Artículo de investigación

Presenting and demonstrating new algorithm for optimum resource allocation in cloud computing based on Kalman filtering

Presentar y demostrar un nuevo algoritmo para la asignación óptima de recursos en la computación en la nube basada en el filtrado de Kalman

Apresentando e demonstrando novo algoritmo para a melhor alocação de recursos na computação em nuvem com base na filtragem de Kalman

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Abstract

In recent decades lots of attention attracted toward Cloud Computing, and that's only because of services and powers which present by cloud providers. They present different kind of services, such as: processing ability, storage capacity, Platform as a Service, Software as a Service. According to experts and managers of different industry opinions, two main difficulties in front of organizations and companies in order to migrate to cloud computing is security and accessible resources. In this paper we want to introduce new allocation algorithm for cloud resources. This algorithm is smart algorithm, which is based on Kalman filtering and allocates resources and powers to the users based on their usage backgrounds and their present demand.

Keywords: Cloud Computing, Kalman Filter, Resource Allocation.

Resumen

En las últimas décadas, se ha prestado mucha atención a la computación en la nube, y eso solo se debe a los servicios y poderes que ofrecen los proveedores de la nube. Presentan diferentes tipos de servicios, tales como: capacidad de procesamiento, capacidad de almacenamiento, plataforma como servicio, software como servicio. Según expertos y gerentes de diferentes opiniones de la industria, dos de las principales dificultades frente a las organizaciones y empresas para migrar a la computación en la nube son la seguridad y los recursos accesibles. En este documento queremos introducir un nuevo algoritmo de asignación para los recursos de la nube. Este algoritmo es un algoritmo inteligente, que se basa en el filtrado de Kalman y asigna recursos y poderes a los usuarios en función de sus antecedentes de uso y su demanda actual.

Palabras claves: Computación en la nube, filtro de Kalman, asignación de recursos.

Resumo

Nas últimas décadas, muita atenção atraiu a computação em nuvem, e isso é apenas por causa dos serviços e poderes apresentados pelos provedores de nuvem. Apresentam diferentes tipos de serviços, tais como: capacidade de processamento, capacidade de armazenamento, Plataforma como Serviço, Software como Serviço. De acordo com especialistas e gerentes de diferentes opiniões do setor, duas principais dificuldades na frente de organizações e empresas para migrar para a computação em nuvem são a segurança e os recursos acessíveis. Neste artigo, queremos introduzir um novo algoritmo de alocação para

recursos da nuvem. Esse algoritmo é um algoritmo inteligente, que é baseado na filtragem de Kalman e aloca recursos e poderes aos usuários com base em seus históricos de uso e demanda atual.

Palavras-chave: Cloud Computing, Filtro de Kalman, Alocação de Recursos.

1. Introduction

Cloud computing have deep influences on computer industry. From one decades ago, up to now, when cloud providers launch software's online as a kind of cloud computing services, they affect on the working of software companies. Cloud providers present different software's through this technology only by getting nominal charges. They serves users with latest versions of software's without buying licenses, they support their users by giving them the opportunity of team working on one particular project. After presenting Software as a Service (SaaS), and the success of this service they present more services such as Platform as a Service (PaaS), Infrastructure as a Service (IaaS) (Figure 1 shows plan of profit for cloud computing (Francis, 2009). Most of the users and organizations which use cloud computing, claim that this great interesting is because of charge saving property of cloud computing. Also, the secondary reason, behind this interesting is, cloud computing help the users with more easily decision making process (Menasce & Ngo, 2009).

Cloud providers empower the staffs of one organization or company which built their internal network (or their working network) based on cloud computing, to work simultaneously on one project. Also, another potential of such technology that motivate lots of organizations and companies to migrate to such network is remote working. This ability gives the opportunity of login into their own profile and does their particular task from anywhere (Campbell et al 2013; Buyya et al, 2012). Also, cloud providers do their best to add more flexible features to their services in order to attract more organizations and users. In recent years they provide Communication as a Service (CaaS) and Network as a Service (NaaS). Communication as a Service is a kind of services which enable users with real-time communication. We can point to VoIP (Voice over IP), video conferencing, instant messaging, etc. as such services. Network as a Service (NaaS), enable users from everywhere to establish inter-cloud network, in order to share their data or work on one project (Cryans et al, 2008; Madhavapeddy et al, 2010).

Lots of research projects and thesis were define on the topic of cloud computing these days and as an outcome lots of journals and papers publishes every day about different aspects of cloud computing. Even some papers debate that cloud computing is not a new technology; it is only an upgrade of utility computing and grid computing. Some scientists call cloud computing as "emerging phenomenon". Also, lots of researches were existing about how to improve different services of such technology or how to use these services in more optimum way. We can define "Cloud Computing" phrase in different ways. But the best and ideal concept can define based on the usage, needs, capabilities and resources which one particular company ask from cloud providers.

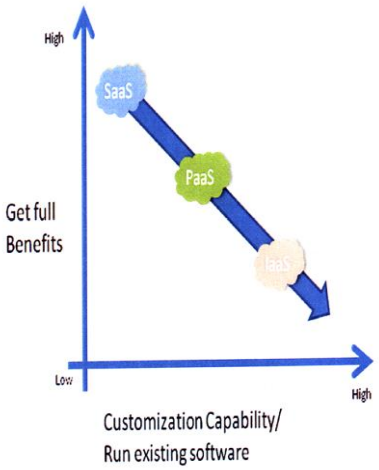

Fig 1. Plan of profit V/S User Potential Boundaries for Cloud Computing (Francis, 2009).

Up to this section, we do our best in order to give general concept and comprehend about cloud computing (Kashefi & Darbandi, 2011). In the next section, we want to review some problems of one typical business company which uses traditional server and systems. After that, in the third section, we introduce cloud computing as an answer to such problems and rising demands. In this section we will highlight some potentials of this technology. In the fourth section, we will discuss on one topic that similarly attract lots of attentions in these days. We will discuss about the necessity of existing and using of an optimum resource allocation algorithm, because in these days and because of lack of fossil fuels we really need optimum use of energies. In the fifth section, we will present our novelty, which is introduction of intelligence algorithm for allocating resources to users based on the previous usages and their present demand. Sixth section will be the conclusion and the last section is references (Darbandi, 2017c).

2. Review on Traditional System Problems:

Suppose you are manager of a business company and you want to transfer the accounts and identifications of your customers from traditional archives (accounting notes) into computer systems. You should buy server and some powerful system for your accountants in order to be able to save the identifications and data. Also, you should buy an accounting software and also number of licenses of that software, in order to install and use it in your accountants systems. For repair and maintain of your systems and server you need to employ an IT expert, who is professional enough to remove any probable problems and also prevent from any Trojan or virus attack. Also, if you are in a trip and you want to control the accounting system or performance of your employees, you have no way to do so. Every year because you may bring new products for selling in market or because adding new customers into accounting system, you need to upgrade your software and even your hardware's and as a result you should spend lots of monies in such issues. Also, every month when the postman delivers the electrical bills to you, you understand that your systems and servers waste lots of electrical energy, because your systems should active and accessible 24 hours a day and 7 days of the week, but you didn't have enough processes to busy these systems during this period. Also, when your server locates in one particular room, one of your employees who need more salary this month, will do malicious actions in your accounting system; or suppose you want to pay the salary of your employees but your system was crashed or hanged, ¿what will you do? You have similar problems with your accounting software, as an example, suppose you updating your accounting software, you should buy licenses for using of that software. And again you will waste lots of money.

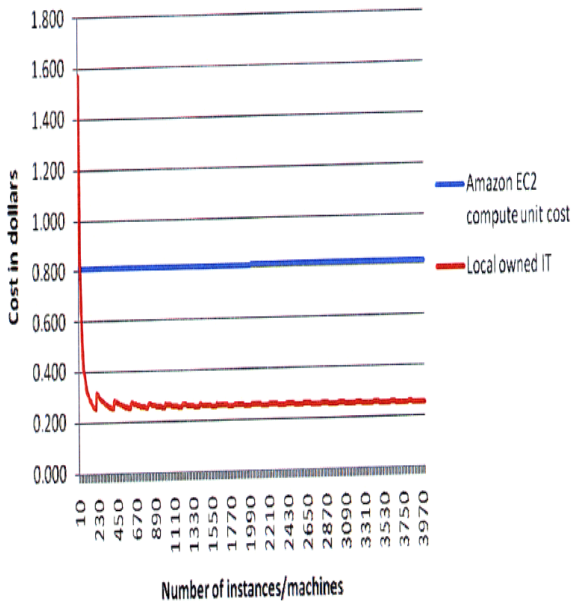

Fig 2. Comparison Charge for Cloud Against Owned Computing Resources (Francis, 2009).

3. How to remove such problems?

As we told in the first section of this paper, cloud computing delivers different type of services according to your request; cloud providers will give you and your company infinite processing power and storage capacity only by getting nominal charges. By using of cloud computing (transferring the server and systems of your business company) into cloud computing you are able to monitor the performance of your employees and also see the availability of products in your stores (Figure 2, illustrates contrast of costs for cloud versus owned computing resources (Francis, 2009). You and your employees can access into the system and do your job from everywhere, and you haven't any oblige to be present in the coverage of your internal network.

You can access to the network of your company from everywhere only by use of broadband connection and simple computer system or even your mobile phone. Cloud computing, enables you and your team to simultaneously work on one project. By using of cloud computing you will use the latest version of the software's. Suppose you do lots of your duties in the company with Microsoft Excel, every time when you login into your account you will see the latest version of this software were ready for your use. Also, because you didn't have any server you didn't need to employ an IT expert for maintaining such equipments (Figure 3, illustrates contrast of charges for Cloud Versus owned Computing Resources; example running time is 12 hours daily (Francis, 2009).

Also, if your database is based on Microsoft Access, but one of your collaborator companies sends you a file with MySQL format or undefined file format, you didn't need to ask someone about how to open that file. In cloud computing, your files will open with relative software automatically. Also, you can save lots of money by using cloud computing, because you didn't use servers anymore and as a result the consumption of electrical energy in your company is decrease. The cloud computing has the best firewalls and security layers, so you have not any anxiety about your company data which located in the clouds. Cloud computing made you free from upgrading the hardware's of your server and systems, because you didn't utilize the power and abilities of your own systems. You didn't have any anxiety about hanging of your system when you work on complex and huge volume of databases, because you will use the powers and abilities of the clouds.

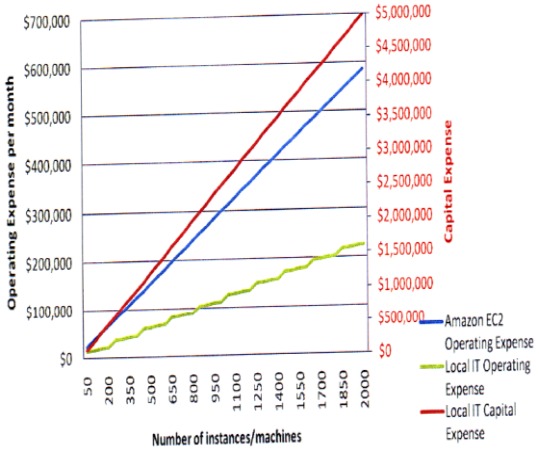

Fig 3. Comparison of Overall Payments for Cloud Computing Against owned Computing Resources (Francis, 2009).

Oblige of Optimum Resource Allocation from Environmental View:

Some years ago Microsoft does one research project with the cooperation of Accenture and WSP companies, about comparing the amount of greenhouse gas emissions from traditional

computer networks and cloud computing servers, and affect of such hazardous releases on the environment. In this study, they survey about releases from networks with 100, 1000, and 10.000 users. The results of this experiment show that, for small dimension networks, migrating from traditional systems into cloud computing is more helpful for the environment. This research shows that, when a network with 100 users migrates to cloud computing the amount of greenhouse gas emissions decrease rather than 90 percent. This is only because of using shared servers with other networks (Figure 4, illustrates common employing from resources in one company with lots of data processing and duties during one day).

Some experts told that cloud computing are something like transportation system. Data centers make use of computer software's in order to transferring data (Figure 5, illustrates fee assessment for real world handling simulation (Francis, 2009)). Unlike, the public transportation system, we didn't have any loss of performance here. On the other hand in most of the networks all around the world, most of the servers work with 10 percent of their power. This means that they take energy for full performance (under full load) works, but we only use 10 percent of their powers. In cloud computing one server can be used to serve to several users simultaneously. By using of cloud computing in your company, you will help in reduction of greenhouse gas emissions.

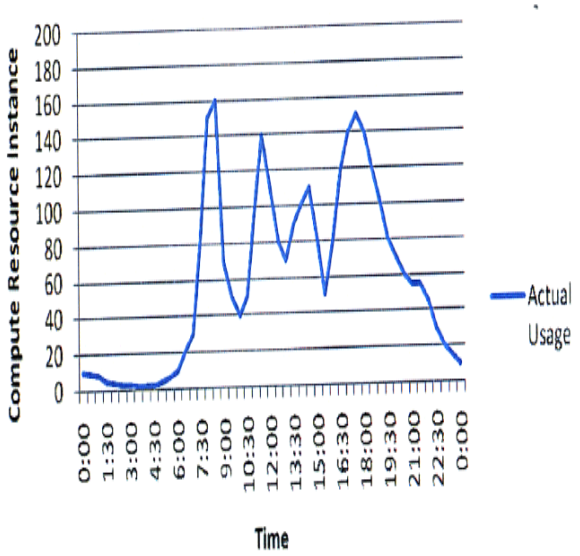

Fig. 4: Typical Usages of Resources in One Company During One Day (Francis, 2009)

4. Introducing Comprehensive Algorithm for better Resource Allocation:

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. In the third section, we introduce cloud computing as an effective solution for such problems. In previous section, we told about obligation of using cloud computing from environmental aspect.

In this section, we want to introduce new smart algorithm for better allocating of resources into users. The main aim of this paper is to introduce and demonstrate an optimum algorithm for better resources and power allocating through cloud computing by the means of Kalman filtering.

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 expand the security of such network (Bruce Berriman et al, 2011). But, before demonstrating our scheme we evaluate 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 usage 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 (Darbandi, 2017a; Darbandi, 2017b).

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 (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017). The Kalman filter is class of statistical filter and employed in existence of uncorrelated white noise (Chard et al, 2008). By employing of Kalman filter, the classification concern is degraded into state estimation of dynamic system. Filter development pursue for linear case studies which is pursued by its logical extension to the nonlinear case (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017).

Specifying the Optimized Linear Filter:

The formulas for the state-space modeling of one dynamical system are (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

$$\underline{z} = H\underline{x} + \underline{V} \tag{2}$$

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 (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

$$\underline{z} = H\underline{x} \tag{4}$$

Also, t is the time of estimation of true state (Lundblad, 1974). 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 $\underline{\hat{x}}$:

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

The following formula shows the error is such estimation (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

And covariance matrix of such errors:

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

With referring into Gaussian distribution, we understand that the mean of $\underline{x}$ denotes the climax of its PDF (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

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 (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

For an unlimited system with n state factors:

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

In the above formula, E denotes the variance. So, the problem is to climaxing$P(\underline{x})$, under the confines of measured output (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

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

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

Derivation of $F(\underline{x})$ by $\underline{x}$ is (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

Maximization means (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

By taking transpose, we have:

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

By using symmetry:

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

$$\underline{x} = \underline{\hat{x}} - \underline{\lambda}\, EH^T \tag{6}$$

From measurement function, we will have (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

Or:

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

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

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

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 (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

Where:

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

For determining new covariance matrix by using of (9) formula we will have (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

Thus,

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

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

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

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

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

$$E' = E - kHE \tag{14}$$

As we told above, we have (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

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

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

By hypothesis of process noise to be zero-mean the above formula can declare as (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

$$\underline{\hat{\dot{x}}} = B\underline{\hat{x}} \tag{16}$$

B is matrix of coefficients:

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

State estimation error can be declared as (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

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

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

In conclusion (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

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

The process noise covariance matrix is:

$$Q = \overline{\underline{ww^T}} \tag{18}$$

Time rate of variation of error covariance matrix can be presented as (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017):

$$\dot{E} = BE + EB^T + Q \tag{19}$$

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, $\underline{\widehat{x'}}$ 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 (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017).

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 (Lundblad, 1974; Farahani Rad, 2013; Darbandi & Yousefi, 2017).

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, (cloud computing) by giving history of using of different resources and features of cloud computing and also giving the present demand of that company into the Kalman filter, it predicts and estimate the amount of powers that may need by those company.

5. Conclusion:

Nowadays, cloud computing permeates to most of handheld devices, for example iPhone mobile phones run lots of their applications and software's based on cloud computing. Any handheld or simple computer system can do lots of complex tasks only by use of cloud computing. In this paper, we present and demonstrate new algorithm for optimum allocation of resources through cloud computing. This algorithm is based on Kalman filtering.

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