Intensifying Cloud Security By New Smart Algorithm Based On Kalman Filtering

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Summary
Cloud Computing was introduced as new generation of the internet, but it delivers processing and storage capacity, too. Also, by using this technology, you can work on one project simultaneously with your team. Furthermore, you can access to your account and work on your data and project from anywhere, and monitor the progress of the project which your employees work on it. An important criterion in such technology is security, because as you can easily login into your account and do your jobs - if this technology hasn't enough security - hackers and crackers can also reach into your account and misuse your data. In this paper, we want to propose new security algorithm for using in cloud computing to be able to diagnose the present behavior and predict and estimate the next goal and behavior of hackers. By knowing next goal of the hackers, we're able to prevent them from doing any more hostile actions.

Keywords:
Cloud Computing, Kalman Filter, Estimation and Prediction

1. Introduction

Cloud Computing is new computing technology based on the internet and made you free from the laptop and computer problems. It opens new horizons of team working in front of you. Cloud computing is kind of processing and storage ability in an area (cloud) that could deliver IT services [1]. It enables users of this technology to utilize this network without knowing professional information about processing or hardware specifications [2]. Lots of research and developments has been done in different aspects of cloud computing. Because the architecture and layers of this technology is still concealing, researches suppose cloudy environment in cloud computing, and propose new ideas for better utilizing of its features. Or lots of papers have been published to highlight cloud computing privileges among other similar technologies. Even, some scientists have denominating this technology as "next big thing" and they expect that this technology will exist in top ten technologies of the future [3].

Some experts believe that by 2020, most of the users will exist in cloud environment, instated of using traditional systems, they will use cyberspace software to be able to connect and use cloud computing. Many of mobile, TV, watch, and etc. manufacturers design their new products by utilizing of cloud computing as the main core of processing and storage [4]. In this technology if the computer of one user hasn't enough free space for installing particular software, he can use that software in cloud environment without any concern, only by having internet connection and web browser [5]. They didn't need to buy this software or buying the license for such software. They only pay nominal charges to rent the latest version of this software from cloud providers (A brief schematic of Cloud Storage is shown in Figure 1 [4]). Also, because you didn't need to install lost of software and applications on your system, your computer will boot and start swifter [6].

Revolution of cloud computing pursuing by well-known companies, like: Google, Amazon, Sales-force, Yahoo, Hewlett Packard, etc. and every day they place their latest versions of their software and products in cloud computing. As you can see, by using such technologies and abilities, the need for huge and exorbitant servers has eliminated and you use the capacity and processing power of clouds. In today, life, because of lack of fossil fuels and the need to optimum use of energies, if we use cloud computing inside of the companies and organizations, the necessity of using data servers were eliminated, and because of that lots of energy (which were consumed by such servers) is saved [7].

2. Problem Explanation:

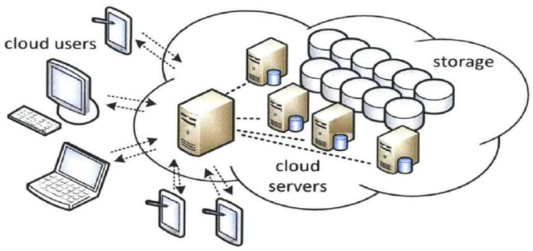

Fig. 1: An Overview on Cloud Storage [4]

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Suppose one hospital wants to save the identifications of their patients and also storage their experiments and results. They should spend lots of money for buying powerful servers and also employing some technicians for maintaining the servers [8]. Each year, because of having new patients and new input data that they have, they should do some enhancements in their hardware; such as buying new external hard disks or put new CPU's and RAM's in their servers [8]. Also, every month they should waste lots of money because of electrical bills. Furthermore, because they storage their data and their servers in one building and even one room, they may easily face with stealing or surveillance treatments [4]. Also, if their server faces with virus or Trojan attack or maybe their server face crashing, all of their data and patient backgrounds and their economical transactions may loss. Moreover, if one of the hospital managers or one of the specialists, wants to access to the system and search one data inside of the hospital database, he/she should be inside of the hospital and use the internal network of the hospital for his purpose [1]. Also, every year they should buy new hubs, switches and routers, because as we told earlier, when the volume of the data is increased, and they didn't enhance and up to date their switches and routers, these instruments may crash under such traffic of data. Or one day if the IT manager of the hospital upgrade the operating system of the server or update their software and database, he should go to the office of each staff and specialist and upgrade their systems manually too [9]. The IT manager should be professional in computer technology, in order to be able to, remove the errors and even crashes of the server and systems.

3. How to Remove Such Problems:

Cloud Computing delivers hardware and processing and storage capacity to the users and industries only by nominal charges. It support their users by allocating infinite space for saving their works and data, also you can access to your data and work on them from everywhere. Suppose you are manager of a hospital, and you are in trip, only by login into your account you can monitor the activity of all staffs and check the transactions of your accounts [10]. Also, if you and other staffs of your hospital working on one project you can do your duties simultaneously with your staffs, and see the results of each work simultaneously (team working on one project). By using of this technology you didn't need to upgrade your system, only by using of simple computer system or smart phone and a broadband internet connection you are able to access to your account and use your data [11]. As a result, you didn't need to hire one employee as IT manager to maintain and protect over your systems and servers. Because you didn't have any more servers, you hire powerful servers from cloud computing providers. One intrinsic feature of cloud omputing is, when you login into your account you will face with the latest version of software and applications which you hire for your work. So you didn't need to up to dating your software and buy license for them; by using of cloud computing and only by paying nominal charges you are able to use latest version of the software (Figure 2, Illustrate brief comparison between fixed and secondary cost of IT before and after implementing cloud computing [12]).

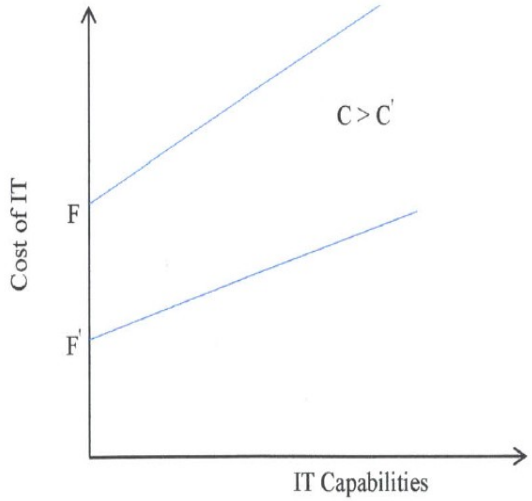

Fig. 2: Comparison between fixed and secondary cost of IT before and after implementing Cloud Computing [12]

According to this feature if one of your friends send a file to you and you didn't know the extension of that file and with which software you should open it, cloud computing will help you. It employs the latest version of related software to open that file. Because you didn't have server in your hospital or organization, you didn't consume lots of electrical energy and as a result you save lots of money and progressing the green energy [13]. Also, because you save your data in new generation of the internet, you can access to your data from anywhere and you didn't have the boundary for connecting into your network (Figure 3, illustrates fee comparison between Amazon AWS as one of the Cloud service providers and owned resources [14]).

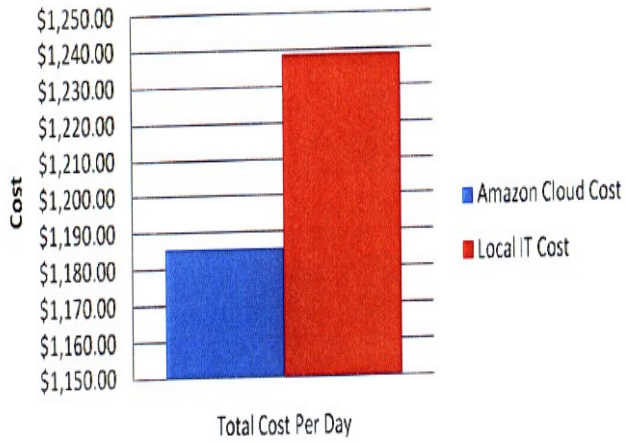

Fig. 3: Charge Comparison: Amazon Cloud Against Owned Resources [14].

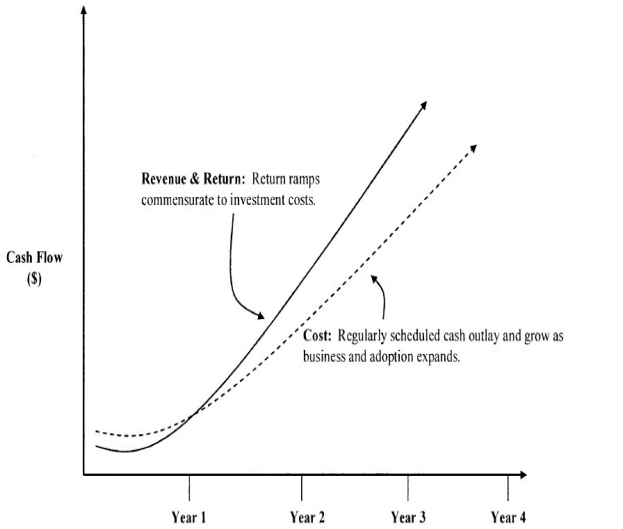

Fig. 4: Cash Flow for Cloud Computing Datacenters [11].

The cloud computing servers may not face with crash or you may not face with low processing speed, because numerous powerful servers exist in the background [1]. As we told earlier, every time when you login into your account you will utilize the latest version of each software, and as a result the firewall and antivirus scanners of your system and even your servers are up to date, and you do not have any concern about virus or Trojan attack. Furthermore, by using of cloud computing, you and your staff are able in remote working, means that you can manage your work and analyze the data and do your duties from everywhere only by using of one system and broadband internet connection [9].

By using of cloud computing you didn't need to upgrade the hardware components of your system. You are easily able to work on huge and complex datasets and see the results of your works within a moment, because in cloud computing according to your task and project the resources will allocate (Figure 4, illustrates cash graph for cloud datacenter [11]). If you work on complex data like DNA of patients they allocate more processing power to you, but if you have simple project most of the processing power will allocate to another user, this means cloud computing had smart and intelligence ability in allocating resources [5].

4. Algorithm Explanation:

Up to this section, we discuss the basic definitions of cloud computing and also the potentials of this ground breaking technology. After that, by one exemplify we discuss about some problems of traditional database and server systems [4]. In the third section, we discuss about some potentials of cloud computing and by use of that special example (hospital system), we debate on some of privileges of cloud computing [5]. The only problem that exist in cloud computing and because of that, some governments and organizations resist to migrate to this network, is security, because they think their private and high-level data maybe used and available for other users. The main goal of this paper is to propose new smart security algorithm [2]. Now, in this section authors want to present and introduce their new algorithm. Their algorithm is based on Kalman filtering, and the goal of this algorithm is to augment the security of such network [5]. But, before presenting our algorithm we review some basic definitions of this filtering. One of the best approaches which attract lots of attentions in recent decades knows as statistical filtering. This interesting and its ground-breaking usage comes from this fact that it used all accessible data of the system. I mean, statistical filtering will use the noise of the system and also the state of the system [8].

Weiner was introduced the filtering and statistical estimation in 1930's. His approach and system analysis criteria's was progressed by Kalman in about 1960's. He minimized the error in model of the estimation of the system by using, covariance matrix in linear filter. The

Kalman filter is kind of statistical filter and used in existence of uncorrelated white noise [15, 9]. By using of Kalman filter, the identification issue is degraded into state estimation of dynamic system. Filter progression pursue for linear case studies which is pursued by its logical extension to the nonlinear case [15, 9].

5. Specifying the Optimized Linear Filter:

The formulas for the state-space modeling of one dynamical system are [15,9]:

$$\dot{\underline{x}} = \underline{f}\left(\underline{x}, \underline{u}, \underline{p}\right) + \underline{w} \quad (1)$$

$$\underline{z} = H\underline{x} + \underline{V} \quad (2)$$

In these formulas linear relationship exist among state and output. For simplifying the noise parameters $\underline{w}$ and $\underline{V}$ will removed. So, dynamic system equation is reduced to:

$$\dot{\underline{x}} = \underline{f}\left(\underline{x}, \underline{u}, \underline{p}\right) \quad (3)$$

$$\underline{z} = H\underline{x} \quad (4)$$

Also, t is the time of estimation of true state [15, 9]. If we measure the parameters of the system several times, the values which acquired will approximate a Gaussian distribution. So, the optimum state estimation of one system $\hat{\underline{x}}$:

$$\hat{\underline{x}} = \overline{\underline{x}} = \int_{-\infty}^{+\infty} \underline{x}\, P(\underline{x}|\underline{z})\, d\underline{x}$$

The following formula shows the error is such estimation [15, 9]:

$$\underline{e} = \hat{\underline{x}} - \underline{x}$$

And covariance matrix of such errors:

$$E = \overline{(\hat{\underline{x}} - \underline{x})(\hat{\underline{x}} - \underline{x})^T} = \overline{\underline{e}\,\underline{e}^T} \quad (5)$$

As you know from Gaussian distribution, the mean of $\underline{x}$ denotes the climax of its PDF [15, 9]:

$$P(\overline{\underline{x}}) = \max[p(\underline{x})]$$

So, an optimum approach for specifying optimized estimation of $\underline{x}$ is through specifying the value of $\underline{x}$ which climaxing it's PDF. For specific random variable y, the standard form of Gaussian PDF is:

$$P(y) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{\frac{-(y_0-\bar{y})^2}{2\sigma^2}} \qquad (-\infty < y < \infty)$$

For an extended system with n state parameters:

$$P(\underline{x}) = \frac{1}{(2\pi)^{\frac{n}{2}} E^{\frac{1}{2}}} e^{\frac{-(\hat{\underline{x}}-\underline{x})(\hat{\underline{x}}-\underline{x})^T}{2E}}$$

In the above formula, E denotes the variance. So the problem is to climaxing $P(\underline{x})$, under the limitations of measured output [15, 9]:

$$\underline{z} = H\underline{x}$$

$log[p(\underline{x})]$ Acquires the climax value for $\underline{x}$, so we can specify the problem with using of Lagrangian multipliers as follows:

$$F(\underline{x}) = log[p(\underline{x})] + \underline{\lambda}^T(\underline{Z} - H\underline{x}) = \log\left[\frac{1}{(2\pi)^{\frac{n}{2}} E^{\frac{1}{2}}}\right] - \frac{(\hat{\underline{x}}-\underline{x})(\hat{\underline{x}}-\underline{x})^T}{2E} + \underline{\lambda}^T(\underline{Z} - H\underline{x})$$

Derivation of $F(\underline{x})$ by $\underline{x}$ is:

$$\frac{dF(\underline{x})}{d\underline{x}} = (\hat{\underline{x}} - \underline{x})^T E^{-1} - \underline{\lambda}^T H$$

Maximization means [15, 9]:

$$\frac{dF(\underline{x})}{d\underline{x}} = 0 \rightarrow (\hat{\underline{x}} - \underline{x})^T E^{-1} = \underline{\lambda}^T H$$

By taking transpose, we have:

$$(\hat{\underline{x}} - \underline{x})\,(E^{-1})^T = \underline{\lambda}\, H^T$$

By using symmetry:

$$(\hat{\underline{x}} - \underline{x}) = \underline{\lambda}\, EH^T$$

$$\underline{x} = \hat{\underline{x}} - \underline{\lambda}\, EH^T \quad (6)$$

From measurement function, we will have [15, 9]:

$$\underline{z} = H\underline{x} = H(\hat{\underline{x}} - \underline{\lambda}\, EH^T)$$

Or:

$$\underline{\lambda} = \frac{(H\hat{\underline{x}} - \underline{z})}{HEH^T} \quad (7)$$

By substituting (7) formula into (6) formula:

$$\underline{x} = \hat{\underline{x}} + EH^T\,[HEH^T]^{-1}(\underline{z} - H\hat{\underline{x}}) \quad (8)$$

This formula, will maximizing the PDF and also the optimized estimation of the system; also, if we enter (V) (measurement noise) in the (4) formula, then the state estimate [15, 9]:

$$\widehat{\underline{x'}} = \hat{\underline{x}} + EH^T\,[HEH^T + R]^{-1}(\underline{z} - H\hat{\underline{x}}) \quad (9)$$

Where:

$$R = \overline{(\hat{\underline{V}} - \underline{V})(\hat{\underline{V}} - \underline{V})^T} \quad (10)$$

For determining new covariance matrix by using of (9) formula we will have [15, 9]:

$$E = \overline{\underline{e}\,\underline{e}^T}$$

So,

$$E' = E - EH^T(H^T + R)^{-1}HE \quad (11)$$

By doing some simplification on (9) and (11), we would have new parameter k as the gain:

$$k = EH^T\,[HEH^T + R]^{-1} \quad (12)$$

Make some reduction on (9) and (11) [1, 3]::

$$\widehat{\underline{x'}} = \hat{\underline{x}} + k(\underline{z} - H\hat{\underline{x}}) \quad (13)$$

$$E' = E - kHE \quad (14)$$

So as stated earlier, we have[15, 9]:

$$\dot{\underline{x}} = \underline{f}\left(\underline{x}, \underline{u}, \underline{p}\right) + \underline{w}$$

Optimized estimation for $\dot{\underline{x}}$:

$$\dot{\hat{x}} = f\left(\hat{x}, u, p\right) \quad (15)$$

By assumption of process noise to be zero-mean the above formula can stated as [15, 9]:

$$\dot{\hat{x}} = B\hat{x} \quad (16)$$

B is matrix of coefficients:

$$B = \frac{\partial f\left(\hat{x}, u, p\right)}{\partial x} \quad (17)$$

State estimation error can be expressed as [15, 9]:

$$\dot{e} = \dot{\hat{x}} - \dot{x} = B\hat{x} - (Bx + w)$$

So, the time derivation of the error covariance matrix is:

$$E = \frac{d}{dt}\left(\overline{e\, e^T}\right) = \dot{e}\, e^T + e\, \dot{e}^T$$

Finally [15, 9]:

$$\dot{E} = BE + EB^T + \left(\overline{ww^T}\right)$$

The process noise covariance matrix is:

$$Q = \overline{ww^T} \quad (18)$$

Time rate of variation of error covariance matrix can be presented as[15, 9]:

$$\dot{E} = BE + EB^T + Q \quad (19)$$

The above equation (19) is controlling formula in the shifting of covariance matrix alongside the dimension function over time. By using of (13), (14), (15) and (19) any kind of estimation problems can be explained. Equation (13) will verify the optimized estimation, $\hat{x}$ of the state parameters at specific time. This will do by climaxing the model PDF by use of previous estimation of the system $\hat{x}$, and also the present measured output z. By use of the (14), we can determine error covariance matrix. (15) and (19) will update the error covariance and state matrices. Such values are used to optimize the model and process estimations [15, 9].

An important factor in being able to model one dynamic system is to being able to model that system through series of differential formulas [15, 9]. To do this, different identifications and aspects of the specific system should be known, to be able to do precise estimation and prediction. But in our experiment (cloud computing technology), we do not knowing anything about important criteria's and even layers of such network. So, we only introduce our algorithm [15, 9].

When a hacker permeate into cloud computing account by studying and controlling his behaviors we can estimate his goals and the next state of his actions by using of Kalman filtering (just like tracking high maneuvering objects). After that, when we estimate his next goal (by studying his present and past actions and treatments), we can easily prevent him from doing malicious works and wipe out the hacker from cloud computing [13].

6. Conclusion:

Cloud Computing is the new generation of the internet and all the days more applications and services were present through this network. Also, lots of organizations and universities wants to build their working and internal system on the basis of this technology. But they have anxiety about the security of this network. The aim of this paper is to present new smart procedure for removing hackers and crackers from cloud computing. Authors believe that, by equipping cloud infrastructures by smart estimator and predictor (Kalman filter) and by monitoring and collecting data about past behaviors of hackers and crackers and also their present state and action, we're able to eliminate them from system very easily.

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