

# Addressing Service Quality Challenges in the Cloud and IoT Integration: A Case Study of Tourist Remote Healthcare System

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## Abstract

The new paradigm of the Internet of Things (IoT) has attractiveness in healthcare so that it is used for medical purposes such as health monitoring for chronic diseases and caring for the elderly. The use of IoT technology can reduce costs, increase the quality of life and increase the Quality of Service (QoS). Remote monitoring applications that utilize technological advances in the IoT can deal with a large amount of real-time data. For this purpose, the cloud service attributes (e.g., high storage space and data processing capabilities at the edge) can be very valuable. Therefore, the integration of the cloud and IoT (a paradigm called CloudIoT or CoT) in improving healthcare delivery is becoming essential. In this article, we intend to express the challenges of service quality in remote care systems, to facilitate tourists' access to medical and specialized services by designing different scenarios using an intelligent routing system in different scenarios. Because usually, the people who need quick access to health and emergency services are tourists who do not know their current situation in advance. By designing three scenarios, we propose an approach to improve QoS challenges in the remote healthcare field. These three scenarios include routing without emergency situations, routing by considering healthcare services, and routing by considering emergency situations. This intelligent routing helps users choose the optimal treatment path or the optimal time path according to their needs. Finally, by analyzing the routing system in different scenarios, we suggest how much the service quality can improve in the field of intelligent healthcare through the cloud and IoT integration, and how the challenges of service quality can be addressed. These analyzes using the AHP (Analytical Hierarchy Process) program show that by using the intelligent routing program, improvements in real-time data processing, and data consistency can be achieved.

**Keywords** Internet of Things · Cloud computing · Quality of service · Intelligent health · Intelligent routing

# 1. Introduction

A new paradigm being recently proposed by researchers is the integration of the cloud and the Internet of Things, known as CoT or CloudIoT[1]. Although the IoT and the cloud are two separate, independent technologies, they need to be integrated to complement each other and to support pervasive computing. In CloudIoT, the cloud acts as an intermediate layer that provides interaction between objects and applications in order to develop intelligent applications and services. While the IoT can utilize almost unlimited cloud processing and storage resources, the cloud can successfully extend its services to objects in the physical world [2]. One of the applications of this integration is in smart healthcare and tourism. Today, providing medical and health services to domestic and foreign tourists is one of the main concerns.

In the field of smart healthcare, with the integration of the cloud and the IoT, there are challenges that will be described in this paper. Our focus is to explore the Quality-of-Service (QoS) challenges in the cloud and IoT integration approach (which is stated in part 2). Then in the third part, by examining the characteristics of cloud and IoT integration characteristics, we describe the challenges in providing the best remote healthcare services. Finally, in the fourth part, using a system developed for intelligent routing for tourists and providing healthcare and medical services, we will present an approach to address the challenges of QoS in remote healthcare in three different scenarios.

## 2. Background

### 2.1. The Cloud and IoT Integration

The term IoT briefly describes the paradigm that provides the network platform for reaching the world of physical objects. The IoT is characterized by highly heterogeneous devices, technologies and protocols, and is characterized by a variety of important properties such as scalability, interoperability, flexibility, reliability, performance, availability, and security[3]. In order to obtain an End-to-End Service Level Agreement (SLA) for Internet of Things applications, QoS mechanisms should be presented in each layer of IoT architecture (sensing, gateway, network, and cloud). The QoS mechanisms associated with the IoT metering layer depend on the communication technologies used by the objects of the IoT. Some of these communications technologies are adapted to the IoT, while others are specifically designed to use the Internet [4].

Patient remote monitoring systems that use technological advances on the IoT, the semantic web, data analysis, and cloud computing are used as an appropriate alternative to the traditional care methods. However, such systems generate large amounts of real-time data in terms of volume, rate, and variety [5]. This can become a major challenge in terms of how to match such information with patient data history and combine and analyze it to provide meaningful diagnostic recommendations in acceptable formats (Considering QoS requirements and service level agreements) [6]. Usually, people from healthcare units expect a quality healthcare system. But the delivery of high-quality healthcare to patients is difficult to reduce costs and solve the problem of nursing staff shortages [7]. This type of smart healthcare unit is expected to help the patient. It is essential to design a healthcare system that is beneficial to all people. Over the arrival of various technologies in medical

and healthcare, many changes have been made to improve healthcare systems standards [8].

Today, healthcare systems are largely collecting clinical data that is accessible electronically. This huge amount of data would be unusable without management [9]. Currently, IoT validation plays a vital role in framing and designing smart healthcare units. These advanced technologies should be introduced in the medical field to "support and improve health care standards and biomedical related processes". A smart healthcare sensor (SHS) is used to track the patient's body condition. This SHS is well designed and is capable of automatically identifying some of the individual's health factors such as pressure, temperature, heart rate, movement, heart rate, etc. After detecting the person's body condition, the collected information is sent to the health monitoring server [10]. RFID bands have a unique ID, similar to the patient ID used in hospitals. Based on the sensed details, the exact prescription is given to patients by the proposed Pro Prediction algorithm, which uses deep learning as its platform. A huge cloud database acts as a repository for all the solutions to various symptoms. By referring to health records and treatments provided to different patients, this database has solutions for different symptoms. The database only holds the health records of a patient and the treatment provided by doctors [8].

In such a situation where we are dealing with a lot of data, both cloud computing and IoT services offer architectural solutions in order to ensure a high quality of service through standard communication mediums. One of these solutions is broadly known as cloud and IoT integration, in which heterogeneous networks support different types of data and services. Therefore, these networks need to have the flexibility to support all data types in accordance with their requirements, along with the support of service quality. However, maintaining the guaranteed QoS for remote-healthcare applications is challenging [11]. This is due to the lack of necessary standardization, end-to-end approaches to service quality assurance (between the end user, IoT, and the cloud devices), the integration complexity in different layers of the cloud and IoT, and a large number of constraints on QoS parameters in each layer of the IoT architecture [12].

In this paper, we identified the challenges in ensuring the QoS of remote healthcare systems by means of smart routing and different scenarios.

## **2.2. CloudIoT in Healthcare**

CloudIoT has revolutionized e-health by collecting, analyzing and sharing medical data in real time. The combination of cloud computing and IoT technologies enables healthcare providers to access large amounts of patient data, including multiple sources, wearables, medical devices, and Electronic Health Records (HER) [13]. CloudIoT has several advantages in healthcare. Among other things, we can mention real-time monitoring to detect any disease and take timely action in that case. Also, cost savings that happen with the help of optimizing mechanisms and reducing unnecessary hospitalizations.[6]. Of course, to increase the efficiency and quality of services, calculations at the edge of the network are more recommended [14]. Edge computing is a computational model that is able to process and analyze data in a single cloud or data center closer to the data source. In remote healthcare, edge calculations can be used to provide monitoring and analysis in real-time data of patient data even in places where reliable internet connection is limited. Some of the technologies used in edge calculations in healthcare are wearable devices such as smartwatches and sensors that can be used to collect patient data, including vital signs such as heart rate and blood pressure, and transfer these data into an edge computational device for data analysis. The next technology is to use remote monitoring systems to collect and transmit patient data from medical devices such as blood glucose monitors and ECG devices

[15–18] to an edge computing device for real-time analysis. Even artificial intelligence and machine learning algorithms can be used to improve data analysis in edge calculations [19].

### 2.3. Quality of Service Challenges in Remote Healthcare

Smart devices play an important role in IoT healthcare applications, but there are always challenges. One of the biggest challenges is ensuring the reliability and availability of telehealth technologies, such as telemedicine platforms. In areas where high-speed Internet or remote monitoring equipment are not available, this challenge will be more noticeable. Another challenge is patient privacy and security. Ensuring that these technologies are safe and maintaining the security of patient information can be a significant challenge. In general, ensuring high-quality telehealth care requires a combination of reliable technology, security and privacy protocols, and trained health care providers who can effectively deliver patient care from Manage remotely.[6]. We explore the quality of service challenges associated with telecare services in more detail below:[12]:

- Special techniques and technologies for data analysis and evaluation: Since the volume and speed of healthcare data and also the diversity of healthcare sensors are expanding, the need for techniques and specialized technologies to analyze and evaluate these data is increasingly necessary. In this regard, two approaches are considered: natural language processing (NLP) and artificial intelligence (AI). Real-time data monitoring can also be used to collect real-time data, which can then be used to monitor a patient's health and detect any potential problems before they become more serious. Some limitations (e.g., inability to guarantee QoS) can negatively impact patient care, especially regarding timely alerts and diagnostic suggestions.
- Limitation of sensor data usage: While sensor data is a powerful tool that can be used to address QoS challenges in telehealth, there are several limitations to its use. Among these limitations is that sensor data may not always be accurate and may be affected by various factors such as environmental conditions and patient behavior. Sensor data can also be affected by technical issues, such as connection problems or device malfunctions, and therefore may not be reliable [20]. In some cases, if sensor data is not properly protected, it can be vulnerable to security breaches and data theft. Another challenge is the lack of standardization in sensor technology, which can make it difficult to compare and analyze data from different devices or platforms [21].
- Big data: Big data can create several challenges for the quality of telecare services. One such challenge is data overload, which can be overwhelming for healthcare providers. The sheer volume of data can make it difficult to identify meaningful diseases and trends, which can affect the quality of care. Also, as big data can provide a lot of information, the quality of the data is critical to its usefulness. If data is inaccurate, incomplete, or inconsistent, healthcare providers may make incorrect diagnoses or treatment decisions [22]. In addition, big data must be protected to ensure patient privacy and prevent data breaches. Another challenge is that big data can come from different sources such as electronic health records, telehealth platforms, and wearable devices, which can be challenging to integrate from different sources. Especially if the data is not standardized.

- Challenges of ensuring QoS in CloudIoT remote care applications: Ensuring QoS in telecare applications poses several challenges due to the heterogeneity of devices in CloudIoT. One of the existing challenges is security, which should be sensitive to the transfer and storage of patient data. Another challenge is reliability, as any disruption or outage of the internet can affect the quality of care and cause delays in treatment. Also, telecare applications must be scalable to accommodate changes in data volume and patient numbers. On the other hand, remote care applications in CloudIoT often involve the integration of multiple technologies and platforms. Ensuring that these technologies are interoperable and able to communicate with each other is critical to delivering integrated care across different care settings and providers. Finally, ensuring the affordability and availability of applications is critical to ensuring that all patients have access to quality care.
- Defects of standardized methods for end-to-end QoS (between end user, IoT device and the cloud): Standardized methods for QoS in CloudIoT telecare can have a number of flaws that can affect the quality of care provided to patients. Among other things, we can mention the lack of flexibility, which may not fully meet the needs of all users and cause a decrease in the acceptance rate and decrease in effectiveness. Also, the complexity of standardized methods for QoS can lead to longer deployment times, higher costs, and increased maintenance requirements. Another challenge is the limited scope of services that may not cover all aspects of the care delivery process. In some cases, the interoperability of devices can lead to incompatibility problems that affect the quality of care provided to patients.[23].
- The complexity of merging different layers of the cloud and IoT: Integrating different cloud and IoT layers into CloudIoT remote care is a complex process, and ensuring that the different layers of the CloudIoT infrastructure are interoperable is critical to the success of CloudIoT remote care. Using standard communication protocols, normalizing data and converting data from different sources into a standardized format, implementing semantic interoperability using ontologies or other semantic models, and using open standards can integrate devices or systems to make it easier for new infrastructures. Healthcare providers should consider these strategies when selecting and implementing CloudIoT telecare solutions to ensure they deliver high quality care to patients.
- **Real-time requirements:** Real-time requirements refer to the need for immediate data processing and action to ensure that patients receive timely and effective care. Some of the real-time requirements in remote care can include real-time data collection, and simultaneous data processing, which requires the use of real-time data processing technologies, such as edge computing or fog computing, which can process data quickly and efficiently. On the other hand, real-time alerts and real-time communication require the use of video conferencing or instant messaging to enable healthcare providers to communicate with patients quickly and efficiently.

To address each of the above challenges, separate research projects are needed to fully use all the integration capacities of cloud services and IoT. For example, in the field of healthcare, which is one of the scenarios related to the integration of cloud and IoT, remote patient monitoring systems that use technological advances in the field of IoT, the semantic web, data analysis and cloud computing are good alternatives to traditional patient management systems in order to reduce the burden on healthcare services. However, such systems have become a source of creating large volumes of real-time data that needs to be transferred in high speed between a wide variety of data sources and destinations. In this paper, by presenting a smart routing system and designing different scenarios, we explain

how effective this system can perform as an example of how to address the above challenges.

### **3. Case Study: An Intelligent Routing for Tourists' Access to Medical Facilities**

In the past decade, travel advice systems (TASs) that use information communication technology (ICT) have been a major source of information for tourists to help them in choosing the best possible services particularly when they travel in unfamiliar regions[24].

In particular, IoT is capable of providing the necessary assistance and support to achieve good life qualities to patients and people with disabilities. One of these services is providing access to medical centers during their trips as tourists [25, 26].

In [27], several scenarios for smart tourism are presented: from services to helping choose destinations, to searching for the right travel arrangement, to support tourists during the trip, and to help discovering the nearest places of interest. In this research, the aim is to help tourists with intelligent routing systems in order to facilitate accessing the nearest medical centers according to their priority, particularly if they have a previous illness are involved in a medical emergency.

In this case study, cloud and IoT integration will greatly facilitate its implementation. So that, using cloud storage capabilities, the required databases are stored in the cloud, so that they can be used anytime and anywhere. Then, using IoT capabilities and intelligent sensors, we determine intelligent routing based on the user's status. The status and position of the user in this project are defined in three scenarios.

This study is to determine the treatment path for the three diseases of children, heart, and flu and provide the best path from a specific origin to a specific destination. The optimal route in the routing algorithm is the route in which the number of medical centers is maximum so that medical services can be provided to tourists in the shortest possible time. Therefore, in the first step, transportation network modeling is presented as an important step. The various sources of information are then described. Finally, in the last part, the implemented routing algorithm will be examined (this program is written in MATLAB).

#### **3.1. Routing Method**

In general, the information needed to solve the routing problem in this research is stored in three different databases which is considered as the input to the developed application. Below are these three databases described:

*Urban Transportation Database:* This database gives the geographical information needed in urban transportation network modeling. This database identifies information about urban streets, their intersections, underpasses, and overpasses. Also, in this database the speed limit on each street, the length of each street, information about being the one-way or two-ways are provided. In addition, the location of touristic places of interest are stored in this database.

*Tourist Database:* In this database, the information about the tourists is stored, which includes personal characteristics (name, surname, age, nationality, residence) and location of each tourist (starting position), time of journeys of the tourist, the final destination of the tourist and finally the medical history and medicines being taken by the tourist.

*Medical Centers Database:* In this database, medical center's information includes the location of hospitals and medical centers, the type of medical center (specialized or general), services available in each medical center and hospital, as well as the average waiting time of providing services for each medical center.

Using the information of these three databases, the required data of the routing system is supplied to the application. The sensors in the smart device(s) carried by the tourist (mobile, tablet, smart gadget, etc.) optionally monitor her health regularly and send it to the application, the system will provide the tourist with the nearest medical center based on his needs and will guide him to his final destination.

With the availability of input data, the next step is to select the appropriate routing algorithm to determine the optimal path with the highest number and distribution of medical centers and hospitals in the city along the path. The routing algorithm proposes a route in which the number of medical centers is more than on other routes. Which we named the optimal treatment route. In contrast, the optimal route is when it offers the shortest route in terms of time, which may be minimal in medical centers. It is up to the user to choose which route to take. Considering that the urban transportation environment is modeled as a graph, one of the best methods for determining the optimal path in graph space (sampling space) is Dijkstra method [28]. This algorithm is a graph search algorithm to find the shortest path, in other words, the path with the least cost. The necessary condition for determining the shortest path by this algorithm is the absence of edges with a negative cost. The Dijkstra's algorithm is a single-source algorithm that for a source vertex (starting vertex) in a graph, finds the path with the least cost between this vertex and the other vertices of the graph and produces the shortest path tree. By applying a termination condition to the algorithm if a certain vertex is reached, the shortest path between two specific vertices can be found. The path in the graph means a sequential set of edges (each two edges being joined in a vertex). Therefore, the optimal path is the path that the sum of the weights that the edges are collectively forming is optimal. As a result, determining the weight of urban transportation graphs is important.

Since the aim of this study was to determine the optimal pathway with the highest number and distribution of medical centers and hospitals, the effect of the number of medical centers should be applied on the weights of the graph edges. For this purpose, the weights are determined by [29] have been used with a slight change. In order to determine the weight of each edge, it is necessary to specify the nearby medical centers and hospitals along each edge. In other words, the concept of proximity to medical centers and hospitals for each edge should be clearly stated. The concept of proximity is determined by the amount of CHCC if the distance of the treatment center from the edge is less than this value and also the desired treatment center is located between the beginning and end of the edge, this treatment center is a close treatment center. In addition, in this study, medical centers and hospitals are generally divided into two types general medical centers and specialized medical centers and based on the type of medical centers, they are assigned a weight. As a result, if the edge of the  $i$  graph is displayed with  $e_i$  the weight of this edge ( $W$ ) can be calculated based on the number of medical centers as Eq. 1:

$$W_{e_i} = \frac{num_{CSHCCi} \times W_{CSHCC} + num_{CGHCCi} \times W_{CGHCC}}{TN_{HCC}} \quad (1)$$

In the above relation  $num_{CSHCCi}$  number of specialized medical centers close to the edge of the  $i$ ,  $W_{CSHCC}$  weight related to the specialized medical centers,  $num_{CGHCCi}$  number of general medical centers close to the edge  $i$ ,  $W_{CGHCC}$  weight related to the general

medical centers and  $TN_{HCC}$  number All general and specialized medical centers are located in the geographical area.

Also, the distribution of the number of medical centers and hospitals in the  $i$  edge of the graph ( $Dis_{ei}$ ) is calculated from the Eq. 2:

$$Dis_{ei} = \frac{NumFr_{ei,HCC}}{NumFr_{ei}} \quad (2)$$

To calculate this relationship, first the length of the interval is specified by the user and then the length of each edge is divided into a number of specific intervals ( $NumFr_{ei}$ ) based on this interval length.  $NumFr_{ei,HCC}$  also specifies the number of intervals that have at least one nearby health center.

After calculating the distribution of health centers on each edge, the following relation is used to determine the combined weight based on the treatment centers for edge  $i$ , where, in fact, the weighted averages between the distribution of care centers on edge  $i$  and the weight of edge  $i$  are calculated based on the number of health centers from Eq. 3:

$$CW_{ei} = a \times Dis_{ei} + (1 - a) \times W_{ei} \quad (3)$$

In Eq. 3,  $a$  is a value between zero and 1 and is specified by the user, which in fact determines the importance of each of the two quantities of the number of medical centers and the distribution of medical centers.

By determining the combined weight of each edge, the edges that do not have medical centers have a weight of zero and according to the mechanism of Dijkstra algorithm in the mode of determining the path with maximum weight and the optimal path with minimum weight with infinite weight are removed from the search process. As a result, the route may have more medical centers, but this route is not selected due to the lack of a medical center on one edge.

According to the above, to solve the edge problem with zero or infinite weight, the cumulative weight of each edge is calculated from the total combined weight of the starting point of the path to the end point of the desired edge divided by the number of edges from the starting point to this edge. As a result, the cumulative weight of the end point of the path is obtained from the sum of the combined weights of its constituent edges divided by the number of edges, which is specified in Eq. 4:

$$WC_{ej} = \frac{\sum_{i=1}^n CW_{ei}}{n}$$

In Eq. 4, ( $WC_{ej}$ ) the cumulative weight of the edge  $j$ , ( $CW_{ei}$ ) is the combined weight of the edge  $i$  forming the optimal path from the starting point to the end point of the edge  $j$  and  $n$  is the number of edges forming this path.

By determining the cumulative weight of each edge, what matters in a trip is the travel time. As a result, the effect of travel time should be applied in calculating the weight of graph edges so that between two routes with the same length and also the number and distribution of the same treatment centers (same WC for two routes), a route is selected that has less travel time. As a result, the final weight of each edge of the urban transport graph is calculated as Eq. 5:

$$TW_{ei} = \frac{\sum_{i=1}^n \text{distance}_i / \text{Velocity}_i}{WC_{ej}}$$

In Eq. 5,  $\text{distance}_i$  is the same distance traveled on edge  $i$  and  $\text{Velocity}_i$  is the driving speed on edge  $i$ , which is determined by dividing these two values of travel time on edge  $i$ . Also, as can be seen, the optimal path is less final value ( $TW_{ei}$ ). In other words, its travel time is minimum and the number and dispersion of medical centers are maximum. In this study, in order to determine the optimal path, three different scenarios have been considered for the three diseases of children, heart and influenza, which are described in detail below.

### 3.1.1. Scenario 1: Determining the Optimal Path Without Emergency

In the first scenario, it is assumed that during the optimal treatment path, the tourist patient (user) does not have an emergency situation and there is no urgent need to go to the medical center. In order to investigate the algorithm in this scenario, three areas have been considered in the study area (Isfahan city) that have different number of hospitals and clinics. After determining the parameters of the algorithm, the optimal therapeutic pathway between the first and the end points of the pathway for three paediatric diseases (green), heart (red) and flu (blue) as well as the optimal time path (the path with the minimum time in black) has been calculated in the study areas. In Fig. 1, the mentioned paths are drawn.

As can be seen in Fig. 1, based on the location of the medical centers specialized for different disease, the optimal treatment pathway for different patients may vary. In fact, the

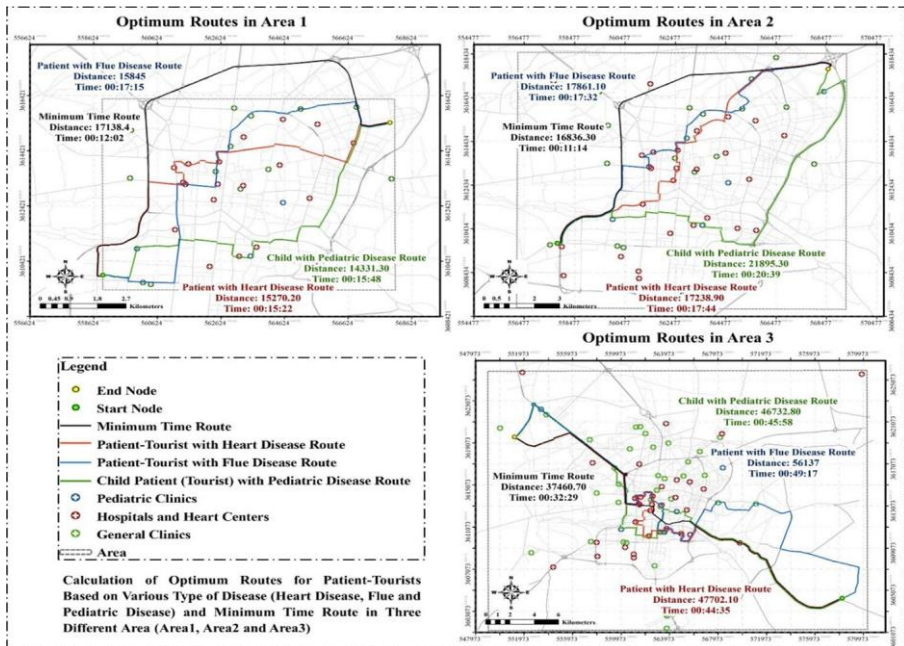


Fig. 1 Routing in three study areas of the first scenario

optimal treatment route passes through the streets that include more medical centers, so that the travel time between the beginning and the end points is minimum. For example, the optimal route is a route that passes through the western and the northern highways of the city regardless of the location of medical centers in order to reach the destination in the shortest possible time. The time and distance traveled in this path are displayed in Fig. 1. If the tourist has any of the default diseases (heart disease, flu or children), the optimal pathway is routed based on the type of treatment centers specific to them. In this case, priority is given to the nearest specialized medical center for the desired disease and with the shortest access time. Due to the importance of the time parameter along with the parameter of the number of treatment centers in calculating the optimal treatment route, in the proposed method, a limited number of treatment centers are selected so that the travel time does not increase much. As a result, the number of medical centers providing services is higher than the number of selected medical centers, and this reduces the percentage of selected medical centers. In Fig. 2, the average travel time of the optimal treatment route for heart patients, children and influenza in three study areas is calculated and compared with the minute time is compared with the optimal time route.

According to Fig. 2, the travel time of the optimal treatment paths in each study area is almost close to each other, and naturally, the wider the study area, the longer the travel time. In addition, it should also be noted that the location of medical centers has a greater impact on determining the location of the optimal route and, consequently, the route time, rather than the number of medical centers that the route passes through. In fact, due to the location of the medical centers, the route may cross streets that have a very low speed, and this affects the route time. Also, according to the diagram, it can be clearly seen that in all three areas, the optimal travel time is much less than other optimal treatment routes. In fact, due to the proximity of medical centers by optimal time routes, despite the increase in time, health and providing medical services to tourists is preferred over travel time.

### 3.1.2. Scenario 2: Determining the Optimal Pathway Considering Non-emergency Health Services Along the Way

In the second scenario, it is assumed that during the journey along the route, the tourist goes to a medical center at a certain time and receives medical services, and then continues on her path to the end point. In this scenario, three cases may occur: (1) the existence of a medical center in the calculated optimal route that is present within the specified time limit of the tourist; (2) the unavailability of a medical center in the optimal path calculated, but the existence of a medical center in the region that can be accessed

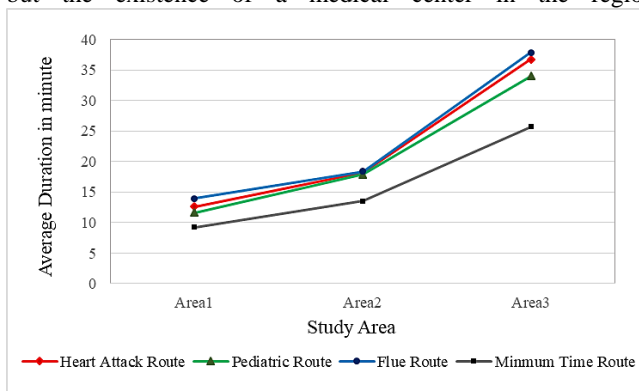


Figure 2- The average travel time of the optimal treatment path in the three study areas

by changing the routing in the specified time limit of the tourist; and (3) the unavailability of a medical center in the region within the specified time limit, so that the tourists needs to change the journey time. Considering that the second case is more general than the first one, the second and third cases are considered in Fig. 3. Then the optimal treatment pathway for patients with heart disease has been calculated between the start and end points.

According to Fig. 3, two paths are considered. In the first route (blue route) which lasted 45 min and 49 s, the optimal treatment route between the starting point and the hospital (blue hospital) has been drawn so that the patient has reached the hospital without changing the start time of the journey. In this way, the total time from the starting point to the hospital and from this hospital to the end point is less than the time needed to reach to the other hospitals. In Fig. 3, by calculating the route to other hospitals, another optimal path is displayed (red and orange paths) with a travel time of 44 min and 42 s. In fact, if the patient changes the time of movement from 17:50:00 to 17:52:30, within the specified time limit, she will reach a hospital (red hospital) so that the total travel time (from starting point to hospital and hospital to end point) is less than the time needed for reaching any other hospitals in the region. As a result, the patient can choose the same path from the two suggested paths. It should be noted that although the time difference between the two routes is very low, considering the traffic data in solving the problem, this time difference will become very noticeable. Also, the reason for determining the optimal treatment pathway instead of the optimal time path between the starting point and the hospital as well as the hospital and the end point in the two routes is that something may happen to the patient along the path that requires immediate transfer to a medical center. As a result, in this case, the patient's health is preferred over the time.

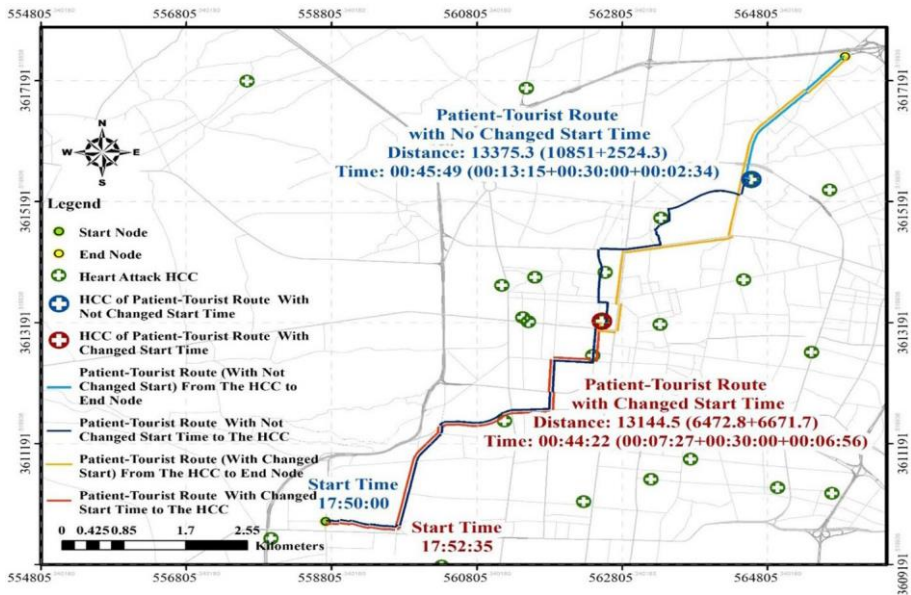


Fig. 3 Routing in the second scenario

### 3.1.3. Scenario 3: Determining the Optimal Path Considering the Occurrence of Emergency Situation Along the Way

In this scenario, it is assumed that the tourist will have an emergency while moving along the optimal treatment path. In order to investigate this scenario for patients with heart disease (because most people are unaware of their heart condition, early detection of cardiac abnormalities through electrocardiography (ECG) is essential to reduce the prevalence of cardiac arrest worldwide [30].) and Influenza disease, the optimal treatment pathway has been calculated and it is assumed that at two specified times (which happens in real cases randomly) the person will have an emergency. As a result, the time to reach the nearest medical center is compared with the time to reach the nearest medical center in the conditions that this happens at the same time on the optimal time path. In Fig. 4, the optimal treatment pathway and the optimal time path between the two starting and ending points for patients with heart disease with the starting time at 18 pm are calculated. It is assumed that an emergency situation occurs at 18 and 5 min.

As can be seen in Fig. 4, the destination changes in both directions (optimal time path and optimal treatment path) after emergency situation at 18:05 and the path to the nearest

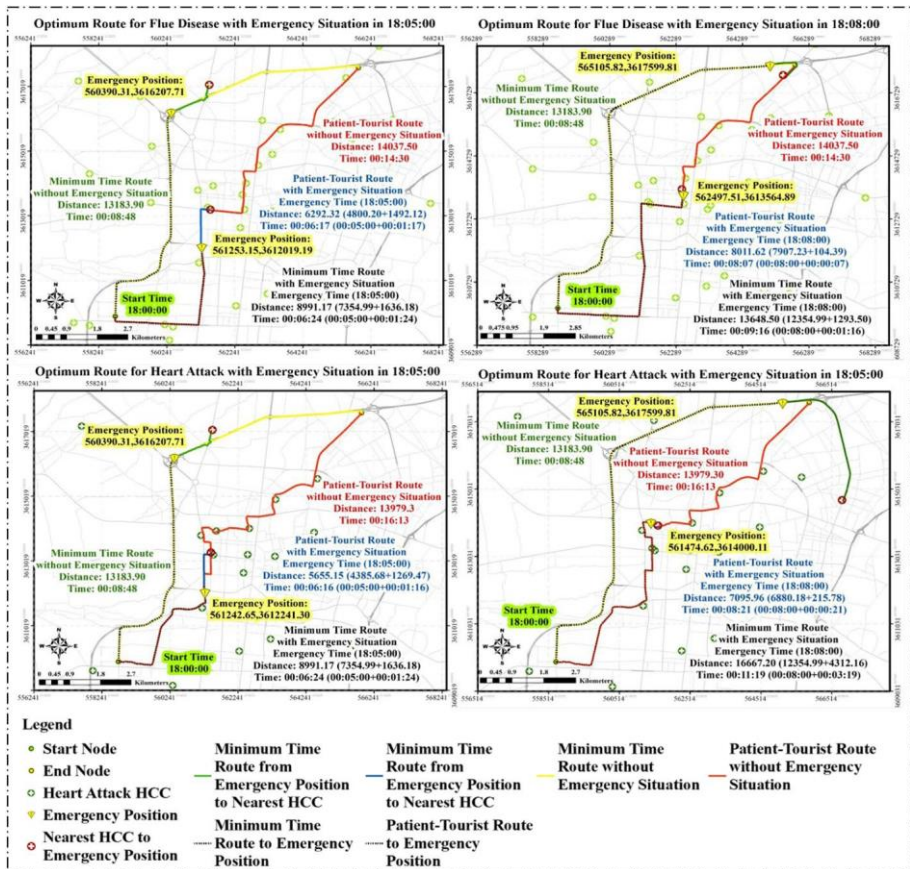


Fig. 4 Routing in the third scenario

medical center changes too. For the optimal treatment route, the time of emergency situation to the nearest medical center (hospital) is 1 min and 16 s, and for the optimal route, the time is 1 min and 24 s, which is about 8 s closer to the treatment center. Also, in Fig. 4, it is assumed that in the optimal treatment pathway for cardiac patients, and in the optimal time path starting at 18 pm, an emergency situation occurs at 18:08. For the optimal treatment path, the time of emergency situation is 21 s to the nearest medical center (hospital) and 3 min and 19 s for the optimal route, which is about 2 min and 58 s closer to the treatment center.

The optimal path in the event of emergency is composed of two parts: The path from the starting point to the point of occurrence of the emergency situation, which due to the importance of the tourist's health, the navigation time is in accordance with the optimal treatment path (the optimal treatment path). The path after the occurrence of the emergency situation, which due to the importance of the time, the path with the shortest time to the nearest treatment center is calculated (Optimal time path).

#### 4. Results

The aim of this study is to use the scenarios presented in the routing system to improve the challenges about the quality of remote healthcare services. The important point in these three scenarios is having an optimal treatment route or time by maintaining the shortest possible time to access the nearest centers providing the health services needed by the tourist. As a result, ensuring the QoSs provided to tourists is one of the priorities of this system. In Table 1, the challenges of QoS in remote health services are presented together with to the challenges that either improved or have not been changed with the implementation of this system. We also used AHP (*Analytical Hierarchy Process*) analysis to determine that the service quality assurance challenge has the highest priority among telemedicine service challenges. The challenges of real-time data, the complexity of integrating cloud layers and IoT, the limitations of using sensors, the shortcomings of synchronization methods, big data, and special techniques and technologies for analysis are in the next categories of this priority (Fig. 5).

Figure 6 also shows the relationship between challenges and service quality improvement in the AHP program. As shown in Fig. 6, real-time data is most closely linked to improved service quality in telemedicine services.

Figure 7 also shows the sensitivity percentage of service quality challenges in remote health using the AHP program.

As shown in Fig. 7, of the challenges posed to the quality of service in remote health (left image), the challenge of quality assurance has the highest percentage of service. Real-time data challenge is also the second factor in the challenge of service quality in remote health. But in the challenges (right side of the image), real-time data is the most important factor in improving service quality.

According to Table 1, the improvement of challenges can be described as follows:

- Special techniques and technologies for data analysis and evaluation: Due to the increase in the volume and speed of data and a variety of healthcare sensors, special techniques, and technologies are needed for data analysis and evaluation. According to data from different databases, such as tourist databases and the medical center's database, the program guides the tourist to the nearest specialist treatment center, which

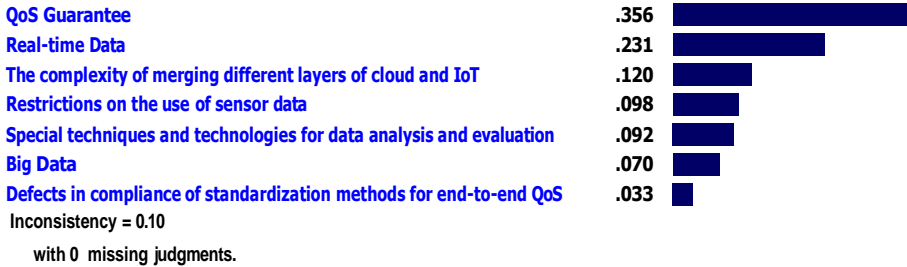
**Table 1** Improving QoS challenges in remote health services using intelligent routing program

Challenge	Data Analysis	Heterogeneity	Big Data	Compliance of Standards	Real-time Data
Special techniques and technologies for data analysis and evaluation	↑	↑	↑	–	↑
Restrictions on the use of sensor data	↑	↑	↑	–	↑
Big Data	↑	↑	↑	↑	↑
QoS Guarantee	↑	↑	↑	↑	↑
Defects in compliance of standardization methods for end-to-end QoS	–	–	↓	–	–
The complexity of merging different layers of cloud and IoT	↑	↑	↑	↑	↑
Real-time Data	↑	↑	↑	–	↑

↑: Improve performance, –: Unchanged, ↓: Weaken Performance

**Priorities with respect to:**

**Goal: Challenges of Quality**



**Fig. 5** Prioritize challenges using the AHP method

**Synthesis with respect to: Goal: Challenges of Quality**



**Fig. 6** Relate the challenges with improving the quality of service

## Dynamic Sensitivity for nodes below: Goal: Challenges of Quality

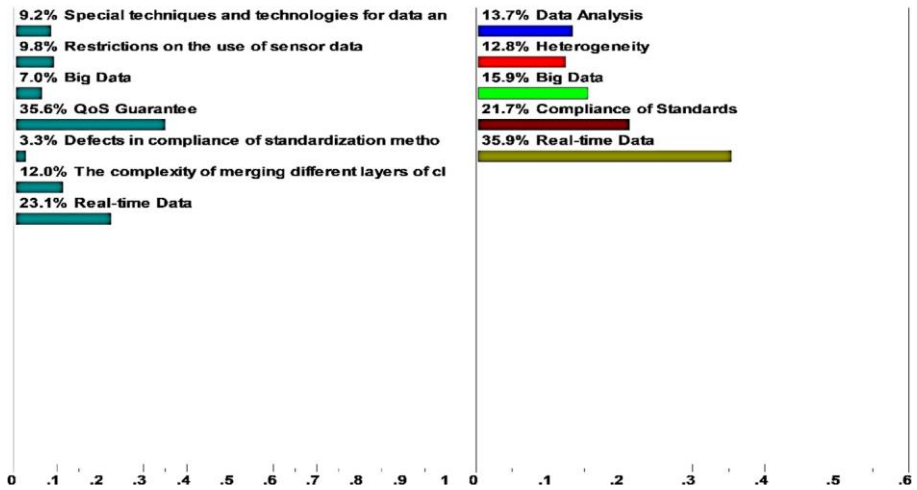
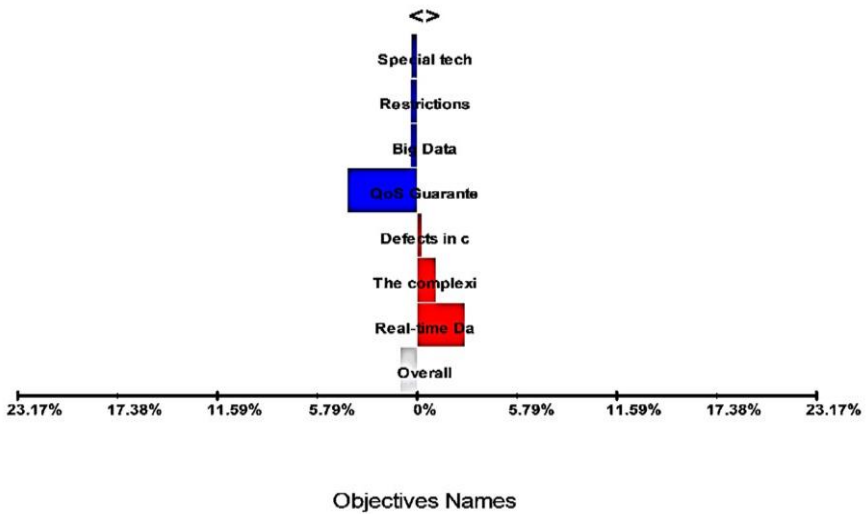


Fig.7 Percentage sensitivity of service quality challenges in remote health

provides the services needed for him (the second and third scenarios). Therefore, the result of data analysis has improved (due to the integrity of databases in cloud integration with IoT). The output is to provide an optimal pathway to access specialized health services as quickly as possible. Due to online data analysis, the performance of real-time data also improves. The heterogeneity in the data has also been enhanced due to the use of different sources (databases, applications, and various intelligent tools such as mobile phones, tablets, different gadgets, etc.) and cloud and IoT integration. The system will not address the challenge of compliance with standards.

- Limitation of the use of sensor data: This system, according to the information of the user's intelligent tools (improving heterogeneity in the condition that it is not a defect in the sensors) and data that is extracted from different profiles and databases and due to the occurrence of an accident or lack of events, leads the tourists to the nearest specialized medical center (all three scenarios). Using the AHP analysis program, the challenge of heterogeneity in the analysis of data also determines how each of the challenges affects this heterogeneity (Fig. 8). Therefore, improving data analysis, improving large data, and real-time data are also performed due to the online use of data and the impact of cloud and IoT integration. The program has no impact on the standards.
- Big data: Much data obtained from the database in question, according to the architectures in cloud integration and the Internet of Things (CloudIoT), can be stored in the cloud environment and will improve the challenge of big data. Also, with the help of cloud environment, data processing can be done in real-time. Therefore, other challenges are also improved with the help of cloud and IoT integration through the routing system. Figure 9 also shows the AHP analysis for big data relative to data analysis. As shown in Fig. 9, real-time data play a major role in the big data challenge.

## Weighted head to head between Data Analysis and Heterogeneity

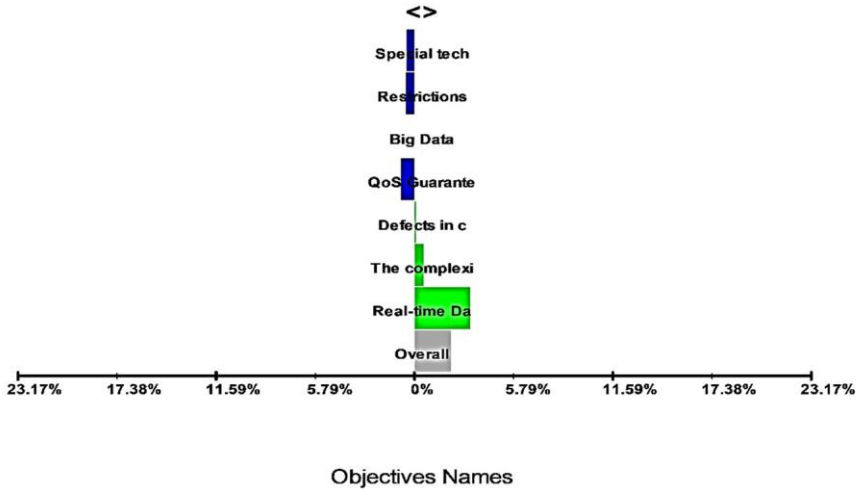


Objectives Names	
Special tech	Special techniques and technologies for data analysis and evaluation
Restrictions	Restrictions on the use of sensor data
Big Data	Big Data
QoS Guarante	QoS Guarantee
Defects in c	Defects in compliance of standardization methods for end-to-end QoS
The complexi	The complexity of merging different layers of cloud and IoT
Real-time Da	Real-time Data

Fig. 8 Heterogeneity challenge ratio to data analysis versus remote health challenges

- Challenges of ensuring QoS in CloudIoT remote care applications: To ensure the QoS, it is required to choose the best possible network connection, due to the variety of devices connected to the network, so that the connection is always established. Also, the possibility of analyzing and processing data in real-time considering the huge volume of data, and in the shortest possible time, is one of the factors ensuring the QoS. Therefore, in the intelligent routing system, considering the traffic check for different routes, processing user profile data and the type of accident occurred for the tourist, the optimal route in terms of time and distance to the required specialized treatment center is suggested to the tourist. In this way, the QoS in question is guaranteed (in all three scenarios). By ensuring QoS in routing system with CloudIoT approach, which increases scalability and reliability, all related challenges are improved.
- Defects in compliance of standards methods for end-to-end QoS (between end user, IoT device and cloud): Using QoS-aware can overcome the defects of these methods. However, if QoS-aware is used, since large data centers are used in the cloud

## Weighted head to head between Data Analysis and Big Data



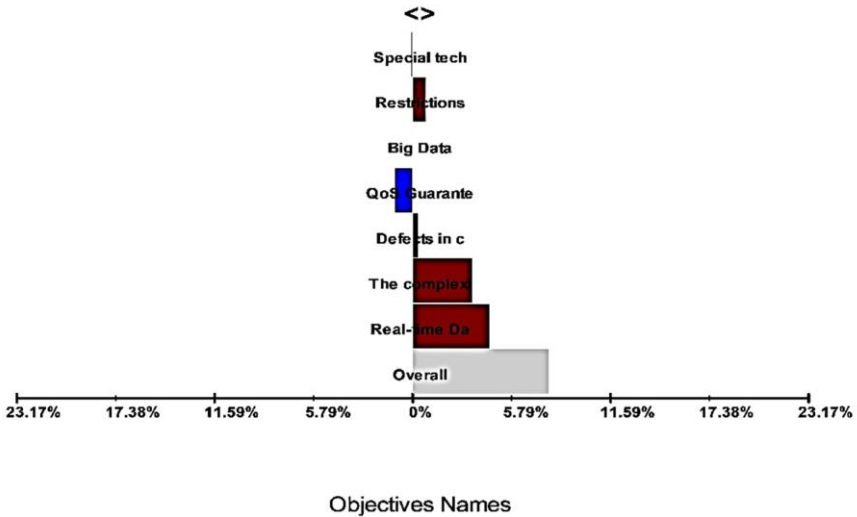
Objective Name	Description
Special tech	Special techniques and technologies for data analysis and evaluation
Restrictions	Restrictions on the use of sensor data
Big Data	Big Data
QoS Guarante	QoS Guarantee
Defects in c	Defects in compliance of standardization methods for end-to-end QoS
The complexi	The complexity of merging different layers of cloud and IoT
Real-time Da	Real-time Data

• **Fig.9** The ratio of big data to data analysis

environment, this method reduces the performance of the routing system and may not produce timely results. Therefore, the big data challenge will weaken the performance of the routing system. Other challenges will not have a serious impact on the system In AHP analysis, real-time data also have the greatest impact on the standard heterogeneity defect (Fig. 10).

- **The complexity of merging different layers of the cloud and IoT:** The complexity of merging cloud layers and IoT has been predicted in CloudIoT architecture. However, in the routing system, to ensure QoS in healthcare applications, it is necessary to monitor workload criteria (data volume, data speed, data types, resources, types, and combination of search queries) through large data processing frameworks and different ontological reasoning systems. The program directs the tourist to the nearest suitable specialized treatment center (in all three scenarios), according to a review of the various data obtained from databases (integrated into CloudIoT) and tourist profiles. In this way, all challenges are improved using this system.
- **Real-time requirements:** In this system, despite its different scenarios (all three scenarios), the system monitors the incoming data in real-time through integrity in the shortest time. If needed, the tourist has suggested the nearest optimal route in terms of

## Weighted head to head between Data Analysis and Compliance of Standards



Objective Name	Description
Special tech	Special techniques and technologies for data analysis and evaluation
Restrictions	Restrictions on the use of sensor data
Big Data	Big Data
QoS Guarante	QoS Guarantee
Defects in c	Defects in compliance of standardization methods for end-to-end QoS
The complexi	The complexity of merging different layers of cloud and IoT
Real-time Da	Real-time Data

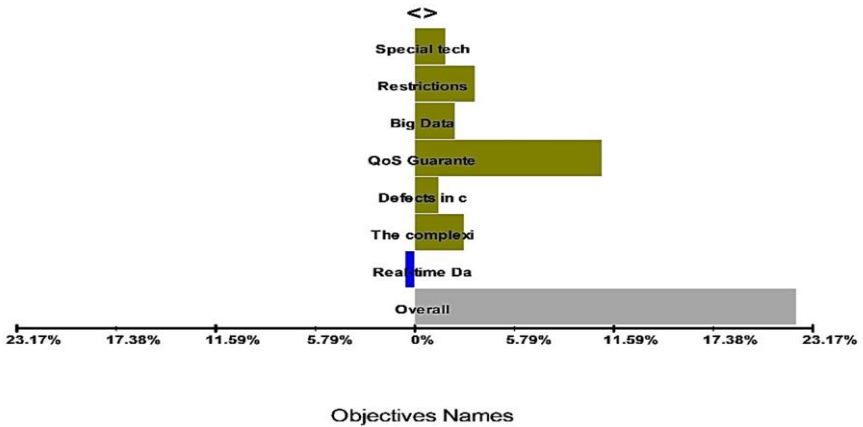
Fig. 10 Standard heterogeneity ratio to data analysis

both the lowest access time and the shortest distance to the required specialized medical center. Therefore, in this option, all challenges will be improved but the challenge of compliance with standards remains unchanged. AHP analysis also shows that quality assurance of service poses the greatest challenge for real-time data (Fig. 11).

## 5. Conclusion

The Internet of Things is a technology that uses artificial intelligence to efficiently connect physical objects to the Internet. Smart devices play an important role in IoT health care applications. Today's medical instruments are available with IoT features, independently and with basic capabilities such as measuring (collecting health-related information) and processing information. Due to the increasing volume and speed of data and various types of health care sensors, special techniques and technologies are needed to analyze and evaluate the data. Remote monitoring applications that take advantage of technological advances in the Internet of Things (IoT) face the

## Weighted head to head between Data Analysis and Real-time Data



Objective Name	Description
Special tech	Special techniques and technologies for data analysis and evaluation
Restrictions	Restrictions on the use of sensor data
Big Data	Big Data
QoS Guarante	QoS Guarantee
Defects in c	Defects in compliance of standardization methods for end-to-end QoS
The complexi	The complexity of merging different layers of cloud and IoT
Real-time Da	Real-time Data

Fig. 11 The ratio of real-time data to data analysis

challenge of large amounts of real-time data. Limitations such as the ability to guarantee QoS can negatively affect patient care, especially with regard to time warnings and diagnostic recommendations, but as the researchers noted, the integration of cloud services and the Internet of Things can be an effective help in meeting existing challenges.

In this paper, we presented a routing program with regard to the challenges posed in ensuring service quality in remote healthcare, which suggests that the challenges of ensuring QoS can be improved using cloud and internet integration. With this method, tourists can be helped to have a timely access to specialized medical centers needed during their urban and suburban trips. This method with a specialized health and treatment approach shows the effects of the cloud and IoT integration, and that with the help of this integration the challenges of service quality resulting from this integration can be overcome. We also used AHP analysis to show that the analysis we provided to improve the quality of service using the routing system was close to reality. The priority of this system in the case of tourist's need for health services is to provide an optimal route by maintaining the minimum time and the shortest distance. This system with the three proposed scenarios can meet the basic needs of tourists in accessing specialized health services and ultimately can help to ensure the quality of the cloud services. The routing system shows how effective the cloud and IoT integration in the application layer can be in addressing the challenges of service quality. This system is an example that shows the significant potentials of CloudIoT in a wider area of applications in addressing the associated challenges with similar performance.

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