



Factors influencing Fog Computing Adoption for Public and Private Organization

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Abstract:

Improved cloud computing is the emerging technology for the public and private organizations. There are several prospects of development when we work after the adoption of the new emerging technology with respect to the public and private organizations. Adoption of new technology deals with the factors like target users, geographical distribution, content generator and consumer, data storage, data processing, latency tolerant, security and decision making are etc. Fog computing helps cloud computing to reduce the challenges faced. This paper addresses the challenges faced by cloud computing and its remedies. The results are verified on the platform of python using pandas, seaborn, numpy, matplotlib, scipy and sklearn tools with random dataset.

Keywords:

Cloud computing, Fog computing, Data analysis.

1. Introduction:

The Internet of Things (IoT) has become a part of humans and machines in today's life and environment. Humans desire rapid extension of these connected devices. IoT is expected to connect billions of devices for the betterment of humans. In this environment, fog computing along with edge computing. Big data is the biggest commodity of the data driven systems. Data generated digitally in 2010 surpassed 1 zettabyte [1], 2.5 exabytes in 2010 [2] and 50 billion connected devices in 2020 [3]. The Internet of Things is the backbone of connected devices.

This article represents the adoption of fog computing in the public and private organization, how fog computing meets the challenges of the demand in the public and private sectors.

During the contemporary age, there was a fresh attention among entrepreneurs as well as their prosperity and inspiration. Growing sanctions from society and unquestionable stories of achievement regarding a few famous entrepreneurs bundled with a changeable market producing enough uncertainty

has resulted in the launch of own fresh ventures, both as a barrier as well as prospects.

Basically, an entrepreneur refers to an individual who assumes responsibility of asset making and value creating procedure by the help of nourishing conception, accumulating inputs and executing ideas into reality according to Kao (1993)[8]. During implementing the ideas, an entrepreneur behaves as drivers of economic prosperity and assists in improving the nation's economy and at the same time plays an important role for the growth of the nation. Thus, entrepreneurship has high importance among the most valuable strategies for economic advancement which assists to maintain a nation's competency to manage the influence of globalization.

In order to compute bridges, the vacuum in between the machine and cloud is filled by making it capable of storing, computing, networking as well as data management throughout nodes of the network with the proximity of IoT equipments. On the other hand, data management, storage, computation, decision making and networking may be executed in cloud and simultaneously throughout the IoT to cloud path because data lets in to the cloud [7].

John and David [1] discuss the growing factors of data in just five years. 75% of digital information is generated by individuals. McAfee and Erik [2] speak about how decision makers learn to ask proper questions in a proper place with evidence-based decision making. Dave Evans [3] sometimes addresses IoT as the Internet of Objects, which will change human life and related instruments around it. Babak and Ioannis [4] speaks about the storage issues in traditional methods and implementation to cloud solves the storage issues with volume and variety. Ben, Nitesh and his team [5] describes the diverse needs of IoT and its applications around the world. Joydeep and Sudhanshu [6] speak about key factors of IoT: the Intelligent Transportation System (ITS) and Locations Information System (GPS). Ashkan, Caleb and his team [7] expects rapid application in the number of interconnected devices with humans to promise multi-access edge computing, cloudlet etc. Raymond [8] discusses the entrepreneurship prospects of the interconnected devices and the developments.

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1. Background and Justification of the Study

There are huge prospects fostered by fog computing due to its alignment with deploying cloud computing that can serve varying business requirements. Fog computing has few limitations like delivery of service quality, less processing capacity and so on. Enterprises are still thinking that cloud computing has sufficient processing ability, so they are more impressed with cloud computing. Still fog computing is emerging more and more nowadays in industries for its distinct advantages than cloud computing. Fog computing has capability to render many services because of its several advantages whereas data centres of cloud computing have poor performance related to network cost, service latency, accessibility etc. Fog computing serves many tasks that are competent for companies interested to outsource the activities to outside service providers. Fog computing can complement cloud computing in consideration of many parameters like time of service response, demand related to far cloud resources, latency of service, etc. Still more analysis are needed to enhance reliability and performance of fog computing.

Pseudo-code [9]:

- Step 1. Find the factors affecting fog computing.
- Step 2. Collect data to create the dataset.
- Step 3. Using Fuzzy logic measure the participation of each factors.
- Step 4. Implement proposed data analytics model to the dataset.
- Step 5. Find the relation between the factors in the model.
- Step 6. Find the accuracy of the proposed model.
- Step 7. End

2. Fuzzy Logic

Fuzzy Logic is one type of multiple-valued logic where the truth value of the variables can be a real number varied from 0 and 1. This is executed to deal with the idea of partial truth in which, truth value might vary in between absolute true and absolute false. When Boolean algebra and binary logic fails to express the situation analysis of a particular factor then fuzzy variables express the truth of the belongingness of the factor to the event. This belongingness is expressed as the membership function of the variable, an example is shown in Figure 1. The sample shows the weather condition transforming from cold to hot and vice versa.

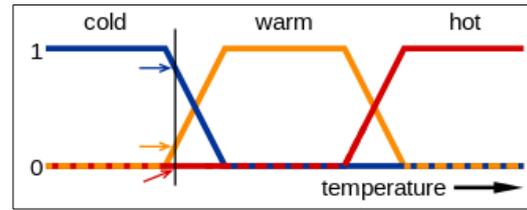


Figure 1: Illustration of Fuzzy Logic

3. Logistic Regression

Logistic regression is related to regression analysis. It refers to calculating the parameters of some logistics models. Logistic regression is used when the dependent variable is categorically used and decision sets are achieved. This expresses the confidence of the predicted values. Data usually fit to linear regression. A sample of logistic regression is expressed in Figure 2

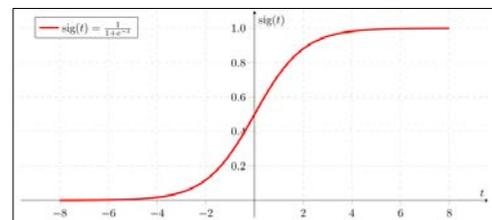


Figure 2: Logistic Regression

4. Random Forest Classifier

These are to classify the random forests. Random forests refer to ensemble learning procedures to classify and do other activities which activate by making a multitude regarding decision trees during training. In the example, two ones and five zeros with combination of red and blue digits, we have to separate the coloured one and the underlined one from the forest of zeros and ones, shown in Figure 3.

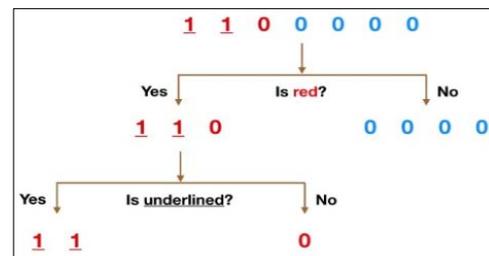


Figure 3: Illustration of Random forest

6. Factors Affecting Fog Computing

Target user (Tu) – Logistics and Transportation, linking health, smart production, smart energy, and automation are related to it. A group of targeted audience is created from identical factors like target market, though this is more ascertained and is capable of effecting remaining factors.

$$Tu = \{(Tu_i, \mu_{contribution}(Tu_i): Tu_i \in TargetUser)\}$$

.... (1)

Geographical distribution (Gd) – The natural arrangement and apportionment of the various forms population distribution of the customers may be covered in this area.

$$Gd = \{(Gd_i, \mu_{contribution}(Gd_i): Gd_i \in GeographicalDistribution)\} \dots (2)$$

Content generator and consumer (Cg) - Content is emerging as the foundation for brands to create awareness in online mode. The behaviour of consumers has shifted towards becoming highly “research-oriented” as a vacillation of consumers shifting online owing to research at first and then moving out to physical store and massive amount of consumers go through search engines while they intend to purchase products.

$$Cg = \{(Cg_i, \mu_{contribution}(Cg_i): Cg_i \in Contentgenerator)\} \dots (3)$$

Data storage (Ds) - In order to be really optimistic about IT infrastructure, the best idea is to inculcate an extensive and alive pathway to hybrid cloud which lowers the costs barring cloud lock-in, unites and operates well with present solutions; all when facilitating management, containerization, software based storage as well as updated data protection.

$$Ds = \{(Ds_i, \mu_{contribution}(Ds_i): Ds_i \in Datastorage)\} \dots (4)$$

Data processing (Dp) - If somebody handles huge volumes of raw data or works with little data, he/she understands that data processing as well as data conversion are crucial to business. In accordance with increasing salaries of staff, overhead expenditure and infrastructure related burdens, outsourcing of his/her data processing to India may be a better answer to the issue that he/she is facing.

$$Dp = \{(Dp_i, \mu_{contribution}(Dp_i): Dp_i \in Dataprocessing)\} \dots (5)$$

Latency tolerant (Lt) – One viable approach to computer network architecture may be delay tolerant networking which attends the technical matters in the network which might have deficiency of uninterrupted network connectivity.

$$= \{(i, \mu_{contribution}(i): i \in Latencytolerant)\} \dots (6)$$

Security (Sc) – Network security depends on simplicity security and scalability of the data packets.

$$Sc = \{(Sc_i, \mu_{contribution}(Sc_i): Sc_i \in Security)\} \dots (7)$$

Decision making (Dm) - Considering the fact that cyber-security competency development is the fundamental of simulation games, in the beginning we review the capability development in short. Following that, we cultivate the vital theoretical framework related to simulation games which is founded on the doubtfulness of cyber issues and lateness in development of cyber-security ability [9].

$$Dm = \{(Dm_i, \mu_{contribution}(Dm_i): Dm_i \in Decisionmaking)\} \dots (8)$$

Correlation equation

The variables of the above discussed factors are responsible the decision in the cloud. The respective of the variables are briefed in the table 1. The variables affecting fog computing are considered randomly within the range zero and one. The average and the standard deviation of the variables are given the Figure 4.

Activation correlation between the variables is given in equation (9):

$$f = \frac{1}{n} \sum (Tu_i + Gd_i + Cg_i + Ds_i + Dp_i + Lt_i + Sc_i + Dm_i) \dots (9)$$

Equation of the relation of the variables is given equation (10):

$$\hat{b}_1 = \frac{(\sum x_2^2)(\sum x_1 y) - (\sum x_1 x_2)(\sum x_2 y)}{(\sum x_1^2)(\sum x_2^2) - (\sum x_1 x_2)^2}$$

$$\hat{b}_2 = \frac{(\sum x_1^2)(\sum x_2 y) - (\sum x_1 x_2)(\sum x_1 y)}{(\sum x_1^2)(\sum x_2^2) - (\sum x_1 x_2)^2} \dots (10)$$

where the symbols have their usual meanings.

Table 1: Variables affecting fog computing

| Symbols | Descriptions |
|---------|--------------------------------|
| Tu | Target user |
| Gd | Geographical distribution |
| Cg | Content generator and consumer |
| Ds | Data storage |
| Dp | Data processing |
| Lt | Latency tolerant |
| Sc | Security |
| Dm | Decision making |

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Confusion Matrix
[[86 20]
 [37 57]]

[86 20]
*****
[37 57]
*****
Test model accuracy on test data on confusion matrix

[[86 20]
 [37 57]]
Testing Accuracy = 0.574626865672
$$$

[[73 33]
 [34 60]]
Testing Accuracy = 0.58125
$$$

[[82 24]
 [39 55]]
Testing Accuracy = 0.556338028169
    
```

Figure 5: Confusion Matrix of the model

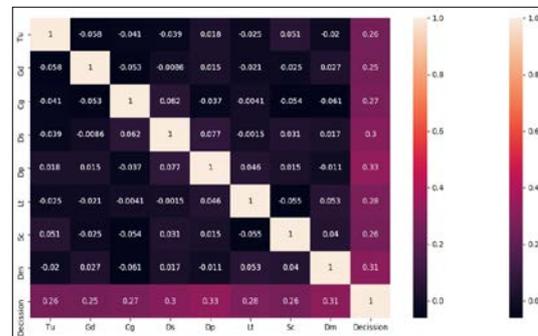


Figure 6: Heat map of the variables

7. Results

The 801 values of the individual variables are evaluated in figure 4 and their belongingness, regression and classification are found, including confusion matrix in Figure 5 along with the accuracy rate of the designed model. The accuracy of the Logistic Regression Training is 0.718333333333 and Random Forest Classifier Training accuracy is 0.988333333333. The heat map Figure 6 expresses the inter-relation between the variables. The inter-relation between the factors lies between -1 to 1. If the factors' values lie between -1 to 0, then no relation exists and if the factor comes more than 0 and less than equal to 1, then it symbolizes the effectiveness of the relations.

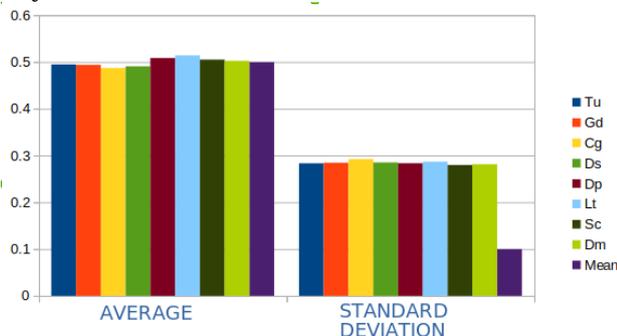


Figure 4: Average and Standard Deviation of the variables

8. Conclusion

The study predicts the factors influencing fog computing adoption in the public and private sectors with the help of fuzzy logic and Big Data Analytics. The study tries to predict the factors with few basic components. The data set is of 801 heads of feedback of the basic requirement of the study. The equations of the variables are designed with fuzzy logic and its membership function to find the participative of the factor to the adoption. The regression function of the variables is designed to find the participation of the individual factor of the fog computing. This paper deals with 8 factors of the stock market with successful parameters and results. The accuracy of the model is measured by Logistic regression and Random forest classifier. This paper finds the relationship between themselves and the dependencies among them.

The paper has few limitations. This paper gives an overview of fog computing. But it does not provide in-depth application of fog computing. It highlights some challenges and offers few suggestions to overcome those points. Still there are some other inconveniences of fog computing which are still to be managed.

Only eight factors is not sufficient enough to describe the responsibilities of fog computing with

respect to IoT and IoT. Fuzzy is such a dynamic model it will help other factors easily. These are the future prospect of this model.

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References

1. J Gantz, D Reinsel, Extracting value from chaos, IDC iView, 1142 (2011)(2011), pp 1-12
2. A McAfee, E Brynjolfsson, T H Devenport, D Patil, D Barton, Big data: the management revolution, Harv. Bus., 90 (10)(2012), pp-6068.
3. D Evans, The internet of things: How the next evolution of the internet is changing everything. CISCO white paper, 1 (2011)(2011), pp. 1-11
4. B Ravindi, I Papapanaiotou, A self-learning scheduling in cloud software defined block storage, 2017 IEEE 10th International Conference on Cloud Computing (CLOUD), IEEE (2017), pp. 415-422
5. B Zhang, N Mor, J Koib, D S Chan, K Lutz, E Allman, J Wawrzynek, E A Lee, J Kubiawicz, The cloud is not enough: saving IOT from the cloud. Hot Storage (2015)
6. J Acharya, S Gaur, Edge compression of gps data for mobile IOT, 2017 IEEE Fog World Congress (FWC), IEEE (2017), pp. 1-6
7. A Yousefpour, C. Fung, T Nguyen, K Kadiyala, F Jalali, A Niakanlahiji, J Kon, J P. Jue, All one needs to know about fog computing and related edge computing paradigms: A complete survey, Journal of System Architecture, Vol 98, September 2019, pages 289-330
8. Raymond W Y Kao, Creativity and Innovation management, Willey Online Library, March 1993
9. Taraknath Paul, Fintech Empowers Prediction of Stock Market Index Using Artificial Neural Network, IEEE Explore, International Conference on Artificial Intelligence and Computer Science Technology, E-ISBN- 9781665424042