

Physiology of Enterprises Application Integration

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Abstract: Business Integration has become a key issue for many companies to extend business market by integrating and streamlining processes both internally and with partners. To address this issue, whole marketplace has emerged for software solution that can help to achieve improved business integration which is referred as EAI. Originally EAI was only focused around integrating ERP with other applications within enterprise but now it is generally used as a catch-all term to cover all the other aspects of business integration. Major EAI approaches and evolution of enabling technologies ranging from EDI to Web Services and XML based process integration are analyzed to provide flexible, scalable and adaptable EAI framework. Solution comprises the challenge of efficiently integrating diverse business processes and data across the enterprises, allowing the organizations to keep pace with and respond to market changes.

Keywords: EAI, B2B Integrations, Business Process Integration, SOA, Business Integration Framework

1. INTRODUCTION

Due to the explosive growth of Internet, complex business expansion, competitive pressures, new business models, and the need to streamline business processes both internally and with partners or suppliers/value chain has made Business Integration key issue for many companies.

Enterprises need the level of internal and community based integration solution to help reduce cycle times, minimize the cost, and risk of connecting to entire value chain [1], and increase response and outpace the competition. Every business need to constantly adapt and reconfigure their IT assets, systems, and business operations to meet changing customer demands; compress business cycles; and differentiate from competition. However, most enterprises have invested in packaged, legacy, and custom applications that perform specific business functions which operate within an extremely complex, inflexible, and mostly ad-hoc architecture consisting of monolithic silos, point-to-point connections and coupled hard coded interfaces. This makes it difficult to quickly assemble and reassemble the services. They provide as part of internal business processes or external business processes that support new and changing business requirements.

The ultimate goal of business integration is therefore to have inter and intra-enterprise applications evolve independently, yet allow them to effectively and

conveniently use each other's functionality. Major challenge in business integration is interaction, which can be defined as consisting of interoperation and integration with both internal and external enterprise applications. Because enterprises applications are composed of autonomous, heterogeneous, and distributed components therefore offer challenges because of issues like scalability, volatility, autonomy, heterogeneity, and legacy systems. Business integration also requires conversion of varied data representations between partners' systems and connecting proprietary/legacy data sources, ERP, applications, processes, and workflows to the Web, and trading partners' systems.

Physiology of EAI is explained through continuum of EAI enabling technologies [2, 3], which has been used to solve business integration problem and classified as EDI based, component based message oriented middleware, workflows, XML framework, and Web Services. The study demands state of the art complementary EAI framework based on business process management harnessing the Event Driven & Service Oriented Architecture (EDA & SOA) [4].

Entire study of EAI approaches provide basis for proposed EAI collaborative solution framework that provides inter-enterprise and intra-enterprise wide process and data integration to enable real time business. It is recommended that real-time framework offer following Architectural features: (scalability, security, heterogeneity, adaptability, manageability, distributivity, decoupling, autonomy), real-time requirements: (asynchronous, publish/subscribe), and Business requirements: (flexibility, agility, usability, reliability) for productivity.

The purpose of this paper is twofold; first, highlight the major approaches and trends in enabling technologies of EAI and, second, propose appropriate EAI solution framework guided by research dimensions. The structure of this paper is as follows: Section 2 discusses the basic concept of Enterprises Application Integration with classified series of enabling technologies and important issues. At the end of this section, major EAI platforms are presented with names of different EAI research projects. Section 3 identifies the basis of scalable EAI solution framework by analyzing the characteristics of various EAI approaches and technologies. The proposed architecture is presented by detailing its layers, necessary supported requirements, technologies and deployment model. Finally the EAI Collaborative Solution Framework (CSF) services are enlisted, followed by the conclusion in Section 4.

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2. EAI & ENABLING TECHNOLOGIES :

2.1 Enterprises Application Integration:

EAI entails integrating applications and enterprise data sources so that they can easily share business processes and data. Integrating the applications and data sources must be accomplished without requiring significant changes to these existing applications and data.

Those enterprise applications that were not designed to interoperate, need to be integrated, enterprise and community wide [4]. As enterprise departments interact on a real-time basis and business processes cut across multiple enterprises and business lines, the need for information integration leads to the adoption of best suited EAI approach [6]. Thus, legacy and newer systems can integrate to provide the business with greater competitive advantage. The volatile nature of business requirements, the effort to lower total cost of ownership, and the need to rapidly introduce new products in value chains require decoupled, event and service oriented (SOA & EDA) functionality of enterprise applications. These enterprise services not only provide new functionality but also leverage investments in legacy systems running the enterprise's key business-critical applications.

2.2 EAI Enabling Technologies:

Different technologies have been used for business integration. Some of the major technologies are classified as :

2.2.1 Electronic Data Interchange Based Integration:

EDI provides inter-organizational application-to-application transfer of business documents in a compact and standard form (ANSI X12[7], UN/EDIFACT[8]) using VANs to minimize cost, effort, and time incurred by the paper-based transfer of business documents. EDI interaction using mapper, translator is shown in Figure 1. EDI standards define single homogeneous solution for content interoperability and hardly flexible in its ability to expand the defined set of supported document types [9]. Proprietary and expensive VANs are used to provide much secure message delivery and routing with value added services (Automatic error management etc) among partners. Organizations, predominantly small and medium, couldn't afford EDI because of expensive VANs overheads therefore efforts to reduce the cost of using VANs include Internet-based EDI solutions : EDIINT [10] and OBI [11].

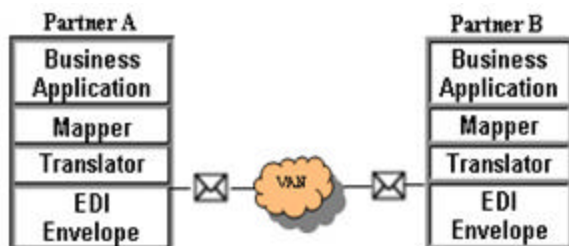


Figure1. Interactions in EDI

EDI over Internet (EDIINT) uses the Internet as a communication medium instead of VANs to reduce EDI communication cost due to the use of VANs. First EDIINT standard AS1 (Applicability Statement 1) set the rules to exchange EDI documents using SMTP protocol. The second standard EDIINT AS2 which supported communication of EDI documents using the HTTP protocol. Initially, there was reluctance to use the Internet for exchanging critical business information due to concerns about security. To deal with this problem, EDIINT AS2 specifies standard mechanisms for securing documents using PGP encryption and digital signatures.

Open Buying on the Internet (OBI) defines Internet based procurement framework and intended for high-volume, low-dollar amount transactions over Internet. It uses HTTP protocol for exchanging messages and relies on ANSI X12 EDI standard to describe the content of order documents which are encapsulated in OBI objects with buyers' and sellers' digital signatures and provide a robust security infrastructure by using SSL[12] over HTTP and also uses digital signatures and digital certificates for ensuring message authenticity and integrity. Thus OBI ranks higher than EDI.

2.2.2 Component Middleware Based Integration:

Component middleware is a framework that provides interconnection of geographically distributed components by supporting the creation, deployment, and interaction among components [13]. Development of integration components in component-based application makes integration effective. Components are defined as modules that can be independently developed either from scratch or by wrapping existing functionalities and then delivered [14].

Component-based integration approach caters for tightly coupled and long term business relationships having small number of partners within an enterprise. However the uses of message driven interaction among components allow the support of loosely coupled relationship. Components are not adoptable because businesses are tightly bound to interfaces published by their trading partners, and develop ad-hoc solutions for defining intra and inter-enterprise business processes by assembling applications from independently developed legacy components. They exhibit limited capabilities dealing with presentation layer.

Major component based middleware frameworks are: CORBA, DCOM, and EJB.

2.2.3 Business Process/Workflow Based Integration:

Business process consists of collection of business related activities formed by data and control flow relationships (see Figure 2). Business process management/workflow management deals with declarative definition, enactment, administration, and monitoring of business processes. Workflow technology is most important for automating business processes which involve access to several applications which makes it much suitable candidate for

integrating, automating, and monitoring business processes in an easy way [15, 16].

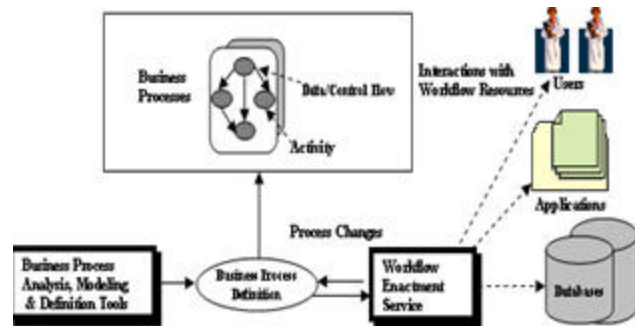


Figure 2. Workflow System

Efforts from BPML.org deliver Inter-Enterprise Workflow Systems -IEWSs that have the ability to integrate inter-organization business processes [17] where as recent projects: eFlow [18] and WISE[19] focus on loosely coupled process with greater adaptability and manageability.

Standardization process of commercial Workflow Management System (WfMS) from Workflow Management Coalition (WfMC) presents Workflow Reference Model [20] which was implemented in jointFlow[21] standard by OMG and lead to development of two standards: Simple Workflow Access Protocol (SWAP) [22] and Wf-XML message set [23]. Few other kinds of work flow systems known as Distributed Workflow Systems (DWSs) were also introduced which were appropriate for single enterprise business process that needs to integrate multiple distributed workflows by using global workflow [24].

Inter-Enterprise Process Management Collaborative Framework:

Inter-enterprise integration solution should have clearly defined public and private processes. Public processes exchange messages to business community by using message exchange protocols, where as private processes are internal business processes which also support public business activities.

The concept of process wrappers can be used in private processes with defined activities to enable interaction between private and public processes. Process wrapper can perform document format conversion required between public and private processes. However when private processes require interaction to legacy applications in local business process management software then the concept of application adaptors [25] can be adopted for process compatibility.

Introducing separate public, private business processes with process wrappers and application adopters in business process management contributes to scalability, heterogeneity and autonomy of this loosely-coupled

collaborative approach. Because local changes has no effect on public processes and business applications, changes related to interaction only effect process wrappers, and modifications in partner's communication will just effect public processes. However new back-end application support will add application adaptor, and new partner relation may require few adjustments. Therefore addition of partners, back-end applications or interaction protocols does not affect private business processes.

2.2.4 XML Based Interaction Framework:

Basic idea behind XML based approach is to allow the use of services on the Web without mediation facilities and dedicated transformation or specific integration of partner's system. Business community will be interconnected in terms of largely agreed upon documents and, those XML documents having common set of XML schema eliminates dedicated translation of information. However effective XML based integration requires standardized domain-related ontologies (e.g: DTDs, Schemas), mapping between different ontologies, means for processing XML documents, and service invocation. Therefore the issue of interoperability has now shifted from the level of applications to the level of standards. This can easily be achieved through protocol and integration engines which will exchange messages according to various standards [26]. Unfortunately, idea of exchanging data through XML documents will increase overhead. General XML based integration framework is shown in Figure 3.

2.2.4.1 Microsoft BizTalk Server:

BizTalk provides orchestration based Business Process Management (BPM) by harnessing SOAP paradigm, through several technologies and standards such as XML, SOAP and S/MIME etc [27]. Its orchestration provides means to define and execute inter-enterprise process. BizTalk is based on centralized schema repository and layered architecture where centralized repository provides schema validation and control but also affects scalability. It refers to XML-based schemas for business documents structure and content description Document in BizTalk comprises of actual business document and its handling instructions, which are described using BizTags (standardized set of XML elements and attributes). More specifically BizTalk Document is a kind of SOAP message and business document is more like structured XML document containing business contents. The superset of these documents serves as basis of communication between BFC servers are BizTalk message which contains BizTalk document, attachments (other BizTalk, XML documents) and transport specific headers.

Framework comprises of three layers: Application, BizTalk Framework Compliant Server (BFC), and Transport. Business applications interact to each other by sending business documents via BFC server and BFC servers use BizTalk messages for communication via communication protocols (like: HTTP and SMTP). Special BizTags make sure reliable delivery and offer manageability; security is provided via centralized security (SSO) and many secured protocols (SSL, PKI, S/MIME, RSA, X.509 etc.)

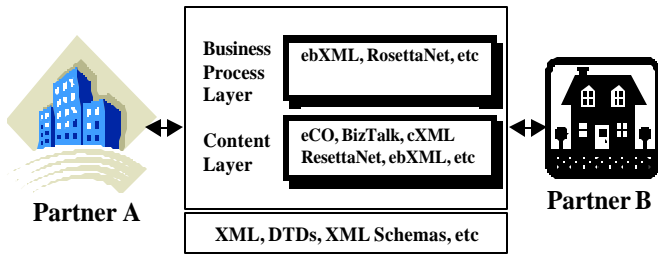


Figure3. XML Based EAI Framework

2.2.4.2 eCO:

eCO enables business to know and access services rather than standards and protocols each partner adopts [28]. eCO developed XML Common Business Library (xCBL) to define common set of XML core documents (xCBL DTDs) used in business transactions. user may use and extend documents regarding business needs. Pre-defined documents affect interoperability because businesses are not limited.

Business Interface Definitions (BIDs) are used for business interaction at business process level to advertise business services. BIDs are simply XML descriptions that specify business services in terms of business documents. xCBL is used to define both interfaces of processes and contents of data elements, and restrict appropriate tag selection by the partners.

To address semantic heterogeneity, domain specific ontologies (schemas) can be defined with necessary mappings. Separation of services description and implementation contribute to autonomy and new business services just require service description (interfaces, types etc.) and integration of service interfaces with internal application. As partner's systems are loosely coupled therefore local changes are limited.

Few other XML based integration frameworks are: Commerce XML (cXML) [29], RosettaNet [30], Electronic Business XML (ebXML) [31].

2.2.5 Web Services Based Integration Framework: Service Oriented Architecture (SOA) Paradigm :

An architectural paradigm for creating and managing "business services" that can access distributed business functions, IT assets, and information with a common interface regardless of the location or technical makeup of the function or data. This interface must be agreed upon within the environment of systems that are expected to access or invoke that service. It supports new business requirements through the creative use and reuse of existing assets in quick and easy way . SOA offers: Loosely Coupled, Request/Reply, and Synchronous Communication support.

Web Services (WS s):

Web Service is an implementation and important aspect of SOA [32]. WSs are loosely coupled applications using open, cross-platform standard which interoperate across organizational and trust boundaries; they are free from

client context and deployment requirements [33, 34].

Specifically Web Services are platform independent, loosely coupled, dynamically located and invoked, firewall friendly and widely accessible which makes them appropriate for economical EAI solution [35, 36, 37]. They use open XML and Internet-based protocols for their description, registration and invocation: Web Services Description Language (WSDL) used for describing operational features [38]; Universal Description, Discovery and Integration Language (UDDI) provides programmatic interface for publishing and discovery [39]. Simple Object Access Protocol (SOAP) [40] offers lightweight messaging framework for exchanging XML formatted data, supported by variety of transport protocols (HTTP, FTP, SMTP), and structured as envelop containing header (features like security, transaction etc) and body (actual data). Other standards like: WS-Security, Monitoring and Management (WS-DM) are developed, in addition to: WS-Reliable Messaging, WS-Eventing and WS-Notification which are in standardization process. Interaction among WSs is shown in Figure 4.

Adoption of an XML based messaging (SOAP), and use of document based messaging model, over well-established protocols enables communication among heterogeneous systems and loosely coupled relationship. Standards like BPEL4WS [41] could be used for business process definition through WSs. Heterogeneous applications (CORBA, Java etc.) may be wrapped and exposed as WSs. However WSDL neither model semantic features (document type: PO etc) nor include security oriented information, such as role based access control etc. regarding adoptability service signature may change, which require automatic detection and handling of changes. Using tagged language for data exchange and use of complex data types, which are not supported in SOAP and require XML parser to load XML schema from remote location, will overload the network. Another scalability issue refers to registry which could be centralized, distributed and replicated.

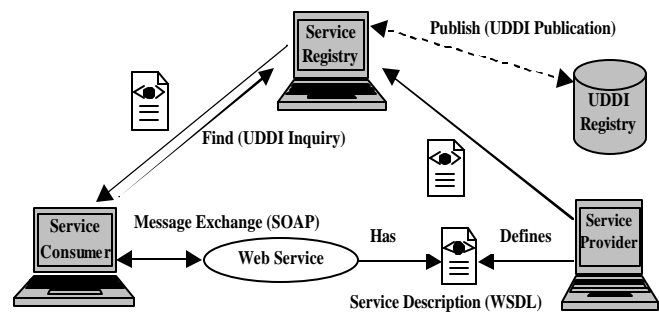


Figure 4: Web Services Reference Model

WS Composition standards for BPM:

Many efforts have been made for developing standards for WS composition [42], such as XLANG [43], Web Services Flow Languages (WSFL) [44], Web Services Choreography Interface (WSCI), Business Process

Modeling Language (BPML) and finally superseding, Business Process Execution for Web Services (BPEL4WS).

BPEL4WS: Widely acceptable standard which provides service composition using orchestration support and combines XLANG (provide structural construct for processes) and WSFL (enable graph oriented process). Business process is defined through many activities (eg: invoke WS), which are combined into Structure Activities; such as: Sequence (order of activities), Switch (branching), While (loops), Pick (path selection), and Flow (parallel execution). It also supports error handling (catch, throw) and compensation (compensation actions) within the scope.

2.3 EAI Platforms & Research Projects:

Following are the platforms to develop EAI solutions: TIBCO Active Enterprise, Mercator Enterprise Broker 5.0, Oracle Integration Server, HP Net Action IOE, IBM Websphere Business Intigration Suit, Miscrosoft BizTalk Server 2004, Microsoft .NET, Sun Open Net Environment, Vitria Business Ware, Versata Global 2000, BEA WebLogic Integrator, Web Methods, and SeeBeyond E*Gate Integrator, etc.

In addition few research projects are also developed using different approaches, like: HeavenStar Flow, eFlow, WebBIS, SELF-SERV, XL WISE, CMI, CrossFlow, and Mentor-Lite etc.

3. EAI COLLABORATIVE SOLUTION FRAMEWORK ARCHITECTURE:

Aim of this paper was to present physiology of EAI with the intent to introduce appropriate EAI solution, therefore the bases of framework are proposed as follow:

3.1 Architecture Service Layers:

Scalable EAI framework comprised of three service layers:

Transport Service Layer: Pure loosely coupled architecture is claimed through document based communication model; therefore business applications communicate through diverse business documents via various protocols. Transport service layer provides appropriate protocols to exchange documents between business communities. In general partners can use different protocols for documents which require gateway service/transport service to translate documents between heterogeneous protocols.

Presentation Service Layer: After receiving the business document from transport service layer it must be identified and understood in such a way that the information provided in that document could be accessed by the system and other lower service layer. Major services of presentation layer are: document transformation (using mappings), information translation and integration among disparate representation. In short we can say that it mostly deals with content semantics regarding type of business document and provides integration of data models and document format.

Value Aided Services (VAS) Layer: The major requirement of business partners is to integrate diverse business processes for cross organizational business processes which is done through VAS/Business Process Integration layer and require well-defined agreed upon business process. After the identification and transformation of business document by presentation service layer the information is transferred to VAS layer where certain business process related to document is applied. Objective of this layer is to provide interaction among business process of autonomous and heterogeneous partners therefore interpretability at this layer is a challenging issue which requires well defined agreed upon business processes.

Layered service architecture (see Figure 5) supports peer-to-peer communication among business partners and it depends upon situation that which level of service is required. Some times business integration may require transport services only, or for some situation business integration is required till presentation service, or it may be possible that business is integrated to highest level known as value aided service layer for process integration.

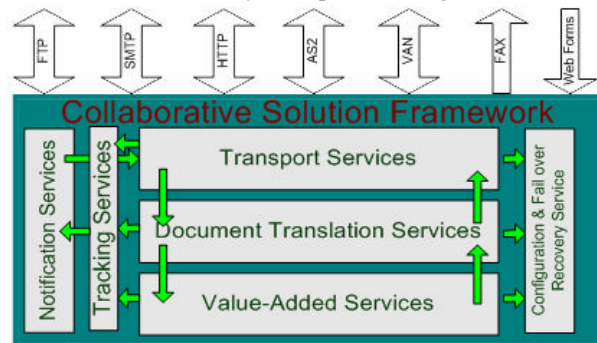


Figure 5: Collaborative Solution Framework Service Layers

There must be few services across all the layers to claim reliability and manageability like:

Tracking Services:

Provide Tracking and Monitoring facilities. Every service informs their activities to tracking manager, which maintain tracking and monitoring log. When any failure is reported to tracking manager it transfers that activity to Notification Manager.

Configuration and Failover Recovery Services:

Configuration manager continuously monitor the services; if any service is found fail then it is informed to Notification Manager. It also maintains system's metadata. Once any business document fails to receive service due to document error or service failure it is notified to configuration manager by that layer which logs failure configuration in configuration database and when the failure is recovered it is kicked back through recovery service. It also offers load balancing.

Notification Services:

Provide Notification Services to monitoring staff through available modes of transportsuch as: e-mail, Fax, and SMS

After reception of failure notice, the failure is recovered.

3.2 Architectural, Real-time & Business Requirement for EAI Framework:

It is recommended that real-time EAI solution framework offer following architectural features: (scalability, security, heterogeneity, adaptability, manageability, distributivity, decoupling, autonomy), real-time requirement: (asynchronous, publish/subscribe) and business requirements: (flexibility, agility, usability, reliability) for productivity.

3.2.1 Scalability: Ability of a system to grow in different dimensions is referred as scalability. In business community establishment of new relationships in low cost and efforts are desirable. Therefore provision of business services component templates and establishment of new business processes through orchestration ensures framework scalability.

3.2.2 Security: It requires mutual authentication, authorization, confidentiality, and non-repudiation. This is supported with Partner's Authentication, SSL, SHTTP, S/MIME and PKI securities.

3.2.3 Heterogeneity: Different levels of heterogeneity exist within partners like: Structural Heterogeneity, and Semantic Heterogeneity. In general degree of dissimilarity between partners is referred as heterogeneity. In document based communication model, it is fulfilled by providing document validation, translation, transformation and transportation in diverse forms.

3.2.4 Adaptability : Ability of system to quickly adapt to dynamic business changes .Because impacts of changes are limited in layered architecture therefore changes are incorporated in specific service component for adaptability.

3.2.5 Manageability: Degree of application's visibility and manageability such as supervision, control and performance of its execution, which is provided by tracking, notification, configuration, and recovery services.

3.2.6 Distributivity: Ability to separate group of common services into different integration levels and connect them appropriately to provide required level of integration. This is achieved by orchestration facility which integrates various service components at different layers and compose them in form of web service for certain business processes.

3.2.7 Loose Coupling: The most important feature of EAI that partners should not be dependent on each other and exchange business information on demand. Impact of changes closely depends on the degree of coupling. Document based communication model is followed.

3.2.8 Autonomy: Provides more local control over local services and allow maximum flexibility to change processes without effecting each other, such as each partner is viewed as a black box. Therefore partner's integrations are not effected due to EAI Hub Model.

With reference to EDA real time business support following is required:

3.2.9 Asynchronous: In asynchronous business demand, information should be sent without the expectation of an immediate response or no requirement of maintaining a live connection among two systems while waiting for response which offer more independence, and achieved by queued document facility by using message queuing facility in asynchronous business demands or in case of failure.

3.2.10 Publish/Subscribe: Provides many-to-many consumer/producer interaction such as once producer produces information about an event that must be received by all authorized consumers. It is accomplished through CSF DB by making consumer/producer relationships accessed by every activated business process service.

Descriptive approach to BPM increase framework usability; and scalable service based layer approach makes business implementation flexible to cover business agility, whereas recovery service and multiple instances framework deployment in parallel claims ultimate reliability.

3.3 EAI Framework Technologies and Architecture:

Business integration is done by making use of descriptive BPM to describe process workflow which involves selection of different service components from respective layers. Transport layer contains common transport wrapper components based on .NET COM components to support different forms of transports. They can be created and customized through common templates. Presentation layer is based on multiple common WSs for mapping and transformations. For process integration; Business validations are enabled using WSs at VAS layer. Common business logics with respect to sectors are already exposed in WSs form which can easily be customized. Inter layer communication is achieved through MSMQ (see Figure 6 on next page).

3.4 EAI Hub Model:

CSF is centrally managed where every partner is required to send their business documents to CSF Hub where their business is integrated. No changes are expected in partner's application except application adaptors for certain situations (see Figure 7 below). CSF Hub must be supported by Backup Exchange.

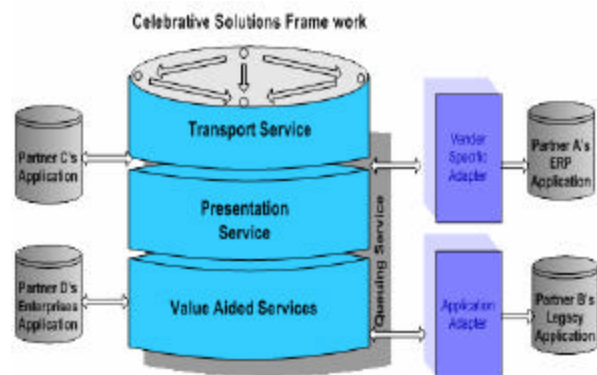


Figure 7. EAI Hub Model

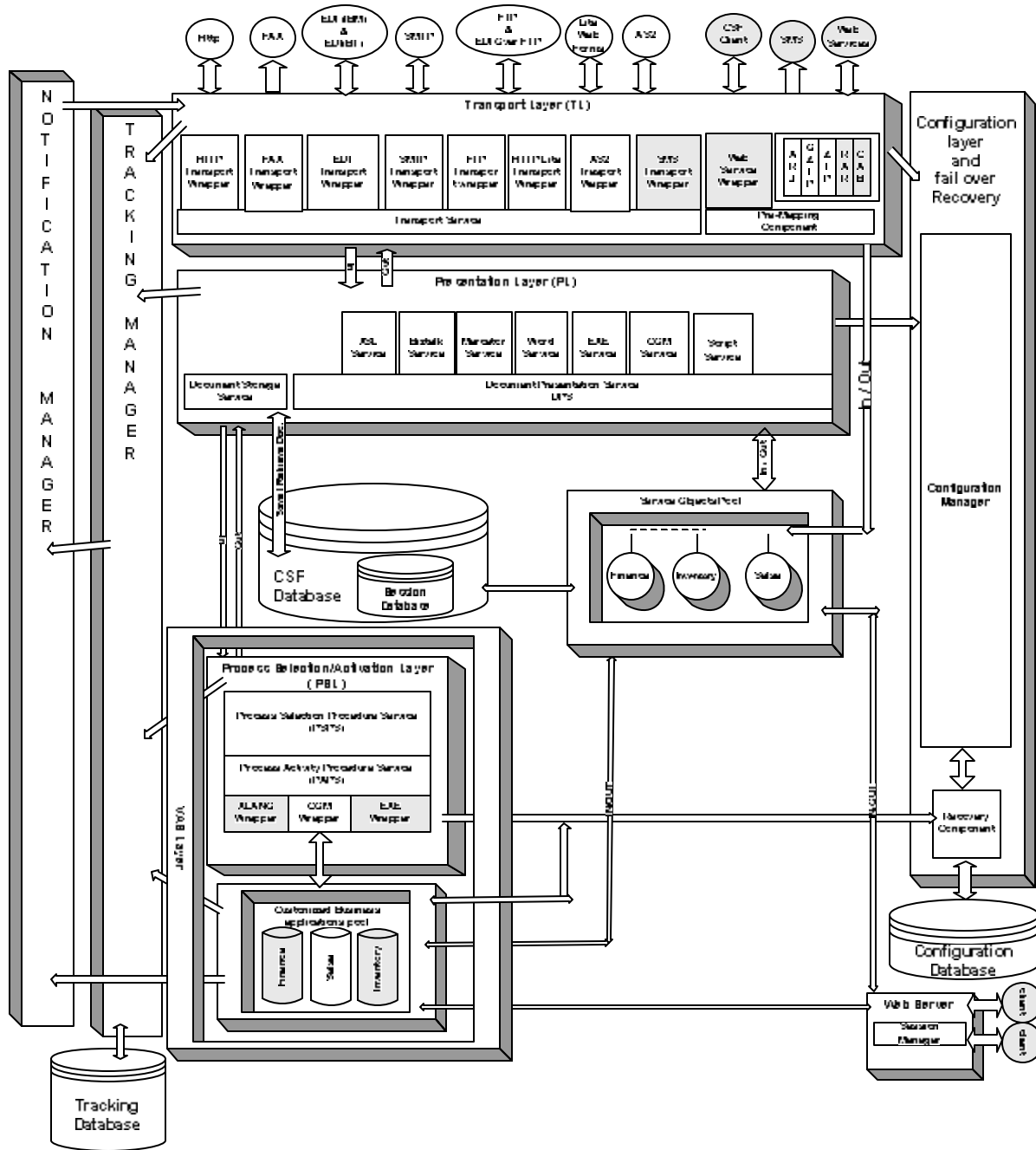


Figure 6: Collaborative Solution Framework Architecture Summary

4. CONCLUSIONS

Different EAI technologies can be viewed as complementary, if they are properly adopted and structured. However basic findings are: making use of graphical BPM which can compose WSs compliant to SOA could be effective. Loosely coupled document based communication seems scalable. XML based data transfer using WSs should be avoided to minimize network traffic,

support wide variety of transports, and easily adoptable for partners.

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