International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

# A Stage Model for Cloud Computing Adoption in E-Government Implementation

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**Abstract:** ***As Governments continuously look for ways to improve their service provision, there is need for restructuring processes and effectively using technology to improve efficiency and effectiveness of their functions. Cloud computing is one of the recent technological trends that support these efforts. The promise of cloud computing has captivated organizations globally. Considering e-Government is one of the sectors that is trying to provide services via the internet, cloud computing is a suitable model for implementing e-Government architecture to improve e-Government efficiency and user satisfaction. The challenge comes in the adoption process. Organizations are faced with question of how to best adopt cloud computing. Existing frameworks of cloud adoption look at different aspects of cloud but stop short of taking a view of the complete spectrum and suggesting adoption path. This study takes a concept centric approach by proposing a stage model for adoption of cloud computing in e-Government. The objective of the model is to help plan about the path to cloud, especially when it is so 'Cloudy' and evolving. The organizations at different stages of cloud adoption exhibit different characteristics and possess distinct competencies, and organizations should not bite more than they can chew, lest their programs fall flat. In this study, the adoption of cloud computing in implementing e-Government services was done through primary research and system modelling. Out of which, a stage model was developed proposing an adoption path for cloud computing in e-Government services. The model will guide Governments in creating cloud-computing strategy by identifying the distinct stages in progression. This makes stage model the most suitable for adoption of cloud computing in e-Government.***

**Keywords:** e-Government, cloud computing, stage model, adoption

## 1. Introduction

E-Government (Electronic Government) means the operation of providing governmental services to the citizens, businesses or to other governments electronically using Information Communication Technologies (ICTs) especially the Internet (Alvarez 2012). That means the governmental services are turned into electronic services ( E-services).

E-government started emerging in the nineties of the last century as project to provide e-services to the citizens in order to save cost, time and effort. With this progress of technology, the development models of E-government began to appear to put the scientific steps to adopting and development of e-Government from zero point. These development models were developed according to different standards that change from one country to another (Alvarez et al 2012).

They developed to become maturity models to assess the progress of any e-government projects. With this change, Cloud Computing began to appear in the horizon as a revolution in the world of information technology. Cloud computing sparked widespread controversy about the future of information technology fields including E-government (Gens, Frank 2013).

Cloud computing means providing the computer resources as services via the internet by providers to customers. These computer resources include the power of CPU processor, storage space, bandwidth and the required applications to manage any operations (Brodkin 2013). Cloud computing services include operation, maintenance and update and manage the applications. That means the computer resources are turned from products to services and the payment of the services done per use.

## 2. Related Work

### 2.1 Case Studies on implementation of cloud computing

Table 1 summarizes the findings of the Case Studies, indicating the service models that are deployed in each case, along with the chosen solution and the benefits.

**Table 1:** Case Studiesfindings on implementation of cloud computing.

| Case study | Service Model | Solution | Benefits |
|---|---|---|---|
| US Government-USA.gov | IaaS | Terramark Enterprises Cloud | 90% saving in operating costs and infrastructure Shorter migration period, Charges based on the use, Enhanced security |
| DoD –DISA | IaaS | RACE | Serves a large number of users, Fast access to resources, Secure and automated self service infrastructure |
| NASA | SaaS,PaaS, IaaS | Nebula | Flexibility, Cost savings, Power savings, environment friendly, Promote collaboration and research |
| City of Edmonton | PaaS | OGDI, Windows Azure | Fast and low cost solution, Enhancement of transparency, flexibility, and digital public services, Fast and effective information dissertation, Decreased IT procurement cycles, automated scaling efforts of analytics applications |
| Japan | IaaS, PaaS, SaaS | The Kasumigaseki Cloud | Reduced costs, Environmental friendly IT operations, Better collaboration, No need for individual systems |
| UK | IaaS, PaaS, | G-cloud (in | Savings of $200 million, Rationalization of existing provision, Reduced |

| | | | |
|---|---|---|---|
| | SaaS | progress) | bureaucracy and management costs, Greater level of awareness of services, Transparency and compromise on supplies. |
| Germany | PaaS, SaaS | goBerlin(in progress) | Development of innovative apps and new digital public services, New forms of collaboration between public sector and companies, Guaranteed interoperability between different services, Trustworthy and safe IT services, Promoting open Government data |
| Greece | IaaS | Open Gov private cloud GRNET | Saving of more than $1.5 million, Easier migration and disaster recovery procedures, Improved energy efficiency, Rapid development of new services |

**Table 2:** Comparison of cloud architectures/frameworks suggested for e-Government

| Reference | Presented as | Special characteristics | Potential advantages |
|---|---|---|---|
| Zhangand chen (2010) | A framework based on cloud computing layers | - | Enhance productivity, efficiency, transparency, participation and Collaboration of traditional e-Government |
| Sharma and Kanungo (2011) | Master/slave model | Distributed data centers | Experiments showed the architecture is energy efficient, eco-friendly and cost-effective. |
| Chuod et al. (2011) | Deployment of Eucalyptus archtecture | Central cloud center owned by the Government | Data privacy |
| Mukherjee and Sahoo (2010) | Deployment of Hadoop | Volunteer nodes, Knowledge Base and Infernce Engine | Can act as expert system |
| Kim et al.(2011) | Deployment of Hadoop | Mobile | Integrated e-Government services to many users |
| Chanchary and Islam (2011) | A framework based on cloud computing layers. | - | Full integration of IT resources dispersed at different Government agencies |
| Vidhya (2013) | Private cloud | Polling system | Scalability and cost reduction |
| Hunget al. (2011) | Private cloud | Distributed data centers | Reduction of common devices, enhancement of service management and better utilization of resources |

## 3. Analysis of primary data from Machakos county Government

Despite of the fact that the county Government of Machakos has some online services, it is evident from the data collected that the Government does not have a structured way of adopting cloud computing in its e-Government initiatives. Much of the cloud computing is used for personal purpose, meaning it is a personal initiative of the IT staff to deploy the services for their own convenience but not to deliver service to the citizens. This confirms the adhoc nature of cloud deployment as proposed in the stage model.

There is evidently no adequate awareness even among the IT staff on cloud computing and intentions of the Government to deploy and utilize it in service delivery. Despite of the service not being deployed, staff have confidence that cloud computing is the way forward in e-Government deployment. The IT staff, who are to support the e-Government services, are not able to tell the extent of cloud computing adoption in e-Government services. From the proposed model knowledge base is key to deploying cloud computing. Accordingly, inadequate knowledge is characteristic of the proposed stage1 of the proposed model. The cost benefits and value for money are factors, which respondents seem to be certain about, as the gains for deploying cloud computing. Currently, e-Government services are utilised by staff through tax compliance and other statutory services, which are mandatory obligations of the citizens to the Government.

It is therefore clear that citizens are ready to consume cloud services once the Government deploys them, going by the rate of consumption of the currently available few Government cloud services. The initiative must be from the Government side. Guiding the Government on how to go about adoption of cloud computing in e-Government implementation will therefore provide a big solution to the current e-Government status.

It is evident that there is no sufficient knowledge in the public to enable them make decisions on cloud computing adoption. Cloud computing is “just a type of outsourcing in IT which offers interesting technical environment”. Despite of the inadequate knowledge, the respondents are confident that cloud computing would increase efficiency in e-Government service delivery.

However, respondents are concerned about security, privacy and vendor lock in once the cloud computing is adopted for e-Government implementation. This scenario provides a fertile ground for systematic deployment of cloud computing. The staff have a positive attitude towards the cloud, despite of the few concerns, which are adequately addressed by the cloud computing adoption stage model provided in this study.

Currently, data storage and email/messaging are the major cloud based services enjoyed among the e-Government services. There has never been a formal discussion at the Government level on how and when to adopt cloud computing in offering e-Government services. It is very clear that the Government has never enlisted the stages and cycles involved in implementation of cloud computing in e-Government.

From the stage model presented, SaaS is identified as the service model component at the initial stage of the model. The findings confirm the same because the current cloud based services in use are SaaS based. It is expected that the

cloud adoption will take place in progression despite of the current status.

The little cloud services utilised in e-Government are majorly owned by private vendors, only some Government agencies own a small proportion of the cloud services utilised by the Government. For this to happen, respondents were very clear that security, legal and cloud computing market knowledge and expertise were critical. Out of the findings it is evident that there is no structured way of adopting cloud computing in e-Government implementation.

## 4. The Stage Model for cloud adoption in e-Government implementation

The stage model presented in this section, was developed following the general principles of stage modelling procedure suggested by Solli-saether (2010). According to them, a stage model evolves to its final state through a process that has the following intermediate states: "Conceptual Stage Model", "Theoretical Stage Model" and "Empirical Stage Model".

In his study, Hans Solli-Sæther (2010) developed a stage model for e-government interoperability. He applied the stages of growth modelling process and proposed a stage model for e-government interoperability. This was based on ideas from previous research, and ideas from practitioners. The theoretical workwas conducted as a thorough literature review of inter-operability research. Putting together ideas from previous research and ideas from practitioners, he suggested a growth model that has four sequential stages for e-government inter-operability. The stages occur as hierarchical progression and involve both organizational, semantic, and technical activities and structures. By systematically developing interoperability in terms of aligning work process (stage 1), knowledge sharing (stage2), joint value creation (stage 3), and ultimately strategy alignment (stage 4), long-wanted benefits from e-government might be expected (P. Gottschalk 2010). The stage model for e-government interoperability is shown in Figure 1.

### 4.1 Using the service and deployment model to develop the cloud adoption stage model

As we move from SaaS through PaaS to IaaS, flexibility of purpose increases (Figure 1). That way an organization needs to have very clear purpose why they need a cloud solution. On the contrary, along the same order, the level of abstraction decreases. A user only interacts with the interface without bothering with the background details. Therefore in the order of service levels, SaaS presents the best option for a one time user to enjoy the services of cloud computing. This way, e-Government can utilize the different Software services in an ad-hoc manner without any consistency nor strict guidelines to solve one-off problems.

Similarly, as you move along the deployment model from public through hybrid to private control and governance increases while economies of scale increases. This is a clear indication that at the lowest level, public cloud would be the most appropriate for e-government adoption while private cloud is the most suitable for a large entity. At some point in the progression of cloud adoption, an organization will utilize both public and private cloud models as they transit to a solitary state. It is would be expected that a government system adopts cloud computing in clear consideration of economies of scale and with keen interest on control and Governance of the service. At the highest level of adoption, the Government would need policy to drive the cloud services to guidance on issues of security, data ownership, legal issues, flexibility of use, return on investment and availability over the targeted population.

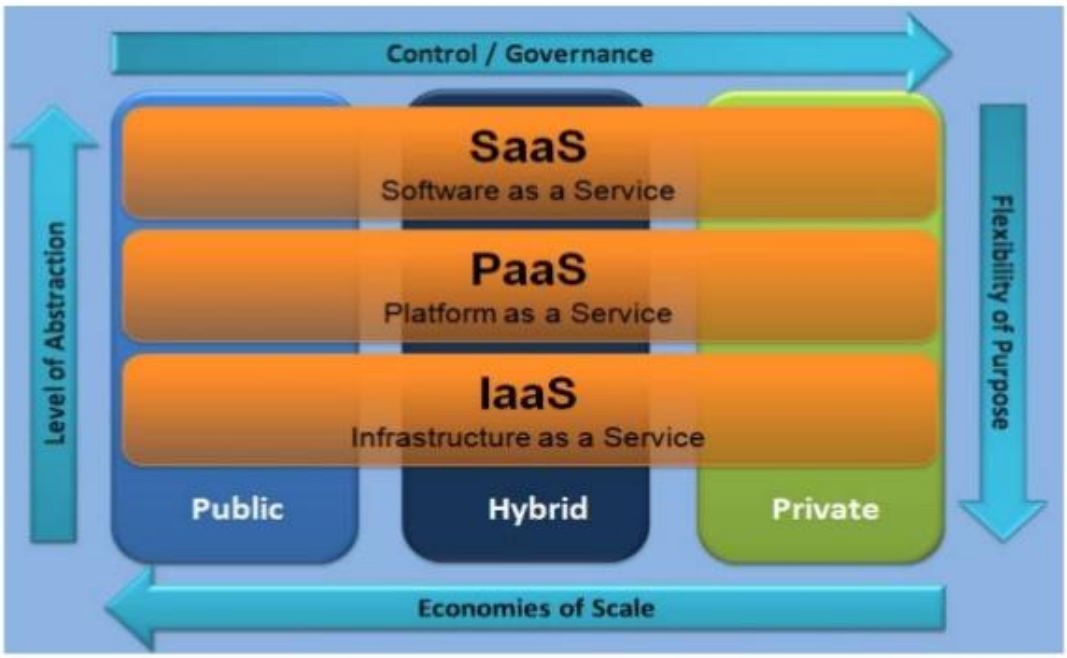


**Figure 1:** Service model against deployment cloud computing model

Given the successiveness of the stage model by P. Gottschalk (2010) and the service against the deployment model, we can deduce that the two models have a systematic way of implementation. One level integrates to the other one. Otherwise, it is also possible to be at two levels at the same time but progressively feed into the next more suitable level as the adoption appetite increases and as the systems grow.

Similarly, borrowing from the integration of the service and deployment models, it is clear that for e-Government to adopt cloud computing in its implementation, there has to be a defined approach. This can be achieved by first identifying the stages so involved in relation to an existing models, service model shall be used in this case. It is expected that at the initial stages of adoption of cloud computing some organizations will implement solutions which only address specific cases. As the system grows, a structured way of addressing cloud solutions has to be developed. In the later stages, the cloud adoption process has to be driven by policy, especially when so many players are in place trying to claim space as users as well as clients.

As presented in Figure 2, the proposed model consists of four stages, Ad-hoc e-Government solutions (Stage 1), cloud based public clouds (stage 2), e-Government clouds (stage 3) and e-Government cloud policy (stage 4). The horizontal axis represents the degree of cloud computing adoption in e-Government, and the vertical axis represents the organizational and technological complexity of the solutions included in each stage.

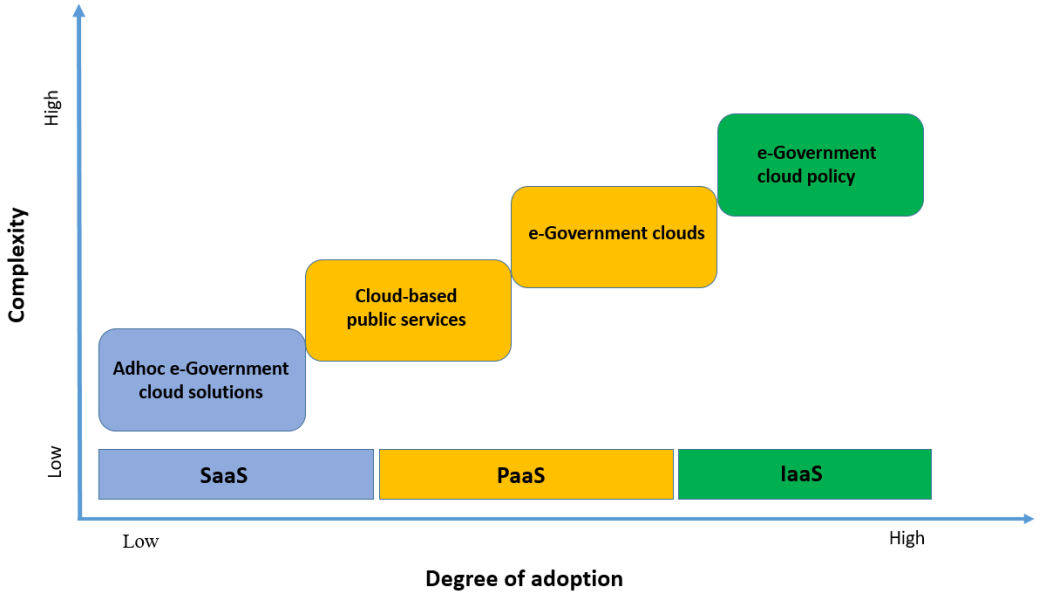


**Figure 2:** A Stage Model for Cloud Computing Adoption in e-Government

Different agencies or public organizations in a country may use cloud computing in various ways. The stage model provides a guide into how e-Government can systematically adopt cloud computing against the already existing models. From the known service model, a Government entity can evaluate the level of adoption depending on the services they are already utilising (Zhang, 2010). As such, in relation to the cloud adoption model, they are able to establish their level of adoption. Out of which they can systematically adopt cloud computing in e-Government processes as guided by the stage model.
Table 6 highlights the main differences between the stages of the model, which forms the basis of the model as shall be discussed in the subsequent headlines.

**Table 2:** Main differences among model stages

| | STAGES | | | |
|---|---|---|---|---|
| Variables | Stage 1<br>Adhoc e-Government cloud solutions | Stage 2<br>Cloud-based public services | Stage 3<br>e-Government cloud(s) | Stage 4<br>e-Government cloud policy |
| Type of services | Internal agencies | External (citizens and businesses) | Internal and external | Internal and external |
| Provider | Individual vendors | Individual vendors | Government | Government and individual vendors |
| Main change in | Procurement of IT services for Government | Provision of public services | Architecture of e-Government systems | Government IT strategy |
| Service Model adoption | SaaS | SaaS/PaaS | PaaS/IaaS | IaaS |

**Stage 1: Ad-hoc E-Government Cloud Solutions**
At this stage, agencies or public organizations use cloud computing only for covering their needs in IT resources and enhancing collaboration with other agencies, and not for providing digital services to citizens or businesses. Due to absence of Government Cloud(s), the cloud services (SaaS) are entirely provided by individual vendors. In the absence of an official Government policy, each agency decide how

and to what extent it will use cloud services on its own. For this reason, adoption of cloud computing in this stage is very erratic. With no central guidance or clear familiarity with cloud computing adoption concept, there will be few agencies that will still use cloud computing most likely on trial and error basis. Thus, the degree of adoption in this stage will be very low.

The organizational complexity of this stage is expected to be low too, considering that the change that happens is internal and limited. As for the technological complexity, the organization continues to operate with little technological change, due to the uncertain nature of the adoption. The provision of cloud services in this stage can be considered as a form of outsourcing. For this reason, the degree of engagement is also very low and the agencies can revert to the previous modes quite easily. The low degree of adoption combined with the low technological and organizational complexity places this stage of the model near the origin of the axes.

An example of this stage would be the implementation of the "Government to Cloud" or "Government to Cloud to Government" business model proposed by Deussen et al. (2011). A more tangible example that belongs in that stage is the case of "Apps.Gov" portal of US Government. Although in that case there was an involvement of the central Government, the agencies were the ones that decided whether they would use cloud services for their internal operations and which services they would procure. The fact that the portal was closed in December 2012 is consistent with the low engagement, which characterizes this stage. It further shows that this kind of initiatives alone are not enough for the consolidation of cloud computing in e-Government.

**Stage 2: Cloud- based Public Services**

At this stage, cloud computing is used by agencies and municipalities in order to provide digital public services to citizens and businesses. The public services are based on Software as a service (SaaS) and partly Platform as a Service (PaaS) models provided by individual vendors. The decisions related to cloud computing are made at agency or municipal level. The degree of engagement is still low since the Government holds also in this stage only the role of the customer of cloud services, but the fact that there are more stakeholders (citizens and businesses) in this case makes the return to the previous state more difficult. This is the stage where cloud computing can promote Open Innovation and Open Data Initiatives (Charalabidis et al., 2011). Since cloud solutions that appear at this stage are more sophisticated and are not limited to use of SaaS or storage services, there is an increase in technological complexity. Organizational complexity is also increased due to the use of cloud computing for interaction with citizens.

Furthermore, the decision to deploy PaaS solutions for providing e-Government services implies a higher degree of awareness of cloud computing on the part of Government officials. The cloud-based platforms for e-Government services that have been proposed in literature (Charalabidis et al., 2011) require the active participation of organizations' administrators in the designing process of the services. This involvement of agencies' personnel should result in further familiarization with cloud computing and make agencies more active in using it largely. It should also not be forgotten that the presence of agencies in a Government that deliver public services through PaaS, does not prevent the existence of agencies whose cloud use falls into the first stage. Therefore, the degree of adoption for Governments that have reached the second stage is higher than the first stage.

The increase in both organizational and technological complexity, and degree of adoption that occurs in this stage places it above and to the right of the first stage. The business models "Government to Cloud to Enterprise" and "Government to Cloud to Citizen" suggested by Deussen et al. (2011) describe possible examples that fall into this stage. Moreover, as was discussed in the Case Studies section, the City of Edmonton in Canada has already used cloud computing platform in order to offer census data and other public information online. This confirms that Platform as a Service (PaaS) model is suitable for the second stage of cloud service adoption in e-Government service delivery. It therefore provides a perfect synergy for integrating the second stage of the stage model under discussion.

**Stage 3: E-Government Cloud(s)**

The main change in this stage is the development of one or more Government clouds. The private clouds can belong either to the central Government or more often, to agencies or Government organizations. They are used in order to replace the former e-Government information systems that the organization probably had and can support the provision of both internal and public services. The fact that a private cloud offers more security and control than the other deployment models may encourage the organization to use cloud computing more broadly. There are also some cases where the agency handles sensitive Government data and the development of its own private cloud is the only way to adopt cloud computing. The turn of the Government from customer of cloud services to owner of a Cloud, increases the organizational complexity along with the degree of engagement. Although it is not impossible in theory to quit the use of cloud computing in the future, it is highly unlikely that the organization will leave its own cloud to turn again to traditional computing.

While a private cloud can be operated by a third party, in practice the public organizations choose to build an on-premises cloud. This can be attributed either to their distinctive security requirements, or to the fact that Government organizations usually have their own data center and want to utilize its resources. A lot of technological changes take place in this stage, with the virtualization of the data center being the most significant. The organization is also responsible for the security of the virtualized data center, so technological changes will probably occur in this field too. These changes, which are not found in the previous stages, increase the technological complexity of this stage.

A typical example of a Government cloud is the Open-Gov Private Cloud of Greece Government that accommodates various applications of e-Government. At the agency level,

the cases of US, DoD and NASA illustrate how cloud computing can be incorporated in public organizations with special needs in terms of security and control (Zhang, 2010).

As the above examples indicate, private clouds are usually developed either by large public organizations that their considerable needs in IT resources justify such a decision or by Governments that intend to use cloud computing for hosting their central information systems but they want to have the control of the IT resources they use.(Frost & Sullivan, 2011) In either case, the Government or organization will have to follow an organized approach or strategy in order to move its information systems to a cloud environment (the US DoD's Cloud Computing Strategy presented in literature review is such an example). (US DoD, 2012). The degree of adoption in this stage is expected to be higher than the previous due to the organized effort and the number of units or agencies that large organizations/Governments include.

**Stage 4: e-Government Cloud Policy**
At this final stage cloud computing adoption is fully supported by the central Government of a country. While in the other stages the use of cloud computing is usually a result of individual initiatives of agencies and municipalities, here the central Government promotes cloud adoption in e-Government through policies and roadmaps.

The coordinated effort for integrating cloud computing in e-Government that takes place at this stage has as a result a very high degree of engagement. A special IT strategy is developed to facilitate cloud deployment by all departments of the Government, and the Government clouds that in Stage 3 were sporadic at this stage are becoming common. In addition, the Government encourages smaller agencies and public organizations that have not developed private clouds to procure cloud services from individual vendors, by establishing a cloud marketplace for public sector. In that way, the quality of cloud services can be ensured and the procedure of IT procurement can be easier for agencies. Successful initiatives in this stage should lead to the highest degree of adoption for a Government. Even small agencies will be motivated to try cloud computing through the information and guidelines that central Government provide.

The diffusion of cloud computing in the whole e-Government system of a country raises also complexity since the organizational changes that happen in this stage are significant. At this point, the change of mind set from assets to services, which is a step of many cloud adoption strategies (Kundra, 2011), occurs. In contrast to the previous stages, the change here refers to the IT culture of the Government. The Government should also take steps in order to resolve the legal issues that according to several scholars (Clemons & Chen, 2011; Hada et al., 2012; Macias &Thomas, 2011b; Zissis &Lekkas, 2011) hinder the adoption of cloud computing in e-Government.

Another important issue that should be resolved in this stage is the absence of standards. According to the recommendations of NIST (2011b), cloud computing standards should be developed and used widely from Government agencies to support Government's requirements for interoperability, portability and security. In the previous stages, cloud computing is adopted for covering the needs of individual public organizations or central Governments and the related decisions do not affect other organizations or agencies outside of organization's/Government's direct authority.

In this stage, for the diffusion of cloud computing in the whole Government, standards are necessary to ensure the interoperability of the different information systems. The development of technological standards characterizes the technological complexity of this stage. Although there are no countries that have reached this stage yet, it seems that United States and United Kingdom, which both have launched cloud initiatives, aim at this direction.

## 5. Discussion

Based on the data collected, it is evident that "Adhoc stage" is the most basic of cloud computing adoption. There is no systematic way of approaching cloud issues neither is computing purposed to a specific target. At the "adhoc stage", the Government has not conceived and discussed cloud computing adoption neither how to integrate the e-Government systems. Every department adopts a solution to solve specific problem in the short term.

It is evident from the analysis that benefits of cloud computing cannot be realised at the lower stages of cloud computing adoption, "adhock" and "public cloud based services". Users only go for the most essential services, which require compliance like filing tax returns. At the "public cloud base services" stage, cloud computing is already a conceived idea and Government departments and agencies use the service for convenience but not to achieve a preconceived cloud computing objective. Insecure availability, immature technology, Vendor lock in, Legal and security issues are the main concerns regarding the use of cloud computing in e-Government at this stage.

Email and messaging, Data storage and content management system are the cloud services the Government uses frequently at "public cloud based services" stage. Disaster recovery, automation, more core business focus and better scalability areviewed as the most important benefits of using cloud computing in the Government services. Software as a service (SaaS) and Infrastructure as a service (IaaS) are the types of cloud computing that the Government uses to achieve cloud-computing objective in e-Government at "public cloud based services" stage.

The "e-Government cloud" is the penultimate stage of cloud computing adoption process. At this stage, Cloud computing is discussed formally as part of IT strategy in e-Government. Data storage, Business process management on cloud, Business intelligence, Application hosting, Desktop office software and Business specific programmes are identified as the most common used cloud applications in e-Government. The IT profession is impacted by becoming strategic, reduced departmental headcount, More outsourcing andAbility to offer more service to the business and Less time spent updating infrastructure. At this stage, the Governmenthas already moved majority of its business

critical systems to the cloud. The clouds are either Government owned, Private owned or community owned.

The "E-Government cloud policy" is the highest level of cloud computing adoption in e-Government. All processes are driven by policy, which addresses issues of implementation process, cloud ownership, Security, Legal issues and Compliance. The cloud policy should further address Cloud adoption architecture and model, business strategy, cloud implementation standards, data ownership and access controls, cloud service governance, business service continuity scheme and cloud service governance. Cloud impact triggers taxation issues in the service provider's country as well as in the customer's country. Therefore, taxation should be addressed clearly especially in public, community and hybrid clouds.

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