Cloud Integration - Strategy to Connect Applications to Cloud

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***Abstract*— Cloud Computing is being widely hailed path by enterprises to realize benefits without compromising control. However, enterprises concern is the integration of applications hosted both on premise, Cloud and partner environments. In spite of enterprise's strategic imperatives to meet their business goals by building integration services between these environments, new integration challenges are posed with the advent of areas like Cloud, Social, and Mobile that are augmenting to the existing complexity.**

The key challenges being Performance and Usability of these services which cut across Legacy, On Premise, Cloud applications and SaaS applications. Enterprises are spending highly on these integrations as these are crucial for their business process to be executed seamlessly. Key Patterns w.r.t Enterprises Integration considering the widely adopted Cloud scenario are:

- **On-Premise Application to Cloud Application Integration**
- **Cloud Application to On-Premise Application Integration**
- **Cloud to Cloud Application Integration**
- **B2B Integration**
- **Web API Publishing**

This paper helps in adoption of an efficient integration strategy to connect applications on cloud with effective cost benefits and lowered total cost of ownership (TCO).

Keywords: Cloud Computing, Cloud Integration, Cloud to Cloud, On-Premise to Cloud, Business to Business (B2B).

I.INTRODUCTION

In the yesteryears of IT, integrations were simple and point-to-point, as number of integrations channels grown, solutions became complex. As the maturity of integration was grown – Enterprise Application Integration was widely adopted by enterprises through APIs, Web Services, adapters and integration brokers. Today's enterprises drive B2B Applications integration where applications need to interact with partners, suppliers and other stakeholders by leveraging Enterprise Data Integration (EDI) channels. Every enterprise started using these integrations mainly for transactions related to data which can be of different types as well as events required for the applications. In the present times, integration has become very complex as the need for transformation of data in a seamless manner in real-time conditions much quicker is very crucial for business to success. As the cloud has become very predominant and being adopted by enterprises, movement of enterprise level data across miscellaneous applications for intra and inter organization level transactions are looking towards cloud integration.

This paper provides a detailed insight of how to plan for integration with multiple environments by adopting a simple and efficient cloud integration strategy. Section-2 provides the details on what is the need for cloud integration. Section-3 outlines the process of How to build a cloud integration strategy and what factors need to be considered at that point of time. Section-4 provides detailed insight on Cloud Integration Strategy and its setup. Section-5 provides the key benefits of an efficient cloud integration strategy.

II.NEED FOR CLOUD INTEGRATION

With the increased business needs to be fulfilled by enterprises, IT Enterprises are developing new applications by using emerging technologies like social, mobile and most of these new applications are being hosted on cloud for various reasons. In reality, most of the enterprises follow different types of integration and varied levels of adoption. When it comes to cloud computing and at the time integration is required on cloud, enterprises need to think about "What problem is the integration solving?" As cloud integration not just addresses the integration between cloud based applications (i.e.) applications hosted on single cloud platform or multiple cloud platforms, but also between cloud-based applications and on-premise applications. So, it is very crucial to determine what exactly is integrated and what the purpose of integration is. In many scenarios, enterprises need to achieve cloud-to-cloud as well as cloud-to-on-premise integration patterns, but at the same time, it is important to understand the objective from integration perspective and needs to be considered as a key requirement.

During cloud integration, another aspect which need to be thought through is "How can integration help solve the

problem at hand?" Until, recent past, most of the enterprises considered integration only in a single scenario (i.e.)

- On-premise Application-to-Application
- Business to Business Applications

Above mentioned integration scenarios were always thought as separate use cases. But, in today's world, as the approach is changing, enterprises are in the quest of comprehensive solutions to address the integrations across the business channels. Section-3 provides a detailed insight on how to build a simple and efficient cloud integration strategy.

III.CLOUD INTEGRATION STRATEGY

IT Enterprises moving onto cloud encounter many challenges. But one of the most important requirements to be met is to come up with a simple and efficient cloud integration strategy. While developing Cloud Integration Strategy, enterprises should do a rigorous exercise for identifying the complexity factors w.r.t integration. Some of them are detailed below:

1. Enterprises are aware that, similar to on-premise application integration APIs, even the cloud APIs can be heavy and cumbersome where complexity outspreads connecting to the APIs themselves. So, we need to identify the factors of complexity from APIs perspective for both on-premise application APIs as well as cloud based APIs.
2. Enterprises also needs to consider how data that comes from an on-premise application will be translated into cloud based application and vice-versa that needs to be factored into complexity from integration perspective.
3. Enterprises think that it is simple to add one cloud service at a time and they do not expect the inevitable complexity of multiple cloud providers for integrating their applications running on different cloud platforms which end up with a traditional way of point-to-point integration approach. So, enterprises need to think about the complexity on integration of multiple applications on different cloud platforms along with on premise applications.
4. Security is also very critical and needs to be considered while dealing with cloud-based data integrations. Generally, systems integrating with internal systems assume a certain degree of security which is innate. However, while moving data to and from the cloud, we should not go with assumptions on the same degree of security. It should be considered based on the type of data being moved to and from the cloud, align the organization's security strategy accordingly without impacting performance for no real benefit. Also, security strategy defined for cloud-based data integration solution that deals with data both at rest, stored on the cloud, on-premise, and data in-flight which needs a separate approach for encryption.

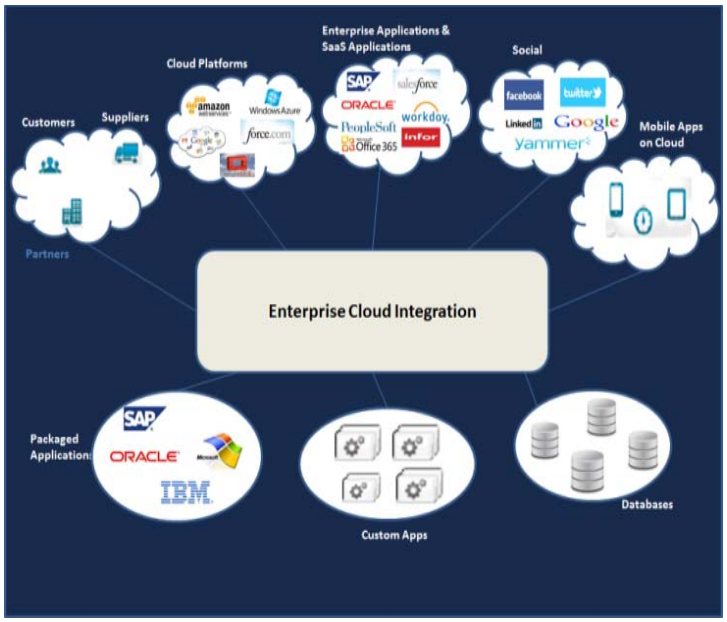

Fig. 1. Enterprise Cloud Integration Topology

Above Figure 1 depicts the scenario where an organization has heterogeneous applications hosted on-premises as well as on cloud leveraging enterprise cloud integration strategy.

By considering the above mentioned complexities, enterprises need to develop a simple and categorical cloud integration strategy at the earlier stages of cloud adoption process. Considering different scenarios from cloud services perspective (i.e.) back-office applications, business-to-business (B2B) applications, enterprise applications, social applications, collaboration based applications, Information Management applications etc. which provides incredible efficiencies hosted on cloud platform, realizing these efficiencies needs a robust coordination and integration strategy. As the number of cloud platforms being used by organization increase, the complexity w.r.t coordination and integration also increases appropriately. Keeping the complexity factors in mind, enterprises need to come up with efficient approach w.r.t integration platforms for on-premise applications, cloud applications, and any other applications. This need leads to establishment of integration platform-as-a-service (iPaaS) [1] where enterprises can come up with iPaaS on their own or adopt a third party integration brokerage provider based on the business needs, maturity level of integration, integration competency skills of the organization .

While developing a Cloud Integration Strategy, enterprises needs to come up with the details on what type of integration patterns are being considered. Integration

Patterns are mainly considered for the scenarios given below:-

- Cloud to Cloud Application Integration (C2C)
- On-Premise Application-to-Cloud Application Integration (O2C)

Also, enterprises need to identify the integration patterns. Some of the key patterns are listed below:-

- Remote Process Invocation – Request and Reply
- Remote Process Invocation – Asynchronous Messaging
- Batch Data Synchronization
- Remote Call-In
- UI Updated Based on Data Changes
- File Transfer
- Shared Database

Above mentioned Integration Patterns needs to be mapped with the scenarios (i.e.) O2C or C2C or both.

To further analyze, enterprises needs to identify detailed sub-scenarios for C2C and OAC as a part of the above mentioned mapping. Few Sub-Scenarios which can fall under C2C are listed below:-

a) Custom built Applications hosted on Cloud to Line of Business (ERP, CRM) Applications on Cloud
b) Custom built Applications hosted on Cloud to Social Applications like Facebook, LinkedIn, and Twitter etc.
c) Custom built Applications hosted on Cloud to other Custom built applications on Cloud
d) Custom built Applications hosted on Cloud to Mobile Applications

While determining the efficiency of cloud integration strategy roadmap, Enterprises needs to consider the following factors:

A. **Integration as Core Competency:** Enterprises needs to assess their core competencies w.r.t integration. Accordingly, build the human resources efficiently to deliver and manage cloud integration Solutions.
B. **Integration (CAPEX Vs OPEX):** Enterprises have to assess the needs for building integration capability both in-terms of capital expense (i.e.) skilled human resources and required integration software. Where capital expenditure is a constraint, they need to build the integration capabilities by operating expenses through third party integration brokerage service.

As the key principles and requirements around data management continue to increase, cloud integration plays an important role. It becomes inevitable that the enterprises develop a comprehensive cloud integration strategy to scale up to the needs of the businesses.

Section-4 provides the detailed information on Cloud Integration Maturity Model that provides the process to understand cloud integration capabilities

IV.CLOUD INTEGRATION STRATEGY SETUP

At the present speed and scale, enterprises need to come up with a proper strategy to handle complex integration scenarios, especially enterprises which are looking for cloud adoption. Without cloud integration strategy, enterprises will end up either with building point-to-point connections between the systems or less efficient integrations whether the applications are hosted on-premise or on cloud. This leads to anarchy and any changes in the architecture will become more expensive in terms of time and resources. To avoid such situations, enterprises needs to develop a cloud integration strategy. A Five (5) step process regarding the same is detailed below:-

1. **Understand Cloud Integration Maturity Model:** Enterprises planning to come up with Integration Strategy need to assess themselves where they stand in terms of their integration capabilities. Cloud Integration Assessment Questionnaire (CIAQ) helps the enterprises to understand their integration capabilities from cloud perspective with a set of questions.

In a nutshell, CIAQ helps to determine:

1. The integration needs of an organization from Cloud perspective
2. What are the current fulfilled cloud integration needs of organization
3. Capabilities of Organization that needs to be improved for cloud integration

CIAQ Questions are formalized on different areas like connectivity, integration, Governance and Operations etc. which are listed below in Table –I:-

TABLE I. CIAQ QUESTIONNAIRE

S.No	Assessment Questionnaire
1	What is the level of integration and % of applications that leverage integration at your organization?
2	What kind of integration solutions are used to connect with in the other applications within the organization? (Point-to-Point, SOA, web services etc.)
3	What kind of integration mechanisms are used to connect with partner applications across the enterprise (MQ Series, EDI, Gateway Managing with different protocols, Unified Central Partner Management)
4	What is the security mechanism adopted while integrating the applications to secure external services/APIs?
5	How much of your application portfolio is integrated through ESB model? What ESB tools are being used for the respective integration?
6	How do the legacy applications integrate with other applications (On-Premises and Cloud)? What kind of integration solution is used currently?
7	How does your organization expose business functionality as a reusable service (Java/.NET APIS, SOAP etc.)
8	What Kind of applications are planned to be integrated from the Cloud (ERP applications, Social Applications, Mobile Applications, Web Applications, Collaboration Applications)
9	Is there any process established to integrate SaaS based applications in real time?

10	What is the mechanism to integrate cloud applications for capturing and publishing of data? (Social Networking, Collaboration on Cloud) currently?
11	What is the ability of your organization to expose existing services via a web channel?
12	What is the capability of your organization to model and reuse data formats and transformation?
13	What is the capability of your organization to expose parameters to manage the configuration of processes without any impact?
14	What is the capability of your organization to test integration services and processes as a part of integration cycle?
15	What is the ability of your organization to manage cross-cutting concerns across integration processes without any impact?
16	What is the ability of your organization to manage data from multiple systems in the same integration process through orchestration?

2. **Setup a Governance and Competency Center:** Enterprises need to setup a Cloud Integration Competency Center [2] to govern, manage and guide the integration activity. This group should generally be an extension of the existing Enterprise Architecture group so that the integration solutions are aligned with the Enterprise architecture strategy of the organization catering to the Cloud integration appropriately. Following are some of the activities handled:
    a. They need to have a visibility of where information comes from and where it going?
    b. They need to track/decide the methodologies that are used for integration which help to drive effective and efficient business processes and decisions
    c. Mechanisms to protect data to reduce security risks and ensure compliance with corporate, industry and government regulations
    d. Help in building the right competency needed for the organization to build the integrations
3. **Development of Reference Architectures:** As an extension to the Enterprise Architecture reference models [4], reference models related to Integration need to be built so as to provide a guide line to the different teams that need and provide integrations. At an organization level there might be numerous applications out of which some might be hosted on cloud and some on premise. To achieve seamless execution of the defined business processes these applications need to be integrated and at the same time abide by the specifications laid down by the reference models. This helps in achieving the key metrics for the Integration areas as well i.e. Performance and Usability.
4. **Reusability through SOA**: SOA plays a key role in the current IT scenario where in some of applications are hosted on multiple cloud platforms and some on premise. As the applications move to more heterogeneous environments, the integration process gets more complex. This can be handled by adopting SOA. The existing services of those applications can be retained based on the technical aspects and then integrated to other applications using SOA. This helps in reuse of the services and also improves Time to Market and Manageability.
5. **Use Integration Design Patterns**: As discussed earlier the applications in an organization are heterogeneous in nature developed using different languages, running on different platforms and understanding different data formats. To fulfill business processes these applications need to exchange data over networks in a reliable and secure manner. In this kind of a scenario it is best to use Integration design patterns [3] by adopting the right and appropriate pattern templates which provides a consistent structure and the information provided and it also provides the required consistency while designing the systems as these are tested solutions for specific design problems encountered across years while integrating the IT systems. Some of the Integration patterns are listed but not limited which are commonly considered while creating integration solutions:
    a. **Integration Broker Pattern**: It helps in decoupling source systems and target systems that interact by remote service invocations through relative brokers (i.e.) Direct Broker, Indirect Broker, Message Broker whenever applicable.
    b. **Integration Adapter Pattern:** It is similar to classical object-oriented adapter which connects the interfaces of source and target and translates between the two interfaces. It accesses application's APIs or data and publish messages on a channel based on this data, and that likewise receives messages and invoke functionality inside the application.
    c. **Enterprise Service Bus:** It is provided with hub-spoke architecture between the sender and receiver systems aligned with SOA. It supports different patterns listed below:-
        i. **Web Services:** It provides integration between the systems to communicate by proven open standards such as XML, URL, HTTP, and REST based protocols.
        ii. **Messaging:** A software component mediates between applications that need to exchange data. It does the job of accepting messages from providers and delivers to the respective consumers. There are many variations to this design pattern that can be used based on the requirement
        iii. **RPC:** The provider application exposes its functionality using interfaces and the consumer needs to

be aware of those and invokes those using stubs. This is synchronous in nature.

d. **Data Integration Pattern:** Integration of applications at the data layer is achieved through different patterns which are discussed below:-

   i. **File Transfer:** The information exchange is done here using files and the files are shared at some common location

   ii. **Shared Database:** Information exchange between multiple applications is done here by storing data in a single database by defining a schema that handles the needs of all relevant applications.

   iii. **Maintain Data Copies:** Information exchange between multiple applications is done by maintaining multiple copies of data as well as maintaining state integrity between the copies.

Let's look at a very simple example of using cloud integration patterns using Salesforce.com and integration of the same with on-premise applications. A customer who is having their customer relationship management solution covering case management, chat & remote assistance solution, telecom, IVT & CTI solutions being hosted through Salesforce.com. Customer's support & services covering service channel management, knowledge management, finance management, BI analytics, Master data management systems are being implemented through on-premise customer's own data center due to confidentiality of customer data which will in-turn be used for forecast management. Also, customer has other boundary applications like Supply Chain Systems, Product Quality Systems, Enterprise applications which are using SAP services which are integrated with Salesforce.com – CRM system. All these systems can be integrated by using an enterprise service bus (ESB) like Tibco or Mule soft which can leverage different integration patterns like RPC, Messaging, and File Transfer etc. Cloud Integration architecture depicting the integration between Salesforce.com, Customer Support & Services Systems, and Boundary Systems is given below:-

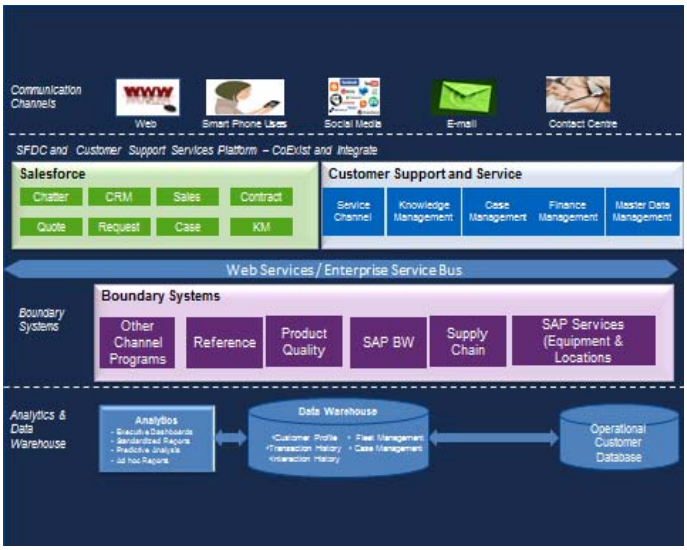

Fig. 2. Integration Architecture between Salesforce.com, Boundary Systems

Integration requirements in the above integration scenario are:

- Data Integration and Message Continuity maintained across multiple systems
- Support of multiple integration points with loose coupling
- Provide integration capabilities onto existing Customer Support & Services systems, Boundary Systems/Applications to incorporate message exchanges with Salesforce.com CRM application in a seamless manner

In a simple use case scenario of customer service management where Customer service representative(CSR) trying to access case history for a customer problem, he requests to retrieve the case details through CRM system (Salesforce.com). To process this request, Salesforce.com leverages a Remote Process Invocation (Request & Reply) integration pattern to get the case details of the customer which is initiated through SFDC on Cloud. Response needs to be processed from case management system which is on-premise and provides the details back to CSR.

Key benefits achieved are:

- Seamless Integration of SFDC (CRM System hosted on Cloud) with on-premise Customer Support & Services Systems, Boundary Systems.
- Automation of Integration Services by leveraging different integration patterns by adopting an efficient integration approach

Cloud Integration becomes a complex situation as the integration is required between different systems which are hosted on different cloud platforms, on-premise

applications, partner applications which can create challenges in different areas like coupling of applications (tight coupling), latency, scalability, network access, connectivity, authentication, reliability etc. To address these challenges, we need to come up with right reference architectures for cloud at enterprise level based by considering the right integration pattern like RPC (Request and Reply), File Transfer, and Messaging etc.

Section 5 gives the insight on key benefits achieved by adopting the right and appropriate cloud integration strategy at enterprise level.

V. Cloud Integration Strategy - Key Benefits

Enterprises which come up with efficient cloud integration strategy will be able to leverage SOA principles efficiently by coming up with the right and appropriate integration patterns which are needed within the enterprise. Also, it helps to come up with define and create required reference integration architectures by adopting different integration patterns. It also helps transforming complex application integration into agile and reusable service-based connectivity by mediating, routing, and managing interactions between the services and applications in the enterprise and the cloud. Having an efficient cloud integration strategy helps enterprises to maximize their options and lower the risk with the adoption of efficient cloud integration strategy and its setup explained in Section III and IV. Some of the key benefits that an organization can get by following the above mentioned strategy are:

- ✓ **Reduction of TCO:** Building an efficient cloud integration strategy helps in coming up with all required integration patterns designed, developed at the enterprise level which also gives the reusability across different business units with the help of enterprise-level integration reference architectures covering different integration scenarios.
- ✓ **Time to Market:** As the processes, guidelines and reference models are steam lined, the solutions can be put in place at much faster pace making the integration service available sooner.
- ✓ **Reusability:** As the integrations are developed based on the guidelines provided by the Governance center which monitors and approves the integrations, the level of reuse is improved manifold.
- ✓ **Improved Metrics:** Performance and Usability are two metrics that need to be considered. These are improved considerably by implementing relevant Integration patterns
- ✓ **Cost Optimization:** With the implementation of cloud integration strategy at enterprise level, it helps in simplification and re-use of integration processes which in-turn provides the cost benefits.

Conclusion

In summary, the adoption of a simple and efficient integration strategy between the applications on various environments including enterprise applications, SaaS based applications etc. plays a pivotal role for the success of an organization.

Selection of an appropriate cloud integration strategy by enterprises must be extensively thought through by considering repercussions across the business processes. Enterprises derive good value from real-time information, faster processing, providing additional value add services for customers and increased business visibility. Beyond technology, enterprises have to build an integration capability by adoption of efficient integration strategy at enterprise level.

Integration Platforms built on real-time messaging can handle many of the complexities which are possible only by adoption of proper integration strategy. Enterprises that have established a cloud integration strategy in a right manner can either add or remove systems as needed with minimal efforts. This helps in gaining increased value from the platform with reduced integration and implementation costs. In Cloud, it is very important to consider scalability and Usability in terms of customer base and expansion of business. Best-of-breed integration strategy will emulate the cloud value proposition allowing scalability and usability as businesses grow and change over time.

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