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# Kalman Filtering for Estimation and Prediction Servers with Lower Traffic Loads for Transferring High-Level Processes in Cloud Computing

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## Abstract

**Cloud computing has deep influences on the resources which required for processing and storage data of individuals and industries. Deploying of cloud computing, does not need high expertise in computer engineering. It delivers lots of different services and applications to the users. In this paper, we wants to present new intelligence algorithm which is used Kalman filtering for estimation and prediction about, servers with lower traffic loads to transfer high-level processes on to them. By doing this, we can give priority to high-level processes and also we can guarantee QoS in our network.**

**Keywords**: Cloud Computing, Kalman Filter, Priority of Processes.

## Introduction

Cloud computing make a big revolution on how the applications were created and how they are used. If you need specific software, you didn't need go to IT market and buy it, in cloud computing you rent the latest version of that software from cloud service providers only by nominal charges. Cloud computing enables users and companies all around the world to share the processing power and storage capacity between each other, when they do not use it completely. As a result you wouldn't have complexity and also you wouldn't waste lots of money in operational costs. Cloud computing contains different service models, some of the popular and well-known service modelsare: Software as a Service (SaaS), Infrastructure as a Service (IaaS), and Platform as a Service (PaaS).

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SaaS is a most common servicing model, which makes users free from buying software's and licenses (Figure 1, illustrates worldwide prediction on cloud market dimensions [16]). In cloud computing and by use of this servicing model users can rent the latest versions of software's from

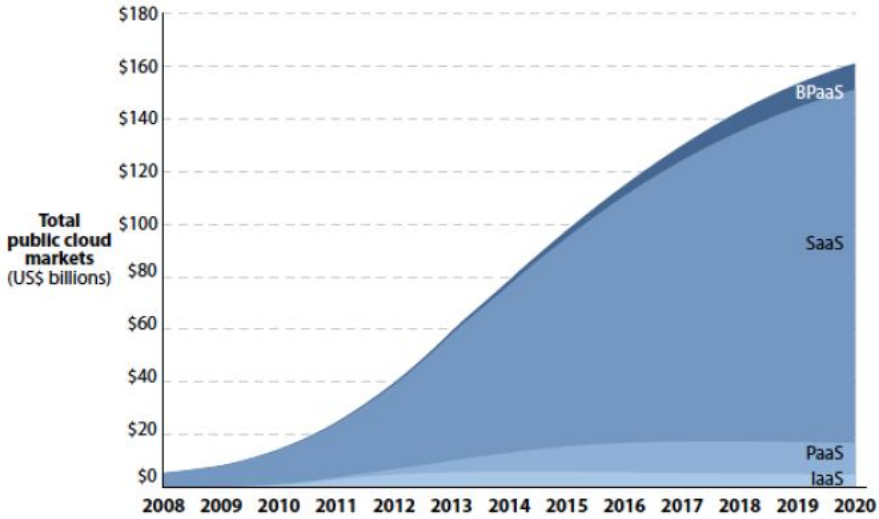


*Fig. 1: Predicting Worldwide Public Cloud Market Dimensions (during 2008 to 2020)[16]*

cloud providers. In IaaS, they can rent utility as a services, and consequently in PaaS, organizations can establish their own private network on cloud platforms, or even users can built one particular application on such platforms and rent it to other users. Prior well-known companies which deliver different services in cloud computing are Salesforce.com and also Amazon Web Services (AWS). But in these days most of other companies start launching their own servicing in cloud computing. Some of these service providers are Apple, Microsoft, IBM, HP, Google, and Rackspace. Cloud service providers, commonly get nominal charges for the services which they provide through this network, or they establish some kinds of subscription models.

This business and servicing models has deep influences on the software and processing markets (Figure 2, shows ten years stock price growth for three well-known companies [16]). Each one of the users and even industries can rent processing power, or different applications which they need, and they didn't need to buy software's and licenses from market and install those software's manually on each of the systems. Even, suppose you are general manager of a distinguished newspaper. If you want to archive all of your past issues electronically, classify them, and store them in your databases, you didn't need any more servers or big databases; you will rent processing power and storage capacity from cloud service providers according to your needs and do your tasks by that technology. By using of such technology, you will save lots of money and you didn't need to allocate lots of your office spaces to computerized resources and also your staffs. Even, if you and your staffs used different operating systems in your company, you can still use them in your cloud private network. You establish your private network in clouds, and install different operating systems which you need on it, and even you can define the accessibility levels of your staff's to different parts of your network.

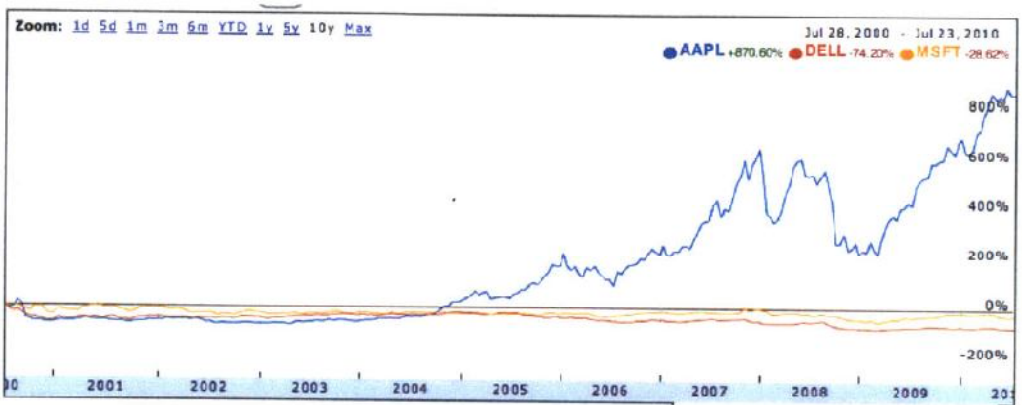


*Fig. 2: Ten years stock price growth for Apple, Dell, and Microsoft [16].*

This paper organized as such: the first section is introduction, in which we gave general conceptions of cloud computing and we point to some basic features and services of this network. In the second section, we will review some weaknesses of traditional systems, and by review on some weaknesses of traditional systems we're ready to study some remarkable potentials of cloud computing, in the third section. Furthermore, in the third section we do our best to show that all of the users can address all of their needs and usages in cloud computing. In the fourth section, we will discuss on our novelty, which is presenting new intelligence algorithm for allocating the servers with lower processing loads to the high level and high priority processes. By use of such algorithms we can persuade owner and general managers of military organizations or other industries to migrate to this network more easily and without any anxiety. They will know that, whenever they have sensitive and high level processes, they have accessibility to powerful resources and their tasks will do with servers with lower traffics and with higher priority levels. Section 5, will be the conclusion and in the last section (section 6), we will have references.

## Weaknesses of Traditional Systems

Suppose you are IT manager of one military organization and you used traditional systems and servers inside of your organization. You should buy your particular software's and licenses of them and install them manually and system by system. Also, for updating your software's you should connect each system to the internet and downloading the update files and install them on each system. Also, every time you should be aware about sniffing and virus attacks, or even if, one of your systems has an error or if your server is crashed, you should pay lots of money and repair it by yourself. Furthermore, if one of such disasters happen when you are not in your office (you are in off-time), what will you do? Or if you forgot to install the updates on one of your servers, what will happen?

If one of your organization managers is in a mission and he needs to login into the network of organization, how can he do that? Moreover, your organization should pay lots of money annually for upgrading their computerized resources and software's. Suppose one day your scientists want to do very complex project, which needs very high processing power. How can you allocate such processing power to them? Furthermore, suppose one of your scientists receive an e-mail with an

indiscriminate document as an attachment to that e-mail. He will ask you about, how to open that file, or with which software he can open it? And you don't know his answer, what will you do?
According to above weaknesses using of traditional systems has lots of problems and is not cost effective. In the next section of this paper, by review on some remarkable potentials of cloud computing you will understand why we need it.

## Potential of Cloud Computing

By using of cloud computing inside of your company or organization you can overcome all of the above problems. In this section we will debate on some potentials of cloud computing and you will understand how cloud computing overcome to such problems. Again, suppose you are IT manager of a military organization. You didn't need any more servers or routers and network cables, because in cloud computing, service providers will gives you all of the services that you need. By use of cloud computing your scientists can login to their accounts and do their duties from everywhere, also they can create a work group and working simultaneously on one project. You didn't need to have a professional computer system to be able to login to your account, only by use of simple computer system or even with use of your mobile phone you can login into your account and used your data (see figure 3, for more explanations). Suppose your scientists need particular simulation software, you will have no more anxiety about your systems requirement for installing that software, because in cloud computing you will access to infinite processing and storage capacity. Also, most of the software's and applications are existing in cloud computing, and users are able to use those software's only by paying nominal charges. Another remarkable potential of cloud computing is that, if one of your scientists receiving an indiscriminate file that he doesn't know how to open it, he can open that file as easy as possible in his cloud account. In cloud computing all of the file extensions are distinguished and each file will run with the related and updated software. By employing cloud computing inside of your organization, you are able to save lots of money, that's because of you haven't anymore servers or network instruments. Also, you didn't have any more anxiety about crashing of your servers. Because, you didn't have any servers and also your data were located in clouds and because of this potential, your scientists can access to the network from everywhere. Furthermore, every time when your scientists login into their accounts they will used the latest versions of the software's.

As you understand from above potentials your organization will save lots of money and physical spaces by using of cloud computing. But as we told before, some organizations have high-level and very sensitive data, and their processes should be done immediately. The goal of this paper is to propose and demonstrate new algorithm for estimating and predicting servers with lower traffic loads, and transferring such high-level processes to those servers.

## Discussion on Novelty

In the first section of this paper we provide reader with general conception of cloud computing. In the second section, we told some of the problems of traditional servers and systems. In the third section, we introduce cloud computing as an effective solution for such problems. In this section, we want to introduce new smart algorithm for estimation and prediction of servers with lower traffic loads and transferring high-level data and processes onto them.

However, in this section we want to present and demonstrate our new algorithm. Our scheme is derived from Kalman filtering, and the purpose of this scheme is to gives priority to sensitive data and processing them with low traffic servers immediately. But, before demonstrating our scheme we review some basic principles of this filtering. One of the finest schemes which draw lots of attentions in recent decades knows as statistical filtering. This motivating and its ground-breaking usages comes from this fact that it used all available data of the system. It means that, statistical filtering will employ the noise of the system and also the state of the system.

*Fig. 3: Users can login into their cloud accounts by use of, even their mobile phones and tablets [8]*

Weiner was invented the filtering and statistical estimation in 1930's. His algorithm and system investigation criteria's was advanced by Kalman in about 1960's. He minimized the error in model of the estimation of the system by employing, covariance matrix in linear filter. The Kalman filter is class of statistical filters and employed in existence of uncorrelated white noise. By employing of Kalman filter, the classification concern is degraded into state estimation of the dynamic system. Filter development pursue for linear case studies which is pursued by its logical extension to the nonlinear case.

## Specifying the Optimized Linear Filter

The formulas for the state-space modeling of one dynamical system are [1, 3]:

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

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

In these formulas linear relationship is present among state and output. For simplifying the noise parameters $\underline{w}$ and $\underline{V}$ will removed. So, dynamic system equation is reduced to [1, 3]:

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

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

Also, $t$ is the time of estimation of true state [1]. If we compute the parameters of the system several times, the values which acquired will approximate a Gaussian distribution. So, the optimum state estimation of one system $\underline{\hat{x}}$:

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

The following formula shows the error is such estimation [1, 3]:

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

And covariance matrix of such errors:

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

With referring into Gaussian distribution, we understand that the mean of $\underline{x}$ denotes the climax of its PDF [1, 3]:

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

So, an optimum scheme 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 [1, 3]:

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

For an unlimited system with $n$ state factors:

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

In the above formula, $E$ denotes the variance. So the problem is to climaxing $P(\underline{x})$, under the confines of measured output [1, 3]:

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

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

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

Derivation of $F(\underline{x})$ by $\underline{x}$ is [1, 3]:

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

Maximization means [1, 3]:

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

By taking transpose, we have:

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

By using symmetry:

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

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

From measurement function, we will have [1, 3]:

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

Or:

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

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

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

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 [1, 3]:

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

Where:

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

For determining new covariance matrix by using of (9) formula we will have [1, 3]:

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

Thus,

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

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

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

Make some lessening on (9) and (11):

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

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

As we told above, we have [1, 3]:

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

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

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

By hypothesis of process noise to be zero-mean the above formula can declared as [1, 3]:

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

$B$ is matrix of coefficients:

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

State estimation error can be declared as [1, 3]:

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

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

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

In conclusion [1, 3]:

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

The process noise covariance matrix is:

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

Time rate of variation of error covariance matrix can be presented as [1, 3]:

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

The above formula (19) is controlling equation 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. (13) Formula will confirm the optimized estimation, $\underline{\hat{x}'}$ of the state factors at specific time. This will do by climaxing the model PDF by use of previous estimation of the system $\underline{\hat{x}}$, and also the present measured output $\underline{z}$. By employing (14) formula, we can resolve error covariance matrix. (15) and (19) will update the error covariance and state matrices. Such values are employed to optimize the model and process estimations [1, 3].

Significant factor in being able to model one dynamic system is to being able to model that system through series of differential formulas. To do this, various identifications and aspects of the particular system should be recognized, to be able to do accurate estimation and prediction. But in our research (cloud computing technology), we do not knowing anything about significant criteria's and even layers of such network. So, we only introduce our scheme [1, 3].

As we told before, our proposed algorithm is based on Kalman filtering, and from above equations we understand that Kalman filtering survey on past data and present state, of the goal in order to extract a mathematical equation between variables of the system. So, in our system, when we receive high-level data from an specific organization or individual, we estimate and predict which one of the cloud servers can do this process sooner (we assume that we have statistical information about present traffic of each server, and by use of that traffic information we will understand which one of the servers has the lower traffic), finally we transfer that sensitive and high level data to that server for processing.

## Conclusion

In recent decades by advent of cloud computing, the definition of processing and computer services has been changed. Cloud service providers are delivering different service models to the users, only by getting nominal charges. The most important criteria among such servicing are, when an important and high-level process is needed to be done as soon as possible, cloud computing do it immediately. In this paper we introduce and demonstrate new intelligence algorithm for estimation and prediction of cloud servers which has lower traffic loads, in order to transfer high-level processes onto them. Our algorithm is based on Kalman filtering. And by use of such technique we are able to give priority to different processes.

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