



ANALYSIS OF CLOUD SERVICES INTEGRATION WITH ENTERPRISE INFORMATION SYSTEMS

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ABSTRACT

This paper reviews problem and different solutions designed for integration of cloud services with enterprise information systems. Paper gives special attention to cloud communication service and describes different types of enterprise information systems. As result, this paper determines mashups as a best solution for such kind of integration.

Keywords: *Cloud Integration, Enterprise Integration Solutions, Integration Problems, Cloud And Enterprise Integration.*

1. INTRODUCTION

This article reviews the current publications, from 2009 onwards, related to the topic of cloud services integration with enterprise information systems, which allow to estimate the current state of solutions in this field. The main problem is that there are many services, that works independently, but their consistent use should provide additional benefits rather than separate use. The aim of the article is to determine further direction of researches in integration of Internet communications cloud service with enterprise information systems. This direction of integration is a special case of cloud services integration; however it has a particularity that the main advantage of integration consists in working with Internet communications functionality, which can be used in enterprise information systems.

Application of such solution will allow to provide enterprises of various industries with improved communication capabilities both with product customers and with suppliers. Thus, the integrated communications will improve the efficiency of enterprises. This article shows that for Internet communication services the best approach is use of mashups for integration with other information services.

2. TYPES OF INTEGRATION SOLUTIONS

Division of data integration into several levels is generally recognized. It was presented for the first time in 2004 in the article "Three Decades of Data Integration — all Problems Solved is conventional?" [1], and it was confirmed in 2009 [2]. In this article, the integration levels are defined as follows:

- Common Data Storage. Integration is performed by data fusion from different data storage systems into one common.
- Uniform Data Access. On this level, logical data integration is carried out. Various applications receive uniform vision of physically distributed data. Such data virtualization has its undoubted advantages, however the data homogenization requires a lot of resources in the course of operation.
- Integration by Middleware. Software of this level plays a mediating role. Its components are capable to perform certain functions assigned to them; the integration problem is solved completely in interaction with applications.
- Integration by Applications. An application provides access to different data sources and returns summary results to a user. Complexity of the integration on this level is explained by a large variety of interfaces and data formats.
- Common User Interface. The use of the interface enables uniform access to data, for example, by means of some browser, but in



this case the data remains unintegrated and inhomogeneous.

- Manual Integration. The user combines data using different types of interfaces and query input languages.

With the development of Web technologies, Web 2.0 concept and first using of the Web browser as a single point of access to various information systems, including to enterprise information systems, as shown in [3, 4], it becomes necessary to perform a web-integration. Existing ways of cloud integration of applications are analyzed in the article "Cloud integration of applications. Which way is optimal?" [5, 6]. The list of existing integration ways, ordered by level of complexity, is provided below:

- Screen integration or mashups (collages) — iFrame designs, transferring information necessary for extraction from other cloud, combine on the software code level.
- Integration on representation level comes down to creation of a middleware server alongside, which is able to refer to another service; that makes possible to build in certain data fields (as opposed to mashups which are able to insert only the entire page).
- Business Logic Integration represents a higher integration level, as the application context is saved, and there is an access to web services and security. The decisive condition for such integration is availability of accurate documentation.
- data integration comes down to a direct query to the application database in the cloud. This approach is considered as unsafe, but it is justified when large data volume is needed to be read.

The particularity of this classification is that integration on the business logic level is classified separately. Comparison of the classifications above indicates that in the first classification, the integration on the user interface level is a special case of integration on the data level, while in the second classification these types are separated. It allows to draw a conclusion, that distinction of integration types is very conditional, and all integration types are closely related to each other.

Development of the integrating sphere led to formation of several approaches and technologies, which are used on different levels [7]:

- enterprise application integration (EAI) — a set of software, technologies and services,

forming the Middleware, directed on systems and applications integration across the company. An example of such solution is the concept of the enterprise service bus (ESB), which realization was widely adopted in the market of integration solutions, because the market research in 2011 revealed that the preference to ESB solutions is given by 57% of respondents [8].

- extract, transform, and load (ETL) — data view in target storages on the basis of data from many sources.
- enterprise information integration (EII) — unified view of all company's data by providing access to data from different sources in the required form.
- In addition to the technologies, specified in the article [7], the following approaches should be noted:
- Comprehensive integration solutions (CIS), combining various ways of software and data integration [9].
- Portals and mashup technologies [10], focused on web technologies, which combine access to various web-information systems. Referring to the object of the article, this approach is particularly interesting, because it is initially intended for user working with integrated functionality and data of various systems.

With cloud technologies development, software solutions for integration are gradually shifting towards clouds. Meanwhile, the reviews of analytical agency Gartner predict further growth of the market of integration solutions on the following directions [11]:

- by 2016, medium and large companies will incur expenses by 33% more in the direction of application integration, than in 2013;
- by 2016, data integration on mobile devices will make about 20% of all expenses for integration;
- by 2017, more than two thirds of all new integration streams will cross a corporate firewall;
- by 2018, more than 50% of creation cost for 90% new large systems will be spent for integration.

In the same way, the volume growth of the public cloud services market to 107 billion dollars is expected by 2017 [12] that corresponds to an annual gain in 23,5% that is five times more, than the predicted growth rate for whole IT industry. At the same time it should be noted that the VoIP

market develops much more slowly and according to Gartner, following the results of 2014, the VoIP market is expected to grow only by 1,3% in 2014 [13]. This is due to the fact that the market is generally quite large (the total volume for 2014 is estimated at 1,655 trillion dollars).

Based on the obtained data, the direction of the Internet communications cloud service is revealed, that is cloud integration service with additional options. One of the main options is service provided together with some information systems in order to enhance its value and attractiveness to the customers of other products in the field of communications. In terms of the Internet communications cloud service, of interest is integration on data level, as well as on functionality level. Consideration of these ways will help to ensure complete interaction between the service and information system.

3. EXISTING SOLUTIONS ON THE CLOUD INTEGRATION MARKET

In the market, there are a lot of cloud services intended for ensuring integration. That is why to determine the best integration mechanism, it is necessary to consider existing solutions in the integration market. The list of the leading participants of the integration market is provided below (range based on search results):

- Informatica Corp
(<http://www.informaticacloud.com>);
- Dell Boomi, DELL Corp division
(<http://www.boomi.com>);
- Pervasive Software, Inc
(<http://integration.pervasive.com>);
- SnapLogic Ltd., SnapCloud
(<http://www.snaplogic.com>);
- JitterBit (http://
www.jitterbit.com/Solutions/cloud-integration-tools).

Referring to the Article object, the consideration of these solutions is carried out for determining the integration solution type, applied in a particular product. It will allow to draw a conclusion on possibility to use this solution for integrating of the Internet communications cloud service and enterprise information systems.

Informatica Corp (USA) offers software and services for data integration in the cloud, as well as a platform for developing and deploying custom services and integration. The producer offers the

SaaS and IaaS services. At its core, this set of software products is the ETL, directed on collecting, converting and placing the data in target storages. Type of integration solution: ETL.

Dell Boomi (USA) offers solutions in the field of Integration Cloud for any application type: already developed, developed by means of AtomSphere tools or developed by Dell Boomi by the user's request. The AtomSphere enables integration of any combination of SaaS- and local applications, installed on a customer's platform. The big list of applications, including both enterprise applications such as Oracle E-Business Suite, PeopleSoft and SAP Business Suite & NetWeaver, as well as various systems of DBMS, CRM, social networks and other is provided. Functional integration is based on use of widgets that can be built in any website with a few code lines. The integration is carried out in the user interface, where the user has the possibility to configure and expand integration tools in single step mode. Widget Designer is provided. In the process of designing, widgets build in the integration process; the required properties are defined, ranging from user authentication to interpretation of logical values. Integration solution type is integration on functionality level, EII and ETL, so it can be considered as a comprehensive integration solution.

Pervasive Software (USA) specializes in integration solutions for users, which solve integration tasks both for cloud and ordinary systems. Pervasive Data Integrator is proposed with the following functions: integration processes design for corporate database storage download, data conversion to different formats, expansion of complex integration scenarios, local and cloud applications integration. Integration solution type is ETL.

MuleSoft, Mulesoft iON (USA) is one of the most well-known suppliers of the Mulesoft iON integration platforms with open code. The Mulesoft offers integration, based on Mule ESB (enterprise service bus). Integration solution type is ESB.

SnapLogic Ltd (USA) offers cloud integration platform for quick access and data delivery through the cloud and local applications and data sources. The SnapLogic integration tools are based on SnapLogic Server. The server controls such integration functions as security, logging and execution of other components and can be installed



on a local device or in the cloud. The architecture is based on Internet standards. Each interoperable application has a configured component for authentication and data access. The application integration is provided by accession to the integration pipeline, carrying out necessary operations. Integration solution type is ETL.

Jitterbit (USA) offers integration tools, allowing organizations to replicate, delete and synchronize data, hosted in the cloud, with local enterprise applications and systems. Integration tools support SOA and event-driven architecture. By definition, the product is a middleware, directed on data integration between applications. Type of the integration solution: ETL.

Results of comparison of the specified participants are given in Table 1.

Table 1 – Integration Solution Types Of Integration Market Main Participants

Software program	Integration solution type
Informatica	ETL
Dell Boomi	Comprehensive integration solution EII and ETL
MuleSoft	ESB
SnapLogic	ETL
JitterBit	ETL

Based on a comparison of existing solutions, it was revealed that the majority of players offers traditional ETL solution, which does not allow to implement functional integration necessary for complete integration of the Internet communication service with enterprise information systems. The Dell Boomi product stands apart, as it has the possibility of functional integration, which provides not only integration on data level, but also functional integration and integration on representation level.

To determine the existing integration solutions for specialized communications services, we will consider a number of existing solutions, related to software integration for communications in enterprise information systems:

- The Akreion company's product (<http://www.akreion.com/open-source-contributions/openerp-asterisk-voip-connector>), which comprises ability to integrate IP PBX Asterisk and OpenERP accounting system.

- Integration module with IP PBX Asterisk for the SugarCRM CRM-system (http://www.sugarforge.org/resources/?group_id=1099).
- Extension for IP PBX Asterisk, adding functionality of CRM (<http://astercc.org/products/astercrm>).
- Integration module with IP PBX Asterisk for the vTigerCRM CRM-system (https://wiki.vtiger.com/index.php/PBX_Manager_Module).
- Callinize service (<http://www.callinize.com/>) for the VoIP system integration (supported by Asterisk only) with CRM systems (supported by SugarCRM only).
- "1C Telephony" software - an extension for the "1C Enterprise" software (<http://simplit.com.ua/index.php/ipphone-integration-menu/199-1c-asterisk-about>), allowing to make calls directly from the 1C software using Asterisk or a number of VoIP providers.
- Zingaya Service (<http://zingaya.com>), which allows to make calls from a web browser from the page, where the software module for calls is built in.

As you can see, there are a number of solutions in the market, providing such functionality, but all of them are limited in terms of used communication system or used business system. The approach focused on integration with enterprise information systems of office telephony, designed on the basis of the PBX Asterisk software, dominates. But the approaches, used for this direction, can't be used in practice for cloud communication service integration, because the interaction principle differs. The Zingaya software product, which can be integrated into any information system and access to which is provided via a web browser, is of a certain interest. At the same time, the service has limitation; it is focused on communication with only one subscriber and on only one communication type. Due to such limitation, this product can't be used for solving the article task; it implies to summarize several approaches.

4. TYPES OF ENTERPRISE INFORMATION SYSTEMS

When considering the integration of the Internet communications cloud service with enterprise information systems, it is necessary to identify classes of enterprise information systems, as well as the need for communications implementation to



them. We will identify the main classes of information systems, used in enterprise environments:

- CRM (Customer Relations Management) — an application software for organizations, intended for automation of interaction strategy with clients to increase sales, optimize marketing and improve customer service by storing information on customers and history of relations with them, to establish and improve business processes and subsequent analysis of results. For this class of information systems, communications are one of the priorities, defining the quality of customer relationships.
- ERP (Enterprise Resource Planning) — an organizational strategy for production and operations integration, human resource management, financial and asset management, focused on continuous balancing and optimization of enterprise resources by means of specialized integrated package of the applied software that provides a common model of data and processes for all activity fields. The ERP-system is a specific software package that implements the ERP strategy. Communications in this case are important, because they allow to optimize the company performance in terms of employee engagement, both among themselves and with external contractors.
- ServiceDesk — systems, designed to ensure processing of user applications. They were originally used in technical support of software products, but the application field gradually expanded. For this class of information systems, communications are one of the priorities, defining the quality of customer relationships.
- HRM (Human Resource Management) — a field of knowledge and practical activities, aimed at ensuring an organization with qualitative personnel, capable to perform labor functions assigned to them and its optimal use. Human resource management is an integral part of the quality management systems of an organization. Communication in this case is also important, because it will ensure high-quality interaction with company staff.
- MES (Manufacturing Execution System) — a specialized application software, designed to meet the challenges of synchronization, coordination, analysis and optimization of products within any production. The MES-systems are a class of plant-level control

systems, but they can also be used for integrated production management in an enterprise as a whole. In this case, communication is a secondary task, and it can be used to notify interested parties on status of an operation in a production process.

- WMS (Warehouse Management System) — a management system, providing automation and optimization of all warehouse operation processes of a profile enterprise.
- EAM (Enterprise Asset Management) — an application software for an asset management of a company. Its application is focused on reducing the cost of technical maintenance, repair and procurement without decrease in reliability level, or on rising the number of equipment operating parameters without increase in expenses. In this case, communication is a secondary task and it can be used to notify interested parties on implementation of certain stages in the processes of asset management.

A complete list of enterprise information systems classes cannot be determined in view of specifics of each company and, respectively, functions, which are automated by software within this company.

Classes of enterprise information systems are directly related to functionality that is implemented in a particular department, and likely to the traffic between the company departments, a necessity of designated information systems integration appeared. In this case, the integration aim is to receive a piece of homogeneous space; the user, getting access to it, has an access (limited by his rights) to all necessary data and presentations. Another integration aim is to enhance the software functionality that allows to optimize user activities of the software, thus increasing attractiveness of the product.

Thus, the most promising classes of enterprise information systems, which can be useful for integration of Internet communications cloud service, are CRM and Service Desk. Also we should consider the integration with such popular class of enterprise information systems as ERP. At the same time, there is a gradual movement of CRM and Service Desk to the "cloud" and the ERP remains in the traditional paradigm of applications, developed at the company's facilities. The integration solution for ERP will cover the integration of Internet communications cloud service with information systems, distributed on



different models. Besides the specified classes of systems, it is necessary within the research to consider some enterprise information systems, which are not included in this list that will allow to draw conclusions on a similarity of the applied techniques.

5. INTEGRATION PROBLEMS AND EXPERIENCE

Integration of software solutions, besides advantages has a number of concerns and problems, which will be covered in this paragraph.

A number of articles are devoted to development of integration systems. In particular, the article «A review of enterprise IT integration methods» [14] deals with the state of things in the field of enterprise information systems integration and the conclusion is drawn that the enterprise service bus, over which the architecture, focused on services, and architecture, focused on events, has to be a basis for integration.

Some authors, aiming to identify problems, associated with integration, also suggest to use a survey of a number of experts, involved in the integration [15]. As a result, they faced with the following issues, arising from application of integration technologies:

- difficulties in applications integration , developed by third developers;
- necessity of timing, coordination on functionality, coordination of data and components of an integration platform and their installation;
- limited opportunities of the integration reuse;
- difficulties in errors determining, because integration solution is a new software.

Further, when performing researches, these issues have to be considered to improve the efficiency of the developed methods and solutions.

Another considered question is the difference between integration in the cloud and in the traditional environment. The authors of the article «Cloud Implementation and Cloud Integration» came to a conclusion about similarity of these environments, which means similar opportunities of using integration technologies [16].

A number of articles are devoted to mashups direction (means mixing of data and presentations from several sources). This direction is connected with creation of a user view that combines data and

functionality of several sources. This is one of the modern directions, which focuses on Web 2.0 technology and creation of a homogeneous access to various information systems. The SOA technology has limitations in terms of use to Web-applications and applications that are not designed for integration. An approach, based on the new OSGi standard for combination of various software products (portlets, web applications, widgets, legacy applications, JavaBeans) is offered as a solution. As an example, the authors give the description of solution, based on mashups for IBM Lotus Expeditor [17]. As a part of the article, it should be noted that the authors transfer the "integration" concept to the "composition" concept. This transition is absolutely appropriate in terms of the integration of Internet communications cloud service, as specifically composition corresponds more accurately to the integration method of such services. Such approach is offered by the authors of the «ASaaS: an approved Architecture for SaaS Service Composition» article, offering the mechanism of ensuring collaboration of SaaS services, integration technology and problems of such integration on the level of presentation, functionality and data, and also an example of practical implementation of this approach in an enterprise.[18]. The issue of mashup application in enterprises is considered within integration of different cloud services in B2B scenarios. The service prototype with such functionality is also given in the source [19].

In the article «Application integration on the user interface level: An ontology-based approach» [20], the authors propose the applications integration by means of plug-ins that implement some functionalities of applications. Plug-ins are divided into categories. Despite the fact that the authors propose to use this approach for integration at a user interface, in fact, it combines both the functional and data integration.

A separate topic, to which the attention is paid in sources, is an obtaining new opportunities at the time of integration into CRM: improving the efficiency of customer relationship management, additional functionality and transition to the e-CRM concept, where it is possible to communicate with customers in real time [21]. Questions of integration of CRM and enterprise data warehousing are raised in the article «SaaS and Integration best practices» [22], where the problems, arisen in the company during transition from a traditional CRM system to the cloud CRM,



are considered. The authors suggest using of enterprise integration software, implementing the ETL, and conclude about the prospects of solutions "integration as a service." In the article «Cloud computing: issues and challenges» [23], combined use of gmail service and Salesforce.com is for Human Resource Management considered.

The integration approach with ERP system is considered in the thesis of Shi Jia "Integrating Conventional ERP System with Cloud Services: From the Perspective of Cloud Service Type" [24], where the questions of integration of cloud services and traditional ERP systems are covered from the point of view of the cloud service type. The conclusion about various advantages, which cloud technologies provide for ERP systems, is also drawn up and, in particular, extension of functionality of ERP systems by integration with SaaS solutions is considered.

Questions of authentication and authorization are common to any system; in particular, they are relevant for cloud environments. In the article "Open Identity Management Framework for SaaS Ecosystem" [25], the practice in the application of the OpenID and OAuth mechanisms for composition (integration) of SaaS applications is considered. Similar questions are considered also in the article [26], where the authors propose the solution for user authentication in cloud environments, and also efficiency of the proposed solution is analyzed.

6. CONCLUSIONS

The analysis of experience in application integration shows that there are a number of basic conceptual solutions, which are defined in the analyzed sources:

- Main integration solutions on the data level are focused on application of the ESB technique. But this approach is not appropriate for the considered problem, connected with functional integration, as the ESB allows only integration on the data level. For this reason, the ESB won't be considered for further consideration.
- Integration has a number of problems:
 - difficulties in integration of applications, developed by third developers;
 - need of timing, coordination on functionality, coordination of data and components of an integration platform and their installation;

- limited opportunities of the integration reuse;
- difficulties in errors determining, because integration solution is a new software.
- It should be noted that these problems are common to any software. The only issue, associated with low reusability of integration solutions, is single out. This issue should be taken into account when carrying out further researches.
- the promising direction for further development of cloud communication services, i-e- integration with other solutions, is revealed as a result of review of analytical agencies reports on prospects of the integration solutions and communications market;
- following the research results of the main enterprise information systems types and ability of the Internet communications cloud service's integration with them, the prospects of integration with systems of the ERP, CRM and Service Desk classes, which covers the majority of possible scenarios of integration are revealed;
- Integration in the cloud is carried out using the same principles, as the integration in traditional infrastructures.
- the most interesting solution for web-based information services is the mashups or plug-ins direction.
- Integration of web-based information services with enterprise information systems can improve the efficiency of these systems.
- The one of the key issues that should be resolved during integration is an authentication and authorization of users, which is solved by such technologies as OpenID and OAuth.
- There are works, considering integration ways of Internet services with separate enterprise information systems. At the same time, there is no comprehensive approach, concerning integration with different classes of enterprise information systems. The existing variety of enterprise information systems demands formation of some generalization, which will increase a reuse of integration solutions.

So, based on these results, for integration of Internet communication service with information systems should be used mashup approach, which can provide additional benefits for enterprises.

Thus, the further research should be focused on development of a generalized approach, based on mashups that can be reused when integrating Internet communications service with enterprise information systems of various types. In particular, this approach also has to solve issues of user authentication and authorization (this question is open for further researches).

7. ACKNOWLEDGEMENTS

The article is published under financial support of the Ministry of Education and Science of the Russian Federation. The unique identifier of the applied scientific research RFMEFI57614X0081.

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