Volume: 13 Issue: 04 Pages: 5069-5075(2022) ISSN: 0975-0290

Optimizing IoT Based Parallel Server in a Low Power Operational Environment

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ABSTRACT

Despite, the fact, Internet of Things (IoT) has indeed proven an effective technology in transportation, agriculture, healthcare, industrial automation, and emergency response to natural and man-made disasters, IoT inherits limitations from power of the devices in the IoT infrastructure. Such limitations, demands the need to have optimization research. The aim of this study is to develop a parallel server architecture in an IoT-based service in a low-power environment. The need for parallel computing is necessary for IoT-enabled devices and system architecture. The server-oriented IoT-based cloud architecture study needs immense capability and efficiency to produce satisfactory throughput. Although the efficiency is relatively acquired by the services, the demand for security is also a matter of concern in the modern platform of IoT-supported services. The concurrent process of the encryption system, data processing and computation in the service transactions, and effective, reliable management of the servers working simultaneously in an energy-efficient network service architecture is the aimed product of this study. The focus is to provide the data and task level parallelism to ensure lesser transaction delay in the system.

Keywords- **Architecture, Concurrent, Immense, Parallel, Transaction.**

Date of Submission: Feb 09, 2022 Date of Acceptance: Feb 22, 2022

1. INTRODUCTION

The Internet of Things (IoT) is one of the most active and fascinating advancements in information and communications technology.This technology provides particular possibilities for establishments to enhance their performance, innovativeness and as a result, pursue competitive advantages [1]. Although networking technologies have grown more widely used throughout the last two decades, they were mostly used to link traditional end-user devices such as laptops, computers, mobiles, etc. The Internet of Things, or IoT, states to billions of physical objects connected to the internet, collecting and replacing data throughout the world. Any physical thing that can be linked to the internet and operated can be turned into an IoT device [2]. Sensor-equipped devices and items are linked to an Internet of Things platform, which combines data from many sources. Devices and objects with built-in sensors are attached to an Internet of Things platform, which combines data from various devices and uses intelligence to distribute the most useful information with apps tailored to individual needs.

The approach of arranging all resources to optimize speed and programmability within the constraints set by technology and cost at any particular moment is known as parallel computer architecture. Parallel processing has emerged as a useful technique in modern computers to fulfil the demand for better speed, higher performance, and more accurate outcomes in real-world applications [3]. So parallel processing is very important to get the performances efficiently within the shortest time. Parallel server architecture will help the system to perform parallel processing which includes high performance, low latency, high-speed transaction of data, low power consumption, and load balancing. Parallel computing technology is used in web servers. Parallel web servers used parallel processing to respond to all requests as quickly as possible. A parallel server will optimally utilize all of the system resources in a single node, as well as use more computers during high-load periods to reduce response time or latency and use fewer machines during low-load periods to save expense. In parallel server architecture, a master node is used to receive the request from the clients. then it will select one or multiple slave nodes to transmit the jobs. In general, the master node assigns the job to the slave node and then the slave node performs the tasks.

To link low-configuration devices to the internet, the IoT application protocol technology [4] of 6LoWPAN is used. Wireless sensor networks are one of the many uses for the 6LoWPAN technology. 6LoWPAN is a protocol for transporting IPv6 packet data across IEEE 802.15.4 and other networks. It supports end-to-end IPv6 connection, allowing it to give through connectivity to a wide range of networks, as well as the Internet. Because there are so many low-power wireless sensor networks and other types of wireless communications, each new wireless system or technology must address a specific region. Though there are many other types of wireless networks, including wireless sensor networks, 6LoWPAN focuses on a problem that no other system presently solves [5]. The whole system is designed to provide low-data-rate, low-duty-cycle wireless internet access. 6LoWPAN is utilized in a variety of applications, including general automation, home automation, industrial monitoring. The Internet of

Things, or IoT, is predicted to provide hackers with a tremendous chance to gain control of poorly protected devices and use them to assist target other networks and devices. As a result, security is a key concern for any standard, such as 6LoWPAN, which employs AES-128 link-layer security. This encrypts and authenticates the connection. The transport layer security methods give additional security.
To prevent any server from getting overloaded load balancer is necessary. It ensures service availability and the systematic and effective distribution of network or application traffic among many servers in a system. In the proposed model, hybrid load balancing is used to share the workload among processes.
However, the aim of this study is to develop a parallel server architecture in an IoT-based service in a low-power environment. The aim is discussed based on IP based sensor networks. In this scenario, 6LoWPAN is used, as the 6LoWPAN concept originated from the idea that "the Internet Protocol could and should be applied even to the smallest devices".

The problem arises when parallel multicore processing in-network, link, and transportation level is not well suited for the small-scale environment. Even in the large-scale environment it is not properly verified yet for intervals more than 3 hours for its parallel processing mechanism in the study.

2. RELATED WORK

In IoT delay happens when a huge amount of data is processed by sensors and spent energy. To reduce energy, lossy multicore technology is used with IoT. 6LoWPAN is used to connect low configured devices with the internet. Different health factors are processed in parallel using Task Level Parallelism (TLP). TLP makes the best use of the resources at hand. It improves the efficiency of their system. Their proposed system improves performance by up to 65.5%. An efficient system also reduces the power consumption of the devices. People from rural areas can get help easily with the help of IoT and reduced waiting time for treatment using parallel computing.

In the current system, there are security issues. Small-scale hospitals will benefit from the suggested system. Using a central device for smart city processing is insufficient for smarter healthcare [6]. For smarter healthcare, a large amount of storage capacity is also necessary. As a result, cloud storage is used in this situation.

The use of GPU in the IoT environment to support parallelism is a massive revolution in IoT technology. The number of users is devices enlisted under IoT is growing rapidly. The modern IoT must not be dependent on several servers and a huge number of network gateways. The performance of the processing time is much faster than the sequential processing. The data analysis, edge device management, and gateway-related tasks are managed more efficiently. It is way more efficient in the form of collected data analysis in IoT for faster service in hours. The performance of the processing is not satisfying for a small-scale environment but it outperforms the serial execution of processing in the case of a large-scale IoT environment. Thus, the quick growth of technological advancement must be reliable for this type of parallel processing in IoT in the upcoming days. The time does not increase in parallel processing for a particular period [7].

The advantage is that the processing gets gradually faster in IoT in terms of parallel execution using multicore technology for large-scale environments. As time progresses it gets exponentially faster in terms of processing efficiency than the sequential processing of data. It is well suited for a large-scale environment. The efficiency of processing in the large-scale environment is 25% faster than sequential processing.

2.1 Parallel Processing in A Cryptosystem

The need for a cryptographic approach is a must thing in the IoT environment. Cryptography is responsible for ensuring safe and reliable communication [22].The process of encryption can be done by the process of parallel computation. The mentioned literature is over the encryption scheme through parallelism.
The authors in the paper [8] have proposed an encryption technique primarily based totally on Stream encryption. They used pseudo-random variety turbines with excessive precision arithmetic and facts processing in parallel with collective communication. Profiling and parallel computing strategies permit the detection of an appropriate variety of processors had to promote the cryptosystem's efficiency. In that instance, faster processor speeds reduce the time it takes to generate chaotic sequences and run the encryption method. To check the scalability, they implement the system in different operating systems and different machines.

The advantage is that the experimental result indicates that their approach can enhance the performance of the embedded cryptosystem and is proven to be according to Amdahl's law. Their security analysis additionally indicates that; their proposed cryptosystem can cope with numerous assaults which become one of the primary issues or the restrictions of the previous paper. However, the execution instances of this system applied with parallel processing are stricken by the execution of different applications and offerings of their implementation of the proposed approach. That's why the theoretical estimations of the overall performance thing and system performance might also additionally vary from real-time execution results.

Designing parallel computing the usage of raspberry pi clusters for IoT servers on Apache Hadoop may be one of the implementations of parallel computing to the IoT. The associated paper is discussed below.

The implementation of IoT requires connectivity, device, and server. Servers that might be related through many

devices could have increasingly more computing processes. The server computing method desires an excessive-overall performance but small-length server device that is straightforward to hyperlink to different devices. Apache Hadoop is a famous parallel computing generation now. This study used a clustering method with four Raspberry Pis' and parallel computing generation from Apache Hadoop and siege equipment are getting used for trying out. The author's studies at the implementation of parallel computing [9] the use of four Raspberry Pi clusters to check the IoT server located that the maximum perfect is the request as excessive as 50 with a 260 percent growth in trying out transactions, transaction rates, and throughput from a single node to cluster. Only a 50% to 60% improvement in trying out with 150 requests is possible. Applying opportunity solutions to enhance server availability is an offer for similar studies. Heartbeat, Ucarp, and Ldirectord are processing assets for restoration solutions.
The need for data security is left out through the usage of the cryptographic approach. So generating ciphertext is a must of securing data from being compromised. The work of encryption is in this parallel scheme is discussed below:

Encryption is a strong process of securing messages and data from malicious access. It is a kind of complex mathematical process which ensures the plaintexts are hard to determine. AES (Advanced Encryption Standard) is a symmetric algorithm of encryption that is improved in the scheme by enhancing the key generation procedure from one step into two. The ECC algorithm is also a three-dimensional point-based encryption system of mathematics which makes it hard to determine in which exact point values of x, y and z co-ordinate intersects. AES is a fast algorithm and ECC uses a fewer number of keys for encryption. This paper [10] proposes a Parallel Partial Model (PPM) algorithm for GPU which may speed up the encryption process of the Central Processing Unit. The execution of the existing model of AES and ECC has more execution time than the proposed PPM algorithm of Improved AES-128 and Modified ECC. The speeding encryption of AES in the dynamic environment is well suited. It serves the need for speed and security at a balanced rate. Yet the ECC uses a very 164-bit key for ciphertext generation compared to the other encryption algorithms like RSA (2048 bits. As ECC is based on a particular mathematical curve equation, it could be on hand for the attackers to decide the keys through going via the mathematical procedures. The equation of a curve is structure-specific yet finding the exact coordinate is a challenge.

As the IoT industry is highly based on hardware and software level data, encryption system like AES or modern symmetric key cryptosystem is a must-needed technology for this type of environment. Yet, these huge amounts of data encryption need a large number of computational devices and resources. So, the concept which has been proposed through the authors of this article [11] is to apply the parallel computing scheme in the AES encryption technique. The dynamic environment of the industry is much dependent on the faster processing techniques of cipher text generation. So the concept is based on the CPU and GPU-oriented AES-128 encryption for each parallel node. Some steps including the data converted from string to an array of 0's and 1's follow the flow of generating plaintext to ciphertext. Then the text stream is moved from the CPU to the GPU. GPU divides the streams into 128 blocks for each node and performs the AES-128 functions of AddRoundkey, SubBytes, ShiftRows, MixColumns 10 consecutive times. Then all the ciphertexts are added together and moved to the CPU from the GPU. The performance of the AES algorithm is compared upon i5, i3, i2, and GPU among 100, 500, and 1000 split texts. The execution time is initially a bit longer than i5 in the process of CPU-GPU parallel encryption. The texts are taken as split texts and this enables the less complex computational resource and leads to faster encryption than serial encryption technique. The parallel performance of CPU and GPU helps to generate node of 128-bit stream for several inputs at a time and it is both efficient and secured.

The process of parallel computation in terms of image, audio, and video file encryption is also a matter of concern in IoT for network security-related issues. In this paper, Xingyuan Wang. Le Feng, Hongyu Zhao proposed [12] a computational version for parallel image encryption algorithms of two stages (diffusion and Permutation). The speedy image encryption version that they supplied is appropriate for each distribution and parallel computing environment. Their TIDBD approach can cope with undeniable assaults and additionally in a parallel version, their proposed diffusion will take very little time.

2.2 Design and Analysis of a Distributed Parallel Computing System for Remote Control via the Cloud

In the article "Design and Analysis of Proposed Remote Controlling Distributed Parallel Computing System over the Cloud" by ZryanNajat Rashid, Subhi R. M. Zeebaree, AbdulkadirShengul proposed [13] requirements and a system design analysis for a platform that can combine and apply distributed parallel processing via distributed cloud computing to solve some specific and large client problem than required unusual processing power and can be solved in a short amount of time. These activities are based on cloud computing principles and involve performing parallel processing procedures for distributed loads across servers. Finally, their proposed system can be expanded to incorporate an unlimited number of servers that can readily participate in the problem-solving process, depending on the problem complexity requirements. Though their suggested mechanism encompassed two nations it can be expanded to cover an infinite number of areas at multiple geographical distances without incurring any further cost since it was created by the fundamentals of a distributed system.

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2.3 Server Management and Parallel Computation in Network

In terms of server management and deployment, parallel processing is very efficient and successful. The installation process of multiple applications in parallel is a challenging task. The application dependencies over the particular server are a matter of concern in this case. So there needs to be a protocol that permits the set-up of multiple applications over a selected cloud-primarily based server wherein the server dependencies are automatically examined out via way of means of the system prototype. It should be easier for the consumer side, that the applications are installed automatically in a small amount of time from the servers through parallelism. Several composite applications are inherited through the server for the specific end node of the server architecture. The efficiency gain, in this case, is the reduced time of installation and lesser user burden. In the article "An Automated Parallel Approach for Rapid Deployment of Composite Application Servers" by the authors, YasuharuKatsuno and Hitomi Takahashi have indicated a framework independent protocol to automatically install the applications from the servers in a parallel manner [14]. Yet more than one installation system should be used in this type of process performance observation and system elasticity detection. There should also be a framework that is capable of working through 5/6 server-oriented applications simultaneously to a general user workstation. The installation process should be platform-independent and organization-specific.

2.4 Parallel Simulation Framework and Tool

The network servers and the system must be maintained and managed in a very precise manner. Thus, this network must experiment with a satisfactory simulation environment. Cloud-based platforms are increasing in rapid growth in modern industry. Especially the IoT-based system platforms are dependent on the cloud storage and architecture for successful industrial data management. The performance, scalability, and efficiency of these types of Cloud platforms must be evaluated via some sort of simulation tasks conducted by the dedicated researchers. Such a platform can be considered as the "CloudSim" presented by Saurabh Kumar Garg and RajkumarBuyya from Cloud Computing and Distributed Systems (CLOUDS) Laboratory at the University of Melbourne, Australia. The resource allocation-related problems are often a matter of concern in the IoT Cloud servers like the number of consumers are very high and the system load has to be at the peak sometimes. So the simulation process helps to enhance the scheduling algorithm for resource allocation. The algorithm is based upon a queue and 4 different stages of the data for execution, send, receive, and finished. The algorithm works accordingly as per the stage or state of the data packet requires. The queue is often cleared while the completion of the task is done and the datacenter authority is notified [15]. Though this is a very efficient approach yet the trace of the data and the history should be managed by applying backup storage for the scheduler. Thus the resource allocation would be more reliable and less failure-prone. A parallel simulation kernel, a set of microarchitecture components, and an included library of power, thermal, reliability, and energy models make up the proposed system Manifold, an open-supply parallel simulation framework for multicore architectures [16]. Manifold presents the component-primarily based total improvement of several parallel simulation models, in addition to the clean integration of extra factor tools, model sharing, and physical model integration.

Incorporation of validation techniques, enhanced scalability, and amplifying the simulation functionality to multiple running device domain names had been the most important demanding situations of the proposed model.

2.5 IoT architecture in 5G and Fog computing through Parallelism

The subsequent technology IoT structure based on the new era is proposed [17] wherein the necessities of future packages, services, and generated records are addressed. specifically, this shape includes Nano-chip, millimeter Wave (mmWave), Heterogeneous Networks (HetNet), device-to tool (D2D) conversation, 5G-IoT, device-type communique (MTC), wireless community function virtualization (WNFV), Wi-Fi software program described Networks (WSDN), advanced Spectrum Sharing and Interference management (advanced SSIM), mobile aspect Computing (MEC), molecular Cloud Computing (MCC), information Analytics and massive information. This mixture of technology is capable of satisfying the necessities of new applications. The proposed novel structure is modular, green, agile, scalable, easy, and can satisfy the immoderate quantity of statistics and alertness demands.

The structure is modular, green, scalable, reliable, simple, and it can help excessive software demands. Indeed, the proposed structure is capable of meeting the desires of the subsequent era IoT packages and helping IoT professionals to lay out extra green and scalable IoT systems. Moreover, IoT is fast growing within automated life [18].The article gives a systemic investigation on statistics circulation processing and analytics in the context of Fog architecture. They studied 4 traditional Fog streaming applications, consisting of IoT stream analytics, event monitoring, networked management, and real-time cellular crowdsourcing, which display their commonplace houses and the multi-disciplinary nature of Fog streaming research [19].

2.6 Operating System Process Management

The researchers have carried out more than one assessment in real situations with a particular OS and a hard and fast wireless protocol. In those tests, there are numerous processing and conversation obligations timing parameters, similarly to their assigned priority ranges. The results received from those tests display that there may be a near dating between the various tendencies of the processing duties and the overall performance, particularly while the processing computational load is high. Further, those effects additionally show that the computational load is not the most effective detail chargeable for the communication overall performance degradation, as the connection among the processing duties and the protocols timing parameters moreover performs a position.

In this work [20], an empirical observation of the cross-affect that the computational load of processing responsibilities has withinside the verbal exchange overall performance while the usage of an OS for IoT sensor devices. The essential end drawn from this article is that the boom in computational load outcomes of a chain of cross-outcomes among the processing and verbal exchange responsibilities could appreciably affect their overall performance.

2.7 Parallel Processing from Large Databases

The technology works by storing and comparing face embedding of the subject and later recognizing them in a live video feed. Their proposed model was able to develop a system that could save, retrieve, and analyze facial embedding for face recognition. The method runs more efficiently as a result of our use of CPU parallelization, without losing accuracy. It is mostly used for criminal investigations while entering or exiting a public area. This technology is efficient and can identify people in real-time using their ID. The authors showed [21] a unique face recognition system that can identify a person in real-time if their resemblance has already been stored in the system. After all, the face recognition model and facial embedding calculation employed in this technique are naturally quick, moreover, these can become significantly slower when face matching is performed on a big dataset.

3. PROPOSED MODEL

The proposed scheme in this study is provided in this section along with its system features and specification.

3.1 System Features

- The server consumer machines will install the applications from the client-side automatically. This process will be conducted in parallel for the multiple applications for the user. It means to bring the server into operation. So that, it may bring the operation so fast and the client can do several works at a time.
- The Load Balancing is two types, one is Static Load Balancing and another is Dynamic Load Balancing. Then it is combined and act like the hybrid manner of Load Balancing. Hybrid Load Balancing increases reliability, speed, and cost-effectiveness to deliver content no matter where it is located, resulting in an optimal user experience. Hybrid Load Balancer requires only a special configuration for the backend service. The frontend configuration is the same as any other load balancer. The processes are interactive and these share workloads among the processors. The entire set of data is initiated for a task before the start of computation.
- Server applications encrypt the data transformed by the implementation of parallel AES with the intervention of CPU and GPU.It provides the possibility to relocate the AES stage to take advantage of AES parallelism to avoid frequent shared memory access. This significantly improves encryption speeds over traditional GPUs, especially CPUs.
- The whole scheme is organized to fetch multiple users concurrently.As a result, it is a low-latency service architecture for efficient use of load balancing and multi-server parallelism in the implemented scheme.

3.2 System Specification

- Multicore System of IoTfor compact energy consumption. The benefit is that the processing in the IoT is progressively getting faster in terms of parallel execution with multi-core technology for large environments.
- Load Balancing in a hybrid manner so the overhead is managed efficiently and this is also used to share the workload among processes.
- Implemented an energy-efficient 6LoWPAN network having 60% energy efficiency.6LoWPAN solves a problem that no other system can currently solve. The entire system is designed to provide wireless Internet access with a low data rate and low duty cycle.
- Multiple serversare there to deal with computational overhead by parallel processing.The communication allows the multiple servers to process the overhead more efficiently. Parallel server architecture of IoT makes it user friendly, fast, and efficient.
- Concurrent encryption from both ends frequently during the transaction of data among the user and server. The data is converted to the digital stream sequence.
- Both data (fetch and encrypt) and Task (process and execute) level parallelism. Task parallelism makes a specialty of dispensing tasks simultaneously completed via way of means of procedures or throughout different processors.
- The parallelism makes the lesser amount of user transaction delay.The main goal of parallel computing is to increase the available computing power to speed up application processing and problem solving.
- Distributed memory design is there to handle data locally and to reduce space-related dilemmas.The distributed memory is an abstraction for solving problems that are too big to fit on a single machine. Essentially, it simply describes a network cluster of individual computers, each with its own private memory that other machines cannot access.

A glimpse of the system architecture of the parallel server of IoT system is given below:

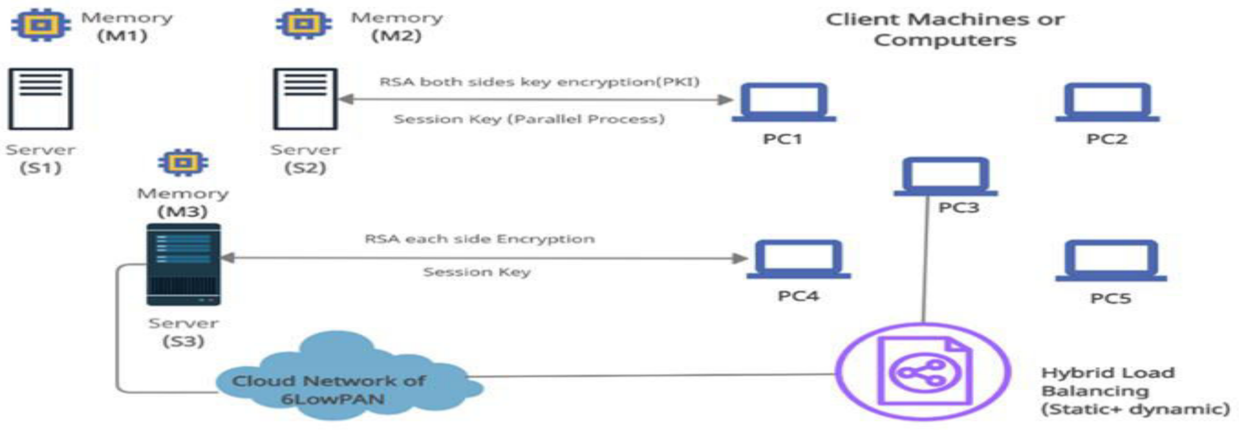

Fig. 1.The design of parallel server architecture in an IoT-based service in a low-power environment.

4. DISCUSSION

The study has proposed the architecture of a parallel server for an organization in a low-power network environment. The design is managed in such a manner that it focuses on the load balancing and parallel processing of the servers simultaneously. The client-side applications are provided to the client machines on the left side for the successful transmission of data. This architecture supports the concurrent processing of the server machines to serve the client machines. The servers use the distributed memory architecture that involves different memory for each of the servers in the service implemented in IoT. As it is using the memory for one server each so the parallel platform may involve the distributed design to fetch and process data in parallel. So the pressure over a centralized global memory is reduced here.

The cloud storage in the network is proposed to be in the 6LoWPAN environment. It is low power and energy-efficient network scheme which may reduce the wastage of energy. As the storage has been thought to be in the 6LoWPAN environment, the consumption of energy can be reduced in this type of network at a higher rate. There can be several servers in the design and all of them can work concurrently in the network.

The load balancing in the design is implemented with the hybrid load balancing. This load balancing technique is aimed to be implemented with both Static and Dynamic load balancing techniques as per the requirement. When large data needs to be processed then dynamic load balancing is used to have the information regarding the type and format of data to be processed in the service. While the data is long enough and does not require any information over the format of data while processing, only then the Static load balancing is needed. So the system algorithm itself decides in which cases it needs to implement which sort of load balancing technique.

The IoT network is also providing security in this scheme as the parallel servers are providing the session key to establish communication with the client-side machines. Also, these session keys are encrypted with asymmetric RSA encryption which is a very strong encryption system for key security and service integrity.However,RSA is a widely used public-key cryptographic system for secure data transmission and this cryptography is not required for all communication. So, at the same time, multiple servers are capable of serving multiple machines on the client-side via establishing parallel communication like a bipartite graph manner.

As the concurrent processing is occurring, the service delay or the latency would be considerably less for straightforward communication among the system machines. The transaction of data would be fast for load balancing and parallel architectural platforms. Next, the storage is within the 6LoWPAN environment. This will lead to lesser dissipation of energy while processing. The session key parallel process and load balancing may lessen the data transmission overhead and this may reduce time, energy wastage. Thus the communication allows the multiple servers to process the overhead efficiently. This is why the implemented parallel server architecture of IoT is user-oriented, fast, efficient, and power planned.

5. CONCLUSION AND FUTURE WORK

The proposed scheme of parallel servers in IoTis aimed to be implemented over a low-power environment. The key concern of the study is to establish the theory to support the feasibility of a parallel server architecture in the future for specific IoT-based services. The design is managed in such a manner that it focuses on the load balancing and parallel processing of the servers simultaneously. It is low power and energy-efficient network scheme which may reduce the wastage of energy. The design focuses on load balancing and cloud storage management in a low-power environment. As a result, the implemented scheme will be less delay-prone and low latency service architecture for the efficient use of load balancing and multi-server parallelism. The concept proposed here supports the independent servers which themselves have internal memory rather than global memory. Thus the processing overhead would be well managed in terms of the high

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pressure of transactions from the client side. Altogether the scheme provides a fast, secure, low latency based and less power-consuming server architecture with less complexity in the design concept. The conclusion should consist of a summary of the discussion and the implication for further research.

6. ACKNOWLEDGMENTS

The authors would like to thank the Department of science and technology and the American InternationalUniversity-Bangladesh and a special thanks to Sajid Bin-Faisal for earlier contributions in this paper. The author appreciates the voluntary efforts of global board members and reviewers to the journal.

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