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Middleware Technologies for building efficiencies in the migration process of switching from E-governance to M-Governance

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Abstract—Adoption of the mobile delivery platform by the Governments worldwide for deployment of services has not only increased its accessibility and penetration in human settlement, but also has posed varied challenges in the integration of emerging nascent technologies with greater agility in synchronizing two different disparate service delivery support system. Interoperability among such new class of technology applications is driven by means of protocols, standards and middleware component to support upcoming service demands. To accommodate these new requirements for building efficiencies in mobility, middleware needs to be designed to reduce the lead time and improve ease of adoption.

This paper suggests a framework model for adopting mobile devices as a delivery platform for existing e-governance practices. It brings into picture the technological components necessary for successful adoption of mobile technology platform with respect to various delivery channels. It begins by identifying the existing technology integration layer consisting of middleware and standards as a prerequisite for such upgradation. Further, it brings forth the critical factors and components needs to be considered for supporting features like SMS, USSD, LBS, etc., which can be provided by means of wireless and mobile devices.

We have identified various middleware components with the help of professionals from various service providers associated with e-governance and m-governance projects. The investigation has been done to identify the types and categories of middleware with their functionalities and components. The outcome of the investigation is a mapping of middleware technologies and components with the subsystems of e-governance and m-governance hardware and software infrastructural set ups.

Keywords—E-governance; middleware; M-governance; Architecture; Migration;

I. INTRODUCTION

Advancement in wireless and mobile technology has given a new dimension to existing e-governance services by involving the use of mobile technologies (i.e. SMS, USSD, LBS, etc.). It is well known that mobile phones with its high penetration rates that the internet in recent years has contributed in making Government ubiquitous. The integration of the hardware, software and networking components pertaining to e-governance with that of m-governance is a critical issue. The middleware component supporting such integration should ensure scalability, interoperability, reliability and performance in the overall scenario. There should be some mechanism by which the efficiencies in terms of execution time and cost should be raised by adding supporting components to the existing infrastructure.

The inclusion of mobile technologies demands for supporting physical infrastructure (e.g. Technology, equipment and networks); software, applications and systems; and related standards and protocols. By such inclusion there comes a strong need of the middleware which can provide the integration in a seamless fashion. Moreover, the availability of multiple channels can raise issues of interoperability, data quality and transparency of delivery across systems.

The paper depicts the essential e-governance architecture with the description of middleware requirement. The investigation has been done to identify the categories of middleware with their functionalities and components supporting e-governance practices. The outcome of the investigation is a mapping of middleware technologies and components with the subsystems of e-governance and m-governance hardware and software infrastructural set ups.

II. E-GOVERNANCE ARCHITECTURE COMPONENTS AND THEIR INTEGRATION

The overall implementation of e-governance project can be organized in the form of layered architecture for better flexibility, maintainability, performance and scalability. Government, citizen, agencies are the stakeholders [3]. The services are managed and outsourced to the service providers like internet service providers, banking and financial institution, third party software vendors, hardware vendors, cloud service providers, security agencies, etc. The overall communication and coordination between the above mentioned entities are provided by means of integration layer. Interoperability is the main issue which is addressed by the integration layer which consists of middleware and standards to streamline the connection between service providers, applications and databases across communication network.

The architecture is depicted as a set of the presentation, business logic and data access layers closely integrated with the set of middleware and standards for providing better interoperability, security, scalability and flexibility features.

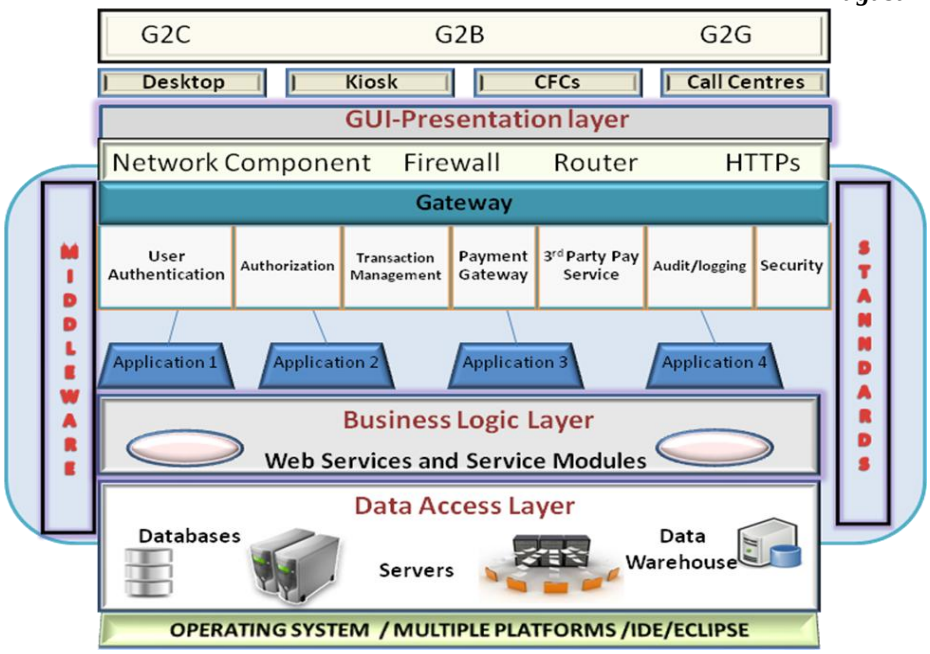

Fig. 1. 3-Tier E-governance Architecture

The presentation layer consisting of the user interface developed using Java, HTML, PHP, Servlets, JSP, java script ,etc. which communicate with the application of the business logic layer by means of API and network components like gateways, which become the part of the middleware.

The business logic layer provides a means of integration of the application and portals developed by different vendors to communicate. It also provides security, locking features by virtue of two components.

A) The Communication protocol standards like TCP/IP, UDP, SSL, HTTP/HTTPS, RMI/IIOP, SMTP, ICMP, IMAP, POP3 and security standards like SET, PKI for providing security, authorization and authentication features to the application and the users.

B) Middleware technologies which include web servers, application servers, content management systems, and tools support application development and delivery. It is a software layer supported by components based on Extensible Markup Language (XML), JavaScript Object Notation (JSON), Simple Object Access Protocol (SOAP), Web services, SOA, Web 2.0 infrastructure, and Lightweight directory access protocol (LDAP)[5].

The web services convert the application into web application, which in turn can publish its function to the rest of world. It is defined by a URL, which help external system to interact with the existing system in the manner prescribed by XML-based messages conveyed by Internet protocols, for this reason the basic web services platform is made up of XML and HTTP [2].

The web service model consists of three entities, the service provider, the service registry and the service consumer. Services will be published by the service provider in a standard format using service registry. A consumer will find the service from the service registry [6]. All these exchanges happen using XML based message format.

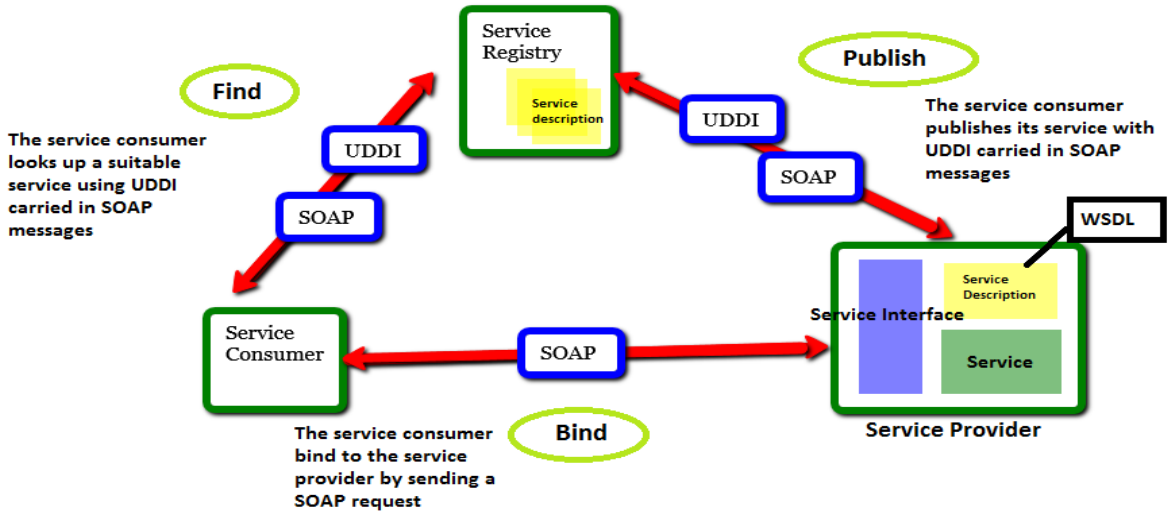

Fig. 2. The Web Service Model [6]

Web Services have three basic platform elements associated to it [5]:

1) SOAP -- Simple Object Access Protocol is a lightweight protocol used for exchanging XML-based information in a network between the entities.
2) UDDI -- Universal Description and Discovery Integration Protocol, which provides a registry mechanism for clients and servers to find each other. It uses SOAP for communication.
3) WSDL -- Web Service Description Language which is an XML-based language for describing network services with its capabilities and location. WSDL works like an interface description language for Web services. It covers the description of which arguments and results are involved in the interactions along with the data formats and protocols used for the message exchange between the applications.

The lower layer known as the data access layer of the architecture deals with the technology framework which includes storage, integrated databases, data warehouse, operating system, integrated development platforms. Java platform architecture like CORBA, RMI, EJB and Open source technologies like Linux, Apache, MySql, LDAP, Enterprise Java APIs (JDBC,JMS etc.), ECLIPSE are the options available.

III. MIDDLEWARE REQUIREMENT AND CATEGORIES

Government systems are built on multiple platform and support services offered by heterogeneous and geographically dispersed data centers. They are massive systems which involve multi-department and multi-agency workflows. Interoperability of such system becomes a big issue when services are provided by different systems build on heterogeneous platforms routed across various delivery channels. Middleware has been described as the software glue that ties applications together across a network [6]. Middleware technologies allow disparate information technology (IT) systems to be integrated into one seamless, efficient system, ensuring scalability, interoperability, reliability and performance. Several researchers have explored different aspects (technical [1] [12] [4], semantic [1] [10], syntactic [10] [12]) of e-Government interoperability.

With the development of new Government service modules and increase in the number of users by the introduction of modern delivery platforms, integration technologies are in much demand. Deploying such services efficiently at efficient cost has become a big challenge. Middleware in the form of gateways facilitates the integration of upcoming technologies with legacy systems. Middleware gateways under such scenario should be capable of scaling with time, in terms of number and complexity of applications, number of locations and number of users' usage. It should be reliable, and should provide assured levels of service for uptime, availability and performance [7].

Based on the services provided by e-governance projects following categories of the middleware are presented in the next section.

A) Types of Middleware

These classifications middleware either assists an application or helps with the integration of multiple software modules into an integrated Government system. Some of them can be combined to achieve the requirement of the application. Following are the types identified after literature survey [8] [9] [14].

1)Data Access and link management Middleware: It enables client applications to communicate with one or more local or remote database or applications by establishing connection across multiple channels via API running in client address space [14]. Service access directory is maintained to look up for specific services. User authentication and authorization gateway authenticates and validates requests and routes XML messages to the appropriate service provider's data server. Once a request is sent, the gateway listens for the returned requests on the respective queue and submits results to the user. Data access middleware here ensures continuous service, even in the event of a server or system failure. High availability of the server is the crucial factor responsible for optimizing performance and response time.

2) Message-Oriented Middleware: It facilitates communication by message exchange. They can be used to providea number of functions including event notification and requests for service execution. It is particularly well suited for distributed event notification and for published and subscribed services. It can provide an asynchronous service using message queues and stores message in case the target is unavailable. The main feature of this middleware would be to translate messages between different formats supported by different application module.

National e-Governance Service Delivery Gateway (NSDG)[11], a SOA based messaging middleware routes messages across government departments, thereby enabling cross state and cross domain service delivery, overcoming challenges of interoperability and integrations while delivering services to citizens through a single window [10].

3) Web-based Middleware: It supports user operations online by connecting to the application servers. It provides authentication service at the application level for a large number of applications and inter-process communication that is independent of the underlying operating system, network protocols, and hardware platforms [6]. Some core services provided by web-based middleware includes directory services, e-mail, billing, remote data and application access supporting facilities for downloads documents, program access, and browsing.

4) Transaction Middleware: It supports the transactions running across multiple hosts by means of a transaction ensures that the software that sits between a requesting client program and databases, ensuring that all databases are updated properly. It uses the two-phase commit (2PC) protocol to implement these transactions which allow servers and database management systems to be easily integrated [13]. Each transaction is identified by a unique transaction

ID. Middleware components keep track of successful as well as unsuccessful transactions routed through it, ensuring transaction logging and auditing. Payment gateways provided by the banking and financial institution are the component which take care of the transaction initiated by the user for bill and tax payment, etc. The gateway also takes care of user authentication and authorization process.

5) Application Integration Middleware: It provides interfaces to a wide variety of applications by means of web services. It make use of a framework based on SOAP,UDDI and WDML.This represents the main intelligence of the entire SOA, processing each request in the form of a message, building the request, and intelligently route to the respective web service. It can provide ways for legacy systems to interface with network clients or ways to execute functions across a network from one application to another by means of web services[13].

IV. TECHNOLOGY REQUIREMENT FOR M-GOVERNANCE PRACTICES

M- Governance can help to make public information and government services available anytime and anywhere to the citizens irrespective of the device and network provider. The unprecedented penetration of mobile device usage across country have open up a new paradigm of delivering services via various delivery platforms like SMS, IVRS, USSD, Cell Broadcasting (CBC), WAP,3G, Location Based Services(LBS), etc. The integration of context and location information with applications is fast becoming the next level of ubiquitous government.

Migrating to alternative delivery channels and platforms requires use of optimized interface to connect multiple service providers like telecom operators, mobile internet service provider, financial institution supporting mobile payment, technology enablers etc.

Interoperability framework consisting of mobile middleware with the gateway as network component is required to connect mobile applications with various service providers. Mobile network, supported by Wireless Access Protocol (WAP) model needs a gateway to convert mobile device generated WML/WML script request to HTTP request in a form of URL to fetch data from the web server. Mobile application which provides user interface to mobile client are designed using technologies like J2ME, Objective C, BlackBerry JDE,CE .NET C# and VB.NET based on mobile operating systems like android, blackberry, IOS, Symbian OS etc[15].

Mobility brings unique challenges specific to mobile device and wireless channels which should be considered while developing infrastructure components and mobile solutions[17].

1) Mobile devices have Limited memory. Transfer of information should require limited usage of mass memories.
2) Small LCD on a mobile telephone can only display a few lines of text, mobile compliant contents and websites are developed for the same.
3) Browsers on mobile devices use wireless markup language (WML) instead of HTML, encoders and decoders are required to support such conversion.
4) Wireless channels are prone to frequent disconnections, which cause failures due to data loss during a transaction; therefore, the system should be able to manage such sudden disconnections by providing mechanisms for information replication and transaction recovery.
5) Support of reliable and efficient networks like 3G & 4G services to provide uninterrupted connectivity.
6) Standards are needed to address security and privacy concerns of users as well as interoperability between various implementations.
7) Use of open source technologies to maximize interoperability and data-sharing capabilities between technologies and streamline development, deployment and migration.

Need to wrap the existing database using semantic wrappers and to make data accessible through the use of web services and API.

V. MIDDLEWARE SUPPORTING INTEGRATION OF MOBILE TECHNOLOGIES WITH E-GOVERNANCE

Implementing m-governance can be viewed as the process of:

A. Extending the existing applications to mobile devices and

B. Integrating the new services supported by the mobile delivery platform to the existing e-governance systems.

Both of the above process demand for seamless integration of mobile channels with backend systems through existing e-governance system. In some cases, existing middleware layer is modified to support integration and with some new customized components are integrated. Below listed are the requirements:

1) Compatibility and interoperability platform for communication with external entities.
2) Common interface for mobile based services (SMS, USSD, GPRS, 3G, CBC, etc.).
3) Service Discovery Directory to locate the services which can be then routed to the appropriate data centre.
4) Security and privacy module to authenticate mobile devices.

Taking into consideration the existing middleware of the e-governance system, following are the types of middleware required for supporting migration to m-governance.

1) *Service delivery Middleware:* It consists of a gateway for connecting mobile systems with the existing e-government systems/servers. Mobile applications shall be integrated and deployed by means of this gateway[13]. The service request will be firstly pre-fetched and aggregated on the wireless application gateway, then will be forwarded to data centres for fetching requested data. Data exchange takes the form of desktop synchronization. It provides almost the same functionality as Application Integration Middleware discussed above.
2) *SMS Middleware:* It enables citizens to receive information in the form of pull or push a message via SMS service of the mobile phones. For pull messages, information will be requested in a predefined standard format defined by W3C, XML, SOAP, etc. for message communication purpose. The gateway will perform the syntax and schema validation as per the exchange standards. It maintains a Service Directory for the services offered, performs validation and finally forwards the request to the respective department in the back offices [10]. It then sends an SMS depicting the response of the requested service. In case of push SMS, then it coordinates the transmission of unsolicited push messages from the backend to mobile devices. The integration of SMS gateway is done using the API.
3) *Mobile Payment Middleware: It Involve the third party payment gateway module to support payment transaction*. Various banks are offering mobile payment services by means of mobile application will be integrated by this middleware. Transaction middleware will perform the audit and log management.
4) *Security & Authentication Middleware:* Mobile governance platform need to support multilevel security and authentication process. Moreover, involvement of multiple service providers makes it more prone to security attacks. Middleware deal with the development of a lightweight security module for mobile devices to protect them against network attacks, authenticate the user and permit secure download of new applications and configurations. Mobile number, registration ID, biometric credentials, One-Time-Password (OTP) can become the basis for checking for consistency of the message, check for a repeat attack on the server.
5) *Content Delivery Middleware:* The content delivered for desktop applications and portals are not compatible with mobile devices because of the storage and screen size constraints. Gateway here performs necessary filtering and conversion of the content as per the recipient's device configuration. It also helps in performance optimization of website and mobile application. To streamline the process M-governance will require development of separate mobile-ready content. Mobile device compliant websites and application needs to be developed using open source technologies and cross platform technologies like PhoneGap, appMobi, QuickConnect, etc.
6) *Mobile Device Management (MDM) Middleware*: It deals with the issue of identity management of the devices. MDM Gateway is an entry point for the request made by the managed devices. It establishes a connection with a server to authenticate the incoming connection request made by a mobile device.
7) *LBS Middleware*: Location based services can be defined as services that integrate a mobile device's location or position with other information so as to provide added value to a user. Gateway here provides connection between LBS applications, data server and positioning system. As soon as the user activates the positioning device, the positional parameters are conveyed to the LBS application, which then query the database server for information pertaining to the position. The syntactic interoperability is provided by the LBS middleware to support synchronization.
8) *Real time middleware:* A new class of service can be identified by using real time middleware is session service whereby a constant connection is established between the sender and the receiver for the near real-time exchange of messages. Real-time is characterized by the right data being provided on time otherwise it is no longer the correct data [16]. The real-time middleware supports time-sensitive request and scheduling policies. It does this with services that improve the effectiveness of the user applications. Real-time middleware can be divided into the different applications using them (real-time database application, sensor processing, and information passing) [14].

VI. CONCLUSIONS

By virtue of competition in the marketplace, various vendors create a plethora of middleware with a lure of profit. It is very much possible, especially, in an Indian setting, after getting feedback from the stakeholders and the end users, we shall leverages existing middleware technologies or place order for customized solutions. Before we wait for it to come on the market, there can be a tailor made solution. We are also confident that instead of creating a standalone mobile service delivery system, it is worth creating a hybrid system by migratory processes leveraging middleware technologies.

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