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A Systematic Literature Review on Fog Computing

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Abstract

The growth and usage of Fog computing is drastically growing in the field of cloud-based solutions. Rather than the required services provided by the Cloud to the Internet of Things (IoT) systems Fog has been used in variety of services. Fog Computing moves the storage and computing resources closer to the IoT devices. FC arises when the need for immediate responsive tasks emerges and increases in IoT applications. FC is a decentralized system which is subjective by the context-aware information of the data sources such as response time, location, resources disbursed by the service, etc.FC is provided at the edge node in the network either physically or in virtual form. In this review, the architecture of FC, its various deployment models, recent IoT applications where FC is utilized, advantages of FC rather than Cloud are revealed. Apart from the issues in the implementation of FC hardware platform, number of issues in service deployment and service provision in FC which are addressed at the end of this survey.

Keywords - *Cloud, Fog Computing, IoT applications, Service deployment, Service Provision, Edge Computing*

1. Introduction

In [1], the broader approach of Edge Computing is Fog Computing (FC). In Edge Computing, instead of sending all the data to the Cloud either from Mobile or IoT devices to do the tasks, the application build on the edge system of the network itself handles the data for the specified task to reduce the latency. FC provides the collaborative scenario at the edge of the network to provide both static as well as dynamic services. Processing close to devices reduces the response time, bandwidth usage, and enables the real-time applications. FC is a distributed way of service provision in the network. It reduces the limitations of centralized system. Virtual machines can also be used in edge devices.

FC with IoT and Cloud is the current trend in research. The most interesting challenges in FC lie in Things Collaboration, Run-Time Implementation, and the Service Operations. As the humanism needs autonomous system even in their regular day-to-day activities, the innovations and inventions in FC will support this modern digital world vigorously.

2. Applications of FC

FC provides the IoT services from EC. It should be mobility supportive, context-awareness one, manageable of geo-distribution, and low-latency problems.

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The characteristics of the applications which can run in FC are stated below [2].

a. Reduce latency
b. Bandwidth optimization
c. Computational offloading
d. Privacy and security
e. Service management
f. Monitoring edge devices
g. Energy efficiency
h. Cost saving
i. Content caching

In [1], the model of FC in Flood Warning System as a forecasting model was discussed. It requires real-time perception and interaction with the environment. Through FC, the accuracy of forecasts and warnings can be augmented. This model is provided with four types of resources such as Dam Level Sensor, Temperature Sensor, Soil Moisture Sensor, and Dam Gate Actuator. The Precipitation Service also provided by the model to monitor predicts the rate of rainfall. Based on the threshold value with the consideration of water inflow, temperature, and soil moisture rate, the output from the system may trigger the state change in floodgate.

Day-by-day, the usage of FC and the ideas of utilizing FC are growing tremendously in most of the autonomous or semi-autonomous systems. In real-time systems, for immediate decision-making system, FC is most welcoming technique. Its applications include LiveMap, Wearable cognitive assistance, Live video broadcasting, Visual security and surveillance, Traffic congestion management, High-scale drone package delivery, Process manufacturing, Smart buildings, Real-time subsurface imaging, Patient monitoring, Autonomous driving, Robots simultaneous localization and mapping, Mobility-as-a-service, ARQuake, FAST, eWall, Smart street lamp, Power consumption management, Vehicular video processing, Vehicular pollution control, FogLearn, Telemedicine, SWAMP, Smart waste management, Drone traffic surveillance with tracking, GPU-assisted antivirus protection in Android devices, Cachier, Edge Courier, MMOG, Edge content streaming for mobile streaming, etc.,

The list is ever growing one since the increase in usage of IoT devices with Cloud compatibility. These applications are provided with the proper hardware platform to provide FC as the middleware component between the Cloud and the mobile devices.

3. Architecture of FC

Now-a-days, latency-critical applications [2] like IoT and augmented reality are designed with the support of FC. The Fog Nodes acts as the middleware component between the IoT devices and the Cloud. For immediate response and decision taken, the computing will be done at Fog Node itself. But for the computations which requires more resources for the process as well as the storage are done at the Cloud. The potential Fog Nodes are classified as Static Nodes and Mobile Nodes. The base stations, switches, routers, and laptops like devices are considered as the Static Fog Nodes. Single-board machines, drones, vehicles, etc. are known as Mobile Fog Nodes which are physically small and less resourceful devices. The nodes can be aggregated horizontally [2].

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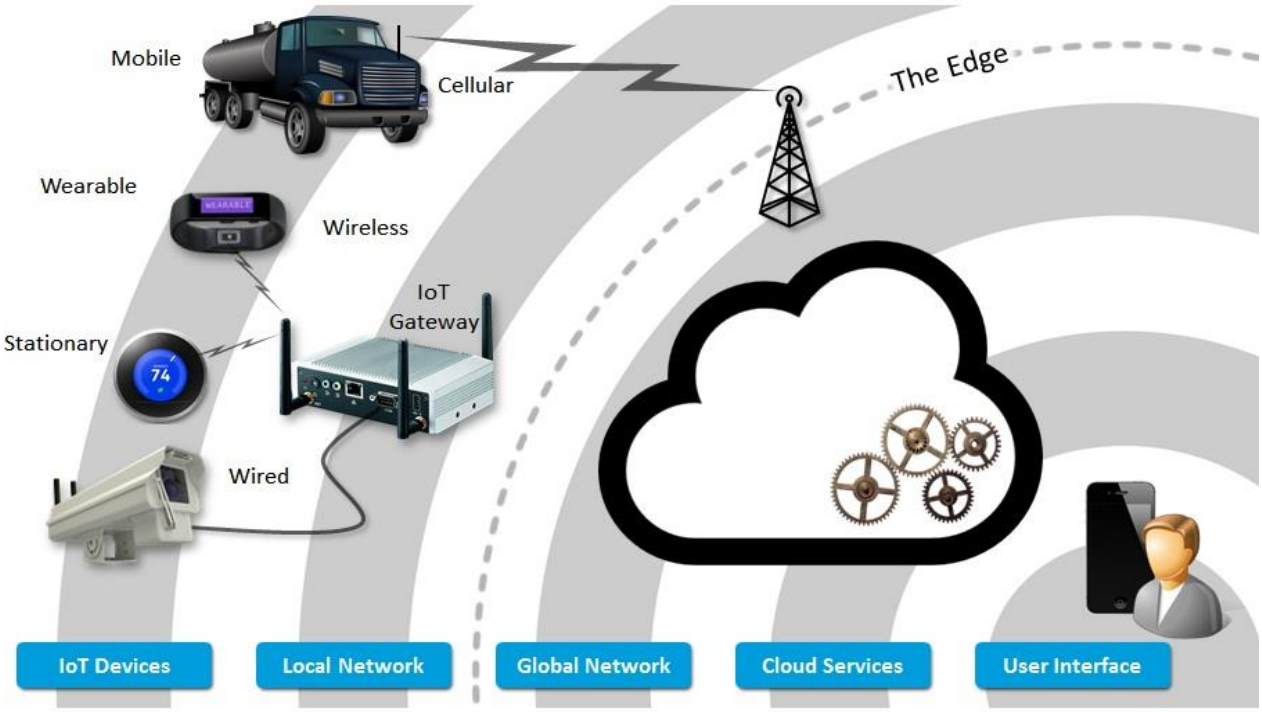
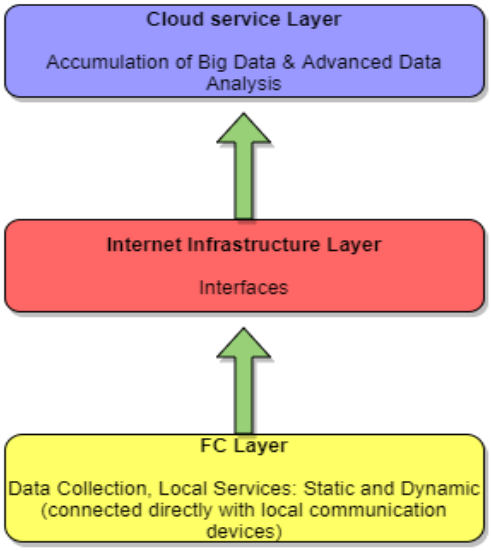


The architecture of FC accomplishes three basic layers, i.e., Cloud services layer in the top, Internet infrastructure layer in the middle, and Fog layer in the bottom level.



The data send by the communication devices like sensors, mobile devices, etc. are received by the Fog Node in the network of systems. The collected data from different sources may vary in their format. It requires data formatting to get all data in certain standard format.The Fog Node itself is installed with the applications to provide static services as well as dynamic services which will provide the output data to act according to the environmental changes.

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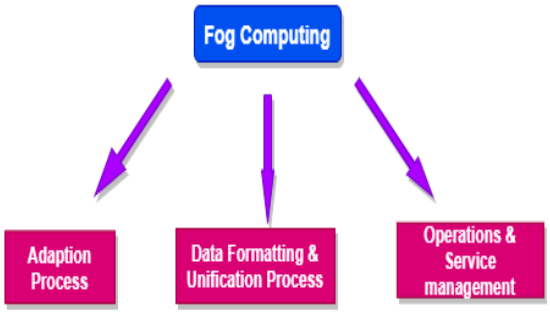

According to the above figure, FC comprises three main processes, named Adaptation process, Data formatting and unification process, and Operations and services management. The adaptation process provides the configuration details of the sources of data. It considers the dynamism in the environment i.e., availability of source devices, scaling of devices, etc. Whereas the data formatting and unification processes filters the noisy data and transforms the data in unified standard format. Then the data will be fed as input into the application which is already installed in FC. There are two kinds of services are installed, one is to handle static services like preparing the periodical summary report in descriptive format and sending it to the specified system. Another one is to handle dynamic environment such as Alarm Blowing System, Flood Warning System, etc. The messages should be transferred immediately to the authoritative systems as well as immediate actions should also be taken with the help of human intervention. The aggregated report of FC may be updated in Cloud also [1].

FC requires the middleware software in order to support Data stream processing systems, Function-as-a-service, Message-oriented middleware, Web application servers, etc. FC deployment model is classified as four models based on its infrastructure and the underlying resources.

a. Private fog
b. Public fog
c. Community fog
d. Hybrid fog

The private fog is meant for single organization and it is being owned and maintained by some organization or third party. The public fog is for the open usage of public which is created and maintained by the academics or government organizations. Communication fog is for the usage of the organization and its consumers. It is maintained by the organization or third party. Hybrid fog combines the usage of all or any of the above specified types of fog model [2].

4. Literature Survey

[1] Jabril, et.al proposed the architecture model of the FC. Its underlying devices and the necessity of unified data were revealed. The use case scenario of Flood Warning System was illustrated with the potential adaption and the applications required for this model. They identified the research challenges in FC includes service operation, runtime implementation, and thing collaboration.
[2]Arif, et.aldiscussed the impracticality of sending the massive data produced by the IoT devices to the Cloud data center for immediate response required services. Examples of the applications and their utilization of FCwere listed to provide clear idea about the feasible areas were FC is applicable. The deployment models of Fog include Private, Public, Community, and Hybrid Fogs. Based on its hardware platform, Fog Nodes were categorized as Static Fog Node and Mobile Fog Node. IoT applications require close proximity of end-users to send and process the data which takes the

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advantage of single-boards machines like vehicular-based applications, drone-based applications and compute-intensive applications. FC provided the distribution model in two different forms such as hardware distribution, and software distribution. The service models of FC were further classified as Fog-Software-as-a-Service (Fog-SaaS), Fog-Platform-as-a-Service (Fog-PaaS), and Fog-Infrastructure-as-a-Service (IaaS). Multiple data providers, different characteristics of workload, and various levels of data sensitivity were also revealed.The proposed study would be more useful for platform designers.

[3]Redowan, et.al addressed the issues in structural, service, and security related challenges. The challenges varied in the usage of different kinds of processors in different components from the core network and the edge in FC infrastructure. The problems faced in the implementation of large scale applications in resource limited Fog Node also revealed. Importance on the development of authenticated systems and issues to maintain privacy in largely distributed system also discussed. FC taxonomy provided with the list of existing works in FC. The taxonomy explained the analysis of FC based on the approaches towards the addressed challenges.

[4]Ranesh, et.al surveyed the trends, architectures, requirements, and provided the research directions in FC. The taxonomy of FC listed with the infrastructure, application and its platform. They recognized that the Fog Cluster as the base for cooperative processing of multiple Fog devices. They compared the computation cost, and energy consumption of FC with Cloud which renowned the benefits of FC. The layered representation of FC and the significance of their components were discussed. The nature of the FC applications were characterized as scalability, heterogeneity, interaction timelines, mobility, variances in user requirements, application modeling, and various dimensions of FC applications like smart transform systems, vehicles as FC, augmented and virtual reality, healthcare, and smart city. They concluded with the research focus on workload generation and the need for different simulator for FC rather than the utilization of Cloud simulator.

[5]Schahram, et.al focused on Edge and FC. They discussed the paradigm of both Cloud and FC based on their individual characteristics and use cases. Furthermore, they explained the future challenges like security and privacy, network management, and resource management. They pointed that the research solution should be adaptable in the society. Smart city scenario and their applications in FCin customizing their environment were revealed.

[6]Shakir, et.al produced the list of correlation between the attributes of both Fog and Cloud Computing which may differ in outline, devices, arrangements, and administrations for associations and clients. This comparison resulted that the performance of FCwas considered well in both data processing service and low bandwidth consumption.

[7] Mohammed, et.alexplained that the FC as the complementary approach to Cloud Computing. As today's research world in the urge of designing the product-service-system instead of product, as well as in the context of Industry 4.0, the system has to deal with large amount of time-critical data and in the need of immediate analysis report. In this paper, they elaborated the benefits of Cloud and FC in same concert.

[8]Sourav, et.al Cloud-FC from the perspective of architectures, applications, and their security challenges. They discussed the three layered architecture for FC and proposed the novel architectures like Energy Lattices, UXFog, MediFog, Connected Parking System, and FoAgro in order to utilize the features of FC and be benefited.

[9] Minh, et.al reviewed the survey on IoT and Cloud Computing for Healthcare. They revealed the enormous interest required from industry, research community, and the public sector to provide smart Healthcare system with the supportive IoT applications for the safety of patients, and staff, and for operational efficiency in medical industry. The three major components of IoTHeF, IoT in Health care framework were topology, structure, and platform. These systems were used to collect the data about patient's health status through the multiple sensors which were set in their body. The collected data were send to the remote server for the purpose of analyzing, and provide the real-time reports to the monitors or the assisting doctors. Short-range communication and medium-range communication

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were used in the context of IoT and Cloud Computing based Healthcare system.The challenges in security vulnerabilities, policies to be adopted by the Government were also mentioned.

[10]Minh-Quang, et.al proposed the solution to the real-time application, Intelligent Transportation System (ITS) in Ho Chi Minh City with FCto maximize the Fog device utilization. The proposed task placement on FCwere reduced the latency, network load, energy consumption, and the operational cost. It considered the context-aware multitier FC scheme with location identification, network condition, type of service required, and the Quality of Service such as the response time. The proposed task/service placement model was approached with two major criteria such as hard criteria which considered the response time should be less than or equal to that of expected completion time, and the soft criteria to maximize the number of tasks deployed in Fog landscape. It maximized the utilization of virtual resources in FC. In this proposed model, Fog colony was formed with Fog Orchestration (FO) node for providing extended services like management of resources as well as control the placement of task and its execution. The FO gathered the Fog cells resources availability details and based on that details, it found the suitable Fog cell for task placement with reduced energy consumption and response time.

[11]Rashid, et.al discussed the FC as the efficient platform for Cloud resource management. FC was considered as micro-Cloud or nano-DataCenter(m/nDCs) since it provided the services as like Cloud but with greater extent and proximity. But FC needed coordination and integration with the existing distributed paradigms. nDCsreduced the energy consumption. It made a better platform for the smart devices with the lower utilization of RAM and CPU.

[12]Yenumala, et.al reviewed the conceptual live VM migration framework, issues in it, various applications and the challenges incurred behind the scene. In FC, virtualization technique is used to share the resources of physical systems. They proposed a Pre-copy live migration approach to confer with VM migration. It periodically checked the system failure and associate attack on FC node. It made the optimum utilization of Fog resources.

[13] Sirisha, et.al analyzed the enhancement in cloud storage method on behalf of FC. The characteristics of FC like heterogeneity, interoperability, real-time communication, support of mobility, prevalence to wireless access, low latency and location awareness, and large-scale sensor networks were considered towards the provision of secured data access in FC.

[14], Redowan, et.al proposed the latency-aware application module management system to manage FC environments. The large-scale application was decomposed into number of interdependent modules. These modules are installed in the distributed FC based on the amount of data signals to be processed in unit time for the different types of applications.

[15]Kirthi, et.al analyzed the secure data access control with cipher text and its outsourcing in FC. In Cloud there was a data theft attack. The user's behavior on the usage of the system was monitored. As like other systems, data security, user authentication are important one in FC also. Based on the learned factor, security based questions were raised to the users for authentication. OTP based confirmation could also be done to confirm the authenticated user.

[16]Virushabhadoss, et.al. The anonymous user's behavior could be analyzed by monitoring their sequential actions. Best statistical methods were used to identify the rouge nodes in FC.To detect the anomaly usages in FC, the behavior profile algorithm was analyzed.

[17]and [18], Tilak, et.al and Atlam, et.al respectively highlighted the benefits of FC rather than the sort of services done at Cloud in the case of IoT applications. The open issues in the integration of FC and Cloud as well as FC and IoT devices were also discussed.The tremendous support given by the Cloud is benefited by today's digi-world. Rather than its voluminous service provisions, on the other end there are the issues in the maintenance of Data Center like reducing the energy consumption by reducing the load. Invention of FC is the blessing one which submersesmost of the issues in overloading of servers in Cloud Data Center. When possible processesare done at the Fog nodes reduces the load of Cloud significantly as well as users will also be satisfied as because of quick response with reduced cost.

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[19] Liu, Z., Yang, Y., Chen, Y., Li, K., Li, Z., &Luo, X. (2019) Proposed a bound together multi-level cost model, including the administration delay and a straight opposite request dynamic installment plan to tackle a cost-minimization user planning issue in multi-level FC networks. The COUS can offer close ideal execution as far as the general expense. The proposed dynamic installment conspire adequately plan UEs to limit the general expense for FCN.

[20] Dang, T. D., & Hoang, D. (2017) proposing a Region-Based Trust-Aware (RBTA) model for trust interpretation among fog hubs of regions, present a versatility administration for area enrollment, which gives effectively area administrations to fog gadgets and empowers users sending applications with high portability and plan a fog protection job-based access control to concede users' authorization and approve demands based on allocated jobs that empower framework to identify assaults based on the review records. A data security model is utilized for FC to ensure data and handle versatility. The results showed the plausibility and proficiency of the model.

[21] Mebrek, A., Merghem-Boulahia, L., &Esseghir, M. (2017) Proposed a proficient green answer for adjusted vitality utilization and deferral in IoT-fog-cloud computing. The proposed methodology stands out as an energy-efficient arrangement. The proposed methodology with an enormous number of constant, low idleness IoT applications.

[22] Yuan, X., He, Y., Fang, Q., Tong, X., Du, C., & Ding, Y. (2017) An Improved Fast Search and Find of Density Peaks-based fog hub area algorithm is proposed to accomplish reasonable fog hub destinations and apportion the assets and administration cost for each found fog hub for our fog hub area model. The proposed fog hub location algorithm can accomplish the best help execution and best algorithm time effectiveness without a lot of administration cost expanding. It has low time multifaceted nature. Density top clustering algorithm to all the more likely handle low-density clustering errands.

[23] Bousselham, M., Benamar, N., &Addaim, A. (2019) Proposed another fake innovation DT and user behavior profiling (UBP) as an elective answer for conquer information security, protection, and trust in vehicular cloud servers utilizing a FC design. The proposed component is a high productivity by conveying bait records in such a manner making the gatecrasher unfit to separate between the first and fake documents. The security component could give remarkable degree of security in the vehicular networks and the VCC.

[24] Schleicher, E., Graffi, K., &Rabay'a, A. (2019) proposed peer-to-peer (p2p) fog model improves FC by including the p2p system into the fog layer, which enables the fog hubs to team up so as to address the customer's issues. The proposed technique gives better results in terms of bandwidth throughput contrasted with cloud computing and FC models. The proposed technique will have in the IoT frameworks by lessening the bandwidth throughput of the cloud hub in a colossal way.

[25] Ennya, Z., Hadi, M. Y., &Abouaomar, A. (2018) Proposed an alliance game based answer for persuading the fogs to cooperate and participate, which thus forms enormous measures of information inside a short postponement. The proposed model offers better inactivity and improved burden adjusting of the fogs assets.

[26] Hendrik L. Cech, Marcel Großmann, Udo R. Krieger (2019) proposed a FC Architecture to Share Sensor Data by Means of Block chain Functionality. This proposed methodology is utilized for utilization of the system, for example in medicinal services, additionally used to promote potential abilities of the outlined incorporated fog-square chain approach, for example, agribusiness, coordinations, or keen city applications. MultiChain gives a compostable virtualized usefulness of a FC hub to acknowledge greater data preparing chains for further developed IoT applications.

[27] Hasenburg, J., Grambow, M., Grunewald, E., Huk, S., &Bermbach, D. (2019) Proposed MockFog, a framework for the copying of FC foundation in subjective cloud conditions. MockFog plans to rearrange the testing of fog applications by furnishing engineers with the way to characterize and bootstrap an imitated testing foundation that can without much of a stretch be controlled to encourage various situations or assess how bombing machines and inaccessible associations influence tried applications. MockFog is equipped for imitating a foundation that is fundamentally the same as its physical partner and appropriate for some, FC cases.

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[28] Dong, Y., Han, C., &Guo, S. (2018) Proposed a joint enhancement of vitality and QoE with reasonableness in agreeable FC framework. Decency Cooperation algorithm can viably lessen reaction time decrease and energy utilization. The proposed algorithm has preferred execution over the cutting edge.

[29] Mohammad Heydari, AlexiosMylonas, VasiliosKatos, EmiliBalaguer-Ballester, VahidHeydariFamiTafreshi, Elhadj Benkhelifa(2019) Proposed a vulnerability aware confirmation model for FC in IoT. Proposed a novel expectation model based on the augmentation of Attribute-Based Access Control (ABAC) model. The prediction model made by strategic relapse has a better execution as far as precision (88.14%) and has lower computational intricacy than different algorithms.

[30] Li, Z., Wang, K., & Kong, X. (2017) Acquaint a tree network with oversee associating layer in FC, which is named as CAN (content-addressable network) Tree. All assets are mapped in a 2-D space. Each fog server handles a zone in the space. CAN Tree oversee fog servers joining and takeoff to keep away from piece, and give better directing in fog servers.

[31] Ye, D., Wu, M., Tang, S., & Yu, R. (2016) Proposed a versatile FC with administration offloading in transport networks. The transport fog server is the expansion of the roadside cloudlets. The roadside cloudlets broaden calculation capacity from the transport fog servers in the worldview. A designation technique utilizing a genetic algorithm (GA). With this technique, the roadside cloudlets spend the minimal expense to offload their calculation undertakings. The roadside cloudlet spends the least cost while all the portable clients have better client experience by means of the procedure.

[32] Pooranian, Z., Shojafar, M., Naranjo, P. G. V., Chiaraviglio, L., & Conti, M.(2017) Proposed a novel conveyed the fog-based networked design to safeguard vitality in fog server farms. Propose a dispersed Fog-bolstered IoE-based structure and broaden their connected with segments that target concentrating on SG applications. The proposed methodology spares energy utilization astonishingly in the Fog data Center contrasted and the current strategies. A scientific model for the FDC focused on the computing and correspondence of the FDC segments (i.e., servers and VMM) circulated, and to take care of the issue by utilizing some avaricious systems.

[33] Tuvakov, J., & Park, K. (2018) Presented a theoretical fog hub model for multi-reason FC systems. This fog hub model contains modules, for example, examination tools, cooperation rationale, cryptography, and so forth that are basic to achieve the objectives of FC. Fog hubs are the principal component of a FC framework since they embrace the arrangement of computing and capacity administrations at the edge of the network.

[34] BastienConfais, AdrienLebre, Benoıt Parrein (2017) Proposed a top-notch object-store administration for Fog/Edge offices. The proposition is worked with Scale-out Network Attached Storage systems (NAS) and IPFS, a Bit Torrent-based article store spread all through the Fog/Edge foundation. The proposed technique gives a couple of bearings to improve the exhibition and adaptation to the non-critical failure criteria of the Fog/Edge Object Store Service. The Scale-out NAS likewise gives IPFS an entrance to nearby records if there should arise an occurrence of network dividing (when a site can't arrive at the others) in light of the fact that the DHT is possibly gotten to when a read is performed from a remote site.

[35] Mohammed Al Yami, Dirk Schaefer (2019) Proposed a FC as a Complementary Approach to Cloud Computing. Incorporating Cloud and FC can help endeavors in acknowledging new chances of data-driven organizations while ending the natural issues. The mix encourages business to accomplish current open doors in different manners. The mix is utilized to incorporate the utilization of compelling catastrophe recuperation frameworks, upgrading business deftness, misfortune avoidance, improved data wellbeing, and new income streams.

[36] Yuan Meng, ShanshanTu, Jinliang Yu and Fengming Huang (2019) Proposed a clever attack guard scheme based on Double Q-learning (DQL) algorithm in MFC (portable FC). Five shrewd attack modes are set up in the model when malicious clients communicate with legitimate clients in fog hubs. Legitimate clients pick two distinct modes to shield, one utilizing only physical

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layer security (PLS), the other utilizing both PLS and higher-layer security protection mechanisms. The security model including malicious clients in MFC is portrayed. Based on Prospect Theory (PT), a static technique for emotional lose-lose situation between malicious clients and legitimate clients is constructed. A dynamic emotional game scheme based on the DQL algorithm is proposed to oppose insightful attacks.

[37] AsfaToor, Saiful Islam, NimraSohail, Adnan Akhunzada, JalilBoudjadarHasan Ali Khattak, IkramUd Din and Joel J.P.C. Rodrigues (2019) Proposes an adaptive performance and vitality aware scheme for Fog–IoT computational environment. To evaluate the viability of the proposed approach, simulations are configured through the iFogSim simulator and the outcomes are compared with the state-of-the-art technique. This proposed scheme is also formally checked for safety properties. To incorporate execution and energy-mindful Fog–IoT computing utilizing the green-sustainable power source with a dynamic recurrence scaling instrument.

[38] Mohammed Al-khafajiy, Thar Baker, Hilal Al-Libawy, ZakariaMaamar, MoayadAloqaily and YaserJararweh (2019) Proposes another Fog-2-Fog (F2F) collaboration model that advances offloading approaching requests among fog hubs, according to their load and preparing capabilities, via a novel load balancing known as Fog Resource management Scheme (FRAMES). A formal mathematical model of F2F and FRAMES has been formulated, and a lot of investigations have been carried out demonstrating the technical do the ability of F2F collaboration. The performance of the proposed fog load balancing model is compared to other load balancing models.

[39] Juan Luo, Luxiu Yin, Jinyu Hu, Chun Wan , Xuan Liu, Xin Fan and HaiboLuo (2018) Proposed a multi-cloud to multi-fog architecture and structure two sorts of service models by utilizing containers to improve the resource utilization of fog hubs and decrease the service delay. According to the two service models, A task planning algorithm for vitality balancing. The architecture and plan several components to unravel potential security issues caused by multi-cloud to multi-fog as well as to diminish the construction and maintenance cost of service designers. The algorithm is based on the transmission vitality consumption of terminal gadgets and utilizations a dynamic limit strategy to plan requests in real-time, consequently guaranteeing the vitality balancing of terminal gadgets without increasing the transmission delay.

[40] Manoj Kumar Mishra, Niranjan Kumar Ray, AmulyaRatna Swain, Ganga BishnuMund and BhabaniSankar Prasad Mishra (2019) propose an adaptive multi-criteria decision-making (A-MCDM) model to obtain an optimal ranking of alternatives in dynamic and scalable environments. An epic and proficient multi-criteria decision-making (MCDM) model has been proposed to obtain an optimal ranking of alternatives in a scalable and dynamic environment with less time unpredictability and smaller response time. To named the technique as an adaptive multi-criteria decision-making model (A-MCDM) for the FC environment. The time unpredictability of the proposed A-MCDM is O (nm) in general, and it takes only O (m) time to assign a rank to an alternative where n is the number of criteria and m is the number of alternatives.

[41] Jorge Pereira, Leandro Ricardo, Miguel Luis, Carlos Senna and Susana Sargento (2018) proposed a conventional architecture and a proof-of-concept framework that aims to utilize FC to convey versatility applications in VANET environments for traffic anomaly detection and travel time estimation. Give a proof-of-concept framework to perform data analytics in a half breed VANET/Fog environment. The VANET is partitioned in three major components: the On-Board Units (OBUs) as part of the ad-hoc portable infrastructure, the Road-Side Units (RSUs) in the fixed access infrastructure, and the Cloud Layer. The framework is utilized by two Fog applications, one for city traffic anomaly detection, and another to estimate the transport time of arrival to nourish traveler information. A half and half VANET/Fog design empowering the improvement of dependable keen versatility applications. A half and half VANET/FC is as viable as the Cloud in any event, considering that it has less accessible data and less computational power.

[42] Dongcheng Zhao, Gang Sun, Dan Liao, ShizhongXu and Victor Chang (2019) Proposed an SFC sending the algorithm to initial convey Service Function Chains (SFC), and then so as to save

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bandwidth resources and diminish the vitality consumption, set forward a VNF consolidation and migration algorithm. Propose two SFC migration strategies: the base number of Virtual Network Functions (VNFs) migration strategy and the two-advance migration strategy to improve the reconfiguration cost, the migration time, the personal time and the remapping achievement ratio of the SFC migration request. To improve the personal time and migration time of the SFC migration request, in the two-advance migration strategy. In the SFC two-advance migration algorithm, we guess that the SFC migration request is dynamically arrived as per the Poisson procedure, and these SFC migration requests are put away in the queue Arrived SFC. The SFC migration in the cloud–FC environment to upgrade the migration performance when the versatile client moves from a fog radio access network to another fog radio access network.

[43] ShreshthTuli, RedowanMahmuda, ShikharTuli and RajkumarBuyya (2019) propose the FogBus framework that can integrate distinctive IoT-enabled systems to both Fog and Cloud infrastructures. The framework facilitates IoT application sending, resource monitoring and management. Framework Services of FogBus are created in cross-platform programming languages (PHP and Java) and are utilized with extensible application layer convention (HTTP) that help FogBus to conquer the OS and P2P communication-level heterogeneity of various Fog hubs. Additionally, the FogBus framework functions as a Platform-as-a-Service (PaaS) model for an integrated Fog Cloud environment that not just assists application designers to assemble various sorts of IoT applications yet, in addition, underpins clients to modify the services, and service suppliers to manage the resources according to the context of the framework. Since some IoT-enabled systems, for example, health monitoring and utility service metering deal with delicate data, FogBus applies authentication for data privacy and Blockchain for data trustworthiness. To acquire data transfer across a less secure network, encryption techniques are applied in FogBus. Based on the standards of FogBus, a cost-productive model for Sleep Apnea analysis is also created.

[44] Ryuji Oma, Shigenari Nakamura, DilawaerDuolikun, TomoyaEnokido and Makoto Takizawa (2018) proposed a vitality proficient model for FC in the Internet of Things (IoT) to diminish the electric vitality consumption of the hubs in the IoT. Here, fog hubs are linearly connected from sensors to servers. The linear FC (LFC) model is straightforward and helpful for fewer quantities of sensors. In any case, a large amount of sensor data cannot be effectively handled by each fog hub because of the constrained computation capability of each fog hub, especially, edge hub. In this paper, we propose an increasingly general model, a tree-based FC (TBFC) model where procedures and data are circulated to a tree structure of fog hubs whose root hub shows servers in clouds and leaf hubs are edge hubs which communicate with sensors and actuators. We evaluate the TBFC model compared with the cloud computing model regarding total electric vitality consumption and the total handling time of the hubs.

[45] Tian Wang, Yuzhu Liang, WeijiaJia, Muhammad Arif, Anfeng Liu and MandeXie (2019) Proposed Coupling resource management based on FC in smart city systems. Propose a FC show and stretch out the Hungarian algorithm to manage the coupling resource which can get smaller delays to realize powerful and sustainable services. The FC layer acts as a buffer and controller between Cyber-Physical Systems (CPS) layer and cloud layer which can handle malicious attacks to manufacture exceptionally sustainable systems. The Hungarian algorithm with buffer queue (EHGB) to obtain the base cost timetable and maximum resource utilization. In addition, we structure a buffer queue in the FC layer which will restore the outcome to the cloud layer straightforwardly.

[46] PetarKochovski, Sandi Gec, VladoStankovski, Marko Bajec and Pavel D. Drobintsev (2019) Proposed a trust management architecture for DECENTER that depends on the utilization of blockchain-based Smart Contracts (SCs) and specifically planned trustless Smart Oracles. The architecture is executed on Ethereum record (testnet) and three trust management scenarios are utilized for illustration. The scenarios (trust management for cameras, believed data stream and QoS based computing hub selection) are utilized to introduce the advantages of establishing trust relationships among substances, services, and stakeholders of the platform. Trust traits investigations and distinguishing proof so as to address the prerequisites of dynamic, complex and multi-level

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shrewd applications and conditions. A blockchain-based trust management framework appropriate to multi-party decentralized Edge-to-Cloud computing.

[47] ProsantaGope (2019) Present new privacy-safeguarding security architecture for FC model with the cooperative D2D communication support, which can be helpful for various IoT applications. Subsequently, based on the basic foundation of the proposed security architecture to structure three lightweight anonymous authentication protocols (LAAPs) to help three particular circumstances in D2D-Aided FC. FC has its favorable circumstances because of its edge location, and thusly can bolster applications (e.g., gaming, increased reality, continuous video stream preparing) with low idleness prerequisites.

[48] Xuefeng Xiao, XueshiHou, Xinlei Chen, Chenhao Liu and Yong Li (2019) proposed the temporal and spatial distribution of potential computation capacity of vehicular FC on a city-wide scale. A realistic scenario of vehicular FC where end-gadgets are based on grouped vehicles. To give a review of the vehicular FC framework, and further propose its basic theoretic model. To made prediction of potential computation capacity of a vehicular fog utilizing an immigration-death model and watched the relationship between computation capacity and vehicular fog radius. A vehicular FC framework contains all vehicles furnished with implanted PCs bunched around the convergences of a city, where road-side units (RSUs) may likewise be sent to interface with the remote clouds.

[49] Y.C. Liang, W.D. Li, X. Lu, S. Wang (2019) Proposed an innovative fog and profound learning-enabled framework for machining process visualization and optimization. To improve data transfer, monitored data acquired on equipment are handled on a fog layer to recognize faults proficiently utilizing the trained CNN conveyed locally. Concentrated computations, for example, the training procedure of the CNN and re-booking optimization to address abnormal situations are carried out on a cloud layer. The architecture, monitored signals during machining gathered on the terminal layer are handled utilizing the trained CNN sent on the fog layer to proficiently identify abnormal situations. Serious computing activities like training of the CNN and framework re-optimization responding to distinguished faults are carried out dynamically on the cloud layer to leverage its computation powers.

[50] Luying Zhou, HuaqunGuo and Gelei Deng (2019) proposed A FC based way to deal with DDoS alleviation in IIoT systems a mechanical control framework testbed and the investigations assess the detection time and rate for two sorts of DDoS attacks and show the adequacy of the plan. yFC approach in the IIoT condition to alleviate DDoS assault by allocating computation limit nearer to activity process and circulating the outstanding burden in the framework through a three-level moderation design so as to convey quicker and increasingly precise assault detection. In the field control level, Firewall is applied to conversely channel the assault bundles based on realized assault traffic marks. In the neighborhood control level, servers are abused to look at the traffic by means of launching virtual network functions (VNFs) to perform specification based traffic detection, and in Cloud level, a focal server connects and merges the data from different locations and sources to settle on increasingly precise detection choice.

5. Task Allocation, and Load Balancing Concerns and their Future Research Direction

Even FC is in decentralized distributed network system, as like Cloud,FC also provides the services as Virtual Machines to the IoT applications. The Fog Node is implemented with number of services. The dynamism should be considered in FC, incoming tasks and their context. When the deployed services in FC and the IoT devices to which the services have to be provided are known prior, the prediction of incoming workload is also possible which may ease the scheduling process. The task allocation and load balancing concerns can be dealt with proper scheduling algorithms. The following are valuables which may be adopted in scheduling algorithms to optimum solution in the maintenance of Fog load as well as task allocation.

a) Set Fog Orchestration Node to monitor all incoming tasks to the network of Fog Nodes

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b) Prediction of incoming tasks
c) Analyzing the workload of Fog Nodes in the network
d) Calculating the remaining execution time of the existing services in run state
e) Consideration of tasks in queue
f) Migration of VMs from overloaded Fog Node into optimum destined Fog Node
g) Providing the communication between Fog Nodes to exchange or forward their incoming tasks when the other node is free to handle the incoming task
h) Formation of Federated Fog Network

Even it is the trend to introduce the IoT services at FC, the issues relevant to the minimal configuration of resources in FC, the issues in handling of scheduling processes are addressed, recently. Like Cloud, energy consumption at the FC should also be reduced at no cost. The researchers started with the analysis of issues in these areas will also lead to the solution path also.

6. Conclusion and Future Work

Fog Computing is the middleware component between IoT and Cloud. In this survey, various applications implemented in FCand their attained benefits are discussed. It includes the pretentious architecture model of FCfor good understanding and its various deployment models. In the distributed network system, FC provides the services in Virtual form. From the literature survey, it is revealed that FC is the boon to IoT applications and Cloud by providing the services with reduced response time, energy consumption of Cloud Data Center, increased performance, and so on. It reduces the Cloud load abruptly in the case of IoT services. Apart from all these advantages, there are significant issues in the implementation of services and utilization of services in FC. Allocation of VMs for incoming tasks in appropriate Fog Node in the network, and maintaining the load of Fog Nodes require more attention of the researchers.

In future work, the issues in balancing the load of FC will be addressed and will find the optimum solution for it.

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