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Emerging wireless communication technologies in Iraqi government: Exploring cloud, edge, and fog computing

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Abstract

This study aims to structure the implementation of a governmental cloud of things (CoT), edge computing (EC), and fog computing in Iraq in the context of sustainable wireless communication. A base of literature was built that included any challenges, opportunities, and best practices relevant to these innovative technologies to set up the background for this paper. A concept model was created that included core components (cognitive technologies and fog computing), key processes (resource analysis, infrastructure design), and stakeholders (governments, industry, community). A strategic methodology made up of stakeholder involvement, capacity building, and pilot projects was used in the project. Concerning IoT planned deployment and services provision, network infrastructure was put in place to support the devices and a higher level of security measures were recommended. Using scenario hypothesis, MATLAB simulator was employed to simulate data value distribution as well as received power distribution based on different institutions for 12 months. Monitoring and evaluation should be followed to measure performance indicators and effects on this process. Continuously improvement strategies were the highlight of the session which further stimulated innovations. Acquainted projects will be put in the function to extend the range of activities by including additional government agencies, regions, or sectors. Reporting of the collected data and funding will be done with stakeholders to share and pool knowledge.

Keywords: Cloud of things, fog computing, sustainable wireless communications, edge computing, governmental sector, Iraq, IoT devices, UWB, stakeholder engagement, capacity building, network infrastructure.

1. Introduction

The distributed computing paradigms of "fog" "cloud", and "edge" are not the same as each other as explained by Figure 1; they have different purposes and benefits, and they call for the solution of different tasks. The target of fog computing, which in some cases called edge-fog is computing, is to move computer resources close to the edges of a network, which is usually in the close presence of devices that users interact with. This way is tried that the data is handled locally instead of it transmitted to a far cloud server which leads to a difference in latency and an increase in efficiency. For example, IoT devices, smart sensors, and industrial automation systems stand among applications that benefit from the ability of fog computing to do the processing of data instantly and in real time [1-4].

As opposed to cloud computing which uses remote servers over the internet to do computing tasks and data storage, other methods utilize local devices of the computer user. Through automating processing in distant data centers managed by third-party service providers, cloud computing gives computing a whole new scalability perspective, as well as a level of flexibility and affordability that was not available before. It can be said that this type is good at programs that can't be physiognomic without high storage space, processing capacity, and the capacity to be accessed from any place that is internet-connected. Certain kinds of enterprise applications may usually not need real-time processing, speedy data storage, and software development the common uses of cloud computing.

The key feature of these three concepts is that they aim to process data close to the end devices or the sources they produce, including smartphones, wearables, and IoT sensors. Through this, edge computing can lower the time delay and the amount of network bandwidth utilization while still being able to analyze and make decisions on the data in a real-time manner. This method is especially good for applications, that require prompt reactions, such as sensors that warn of crises in healthcare systems, smart cities, and automatic cars. Edge computing, employing complementing cloud computing and hence reduction of variability, greatly improves both the system response and speed of the operations through the localization of the calculations.

In conclusion, cloud computing takes data and stores and processes it remotely on servers to be able to access and expand it, while fog computing is concerned with the efficient and quick processing of data that takes place at the network edge. To speed up the response, minimize the use of the central resources, and analyze data in real-time at the ends of the wireless endpoints called edge computing is a new technology. Making clear the disability to understand the peculiarities of each of the computer models and deciding on what one to use for a particular issue is one of the problems emphasized because each paradigm has its advantage and is for special purposes.

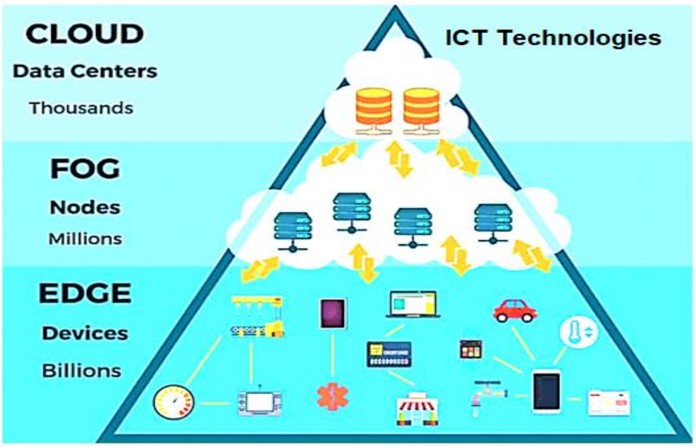

Figure 1. Cloud, fog, and edge computing

2. Literature survey

In the case of the country of Iraq, without digitalizing their systems, the e-governments and cloud technologies are still lagging. The projected 25% e-governance services online conducted by 2012 in Iraq means that it has only 25% implementation (the report by UN E-Governments Survey,2012) [5]. The undertaken cloud computing projects are not as full-fledged as they could have been to our great disappointment, so far, as far as the inner setting of e-government services is concerned. In the wake of cloud-based e-government multiple options beneficial for an organization have appeared like less scattered and cheaper data storage, more advanced security control, scalability, and more responsibility as well, all this is discussed against the backdrop of the e-government and the cloud in Iraq. The government decided not to spend the present situation of clouds the way as there was no slip-up (indicating the absence of any technical mistakes) in this technology. Therefore, it is very encouraging to carry out an e-government survey in Iraq. A verifiable investigation by Wahsh and Dhillon in [6] which is on cloud computing being used effectively in e-governance in Iraq is another example. This study's results exemplify that none of trust nor technology readiness has a significant influence as the determinant factor of e-government and cloud computing usage. However, the overall argument indicates that conceptual and non-technical factors are more crucial than technology-related ones. It is in [7] that the University of Technology in Iraq is supposed to design a prototype of the cloud system. An online set of services, like Google Drive, and programs, like Microsoft Office, will be available on the website soon. The project with us made it possible. This project is a big deal for Iraqi universities because they will be able to reduce costs, improve the opportunities afforded by time, and lastly, make concrete material in IT will be done easily. Through the lens of [8]: you get a closer look at the social and technical aspects of cloud computing adoption by Iraqi educational institutions. The core of the scientific survey, developed by the unified theory of acceptance use of technology (UTAUT), has been integrated. As to survey participation, stratifying responses vividly on faculty, students, and non-members.

To avoid getting mired in infrastructure modernization and maintenance, the academic institution should choose a cloud computing platform standard model as reported by Mohamed S. Al-Khayat et al. [9]. It has six service layers. To find a way out, Muzhir Shaban Al-Ani and his team have come up with an option of a structured cloud environment for the Iraqi Ministry of Science and Higher Education. A few college avenues within the ministry are hitting the nail on the head about applied practice. Load balancing and routing protocol techniques may also help to give a way out to the problems. Some of the acronyms like ITS, C2C, and VANETS have been used in Intelligent transportation systems [10, 11] facilitated by mobile computing and cloud. They demonstrated the creation of a framework for the mental functioning of disasters. The structural design and components of the disaster management system are tried in the modeling and simulation that are used in the evacuation of the Iraqi city of Ramadi which shows that the evacuation there takes less time.

In [12], a definition of cloud computing services and e-government in Iraq is explained. In addition, the study administers a respondent-based survey to gauge the benefits such services could bring to Iraqi citizens. Moreover, they have given more insight into making Iraqi citizens use their own identities to access cloud computing and e-government services. Over 110 different e-service proposals were put forward by knowledgeable Iraqi people as per the survey results. The article informs the mandatory e-services presented above with the help of the given statistical list. Being able to pinpoint the technical and the non-technical problems that localize the growth of the Iraqi e-government and cloud computing, this research study will be a huge step in this direction of improving the functionaries of e-government and cloud computing systems according to the target groups of the citizens. Peer-to-peer applications, commonly referred to as critical instruments in ICT, are among the most crucial technologies in e-government and cloud computing. Adopting standard materials and international certificates as a base, this study stands for a 3-year plan for duly modernizing the Iraqi e-Governments database and making it available to both the public and the respondent officials while using Information and Communication Technology.

The article in [13] gives a general picture of fog computing along with the cloud of things as well as their operating mechanism. Moreover, some sustainable applications of those technologies in Iraq are reported as well as making them persistent. A lot of people worldwide are interested in cloud computing, which enables users to meet the needs of scalable and temporary computer resources. A cloud of things and fog computing on the other hand are improved aspects of the Internet of Things; they move the computation in the device. This research sheds light on fog computing and IoT (Internet of Things) in Iraq, both current as well as potential for future use, as well as expected challenges and opportunities this technology gives. The study reveals that strict cybersecurity, flexible policy design, infrastructure development, and other progressive measures are just some of the essentials of Iraq reaping the benefits of fog computing and the Internet of Things. The questionnaires are one of the contents discussed in this research. It is made up of two dissimilar parts. In the initial section of the survey, these questions address the department of the respondents and their role within the organization, organization size, and ministries. Cyber security, privacy, sustainability, the implementation cost, practicality, trust, information, and technology infrastructures, and government support are some of the other themes of this study. It ended up with diverse views on the precise type of fog computing and IoT in cloud services requested by the Iraqi government based on applied results.

Cloud computing is a way to deliver at-need resources that include cloud servers, databases, networking, storage, software, analytics, and more through the internet on a "pay-for-use" basis [14]. The simple software interface, which is just a click away, will enable users to access it anytime from anywhere and will overcome the plenty of small interactions and interior issues that are associated with it. The utilization of this technology is limited at the public institutions in Iraq case due to several factors and reasons. The study investigated the major reasons causing no adequate cloud technology to be addressed in Iraqi government structures by giving a conceptual model that integrates the techniques of TOE, Iacovou, and DOI. The review of relevant literature has helped to define and identify the pivotal factors influencing the choice of cloud computing infrastructure. To seek the objective of this research, the methods of quantitative research have been employed alongside a self–self-administered questionnaire that has been used as a key primary data–gathering tool, and it has been analyzed through the statistical SPSS program. Furthermore, the performance of cloud computing technologies is evaluated in real-time using the CloudAnalyst simulator. This has resulted in the application of the AHP and ECDSA techniques that help in discovering the weight of variables as per the results of the questionnaire and identify the extent to which these technologies can be secured as well as manage privacy. Lastly, a comprehensive set of guidelines was nominated for Iraqi government departments that are adopting the cloud platform.

The article [15] in summary discusses cloud and fog computing as well as the possible usage of these technologies by Iraq. The cloud computing idea has become very popular because it gives users flexible and scalable computer resources. However, edge computation on the cloud core scalability is achieved by fog computing. The purpose of this study is to examine the existing applications of cloud and fog computing in Iraq, the challenges faced during implementation, and their potential future uses; special focus is put on the applications at the IT and management levels. This will be an inquiry conducted using questionnaires. The system consists of two interacting elements that work separately. Part one of the poll consists of questions with regards to fog computing, direct and indirect cloud of things, and also responses on how knowledgeable they are in these aspects. In part 2 of the study, we will go through the rest of the components of the exam. From here stem fears about risks such as the lack of governmental support, financial feasibility, company size and team culture, degree of process difficulty, and legality. To get a variety of perspectives on a cloud of things and fog computing services with the government, an open-ended question was added to the final poll.

3. Conceptual model

In a context where the governmental sector in Iraq needs to use a cloud of things (CoT), edge computing (EC), and fog computing for good, a well-defined roadmap should be drawn out and its implantation followed as a priority. According to this plan, several stages are likely to be introduced, such as the formation of the plan and further evaluation and improvement methods to create a holistic approach to technical innovation implementation.

Phase one of the plan is dedicated to organizational effectiveness, where the direction of government services, infrastructure, and emergency response system will be assessed for the country of Iraq. The evaluation will assist in pointing out the most suitable options where CoT, EC, and fog computing may be applied in great value. A successful deployment of these technologies will require a collaborative effort with various essential stakeholders such as public agencies, technology providers, and citizens to establish a support base for these technologies and to impart an understanding of the benefits they can bring about in service delivery and service improvement.

The capacity structure of public laborers should be organized together with instructional programs to help them master the jobs of configuring, posting surveillance, and maintaining Internet of Things devices, cloud services, and fog computing infrastructure. Selected pilot projects should be introduced in particular to government agencies and the regions to establish validation of the CoT, EC, and fog computing technology applicability and utility in real life. They will test the technologies to see how they are performing, who they are helping at what cost, and what users think about them.

Building a capable network platform, capable of maintaining the steady operation of IoT devices, cloud infrastructure, and fog computing features, is a priority that needs to be fulfilled. Data security measures at the minimal level should encompass the protection of all kinds of information collected through IoT devices and cloud services and should comply with local laws and standards. The partnership of government agencies, technology companies, academia, as well as other involved parties for successful execution, is a must, to take advantage of the competencies and resources that they each have.

Observation and evaluation of the Key Performance Indicators (KPI), user opinions, and fog computing actions are needed to conclude their efficiency, increase public services, and bring social-economic benefits. Targeted projects that proved themselves effective and efficient must be scaled up to other relevant Iraqi governmental agencies and regions, nations, and institutions while revising those best practices and lessons from pilot projects.

Generation and sharing of a culture of continuous development and innovation through experimentation with new technologies such as CoT and EC apps, cloud services, and fog computing are prerequisites for strategy development to increase the impact. Adopting this focused roadmap, the governmental institutions of Iraq can take advantage of the ability of CoT, EC, and fog computing to provide high-quality service delivery, promote active and efficient management in all sectors, and deal with the continuous challenges brought by the changes in society. Through this pathway of strategic measures, the Iraqi government can make use of CoT, EC, and fog computing to better serve its citizens, in addition, this aspect will strengthen the effectiveness of governance, and respond to the evolving needs timeously.

4. Method

This paper employed a structured literature review approach to give an explication of the CoT, EC, and fog computing concepts as components in the government conjunction in Iraq. The assessment shall consider the crucial obstacles, approaches, and deluge of knowledge on the adoption of CoT, EC, and fog computing in government services.

Therefore, the model structure for the studies of clouds of consciousness and fog computing that are in the government sector in Iraq will be defined according to the literature review. The study will be structured in such a way that the formulation, range, as well as results, are precisely formulated, serving as a basis for the research to be done. The MATLAB simulator was accepted as an implementation tool for the model and will also be enumerated to achieve the conceptualization.

Stakeholder engagements shall be an integral part of the methodology that will comprise communications with major players, for example, government agencies, technology suppliers, academia, and civilians.

A training program with capacity building will be launched to prepare government staff emotionally for the fieldwork, system monitoring, and maintenance of IoT systems, cloud services, and edge computing devices. Training sessions in practical classes, seminars, and workshops such as, can be organized to help with skills and knowledge acquirement in the technologies of Fog computing and edge computing.

Small-scale pilot projects can involve picking government organizations or regions to present the appropriateness and clear benefits of a cloud of things and fog computing technologies. General purpose programming languages like Matlab can be used in these regions to monitor, assess, and simulate fog computing and IoT networks as well as cloud services deployment.

Basic grids can be established as a priority to support the installation of IoT devices, cloud services, and edge computing functions. Privacy and security of the data will undoubtedly be taken care of since this information can be collected by using the devices of the Internet of Things.

To systematize the overall performance of machine translation and fog computing initiatives, data can be collected using metrics monitoring, user feedback, and impact assessment channels. The efficacy of these technologies in the improvement of service quality, governance outcome, and society benefit development is the major area that will be researched.

A continuously improving’ approach along with trials for novel CoT applications, EC services, and fog computing solutions can be adopted to drive innovation. We can be ready to adjust to the cases learned from pilot projects to scale up the intervention model.

Successful projects can be multiscale by the expansion of the project implementation to the additional governorates or service sectors in Iraq while using practices of the best ones. Results and developments can be disclosed to relevant authorities to increase the dissemination of information and solidarity during the project’s lifetime.

5. Results and discussion

Through the data's myriad of alternative numbers of gigabytes of data for Iraqi institutions as scenario hypothesis, we can investigate how most of the organizations used their data in the last twelve months tremendously. Now that we have the visualizations and calculations as follows:

Statistical distribution of data for every institution over a year - Figure 2 depicts gigabytes referred to the twelve months belonging to each college. This kind of graph provides us with insight into what researchers and businesses do with data differently. University A may have a steady consumption pattern of data while University B`s growth in student body enrollment may lead to a critical shift in data intensity.

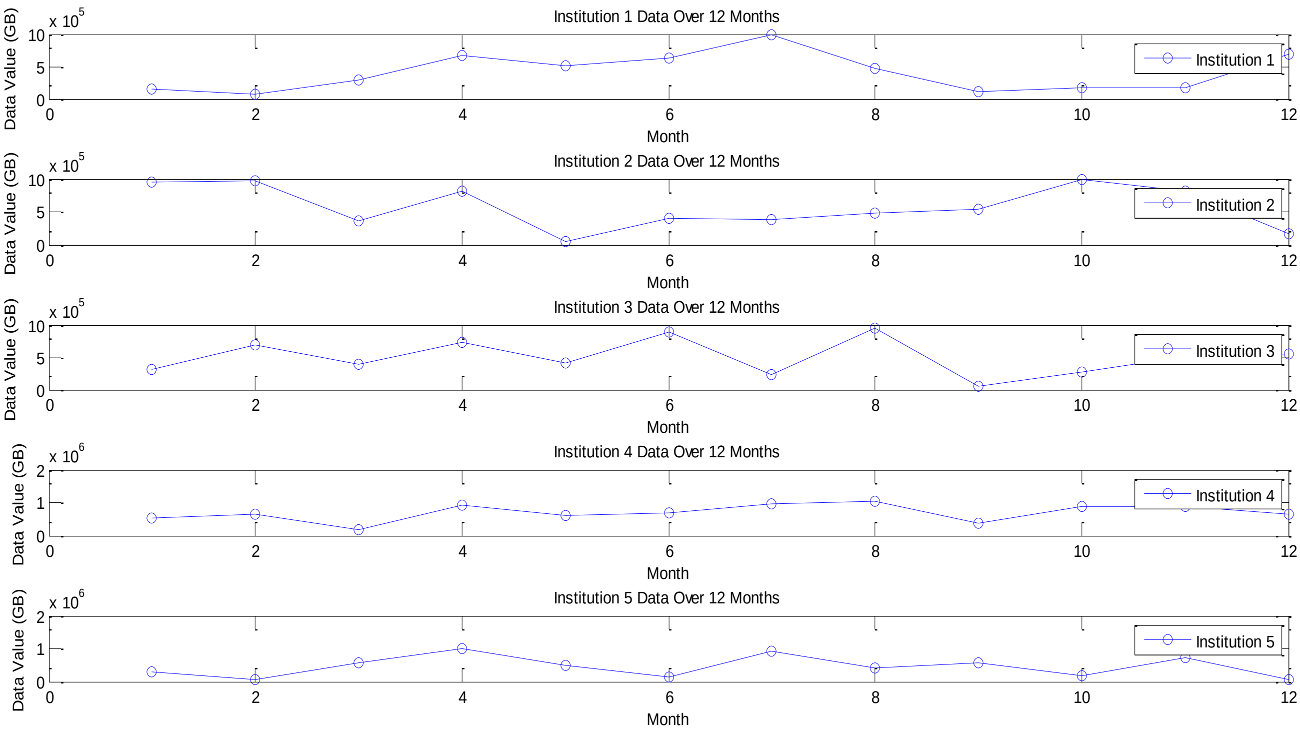

Figure 2. Simulated data value distribution based on different institutions for 12 months

The second metric is the monthly total data consumption - You can trace the evolution of data utilization as does all the organizations in Iraq over time as demonstrated by the bar chart that shows overall data for every month. Through Figure 3, we can resolve the relation between the data on the Internet consumption per month and other factors, such as seasons or specific incidents.

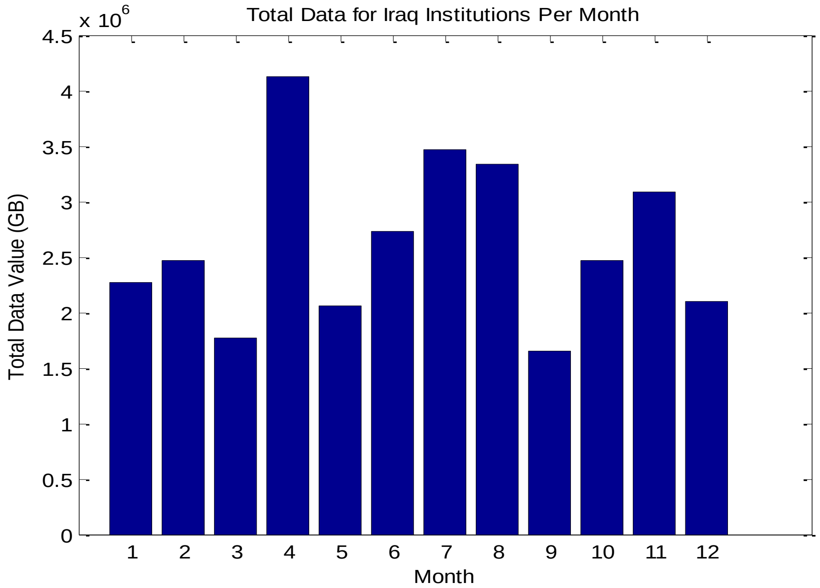

Figure 3. Simulated total data consumption per month

Institutional Data Consumption on Average - The amount of data usually used by every institution is shown in this bar chart where the average data usage per institution is presented. Organizations that tend to be more data-intensive in their operations and use up more resources have average data values that are elevated. Allocation of resources and capacity planning are two areas that can be of great help due to this data as in Figure 4.

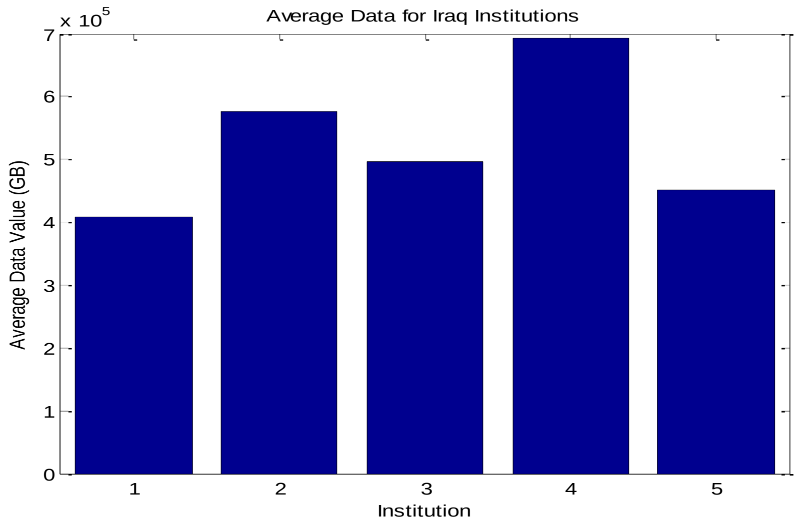

Figure 4. Simulated institutional data consumption on average

The Upper Limit for Data Usage Per Institution - The smallest data transmission level of each institution within the 12 months of the study is shown in the bar chart as well as the largest amount of data incorporated among all the institutions. If you need to locate institutions that require some special attention in the period of maximum traffic or need for improvement, knowing the highest values will give you this possibility as in Figure 5.

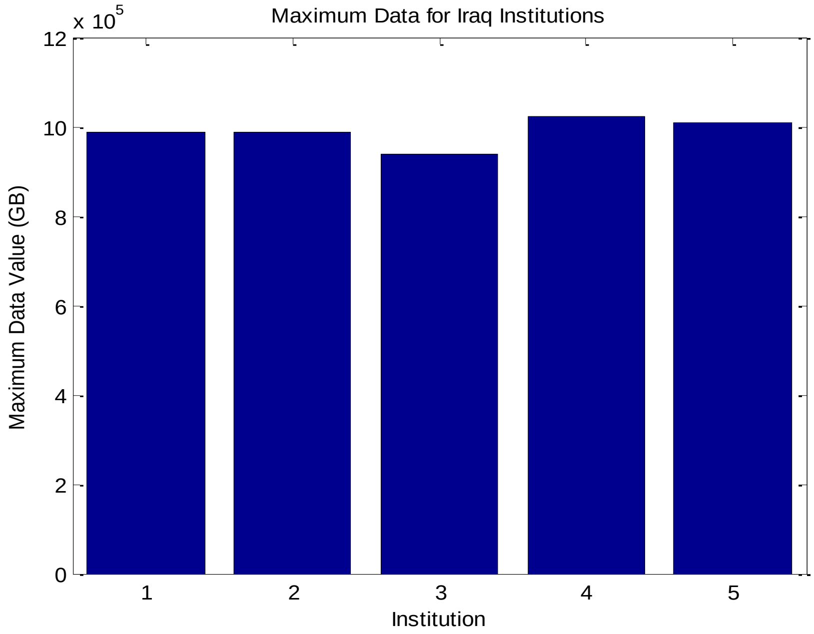

Figure 5. Simulated maximum institutional data consumption

Indeed, stakeholders can gain a lot of valuable information from data usage applications, distribution, and networks by studying the petabytes of data that have been produced for the Iraqi institutions and analyzing the represented visuals and given figures. From this data, we can make informed decisions for the efficiency of data operations and management in Iraq's public institutions, and we can also influence growth in resource management.

The MATLAB simulation provided subsequently elaborates on the year of data transmission and reception carried out by five Iraqi institutions as in Figures 6-7 through Ultra-Wideband (UWB) antennas as follows:

1. Authority Granted to Every Organization 12-month Period. One of the features we have is annual jurisdictional power that is reflected in the plots. A self-evident point is the path loss, which is in direct correlation with the seemingly random distances affecting the sending and receiving antennas, which results in the consequent power fluctuations. Within the neighborhood, the nearer the institution lies to the transmitter, the higher power is received, while further away institutions the power received is reduced.
2. Proportion of Total Power Received by Each Institution: - The entire range of average received power by each institution in the different months is shown in the bar chart. The simulation proceeded with an average power calculation for the effective radiation of each Institution throughout the course. Smaller distances or better conditions of a certain route are major factors for higher signal reception levels at organizations that demonstrate average power values at the maximum level.
3. Analysis: The displays of power obtained through simulations demonstrate the fact that the strength of a signal can be limited by distance in UWB networks. Signal strength is proportional to the distance between the educational institution and the antenna transmitting station; path loss is the case of signal weakening at longer distances.
4. Use: Being able to recognize both incoming and outgoing power levels can be quite useful for the optimization of antenna placement and signal processing technology as well as power management. Through the means of stakeholders, it is possible to optimally set the communication architecture and the places to raise the signal reception by conducting the average received power per institution.

The effect of path loss and distance on the development of communication systems to efficiently transmit and receive data is shown also via the rendered results and simulation images of the service quality of the Iraqi institutions.

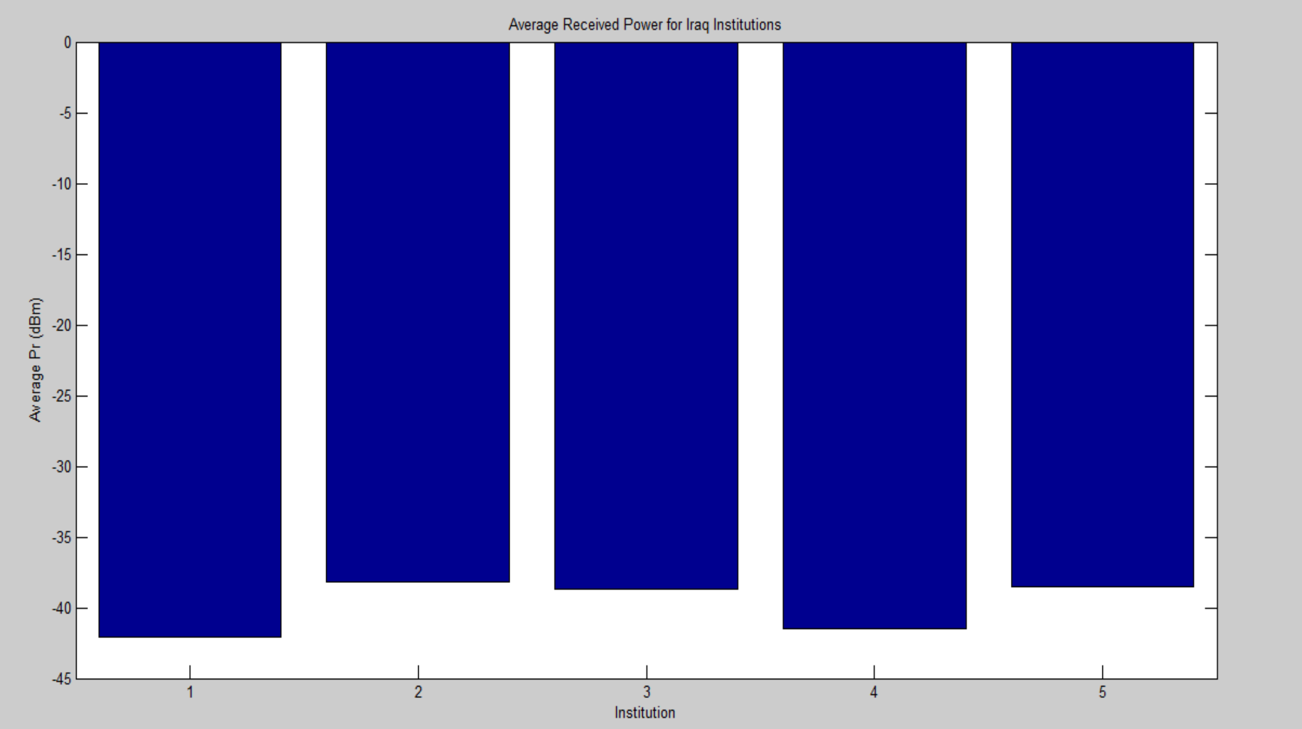

Figure 6. Simulated average received power by each Institution in the different months

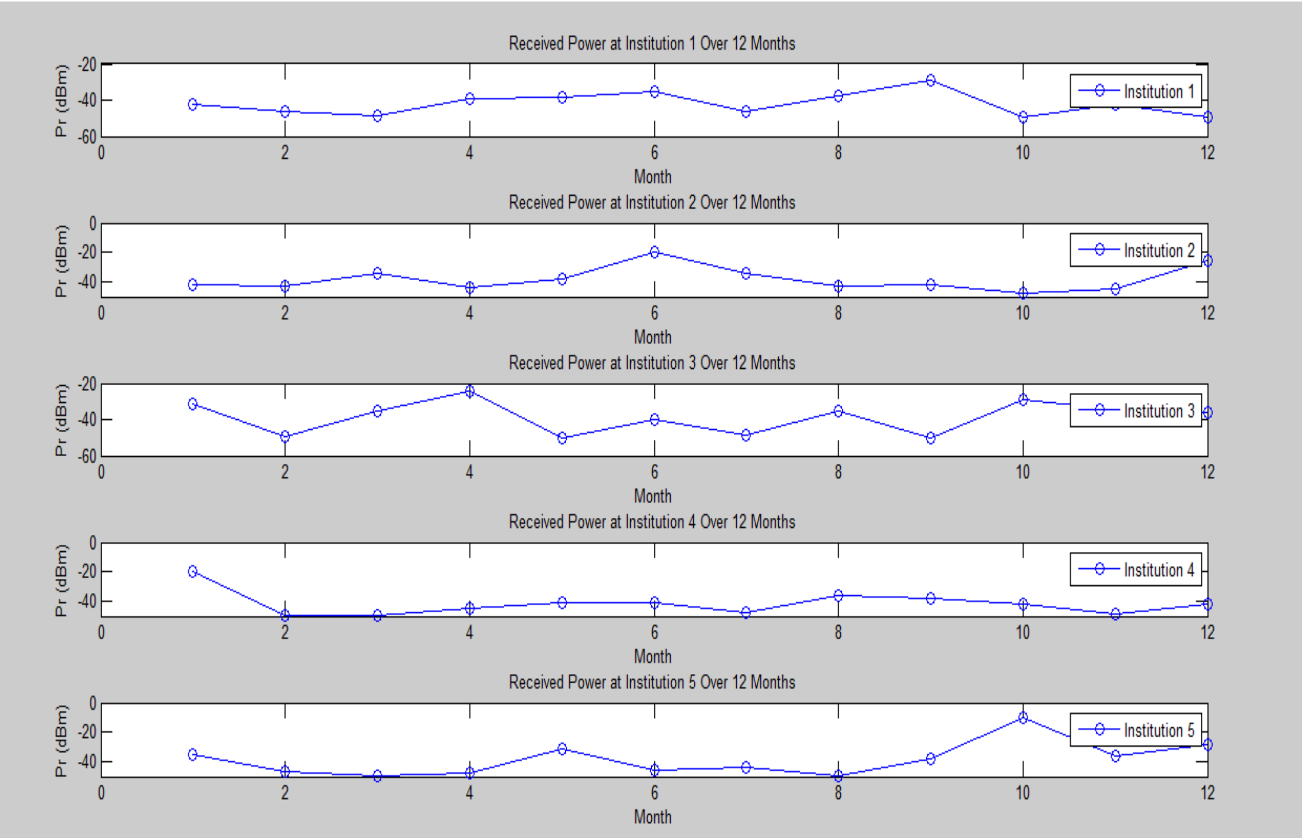

Figure 7. Simulated received power distribution based on different institutions for 12 months

Microstrip filters and antennas are essential components of the networking of fog, cloud, and edge computing by making it possible to have reliable and efficient communication. Being small in size is one of the most significant advantages that microstrip filters and antennas have in common to be used in these applications. The advantage of microstrip filters and antennas, as small as they are, is that they get easily connected in order of IoT sensors, edge computing devices, and other compact systems. Such reduced capacity helps to deploy the communication systems in situations that have restrictions of space, where space can be scarce (for example, fog and edge computing scenarios) [16-24].

Also, microstrip filters and antennas offer a cost-effective solution for communication in fog, cloud, and edge computing systems. In comparison to other overhead RF components, microstrip filters, and antennas, being cheaper, are suitable for application in a large number. Due to this cost-effectiveness, such large-scale communication infrastructure can be easily put in place without absorbing highly substantial costs, thereby promoting the adoption of these fog, cloud, and edge computing technologies in a wide area.

Among their other qualities, microstrip filters, and antennae are not only low-cost but also high performing, with signal quality, bandwidth, and efficiency being the main attributes. These modules are created to provide highly stable and reliable communication created on the fog, cloud, and edge terminals. The performance is highly characteristic of microstrip filters and antennas which is most suitable for the communication application in terms of complex data processing requirements and lower latency.

On top of that, the versatility of microstrip antennas and filters allows the designers to bring in customizations to fit the exact scope of needs in settings with fog, cloud, and edge computing scenarios. Such components can be configured to the overall performance in distinct surroundings, consequently by proving the systems are operational both in inflamed or friendly conditions. Through this agility, Fog computing coordinates with cloud and edge computing applications to build a sturdier basis for efforts, the result is better efficiency and reliability of the whole system.

Several possible applications can benefit from the data derived from the simulation results of received power at various Iraqi universities employing UWB antennas: Several possible applications can benefit from the data derived from the simulation results of received power at various Iraqi universities employing UWB antennas.

The localization and tracking which involve indoors are among the areas where UWB technology stands out because it is known in the market for its pinpoint accuracy. One way of increasing the accuracy of the existing building and campus-based tracking systems is to make use of the already existing various institutions which can be used to find the received power levels at various institutions. Such tasks as indoor navigation, asset tracking, and staff monitoring are just a few realms where this would be applicable.

1. Data Networks and Intelligent Buildings: The biggest strength of the proposed institutions is that they will use IoT positioning methods, that require the information on the power that the device receives – the higher the signal strength, the lower the power. IoT networks can be more reliable and power-efficient by repositioning devices or sensors in environments where signals are received more. Energy allotment, environment hear-say, and smart building applicants are at the core of it.
2. Network Design for Wireless Communications: Institutional wireless communication network planning and optimization can be supported by learning in consideration of the fluctuations of received power levels. To advance the successful transmission of signals as well as data rates, signal power levels within certain areas get a great deal of consideration when new coverage areas have to be improved, the planning of antennas has to be adjusted, or signal boosting techniques have to be implemented.
3. Safety and emergency response systems: Collaboration, off-site communication, and committed labor will be essential for safety protocols and emergency response procedures to be effective. The stakeholders can adopt solutions to keep a connection during emergencies by forming networks that can send and receive models aiming at mapping the coverage area and identifying locations with a weak signal. It will be thereafter that they can get backup communications systems or network amplifiers.
4. Managing Assets and Tracking Inventory: The financial companies would in the future have an instrument through which they would come up with better inventory monitoring and asset management by adapting the provided power levels. Various outcomes like improved accuracy of allocation, tracking of assets, and the loss because of the motion of the moved goods can be due to the correlation of the signal strength and the location inventory items.

5. Ultra-Wideband (UWB) Technology Research and Development: To summarize and to give further directions for forthcoming studies and advancements in UWB technology, we can have our simulation results as a great base. The power radiated can serve as a guide for researchers which is used to optimize antenna configurations, come up with more refined algorithms, or boost the reliability of UWB communication networks in practical situations.

Conclusively, Iraqi institutions will be blessed with a wide range of benefits for the received data of UWB antenna simulations for use in areas like improved indoor localization, the Internet of Things (IoT), wireless communication, emergency response, and UWB technology development.

As for the surrounding area of implementation of CoT, EC, and fog computing technologies in the governmental sector in Iraq, it is essential to employ first-grade filter devices and antennas for all possible improvements regarding the networks of communication and secure data transmission. Government bodies can provide the necessary hardware filters with higher grade hardware to remove the source of the interference and improve the quality of the signal to make sure that the connection between IoT devices and cloud servers is without a hitch. Bandpass filters can be implemented to select the frequency interval and the signals to be processed; with the aim of obtaining meaningful information and minimizing signal distortion.

Concurrently, antennas having high-speed performance capabilities are the backbone of wireless communication between IoT devices and the fog computing nodes in the federal government network. As regards choosing antennas that contain the desired gain, directionality, and coverage patterns, such a step alone can remarkably improve signal strength and range increase, thereby, making robust connectivity between the network elements super sure. In this way use of directional antennas will help to govern communication ensuring higher accuracy in a certain coverage area, and the network effectiveness as a result.

Besides the software, the hardware compatibility and scalability should also be precise for the easy CoT, EC, and fog computing technologies. The government's operations are a necessary part. Government agencies can bear in mind that they have to use hardware components that meet industry standards and that they rely on open-source platforms to guarantee smooth information exchange among all devices and systems. Changes in architecture become a priority, the hardware solutions are scalable - which means they can be an easy expansion for future products and accordingly, customization - for governmental agencies to adapt to evolving technologies and add new opportunities effortlessly.

On the other hand, it is as important that we state how the redundancy of hardware configurations is of utmost importance in ensuring continuous operation. This helps to eliminate downtime. By dedicating a budget towards purchasing quality hardware parts from commendable vendors and implementing redundant systems of hardware setup, such as Power backup and failover mechanisms, system resilience is increased and the potential effects of hardware failures are reduced. Through the recognition of these hardware-oriented elements, government institutions in Iraq can be able to reap the benefits of the Cloud of Things (CoT) and fog computing technologies to optimize the process of data generation as well as communication between people and this will eventually result in improved service delivery in the public sector.

6. Conclusion and recommendation

The governmental sector in Iraq has the potential to be transformed into a completely new level through the adoption of CoT, EC, and fog computing using many processes and services. To effectively synthesize the CoT, EC, and fog computing system in the governmental sphere in Iraq, the crucial concerns raised and reactions include data security and privacy, developing dogged network infrastructure, training government personnel on the new technologies, and establishing bonds between the agencies of government and technology providers. Moreover, the policymakers must ensure the put into place of clear necessary rules and regulations that regulate the use of these technologies in the public domain.

In a nutshell, CoT, EC, and fog computing in the governmental sector in Iraq could lead to a revolution of service delivery, problem-solving, and excellent governance being the result of it all. These technologies which when embraced to facilitate this can put Iraq at the forefront of innovation in service of public good based on:

1. Smart Infrastructure Management: Public authorities can implement IoT sensors and devices in the critical nature of facilities including water supply systems, transportation networks, and energy grids, thus, leading to better monitoring and management of these facilities. It can at the same time allow the real-time analysis of data for prevention of failures and the optimization of resource allocation.
2. Citizen Services: The technology of the cloud means that there can be web platforms via which government services can be delivered online, which enables citizens to get information, apply for permits, pay taxes as well and interact with governing agencies conveniently. Using CoT and fog computing, these services might be delivered in such a way that they will become more responsive owing to the real-time data they use.
3. Disaster Management: A city hailing from a country that suffers many regular auxiliary disasters such as earthquakes and floods, will find the CoT, EC, and fog computing technologies highly valuable in early warning systems, emergency response coordination, and post-disaster recovery processes. IoT devices can do the task of getting information on environmental conditions, infrastructure crusher, and populational movements, whereas fog computing can quickly process this data to make decisions.
4. Healthcare: Cloud platforms in healthcare help to give patients better access to medical services and records, particularly in those areas that are remote and secluded. Healthcare providers will be given the capacity to offer better service using advanced remote monitoring and diagnosis via installed IoT devices. Providing computational capabilities in the fog allows immediate data processing for healthcare services.
5. Security and Surveillance: Governmental commissions may increase public safety via devices such as observational cameras, sensors, and flying drones which are embedded with IoT and meant for monitoring public spaces. Fog computing may be used to locally process the video and sensor data among force officers to detect anomalies and potential security threats in real-time.

Sweeping CoT, EC and fog computing applications into a governmental sector context in Iraq necessitate hardware-related considerations to guarantee that CoT and fog computing technologies may be successfully put to use and managed. Here are some specific recommendations related to hardware filters, antennas, and other components. Here are some specific recommendations related to hardware filters, antennas, and other components:

Hardware Filters - Utilize high-capacity smart filters to ensure good latency and reduce the noise and interference factor in network communication. 'Filters' can decrease noise and make the crosstalk from the IoT device and cloud servers more credible.

Implement bandpass filters to eliminate signal drift and restrict the bandwidth used for transmitting and receiving IoT devices. This would minimize the amount of data that gets processed and minimize the risk of signal distortion.

Antennas - Place robust wind turbines as power source to ensure strong signals between the IoT devices and fog nodes which help with wireless communication. The right choice of antennas with suitable gain, directivity, and coverage patterns can result in improved signal power level and range estimations. Thus, these efforts ensure network-wide coverage of connectivity.

Try antenna directions to be used by the point-to-point communication between the IoT devices and fog nodes that are within the range and are specified. One of the penetrating antenna features is the ability to focus the signal transmission on a certain direction, which improves signal quality and cuts down interference.

Hardware Compatibility - Make possible the native IoT devices, fog nodes, and cloud servers integration via hardware components that follow the industry standards and protocols. Compatibility challenges may appear in the process of data exchange and integration, resulting in a poor connection and thus waste of operations.

Invest in open-source platform hardware components that abide by interoperability standards to minimize the problems of cross-system communication and data exchange among government devices.

Scalability and Flexibility - First of all the most effective hardware solutions should be implemented to facilitate scalability and meet the increasing need for server capacity to handle IoT devices data processing in governmental institutions. Accurate by-scalable hardware at only necessary resources allocated easily supports the operation and future growth.

Choose a model that can work with pre-existing IT infrastructure and can be easily upgraded on a hard-wired basis. The ability of the system of CoT and fog computing hardware architecture allows their wide range of applicability across different application areas and use cases.

Reliability and Redundancy - Discovering the suites of hardware components through the selection of well-known manufacturers and suppliers that provide along with warranty support. Consistent hardware is very important to continuously function and avoid downtime by government services in critical areas.

Maintain multiple copies of vital data, including multi-power supplies, redundant networking equipment, and automated failover mechanisms, which enables the continuity of systems operations in the case that the hardware fails or is disrupted. Redundancy mechanisms improve system reliability and decrease performance degradation caused by possible hardware failures.

Conflict of Interest

The authors declare that they have no conflict of interest, and all of the authors agree to publish this paper under academic ethics.

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