Information Systems Integration, a New Trend in Business

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Abstract: - "Information integration is a key benefit of Enterprise systems. This integration can replace functionally oriented and often poorly connected legacy software, resulting in savings in infrastructure support costs."[1]. The software integration process is complex and it requires a lot of resources to successfully accomplish objectives. Systems integration can be achieved in several ways: integration by entities, integration via portal and integration through business processes. In this paper, we will present some *possible ways of integrating systems (integration through business processes and services)* and some *types of information systems* used by companies as well as possible ways of integrating these systems. Systems integration also implies integration of the data handled by these systems, so we will present also *some ways of data integration*. Finally, we will describe a *technique for testing the integrated operation of a software product*.

Key-Words: - Information Systems Integration, Enterprise Application Integration, Enterprise Resource Planning, Geographical Information Systems, Customer Relationship Management, Supply Chain Management, data integration, Pairwise.

1 Introduction

With the global economic problems generated by the current economic crisis, companies have had and still have, perhaps now more than ever before, the need for advanced information systems. "Many enterprises have implemented novel information technology and developed innovative e-business applications systems"[2]…but performance at this level is basically about integrated computer systems.

The real challenges arise when a company's information systems need integration. The advantages are, no doubt, numerous: from the reduction in the costs of maintenance of several information systems to simplification of work flow. In this paper, we analyze and present some *types of information systems* used by companies *(Enterprise Resource Planning - ERP, Customer Relationship Management - CRM, Supply Chain Management - SCM)* as well as possible ways of integrating these systems *(integration through business processes and services).* On the other hand, systems integration also implies integration of the data handled by these systems, so we will consider also some ways of *data integration* (databases, data warehouses) by means of technologies such as Oracle GoldenGate. Finally, we will describe a technique for testing the integrated operation of a software product, more precisely, an integrated type of testing: *Pairwise, a powerful testing technique*.

2 Integration through Business Services and Processes - Overview

"By definition, Enterprise Application Integration (EAI) refers to *the process of integrating multiple applications that were independently developed, may use incompatible technology, and remain independently managed"*[3]. Within its two basic components, Business Process Integration (BPI) and Enterprise Information Integration (EII), EAI it's the most commonly and efficient approach in complex software development.

Starting from software development patterns and three tier applications development, there are three layers of software integration: data integration, service integration and process integration. The level of complexity rises from data to process integration, and the level of abstraction as well.

Service and process integration lead to the completness and coherence of integrated systems.

Services comprise unassociated, loosely coupled units of functionality that implement actions. Rather than services embedding calls to each other in their source code, services use defined protocols that describe how they pass and parse messages using description metadata.

The most commonly used approaches in service integration are SOA (Service Oriented Architecture) and ESB (Enterprise Service Bus).

SOA implementations are designed using a wide range of technologies like XML web services, SOAP, RPC, CORBA and provide information systems capabilities as composite services that interact and exchange information in order to support all business processes and their functionalities.

ESB generally provides an abstraction layer on top of an implementation of an enterprise messaging system, which allows developers to exploit the value of messaging without writing code. Unlike the classical enterprise application integration approaches, ESB cuts the number of interfaces for interconnection between different systems, being capable of translating interfaces.

Starting from SOA concepts and design, services are associated and combined to work as a whole by using orchestration. The process of services orchestration in order to communicate, interact and exchange data between disparate functionalities, creates the context of business processes.

The most commonly used approaches in process integration are BPM (Business Process Management) and BPEL (Business Process Execution Language).

The scope of business process integration is to automate processes in order to achieve accurately and completely the same outcome as the separate business execution on disparate information systems, with increased efficiency.

Both services and processes, in the context of software integration, adhere to the following principles: abstraction, autonomy, composability, discoverability, formal contract, loose coupling, reusability, statelessness. A system based on a service/process integration mechanism will package functionalities as a suite of interoperable services/processes that can be used within multiple separate systems from several business domains.

Services and processes are reusable and can be discovered and consumed easily as they're developed using guidelines, documentation and designed as services through standardized process management tools. These approaches are cost effective and provide extreme flexibility in software integration processes.

3 Some Types of Information Systems and Possible Ways of Integration

"The challenge is that companies implement multiple applications for a reason; each is designed to support the needs of a particular user group in performing their specific tasks."[5] Owing to their benefits, these systems, ERP, CRM, SCM, are gaining their place slowly but surely, even in Romanian companies. This trend is backed up by companies that manufacture and sell such types of systems.

3.1 Geographical Information Systems (GIS) and ERP Integration

GIS have the ability of storing, manipulating, analyzing and visualizing the geospatial information through maps. Sometimes, visualizing the data on maps is more relevant than looking at the tabular data, which is why GIS has began to be integrated in key business applications also. The synergy between GIS and ERP information systems, offers competitive advantages to any enterprise in both supply chain management and marketing areas.

Logistic firms require shorter order cycle, more reliable deliveries, better warehouse management and they must keep their transportation costs under control. In order to achieve these goals, the integration of GIS, GPS and ERP technologies was proposed by scholars [6] and by commercial software vendors. In the marketing area, ERP/GIS integration would be useful in all marketing mix components: product (segment customers by lifestyle and product category), price (implementation of pricing policy depending on location), place (site selection and delivery routing) and promotion (develop target promotions and campaigns, geocode customers, understand customer spending) [7].

Companies have several options for integrating GIS and ERP: build or purchase software connectors that directly connect a given ERP and GIS package, use passive middleware, or deploy frameworks for comprehensive integration with a given GIS package from an ERP vendor [8]. The most successful integration GIS – ERP was done by ESRI (the world's GIS leader) and SAP (one of the ERP vendor's leader). There are five main technical interfaces available for integrating SAP's ERP and ESRI's GIS software. The integration technical interfaces include: SAP RFC connectors, third-party connectors, SAP generic GIS connector, third-party EAI, SAP EAI and ESRI's partner solutions.

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Sivan Design is another software developer which provides customized GIS solutions combined with ERP capabilities. Using its proprietary technology Geo-ERP™, Sivan Design is able to provide turnkey solutions for establishing lands, roads, or any other infrastructures management platform.

There are already many companies which have chosen to integrate their ERP system with a modern GIS system in order to add the spatial dimension to the business processes. For example, a company in Germany-ivl GmbH—had successfully integrated Smallworld GIS with SAP R/3, using a product they had developed called GISConnect™[9], GPU Energy has also integrated Smallword with SAP R/3 using two main integration pieces (virtual database integration allows the GIS and SAP R/3 data models to be treated logically as a single model, and business process integration, offering a complex business processes freely spread over GIS and SAP R/3), San Diego's Street Services Division has successfully integrated a GIS with ERP [10].

3.2 CRM Information Systems Integration

"CRM is a widely-implemented strategy" [11] that "focuses on initiating, maintaining, and retaining long-term customer relationships"[12] This strategy implies "using technology to organize, automate, and synchronize business processes—principally sales activities, but also those for marketing, customer service and technical support." [11]

That CRM-type of systems have been and continue to be a success, contributing significantly to the increasing performance of a business, is a well known fact, but what is less known and publicized is the effort behind integration of these systems with other systems of a company.

In order to integrate CRM systems with other systems, a range of products are now available on the market, designed to help simplify this process. However, it is not an easy process at all. Tables 1 and 2 show the proposal of the company Scribe Software Corporation [11] regarding the analysis of the integration of CRM systems with ERP, Call Center, Marketing and other system, both in terms of processes and data.

Tabel 1 – CRM Process Integration

Step	From	To	Data	Description
1	ERP	CRM	Product Catalog	Provide CRM with latest available products and pricing
2	CRM	ERP	Quote	Provide ERP with quote for demand planning and calculate "available to promise"
3	ERP	CRM	Quote	Provide CRM with product availability for quote
4	CRM	ERP	Order	Place order with ERP
5	ERP	CRM	Order	Provide order confirmation
6	ERP	CRM	Invoice	Provide ongoing order deliver status and final calculated invoice including shipping and taxes

Source	Data	Description	Value
Web site, marketing lists	Leads	Load leads on real-time or ad-hoc basis into CRM	Increase lead conversion rate and reduce administrative costs
ERP	Orders/Invoices Product line items	Copy and update invoice data along with product details into CRM	Increase revenue through product-based sales targeting & improve customer service
Call Center	Support incidents	Provide real-time support call history and status to CRM	Improve customer service
Field Service	Service tickets	Provide real-time service ticket history and status to CRM	Improve customer service
Call Center, ERP	Support contracts	Copy and update customer support agreements in CRM	Increase contract renewal rates
ERP, Data Providers	Credit history	Provide company credit history in CRM	Increase revenue by targeting credit-worthy customers and reduce collection costs

Tabel 2 – CRM Data Integration

The balance benefits vs. disadvantages of integrating CRM systems with other systems tends to lean more towards the benefits. We do not say this for any reason. The main argument is that an increasing number of companies are contemplating integration of CRM systems with other systems and even integration with Business Intelligence products, according to Market Watch magazine [13]. The first reason is that a large part of the CRM systems have not or have only partially implemented the data analysis component, and Business Intelligence could come to fix this "shortcoming".

And while the benefits of using CRM systems are well known, and we are referring here, primarily to: quality and efficiency, decreased costs, decision support, enterprise agility [11], their integration with the rest of the information systems of a company (in spite of complaints about the high complexity of the final system) comes to increase company's performance and its competitive edge.

3.3 SCM Information Systems Integration

According to the Council of Supply Chain Management Professionals (CSCMP), "SCM encompasses the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management. It also includes the crucial components of coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers"[11].

SCM concept is little known and implemented in Romania, at information system level. Firstly, because "information systems integration" has a rather short "history" and, secondly, because "many SCM applications are based on information available largely within an ERP software that centralizes information to date across all departments" [14] of the company, and because system integration involves high cost that are difficult to sustain by companies, especially in the

current national and global economic climate. Also, it is probably obvious that a SCM system would need to be integrated in the online environment, too, considering that the system will be accessed not only by company employees, but also by persons from the outside, such as suppliers, for example. So even if security of the use of these systems (SCM) should be high, *trust* in business partners is nevertheless another "parameter" worth considering. Therefore, all these disadvantages have determined companies, at least in Romania, to not "venture" too much in implementing this type of system.

However, implementation and integration of SCM type of systems with the other system of a company brings a number of advantages. "The primary benefit of SCM systems is better operational and business planning [..] and the real-time planning capabilities allow firms to react quickly to supply and demand changes."[1]

4 Technologies of Data Integration: Oracle GoldenGate (GG)

Oracle GG uses a low-overhead architecture to capture transactions nonintrusively from a source database by reading online transaction logs, transforming the data when needed, and applying those transactions with guaranteed integrity to a target database in real time. Oracle GG's processes run continuously-even bidirectionally-and support high-volume, rapidly changing environments, moving thousands of transactions per second with very low impact. The target database is a transactional replica at a logical level, which can be leveraged for multiple applications, including a rolling database upgrade. Oracle GG provides the following data replication solutions:

a) High Availability:

- Live Standby for an immediate fail-over solution that can later re-synchronize with your primary source.
- Active-Active solutions for continuous availability and transaction load distribution between two or more active systems.

b) Zero-Downtime Upgrades and Migrations: Eliminate downtime for upgrades and migrations.

c) Live Reporting: Feeding a reporting database so that you don't burden your source production systems.

d) Operational Business Intelligence (BI): Real-time data feeds to operational data stores or data warehouses, directly or via ETL (Extract, Transform, Load) tools.

e) Transactional data integration:

- Real-time data feeds to messaging systems for business activity monitoring, business process monitoring and complex event processing.
- Uses event-driven architecture and service-oriented architecture.

Operational Business Intelligence

For Real-Time Data Warehousing - The Oracle GG Real-Time Data Warehousing solution enables continuous, real-time data feeds for data warehouses or operational data stores, to improve business intelligence. Our log-based changed data capture has very minimal impact on the source, no batch windows and moves the data in sub-seconds. Each transaction's commit boundaries are maintained for data integrity.

Oracle GG's architecture also improves data recoverability in case there is an outage during the data movement. This is an important requirement as data latency decreases in feeding the analytical environment. Oracle GG's trail files that store the changed data are persisted, so if needed they can be reapplied to the target and also source system without having to capture the data again.

Transformations or co-existing with ETL

Oracle GG out-of-the box can support a number of common data transformations often required for data integration. However, where complex transformations are needed Oracle GG can be used to augment an existing ETL solution in several ways:

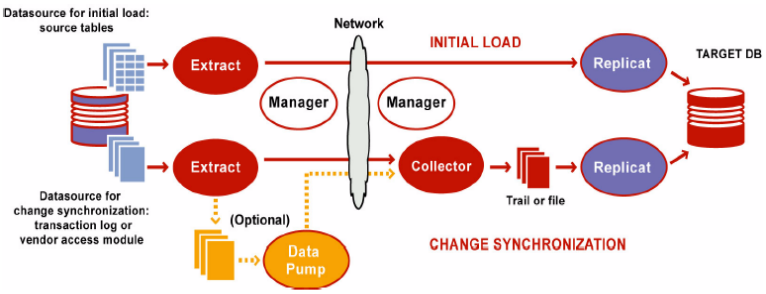
1.First, Oracle GG can deliver transactional data to staging tables in real time, which then would be used by the ETL to extract from and perform transformations and then load user tables. This method works best when the ETL product is optimized to perform the transformations within the target database. This is an "ELT" model.

2. Second method: Oracle GG provides the data to the ETL engine as flat files and in micro-batches. The latency depends on the ETL product and business requirements but we typically deliver every few minutes to an hour.

3. Third method: Oracle GG publishes changed data to a messaging system and the ETL solution (that can subscribes to the queue or topic) receives it in real-time.

In each of these architectures combining real-time change data capture with ETL decreases data latency to real time or near real-time and eliminates the batch window dependency.

Fig. 1 – Logical architecture of Oracle GG; source: [15]



Configuring Oracle GG for Real-Time data warehousing

A data warehousing configuration is a many-to-one configuration. Multiple source databases send data to one target warehouse database. Oracle GG supports like-to-like or heterogeneous transfer of data, with capabilities for filtering and conversion on any system in the configuration. Please see below the process to configure a data warehouse using Oracle Golden Gate:

a) Actions on source systems:

1.On each source, configure the Manager process;

2.Create a primary Extract group on each source:

ADD EXTRACT <ext_1>, TRANLOG,
BEGIN <time> [, THREADS <n>];

3.Create a local trail on each source:

ADD EXTTRAIL <local_trail_1>,
EXTRACT <ext_1>;

4.Create a parameter file for the primary Extract on each source with the following information:

EXTRACT <ext_1> [SOURCEDB <dsn_1>,]
[USERID <user>[, PASSWORD <pw>]]
EXTTRAIL <local_trail_1>
TABLE <owner>.<table>;

5.Create a data pump Extract group on each source:

ADD EXTRACT <pump_1>,
EXTTRAILSOURCE <local_trail_1>,
BEGIN <time>;

6.Create a remote trail on the target and use the following command of each source:

ADD RMTTRAIL <remote_trail_1>,
EXTRACT <pump_1>;

7.Create a parameter file for the data pump group on each source with the following information:

EXTRACT <pump_1> [SOURCEDB <dsn_1>,]
[USERID <user> [, PASSWORD <pw>]]
RMTHOST <target>, MGRPORT <portnumber>
RMTTRAIL<remote_trail_1> [PASSTHRU |
NOPASSTHRU] TABLE <owner>.<table>;

b) Actions on target system:

1. Configure the Manager process;

2. Create a Replicat group for each remote trail that you created:

ADD REPLICAT <rep_1>,
EXTTRAIL <remote_trail_1>, BEGIN <time>;

3. Create a parameter file for each Replicat group with the following information:

REPLICAT <rep_1>
SOURCEDEFS <full_pathname> |
ASSUMETARGETDEFS [TARGETDB <dsn_3>,]
[USERID <user id>[, PASSWORD <pw>]]
REPERROR (<error>, <response>)
MAP <owner>.<table>, TARGET <owner>.<table>
[, DEF <template name>];

5 Pairwise, an Integrated Powerful Testing Technique

It is very important to ensure the usability and interoperability of an application, therefore the tests are invented in response to risks.

An integration test is the last step in the validation phase, and an efficient and powerful testing method is very useful.

Let's consider the next example: supposing that a web site company must operate correctly with the eight most popular browsers: Firefox, Google Chrome, Internet Explorer, Opera, Safari, Maxthon, Flock and Avant Browser (according to Toptenreviews [18]), using plug-ins like RealPlayer, MediaPlayer, or none, running on different client operating systems (Windows 98, ME, NT, 2000, XP and Win7), receiving pages from different servers (IIS, Apache, and WebLogic) and running on different server operating systems like (Windows NT, 2000, and Linux). For a complete integration test, if we intend to execute all possible situations, we could end up with 1296 combinations. Considering that it is absurd to suggest so many test cases, we can analyze it using Pairwise testing technique based, in this situation (or similar), on Orthogonal arrays method. "An orthogonal array is a two-dimensional array of numbers that has this interesting property—choose any two columns in the array. All the pairwise combinations of its values will occur in every column pair. […] Not only will all the pair combinations occur in the array, but if any pair occurs multiple times, all pairs will occur that same number of times." [19].

A representative formula is Fig. 2. Applying it, we can determine the array size: it will be five columns, one for each variable in this example.

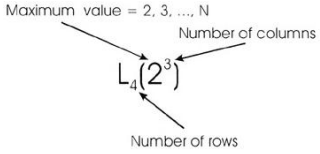


Fig. 2

The first column must support eight different levels (1 through 8). The second column must

support three levels (1 through 3), etc. The required array size obtained is $8^1 6^1 3^3$. Unfortunately, an array with this exact size does not exist. In this case, we choose the next larger array [19]. We obtain orthogonal array $L_{64}(8^2 4^3)$ which meets our requirements. This means that, using this orthogonal array, all pairs of all the values of all the variables can be covered in only 64 tests, i.e. 95% reduction in the number of test cases.

All is mainly based on the next rule: if all of the pairs in a given combination exist in other combinations, we can drop that combination.

Considering that in computer systems, defects usually involve a single condition, independent of any other condition in the system, Pairwise is a powerful technique for reducing the number of tests to be run. Based on the statistics, the use of this method prevents the occurrence of almost all critical and major incidents. But despite this, we have to admit that some disadvantages are presented. One problem appears when there are dependences between two or more variables, or certain options are required. Another problem is that an "all-pairs" table takes a significant time to construct and if we want to test more than pairs-triples, or n-tuples, the problem quickly becomes intractable for a human test planner. Fortunately, to solve these complex situations, special software applications were developed.

6 Conclusion

The integration of the information systems for a company, "today", it is necessary more than ever before, because in the companies, there are tens or hundreds of separate applications, which involves high costs and long time to matching the information. Therefore, the integrated information systems must inter-connect and inter-communicate as a complex, complete and coherent system and all systems parameters should interfere in order to assure compatibility and combined inter-operability.

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