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Interoperability adoption among government and corporate portals in India: a study

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Abstract

Purpose – The purpose of this study is to examine the position of interoperability of government and corporate portals in technological adoption space in India in terms of three critical dimensions: data integration, process integration and communication integration.

Design/methodology/approach – This exploratory study was conducted through a survey questionnaire from 300 portals of government departments and public sector undertakings (PSUs) in India. Data were also collected from portals of Indian companies and the results have been compared with those of the government portals.

Findings – The results show that the majority of government portals in India have initiated integration. Second, the portals of Indian companies are performing better than the portals of government and PSUs for achieving an interoperable position. Third, there is high dispersion in level of integration of government portals in India.

Practical implications – The portals with the lowest level of integration in government in India will determine when government will actually attain full horizontal integration and hence achieve an interoperable portal as there is high dispersion in level of integration of government portals in India. Also, for achieving an interoperable government portal, an organization needs to focus on the weakest factors of each dimension.

Originality/value – This study is the first to examine the position of interoperability in technological adoption space in India. The results lead to a number of recommendations for achieving interoperability for government portals in India. The study also highlights the weakest factors of each dimension that require more improvement than other factors.

Keywords Integration, Interoperability, One-stop portal, E-government, Open systems

Paper type Research paper

1. Introduction

Interoperability among government organizations has been identified as a central issue and a critical prerequisite for achieving a one-stop government portal (Tripathi *et al.*, 2011; Peristeras *et al.*, 2007). The European Commission (2003) has defined interoperability as "the means by which the inter-linking of systems, information and ways of working, whether within or between administrations, nationally or across Europe, or with the enterprise sector, occurs". Interoperability is the ability of ICT systems to work together. As identified by Vogel *et al.* (2008) and Traunmüller (2005), the benefits of interoperability become clear in the following settings: more effectiveness (interconnection instead of isolated solutions), efficiency (reduction of

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the transaction costs and increase of the involved agents' participation), and responsiveness (better access to more information, making possible the fastest resolution of the problems). Economic benefits of interoperability result in lower transaction costs typically utilizing standardized processes.

To achieve an interoperable government, the integration of government information resources and processes, and the interoperation of independent information systems, are essential. According to Gouscos *et al.* (2007), most integration and interoperation efforts face serious challenges and limitations as exchanges of information and services are fragmented and complex, plagued by technical and organizational problems. Stated by Vernadat (2010), the barriers to interoperability comprise political, organizational, economical and technical issues. Problem in government compounded due to multiple diverse sources of data, most of these are unstructured that lies in the form of rules, procedures and concepts, guidelines etc. Data referring to facts and figures treated as operational idea are structured that can be stored in computerized form of database and further used for decision-making (Gupta *et al.*, 2005).

Integration is an act or instance of combining an organization's processes and information into an integral whole (IBM, 2004). A distinction should be made between interoperability and integration. As stated by Klischewski and Scholl (2006), integration is the forming of a larger unit of government entities, temporary or permanent, for the purpose of merging processes and/or sharing information. Interoperation in e-government occurs whenever independent or heterogeneous information systems or their components controlled by different jurisdictions, administrations, or external partners work together (efficiently and effectively) in a predefined and agreed-on fashion. E-government interoperability is the technical capability for e-Government interoperation (Scholl and Klischewski, 2007).

Integration forms the basis for a complete interoperable government. In the government's perspective integration is a process of making the information and processes of two government organizations as a whole (Virili and Sorrentino, 2009). According to the e-GIF (Government Interoperability Framework) if the coherent exchange of information and services between systems is achieved then the systems can be regarded as truly interoperable. Therefore, through integration of information and processes of two organizations, it will be easy to achieve interoperability. The adoption of a new technology such as interoperability involves a proper assessment of the status of integration (process integration, data integration and communication integration) within the government. Higher the level of integration of an organization, lesser the resources needed to adopt the interoperability technology.

Integration can happen in two ways: vertical and horizontal. Vertical integration refers to local, state and federal governments connected for different functions or services of government. An example would be the business licensing process. In an ideal situation where systems are vertically integrated, once a citizen filed for a business license at the city government, this information would be propagated to the state's business licensing system and to the federal government to obtain an employer identification number (FEIN). In contrast horizontal integration refers to integration across different functions and services (Layne and Lee, 2001). An example would be a business being able to pay its unemployment insurance to one state department and its state business taxes to another state department at the same time because systems in both departments talk to each other or work from the same database. The need of

interoperability arises both within the departments as well as between the departments of government.

In India most of the e-government or e-governance initiatives have brought big promise but are facing huge challenge due to islands of information, difficulties in data interchange, and inefficient communication among the government, the businesses and the citizens. Technology incompatibility is only a piece of this "Interoperability Issues Puzzle" in e-governance initiatives in India. Incompatibilities in government processes, diverse and distributed working groups, people, teams, multiple interest perspectives, and interest groups, all create much larger issues for interoperability than the technology alone. Though scope of term "e-governance" is much wider as compared to "e-government", "e-governance" is preferred term in common parlance in Indian and appear in all the related government reports and proceedings, hence we will also use e-governance throughout rest of the paper as the research confines to Indian settings.

Status of E-government in India

India is federal union of states comprising 28 states and seven union territories. India's central government has 49 ministries and two independent departments. There are 18 independent offices in Indian government. In the last decade the growth of e-government has been exceptional. E-government has acquired a special attention in India to facilitate organizational change programs. In India e-governance has steadily evolved from computerization of government departments to initiatives that encapsulate the finer points of Governance, such as citizen centricity, service orientation and transparency. As per West's (2007) report India's rank in e-government has improved from 77 in 2006 to 47 in 2007. Also, per the Economist Intelligence Unit's e-readiness ranking for the year 2009 (EIU, 2009), India ranks 58 among the countries of the world. Over the years, a large number of initiatives have been undertaken by various State Governments and Central Ministries of India to usher in an era of e-Government. Sustained efforts have been made at multiple levels to improve the delivery of public services and simplify the process of accessing them. Nearly all Indian government bodies now have some presence on the web, including fully-fledged e-Government web portals, albeit in small numbers.

Government of India has approved a policy of allocating two to 3 per cent of the IT budget in each government ministry. The "Eleventh five year plan" (2007-2012), has allocated $3.2 billion towards e-government applications in the country. Following to that, a national level e-governance plan (NEGP) was announced on 2006, with an outlay of 33000 crores rupees with the aim of creating the right governance and institutional mechanisms, setting up the core infrastructure and policies and implementing 26 Mission Mode Projects and eight support components at the center, state and integrated service levels in order to create a citizen-centric and business-centric environment for governance (Gupta, 2010). Apart from mission mode projects, three other major components of NeGP include the creation of a State Wide Area Network; a State Data Centre (SDC) and 100,000 Community Service Centres (CSC) to serve a cluster of six villages in the country and provide a range of more than eighty services.

One of the key objectives under the e-government agenda in many countries is to achieve a one-stop government portal (Gupta *et al.*, 2005). In India, agenda of one stop India portal was laid down with the allocation of Rs. 100 crores in the tenth Indian five-year plan (2002-2007) much before NEGP. The plan also conceived the launch of

National Institute of e-governance, Central Repository of Data, Citizen Service Centres for one-stop non-stop delivery of public services, dissemination of information relating to best practices/innovations in e-Governance (including a documentary series entitled "IT in the Service of People"), and awards for best web sites and innovative use of IT in the delivery of public services[1]. India portal is supposed to serve as a one-stop non-stop destination for public access to information on various aspects of government functioning. It is also to serve as a single window for delivery of government services. An Expert Group was set up to conceptualize its draft report, which *inter alia* it envisages setting up of a National Information Services Board and implementing the portal with the support of various stakeholders including industry associations, academic institutions, etc. The first version of "India Portal" was launched 10 November 2005 by National Informatics Centre (NIC). Subsequently "india.gov.in" was included as one of the mission mode projects under the National E-governance Plan approved in 2006. The objective behind the portal is to provide a single window access to the information and services of the Indian government at all levels from central government to state government to district administration and Panchayats for the Citizens, Business and Overseas Indians. This portal aims to provide comprehensive, accurate, and reliable and one stop source of information about India and its various facets (Gupta, 2010).

Success of such comprehensive portal would necessarily require development of information management plans, standards, data architecture, reference data, initial data collection and conversion to digital form, forms, deliverables, migration plan, sustainable strategy and maintenance. Today, nearly all of the government organizations in India have a web presence with over more than 6500 web sites maintained by various government organisation to render information, services, etc. electronically. These portals often face challenge of presenting a significant variety of features, complexity of structure and plurality of services to be offered. India being country of diverse culture, language poses a major hindrance. Without multilingual facility, there is hardly any use of portals for common men. Since the knowledge divide is quite pronounced in the country, people from backward/rural areas would require easy access but also need online help to navigate through the portals[2].

Hence it is often found that these portals are portal in namesake and often struggle to go beyond a web site in terms of contents and features primarily due to lack of backend integration. The mapping over stage models, show only few departments having achieved some type of integration (Gupta, 2010). Portal maturity will depend on degree of integration among disparate systems, which is achievable only if the backend systems are interoperable. In this paper, attempt is made to identify the position of interoperability of these portals in technological adoption space. It takes help of a three dimensional adoption space model proposed by Chen *et al.* (2005) to measure the level of integration. Prior research work of the authors (Tripathi *et al.*, 2011) is dovetailed into adoption space model in ascertaining the level of interoperability and degree of integration. This includes an understanding of critical factors necessary for the successful adoption of interoperability technology along three dimensions of integration – process integration, communication integration and data integration. All the dimensions and organizational factors are inter-related. By measuring the position of interoperability an organization can focus on improving the factors to achieve interoperability.

The structure of the paper is as follows. In the following section, adoption space model for interoperability has been explained. Section 3, discusses the research methodology used in this research. Next, section 4 presents and analyzes the results of the data surveyed. Section 5 discusses the insights of the study and points out the relevant factors. Finally, in section 6 the article offers some conclusions that include limitations of the paper along with future work.

2. Adoption space

To determine portal maturity would require assessment of integration from multiple dimensions. In our previous study, we identified three dimensions of integration (Tripathi *et al.*, 2011):

(1) *Data integration*: Data integration is an issue of combining data residing at different sources and providing the user with a unified view of this data (Halevy, 2001; Srivastava *et al.*, 1996).

(2) *Process integration*: For inter-organizational integration the necessity for process integration increases. Different processes are developed for every level of government organizations (Tripathi *et al.*, 2011).

(3) *Communication integration*: Communication integration comprises the use of electronic computers, computer software and computer networks to convert, store, protect, process, transmit and securely retrieve information (Vernadat, 2010).

The details are given in Table I. Each dimension has further been mapped to sub-dimensions (13 for Data integration, 7 for Process integration and 8 for Communication integration) for an appropriate estimation of the position of respective organizations.

Adoption space refers to a continuum of positions in a three dimensional space over which evolution or progression towards maturity in adoption of technology can be located. Portal maturity, may also assessed, over continua of adoption space, primarily from the integration considerations based on the previous three dimensions (see Figure 1).

Adoption space model as proposed in Figure 1 is logically sound as it measures the Euclidean distance for a particular location. This idea found interesting use by Chen (2003) who explained XML adoption in a technology project.

In the present case, integration for portal maturity is measured in absolute value of the integration vector that corresponds to the Euclidean Distance of integration point (in a three dimensional space) from the origin. This model plots the level of integration of a portal in a three-dimensional Cartesian coordinate system. Each of the three dimensions of integration vector ranges from 0 (nil) to 5 (complete). The highest level of integration is at the point (5, 5, 5) in this three dimensional space, which implies that the organization is completely interoperable. At this position the portals are vertically and horizontally integrated.

Euclidean distance is calculated as the square root of the sum of the squares of the arithmetical differences of the corresponding coordinates of the two points,

Literature referred	Expert consulted (2007-2009)	Factor identified
Data integration		
Gupta *et al.*, 2005	Neeta Verma (2007), Senior Technical Director, NIC, India; Mirulesh (2009), Public Works Department (Delhi), India; Navin Mittal (2008), Collector, Andhra Pradesh, India	*Data centre*
IEEE, 2006	Neeta Verma, Senior Technical Director, NIC, India; Anurag Srivastava (2009), IT Director, Madhya Pradesh India	*Data architecture*
	K.N. Narayankar (2008), Senior Research Executive, Central Water & Power Research Station, India; Shefali Dash (2008), Deputy Director General, NIC-HQ, India	*Data update*
Santos and Reinhard, 2007; Rao *et al.*, 2008; Layne and Lee, 2001	Ajay K. Singh (2009), Director, CRIS, India; Ahmed, Software Programmer, Finance Commission of India	*Compatible standards*
Mach *et al.*, 2006; Hiller and Bélanger, 2001	Dibakar Ray (2007), Scientist, NIC, India; Huzur Saran, Professor, Department of Computer Science and Engineering, I.I.T. Delhi, India; U.C. Nangia, Director, Ministry of Petroleum & Natural Gas, India	*Back office integration*
Eckerson, 1999	Anurag Srivastava, IT Director, Madhya Pradesh India; Navin Mittal, Collector, Andhra Pradesh, India; Jacob Victor (2008), Joint Director (E-governance), Andhra Pradesh, India	*Data security*
Weng *et al.*, 2006; Ding *et al.*, 2002	Dibakar Ray, Scientist, NIC, India; Jacob Victor, Joint Director (E-governance), Andhra Pradesh, India	*Ontology*
Coyle, 2002; The Open Group, 2005	Anurag Srivastava, IT Director, Madhya Pradesh India; Dibakar Ray, Scientist, NIC, India; Jacob Victor, Joint Director (E-governance), Andhra Pradesh, India	*Open standards*
IFEG Version 2.4 Report (2006)	Janmejay, Principal System Analyst, Indian Government Tenders, India	*Message Formatting Language*
	Janmejay, Principal System Analyst, Indian Government Tenders, India	*Data Replication*
	Janmejay, Principal System Analyst, Indian Government Tenders, India	*Data Transformation*
	Janmejay, Principal System Analyst, Indian Government Tenders, India	*Data Modelling*
	Janmejay, Principal System Analyst, Indian Government Tenders, India; D.C. Mishra (2009), *Senior Technical Director,* NIC, India,	*Data Resource Description*
Process integration		
Liu *et al.*, 2005	Ahmed (2009), Software Programmer, Finance Commission of India; Huzur Saran, Professor, Department of Computer Science and Engineering, IITD, India; Ajay K. Singh, Director, CRIS, India	*Process codification*

(*continued*)

Table I.
Factors for measuring the "Integration sophistication" of an organization

Literature referred	Expert consulted (2007-2009)	Factor identified
Ghattas and Soffer, 2008; Wittenburg *et al.*, 2007	Anurag Srivastava, IT Director, Madhya Pradesh, India; Hardeep S. Hora (2009), NIC, India; Huzur Saran, Professor, Department of Computer Science and Engineering, IITD, India; Ajay K. Singh, Director, CRIS, India	*Formulation of processes*
Ceravolo *et al.*, 2008; Wittenburg *et al.*, 2007	Ahmed (2009), Software Programmer, Finance Commission of India; Navin Mittal, Collector, Andhra Pradesh, India	*Process update*
Department of Defense, 1996	Shefali Dash, Deputy Director General, NIC-HQ, India; Jacob Victor, Joint Director (E-governance), Andhra Pradesh, India	*Reuse*
Gugliotta *et al.*, 2005; Liu *et al.*, 2005	Neeta Verma, Senior Technical Director, NIC, India; Janmejay, Principal System Analyst, Indian Government Tenders, India	*Middleware*
	Hardeep S. Hora, technical director of NIC, India; D. C. Mishra, *Senior Technical Director,* NIC, India	*Open standards*
Communication integration		
	Ronald Noronha (2009), Chief Manager, BPCL, India; Mirulesh, Web Developer, Public Works Department (Delhi), India	*Networking*
Strover, 2001	R. Vijaya Chakraboraty (2009), Senior Manager (Systems), National Aluminium Corporation Limited, India	*Connectivity*
Huang *et al.*, 2006; Ardagna and Pernici, 2006; CISCO, 2006	Naveen Agrawal, Technical Director (IT), Department of Land Resources, India; U.C. Nangia, Director, Ministry of Petroleum & Natural Gas, India	*Quality of services*
Layne and Lee, 2001; Bertot and Jaeger, 2006; Evans and Yen, 2006	Jacob Victor, Joint Director (E-governance), Andhra Pradesh, India; Janmejay, Principal System Analyst, Indian Government Tenders, India	*Web and internet technologies*
Lin and Lin, 2008	Anurag Srivastava, IT Director, Madhya Pradesh India; Shefali Dash, Deputy Director General, NIC-HQ, India; Dibakar Ray, Scientist, NIC, India	*Interoperability of technologies*
Straub and Nance, 1990; Rainer *et al.*, 1991	Vinay K. Chaudhary (2009), Engineer, Power Grid Corporation, India; Mittal, Collector, Andhra Pradesh, India	*Security*
IFEG Version 2.4 Report (2005)	Naveen Agrawal, Technical Director (IT), Department of Land Resources, India; U.C. Nangia, Director, Ministry of Petroleum & Natural Gas, India	*Intelligent design*
IFEG Version 2.4 Report (2005)	Jacob Victor, Joint Director (E-governance), Andhra Pradesh, India; Janmejay, Principal System Analyst, Indian Government Tenders, India	*Network Layer Security*

Table I.

Source: Tripathi *et al.* (2011)

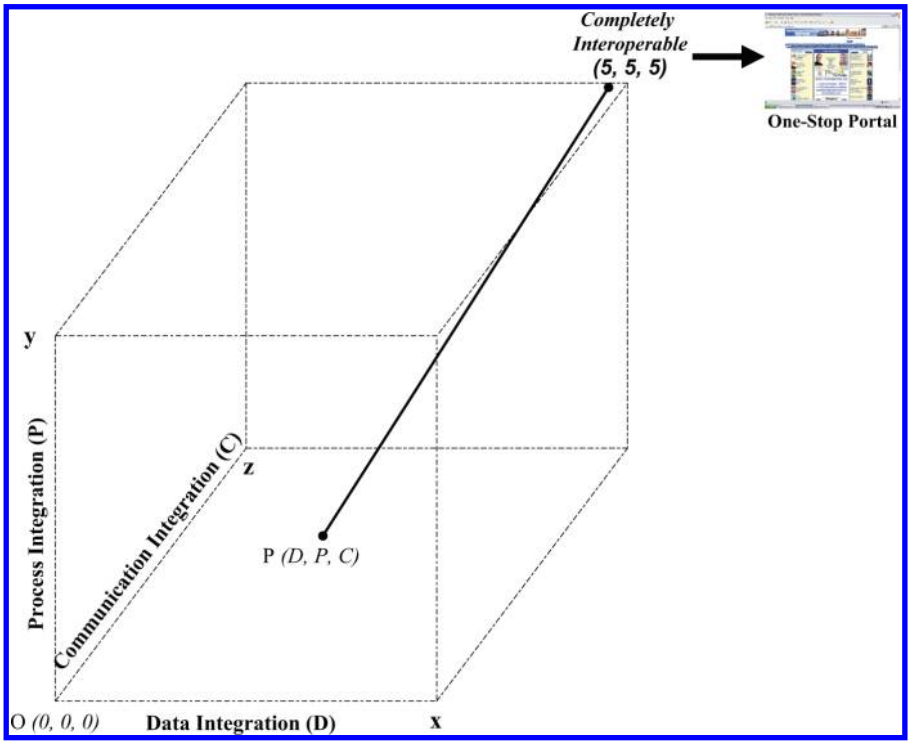

Figure 1.
Adoption space model

$$d(x,y) = \sqrt{\sum_{i=1}^{n} x_i - y_i)^2}$$

$$x =< x_1, x_2, ..., x_n >$$

$$y =< y_1, y_2, ..., y_n >$$

The Euclidean Distance (from origin) of "completely interoperable" point will be $5\sqrt{3}$. This lies outside the scale of 0 to 5 and needs to be normalized (to 5) in order to make comparison meaningful. Therefore, Normalized Euclidean Distance has been used for all our analysis.

$$\text{Normalized Euclidean Distance} = (\text{Euclidean Distance})/\sqrt{3}$$

Considering the position of each organization's portal in the three dimensional space, *t*-test has been applied for significance of the result. This test has been conducted at 95 per cent confidence interval i.e. p value < 0.05. We have applied the test as follows:

- *Normalized Euclidean Distance (NED)*: Comparing the NED of Government Departments, PSU and Indian companies' portals.
- *Individual dimensions*: Comparing each of the three dimensions, for three types of portals (government, PSU and corporate).

Therefore, we have compared the results in four ways: Normalized Euclidean Distance, Data Integration, Process Integration and Communication Integration.

3. Research methodology

To assess portal maturity over three-dimension adoption space model, a questionnaire survey is conducted. Success of the research objectives is dependent on the analysis of a large number of responses. The questionnaires based approach is a well-established technique in obtaining data in social sciences research. A number of Information Technology (IT) research projects with the objective of getting data from user groups have been successfully conducted using this method. Precise, structured multiple-choice questionnaires were designed keeping in mind the need for eliciting the requisite information.

It must be noted that the questionnaire went through a pretesting process before it was administered. The pretesting was carried out with a panel comprising of four high-ranking government officials involved with e-government initiatives in India and an eminent academician. The questionnaire was refined according to the comments and suggestions made by this panel. The modifications that were made were primarily related to the instructions in the survey and rephrasing of some measurement items. Since there were no major comments received, the questionnaire was considered ready for data collection.

Three separate sections were developed for each dimension of integration as to find the current situation of the organization's portal on integration. The section on data integration comprised 13 questions. Six questions were included in the section of Process integration and section on Communication integration had eight questions. Table I show the factors of the three dimensions and how they were identified through literature review and interviewing the experts. One question each was asked for every factor of the respective dimension (see the Appendix, Table AI). Five-point Lickert scale was used where 1 is interpreted as 'not initiated'; 2 – being initiated; 3 – partially initiated; 4 – advance stage of integration and 5 – complete implementation. The answers of the categories are mutually exclusive so that respondent had to select not more than one choice against an item. Apart from this, the respondents were given the opportunity to offer their comments on any issue related to e-government development.

'Zero' (0) was also used in the scale to capture the non-familiarity of the respondents with the terminology and is not aware of the value of factor. Difference between 0 (unfamiliar) and 1 (not initiated) is that if any portal is on scale 1 then it signifies that the organization is aware of the factor and its usefulness but has not initiated yet. Organizational factors can be one of the reasons for not initiating a factor. For example, an organization is aware of the importance of a factor that can help in achieve interoperability. But without the support of top level management (Kambil *et al.*, 2000; Eder and Igbaria, 2001) it is difficult to initiate any factor in any organization whether they are technology related or not. This survey was done to note how many respondents are not even aware of the factors that help in achieving interoperability.

The survey was conducted in August-September, 2010. The questionnaire along with a covering letter mentioning the objective of the study was sent to approximately 400 officials of government departments of India (central ministry, states and union territories), Indian public sector undertakings (government owned and controlled corporations) and Indian companies portals. A large number of government portals are developed and maintained by National Informatics Centre (NIC), India. Regular visits to NIC were made. Only those PSUs and Indian companies were selected that tend to have their corporate/head office in National Capital Region (NCR). The officials were selected on the basis of their involvement with e-government initiatives within departments in central and state governments in India. The questionnaires got hand delivered to the respondents by volunteer students and for this prior appointments were taken.

4. Results and analysis

Responses were received from 273 officials in India (see Table II). Break up include 93 government organizations (including states, central ministries and their departments), 90 Indian public sector undertakings and 90 Indian corporations.

Profiles of respondents

Work experience of the respondents that are involved in e-government initiatives and in field of IT are presented as frequency distribution in Table III. Most of them participated on the condition that their identity is not disclosed. In total, 74 respondents had less than five years experience. There were 54 interviewees with an experience more 15 years. These were mostly the officers at director level and have been working on e-government projects in India for several years.

Table II summarizes the profiles of the usable respondents. Data were collected from 19 states of India. Majority of the state portals are maintained by National Informatics Centre, India. A total of 43 central ministry officials responded to the

Profile	Number of respondents
States	19
Central ministries	43
Independent offices	14
Government departments	17
Public Sector Undertakings (PSU)	90
Indian companies	90
Total	273

Table II.
Profiles of respondents

Experience (in years)	Number of respondents
NA	72
Up to 5	74
5 to 10	51
10 to 15	22
15 and higher	54
Total	273

Table III.
Experience of respondents in E-government and IT

questionnaire and gave information about the portal of their department. Data were also collected from 14 independent offices and 17 departments in India. A total of 90 usable responses were received from the public sector undertakings and Indian companies.

Frequency distribution

Table IV gives a breakdown of Integration maturity on the Lickert scale for 93 portals of government organizations in India. Data revealed that 63 per cent (59 out of 93) of these government portals have initiated some efforts for integration. This signifies that government departments are either connected or, at least, communicating to each other. Table IV further elaborates the situation of portals with regard to integration maturity. Most of the portals that have started working on integration are some where between the levels of initiated and partially initiated (2 and 3 on Lickert scale). This implies majority of the portals are at a lower level of integration. Examining the development of each dimension individually shows that most of the government portals have initiated Communication Integration (83 per cent). Only 52 and 57 per cent of government portals have initiated process and data integration. Moreover, there are very few government portals that have achieved significant levels of integration on any of the dimensions. It has been noted that only one government portal (www.tenders.gov) has completely implemented process integration and is also at significant levels of the other two dimensions.

Adoption space

Results of integration adoption are presented and the coordinates of the three dimensions of all the portals of organization (Government Departments, PSU and Indian companies) are presented (up to two decimal places) in Table V. The coordinates of the sample average of each dimension of government portals, is at the initiation

Table IV.
Frequency distribution of government portals on integration maturity

Integration Maturity (Lickert Scale)	Normalized Euclidean Distance	Data integration	Process integration	Communication integration
Not initiated	34	40	45	16
Initiated	43	33	33	45
Partially initiated	15	16	13	29
Advance stage of implementation	1	4	1	3
Complete implementation	None	None	1	None
Total	93	93	93	93

Table V.
Positions of the surveyed organizations in interoperability adoption space along three dimensions

Indian portals	Normalized Euclidean Distance	Data integration	Process integration	Communication integration
Government	2.34	2.23	2.00	2.61
Public sector undertakings	2.2	2.09	2.18	2.28
Indian companies	2.89	2.85	2.51	3.23

level. It should be noted that every dimension of each of the organization portals is far from the position of (5, 5, 5) i.e. position of complete interoperability. The position of Indian company portals is higher than the position of government and PSU portals in interoperability adoption space in India. Also, it should be mentioned that except for process integration, government portals are performing better than PSU portals in all the dimensions. The sample average of PSU portals at each dimension is at the "Initiated" level.

Comparing the dimensions vertically shows that the position of process integration is the farthest from the final destination (5, 5, 5) in all the three types of organizations. In adoption space, the position of the organization is measured by the Euclidean Distance, and it shows that in India the position of Indian company portals is slightly better than positions of government and PSU portals in India in the adoption space.

Sample average gives the central position of all organizations. However, the collected data has shown significant variations. For meticulous study, Table VI shows the averages of top ten portals of all the organizations that have highest level of integration as compared to the rest of the surveyed portals. Similarly, the bottom ten portals that have lowest level of integration have been computed. This result help us compare the performances between the organizations and with in the organizations as well. As seen earlier in Table V, position of government portal in adoption space is 2.34. But the best ten government portals have higher integration maturity. The Euclidean distance of the best ten average government portals is 3.63, which imply that most of the government portals are close to advanced stage of implementation of integration. On the other hand, average of bottom ten of government portals is very low and shows that these portals have not yet initiated integration. The average of process integration of bottom ten portals is below 1, which implies that process integration has not been initiated and also there are few government departments that are not even familiar with the factors of this dimension. Comparing the averages of top ten portals of government and PSU, indicate that few government portals have

Dimensions	Top ten portals	Bottom ten portals
Government portals		
Normalized Euclidean Distance	3.63	1.32
Data integration	3.66	1.22
Process integration	3.56	0.77
Communication integration	3.68	1.76
Public sector undertaking portals		
Normalized Euclidean Distance	2.97	1.45
Data integration	2.92	1.51
Process integration	3.06	1.24
Communication integration	2.94	1.58
Indian company portals		
Normalized Euclidean Distance	3.81	1.80
Data integration	3.72	1.70
Process integration	3.67	0.99
Communication integration	4.04	2.43

Table VI.
Comparing the averages of best performing portals (top ten) and the portals at the lowest position (bottom ten) in interoperability adoption space of the surveyed organizations

achieved higher level of integration than the PSU portals. On the contrary, bottom ten portals of PSU have higher averages than government portals. This signifies that integration maturity of government portals is varied. The position of Indian companies is better than the position of government portals when comparing the best ten and the bottom ten portals.

In a three-dimension adoption space, the positions of three types of organizations are plotted in MATLAB shown in Figure 2. The adoption space is a three-dimensional Cartesian coordinate system with the origin labelled as O. The *x*-axis represents the degree of sophistication of data integration. The *y*-axis represents the degree of sophistication of process integration. The *z*-axis represents the degree of sophistication of communication integration. Figure 2 has three clusters: Averages of Sample, Top ten and Bottom ten. Each cluster contains the position of surveyed organizations.

As discussed earlier, the position of Indian company portals is slightly better than the position of government and PSU portals. Moreover, the development of government portals is varied.

Significance

- *Government portals and portals of Indian companies:* In Figure 2, the sample average position of Indian company portals (2.85, 2.51, 2.32) in the adoption space model is higher than the position of government portals (2.23, 2.00, 2.61). In Table VII, results are given for the comparison of level of integration of Indian companies and government departments and ministries. Comparison has been done with Euclidean Distance and with the average of each dimension. Each average of Indian company portal is significantly higher than the average of government department and ministries. Significance has been computed and given in the Table VIII.

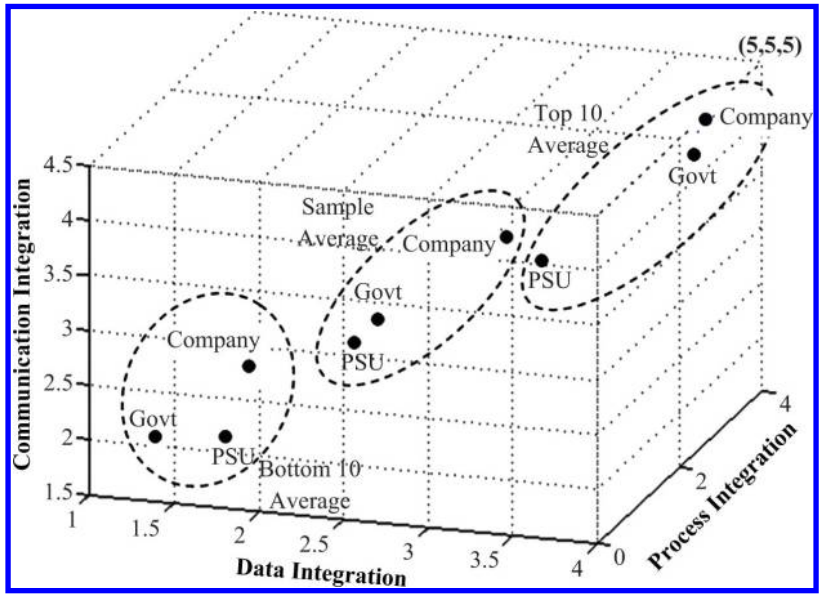

Figure 2.
Three-dimensional adoption space

	Government portals	Indian company portals
Average		
Normalized Euclidean Distance	2.34	2.9
Data integration	2.23	2.85
Process integration	2.00	2.51
Communication integration	2.61	3.23
Variance		
Normalized Euclidean Distance	0.69	0.56
Data integration	0.83	0.61
Process integration	0.93	0.82
Communication integration	0.72	0.54
	t-test (*p*-value)	Remarks
Normalized Euclidean Distance	0.00	Indian Company portals > Govt. portal
Data integration	0.00	Indian Company portals > Govt. portal
Process integration	0.00	Indian Company portals > Govt. portal
Communication integration	0.00	Indian Company portals > Govt. portal

Table VII. VI. Comparing level of integration – government portals and portals of companies in India

	Government portals	Indian PSU portals
Average		
Normalized Euclidean Distance	2.34	2.21
Data integration	2.23	2.09
Process integration	2.00	2.18
Communication integration	2.61	2.28
Variance		
Normalized Euclidean Distance	0.69	0.45
Data integration	0.83	0.52
Process integration	0.93	0.6
Communication integration	0.72	0.5
	t-test (*p*-value)	Remarks
Normalized Euclidean Distance	0.00	Govt. > PSU
Data integration	0.09	Govt. = PSU
Process integration	0.06	Govt. = PSU
Communication integration	0.00	Govt. > PSU

Table VIII. Comparing level of integration – government portals and PSU portals in India

T-test: *p*-value of *t*-test of the two organizations with Normalized Euclidean Distance, Data Integration, Process Integration and Communication Integration is less than 0.05, which proves that the level of Integration in portals of Indian companies is significantly higher than in government portals.

- *Government portals and public sector undertakings portals:* Position of sample average of government portals (2.23, 2.00, 2.61) in the adoption space models is higher than that of PSU portals (2.09, 2.18, 2.28) (see Figure 2). Like Table VII, Table VIII shows the results for the comparison of level of integration of government portals and public sector undertakings portals. The averages of

government portals are higher than the average of PSU portals except at the level of Process Integration. The sample average of process integration of PSU portals is 2.18 as compared to the process integration average of government portals, which is 2. Significance has been computed and given in the table.

T-test: *p*-value of *t*-test of the two organizations with Data Integration and Process Integration is not less than 0.05, which proves that the level of Integration in portals of PSU is not significantly higher than in government portals. Also, the *p*-value of *t*-test for Normalized Euclidean Distance and Communication Integration of government and PSU is less than 0.05 but with government > PSU, which shows that at level of Communication Integration and overall (NED) government portals are at a higher level than PSU.

5. Discussion

The previous results are depicted through candlestick chart of each dimension and normalized Euclidean distance for three types of organizations (government, PSU and company) and are presented in Figure 3. Furthermore, the results of each organization have been divided into three different categories: averages of best performing portals (top ten) for integration maturity; averages of the portals at the lowest level of integration (bottom ten) and sample average. The position of each organization is evaluated on a five-point Lickert scale and the data has been provided in the previous section. The findings of survey and analysis of the government portals in India yielded certain insights.

The portals of Indian companies are performing better than the portals of government and PSUs for achieving an interoperable position. In Figure 3, it can be

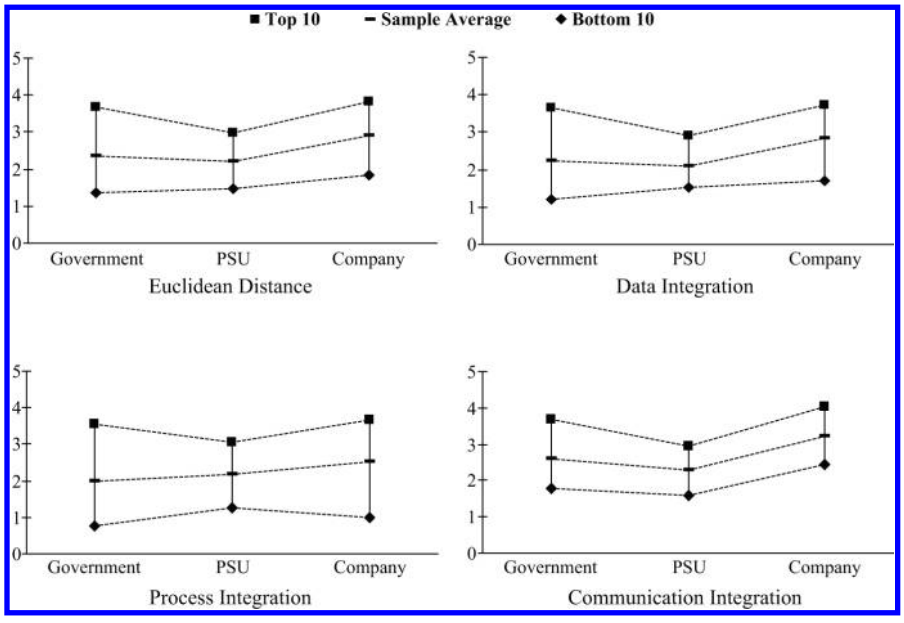

Figure 3.
Candlestick charts of all the averages in interoperability adoption space of each organization

observed that the position of Indian company portals is clearly better than the position of government and PSU portals in India. A comparison of the averages of best performing portals, lowest level portals and sample; reveals that, the position of Indian company portals is consistently higher than position of government and PSU portals except for the average of bottom ten portals of process integration of PSU portals. This is not unexpected as it has always been stated (Scholl, 2006; Escher and Margetts, 2007; Morgeson and Mithas, 2009) that the growth of government is far behind the growth of companies', reasons being legislative barriers, administrative barriers, technological barriers, social barriers etc. This has also been seen that portals of Indian companies have achieved higher level of integration as compared to government portals in India.

Figure 3 also shows that the best ten government portals have achieved higher position of integration as compared to the best ten performing portals of PSUs in India. On the contrary, level of integration of the weakest government portals (bottom ten) is lower than that of weakest PSU portals, except for communication integration. This implies that dispersion of government portals is significantly higher than Public Sector Undertaking portals, i.e. the development of Public Sector Undertaking portals seems to be more consistent. Therefore, we cannot make a conclusive statement on the performance of government and PSU portals for achieving interoperability as the portals with high level of integration and portals at the lowest level in government are moving in opposite directions. This has also been proved through *t*-tests in the previous section. One may say that because of high dispersion in government portals the mean value is not very significant.

High dispersion in level of integration of government portals in India for achieving interoperability shows that some progressive departments in government have taken lead, yet there are also significant laggards. Except for communication integration, the position of bottom ten government portals is at the lowest level of integration among the three types of organizations in India. For achieving a one-stop government portal, both vertical and horizontal integrations are essential. This signifies that all the portals of government must be integrated and for this each portal should attain a high level of integration. The portals with the lowest level of integration in government in India will determine when government will actually attain full horizontal integration and hence achieve an interoperable portal.

Weakest factors of all dimensions of integration in government portals in India

The results of adoption space highlight factors of every dimension that are comparatively weaker than the other factors and require relatively more improvement than the other factors in government portals. These factors have either not been initiated or are at a relatively low scale. Focusing on these factors will help in increase the level of Integration and thus help in achieving interoperability. We have discussed lowest quartile of each dimension. Also, as mentioned earlier that the data has been collected for scale 0 which implies that the respondent is unfamiliar with the terminology of the factor and does not understand its importance for an interoperable portal. One of the major reasons of these factors being low on Lickert scale is that organizations are not aware of the factor.

Data integration: Factors that are the weakest in this dimension are the specialized technologies for supporting metadata (data of data) that are required to accomplish data integration.

(1) *Ontology*: Ontology is categorizing things that exist in same domain. The need for ontology arises for development of portals as government has enormous data from different sources. These data are required to be managed and categorized for an efficient portal. For vertical and horizontal integration, Ontology will effectively combine the data and information coming from multiple heterogeneous sources. Moreover, with the help of ontology the issue of semantics, which is an upcoming problem, can be controlled. The average of this factor is 1.47 on five-point scale among 93 portals of government organizations, which implies that in most of the government organizations ontology has not been initiated. One of the major reasons behind this slackness is that a significant number (31 out of 93) of government officials are ignorant about ontology and therefore, are not making any effort for its use.

(2) *Adoption of open standards*: According to Coyle (2002), features of open standards are that:

- anyone can use the standards to develop software;
- anyone can acquire the standards for free or without a significant cost; and
- the standard has been developed in a way in which anyone can participate.

Apart from being inexpensive, the use of open standards reduces the risk of vendor lock-in and to guarantee data preservation. The position of this factor is 1.62 on a five-point scale i.e. in most of the organization portals this factor has not been initiated. One of the main reasons behind this low average of the factor is same as above that 29 out of 93 government portals are not aware of the importance of the factor.

(3) *Message Formatting Language implementation:* The Message Formatting Language will help in defining the format of data messages and documents that can be exchanged between applications. This includes defining the standards for the data exchange between the organizations. The involved organizations can be the internal government organizations as well as outside agencies (IFEG Version 2.4 Report). Average of this factor is 1.51 out of 5. In more than 50 per cent of the government portals show lack of any initiative on this though majority of government officials (80 per cent) are aware of its importance. Therefore, the reason for low scale may be varied.

(4) *Resource description framework:* Data Resource Description defines the language for representing metadata. Metadata commonly defined as data about data, relates to a set of attributes that will capture the semantics of individual data items (IFEG Version 2.4 Report). Achieving interoperability for enormous data of government requires metadata and therefore data resource description. Like the previous factor, this one also has not been initiated in 50 per cent of the government portals and so its average is 1.52 out of 5. But unlike the factor of Message Formatting Language, the 33 per cent of the government officials are not familiar with the terminology and hence do not understand the significance of the factor.

Process integration: In government portals, Process integration is the farthest dimension from the position of interoperability out of the three dimensions of Integration. Most of the factors in the dimension are weak. But weakest factors that has either not been initiated or have a very slow progress are the following:

- *Adoption of open standards:* As discussed previously, this factor is essential for the development of an interoperable government portal. In the dimension of process integration, adoption of open standards has not been initiated in majority (54 per cent) of the government portals. Few government portals have adopted open standards for combining the processes in some less important sections hence there has been no improvement. As a result, approximately 60 per cent of the government portals are very low at this factor. The same is in data integration, 33 per cent of the government officials working on portal development are not aware of the significance of the factor. Therefore, because if this is the overall position of the factor is effected.
- *Reuse:* Software reuse is the process of implementing or updating software systems using existing software assets (Department of Defense, 1996). This factor has an average of 1.56 out of 5. Sizeable government officials (27 out of 93) are ignorant about potential software reuse. Promoting software reuse will have great bearing on productivity, quality, and reliability, and the decrease of costs and implementation time in e-government projects. An initial investment in starting software reuse will pays for itself after few phases. The development of a reuse process and repository produces a base of knowledge that improves in quality after every reuse, minimizing the amount of development work required for future projects, and ultimately reducing the risk of new projects that are based on repository knowledge.

Communication integration: Communication integration deals with the use of electronic computers, computer software, and computer networks to convert, store, protect, process, and transmit and securely retrieve information. This dimension forms the platform for integration. By improving the weakest factors of this dimension the position of Communication Integration will improve that will further help achieve the position of interoperability. These are explained as following:

- *Web and internet technologies*: Governments worldwide are increasingly using the internet to provide public services to their constituents (Layne and Lee, 2001). Much of the research has focused on practical and technical dimensions while research on how to improve e-government for users remains scarce (Bertot and Jaeger, 2006). Web-based technologies offer governments more efficient and effective means than traditional physical channels to better serve their citizens (Evans and Yen, 2006; D. Evans and D.C. Yen, E-Government: Evolving relationship of citizens and government, domestic and international development, *Government Information Quarterly,* Vol. 23 No. 2 (2006), pp. 207-35. Article | PDF (222 K) | View Record in Scopus | Cited By in Scopus (6) Evans and Yen, 2006). This is considered one of the vital factors of the communication integration dimension. Unfortunately, more than one-third of the government officials are unfamiliar with web and related technologies or have

superficial knowledge as is evident from large number of government portals (57 per cent) are lacklustre and disorganised.

- *Intelligent design of supporting applications (mobile, etc.) by users:* The devices and channels that access government services and applications can be of multiple types. Therefore, applications that can support all the formats are becoming essential. This will not only make the portal flexible but also reachable to most of the citizens (IFEG Version 2.4 Report). A sizeable government officials (30 per cent) involved with portals development do not have proper knowledge of intelligent design. Only 21 out 93 government portals have initiated intelligent design of supporting applications. The average for this factor is the lowest among all the factors of all dimensions (1.29).

6. Research implications

The results from this study provide organizations with a better understanding of factors associated with the adoption of interoperability, which will be useful reference for them to develop appropriate strategies. A high dispersion is found in level of integration of government portals in India. Therefore, for achieving a one-stop government portal, the Government need to focus on those portals with the lowest level of integration. Skilful planning is required for both vertical and horizontal integrations as both are essential for an interoperable portal.

Additional efforts are required to offset the weakest factors of each dimension by way of infusing more on capacity building and skill development among government officials and also marking extra resources allocations. This will enable a positive environment for achieving integration and interoperability. It will be helpful to spread the awareness and significance of the factors, which reflect weakness on the part of government and its employees. The critical success factors would be commitment of key contributors, change in work culture, re-engineering of organization processes and e-inventing governments.

The adoption model can be used for other technologies such as enterprise architecture and enterprise architecture integration that being adopted these days (Kamal, 2009). Enterprise architecture (EA) is particularly relevant to organizations that have a large portfolio of applications where problems such as functional overlap, duplication and redundancy are common. Enterprise application integration (EAI) refers to "the plans methods, and tools aimed at modernizing, consolidating, integrating and coordinating the computer applications within an enterprise" (McKeen and Smith, 2002). At technology level, EAI involves the development of messaging middleware, an integration broker that serves as a hub for inter-application communication, and adapters that allow applications to interface to the integration broker.

7. Conclusion and future work

The present study provides empirical data about interoperability adoption in government portals of India and analyzes the current level of integration sophistication along three dimensions in Indian government portals. The study compares the results with portals of Public Sector Undertakings and Companies in India. An interoperability adoption framework has been used that helps organizations to examine their current status in the e-government environment from the perspective of three domains, namely data integration, process integration and communication

integration. The framework also provides guidelines for government organizations, which need to understand the potential benefits of adopting interoperability technology and then assists them in choosing the appropriate path and proper applications.

The contribution of this paper is two-fold. First, it generates insights into interoperability adoption in portals of government organizations, PSUs and companies in India by providing empirical data through survey. Second, the research highlights the weakest factors of each dimension that are at a lower level and require relatively more resources than other factors to achieve the desired position of interoperability. One of the critical reasons for government portals in India not being able to achieve interoperability is the government official's poor knowledge and appreciation about various issues of interoperability and integration. In general government is not known to have quality people and over this, the lack of technical skills adds up to great inertia governments are infamous far.

This study is the first of its kind to have attempted assessment of the position of interoperability in government portals in India. There are some limitations, which hindered this study from proceeding efficiently. First, only the National Capital Region based Public Sector Undertakings were approached, due to travel and time constraints. As future work, targeting other regions may generate additional insights. Second, this study provides a snapshot analysis of current interoperability adoption. However, e-government is a fast-changing phenomenon and the dynamics associated with it can hardly be well understood in one-shot study. A longitudinal study can be used to find out e-government development trends across periods whereas a snapshot observation cannot. Further, in this study, the equal weights are given to each factor. A future work may consider assigning relative significance (weights) for factors along each dimension. Each factor can be given weights and accordingly suitable strategy will be required to achieve the desired level of sophistication.

Inspecting the results of the survey reveals that while interoperability is an important precondition for one stop portal, several government organizations in India are far from making any serious efforts for the same. Given the complexity of subject and sheer size and spread government organization, it would be unwise to speculate how much time it will take for government portal to be interoperable and therefore achieve some reasonable level of maturity. Furthermore, the dimensions in this paper are identified primarily based on studies from literature and discussions with experts and experience with e-government initiatives in Indian government portals. The underlying theory of this adoption model shall be applicable to other governments as well. The dimensions and their factors can be further developed according to the requirements for portals.

In summary, this study has been helpful in gaining insight into what is coming in a way of government organizations to achieve a one-stop portal. Interoperability is essential. Further, adoption of technology of interoperability will decrease transaction costs and enhance the reliability of government organization.

Notes

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Appendix

A survey to study the issues of interoperability in developing one-stop portal

URL of your portal: www.

In your opinion how far has your organization's portal been able to achieve the following dimensions for a one-stop portal: (Please tick ✓ in appropriate column)

Data integration
(Scale: Not Aware, Not Initiated, Fully Implemented)
An appropriate data centre is in place
An architecture to combine all relevant data accessible through data
A process for updating input of data
Adoption of process for testing of compatibility of updated software versions
Integration of the services delivery departments (systems) to the portal
Ontology for effectively combining the data/information from multiple heterogeneous sources
Mechanisms adopted for data security
Adoption of open standards to reduce the risk of vendor lock-in and to guarantee data preservation
Data replication implementation (automated real time data synchronization enabling locality of access for data access regardless of source implementation)
Data transformation implementation (support data cleansing and metadata interchange through leveraging industry standards) Message Formatting Language implementation (format of data messages and business documents that can be exchanged between applications)
Data Modeling usage [UML (Unified Modeling Language) to provide the conceptual design primarily for human interpretation]
Resource Description Framework in place (representing metadata) [Interoperable character set standards to support the interchange, processing, and display of the written texts of the diverse languages and technical disciplines of the modern world]

Process integration
(Scale: Not Aware, Not Initiated, Fully Implemented)
All the processes for the portal have been codified
Processes have been formulated for connecting service delivery departments to the portal
The processes are being upgraded regularly and new technology is being applied to do so
Open standards are adopted for combining the processes
The architecture for combining different processes has a middleware
Adoption of standardized reusable software components and processes across departments

Communication integration
(Scale: Not Aware, Low, High)
Level of Networking of the data centers of the services delivery departments
Speed of connectivity (bandwidth, response time)
Quality of services (delay and loss of packets) is being provided
Deployment of web and internet technologies in the relevant departments of the Government
Interoperability of the existing technologies
Security measures for the main server(s)
Adoption of Network Layer Security standards for implementing virtual private network (VPN) and secure remote access
Intelligent design of supporting applications (to convert the contents to a format understandable by the multiple access devices/channel, e.g. mobile, etc. by users)

Table AI.
Portal centric

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