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Contemporary Research Challenges and Applications of Service Oriented Architecture

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ABSTRACT

Service Oriented Architecture (SOA) is distributed architectural framework that provides service-based solutions for improving the effectiveness of enterprise's IT infrastructure. In this framework, technical and business processes are implemented as services. A service is an independent software application that has been designed to perform a specific function with emphasis on loose coupling between interacting services and their components. SOA permits developers to utilize many of the resources from existing services to form the distributed applications. This study has investigated to highlight the emerging issues of SOA such as service structures advancement, requirements of evolution for current age applications like mobile-cloud, medical and mechanism for interoperable operations. The paper also uncovers the practical application domains of SOA. It has identified research attentions in these domains with detection of issues to carry further research to overcome constraints in current scenarios.

Keywords : Business Process, Communication Protocols, Service Oriented Architecture, SOAP, UDDI, Web Service, WSDL, Loose-Coupled Systems

I. INTRODUCTION

Service-Oriented Architecture (**SOA**) is an approach in which software applications use services available in the networks. These services are available to develop applications through a communication call on internetwork [1]. SOA permits services to communicate through distinct platforms and languages for developing web applications. In SOA, a service is a self-contained unit of software program designed to carry out a particular task. SOA contains a set of design standards that shape system development and entails combining modules into a consistent and decentralized system. SOA organizes and registers a range of services for communicating in a loose coupling system's style to deliver data for accomplishment of transactional activities. SOA-based services are supplied to different modules by use of software components using ability of communication protocols. SOA services are usable units that can be remotely accessed, operated and updated independently such as online returning and updating temperature of a city. SOA is additionally designed as independent from all stakeholders. There are three main components of SOA: service provider, customer and registry shown in **figure 1**.

A. Service Provider

It is responsible for organizing, managing and making available services for others to use and fulfil demands. Provider publishes services in the registry to advertise them for use. It maintains the type of services, using specified mechanism and its provisioning.

B. Service Customer

It finds the services and its specifications in the registry to generate the required request of components and utilize services.

C. Service Registry

The service registry permits service providers to discover and communicate with customers. It creates a link between these two and provides fast communication through its registered catalog. SOA supports Universal Description Discovery Integration (**UDDI**) specifications.

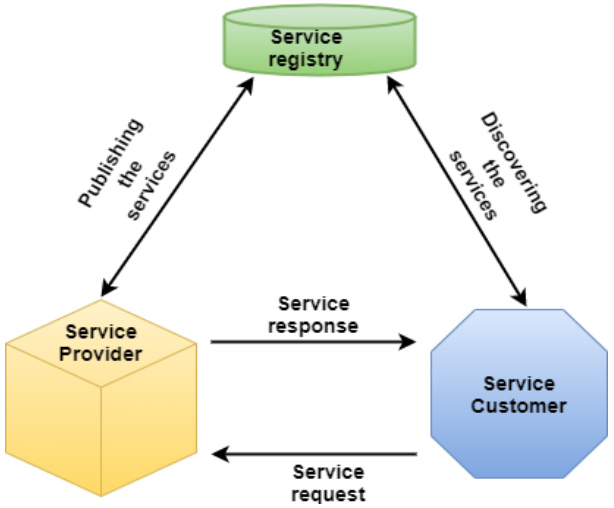

Figure 1. Components of SOA

II. EVOLUTION OF ARCHITECTURE

With the evolution of business requirements, the software development architecture also evolved as shown in **figure 2**. It shows the gradual propagation from monolithic approach to service-based model of applications. Many IT developers and practitioners equally believe that they are getting quite close for making available satisfactory solutions with SOA to develop heterogeneous applications. In order to alleviate the problems of interoperability, ever-changing requirements and heterogeneity with previous architectures [2], it was required to provide a platform for building applications and services with the following characteristics:

- Loosely coupled.
- Location transparent.
- Protocol independent.

Based on such an architecture, provider and consumer do no longer even have to care about a specific service that are communicating with the underlying infrastructure or provider. Therefore, it will make an admirable selection on behalf of the consumer. The infrastructure also hides a lot of technicalities as viable from a requestor. Most importantly, the technical specificities from peculiar implementation of applied techniques like **J2EE** or **.NET** should no longer influence SOA clients.

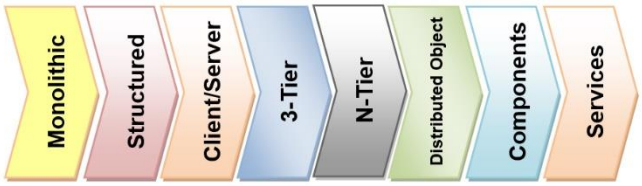

Figure 2. Architectural evolution [2]

III. SOA SIGNIFICANCE

Recent years have witnessed an exceptional shift in distributed computing towards Service-Oriented Computing (**SoC**) [3], which is gaining prominence as an efficient approach for integrating functions in heterogeneous distributed environments [4]. The most famous section of SoC lookup is committed to advances in SOA [5] and SOAP [6] internet services, however the growing reputation of Web 2.0 has brought accelerated interests to **Web Oriented Architecture** and **REST** Internet services as a choice of building service-oriented environments [7].

SOA has become a famous paradigm for system improvement and has many utility domains. In an SOA environment, services can be chosen and composed collectively to satisfy the practical and quality goals. There have been many lookups works addressing the problems in service selections,

primarily based on end-to-end system quality requirements. However, for some real-world applications, there may additional restrained set of alternative services to pick to fulfil the system quality requirements.

It is authentic for some specialized application domains. SOA is a chosen strategy, that can complement service selection methods to fulfil each static and dynamic system quality necessities for reconfigurable services. In many application domains, simple entities can be used to assemble the system's components designed to be reconfigurable. There are a range of benefits that impose an SOA structure and can gain a business, is based totally around services. Some of these are presented as follows:

A. Cost Effectiveness

In business, the capability to limit costs whilst keeping continue preferred stages of output is essential to success. This requirement is also genuine with personalized service solutions. By switching to an SOA-based system, companies can restrict the degree of measurements that is frequently required when creating custom-made solutions for precise business applications. This price reduction is facilitated using loosely coupled systems, that are less complicated when maintaining and do not necessitate the need of expensive development and analysis. Furthermore, the growing reputations of SOA abilities, reusable enterprise features are turning into usual internet services that has made charges lower.

B. Interoperability

A predominant benefit in the usage of SOA is the degree of interoperability that can be really accomplished. SOA no longer uttered exchange between structures to be hindered in operations. SOA supports the exchange and sharing of data with other counterparts. Once a standardized communication exchange protocol has been put in place, the platform architecture and the various standards can continue to be independently supportive for each other. It is now in the position to transmit information between providers and services. Adding to this degree of interoperability, it is correct that SOA can make sure that groups of components can share services that are critical to perform operations.

C. Service Reusability and Maintenance

Service oriented applications are developed from existing services, so they are reusable for developing many service applications. SOA-based development provides high degree of reusability. The essential inspiration for development companies to swap to an SOA is the capacity to code reuse for maximum kind of applications. By reusing code that already exists inside a service, development can substantially minimize the time spent throughout the improvement process. It's not only minimizes the time constraints with the capacity to reuse but also additionally lowers fees that are frequently incurred all improvement of applications. Since SOA allows implementation in various protocols to communicate via key interfaces, so software engineers need not to be extensively involved with many kinds of settings to manage the running services. Services are independent of each other so can be updated and modified without affecting other services.

D. Scalable

SOA-based applications are scalable. When creating applications, one issue that is a cause of problem is the capability to amplify the scale of services to meet the requirements of client. Usually, the dependencies occur to communicate with services that reduces the achievable scalability. By the usage of SOA, there are preferred communication protocols that can significantly limit the stages of interactions required between consumers and services. This can lower the ability to be depended on each other. Therefore, SOA-based software development and implementation enhance the level of scalability.

Within an environment, services execute on many different servers so also improve scalability.

IV. SOA STANDARDS AND FEATURES

SOA is an essential and useful strategy to develop massive organization applications. The World Wide Web Consortium (**W3C**) [8] has referred to SOA as a set of features explained in this section. These features can be invoked, interface descriptions can be posted and discovered. **CBDI** (Component-based Development and Integration) defines SOA as a method which uses unique policies, practices and frameworks. The framework supply services that conform to positive results. These highlights that any form of provider can be discovered with services interface. Services are characterized through certain properties presented in the following section:

A. Hidden Program Logic

Concept of abstraction underlines the requirement to hide fundamental description of a service. It preserves the already defined relationship of loosely coupled style of operations. The business logic is distributed among different composed and organized services referred as **orchestration**.

B. Loosely Coupled

Services are loosely coupled and establish a specific type of relationship inside and outside of service boundaries. Its emphasis is on decreasing dependencies between service implementation, contract and consumer.

C. Service Reusability

The foremost consequence of SOA is its reusability, which is constructed once and use often. It is requisite that any services constructed and deployed need to be reusable.

D. Independent

Services have operated and managed over the logic which they encapsulate. From a service customer point of view there is no requirement to understand their implementation. So, these are independent modules.

E. Availability

SOA services are available on demand request.

F. Composition

A service can be composed by using other services. Using services as a building block the complicated operations can be implemented. Service composition furnished to accomplish business objectives.

G. Discoverable

Services are described by means of files that represent metadata via which they can be efficiently discovered. Service discovery offers a wonderful capacity for using third-party resources.

H. Reliable

Reliability of SOA applications is assured because formed with loosed coupling, modification in one component is easily implementable.

SOA model is used for building larger, complex Internet applications in order to realize a company's strategic goals. The typical SOA model [9] is shown in **figure 3**.

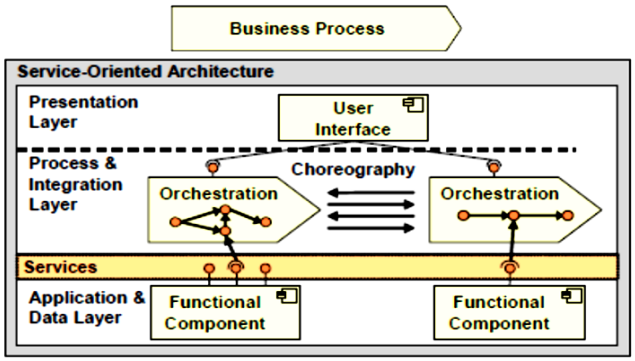

Figure 3. SOA reference model [9]

Distinct SOA based [10] architectures are presented as follows:

- Service-oriented enterprise architecture

(**SOEA**): This forms composition, service and inventory architectures.

- Service architecture (**SA**): This is a physical outline or design of every single service that go over all the resources.
- Service inventory architecture (**SIA**): It is developed from the service inventory scheme. Procedure of activities are automated with help of these service inventories.
- Service composition architecture (**SCA**): All services created utilizing service-oriented design techniques are composition driven, and this is their primary characteristic. This design is an organization of individual models of different services.

Major features of SOA are depicted as hierarchies in the **figure 4**.

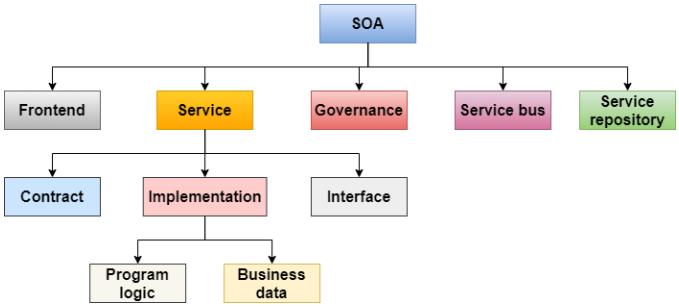

Figure 4. SOA features [11]

V. BUILDING AND WORKING WITH SOA

In SOA, services are usually implemented [12] as **Web Services (WS)**. The Web services are delivered and distributed using technologies such as Web Services Description Language (**WSDL**), Universal Description Discovery and Integration (UDDI), Object Access Protocol (**SOAP**) and eXtensible Markup Language (**XML**). XML is very important for web services implementation. It provides the way how the information will be described. WS interfaces are described through WSDL, which outline operations and connect them with required associated protocols. SOAP defines an envelope with guidelines for flashing data forwarded in the envelope.

SOAP messages are delivered using Hyper Text Transfer Protocol (**HTTP**). UDDI stores the registration information defining web services and name to related elements while registering. SOA tools and frameworks have additionally been produced for the improvement of web services and implementation of SOA. Web service-based solutions are improving the efficiency of enterprises. In SOA framework, business and technical processes are implemented as web services [14]. A Web service is software component that can be accessed via a network to provide functionality to service requesters [13].

SOA based web services solutions facilitate [11] to service requestor and service provider, they have communication via service requesting process. Service requests are messages implemented through SOAP. SOAP requires call support such as Remote Procedure Call (**RPC**) over Internet using protocols as HTTP, **HTTPS** and Simple Mail Transfer Protocol (**SMTP**). If SOAP messages are defined well, then they can be implemented via any transport protocol. Requested functions of web services are executed using web service components. Web service components are presented within a container same as **J2EE** containers. **Figure 5** shows the structure to work with SOA.

Once more, the response of provider sends to the customer takes the form of a SOAP envelope carrying an XML message. These characteristics enable for loosely coupled relationship between requester and provider. This is particularly essential over the Internet, the place where two events may also live in one of the enterprises. However, SOA does now not require the utilization of SOAP. Prior to SOAP, for example, some organizations used IBM's WebSphere MQ to exchange XML files between them.

While this kind of infrastructure actually does no longer guide web services due to the fact that they exchange the messages by use of SOAP. These are other instances of provider's invocation in an SOA. Currently WebSphere MQ is geared up with direct support for SOAP. While SOA services are seen to the client, their underlying web services are transparent. The provider and client need not to be involved with the implementation of the services.

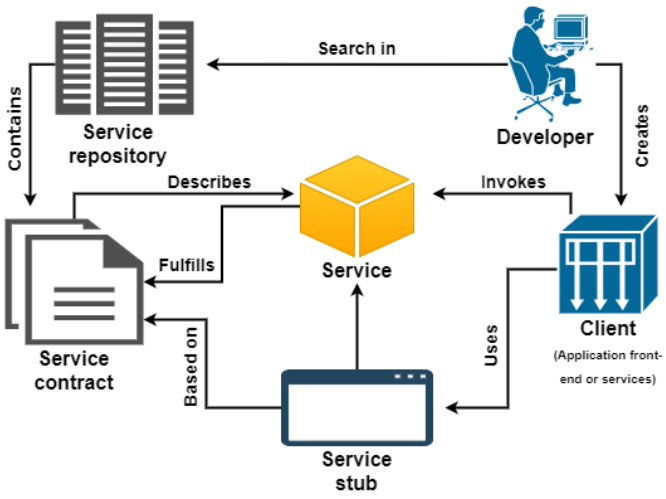

Figure 5. Working with SOA [11]

VI. SOA IMPLEMENTATION APPROACHES

The service-oriented architecture implementation framework envisions a complete framework that gives all technologies, that organizations want to develop and execute. Organizations need an SOA based processes, security, modelling and management. Implementation of SOA requires a shift in how service-based applications are composed while minimizing available IT budget. It requires a shift from writing software program to assembling and integrating services and using guided purposes of SOA.

The organization infrastructure should be assisted for flexibility, heterogeneity and disbursed improvement. For a successful transition to SOA, life cycle stages can be considered as being loosely coupled application components such as services. Discovery in service directory and integration of services with applications and other services are required. Deployment and monitoring of strategies in real time is an issue of analysis.

As businesses are putting into effect of SOA, companies are working to produce options that allow to use such architectures. Three separate procedures for integrating diverse data and systems in the organization are for congregating to secure a top-quality implementation of SOA. It meets the necessities for asynchronous, loosely coupled and coarse-grained services. The following are presented three approaches [15].

A. Enterprise Service Bus (EBS)

The **EBS** is highly reliable SOA implementation method involving distribution of services on network. Integration of distributed services is accomplished in the ESB strategy. It joins with asynchronous message-oriented exchange communications systems [50]. ESB allows the crucial exchange of elements easily with the high-level of integration. The message-oriented structure approves loosely coupled, document-oriented exchanges via systems. In some scenarios, neither the high-level business necessities are integrated nor provides to ensure loose coupling to meet evolving service-oriented needs. Imposing ESB to meet SOA needs requires the improvement with larger overall performance. This is to compose interactive services into enterprise services structure for securing the policy oriented reliable interactions.

B. Business Process Management (BPM)

Companies have lengthy sought to resolve commercial enterprise method's issues by means of enforcing Business Process Management (**BPM**) approach. This method considers about systems and IT resources as things to do on tasks, tasks participate in a coordinated and well-arranged enterprise processes. The approach is not including the

executing infrastructure vital for loosely coupled and asynchronous service interactions. Traditionally, the scheme of BPM is feasible to assemble. The approach gains integration goals and organizations generally use BPM equipment only at layout time and modelling procedures. However, this method certainly belonging to the IT ecosystem. BPM options can craft coordinated approaches that are composed for interoperable services. BPM based solutions needs should be used with loosely coupled integration strategy.

C. Service Oriented Integration (SOI)

SOI method has made use of the concepts of service orientation to assemble an infrastructure of services. The services enterprise customers can dynamically collaborate and create with higher-level processes. The method meets ever evolving and altering business requirements. SOI procedures transcend tough, tightly coupled integration procedures via requiring a disconnection of the customer of all services. For this reason, imposing the crucial element of loose coupling is required for permitting an integration situation to evolve to meet enterprise requirements.

SOI via itself gives no instruction on how to construct the proper services to align modern enterprise needs. It does not furnish an ability to execute services in the highly efficient, accessible way to assurance long-running interactions. Additionally, there are large variety of methods to put to make SOI [16] at executing stage. However, it is unlikely, what strategies are the superior for fulfilling the desires of loosely coupled, interoperable, asynchronous SOA.

VII. IMPLEMENTATION TECHNOLOGIES

Web services implementation of SOA has many essential key benefits over many different implementation strategies. Currently, there are two prevalent options available [17] which are assisting in web services implementation of SOA. These are Microsoft's .NET technologies and Sun Java Enterprise Edition technologies.

A. .NET Technologies

Microsoft.NET facilitates to develop enterprise SOA web services. The .NET product is mostly a rewrite of Windows core which forms Microsoft's preceding platform components for developing organization applications. The new .NET framework replaces preceding technologies, which consists of the web services layer. .NET technologies offer a very useful and interesting feature which is its platform, language independence and interoperability.

Components can be written partially of fully in different development platforms and can be implemented as web service solution. It is possible because of the Microsoft Intermediate Language (MSIL) that convert all code to native format. .NET also contains CLR framework which is similar to Sun JRE. Microsoft has provided a range of servers including cluster server, SQL server, exchange server, BizTalk server, commercial server, host integration server. These servers are used to host enterprise web services and SOA based applications.

B. Sun Java Enterprise Edition Technologies

Java Enterprise Edition (Java EE) is an evolution of Java for server-side application development. Java 2 Enterprise Edition had a popular development environment. The developed applications are not only Java objects but are suitable server-side components. Sun Java Web Services Developer Pack 2.0 (Java WSDP 2.0) and Java EE 8 can be used to develop web services.

For developing enterprise applications, associated tool named as Enterprise JavaBeans (EJB) are used and deployed with web applications and in application servers. For developing web applications,

tools such as Java Servlets and Java Server Pages (JSP) are used and deployed on web servers.

C. Web Service API

JEE and WSDP provide the APIs for WS implementation. JAX-RPC is for deploying and developing SOAP+WSDL web services endpoints and clients. JSR defines implementation requirements for web services clients using JAX-RPC programming model. JAXR is for accessing various types of XML registries and UDDI. SAAJ creates and consumes messages compatible to the SOAP specification. JAXP is Java API for XML documents processing.

VIII. SOA APPLICATIONS

The large adoption of Internet for current work requirements has imposed an awful percentage of greater expectation to today's businesses. This is regarding the alertness and responsiveness to new requirements and changes. The responsiveness of commercial enterprise relies heavily upon the flexibility of IT with automation. The complexity is growing speedily for present day's IT infrastructure. Also, the advanced innovation in technologies presents a quite number of chances to meet new business needs.

Due to the fast changes and increasing complexity in IT infrastructures, it is pushing for rapid evolution in IT infrastructure. The most essential issues need to be observed for considering the flexibility of adoption of changes. This is a substitute of reimplementation based on current and foreseeable technologies where demands of SOA based system are on the peek. Following section highlights some of the useful applications of SOA in various system development domains.

A. Healthcare

SOA is applied to enable smooth integration of extraordinary technologies and services with cloud [18] resources. There are proposed solutions [19] of common architecture with two health care subsystems: one located in the patient's home, and other located in healthcare provider. Based on the research results of Bandung health office [20], there is a simplification SOA process to supply the data and information to customers.

For internal side, the monitoring and evaluating can be finished easily. Further, the proposed service ensures the availability of records and data by implementing SOA architecture. Research done for implementing SOA for building the system, data, and commercial enterprise process. The capacity of standard [21] is for Point-of-Care medical tools and medical ICT systems based on a service-oriented [22] medical device architecture and specification for distributed system architecture.

B. Smart Cities

SOA is used to integrate and manipulate the smart city services applications via a preferred framework that has the ability to develop, install and manage the functions helping elements of the smart city infrastructure. Main objective of SOA implementation [23] is for employing modern IT procedures that produce quick and continuous business change outcomes. The sustainable SOA [24] is applied to enhance viable and flexible smart city applications. The clear separation of concerns as services and aspects are to specify application conduct on a non-technical level which is close to the smart city software domain.

C. Civil Aviation

SOA based systems improves communications [25] between manufacturers, airways and regulatory organizations. It coordinates and reorganize tasks flow among associating collaborating organizations which are for civil aviation operations. Improved operations delivered by use of web services applications, network techniques and SOA. This gives

capability of improving message exchange among heterogeneous systems. These systems form the civil aviation transportation system. A web service is a software program component that supports interoperable component-based interaction over network [26]. Standardized XML interfaces serve as functional entity for providers.

D. Smart Travel

Smart Travel System [27] using SOA is essential to have the web services, presents a one-stop tour solution to accommodate tourism recreation. It also offers end to end services [28]. It additionally helps to limit human errors. Using Intelligent Transportation System [29] based on the idea of SOA solution is proposed in which a node is capable to send wi-fi alerts with the help of WiFi to base stations positioned at street intersection signals for VIP travels.

E. Situation and Context Awareness

SOA is used in many armies and air force situation-awareness [30] and workflow-centric critical applications. SOA provides flexibility in integrating heterogeneous units and communication networks possibly enhance the execution of pervasive applications and context awareness.

F. Internet of Things (IoT)

Internet of Things (IoT) is currently [31] adopting web services for making devices smarter and interact with external services. The estimation of the IoT systems was obtained [32] for SOA. The shortcomings and trouble areas of client-server structure are identified. A modular structure is proposed to deliver scalability, flexibility, compatibility, resiliency IoT applications. SOA based services are used to strengthen massive business enterprise structures [33] and consequently play a vital phase in IoT domain.

Distinct approaches [34] for SOA implementation for IoT is introduced in several research studies. In middleware layer, the common SOA structure is inadequate in the real-time response and parallel technique of service execution. A new approach of Event Driven SOA is introduced to help real-time, event driven, and active service execution. Service-oriented permissioned blockchain [35] in the IoT system usage a single consent protocol for implementation and to accommodate distinct user's quality requirements.

G. Networking

Wireless Sensor Networks (WSN) used in healthcare, military, traffic control and surveillance applications. The elements of SOA [36] and middleware architectures for WSN are gaining extra sturdy and surroundings satisfying performance. SOA and web services composition approaches with their necessities and assessment are benefiting users. Implementation of study [37] applied SOA for traffic engineering inside an SDN architecture in service-oriented 5G networks. Service reuse-oriented performance recommended [38] to make sure sustainability of quality.

In sophisticated sensor networks, provider-oriented design affords a technique to describe, discover and invoke services [39] from the heterogeneous cloud environment. It also supports resource allocation for virtualization [40]. SOA is used in **MANET** monitor computing devices [41] to make it less intricate to manipulate dynamically and to allow online topology changing.

H. Cloud Computing

Cloud computing concentrates on the provisioning and delivery of services in scalable and virtual environment. An integration between SOA standards and deployment processes [42] of cloud-based platforms for supporting on-demand infrastructure services provisioning is a usable solution. SOA based PaaS framework [43] allows local participants to access businesses services. SOA based agile

development practices have shown a satisfactory approach for organizations looking for cloud-based improvement [44]. SOA and Cloud SaaS are the most popular software engineering models. SOA and Cloud SaaS have some shortcomings [45] in terms of performance.

I. Financial Systems

Various aspects for integrating a range of mobile banking services are follows with the application of the concept of SOA [46]. Example of MobiCash [47] application has proven that M-commerce can certainly have digital transaction by SOA implementation. MobiCash is designed to work online for mobile devices and it helps protection and full security for mobile users.

J. Legacy Migration

Legacy systems are developed and deployed based on the older technologies of programming and development. SOA has become popular in latest years; most legacy systems are nonetheless now not SOA enabled. There are four vital methods for migrating legacy systems to SOA: redevelopment, replacement, wrapping and migration [48]. The enterprise systems are rapidly evolving from monolithic structure to distributed applications style with service-oriented bendy utilization schemes [49].

SOA is a widely applied framework for enterprise applications and system development paradigm with web services as basic focus units.

IX. CURRENT AGE CHALLENGES FOR SOA

SOA is extensively employed for service-oriented application development. The research study conducted on empirical observations and previous research reports to identify challenges and improvements for SOA which are listed as follows.

- Service composition issues according to requirements of mobile cloud business procedures.
- Identification and documentation of business changed cases.
- Establishment of relations between business and service models for a cloud environment.
- Techniques for service evaluation and quality measurement for implementation in sensor networks.
- Level of alteration accepted in services to stay unchanged in the existing business process.
- Models for organizational structures in SOA environments.
- Issues and models relating to the adoption and advertisement of services in IoT perspectives.
- Techniques for problems of real-time control of operations support in an SOA environment.
- Processes and methodologies for the development of service-oriented systems as feature-oriented software development and component-based software engineering.
- Requirements analysis, specification, modeling and establishment for separation of concern.
- Service selection criteria for quality, reliability, performance and risk management.
- Modeling of runtime behavior of services in an SOA system and selection algorithm in the registry.
- Analysis and establishment of nonfunctional requirements in terms of QoS.
- Technique for data integration in service-oriented environments.
- Design patterns for service-oriented systems, and mapping of existing and new design patterns.
- Service analysis, design and development for cloud mobile architecture.
- Service integration requirements for smart components.
- Selection criteria for integration technologies.
- Deployment of services in smart cities.
- Validation, acceptance testing and monitoring of

web services.

- Aging analysis in web services applications and its variant architectures.
- Performance degradation analysis of web services' operations.

X. CONCLUSION

SOA has proven a quality framework for the development of enterprise applications over the last two decades. SOA is widely usable and is a fundamental platform for cloud-oriented application implementation, management integration and development. Cloud-based concepts are based on service delivery. Web service is a basic component of SOA that provides a communication with different servers and nodes.

The web services are requested by client and generated through the server. This paper presented a study of service-oriented architecture framework, evolution, implementation approaches and technologies. The paper also highlights the application of SOA and concerning evolving research issues for advancement and need to be addressed to handle the current scenario of SOA. Web services applications are potential threat to cybersecurity risk and facing further aging and performance degradation challenges.

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