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Fog computing in health management processing systems

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Abstract

Purpose – Fog computing (FC) is a new field of research and has emerged as a complement to the cloud, which can mitigate the problems inherent to the cloud computing (CC) and internet of things (IoT) model such as unreliable latency, bandwidth constraints, security and mobility. Because there is no comprehensive study on the FC in health management processing systems techniques, this paper aims at surveying and analyzing the existing techniques systematically as well as offering some suggestions for upcoming works.

Design/methodology/approach – The paper complies with the methodological requirements of systematic literature reviews (SLR). The present paper investigates the newest systems and studies their practical techniques in detail. The applications of FC in health management systems have been categorized into three major groups, including review articles, data analysis, frameworks and models mechanisms.

Findings – The results have indicated that despite the popularity of FC as having real-time processing, low latency, dynamic configuration, scalability, low reaction time (less than a second), high bandwidth, battery life and network traffic, a few issues remain unanswered, such as security. The most recent research has focused on improvements in remote monitoring of the patients, such as less latency and rapid response. Also, the results have shown the application of qualitative methodology and case study in the use of FC in health management systems. While FC studies are growing in the clinical field, CC studies are decreasing.

Research limitations/implications – This study aims to be comprehensive, but there are some limitations. This research has only surveyed the articles that are mined, according to a keyword exploration of FC health, FC health care, FC health big data and FC health management system. Fog-based applications in the health management system may not be published with determined keywords. Moreover, the publications written in non-English languages have been ignored. Some important research studies may be printed in a language other than English.

Practical implications – The results of this survey will be valuable for academicians, and these can provide visions into future research areas in this domain. This survey helps the hospitals and related industries to identify FC needs. Moreover, the disadvantages and advantages of the above systems have been studied, and their key issues have been emphasized to develop a more effective FC in health management processing mechanisms over IoT in the future.

Originality/value – Previous literature review studies in the field of SLR have used a simple literature review to find the tasks and challenges in the field. In this study, for the first time, the FC in health management processing systems is applied in a systematic review focused on the mediating role of the IoT and thereby provides a novel contribution. An SLR is conducted to find more specific answers to the proposed research questions. SLR helps to reduce implicit researcher bias. Through the adoption of broad search strategies, predefined search strings and uniform inclusion and exclusion criteria, SLR effectively forces researchers to search for studies beyond their subject areas and networks.

Keywords Cloud computing, Fog computing, Internet of things, Health management systems

Paper type Literature review

1. Introduction

Today's life is connected to the internet, although it is not usually able to meet its needs. The devices such as sensor nodes, smartphones and wearable techs generally operate with

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battery power. It is very difficult to store or process large amounts of information (Tarek *et al.*, 2019). Although today's cloud structure performs as expected, it cannot be helpful for applications sensitive to latency because the distributed and cloud databases are not connected to the objects and the users of value-added amenities (Panahi and Navimipour, 2019; Zhang *et al.*, 2015). Therefore, many see fog computing (FC) as an extension of cloud architecture, but it connects amenities to the edge of the network (Sohal *et al.*, 2018). In this regard, computing, networking and storing services are facilitated. FC mainly includes the components of the program, namely, smart gateways, routers or dedicated fog devices (Viejo and Sánchez, 2019). Mobility, computing resources, cloud integration, distributed data analytics, communication protocols and interface heterogeneity should be supported by FC to meet the needs of the application with low latency and wide geographical distribution (Liang *et al.*, 2019). Although fog and cloud computing (CC) have several services in common, FC mainly deals with the programs that are not available in the cloud (Hassan, 2018; Wu *et al.*, 2017). One reason is the removal of bandwidth constraints and delay improvements for local control loops, usually found on the internet of things (IoT) text (Hamzei and Navimipour, 2018). Therefore, the reduction of network traffic, inevitability, bandwidth improvement, privacy enhancement, latency reducing, dependability increasing, energy improvement, scalability maximization and resiliency against cloud/network failure are the advantages of FC (Dastjerdi *et al.*, 2016).

Today, the high cost of health-care services is a major concern for health-care organizations. With the growing percentage of the world's elders to 21.5 per cent by 2050, the health-care cost becomes the main challenge. The current developments in information communication technology (ICT) such as IoT and cyber-physical systems are very important in developing health-care solutions for everyday life, especially in clinics (Liang, 2018; Liu *et al.*, 2019). It is necessary to have a connection point among the internet and the sensor network in most health systems based on IoT in smart homes/hospitals. A proficient and structured approach of IoT is required to improve human health. It is anticipated that the IoT-based systems will rehabilitate the health sector regarding social benefits, as well as cost-effectiveness (Dohr *et al.*, 2010; Miorandi *et al.*, 2012; Rahmani *et al.*, 2018). However, the limitation of IoT are storage, battery capacity and processing; the cloud-based solutions can cause unbearable health-care interruptions leading to system failure (Kharel *et al.*, 2017; Kraemer *et al.*, 2017). On the other hand, for many health applications, storing data (patient-related) out of the clinic is illegal. For the others, it is unacceptable to use fully remote data centers owing to patient safety. This is an architectural style for distributed systems in which logic applications are located not only in cloud data centers, but also in their infrastructure components. The gateways, routers and access points are the example of infrastructure components (Kraemer *et al.*, 2017).

Although the FC applications play a crucial part in health management systems, there is no complete review of the FC mechanisms in them. Therefore, classifying the FC techniques, comparing the differences of the selected ones, describing many popular FC mechanisms and outlining the types of challenges are the objectives of this method. Briefly, this paper analytically investigates the related articles and proposes some suggestions for future works. In short, the goals of this paper are:

- delivering helpful data around FC uses in health management systems;
- providing an outline for the current challenges of fog-based applications;
- exploring the upcoming issues of the FC and its role in the success of health management systems;
- presenting the conclusions and comparing them with those of the prior research studies; and
- outlining the significant scopes where future research can develop the use of FC techniques.

This paper explains the following issues. Section 2 discusses and classifies the FC mechanisms in the health management systems and also proposes the taxonomy of the selected techniques. Section 3 reviews the selected papers. Section 4 provides the results. Eventually, Section 5 concludes the paper.

2. Methodology systematic literature review (SLR)

Systematic literature review (SLR) is a well-established review method, first notably applied by professionals in medicine and health care (Khakurel *et al.*, 2018). As a result, systematic examination of all literature sources, comprehensive elaboration of a structured review, explicit explanation of all used methods and reproducible exclusion of subjective examinations allow others to reproduce results (Alyari and Jafari Navimipour, 2018; Steiger *et al.*, 2015).

2.1 Questions

The goal of the present study is to categorize and study all previous works related to FC uses in health management systems. Another aim is to better understand the key related technical challenges, such as data analysis, availability and flexibility. The following questions will be responded in this paper:

RQ1. Why is FC used in the health area?

RQ2. What are the challenges of using health in fog-based applications?

RQ3. What are the classifications of study use?

RQ4. What are the main features of the fog-oriented system in processing health management systems?

2.2 Article selection

The article selection method has three steps. In Step 1, the Google Scholar electronic database has been searched. The used search terms are FC health, FC health care, FC health big data and FC health management system. Therefore, 71 papers have been extracted by a programmed procedure. The spreading of the papers has been indicated in Figure 1. Moreover, the articles' classification has been respectively presented in Figures 2 and 3 based on the publishers and the spreading of the papers over time.

In Step 2, some more factors have been determined to choose suitable works. The editorial notes, reports, working articles and the ones written in non-English languages have been ignored (Hajiheidari *et al.*, 2019). Finally, a detailed analysis has been done of 50 articles. The papers of well-known publishers have been chosen, according to their headings.

In Step 3, the papers have been thoroughly investigated to confirm their relevance. The topic, publication year and the rank of journals are the main factors to select/ignore the

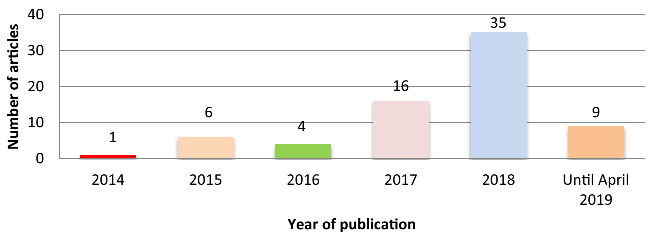

Figure 1.
Distribution of the published articles by year of publication

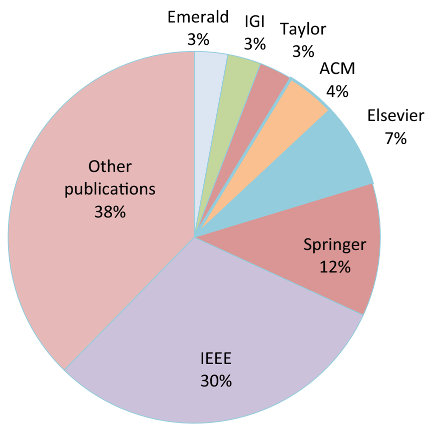

Figure 2.
Percentage of the published articles in each source

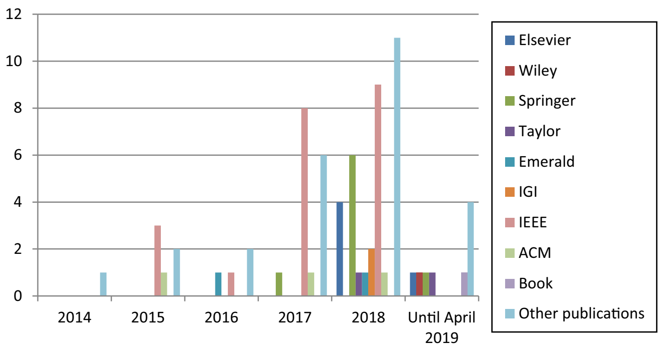

Figure 3.
Distribution of the articles by database sources

articles. Concerning those factors, the papers have been chosen. Therefore, 19 articles have been ignored. Lastly, 31 final papers have been categorized into three groups (Figure 4).

The categorizing procedure has been shown in Figure 5. The searching process led to the identification of 31 relevant articles for analysis in section 4. Moreover, Table I shows the classified papers.

3. Investigation of chosen articles

The current part has classified the chosen articles into three groups: review articles, data analysis and frameworks and models.

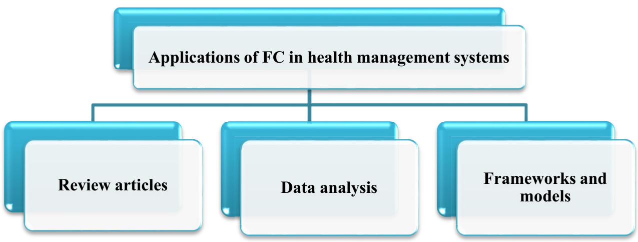

Figure 4.
Categorization of the FC applications in health management systems

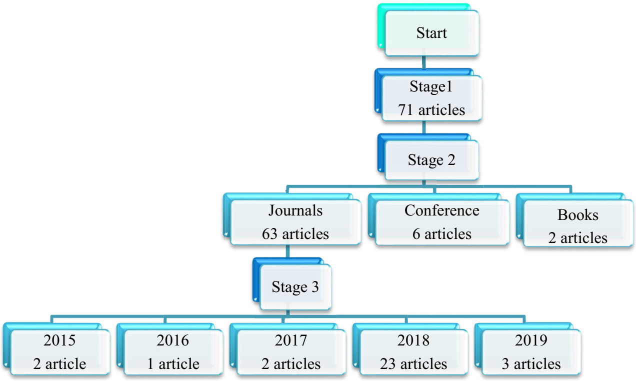

Figure 5.
Details of the selected articles in each stage

Categories	Articles
Review articles	Shi *et al.* (2015) Kraemer *et al.* (2017) Ni *et al.* (2018) Hassan (2018) Naha *et al.* (2018) Kumari *et al.* (2018) da Silva and de Aquino Júnior (2018) Maksimovic (2018) Mutlag *et al.* (2019)
Data analysis	Barik *et al.* (2017) Shukla *et al.* (2018) Sun *et al.* (2018) Barik *et al.* (2018) Barik *et al.* (2018) Thota *et al.* (2018)
Frameworks and models	Cao *et al.* (2015) Ahmad *et al.* (2016) Negash *et al.* (2018) Rahmani *et al.* (2018) Wu *et al.* (2018) Asif-Ur-Rahman *et al.* (2018) Al-khafajiy *et al.* (2018) Isa *et al.* (2018) Gomes *et al.* (2018) George *et al.* (2018) Moore and Van Pham (2018) Achouri *et al.* (2018) Dang *et al.* (2018) Xiao *et al.* (2018) Vilela *et al.* (2019) Hu *et al.* (2019)

Table I.
Classified papers in four main categories

3.1 Review articles

The FC expands storing, computing and networking resources to the edge of the network to support large-scale IoT applications; this is a way for the revolution of the CC (Sun and Zhang, 2017; Tu *et al.*, 2018). The FC overcomes the high inactivity of the cloud having the idle resources of numerous near devices of users (Sun *et al.*, 2018). However, FC performs complex processing based on the cloud. The FC is a decentralized computing concept compared to cloud computing, in which many devices with computation capacity are present. Currently, there are several cores even in a smartphone with low processing capacity. Hence, the processing power and storage capacity are important elements for many devices such as smartphones, routers, switches, base stations and other network management devices acting as fog devices (Naha *et al.*, 2018). On the other hand, the FC can safely restore applications and data in the event of a network/cloud failure (Shukla *et al.*, 2018). However, there are some traditional security threats for users. Some features such as latency, geographic distribution and distance-awareness are not supported by IoT. The FC should be connected to the IoT to spread computing, storing and networking resources to the edge of the network, (Ni *et al.*, 2018; Ray *et al.*, 2019). As a result, there is a lot of research studies and discussions about FC. In this section, we have analyzed some related reviews to emphasize the inspiration for doing this research. Also, we have discussed their strengths and weaknesses.

Shi *et al.* (2015) have discussed the features of FC, the related services in the health-care system and its prospect. They have stated that this computing platform provides storage and network services in a distributed way to solve the IoT delay problem and collaborate with the cloud. The fog performs the tasks of the data center at the edge of the server. Also, sensitive IoT applications have been developed through the fog. However, this article has some limitations:

- not systematical;
- lack of article selection method;
- lack of expression of the future works; and
- lack of paper classification and comparing.

Kraemer *et al.* (2017) have presented the FC reports in the health information section and discussed the discovery, categorization and use of the various applications presented in the literature. In this regard, the programs have been categorized into a list of specific tasks that can be done with the fuzzy calculations. They have discussed how the network can perform such tasks and meet the benefits of health-care needs. The results have shown that there is a significant number of computational tasks in different scenarios and applications derived from FC. Their review shows that computing is an essential element in all health programs that should be done between the cloud and sensors. They have provided a list of such computational tasks and indicated that the nodes could run on the network. The papers have also shown that the calculation is possible at all levels of the network. However, their article has some limitations:

- lack of paper comparing;
- lack of expression of the open issues; and
- lack of expression of the future works.

Ni *et al.* (2018) have done a thorough FC security survey focused on the architecture and features of the fog calculations. Furthermore, the role of fog nodes has been discussed in IoT programs, including real-time services, decentralized computing, transient storing, information distribution and the review of several promising IoT programs regarding the different roles of the fog node. They have provided safety and privacy risks in fog calculations, such as potential privacy risks. They have shown the safety issues, studied advanced solutions for FC in the IoTs. However, their article has some limitations:

- lack of article selection method;
- not systematical; and
- lack of paper classification and comparing.

Hassan (2018) has provided a summary of the benefits, potential uses, new instances and the open issues of cloud and FC in IoT. In addition, specific cases have been specified for IoT, which use CC and FC, correspondingly. As FC is a relatively new model, the summary also covers possible upcoming applications (not completely understood by now). In summary, the results have shown that data creators and users are insecurely attached in space, time and synchronization. However, the article has some limitations:

- not systematical;
- lack of article selection method; and
- lack of paper classification and comparing.

Naha *et al.* (2018) have reviewed the definition of FC and related research tendencies. They have investigated some proposed FC architectures and their mechanisms to expand the FC. Next, the FC classification has been proposed in accordance with the requirements of the FC paradigm. They have also talked about existing research studies and the gap in resource assignment and planning, fault tolerance, simulation tools and fog-oriented amenities. The results of this comprehensive survey will enable the implementation of the IoT program in an FC environment. In this way, this undeveloped computing paradigm will move toward market penetration soon. However, the article has some limitations:

- not systematical; and
- lack of article selection method.

Furthermore, Kumari *et al.* (2018) have covered different challenges of health care based on FC technology, such as data management and interoperability. They have stated that FC helps doctors make timely decisions in intelligent emergencies for health-care applications. It also helps protect sensitive information by reducing latency compared to the cloud-based stand-alone application. In this paper, the three-layer FC architecture for health 4.0 has been presented. In this regard, two studies on health care 4.0 have been discussed. However, the paper has some limitations:

- lack of article selection method; and
- lack of paper classification and comparing.

da Silva and de Aquino Júnior (2018) have provided an overview of FC in health care, in which the layered structural design is wide-adopted for solutions based on the fog. The results have shown that although there is a consensus that the paradigm of fog is in response to some of the important requirements for health-care programs, particularly patient-related ones and environmental monitoring, other important challenges still must be addressed. In particular, security, privacy, reliability and interoperability issues should be well addressed in this area and provided with relevant research paths. In addition, techniques have been used to deal with the errors of the nodes making up the fog. A mechanism guaranteeing the reliability of the information has also been used to ensure security. However, the paper has some limitations:

- lack of paper classification and comparing; and
- lack of expression of the future works.

Maksimovic (2018) has presented the nature of IoT-sponsored health care, listed the types and structure of health data and examined current approaches to address health-care data created by the IoT. The study of data management, resource utilization, privacy and security in a fog-assisted and IoT-based health-care system has been discussed. This effort has been made to gain more insight into FC and its importance in data management in the IoT health-care system. Because the features of health-care information are exclusive and hard to measure, the guidelines for the future development of the proposed prototype have been explored. However, the paper has some limitations:

- not systematical;
- lack of article selection method; and
- lack of paper classification and comparing.

Finally, Mutlag *et al.* (2019) have provided a systematic review of FC technology in IoT systems for health care and prior analysis. They have systematically analyzed 99 articles of health-care programs using different methods, according to their entry and exit criteria. The classification results have been separated into three major classes: frameworks, systems and reviews. The results have indicated that the FC is appropriate for real-time applications, especially in health-care programs. According to all studies, resource sharing, fault tolerance, privacy, low latency, improved scalability, distributed processing and enhanced security have been provided to show better fog infrastructures. However, the paper has some limitations:

- lack of paper classification and comparing; and
- the lack of the FC review.

We have found that various issues in storage and network services have been distributed to solve the IoT delay problem and collaborate with the cloud in problems such as security and privacy in FC, and patient-centric medical data analysis system. We have also found that FC is a new decentralized architecture that revolutionizes CC with the expansion of storage, computing and network resources to the edge of the network to support huge IoT uses. But, it faces old safety risks for users, too. But, the FC applications in health management systems have not been thoroughly studied. Although analytic research studies are very significant for selecting the articles for review, the discussed surveys have not offered a fully organized literature-oriented study of the FC uses for health management systems with a deep examination of their classification and upcoming issues. Table II summarizes the studied works and their key features. As can be seen, the most common drawback in the papers is the lack of choosing the procedure and the non-systematical method. The other ones are detailed comparing and analyzing of the articles. So, in the remaining, we shall attempt to answer these problems and present an up-to-date systematic survey.

3.2 Data analysis

Because of the widespread use of Web-based social networks, data-generating has a fast pace. When the office collects, stores, monitors and examines a large amount of information generated by the health system, the concept of big data appears. The analysis of a large data set can identify new connections for business identification, crime prevention and disease prevention (Lee and Kang, 2015). Secure infrastructure is necessary for sharing, storing and processing public health information. The cloud and IoT are advances ensuring the proper use of information technology requirements for medicine (Malik *et al.*, 2018). Health-related data can be analyzed to find the area with vital health issues to provide appropriate health facilities. In many cases, the spread of diseases is somehow related to the geographical location. The FC can be a lever for analyzing real-world information about diseases and other problems with the location (Barik *et al.*, 2017; Borthakur *et al.*, 2017). Health data are heterogeneous, which challenges the integration of the existing health facilities, interoperability and so on (Constant *et al.*, 2017; Dubey *et al.*, 2017). The IoT generates large processing data examined and filtered by cloud data centers. Transmitting and analyzing a large amount of data increases the response time. Increasing response time will result in service delays for end users. For real-time transmission of the data, low latency is needed (Shukla *et al.*, 2018). The advanced FC as a middleware will be able to eliminate the IoT health-care constraints and increase the network services (Shukla *et al.*, 2018).

Barik *et al.* (2017) have proposed a service-oriented architecture for advanced analysis of spatial data. They have designed the model by employing a win-win spiral design through the case and sequence diagram. The overlay analysis is based on the proposed framework of positive plans for the malaria virus of Maharashtra state in India during 2011-2014. Mobile customers were the test samples. They have conducted a comparative analysis between the proposed fog framework and existing ones based on the cloud. Reduction of corrupt devices, the need for storage and power transfer lead to overall efficiency. The overlay analysis has been performed using the proposed architecture. Similarly, the fog devices add edge intelligence to the analysis of geo-health information by presenting local processing in cloud-oriented settings. Although the proposed architecture offers effective managing of health information through fog tools, it reduces the latency and increases the throughput. However, it suffers from focusing only on one area.

Multiple challenges need to be addressed to understand the real capacity of IoT and fog parameters for real-time analysis. A combination of fuzzy learning and reinforcement has been proposed by Shukla *et al.* (2018). The services and network inactivity in health care IoT and cloud are increasing by this method. This hybrid approach mixes health care IoT tools with the cloud and applies fog amenities to the fuzzy reinforcement learning data packet allocation algorithm. The load loading algorithm applies load to the IoT information to lessen inactivity, and QoS manages the loading tasks to a degree. It has the potential to

Article	Review type	Main topic	Paper selection process	Classification	Comparing	Future works	Open issues
Shi *et al.* (2015)	Survey	FC	Not clear	No	No	No	Yes
Kraemer *et al.* (2017)	SLR	FC	Clear	Yes	No	No	No
Ni *et al.* (2018)	Survey	FC-IoT	Not clear	No	No	Yes	Yes
Hassan (2018)	Survey	FC-IoT	Not clear	No	No	Yes	Yes
Naha *et al.* (2018)	Survey	FC	Not clear	Yes	Yes	Yes	Yes
Kumari *et al.* (2018)	Survey	FC	Not clear	No	No	Yes	Yes
da Silva and de Aquino Júnior (2018)	SLR	FC	Clear	No	No	No	Yes
Maksimovic (2018)	Survey	IoT	Not clear	No	No	Yes	Yes
Mutlag *et al.* (2019)	SLR	IoT	Clear	No	No	Yes	Yes

Table II. The juxtaposition of the studied papers related to FC in health management systems automatically generate the ability to make decisions at FC nodes. The results have shown that the better functioning of the hybrid technique is related to network and service inactivity. While the study suffers from the mobility issue in fog, the cloud performance has improved.

The framework for registering personal searchable files with precise access control in cloud-FC has been proposed by Sun *et al.* (2018). The attribute-based encryption and search encryption technologies have been combined to perform a keyword exploration function and fine-grained access control capability. The success of the keyword list and the trapdoor games makes the cloud service provider only give the search consequences to the user, so that the search results will be more accurate. In addition, they have sent a bit of the encryption and decryption processes to the fog node. According to the decisional q-parallel bilinear Diffie–Hellman exponent and decisional bilinear Diffie–Hellman assumption, they have shown the security of the framework. Although the study focuses only on one area, the simulation experiments show that the framework is efficient.

The impact of FC on analyzing mines in big data of geographic and clinical uses has been discussed by Barik *et al.* (2018). They have proposed and developed a framework based on FC (such as fog learn). It uses the clustering K-means to manage the Ganga river basin and actual information to diagnose diabetic patients with diabetes mellitus. The introduced structure applies the deep learning framework to analyze the pathological data from intelligent watches that are acquired by diabetic patients and the geographic parameters of the Ganges Geological Database. The results have shown that FC is an important promise for analyzing medical and geographical data. The results have also shown that in the absence of machine control, large data analysis has been used to explore patterns of physiological data in a fog environment. Despite its benefits, this study focuses only on diabetic patients.

The spatial data infrastructure (SDI) is a crucial outline for spreading large geographic information through the web. A cloud-SDI method has been performed by a combination of SDI and cloud for transferring, processing and analyzing geographic data. The FC is a paradigm in which latency is reduced at the edge of the network, and efficiency is increased using embedded computers. Barik *et al.* (2018) have evaluated a GeoFog4Health, according to the SDI outline for extracting analytics from geo-health big data. The Intel Edison and Raspberry Pi have been used to build a prototype for studying the comparative performance. Additionally, data analysis has been implemented from geographic data. In addition, they have deliberated energy reservation, cost analysis and scalability of the introduced outline for processing of the information. They have compared the functioning of the outline with the cloud-SDI state regarding the analysis period. The outcomes and deliberations have shown the effectiveness of the system for broadly analyzing geographic data through various measurement frameworks. However, their study suffers from a single focus.

Thota *et al.* (2018) have provided a secure and centralized architecture for the full integration of the IoT-based health systems based on the cloud environment. The FC environment has been used to activate the outline. Health information has been gathered out of sensors data which are safely transmitted to the devices near the edge. Ultimately, the devices transmit data to the cloud for immediate access for clinical experts. Safety and privacy are vital for patient medical information in the adoption and use of IoT everywhere in health care. The main focus of their work is to ensure authentication and verification of all the devices, detect and track mobile devices, set up new items, connect to an existing system and communicate between the devices and data transmission among the remote clinical mechanisms. The introduced mechanism applies unsynchronized communication among the programs and data servers based on the cloud environment. Despite the advantages, their work is not a real-world one.

In recent years, electronic health uses have gained a crucial role in the healthy lives of people. The revitalization of smart devices, wearable people's lifestyles and the development of IoT have increased the ability of these programs. The prospect of large-scale health-care programs must be replaced on the cloud not merely because of limited storage and resource calculations of manual tools. Concerning this, the result of a special health program is that it simulates almost accurate, user-centric and personal recommendations roughly such as personal care around the clock. Therefore, FC has offered sufficient storing and processing structures for data analysis (Ahmad *et al.*, 2016). Table III compares the FC applications in health data analysis.

3.3 Frameworks and models

Controlling the increasing complexity of medical conditions because of demographic aging requires to increase the use of clinical resources and patient managing. Operational management may be realized by automatic health checking systems discussed in the many works of literature (Moore and Van Pham, 2018). The e-health services help monitor and assess the users' health, including elders with disabilities, children or patients (Gomes *et al.*, 2018). Using smart objects, they can be combined with health care to deliver smart amenities for remote checking of the individuals. Because FC is ubiquitous, health-care mechanisms enable the constant checking and managing of the above objects (Al-khafajiy *et al.*, 2018). So, large data that have been distributed, diversified, enlarged and updated requires new technical architectures and analysis to provide insight and open new business resources

Article	Main idea	Main features
Barik *et al.* (2017)	Proposing SoA for advanced analysis of spatial data	Efficient management of health data Low latency High throughput Focusing on one area
Shukla *et al.* (2018)	Providing an architecture for latency reduction	Reduce the time delay Improving the service Improving performance Weakness in mobility
Sun *et al.* (2018)	Presenting a framework for registering personal searchable files with precise access control	High accuracy High effectiveness Focusing only on one area Accurate access
Barik *et al.* (2018)	Exploring the impact of FC on analyzing mines in big data for geographic and medical health applications	Easily analyzing big data Focusing only on diabetic patients
Barik *et al.* (2018)	Evaluating the SDI framework for mining analytics from geo-health big data	High throughput Low latency Energy savings Cost analysis Good scalability Focusing on just one disease
Thota *et al.* (2018)	Providing a secure and centralized architecture for the full integration of the IoT-based health system	High security High privacy Quick access Lack of real-world assessment

Table III. Evaluation of the FC uses in data analysis health

(Andreu-Perez *et al.*, 2015; Lenka *et al.*, 2016). In the context of the FC, many frameworks and models have been developed to improve performance, reduce cost, decrease latency, increase speed, eliminate distance and much more. In the following sections, we have analyzed these frameworks in detail.

Cao *et al.* (2015) have used a worldwide health monitoring application to demonstrate the effectiveness and efficiency of the FC paradigm in health monitoring. Fall is a key element of death among stroke patients. Henceforth, its automatically timely diagnosis reduces stroke in everyday life. They have investigated and developed new fall detection algorithms. They have used an FC paradigm to design an immediate fall identification mechanism such as distributed analytics or edge intelligence. This system splits the detection task between the edge devices and the server. According to the experimental results, the distributed analytics and edge intelligence backed by FC archetype are very hopeful solutions for comprehensive health checking. However, the focus of the study is only on patients with stroke.

To maximize the range of services over cloud applications, special challenges such as information privacy and communication charge, require serious attention. Ahmad *et al.* (2016) have proposed an outline of health in which FC has been used as an intermediary layer between the cloud and the end users. Improving the health plan reflects the success of lowering the cost of additional communications, which is common in similar systems. For greater managing of information privacy and safety, they have also introduced the cloud access security broker as an essential element of health fog on which some policies can run. The design of the health framework can be done using available information from any sources plus a satisfactory level of safety and privacy using present cryptographic primitives. Although this study focuses only on one area, it has some significant benefits such as high performance and low cost.

Negash *et al.* (2018) have focused on the implementation of an intelligent electronic health gateway for the application in the FC layer and connected a network of such gates to both homes and hospitals. The above amenities have been applied to refer to the main issues of IoT, considering the organizations' health-care needs. A geographic network of these smart gates forms the fog, handling each group of sensitive or patient nodes. This gateway cluster provides a continuous monitoring tool for the patients without restricting patient motion in the coverage area. The FC should reduce communication delays and improve the system compatibility for providing remote patient monitoring services. For this purpose, the vital signs of the patient have been processed locally and local information has been provided to the user. In addition, sensory information has been sent to the server for further analysis. The most important benefits of this study are patient' remote monitoring, reduced communication latency, improved system compatibility and patient comfort. However, this study focuses only on one area. Special medical items may add some other scheme restrictions needing fine-tuning of actions of fog layers.

Rahmani *et al.* (2018) have presented the concept of FC and smart e-health gateways in the IoT-based health-care systems. The smart gateways near the sensor nodes in the house/clinic can take their exclusive tactical stance to address the issues of IoT-oriented mechanisms such as mobility, energy efficiency, scalability, interoperability and trustworthiness. They have examined the precise details of high-level services provided by smart gateways in a geographic model at the edge of the network (such as local computing, storing, notification, normalization, firewall, Web services and compression). They have introduced the concept of IoT-based remote video surveillance, which includes UT-GATE smart gateway demonstrations. Utilizing a number of UTGates, they have formed an interface computation layer to illustrate the concept of FC for IoT-oriented health-care systems. Their health system has been used in a medical study called "Early Warning Scores" to monitor patients suffering from acute diseases. Their complete demonstration of the system involves all processes of the flow of information from the extraction of information in sensor nodes to the cloud and end users. Although this study focuses only on one area, its conceptual design shows the IoT health monitoring system benefits: increasing the overall information system, performance, energy efficiency, mobility, interoperability, security and reliability.

Recently, fixed and wearable systems for continuous checking of ECG signals have been used in FC-based medical applications. Wu *et al.* (2018) have investigated a knitted architecture and conductive elements, including cotton/nylon fiber and coated silver to provide signal quality and comfortability (SQC) optimization. Specifically, real-time ECG signals have been measured through four electrodes having various inner architecture and conductive materials. The comfort level, SNR, skin-electrode impedance and electrical features of ECG signal are appropriate places for assessing the functioning of all these textile electrodes. The Ag/Agcl electrode has been applied as a reference electrode for comparing functioning. The results have shown that silver is very conductive and more flexible than copper yarn. The density of the fabric also determines the resistance of the sheet because the effective conducting strands are different at the surface of the fabric. Plus achieving fine ECG signals it can feel good when wearing your skin. The main advantages of textile electrodes are flexibility, comfort, anti-inflammation, high durability and performance variation. However, because of its flexible structure, it easily rubs against the skin and creates a lot of noise (the main limitation of textile electrodes).

Asif-Ur-Rahman *et al.* (2018) have proposed a diverse cloud-oriented outline, according to the internet of health-care things (IoHT) communication with FC. The understanding, mist, fog, cloud and usage layers have been included in the framework. The data routing routes for immediate and conventional data sources have been separately handled using this framework. The end-to-end (E2E) latency and packet drop rate should be reduced to guarantee high QoS of those diverse communication outlines. The proposed QoS framework has been improved through resource assignment and flow managing. The simulation outcomes have indicated that the proposed outline can reach low the E2E latency and packet drop rate. The obtained results have indicated the fitness of the IoHT outline in the clinical area. Although this study focuses on just one region, it uses innovative machine learning methods (such as deep learning) to detect heterogeneous traffic and use an environment-inspired pattern to ensure the use of effective sources.

The FC can improve the QoS provided to the systems needing to process critical information such as those of the health-care systems that can use rapid processing of the information from sensors to monitor patients. Al-khafajiy *et al.* (2018) have presented a notion of IoT-FC in the field of IoT-oriented clinical mechanisms. Also, they have introduced an outline to improve fog functionality using a cooperative strategy between fog nodes to determine the ideal workload and task assignment. An architecture has three layers: things, fog nodes and a cloud data center that has been proposed together with an outline integrating the structure. It provides a framework for collaboration between fog nodes with ideal resource management and job allocation capable of reaching high QoS (such as low latency) in the health-care system scenario. Although the proposed framework needs a feasibility study, it has the potential to reach the desired resources management and maintainable network pattern in the IoT–fog ecosystem.

Isa *et al.* (2018) have investigated the use of FC for clinical checking uses. They have considered a heart checking usage in which patients have been received the ECG signal processing at the fog processing section in the time limit assigned by the American Heart Association. The processing server location has been optimized to minimize the cost of processing the network. The results have shown that based on full analysis and investigation of the ECG signals at the edge of the network, energy-saving is 68 per cent compared to cloud-based processing. However, energy-saving has been decreased at the time the processing server can take more patients. This is because of the network connectivity capacity limitation, which makes it more time consuming than the device to transmit the ECG signals analyzed for lasting storing at the fundamental cloud. In addition, the results have indicated that the ideal place of the processing server is in the GIGABYTE passive optical networks in the optical terminals because it is the closest common point to the patients. However, owing to the limit of the edge-to-edge connectivity of the network to transfer the ECG signal to the centralized analysis of the cloud, saving overall energy has been decreased to 22 per cent when the patient's processing reaches 200.

Gomes *et al.* (2018) have provided FC-based hardware and software infrastructure as an immediate checking mechanism in accordance with the needs of the health environment. The infrastructure can store, process and provide real-time monitoring data based on the FC parameter. To do this, they have used a previous hardware platform and recommended it to the health community. In addition, they have developed it for essential subsets (foglets, planning algorithms and health care plans) for a real-time user. Despite the benefits of the offered real-time platform, the performance of the planned algorithms based on the proposed environment has not been measured. George *et al.* (2018) have described the application of smartphones as an indicator for maintaining the patients' health. Given the various disadvantages of CC, they have talked about using FC for quick data analysis. They have introduced the concept of FC, which is better than CC. The FC focuses on three types of patients: those who are critically injured, those who are only generally admitted to the hospital and those who are needed monitoring suddenly after they have been evacuated depending on the health status. They have proposed using a different technique for each patient. The various unique characteristics such as "possessing edge location," "location awareness," "geographically distributed," "real-time interactions," "heterogeneity" and "latency-sensitivity" are more solitary, advanced and distinctive in comparison to the cloud. The proposed architecture replaces the cloud by FC and eventually reduces expenses and attempts. The key aim of employing IoT in clinical systems is to make health care more precise by removing barriers to monitoring health-care parameters, which has been achieved by more sensors. The delays of the system in the FC is reduced compared to the cloud in the introduces structure because it is a real-time system that requires a quick and delayed response. The sensors in this system improve the interoperability of the mechanism with the present setting. The proposed model is based on data accuracy and data compatibility, which are very important in medical data applications. However, the FC provides access to all data in the system and violates this privacy. It may lead to misuse of confidential mechanism information. FC should focus on scalability, reduced latency and bandwidth usage, which is a tedious task to complete. The all-inclusive answers are needed to answer the massive data transmission among nodes connected to the network. The above aspects should be considered long by decreasing the cost of care and increasing the potential of patient outcomes.

Moore and Van Pham (2018) have extended the patient checking mechanisms in an intelligent-house to a broader intelligent setting that unifies intelligent-houses with the intelligent-town, according to the FC pattern with cloud computing. They have introduced a design that includes fog and CC based on a delayed health surveillance system presenting an efficient foundation for full immediate checking with situational awareness and large data analysis. To validate the execution of it, they have proposed two descriptive situations based on the real-world checking of dementia patients. Although the emphasis of the present article is on monitoring dementia patients, the introduced method will generalize to other medical situations in which checking is needed for the benefit of all participants in clinical mechanisms. Furthermore, the introduced design will generalize to other areas in which low-latency real-time checking is needed. The efficient execution of the design shows the possibility of creating real-time monitoring systems for many areas and mechanisms.

Because the scenario documentation relies on the consumers' accounts, Achouri *et al.* (2018) have introduced a two-layer managing condition structure to decrease the reaction time of emergency scenarios. The introduced method has a two-level structure (smart FC and cloud) with field sensors, smart devices and intelligent decision support tools that continuously monitor and diagnose problems in the smart environment. It ensures efficient situation management and good scalability. The purpose is to identify the immediate initial position of a group of users, determine the limits and the appropriate compatibility so that users can enjoy full multimedia content. This work is based on the top-level ontology model called GUSP-Onto that allows a high-level conceptual matching using different profiles' representations. Moreover, this ontology model can be used to infer appropriate services using formal representation of linguistic, semantic and contextual properties among profiles' concepts. The current research is based on the use of the proposed ontology profile model together with concepts similarity metrics to improve the exploitation of semantic view of context profiles. This result confirms that by using smart fog, the situation' identification time is less than 39 per cent compared to that of similar related work in 20-40 constraints. Because the proposed approach dynamically groups the rules of the similar situation, it checks the urgent situations by considering the intelligent java reasoning rules. However, in the last test with a high number of constraints (80 constraints), the situation identification and management times were each less than 3 s in the smart fog because of high constraints elimination. The offered approach enables users to provide early initial appointments designed to help users meet their daily needs and manage all services at once. The efficiency of the proposed model is better than the cloud, but it still needs improvement.

Dang *et al.* (2018) have designed a plan to share safe data sources for the electronic health information system. The proposal has been designed to make sure of the security of sensitive information in that dispersed storage situation. In the encryption stage, the FC has been used to enhance encryption effectiveness. The model deploys many outsourcing encryption jobs in the fog nodes using (k, n) threshold secret sharing in a MapReduce state. In the decryption stage, for decoding, most heavy operations, such as bilinear pairing, have been outsourced to a decryption service provider. Although this design has not been evaluated in the real environment, the assessment has proved that the scheme can meaningfully reduce the computational costs of terminal equipment, obtain efficient cancellation and back the immediate electronic health uses better.

The prediction and monitoring of health management systems for hydroelectricity equipment have been provided by Xiao *et al.* (2018) based on FC and Docker container. They have used FC to improve the immediate processing capacity of the cloud structure, according to fault prediction and health managing system. Then, a data processing method based on the storm has been proposed to analyze the health index at the edge of the network. The trade intercommunication and unified combination of diverse devices and producers have been achieved using the microservice architecture. Finally, the system will be applied to the ZhenTouBa power plant. The plant's security devices have been provided by the mechanism that can manage the plant's performance well. Finally, a proper application file has been presented in the article. However, this study has not compared the proposed architecture with those of the previous ones.

Vilela *et al.* (2019) have presented a new FC approach for health-care solutions with its main benefits in terms of inactivity, network consumption and power usage. However, it has only evaluated the real test compared to the traditional CC-based approach. The authors have presented an analysis of the concept of a health checking mechanism using fog to back clinical experts in deciding and illness inhibition. The results have indicated that the improving ability of the method is to minimize data traffic in the network core because data is analyzed locally. Owing to many related IoT devices, a multi-tenant approach has become a popular solution for multiple customers. However, the placement of appropriate resources and planning of work have not been completely considered regarding service quality. In addition, in the May environment, the relationship between devices is more complicated because of their heterogeneity. Therefore, a trust managing outline between them is an important issue in health programs.

The health monitoring system combines the new generation of wireless sensors, CC and big data. There are some restrictions in safety protocol, delayed reaction and the forecast of acute illness. To solve that problem, an IP-oriented outline (IPv6) for fog-aided clinical checking has been introduced by Hu *et al.* (2019). This framework is a combination of the sensitive layer of the body, the fog layer and the cloud layer. The body sensor layer produces physiological data, the FC node in the fog layer, the collection and analysis of time-sensitive information. The fog level transfers physiological information to the CC node in the cloud level for more processing. The mobile smartphone connects to the FC node and helps people predict potential illnesses. The results have indicated that the introduced categorization of the scheme for chronic diseases has high correctness in defining the harshness of the possible illness. Additionally, the reaction delay is much lesser than cloud-based internet protocol support (IPv4), but the focus of the study is only on one area.

The ever-increasing demand for comprehensive health systems enhances the health and well-being of the most innovative technologies such as IoT, cloud, sensor and wearable devices. With this acceptance, multivariate data is possible in health-care programs for individuals and patient-based services. To provide real-time data, this technology is available everywhere via smartphones and wearable tools for continuous checking. By the advance of IoT and intelligent tools, information nodes have been displayed at high speed and stored in large datasets for specific reasons in the cloud (Stojmenovic and Wen, 2014). To optimize the whole process, FC can ease those mechanisms as a gateway among the end-consumer and the cloud. The FC structure effectively reduces needless communication from data-producing nodes to the cloud. Furthermore, certain policies and directions can be unified in the fog to ensure data privacy and safety. The FC as an interface among the cloud and the end-consumer has a crucial part in the following: low inactivity, improved visualization and setting awareness. The security in the public cloud can be increased by FC. Furthermore, complex security challenges encounter large data and cloud. FC is the best method to solve the above issues (Ahmad *et al.*, 2016; Bonomi *et al.*, 2012). In Table IV, we have described the important goals and features of the analyzed articles in the frameworks and models of health system management.

4. Results

In the previous section, 31 chosen papers have been tested. The emphasis of the scholars was to enhance a few factors such as performance, response time, bandwidth consumption, security and saving energy. Nevertheless, many of the studies have not tested the method in a real environment. We have compared the accomplishments of the three classes of the articles in Table V. The outcomes have indicated that the best advantages of FC in health management systems are the performance increase, latency and response time reduction. Finally, the outcomes have shown that the key issue of FC in health management systems is security. Therefore, the problems of fog must be discussed before studying the ideal method of health providers.

Article	Main idea	Main features
Cao *et al.* (2015)	Exploiting the pervasive health monitoring at the era of FC	High effectiveness High efficacy Real-time The focus on only one type of disease
Ahmad *et al.* (2016)	Proposing a framework for health and wellness applications	Low costs High performance Focusing on one area only
Negash *et al.* (2018)	Leveraging FC for health care IoT	Remote monitoring Reducing communication latency Improving system compatibility High patient comfort
Rahmani *et al.* (2018)	Exploiting smart e-health gateways at the edge of health care IoT: an FC approach	High energy efficiency High mobility High performance High interoperability High security High reliability Focusing only on one area
Wu *et al.* (2018)	Optimizing the signal quality over comfortability of textile electrodes for ECG monitoring	High flexibility High comfort Anti-inflammation High durability Performance variation Easily rubbing against the skin High noise
Asif-Ur-Rahman *et al.* (2018)	Proposing a heterogeneous mist, fog and cloud-based framework for the internet of health-care things	Low latency High resource allocation and flow control High performance Increasing data distribution Focusing on just one area
Al-khafajiy *et al.* (2018)	Presenting the concept of IoT-FC in the context of IoT based health-care systems	Enhancing fog performance Optimal management of resources and job allocation High QoS Low latency Needing a feasibility study
Isa *et al.* (2018)	Investigating the use of FC for health monitoring applications	Saving energy Remote monitoring Limitation of link capacity at the network edge
Gomes *et al.* (2018)	Proposing a real-time FC approach for the health-care environment	Real-time Failure to measure the efficiency
George *et al.* (2018)	Proposing an IoT in health care using FC	Low costs and efforts Instantaneous response Less latency High efficiency Low privacy
Moore and Van Pham (2018)	FC and low latency context-aware health monitoring in smart interconnected environments	Low latency Real-time

(continued)

Table IV.
Comparison of the FC applications in frameworks and models of health management systems

Article	Main idea	Main features
Achouri *et al.* (2018)	Smart FC for efficient situation management in smart health environments	Better efficiency Dynamically Efficient situation management Good scalability
Dang *et al.* (2018)	Resource-efficient secure data sharing for information-centric e-health system using FC	Reducing costs Good effectiveness High security Not evaluated in the real environment
Xiao *et al.* (2018)	Prognostics and health managing mechanism for a hydropower plant, according to FC	Improving the real-time processing capability Low delay time Low network congestion High safety
Vilela *et al.* (2019)	Functioning assessment of a fog-aided IoT answer for electronic health uses	Low data traffic High data security Low quality of service High complexity Low trust management Providing better insights into the patient's health status
Hu *et al.* (2019)	Introducing an IPv6-oriented outline for fog-aided clinical checking	Low response delay High accuracy Focusing on only one area

Table IV.

4.1 Discussion

To solve the problems of current clinical issues such as delayed patient care, cloud computing is not the only best solution. Furthermore, health-care services and applications that are directly available in the cloud do not meet the needs of the health-care 4.0 setting. It has some restrictions such as the lack of immediate reaction and delay. In medicine, a slight delay can threaten the individual's life, so, FC has come to the picture to enhance services and applications (Kumari *et al.*, 2018). Improving the performance and efficacy of clinical and biomedical mechanisms are the two main goals of current society. In intelligent clinical mechanisms, the IoT-fog architecture provides services with latency sensitivity distributed at the edge of the network. Therefore, managing fog performance and functionalities has become an important aim to avoid latency and system failing because these are critical in health-care systems (Al-khafajiy *et al.*, 2018). Moreover, the researchers have shown that simulation and trial proportions have several benefits such as low latency, fault tolerance, distributed processing, security, privacy and scalability. These benefits are useful for critical indicators of patient monitoring systems that require significant reliability, mobility, field awareness and real-time processing (Mutlag *et al.*, 2019). To build secure infrastructure in fog's calculations, a promising way, blockchain, is a dispersed database keeping an increasing list of documents. The blockchain has first been applied to bitcoin to attain secure online payments lacking a reliable manager. In the fog computations, the blockchain format can store log files in a dispersed method that documents actions, runs in fog nodes and sends messages among clouds, fog nodes and IoT tools (Ni *et al.*, 2018).

Finally, the obtained results have shown that the unification of IoT and FC for clinical aims can bring several benefits such as quick and precise treatment offerings, decreased expenses and improved physician–patient contacts and treatment provision. A number of

Table V. The juxtaposition of the main factors of FC in health management systems

Article	Performance	Response time	Bandwidth consumption	Security	Saving energy	Mobility	Interoperability	Reliability	Flexibility	Comfort	Durability	Reduce latency	Improve QoS	Complexity	Privacy	Scalability
Review articles and related works																
Shi *et al.* (2015)	×	×	×	×	✓	×	×	×	×	×	×	✓	✓	×	×	×
Kraemer *et al.* (2017)	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Ni *et al.* (2018)	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	✓	×
Hassan (2018)	×	✓	×	×	×	×	×	×	✓	×	×	×	×	×	×	×
Naha *et al.* (2018)	✓	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×
Kumari *et al.* (2018)	×	×	×	✓	×	×	×		×	×	×	✓	×	×	✓	✓
da Silva and de Aquino Júnior (2018)	×	×	×	✓	×	×	×	✓	×	×	×	×	×	×	✓	×
Maksimovic (2018)	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	✓	×
Mutlag *et al.* (2019)	×	✓	×	×	×	×	×	×	×	×	×	✓	×	×	✓	✓
Data analysis																
Barik *et al.* (2017)	✓	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	✓
Shukla *et al.* (2018)	✓	✓	×	×	×	×	×	×	×	×	×	×	✓	×	×	×
Sun *et al.* (2018)	✓	×	×	✓	×	×	×	✓	×	×	×	×	×	×	×	×
Barik *et al.* (2018)	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Barik *et al.* (2018)	✓	×	✓	×	✓	×	×	×	×	×	×	✓	×	×	×	✓
Thota *et al.* (2018)	×	✓	×	✓	×	×	×	×	×	×	×	×	×	×	✓	×
Frameworks and models																
Cao *et al.* (2015)	✓	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×
Ahmad *et al.* (2016)	✓	✓	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×
Negash *et al.* (2018)	✓	×	×			×	×	×	×	×	×	✓	×	×	×	×
Rahmani *et al.* (2018)	✓	×	×	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
Wu *et al.* (2018)	✓	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×
Asif-Ur-Rahman *et al.* (2018)	✓	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×
Al-khafajiy *et al.* (2018)	✓	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×
Isa *et al.* (2018)	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×
Gomes *et al.* (2018)	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×
George *et al.* (2018)	✓	✓	×	×	×	×	×	×	×	×	×	✓	×	×	✓	×
Moore and Van Pham (2018)	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Achouri *et al.* (2018)	✓	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	✓
Dang *et al.* (2018)	✓	×	×	✓	×	×	×	×	×	×	×	×	×	×	✓	×
Xiao *et al.* (2018)	×	×	✓	✓	×	×	×	×	×	×	×	✓	×	×	×	×
Vilela *et al.* (2019)	×	×	✓	✓	×	×	×	×	×	×	×	×	✓	✓	×	×
Hu *et al.* (2019)	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×

uses have indicated that the opportunities and benefits of using the IoT, fog and CC integration approach provide low cost, effective, timely and advanced health care everywhere; day-to-day checking, provision of health-care services and the provision of services provided in e-call. In conclusion, it should be noted that FC is better than CC in providing health care and latency services, delay, jitter and supporting user mobility. The fog has restricted the processing power, so it could not bring the formation and implementation set for the novel amenities. Furthermore, upgrading the fog server to obtain cloud capability increases the operational costs (Andriopoulou *et al.*, 2017).

4.2 Open issues and future works

Some important challenges should be considered in future works. The problems have been deliberated and explored in this part. Some important directions for future researchers have been discussed in the rest of this section:

- It has been seen that there is no way to refer to all aspects of the use of FC environments in health management systems. It would be exciting to consider how safety and status can be effectively related to health-care software elements and equipment lacking human communication. With the advances in ICT, remote surveillance programs are increasing to allow patients to take remote treatment.
- Safety is a crucial criterion when a lot of tools are part of the network (increasing the chances of failure, malware infection and vulnerability that could lead to an attack). Therefore, the FC pattern encounters novel security issues far beyond what has been inherited from the CC. Hence, providing a strong encryption/decryption technique is essential to increase patient data security.
- In the FC environment, communication between devices is more complicated because of heterogeneity. Therefore, the trust managing outline between the tools is important in the uses of health management systems. Incremental re-planning of FC infrastructure increases the time efficiency. It is necessary to create an automatic diagnosis by an immediate reaction mechanism. The access time has been improved by considering the mobility of the clinical sensors among various intelligent electronic health gateways. On the other hand, there is a new mechanism for managing intelligent emergencies based on more complex relationships between two or more profiles. Each profile is made in a different description language.
- Although FC is promising as an emerging development, some issues require to be addressed to serve the IoT for efficient applications. Within FC, one can use different tools in the network and transfer devices/things. So, the ability to gather, format, compute this heterogeneous data and communicate among diverse tools will remain an unanswered problem.
- The slow acceptance of the FC in the clinical area is because of safety and privacy. The above problems should be referred to send to the cloud more consistently and gain the advantages of all the answers and enhancements it has.
- Security in FC is an issue owing to its placing in the network. Employing at the network edge may have some risks not present in an organized cloud. In a clinical situation, the attack could compromise a gateway among a patient checking sensor and a fog node. This may lead to serious outcomes related to the patients' health if the attacker changed the processed data (Stojmenovic and Wen, 2014).
- Many research issues related to FC are emerging because of connectivity everywhere and mixed structure. In the FC pattern, the main challenges are the

necessities and the disposition of the FC set as the tools in the fog environment are mixed, so the problem is how FC addresses the new challenges of managing resources and handling defects in such a heterogeneous environment. Hence, the primary necessities for other relevant dimensions, such as disposition, simulation, resource managing, fault tolerance and amenities, are required.

5. Conclusion

FC has been known as a vital path for numerous targets in clinical IoT management mechanisms. The studies in this path are growing. Therefore, the paradigm of FC is now in its infancy, so extensive research is necessary for it. The present study is an organized all-inclusive one around FC use in health management systems until April 2019. It has emphasized the possible fields for upcoming studies. A lot of papers have been chosen from online databases. Initially, an organized choosing method has been applied to efficient explorations. Also, we have detected, discussed and emphasized the benefits and drawbacks of each one. Despite the popularity of FC as having real-time processing, low latency, dynamic configuration, scalability, low reaction time (less than a second), high bandwidth, battery life and network traffic, a few issues remain unanswered, such as security. The most recent research has focused on improvements in remote monitoring of the patients, such as less latency and rapid response. Also, the results have shown the application of the qualitative methodology and case study in the use of FC in health management systems. While FC studies are growing in the clinical field, CC ones are decreasing.

The summary and structure of the FC have been presented and discussed, as well as the same hi-tech technologies in Fog, in this paper. According to the literature, we have obtained a classification for FC by analyzing the need for fog infrastructures, platforms and applications. The results have introduced a good clue about the overall path of FC works. Although this study has provided an overview of the position of FC in health management systems and detected the accomplishments, an organized follow-up study could better illustrate the exact domains. The present study could handle the pace of publications. Also, this study has presented the results of the investigation and procedure as an upcoming direction for authorities in the clinical department.

This research has only surveyed the articles that are mined, according to a keyword exploration of FC health, FC health care, FC health big data and FC health management system. The fog-based applications in the health management system may not be published with determined keywords. Moreover, the publications written in non-English languages have been ignored. Some important research studies may be printed in a language other than English.

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