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# Cloud computing for economic optimization in e-Governance: A Case Study

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***Abstract*— There is an increase demand in the online e-Governance services provided by federal and provincial government in India, a country with more than one billion people, where proper implementation of these online services faces a lot of problems in delivering efficient and cost effective services. Cloud computing is the future generation of computing which is a very new concept in the field of computing characterized by four main entities - Software, Platform, Infrastructure and Hardware. The software, platform and infrastructure are availed as service. In this work a model is proposed with cloud-based infrastructure and economically optimized software solutions by integrating low cost hardware and open-source software and platform which can be useful for the end-users.**

***Index Terms*— Cloud Computing, e-Governance, Economic Optimization, Open Source, SaaS , PaaS , IaaS .**

## I. INTRODUCTION

In the growing age of Information technology in all the sectors, the government of India is putting in a lot of effort towards going IT savvy and making its services more useful for citizens equally in urban and rural areas. However, there are many key issues in making the citizen-centric services accessible in rural areas. It is difficult for the service providers to reach the user needs and scale up the functionality. Accessibility and affordability are major issues for the community with living cost Below Poverty Line (BPL). Different provincial governments and their departments are placed at varying levels of e-governance maturity, as a result, citizens and government businesses processes get varying degrees of accessibility and quality of government services across India. It has been observered by a group of analysts that usage of cloud computing can ensure the reach of citizen services in all provinces of India irrespective of their present e-Governance readiness. Government to Citizen (G2C) services sometime witness periodic unpredictable demand. As a result, ICT infrastructure created as part of e-Governance initiatives often hold excess capacity, which is unused most of the time. There is a clear need to build a super ecosystem and bring the entire community under one roof. This is possible through cloud computing. One instance of an application hosted in the cloud is cheaper and easier to manage than individual copies of similar software installed on each user's desktop system. Upgrading a cloud application only has to be done one time, where upgrading traditional software has to be done for each system on which that software is installed. Cloud services follow the one-to-many model, so cost is significantly reduced over individual desktop program deployment.

In section 2 the current setup and their drawbacks are presented by taking the example of traditional collectorate office in India. A brief introduction about cloud computing is discussed in section 3, followed by the new model which uses open source software and platform over cloud for citizen centric accessibility and affordability for e-Governance operations as the better solution are presented in section 4. Going ahead a scenario from the revenue department Orissa province in India is described.

## II. PRESENT SCENARIO

This section basically describes about the situation and conditions which led to a costlier computing environment. Here the various places of investment and security flaws in the current e-Governance scenario are discussed.

### *A. Hardware & Software*

One of the most popular scenarios to be discussed in the field of e-Governance can be an Office of the collectorate in India. Basically they run with different systems for different departmental operations. All the systems have their own set of hardware infrastructure.

*Table 1. Minimal Hardware used in the PCs of Government offices*

| **Hardware** | **Specification** |
|---|---|
| Processor | Intel Pentium 4 / AMD Athlon 64 |
| Storage | 40 GB |
| Memory | 512 MB |
| Sound | Line Out, Mic In |
| Graphics | VGA Adapter |

Moreover the systems are loaded with the software suited for the official work which can be depicted from the table below.

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*Table 2. Minimal Software used in the Government offices*

| Software | Commercial Implementation |
|---|---|
| Operating System | Microsoft Windows XP |
| Office Suite | Microsoft Office 2003/2007 |
| Anti Virus | Kaspersky Anti Virus |

So by considering table 1 and table 2, one can easily determine the cost involved in the entire computerization system of collectorate offices in India.

### B. Security

These days computers especially which are powered by Microsoft Windows based operating system [1] are greatly infected with virus. Even though we are using Anti-Virus they are incapable of checking virus at time of operating system booting. Flash Disk is rapidly used in the systems for the transfer of data. This adds a promotion to virus, spyware and malware. This will lead to

1. User level personal data such as phone contacts, annual confidential reports can be transferred automatically.
2. Intruders can rapidly try to intrude into system and once getting a breakthrough they may use the resources causing reduction in the system performance.

## III. CLOUD COMPUTING

We define the booming term Cloud Computing as a Big Computing environment. A Cloud Computer is nothing but a big computer explained as a four layered model as depicted in Figure. 1. The Hardware, IaaS (Infrastructure as a Service), PaaS(Platform as a Service), SaaS (Software as a Service) are its major components.

### A. Hardware

The Hardware refers to the province of art of computing and networking equipments capable enough to handleing a larger load. It includes efficient processing engines, storage solutions, fast networks and larger memory etc.

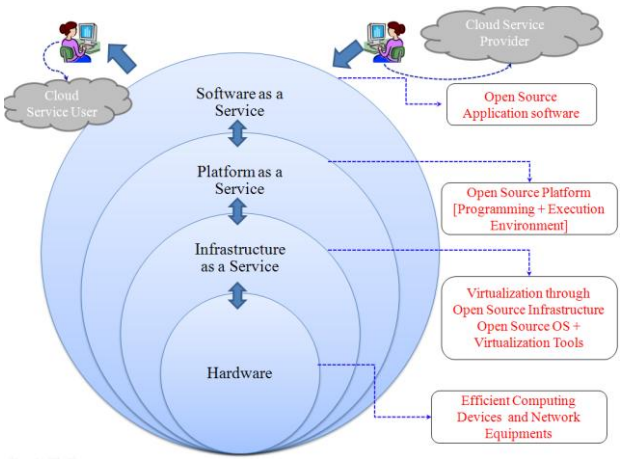


*Fig 1. Cloud Layers*

### B. Infrastructure as a Service

As there would be a larger mass to utilize the resources, a suitable quota management is enforced to distribute the hardware among the users. Infrastructure refers to the Operating System and its virtualization along with other associated tools. The same hardware will behave as different machines for different users. They will be allocated with dedicated CPU, Memory, Disk virtually etc depending upon the user needs.

### C. Platform as a Service

When the environment is used by programmers, the first term they think about it is the platform. It points to the programming models, execution method and programming environment.

### D. Software as a Service

The most important part of the model from the user point of view is the application software as a service. Basically the selected software will be availed to the user as service; for which they need not to have a disk at their terminal installed with the application software suite. They would be accessing the software online and storing the data back in the cloud.

So to avoid these flaws in security we need to go for specialized anti-virus, firewall and intrusion detection system for each machine, which too costly in nature.

## IV. PROPOSED SOLUTION

In this section we provide the detailed architecture of our solution and provide more detail on the central component and thus we discuss how the solutions exactly address the problems above.

### A. Detailed Architecture

The overall architecture of our solution is illustrated in Figure. 1. The terminal at the end user side can be a simple computer running with a minimal version of any open source operating system. The user would be having an access to the security services running in the security server, which in turn having access to a private cloud. The security server is an intermediate machine which is powered with the best intrusion detection system Snort [2], IPCop Firewall and a security validator and is availed to the user as software as a service. The central idea of presence of open sourced IDS and firewall is to reduce workload and unauthorised access to the cloud with a minimal cost. The cloud is powered with only open source software instead of proprietary alternatives except for few which don't have an open source alternative. The end – user terminal on successful validation at the security server will be connected to the cloud through a secure tunnel. All the operations are performed over the secure connection services.

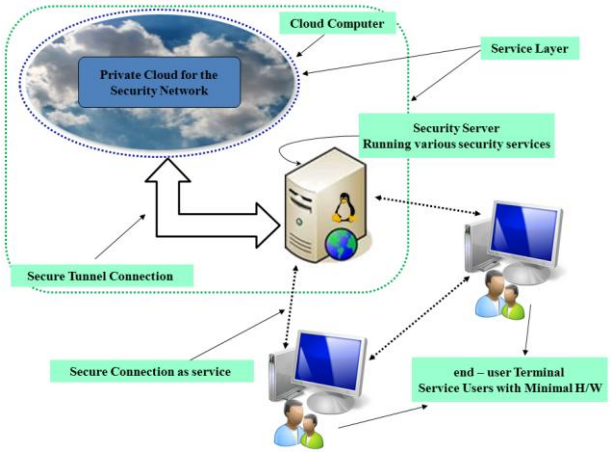


*Fig 2. An overview of the proposed architecture*

*Operation*

The internal operation can be seen in Figure. 2. In the proposed architecture all the office terminals would be provided with a unique user-id and password. The office user request for an access to the security service running in the security server with HTTPS or SSL protocol through their web browser. The firewall service running here checks for an authorised IP and then validates the particular terminal by means of the security validator. In case there is any terminal who is trying to login but failed thrice, will be redirected to the intrusion detection service, which in turn will try to deal with the unauthorised access and threat management. Once the user qualifies the tests conducted by the security services then they will get an access to the cloud through a secure tunnel service. Flash disk and other media devices can be mounted from any terminal at any point of time. The media so connected will be restricted to the local terminal itself. No other terminal can access the same device. When a terminal wanted to save a file over the cloud then it will processed meticulously at the anti-virus services.

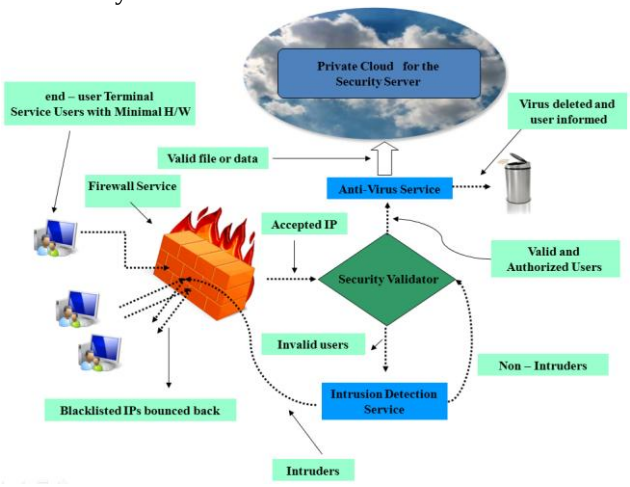


*Fig 3. Internal Operational Mechanism*

### B. The end – user Terminal

The end – user terminal is a small computer which will be located at the users for e-Governance operations. The terminals should have their own set of hardware infrastructure. We recommend the offices to use the data in Table # 3 as a standard configuration for such terminals.

*Table 3. Minimal Hardware used for the terminals*

| **Hardware** | **Specification** |
|---|---|
| Processor | 1.2 GHz Marvell ARM |
| Flash Memory | 512MB |
| Memory | 128MB DDR2 |
| Ethernet | 54mbps |
| Sound | Line Out, Mic In |
| Graphics | VGA Adapter |

The terminal can contain a minimal open source operating system like TinyCoreLinux, Damn Small Linux or Puppy Linux.

### C. The Security Server

A Security Server is a special system that would be working as a security check post for any cloud. The hardware configuration depends upon the number of clients or terminals that would be connecting simultaneously. This server will be connected to the private cloud through a secure tunnel service. This is responsible for providing various security solutions such as firewall, intrusion detection, anti – virus etc… as services to the user.

The server would be running with the software listed in Table 4.

*Table 4. Software to be used at the Security Server*

| **Software** | **Open Source Tools to be used** |
|---|---|
| Operating System | NetBSD , OpenBSD |
| Intrusion Detection System | Snort |
| Firewall | IPCop |
| Anti-Virus | Clam Anti-Virus |

### D. The Cloud Computer

A cloud computer is a high end device for general but multipurpose operations. This comprises of hardware and/or software products that are specifically designed for the delivery of services [3]. This is considered to be the most important portion of the entire model. This can be treated as a supercomputer that would be capable enough to take enormous work load. The hardware specification for this depends upon the various factors which are beyond the scope of the paper to be discussed.

The cloud delivers all the solutions along with its three services IaaS, PaaS and SaaS which we have already discussed. To have an optimistic computing we propose to use open source software over the server to maintain the robustness of model in terms of availability of softwares and easily affordability.

*Table 5. Software to be used at the Cloud Computer*

| **Software** | **Open Source Tools to be used** |
|---|---|
| Operating System | EyeOS , NetBSD , OpenBSD |
| Virtualization Suite | Sun Virtual Box OSE |
| Office Suite | OpenOffice |
| E-Learning Suite | Moodle |
| Many more… | |

In the beginning we can use EyeOS [13] which is a disruptive desktop entirely usable from a web browser, which includes a office suite and some collaboration application like moodle, as well as a full framework to develop new web based applications behaving as if they were desktop applications. Because these are free and open source software so there would be no problem by putting these in the proposed cloud and keeping all the data under the cloud control. EyeOS is not only a web desktop with its own valuable applications; it has been designed from the beginning to enable easy development and creation of new applications. EyeOS 2.0 is the perfect development framework for quick and easy creation of rich internet applications [16]. It has been completely developed with open technology and widely accepted standards such as PHP, MySQL, JavaScript, Qooxdoo, log4php, PHPUnit, OpenOffice and others, enabling the system to function on a common web server without any modifications, and which can easily used by a standard browser without any additional plug-ins installed. However, if open source alternative for a particular purpose like GIS is unavailable , then under that situation the software needs to be purchased in one investment only.

*E. Outcome of the solution*

In this section we discuss how the proposed solution may be used to address the issues raised within the scenarios presented in section 2.

1. Cost Optimization Evaluations

E. Deelman et.al [18] studied the various cost models associated with a cloud and they have been found that the cloud in market is package that includes cost per processing, cost per application software and cost per bandwidth. The total cost of cloud computing is the sum of the cost for infrastructure service and software bundle service.

*2.* Cost benefit in fully non – commercial model

We assume all the employees of a government office in India are of usage level Θ. If it is assumed that the marginal value of software usage by every employee is μ. The utility factor can be defined as U, then all employees at usage level Θ can be represented as

$$U[\Theta, \mu] = \Theta * \mu \quad (1)$$

Let us consider the following parameters important for the said model. Price that a commercial software vendor charges for one license of the software (Pt), upgrading charge (σ), the annual maintenance and service charges (δ). Let NΘ denotes the number of licenses purchased and YΘ denotes the number of years the software will be used by the employee of user level Θ.

The typical existing installation (Ct ) can be defined as

$$Ct = Pt\,N\Theta + Y\Theta(\sigma + \delta) \quad (2)$$

If the upgradation and maintenance charges for the first one year is free then

$$Ct = Pt\,N\Theta + (Y\Theta - 1)(\sigma + \delta) \quad (3)$$

The costing parameters with the proposed system can be discussed in detail which is as followed

Let there would be no commercial software usage and let σ and δ follow their usual representation. Let YΘ denotes the number of years the software will be used by the employee of user level Θ.

If Cu denote the total cost with the proposed model then

$$Cu = \sigma\,(Y\Theta - 1) + Y\Theta\,\delta \quad (4)$$

Let us consider for example an office equipped with 1000 PCs with same configuration. Each machine is installed with same software to be used by employees of usage level Θ. If the application licensing fee is 100$ per PC then Pt NΘ is 100000 USD $ for the office. Generally for up gradation, annual maintenance and service the vendors charge 10% the initial cost, hence σ + δ = 1000 USD $.

Assuming the product to be running for 5 years with the existing configuration and service policy the total cost will be evaluated as

$$Ct = 100000 + 4\ X\ 1000 = 104000\ USD\ \$$$

Applying the same values for the proposed model total estimated cost will be evaluated as Cu (≈ 5000 USD $), which indicates that there is a straight declination of 90 % in the cost with the proposed model.

3. Cost benefit in partial commercial model

Let us suppose there are m number of users of a commercial service and p number of users who needs the commercial service fully. α denotes the total number of users who need the service partially

$$\alpha = m - p \quad (5)$$

If we will assume that all the minimal problems can be solved by the open source software services then the number of target audience β = m-p.

$$Thus, \beta = \alpha \quad (6)$$

The above formulation is based on one software as service. The world of open source is so vast that for every commercial software there exists an open source alternative [14]. If n be the total number of open source software which needs to be implemented with c as the cost parameter and if the utilization and work level with the commercial tool is 100% then the cost incurred in commercial utilization ¥ can be defined as

$$¥ = m\ X\ c\ X\ n \quad (7)$$

If the utilization and work level with the open source tool is 100% then the cost incurred in open source utilization £ can be defined as

$$£ = (m\text{-}p)\ X\ c\ X\ n \quad (8)$$

$$Thus,\ Optimization\ factor\ \xi = ¥ / £ \quad (9)$$

4. Cost benefit in Infrastructures

Ch denotes the actual cost of each system installed at each employee's desk at any typical government office and Cl denotes the cost per system with the proposed model. The systems are highly configured and have their independent processing power and storage. If N is the total number of systems installed and Coi denotes the total cost then

$$Coi = Ch\ X\ N \quad (10)$$

Referring data in Table 3, we can say

$$Cl << Ch \quad (11)$$

Let Cc denotes the cost for implementing the cloud based infrastructure and Cni denotes total cost involved in implementing of the new model.

$$Cni = Cl\ X\ N + Cc \quad (12)$$

Now for very large value of N

$$Coi >> Cni \quad (13)$$

Thus net benefit in new Infrastructure *f*

$$f = Coi - Cni \quad (14)$$

5. Security

People bother a lot when a solution comes integrated with remote storage. The first question hits them is how much safe is our data? In this connection we are not addressing all the security issues but we surely cover few of them. The systems present at the employee's desk are having an interface to access the data present at the cloud. Even though the data is present remotely, the users will b feeling as if they are accessing a standalone machine and data is present locally. All the communication is done over a secure tunnel through a security server. The intermediary security server is fully guarded with powerful intrusion detection system, firewall and anti-virus. The employees are free to use flash disk. Anything they want to store in the cloud must pass through the Anti-virus. The effort of updating system and security patches is no longer required. We need to update the cloud and the security server.

6. Discussion

In a conversation with cloud solution architects and specialists at IBM India Systems Solution Center we derived the curve presented in Figure 4.

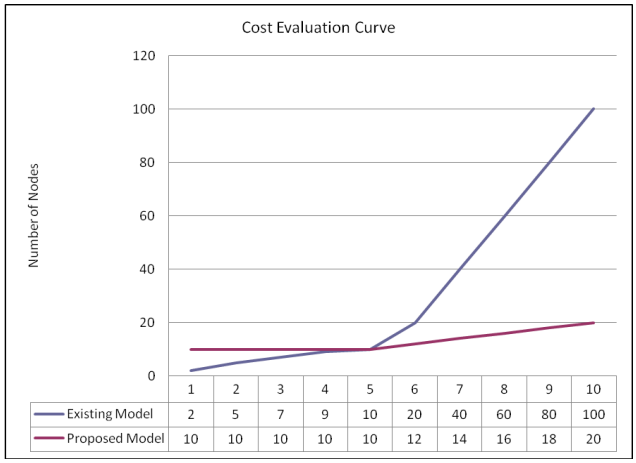


*Fig 4. Cost benefit evaluations with respect to Total cost and Number of nodes used in the computation*

The curve presents the cost benefit evaluation based on a 20 Desktop Monetary Unit in Open Source Cloud based Model, which explains that the OS based model has more benefits compared to the conventional methods.The system is not beneficial if the office has very few numbers of systems, let's say below 10. There would be a great profit in the system setup investment when we seek for more number of systems, say in terms of hundreds to thousands and more.

## V. CASE STUDY

After a careful study and analysis on the formulations discussed so far we tried to implement a similar solution at a Government organization. The Revenue Department in Orissa province of India[20], is the custodian of all lands and is concerned with all land related works, such as i)Assessment and Collection of land revenue, recovery of land ii) Declaration of ceiling surplus land and distribution of the same among the landless poor ii) Maintenance of law and order with the help of police administration iv) Issue of Land Pass Book v) Conduct of Revenue Courts vi) Consolidation and Settlement of Holdings and vii) Redressal of Public Grievances. The department is headed by the Commissioner-cum-Secretary who is in overall charge of the revenue administration, relief and rehabilitation of the victims of the natural calamities. There are three, Revenue Divisional Commissioners (RDC) for Northern, Southern and Central Division to supervise ten districts each. The head of the revenue administration in the district is the Collector (District Magistrate) and is the main officer in charge of land related matters and maintenance of law and order problem.

The district is divided in two subdivisions looked after by sud-divisional magistrate, which is further subdivided into tahasils looked after by Tahasildars. The Tahasil is further subdivided into revenue circles which work as the real revenue administration office for some nearby villages under the supervision of Revenue Inspector (RI). For smooth revenue administration the Orissa province is divided into 30 revenue districts, 58 sub-division, 316 Tahasils and 953 revenue circles. To effectively monitor all the above functions of the department using e-Revenue software hardware systems are deployed at different office premises like 20 systems at secretariat, 10 each at RDC offices, 10 each at district collector office, 5 each at subdivisional office, 3 each at Tahasils and 2 each at RI offices. Altogether 3,494 systems are deployed excluding the servers used for storing the data at NIC data centre. Once the proposed cloud based architecture is put in use, it would be very economic as shown in the graph.

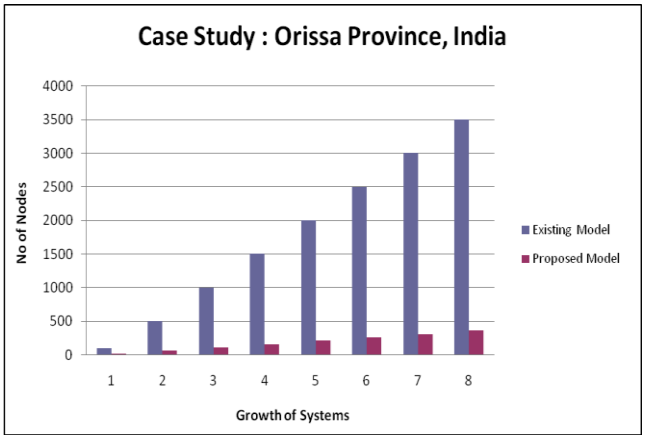


*Fig 5. TCO Evaluation at Orissa Province , India*

Although in the present scenario we are using 3494 systems but we assume to have at least 100 systems to apply analytics upto the no of systems in actual. From the curve we can very well depict that there is a steep increase in the TCO (Total Cost of Ownership) in the present model and the same cost is comparatively very less in the suggested model.

## VI. RELATED WORK

A large portion of the work in cloud computing technology for the e-Governance mainly focused on the cost-effectiveness and easy maintenance of the systems [1]. Most of the work has been descriptive in nature. A special category of work has been done to address a generalized class of computing popularly known to be the high performance computing [2]. The work is greatly accepted by Fouquet et. al [3] and they further enhanced the system by introducing open source tools for live video streaming so as to avail such systems to the common mass. A virtual cloud computer has been described for mobile devices [4]. The author introduces an analysis on smart phones, context awareness, cloud and restful based web services, and explains how these components can interact to create a better experience for mobile phone users.

Mowbray et. al. [5] discussed security at the client side and worked for a privacy manager. Author [6] worked for maintaining the privacy with data present at the cloud while designing up the services. Dan et. al described a new vision towards addressing the issues of the data protection in the Cloud [7]. The authors present the current issues and explain how the issues are resolved by introducing various data protection models. To address risks while handling image publishers and image retrievers of a cloud's image repository, the authors proposed an image management system that controls access to images, tracks the provenance of images, and provides users and administrators with efficient image filters and scanners that detect and repair security violations [8].

Open Source Cloud computing services are available from a number of Organization, for example DuraSpace [12], OpenNebula [13] ,Globus Nimbus [141] , OpenStack [15] etc. Especially OpenStack is a perfect candidate for realizing our system, all that would be required are changes to the user-interface to make Cloud service compatible with the security architecture so as to be usable for non-developers.

## VII. CONCLUSIONS

Cloud computing has the potential to change how organizations manage IT and transform the economics of hardware and software at the same time. On-demand services and Software-as-a-Service (SaaS) solutions have become the preferred mechanisms for e-governance applications to better leverage the power of cloud computing. For any government department, the transition to the cloud is a major decision. Concerns like data control, management, accessibility and security hold the departments back from switching to the cloud. Before implementing cloud any department should first identify and prioritize IT issues and challenges within itself; next the benefits of cloud computing should be mapped against these IT issues. From the point of view of each government agency or department, creating a cloud migration strategy may be of importance. This may call for inter-departmental collaboration to identify the solutions which are easier to transition and create necessary volumes to realize cost benefits. This could be done by the nodal information technology agencies at the apex. Instead of making large investments in creating data centers and networks for e-governance needs, the solution given in our model may be of help for easier transition to cloud.

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