Designing and Demonstrating New Intelligence Software in Cloud Computing with use of Kalman Filtering

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Abstract
Cloud computing delivers different kinds of computing services such as processing power and infinite storage capacity, which delivers by different service providers through the internet. Lots of companies and individuals do their bests to be able to launch their own services and software's in cloud computing, and rent them to the users. The goal of this paper is to propose and demonstrate new health-care system, for control and assessing health level of human beings. In our system, present health level status of particular person, is evaluate and gathered by the sensors, which attached on the patient's body. That information was transferred to cloud computing by use of generic application which is installed in the patient's mobile phone. In cloud computing, such data will process and if the level of one vital parameter (like hyperglycemia or hypertension) is lower/higher than the standard norm, and also by comparing such data by precedent health information of that person, if the software finds out the possibility of apoplectically or other harmful causes (such process and searching inside of his precedent data and also comparing such information by present conditions of patient will done by Kalman filtering), immediately, it will send an alert to patient's nurse and specialist.

Keywords
Cloud Computing, E-Health, Kalman Filtering.

1. Introduction

Cloud computing technology is proposed and invented about 1960's, when sharing processing resources is proposed. Cloud computing delivers different IT services such as software, platform, and infrastructure through the internet (Fig. 1, illustrates cloud computing storage overview [2]). In another words, cloud computing is connecting and utilizing such resources and powers, which are not exist in our adjacency and does not need high level of knowledge or expertise. Even if, the system which you used to connect to your cloud account does not has professional software and hardware specifics, you are able to do complex and very difficult processes as easy as possible, in your cloud account, only by use of broadband internet connection. In cloud computing, you will pay only nominal charges for the services that you used, and you shouldn't pay for the hours that you do not use them. This benefit helps you in decreasing current expenditures of your company, because you do not need any more server or powerful computer systems for your own, and in your company. Up to now, you should pay lots of money for upgrading hardware/software specifications of your system annually, and also you should buy new licenses for your software's after upgrading them, but in cloud computing, you shouldn't allocate lots of physical space of your company for installing such resources, and furthermore you access to more secure and last updated software's through your cloud account, without need of buying licenses for your software's. Also, because you haven't any computerized resources and server in your company which needs to be active 24 hours a day and during 7 days of a week, you will save lots of money (Fig. 2, illustrates a usual datacenter network architecture [15]). Moreover, you didn't need to hire some experts as IT manager, for maintaining and operating your server and remove system errors. Because your data were stored in the internet and at least in one powerful server, you will not have any anxiety about hanging or crashing of your servers. According to this potential of cloud computing, you can login into your account and do your duty from anywhere. Even, you and your staffs can works simultaneously on one project and see their modifications in the project (team-working). As we told above, your data were stored at least in one powerful server, and even if this server is hanged, your data will transfer within a moment onto another powerful server, without any interrupt in your duty. Another benefit of this network is, you can use your own professional software inside of your cloud account, without any anxiety about compatibility or system requirements for your software. Even you can use several complex

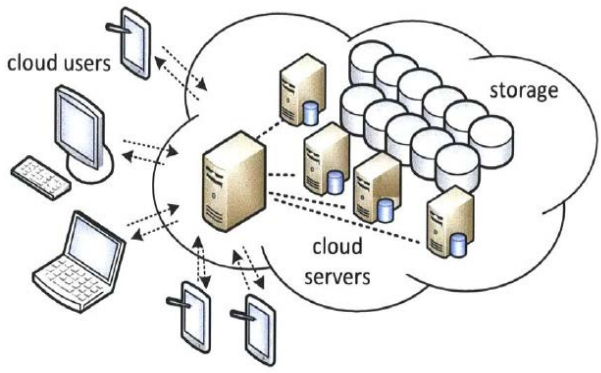

Fig. 1: Cloud Computing Storage Overview [2]

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applications simultaneously, without any anxiety about degrading of processing power.

As we told earlier, cloud computing delivers different services through the internet. But three main services which deliver extensively by cloud service providers are:

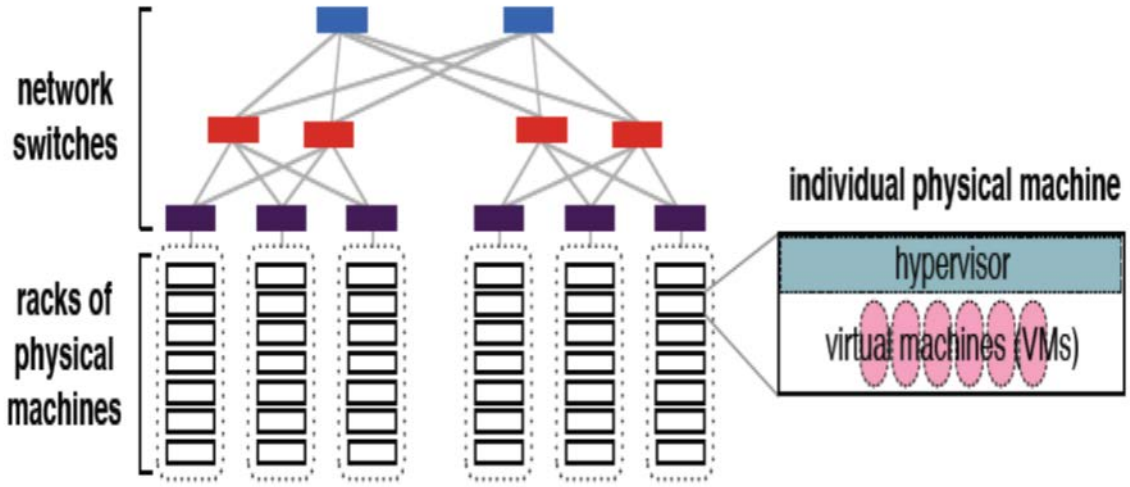

Fig. 2: A Usual Data Center Network Architecture [15]

- **Software-as-a-Service (SaaS):** Delivers different applications and software's through the internet. By using of such software's, you will not have any anxiety about system requirements and storage capacity need of that software in your system. You can easily login into your account, by use of an internet browser and use the last updated version of that software.
- **Platform-as-a-Service (PaaS):** By use of this service you can design and build your own software, and rent it to other users. By use of this service, you can earn lots of money and also you can upgrade your software by use of user suggestions.
- **Infrastructure-as-a-Service (IaaS):** By using of this service, you can rent the hardware's that you need from cloud service providers. As an example, in your company you need to store and classify huge amount of data. If you want to do this by traditional systems, you need to use several powerful servers and external hard drives to be able to do your project. But in cloud computing, you will rent processing power and storage capacity from cloud service providers, just as you need. Also, by use of powers that cloud service providers gives you, you will do your project more easily and faster.

The main goal of this paper is to present and demonstrate new smart system for controlling human health, by use of cloud computing and Kalman filtering (Fig. 3, illustrates visualization view of future health care systems). In the first section of this paper, we review on some basic definitions of cloud computing and we point to some benefits of this technology. In the second section, we debate on Kalman filtering that is the intelligence and processing unit of this technology. In the third section of this paper, we discuss on functionality of our system, we will explain our novelty, and tell about applications of our system. The fourth section is conclusion and finally, the fifth section will be references.

2. Explanation of our novelty:

Our proposed scheme is based on Kalman filtering and by use of such algorithm we're able to survey on precedent information of patients and extract special pattern about healthy level of each person. By use of such pattern and present status information of that patient, we can estimate and predict the possibility of apoplectically or other harmful causes occurrence.

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.

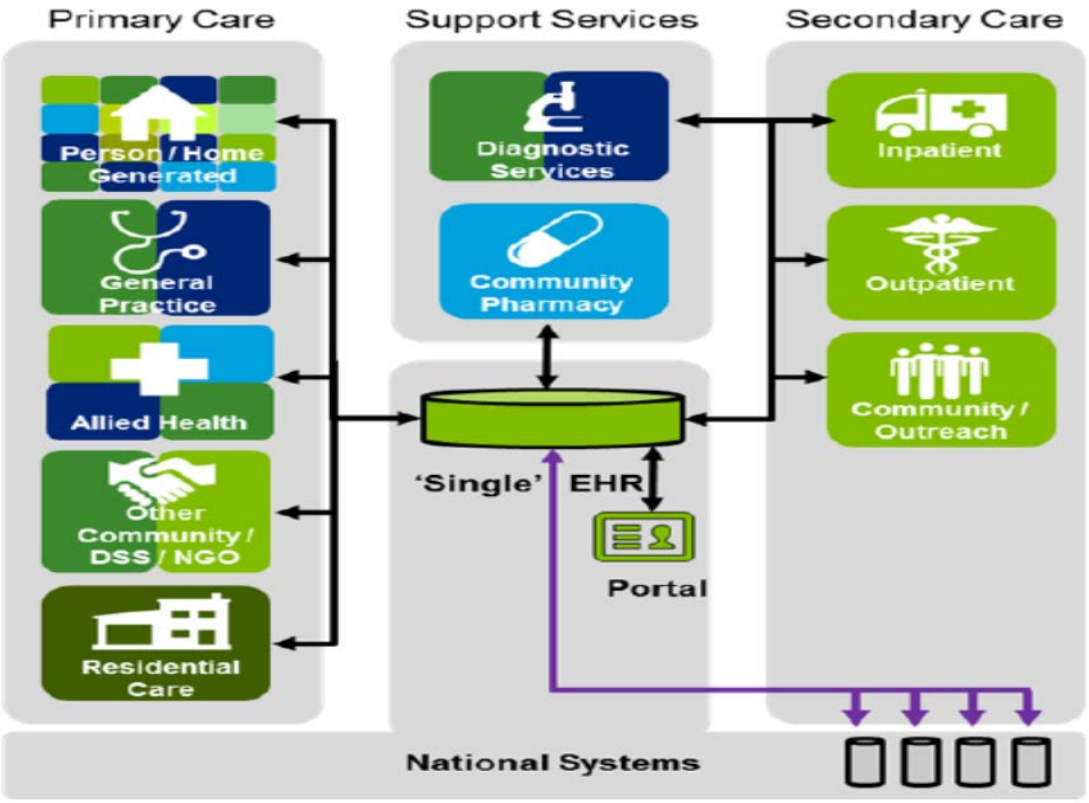

Fig. 3: Visualization view of future Health-Care Systems [14]

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 $\underline{\hat{x}}$:

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

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

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

And covariance matrix of such errors:

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

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

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

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:

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

By using symmetry:

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

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

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

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

Or:

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

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

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

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 [1, 3]:

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

Where:

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

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

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

Thus,

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

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

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

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

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

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

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

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

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

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

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

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

B is matrix of coefficients:

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

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:

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

In conclusion [1, 3]:

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

The process noise covariance matrix is:

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

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, $\underline{\widehat{x'}}$ 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 [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].

3. Explanation of our scheme:

Our proposed application is based on cloud computing and will use Kalman filtering as an intelligence and processing unit. The goal of this application is to design and

demonstrate new estimator for estimation and prediction the possibility of apoplectically or other harmful causes for that patient. From the previous section you remember that, Kalman filtering survey in precedent information and present status information of that patient to extract specific healthy pattern for that patient. In our system, by giving precedent information of healthy of that patient as an input to the system (as previous state), and gathering present healthy status of patient by use of attached sensors on his body (like hyperglycemia sensor, hypertension sensor, heartbeat evaluating sensor), we gave such information's to the Kalman filtering. Also, we defined standard norms for such parameters in our system. The duty of Kalman filtering is to extract specific pattern for hyperglycemia of that patient, as an example, and it understands that when hyperglycemia level of that person reach to particular value, the patient will collapse, as an example. So, when the hyperglycemia level of that patient reach to dangerous span, the Kalman filtering understand the possibility of collapse or other harmful causes occurrence for that person and send specific alert for the nurse and specialist of that patient. The sensors which attached on the patient's body will send the information about present status of patient, by use of particular application which is installed in the patient's mobile phone. In cloud computing, by comparing present status of patient with extracted pattern, the system can find out the possibility of harmful causes occurrence for that person. Because, lots of the deaths is occurred in the sleep and when the patient is alone in the home, and nobody is exist to help him, by use of this system, we're able to prevent from lots of deaths which caused from accidental hyperglycemia or hypertension or similar diseases.

4. Conclusion:

In recent decades, cloud computing makes big revolution in how the computerized services are servicing to the users. Yet, when someone has an indefinite file and he doesn't know how to open that file, he shouldn't search for informed person to ask him about how and with which software he should open that file; by cloud computing, he upload that file in his cloud account and it opened with the relevant and last updated software very easily. Also, this technology has lots of more applications in different industries and sciences. In this paper, we propose and demonstrate new system for continuous control of health level of human beings. Our system is using cloud computing as a platform for transferring information and also processing on such information and also will use Kalman filtering for estimation and prediction on such information, and extracting pattern from precedent information of that patient.

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