layer.

Service Agents can be divided into three different classes of cooperative agents: the *Rewriter Agents*, the *Mapper Agents* and the *Planner Agents*.

Rewriter Agents (RAs) operate on the assigned query by exploiting semantic optimization techniques provided by ODB-Tools [6] in order to reduce the query access plan cost. The query is rewritten incorporating any possible restriction, which is not present in the global query but is logically implied by the GVV (class descriptions and integrity rules).

Mapper Agents (MAs) express the rewritten global query in terms of local schemas. Thus, a set of sub-queries for the local information sources is formulated. MAs dialogue with Proxy Agents that hold the knowledge about GAV mappings and global and local schemata. The mediator checks and translates every predicate in the where clause in order to obtain each local query. The other important task performed by MAs is the rewriting of the original global query in terms of the local queries (as join query), in order to produce the final data answer.

Planner Agents (PAs) are charged with taking the set (or subsets) of local queries and producing the executable query plan. The goal of PA is to establish as much parallelism and workload distribution as possible. The fact that queries are assigned to *Query Agents (QAs)* that move to local sources, means that creating a plan entails trying to balance different factors:

- how many queries have to be assigned to each single QA;
- which sources and in which order each QA has to visit in order to solve the assigned queries or to fuse partial results.

The choice of the number of query agents to be used can be determined by analyzing each query. In some cases, it is better to delegate the search to a single query agent, which performs a "trip" visiting each source site: it can start from the source that is supposed to reduce the further searches in the most significant way, then continue to visit source sites, performing queries on the basis of the information already-found. In other cases, subqueries are likely to be quite independent, so it is better to delegate several query agents, one for each source site: in this way the searches are performed concurrently with a high degree of parallelism. This permits decentralization of the computational workload due to collecting local answers and fuse them into the final global answer to be delivered to the user.

QAs move to local sources where they pass the execution of one or more queries to Wrapper Agents (WAs). Moving to local sources offers a number of advantages. In particular, users can also query sources that do not have continuous connections: QAs move to the source site when the connection is available, performs the search locally even if the connection is unstable or unavailable, and then returns as soon as the connection is available again. Was forge translation services between the global query language and the native query language of the data source. This step is required to make queries executable by local information management system.

When the local answer is available, the corresponding QA has to map this data (whose structure follows the local schema) to the global schema. To do this, the QA interacts with PAs to know the set of mapping rules related to the source.

6. Using WINK

6.1. *Building the global integrated view*

The activities of the AIV manager require that the AIV Manager is kept constantly up-to-date on diverse aspects of the projects s/he is managing, from personnel to materials and components, from costs to non-conformities. We selected the set of sources that store data necessary to support AIV managers throughout their job starting from the requirements we identified by interviewing AIV managers. Due to the internal organization of Alenia, the data sources needed have been created and managed by different units. Each unit has been managing data following different styles and criteria, resulting in a heterogeneous collection of information sources. In particular, we select the four information sources among the ones presented in Section 2.1: the Storage DB, the AIV DB, the SAP DB, NCR DB. Moreover, we added to these sources a data source managed by the PCP module, the WHALES database (that includes MS project import/export functionalities). WHALES has been implemented using Microsoft SqlServer and it materializes data related to specific project management functionalities not present within Alenia`s systems.

The data integration process has been carried out over 70 tables distributed in 5 data sources. We adopt the MOMIS methodology to discover intra and inter relationships among the sources.

Schema-derived relationships. First, the schema-derived relationships stored at the intra-schema level are automatically extracted by analyzing each ODL_{I3} schema separately (the foreign keys).

As an example, we report a few relationships extracted from the AIVDB schema. A table of the AIVDB schema is PRODUCT_TREE. It contains the data related to the product tree of a project. A product tree is identified by the field PT_ID. Some tables contain foreign keys related to the product tree: CI_PRODUCT, that stores the information on each item of the product tree, and CI_PHASE_DEFINITION, that stores the phases to be accomplished in order to realize the tree. MOMIS automatically obtains RT ODL_I^3 relationships:

1. AIVDB.PRODUCT_TREE **RT** AIVDB.CI_PRODUCT
2. AIVDB.PRODUCT_TREE **RT** AIVDB.CI_PHASE_DEFINITION

In this case we have the additional property of an attribute being the primary key of both tables, we detect an ISA relationship thus generating a BT/NT relationship. A BT relationship, for example, is extracted for the tables REQUIREMENT—that stores the requirement of each activity to be executed—and IMAGE_LINK—that stores the links to a technical document for each requirement (such as drawings):

3. AIVDB.REQUIREMENT **BT** AIVDB.IMAGE_LINK

Lexical-derived inter-schema relationships. In this step, terminological and extensional relationships at the intra-schema level are extracted by analyzing ODL_{I3} schemas together. The extraction of these relationships is based upon the lexical relations between tables and attribute names. This is a kind of knowledge which derives from the meanings of the schemas assigned by the integration designer. Meanings are assigned during the annotation phase, when the designer assigns a meaning to each table and attribute name by exploiting ontologies. The system uses WordNet as a base lexical dictionary and, in this application, the NASA Taxonomy, Industry Sectors, Missions and Projects, available in XML format at http://nasataxonomy.jpl.nasa.gov/xml.htm have been added.

We annotated approximately 1400 terms and obtained 900 relationships. A few examples are:

4. `WHALES.PHASE` **SYN** `AIVDB.CI_PHASE_DEFINITION`
5. `StorageDB.request` **SYN** `WHALES.MyPR`
6. `NCR.NCR.item` **SYN** `AIVDB.CI_PRODUCT.CI_ID`
7. `StorageDB.request.Program` **SYN** SAP.ODA.PROGRAM

In 4 and 5 both the preceding and subsequent elements are tables. Relationship 5 says that the `request` table of the `StorageDB` source is synonym of the `MyPR` table of the `WHALES` source (thus requests of equipment storage in STORAGEDB are in relation with the ones in MYPR).

In relationships 6 and 7, both the antecedent and the subsequent elements are attributes. Thus, an item in a non-conformance stored in the `NCR` schema is related to an item of the product tree of the `AIVDB` schema. The same holds for the attribute `Program` that identifies the space program that a request in the `StorageDB` schema and an order in the `SAP` schema refer to.

All relations have been obtained starting from the annotated schema and exploiting WordNet and Nasa taxonomy hierarchies.

Clustering and global mapping. Once the relationships amongst the tables of the schemas have been included in the Common Thesaurus, the integration process goes on with the clustering phase. During this phase, classes with semantic affinity are grouped in the same cluster. The level of semantic affinity is measured by means of the affinity function presented in [8].

In our test case, the Integration Framework automatically recognized twelve clusters. A cluster included from two to six classes, three being the average. Significantly, clusters were built for personnel, resources, material orders, equipment requests, non-conformities, product tree, requirements, procedures and project documents.

As an example, let us consider the cluster where all information concerning orders is grouped. The cluster (named ORDER) comprises of six relationships covering different aspects relating to order management within the AIV Department. First, we find the ODA table from the SAP DB, which stores very general information about an order (buyer, program, item, description). Then, we have two tables taken form the WHALES schema that store additional information such as request and delivery dates, quantity, and supplier. As order is intended here to be an item of the product tree, the cluster also includes three tables from the AIVDB source, reporting the description of the requirements related to the particular item. All this data provides a comprehensive view of the concept of order as meant within the AIV Department.

Given its semantic relevance, a cluster was chosen to form a Global Class. Mappings are defined by means of a table where columns represent the attributes of the local sources tables belonging to the cluster and rows represent the Global Attributes which are the average of all the attributes of all the tables mapped into the ORDER Global Class (see Figure 7).

Global class	AIVDB			SAP	WHALES	
ORDER	DOCST_ DEFINITION	DOCS_ LINK	VER_DO C_LINK	ODA	MYORDER	SUPPLY ORDER
ORDERID				order	ordernumber	orderoid
PROJECT		ci_id	ci_id			projectitem code
MATERIAL				material	material_id	
REQUEST_ DATE						reqdate
STATUS				status		orderstatus
DELIVERY_ DATE				delivery date		
WORK PACKAGE			wp		Supply	
DOC_ID	docs_id	docs_num				
DOC_LINK	Webpage					
REQUIREMENT			req_seq			

Figure 7 ORDER mapping table.

6.2. Querying the Global Integrated View

The typical usage scenario of the WINK system would be the AIV Manager and other users operating the WINK web interface to view and manage project information. The first operation is the logon where the user specifies the node (that represents the user's point of view for accessing and interacting with other nodes), the role (which is the organizational position s/he wants to play for the current session), username and password. After having stated the logon credentials, the WINK system enables the use of the proper functionalities and presents a personalized home page. Figure 8 represents the WINK Personal Home Page for an AIV manager, who can see current alerts coming from relevant project events, ongoing workflow activities, a list of relevant links for easy access to the user's projects and frequently used functions.

The main areas in the WINK Personal Home Page are the following:

- *My alerts*: contains the notification of relevant events that occurred in the project regarding the project and position s/he chooses to select. The user can look at the data that caused the alert, and eventually decide to get rid of it, by ignoring it;

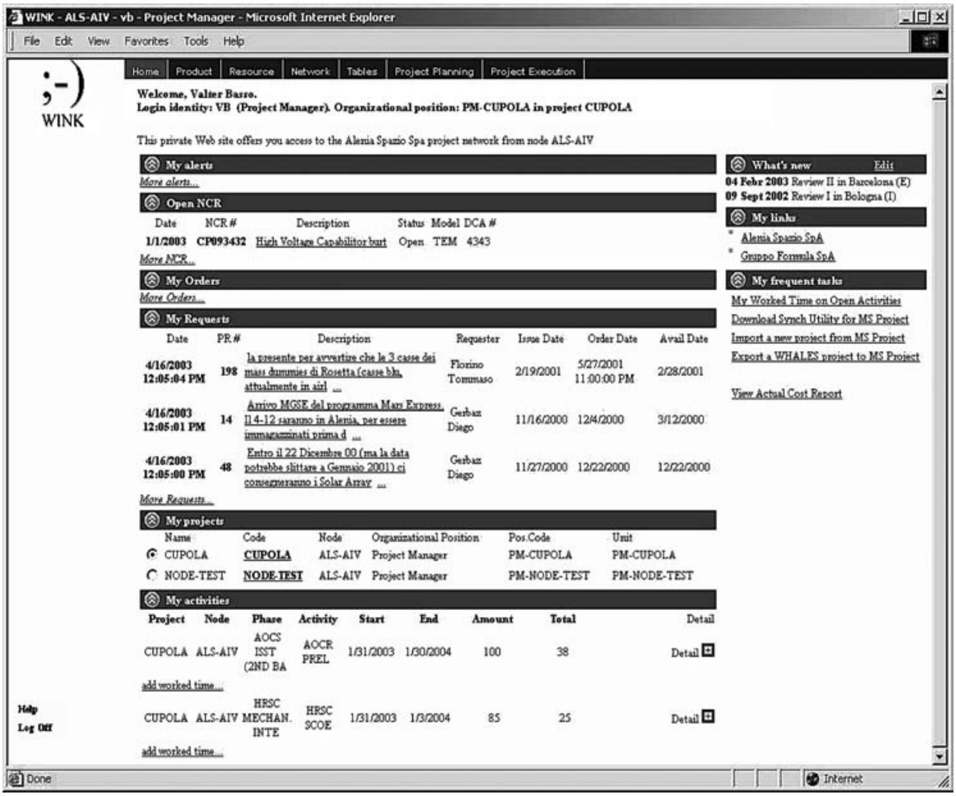

Figure 8 The WINK web user-interface.

- *Open NCR*: contains a list of currently open non-conformities that have to be solved. The user can navigate through the list and access documents that accompany the non-conformance generation;
- *My Orders*: contains the list of all the orders that have been submitted but not yet closed. The user can thus monitor the execution of the orders s/he submitted or the orders for which authorization is required;
- *My Requests*: contains a list of internal equipment requests, reporting the status and tracking any change in their related data. The user can thus know whether a requested instrument will be available on time and subsequently decide alternative actions or requests;
- *My activities*: contains a list of open negotiations that the logged on user must consider, since s/he is requested for authorization or negotiation. The user must follow the linked workflow interaction in order to comply with the negotiation activities s/he is involved in;

- *My Projects*: contains a list of organizational positions that the logged on user has at the moment of logging on. The user can choose among the different projects and organizational positions s/he is in charge of. Whenever s/he selects another position, the home page reloads in order to present the above mentioned collaboration alerts and activities for the specific project and position;
- *What's new*: contains a series of static information that is common to the project network the user chooses to log onto;
- My Links: contains the actor's chosen links (typically to external web sites or applications regarding their particular position;
- *My Frequent Tasks*: contains the most frequently used WINK function of the logged in organizational position, along with the workflow activities it is in charge to activate.

Many of these operations require the execution of queries in order to retrieve up-to-date data, to be subsequently processed. The analysis of the WINK system requirements brought to a classification of the query types according to two orthogonal dimensions. The first captures the design perspective, i.e. whether the query responds to explicit and well-known application requirements or is introduced by users for contingent needs. The second dimension concerns an operative perspective, i.e. the times a specific query has to be submitted. Queries can be submitted either in response to explicit users requests or as scheduled operations, required to keep data up-to-date in an automatic fashion.

Combining the two dimensions, we have four kinds of queries:

- Designed and user-submitted: these are defined at design time to meet explicit application requirements and are executed only when the user explicitly calls an operation that relies on the query execution;
- Designed and scheduled: these are defined at design time to meet user requirements and consist of the automatic execution of queries on a regular basis (to materialize distributed data at scheduled time);
- User defined and user submitted: new queries can be composed and executed under explicit user requests;
- User defined and scheduled: while operating the system, new requirements may emerge and determine the introduction of new queries to be scheduled on a regular basis. This type of query is important for designers when new application requirements are revealed.

All these kind of queries are executed by the WINK system by using the multi-agent query system included within the Integration Framework. The whole query processing for a single "designed and user-submitted query" is shown in Figure 9. First, the user with the right grant composes the query by means of a parametric dynamic web page (realized using a Microsoft ASP pages) of the web user-interface. For example, a daily task of the AIV manager consists of checking the opened (or closed) material orders referred to by its managed projects and requested in a specific period. This implies knowing the order number and material, the date it was requested, the expected date of delivery, the workpackage, the requirement number and documents it was associated to.

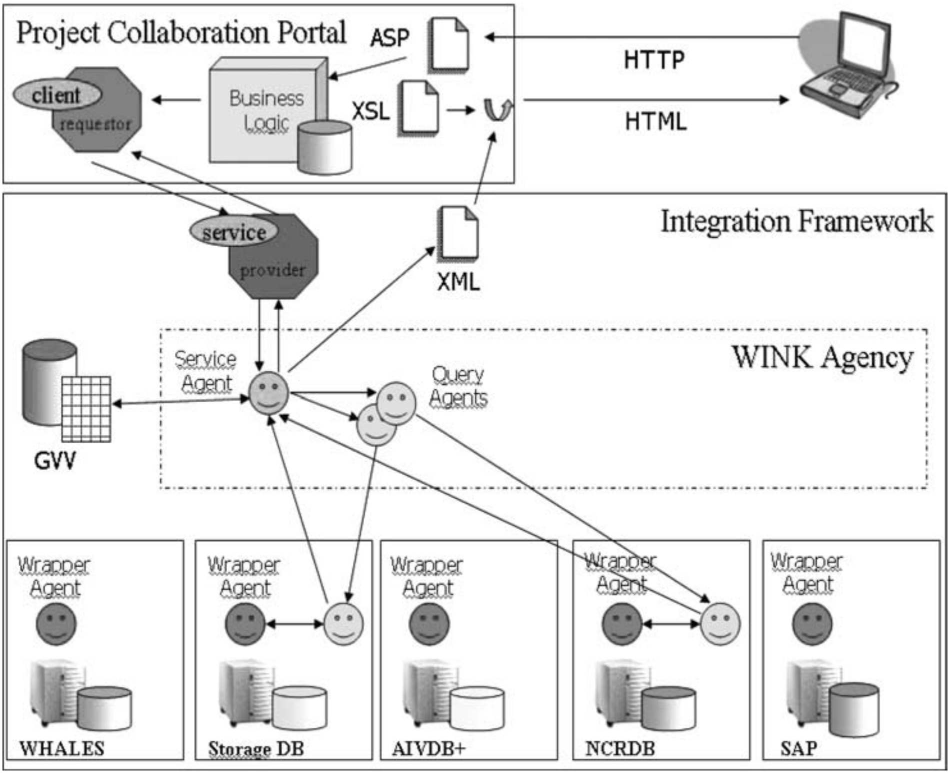

Figure 9 The WINK information flow.

This request invokes a specific function of the business logic with run-time parameters (for example ‘opened order of last month’): the business logic combines these parameters with the user profile information (for example a managed project by the user, let us suppose ‘CUPOLA’), produces the global query over the GVV and requests a query execution to the Integration Framework. In this example, the global query over the GVV is the following:

Q: Select ORDERID, MATERIAL, DELIVERYDATE,
WORKPACKAGE, REQUIREMENT, DOC_LINK
from ORDER
where STATUS-=’opened’
and PROJECT = ‘CUPOLA’
and REQUESTDATE > Date() - 30

The web service enables a Service Agent to perform the rewriting, mapping and planning operation over the global query *Q*. The Service Agent exploits the GVV and the Mapping Tables so as to know which data sources are involved by the posed query.

In the example, all the three local data sources are involved and the following local queries are generated:

SAP source: Q1
Select order as ORDERID, material as MATERIAL,
deliverydate as DELIVERY_DATE
from ODA
where status = 'opened'

WHALES source: Q2
Select ordernumber as ORDERID,
material_id as MATERIAL
reqdate as REQUEST_DATE
supply as WORKPACKAGE
from MYORDER, SUPPLYORDER
where ordernumber = orderid
and projectitemcode = 'CUPOLA'
and orderstatus = 'opened'
and reqdate > Date() - 30

AIVDB source: Q3
Select wp as WORKPACKAGE, req_seq as REQUIREMENT, webpage as DOC_LINK,
ProjectitemCode, DeliveryDate
from VER_DOC_LINK A, DOCS_LINKS B, DOCST_DEFINITION C
where A.ci_id = B.ci_id and B.docs_num = C.docs_id and A.ci_id = 'CUPOLA'

According to this mapping and to the contingent system workload, Service Agents will spawn a number of Query Agents. At this stage, the Query Agent will move to the data source(s)/container(s)and the query referred to, will interact with the Wrapper Agent(s) in order to execute the local query(ies) and will finally report the answer to the Service Agent.

The Service Agent composes the results and delivers them to the Project Collaboration Portal. In the example, the following query is executed by the Service Agent to perform the fusion:

Select Q1.ORDERID, Q1.MATERIAL, Q1.DELIVERYDATE,Q2.WORKPACKAGE,
Q3.REQUIREMENT, Q3.DOC_LINK
from Q1, Q2, Q3
where Q1.ORDERID = Q2.ORDERID and Q1.MATERIAL = Q2.MATERIAL
and Q2.WORKPACKAGE =Q3.WORKPACKAGE

In order to deliver results so as to update the correct information, Service Agents reports query answers in the desired format (in our case, an XML file). The web service making the call reports to the business logic the query acknowledgement and the URI of the resulting XML file: then the business logic applies the desired XSL stylesheet and dynamically produces a web page reporting the information.

For “designed and scheduled” queries, the extraction process is similar. In addition, a scheduler agent is spawned into the multi-agent system. A scheduler agent manages all of the details (such as connection pools and data storage) for querying a source on a regular basis. Scheduler agents are activated during the initial start-up procedures of the WINK system. The configuration of a scheduler agent includes the query to be executed, the data source to be queried, the required drivers to access the source and how results should be communicated back to the WINK system. Communication of results can happen for instance by means of files stored on a given host of the network or by calling a published web service on a given url. This last case is the most suitable any time results have to be further processed. For instance, in our application, scheduler agents call web services whenever modified or new data appear in some particular relation (such as MyReports) in order to fire alerts on the WINK system.

For the two types of “user defined” queries, the extraction process follows the same operations as their respective “designed query” type. What changes is the interface that allows users to compose queries by navigating the metadata of the GVV.

7. Related work

This paper focuses on using an intelligent information system as the basis of a common collaboration platform for a virtual enterprise. The creation of the Global Virtual View of heterogeneous data coming from different applications and enterprises is achieved by means of a mediator based system where a multi-agent infrastructure allows the dynamic connection and query relevant sources.

Summarizing, our system couples two different approaches in order to create a single cockpit for the enterprises. Several approaches were proposed concerning the use of a multi-agent system in the integration area: a particular mention is due the Infosleuth system. Infosleuth is a system designed to actively gather information by performing diverse information management activities. The Infosleuth’s agent-based architecture has been presented in [14]. InfoSleuth agents enable a loose integration of technologies allowing: (1) extraction of semantic concepts from autonomous information sources; (2) registration and integration of semantically annotated information from diverse sources; and (3) temporal monitoring, information routing, and identification of trends appearing across sources in the information network.

While addressing the same goal of information integration, our approach and the Infosleuth system present slightly different features. First of all, the scope of the two systems appears to be different. The mediator system in Wink aims at building ontologies related to the integration domain, and at providing a unified view. Queries have to be posed as global ones on the GVV. Infosleuth bases its data analysis on given ontologies (rather than building them) and provides visibility of data related only to the specified queries. Then, the methodology we apply is characterised by strong reasoning capabilities that are meant to tackle the problem of semantic integration of concepts belonging to multiple ontologies (i.e. how we can discover that two objects belonging to different schema refer to the same real-world concept). Further, as a consequence of these differences, the agent architecture of the two systems is quite different. Agents with common functionalities (translator agents/query support agents and resource agents, user agents, query agents) are still observable even though they reflect two distinct approaches.

Another experience is the RETSINA multi-agent infrastructure for in-context information retrieval [15]. The LARKS description language is defined In particular to realize the agent matchmaking process (both at syntactic and semantic level) by using several different filters: Context, Profile, Similarity, Signature and Constraint matching.

The development of collaboration platforms started on the end of '90s when a new business model, defined as Collaborative Commerce (C-Commerce), arose. C-Commerce aim is to achieve benefits from real-time co-operation with business partner, involving a range of processes that are much wider than simple on-line selling and procurement. C-Commerce is aimed at creating a collaborative framework that allows companies engaging with cyber-market partners for the purpose of creating and connecting agile business processes. There are several issues justifying the development of this new business model: the main one is that the ERP concepts itself and the integrated system added value is perceived only for back-office functions, while leaner solutions are required for front-end applications like Collaborative Project Management. Software supporting collaborative processes have to be flexible as they have to interact with different applications and data being in different systems and work following different logics. Several applications were developed supporting such enterprise business management: with reference to software developed for these specific solutions, leaving out the modules integrated in the main ERP system as SAP, J.D. Edwards, we indicate GroupSystems Cognito, a software to analyze problems, collect information formulate concrete plans and produce reports, and E3 from Dialog Sistemi, a complete software system for sharing and analyzing information among business units.

These applications work following a three phases general architecture:

(1) *ETL*: In the extraction, transform, loading phase, the relevant data of each information system is extracted, collected and modified in order to be homogeneous with the other one. This is a critical phase because of the data quality relies on the procedure developed in this phase.
(2) *Data-warehouse*: The ETL phase allows the enterprise to build a data-warehouse where all the relevant data is integrated and stored. Such architecture requires defining updating policies.
(3) *Business intelligence*: BI applications allow the user to read and analyze stored information by means of OLAP, reporting tools and business dashboards.

WINK system with respect to the indicated approaches, the is more flexible: data is extracted by means of a semi-automatic method (commercial applications generally support this operation only with a graphic tool) and the Business Intelligence we developed does not need to materialize data in a data-warehouse. In this way data is always up-to-date and the ETL phase is cheaper.

8. Conclusion and future work

We described the WINK project which fully addresses the Collaborative-Commerce model.

WINK intends to represent a common collaboration platform for main contractors and their subcontractors in a sector like that of the aerospace industry, where it is important both to preserve the quality and reliability of components and equipments, and to reduce the entire space program life-cycle in order to exploit the advantages offered by the rapid technological evolution and reduce operation costs.

In particular, we described the business tier of the system architecture, whose main components are the Project Collaborative Portal, the Integration Framework (implemented by means of a multi-agent system) and web services to guarantee interoperability.

Finally, we illustrated the flexibility and the easy customisation of the WINK system by using a real scenario provided by Alenia Spazio S.p.A, that is currently deploying the system at its Turin and Rome sites. A first testing phase has shown that the average the number of people taking part in the daily meeting has dropped to 15–20, i.e. a fall between 20 and 40% if compared to a daily meeting not supported by the WINK usage. Furthermore, the daily meeting lasts half an hour on average, representing a 50% cutback if compared to daily meeting duration not supported by the WINK system.

Alenia is planning to extend the access to the WINK web client to some of its main sub-contractors. These are usually charged smaller Verification and Integration tasks and so far the communication between a sub-contractor and Alenia Spazio has been based on very traditional channels, like phone calls and e-mails. The purpose here is twofold: on one hand, sub-contractors have to become active players in the project management, allowing them a degree of access to the project information, on the other hand, they must have the possibility to report their internal partial results through an easy-to-use, configurable means (like the WINK web interface) in a timely and traceable fashion. For this reason, some of the sub-contractors have been assigned not only visibility rights on some of the project's information but have been invited to use the Project Collaborative Portal to update important system data, such as order or workflow data. Such an initiative is helping to obtain a closer collaboration, as the information systems of the participating partners have to be integrated within the WINK platform.

Along with this, Gruppo Formula is also proposing the WINK system to its customers as a solution for their business purposes. Clients mainly belong to the textile and multi-utilities sectors. From these early approaches to new markets, the most appreciated features turn out to be the flexibility of the system configuration and the interoperability with existing or third parties' applications, mainly due to the deployment of agent technology. This means that strong benefits can be foreseen in terms of the time required to tune the system and define the data integration in accordance to the configuration requirements in place. This encourages Gruppo Formula to recommend the adoption of the WINK system to their customers, as a solution for project collaborative management.

Note

1. Our approach is now evolving to a peer-to-peer architecture, where the mediated schemas are mapped by intermediates modules called *Brokering agents*: the activity is carried out within the EU IST-2001-34825 RTD SEWASIE project (www.sewasie.org) [2].

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