Unique Taxonomy for Evaluating Fog Computing Services

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Unique Taxonomy for Evaluating Fog Computing Services

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ABSTRACT

Cloud computing has slowly but surely become the foremost service provider for information technology applications and platform delivery. However, Cloud issues continue to exist, like cyberattacks, slow last mile latency, and clouds lack client-centric and location-aware applications to process real time data for efficient and customized application delivery. As an alternative, Fog Computing has the potential to resolve these issues by extending the Cloud service provider's reach to the edge of the Cloud network model, right up to the Cloud service consumer. This enables a whole new state of applications and services which increases the security, enhances the cloud experience and keeps the data close to the user. This research article presents a review on the academic literature research work on Fog Computing, introduces a novel taxonomy to classify cloud products based on Fog computing elements and then determine the best fit Fog Computing product to choose for the Cloud service consumer.

KEYWORDS

Cloud Computing, Cloud Security, Edge Computing, Edge Security, Fog Computing, Internet of Things, IoT

1. INTRODUCTION

The primary objective of Fog computing is to ensure the user data stays as close to the user by employing geographically distributed computing infrastructure at the edge of the cloud-user network. This involves virtualized platforms, smart devices, sensors and nodes that provide storage, computing and network services located at the edge of the cloud network. Yet Fog computing is not a replacement for Cloud computing. Cloud Computing, Internet of Things and Fog Computing are discussed in this section. Cloud Computing organizes a pool of shared infrastructure of hardware and software stack hosted inside a centralized data center for delivering service layers over the Internet. These performs compute, storage and networking functions to receive, process and respond to user requests. Cloud computing services are related to applications, platforms and infrastructure, delivered to the Cloud service consumers. The hosted resources are shared by the Cloud service consumers as per different commercial models. Current market examples include Google Docs, Sales Force, Microsoft Office 365 and Amazon Web Services.

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Fog Computing refers to a distributed, decentralized system level architecture that extends the reach of Cloud computing, storage, networking and access control right up to the edge of the network near the user and devices involved. This involves the use of intelligence down to local area network level on the smart devices, nodes, data hub and sensors configured as near to IoT data collection point. Transporting data from nodes to the cloud involves several steps.

Edge Computing is an older expression for Fog Computing and actually simplifies the communication chain by reducing points of failure and network architecture complexities. This pushes the processing capabilities like node intelligence, memory and data communication of an edge gateway appliance directly to programmable device controllers.

IoT data is processed by a smart hub locally, as close to the sensor that is generating the data, unlike Cloud architecture which is has centralized computing. E.g. in Healthcare domain, wearable fitness tracking devices, medial home appliances to collecting Electrocardiogram signals with 4Kbps bandwidth channel to an IoT sensor processing node. Automation applications also utilize IoT in motors, bulbs, pumps, generators, relays. Fog Computing empowers the smart hub and nodes to carry out computing and processing functions which otherwise would be performed at a far off centralized data center as Local data processing, Low latency with better QoS, Cache data management, Edge node analytics, Dense geographical distribution and resource pool.

Internet of Things or IoT is an internetworked connection of physical devices, buildings, vehicles and smart systems. These are implanted with sensors, actuators over existing network to act as nodes for collecting and exchanging real time data (Chung-Sheng et al., 2018). Examples of IoT include Kolibree Smart Toothbrush, Samsung Smart Things Hub, Nest Smart Thermostat and WeMo Switch Smart Plug. Fog network works at two basic levels – data level and control level. The data level plans for data management, processing and configuration of the computing resource device nodes. This leads to low latency, faster, efficient management for collaboration and accessibility with edge node devices using wireless networks. The control plane decides the network overview, routing protocols and control architecture as illustrated in Figure 1.

An IDC study on the Fog/Edge Computing trends by Yoko Ono (2017) estimates in 2020, over 10% of the user data would be processed by smart edge devices involving use of Fog computing. Differences between Cloud Computing and Fog Computing are illustrated in Table 1 from features perspective for these two technologies.

Differences and common features between Cloud, Fog and Edge Computing technologies are illustrated in Table 2.

Figure 1. Cloud Computing, Fog Computing and Internet of Things architecture

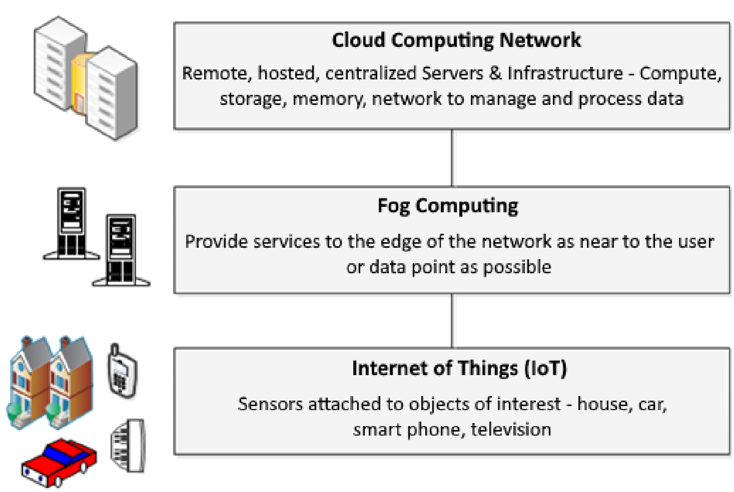


Table 1. Comparing Cloud Computing and Fog Computing

Feature Requirements	Cloud Computing	Fog Computing
Latency involved	High, depends on User to DC route	Low
Response time	Several Minutes	Milliseconds
Service Location	Inside Cloud Data Centre via internet	Edge of Cloud network
Time for data storage	Months or years as per contract	Transient
Hops between user & server	Multiple	One
Location Awareness	None, need manual routing	Very local
Architecture	Centralized	Distributed
Last mile connectivity	Broadband, MPLS, Leased line	Wireless
Attach probability on data	High	Low
End to end Security	Cannot be defined or controlled	Can be defined
Nodes to collect data	Very few	Unlimited
Mobility support	Limited support	Supported

Table 2. Comparing Cloud, Fog and Edge Computing and Fog Computing

<table>
<tr><th>Cloud Computing</th><th>Fog Computing</th><th>Edge Computing</th></tr>
<tr><td>SaaS, Big Data Analytics, Scalability</td><td></td><td></td></tr>
<tr><td colspan="2">Resource Pooling, Elastic Compute, IaaS, PaaS</td><td></td></tr>
<tr><td></td><td>E2E, Data Protection and Session, Modular HW, Real Time Control & HA, complete Network & End to end security, Enabler for multiple IoT verticals</td><td></td></tr>
<tr><td></td><td colspan="2">Data service at edge, Analytics, Real Time, Secure Multi Cloud Internetworking, Device Sensor Management, Node Communication</td></tr>
<tr><td></td><td></td><td>Dedicated but limited App Hosting, Embedded IOS, Partial Security – VPN/FW, Limited Network & Security scope, No IoT vertical integration</td></tr>
</table>

2. IMPORTANCE OF IOT FOR E-BUSINESSES

The reason for businesses to be excited regarding the deployment and use of Internet of Things is described in this section. IoT provides ground breaking, new commercial openings, demands, growth and development prospects in new age sectors like use of wireless, bio-chips, auto sensors, radio frequency identifiers (RFID). IoT is helping improving healthcare services, build smart cities, and control logistics, improving automotive and manufacturing quality, as well as increasing agricultural and farming productivity. IoT helps organizations gather the required information on optimizing deployments & resources, customer satisfaction and grievances, product designing easily. Edge nodes in form of physical devices share information with connected log processing devices. This leads to rapid data sharing and transmission, along with efficiency and cost cutting. Improved data tracking can also help in logistics, storage and inventory efficiency. Automotive and Manufacturing industry can easily become the main beneficiary of IoT apart from retailers utilizing IoT in products such as mobiles and printers.

3. LITERATURE SURVEY

In order to understand existing solutions and research on Fog Computing product evaluation, the author surveyed several research publications and reviewed academic literature works from IEEE, ACM Science Direct, Elsevier and ACM, searching for keywords as Fog Computing, Edge Computing, Nodes, Sensors, Internet of Things and IoT.

Hofer et al. (2011) described the advantage and features for Cloud computing and Fog computing from services and commercial point of view for global corporates entering the Cloud domain for the first time. The authors proposed a tree based structured Fog computing taxonomy. The primary aim of the research was to have a Fog computing taxonomy that classified the Cloud services by arranging the Fog elements in a simple and comparative manner and levels for even a layman to understand and take decisions. The proposed taxonomy levels included Main Services, License Types, and Payment Methods, Intended User groups, Formal Service Agreements, Security Measures and Standardization efforts involved. The authors also included examples and samples in the research paper for better clarity.

The achievement of the research paper by Youseff et al. (2008) is being one of the first serious endeavors to establish a detailed taxonomy of Cloud computing way back in 2008. The authors proposed a detailed ontology with a thorough understanding of Cloud and its adoption with the aim to ensure Cloud domain gets established in a better manner worldwide. Various inter-relations between the Cloud components and its layers were used to establish the ontology, discussing the advantages, strength and limitations of each element in detail.

Cloud computing services have registering a huge interest among the cloud service consumers. Alan Sill (2017) presented the research proposing that the communication between Cloud components including cloud applications, data center devices, humans seem to have diminished their boundaries by colluding between Cloud (centralized access over Internet), Edge Fog (distributed cloud in form of highly diffused setup) and IoT (connected and no connected components). There is hence an urgent need for developing a standard and having clear definition of the components.

Mazin Yousif (2017) focused on associating Fog and distributed computing. The article centered on Fog, Edge and Distributed computing. While Fog processing was initiated in 2014, the paper proposed Edge processing attempts to accomplish a similar objective, through various methodologies. The objective was to define Fog processing moving the computing to the IoT gateways or to the client neighborhood. The paper also evaluated how Edge computing drives the data process and information to the Edge gadgets at the base of the Cloud engineering chain.

The pervasiveness and all-inclusiveness of mobile phones makes them perfect Fog gadgets to extend the Edge gadgets and the Cloud. Dantu et al. (2017) proposed an architecture for enabling reliability and adaptability of smart phones running Android operating systems. The authors illustrated the software architecture, constraints faced by systems and applications and presented options to address he challenges. As a future research subject, this work on Android could be stretched to adjust for other versatile smart phone OSs.

Li et al. (2017) proposed that vehicular networks when integrated with Cloud and Fog platforms can be worthy systems displaying a significant part in day to day social lives and help social marketers. Another application implementation as recommender framework to assist advertisers in enhancing and promoting marketing adequacy. The authors proposed three algorithms to increase the effectiveness of advertisers' promoting viability in view of various assessment measures. The first algorithm chooses those vehicles that can get most extreme advantages for the advertisers, in which the vehicles are chosen in view of passing locales with more advantages. This determination strategy may lose some potential markets in light of area impediments. The second algorithm chooses those vehicles that can achieve the most extreme scope proportion in the city and bring the advertisers all the more showcasing viability later on, despite the fact that the present advantages are not the best. The third algorithm joins the two earlier algorithm results, finding a tradeoff amongst scope and advantages. The viability of the proposed algorithms was assessed with real time information to demonstrate the adequacy and proficiency of selecting vehicles as recommenders for vehicular social networks.

Etemad et al. (2017) proposed that with the expansion of Internet of Things, cloud and Fog computing, involving human services, administrations, sensor systems, and cell phones, a considerable measure of information is being produced at the perception layer. Cloud computing systems are the most reasonable solution for information stockpiling, computing, preparing and administration. Cloud additionally assists in the production of further service administrations tasks, which is refined by the specific situations and prerequisites. Fog computing, in form of an extended cloud existing in the vicinity of hidden nodes, moderate the issues which traditional Clouds can't understand since they are usually independent. Fog provides fast reaction to the applications and preprocess and channels the information as indicated by the necessities. The authors proposed solutions by examining both the cloud-only and cloud-Fog situations with regards to delay in processing and power consumption issues when number of clients are increased.

Xiao et al. (2017) proposed use of Fog computing to convert vehicles into mobile Fog computing nodes. The authors presented a framework and system design to utilize the mobility aspect of vehicles to provide low-cost, on-demand Fog computing for vehicular applications.

Alrawais et al. (2017) discussed the privacy and security issues inherent in the Internet of Things devices. This included limited computing power, restricted storage capacity and need for new upgraded platform for handling and processing data efficiently. Fog computing on the other hand, provides variety of advantages in comparison. These include upgraded security, reduced data transfer bandwidth capacity and decreased latency. These advantages make the Fog a great fit for IoT applications. The authors also displayed potential research options for utilizing Fog computing to improve security and protection issues in IoT application environments.

Yannuzzi et al. (2017) discussed the technical difficulties and issues faced by city communities when implementing smart city ideas and designs as part of Fog computing. The authors outlined standards and lessons learned from implementation activities on Fog processing in Barcelona, Spain. Specifically, Quadruple Silo issue was pointed out in the research paper that has four classifications of silos as physical (equipment) silo, information silo, administration silo and regulatory silo. The article uncovered cases in which Fog computing processing is an unquestionable requirement demonstrating the reasons behind deploying Fog computing.

In context of the growth and issues for Cloud and Fog computing, David Linthicum (2017) analyzed issues for cloud data traveling from Fog devices at the user base to the data centers over the internet, growth rates and time latency issues. The devices included thermostat and wristbands among other devices. The authors proposed that alternatives to cloud need to be determined as use of public clouds in fog scenarios is notan effective implementation and most times it proves to be not feasible.

Garcia et al. (2017) introduced a framework to determine and control the commercial aspects when enabling a shared economy vision by using edge devices for smart city scenarios. The authors contended that the use of edge devices and cloud services is critical component of the Technology Stack for Internet of Things. While both edge devices and cloud services are incorporated for smart city ecosystems, cloud providers do include pricing strategies in their service offerings, but the edge devices do not reflect on the economic aspects.

Mahadev Satyanarayanan (2017) presented many ideas and results from discussions and research collaborations including industry ventures and investments in the edge processing domain. The author presented the origin and roots of edge computing since 1990s starting with Akamai content delivery networks to 2012 when Flavio Bonomi introduced Fog computing. The author discussed the need for proximity location for high result intensive cloud computing services, scalability for edge analytics using Giga Sight framework for mobile devices on real time video analytics, Privacy enforcement for cloudlets to masking Cloud outages. The results pointed out to the use of Edge and Fog computing as the technologies to go for future.

Hao et al. (2017) presented a detailed narrative of research challenges and issues for Fog computing. Based upon the results, the authors proposed a detailed computing software architecture framework to customize the different designs and include user policies and then finally evaluate on the software prototype system.

Rafel et al. (2017) presented a hybrid fog and cloud framework. This interconnected framework was scalable and multi tenanted solution can be easily configured deployment over layer 2 and layer 3 networks across both Fog and Cloud infrastructures. Use of virtualization and underlying Fog and Cloud technologies was implemented as a solution for cross-site networks for Cloud and Fog computing infrastructures.

Lu et al. (2017) presented a lightweight privacy preserving information aggregation model for Fog computing. The paper employed aggregating the data from all hybrid IoT devices into one based on Chinese Remainder Theorem. The three significant contributions by this paper are firstly the use of the Lightweight Privacy model for Preserving Data Aggregation, secondly the data aggregation presented was secure under the defined security model as the model mitigated and blocked differential attacks and thirdly the results indicated the proposed model as being lightweight and suitable for Fog computing.

Deng et al. (2016) proposed investigated the issues related to consumption of power and delays in transmission in Fog-Cloud computing systems and proposed solutions to resolve the relationship and support between the two. The authors proposed implementing optimal workload allocation for Fog and Cloud, consuming minimum power with balanced delay in services. The authors finally concluded that by reducing unbarring computing resources, bandwidth can be saved along with reduced latency, which in turn significantly improved the Cloud computing performance.

Gu et al. (2017) investigated the Quality of Service (QoS) challenges in the healthcare industry for medical cyber physical systems which sense data from medical devices. In order to resolve this issue, Fog computing is proposed as a possible solution. The authors integrated fog computing and the medical systems and also proposed a two-phase heuristic algorithm based on linear programming.

Luiz at al. (2017) analyzed the Fog computing resource management and scheduling issues by focusing on user mobility influencing application performance and using scheduling policies such as concurrent scheduling, Delay priority scheduling and first come first served scheduling.

Chiang et al. (2017) proposed a framework for interconnected Cloud and Fog systems. The proposed framework provided options for cross site virtual networking infrastructures comprising of Cloud and Fog with scalable, multi-tenant solution. The interface designed was simple and generic for implementing across layer 2 and layer 3 networks.

4. PROPOSED FOG COMPUTING TAXONOMY

While a number of research surveys have been published on the Fog computing, this paper is different from them in the following manner:

- Most researchers focus on Fog computing for infrastructure, connectivity or data collection features. Our taxonomy focusses on classifying products based on four specific elements. Other surveys and research papers which are reviewed above have limited scope of research;
- Implementation and usage of Fog Computing against Cloud Computing environments is highlighted in some of the review papers, while our taxonomy proposes a simple hierarchical, layered model which can be extended with little or no constraints on dimensions or the feature elements, which are independent of each other.

The proposed Taxonomy based on the critical aspects of Fog Computing. The first feature relates to Node Configuration which involves the architecture design for the Fog device. The next aspect relates to Association techniques for managing the collaboration between the different Fog nodes. The third aspect involves Resource Allocation which contributes services and resources for provisioning of the Fog nodes. The forth aspect relates to service management objectives to attain when deployed on the edge with services from end devices and sensors going to Cloud data centers. The final aspect deals with Security under situations for data at rest (inside the Fog node) or data in motion (from the Fog node on the Internet to the Cloud data center. These are outlined as in Table 3.

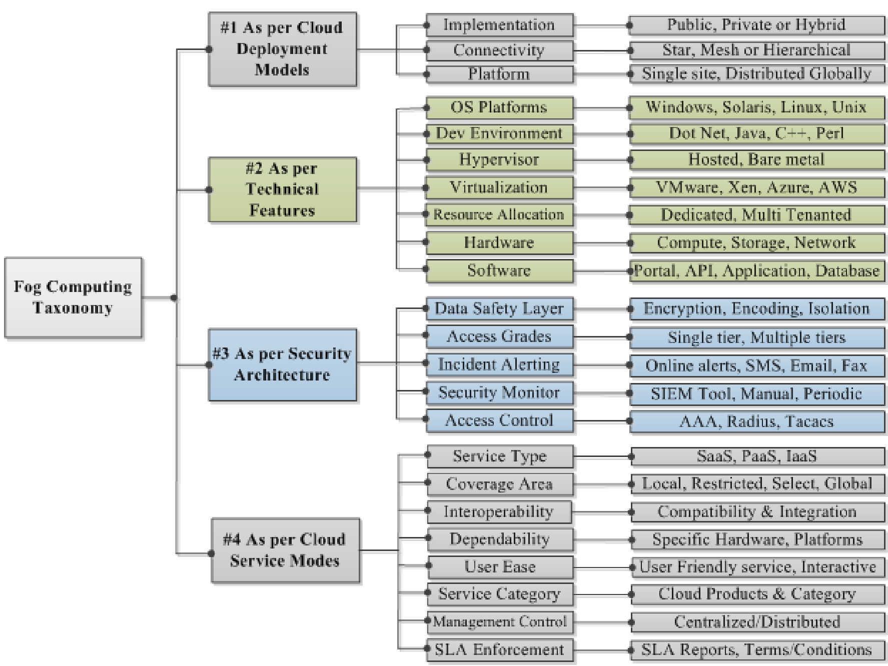
5. PROPOSED EVALUATION METHODOLOGY

The authors propose the methodology for selecting the best matching Fog product as per the Cloud provider and user preference and policies. Each cloud product was graded and scored based on semantic and deterministic element features and sub feature characteristics. The products are then ranked and matching percentage is calculated, based on which the best fit product can be suggested to the Cloud user. The authors propose the below classification of Fog Computing by dividing into four major elements as per Deployment model, Technical features implemented, Security architecture and Service model offered by the Cloud provider in Figure 2.

Table 3. Proposed Fog Computing taxonomy

Fog Computing Taxonomy				
Node Configuration	**Association**	**Resource Allocation**	**Service Management**	**Security**
Basic Edge – OS, Hardware, Network	Peer to Peer	Cost bandwidth, Deployment, Execution	Application, Latency, Network, Compute, Cost	Encryption
Virtualization – Virtual machine, Hypervisor, OS, Hardware, Network	Client Server, Master Slave	Compute, Memory, Storage	Data Management	Privacy, Man-in-the-middle attack
Base Stations, Sensor	Cluster	Data Flow, Size, Rate	Power Management	DDoS attack

Figure 2. Proposed Fog Computing taxonomy



The below equations illustrate the process for calculating the score given to the Fog product based on the below mentioned equations for calculating the Fog Cloud product score:

$$\text{Score (Fog Product)} = {}^{4}\sum_{i=1} Xi \text{ x } \{\text{Fog Element Feature }_{i}\}$$
$$\text{Fog Element Feature} = \sum_{j} \text{ x } \{\text{Fog Element Sub Feature }_{j}\}$$
$$\text{Fog Element Sub Feature} = \left\{\frac{Numerical\ Assigned\ \#\ \ +\ ve\ Feature\,/\,Sub\ Feature}{Total\ Features}\right\}$$

Total Features

$$X_i = \begin{Bmatrix} 1 & if\ Fog\ Feature\ i\ is\ stated\ by\ user \\ 0 & if\ Fog\ Feature\ I\ is\ otherwise \end{Bmatrix} \rightarrow \text{refers to expected characteristics}$$

The various types and score ranges for features and sub features for determining the best fit value of the Fog computing product as illustrated in Table 4.

To determine the numeric value for each Fog element 'score', the allocated scores for 'Yes', 'No' or 'Very Low' to 'Very High' range convert into actual deterministic values for each element feature in Table 5. The authors ranked the linguistic variable with a numerical value. The score is determined from linguistic values as per the four classification elements (Deployment, Technical Configuration, Security Architecture and Cloud Service model as well as considering the features and sub features for being either deterministic or semantic.

Table 4. Fog Computing best fit selection model

Element	Classification	Feature	Sub Feature	Score
#1 Deployment Model	Implementation	Deterministic	Deterministic	Very Low – Very High
	Platform	Semantic	Deterministic	Very Low – High
	Connectivity	Deterministic	Deterministic	Very Low – Medium
#2 Technical Configuration	OS Platform	Semantic	Semantic	Very Low – High
	Dev Environment	Semantic	Semantic	Very Low – High
	Hypervisor	Semantic	Deterministic	Very Low – Very High
	Virtualization	Semantic	Semantic	Very Low – Low
	Resource allocation	Deterministic	Deterministic	Yes/No
	Hardware Type	Deterministic	Deterministic	Yes/No
	Software Type	Semantic	Deterministic	Yes/No
#3 Security Architecture	Data Safety Layer	Semantic	Deterministic	Very Low – High
	Access Grades	Semantic	Deterministic	Very Low – High
	Incident Alerting	Semantic	Semantic	Low - High
	Security Monitoring	Deterministic	Deterministic	Yes/No
	Access Control	Semantic	Deterministic	Yes/No
#4 Cloud Service Model	Service Type	Semantic	Deterministic	Very Low – Low
	Coverage Area	Deterministic	Semantic	Low – High
	Interoperability	Semantic	Deterministic	Yes/No
	Dependability	Semantic	Deterministic	Yes/No
	User Ease	Semantic	Deterministic	Yes/No
	Service Category	Semantic	Deterministic	Very Low – Low
	Cloud Architecture	Deterministic	Deterministic	Very Low – Low
	SLA Enforcement	Semantic	Deterministic	Yes/No

Table 5. Transition from designated to actual values

Linguistic Value	Numeric Value
Yes	3
No	1
Very Low	1
Low	2
Medium	3
High	4
Very High	5

6. EXPERIMENTAL RESULTS

In order to avoid favoring or infringing on any Fog vendor, four cloud products without a brand name are considered for the practical cloud product evaluation and their features are assessed for each of the proposed sub features for Fog Computing best fit methodology model. Initially numeric values are assigned to the Fog computing element classification features for each product. These values are determined by converting semantic to deterministic numeric values as shown in Table 6.

Cloud product score as per customer requirements is illustrated in the graphs below. This is calculated by the values of each element for each product. Numeric values for an ideal cloud product are also displayed, as shown in Table 7. These can help the Cloud product consumer to make calculated decision.

Table 6. Transition from designated to actual values

Fog Element	Classification	Product #1	Product#2	Product#3	Product#4
#1 Deployment Model	Implementation	1	2	3	4
	Platform	2	3	2	4
	Connectivity	2	1	4	3
#2 Technical Configuration	OS Platform	2	3	3	3
	Dev Platform	1	2	2	4
	Hypervisor	2	1	1	2
	Virtualization	1	3	1	3
	Resource allocation	1	3	3	3
	Hardware Type	3	1	3	3
	Software Type	1	3	1	3
#3 Security Architecture	Data Safety layer	2	1	2	4
	Access Grades	1	1	3	4
	Incident Alerting	2	2	4	4
	Security Monitoring	1	3	1	3
	Access Control	1	1	3	3
#4 Service Model	Service Type	1	1	1	2
	Coverage Area	2	2	3	4
	Interoperability	1	1	3	3
	Dependability	3	1	1	3
	User Ease	1	3	1	1
	Service Category	1	2	2	2
	Cloud Architecture	3	1	3	3
	SLA Enforcement	1	1	1	3

Table 7. Product score calculation for Fog elements

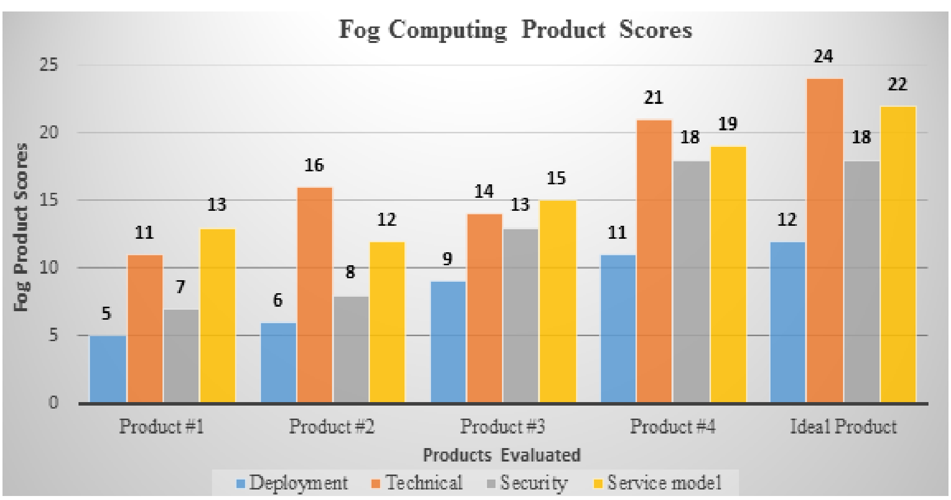
Element/Products	Product #1	Product #2	Product #3	Product #4	Ideal Product
#1 Deployment Model	5	6	9	11	12
#2 Technical Features	11	16	14	21	24
#3 Security Architecture	7	8	13	18	18
#4 Service model	13	12	15	19	22
Score	**36**	**42**	**51**	**69**	**76**

Figure 3 illustrates the four Cloud Fog products and the ideal Fog computing product.

CONCLUSION

This paper initially presents a survey of the academic literature on Fog Computing and then proposes a unique Fog Computing taxonomy model. The primary research performed here is to determine a simple yet effective process for calculating the score for best fit Cloud Fog product. The authors chose the mandatory Fog elements (Deployment, Technical, Security and Service) in order to determine the score of Fog computing products with classification and scores assigned to each feature and sub feature. From the fog Product Score graph, Products 1, 2 and 3 score low to average on most Fog element features and hence can be rejected, while Product 4 scores relatively higher in comparison so can be a good fit as per the user requirements. Product 4 comes across as being relatively close to an ideal Cloud product score, hence can be chosen as the Fog product to deploy and implement by the user. In this manner, any product can be easily compared and an analytical judgment can be established. The proposed Cloud product evaluation model calculates and helps decide on choosing the best fit Fog computing product. As an example, four Fog products are chosen and evaluated (scores ranged from 36 to 69) against an ideal product score of 76. This methodology can be easily be utilized for real time fog product score evaluations and comparisons.

Figure 3. Fog product scores



Future Research

Future research can be aimed at devising a similar model suitable for evaluating Cloud computing service product offerings using Cloud feature elements and sub-features. Yet another future research area can be for real-time Cloud application services. Fog Computing influences and merges a large number of new age, radical technologies, processes and applications for varied business domains. The technology is being designed to take advantage of Cloud Computing infrastructure and systems over unsecure internet yet deployed on hardware which is in fact closer to the edge of the network generating logs and data. Currently a lot of so called IoT devices carry data to and from the Cloud. When dealing with large amount of 'data lakes', this can actually 'submerge' the applications and tax the cloud computing heavily. The future research would be geared towards not just making Fog Computing smarter, faster and efficient from Quality of Service (QoS) perspective, interfacing, resource management but also securing the data in motion from Fog nodes to the machine learning analytics systems. This would turn the architecture into a mini-cloud running on the edge where the data actually originated. Yet another future direction for Fog Computing is to converge IoT, Edge Devices, Radio Technologies, Wireless, Software Defined Networks, Virtual Machines and Mobile applications.

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