International Journal of Management, IT & Engineering
Vol. 8 Issue 8, August 2018,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Resource Allocation in IoT- A Review

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Abstract

IoT is the latest as well as current stage of computing. Nowadays it is the most fascinating area to research due to its fast evolution and also due to increasing number of interconnecting devices. These devices are equipped with various capabilities such as actuator, sensors, electronic software. It has evolved the communication from Human-to-Human (H2H) to Machine-to-Machine (M2M). With such a massive extension, it found numerous applications in multiple fields and faces certain challenges as well. Resource allocation is one of the major challenges. In IoT each and every device in the network has its own priorities, demand, so to make the whole IoT ecosystem work efficiently resource allocation is mandatory. This paper reviews about what resource allocation is and various allocation mechanisms from the perspective of different researchers.

Keywords:

Internet of Things;
Resource allocation;
Quality of Service;
Cloud computing;
Resource management system;
Resource management layer.

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1. Introduction

Internet of Things is one of the newest trends on the internet. It is defined as network of heterogeneous devices having sensing capabilities. These devices are based on a common standard for communication (TCP/IP) and are uniquely identified. IoT is a merger of push and pull effect from technology and humans respectively [1]. It is basically the transformation of wireless network. Smart connectivity with an already existing network is a paramount of IoT [2]. The term IoT was coined by Kevin Ashton in 1999 [3]. The evolution of internet into a network of interconnected networks, not only extract information and interact with

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physical world but uses the prevailing internet standards for all the operations. There are three main characteristics are-anything communicates, anything is identified and anything interacts [4]. IoT is emerging at a very fast pace, fig.1 shows the emerging scenario. Sensory swarm also known as smart devices includes the tablets, smartphones *etc.* [5]. Cloud forms the core part of IoT that provides computational as well as storage services. It is found that by 2020 the number of connected devices will increase to 50 billion.

IoT is used synonymously with "smart". Being smart it found its application in multiple fields shown in fig.2 such as smart home, smart environment, smart city, shopping, hospital and many more to come. As it found applications in multiple fields, it is vulnerable to various challenges *like* security, data storage, privacy *etc***.** Resource allocation is also one of the major challenges. The extension of IoT to heterogeneity (that is to allow multiple devices with different interfaces to interconnect), had made the resource allocation a major problem in IoT ecosystem and this paper reviews the resource allocation problem in IoT.

Figure 1. The current IoT scenario [5]

Figure 2. IoT applications [6]

The paper is divided into different sections. Section 2 describes what is resource allocation followed by Section 3 describing various types of resources. In Section 4, different activities covered in resource allocation and its need is explained. Section 5 overviews the work done by various researchers in the area of resource allocation strategies in IoT. The last section concludes the paper.

2. Resource Allocation

Resource allocation is defined as a process of allocating resources to the requested application/device. It is just a plan that how to use the available resources, so that scarcity of resources does not prevail. Resource allocation is one of the activities that come under Resource Management System (RMS) as shown in fig.3.

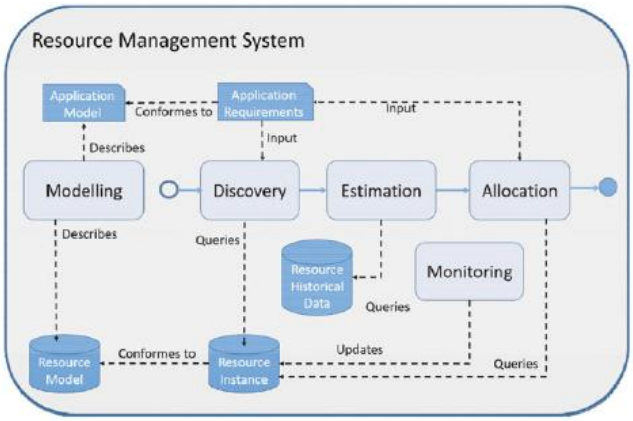

Figure 3. RMS activities [7]

The function of resource management system includes maintenance of database, performance evaluation, benefits administration, scheduling of resources *etc.* All the activities of RMS are handled by Resource Management Layer (RML) [7]. RML is responsible for resource allocation in an effective way such that it does not degrade the system performance.

While allocating resources, two major effects need to be avoided:

a) Over provisioning of resources – arises when resources are assigned more than required
b) Under provisioning of resources – arises when resources are assigned less than required or there may be uncertainty of in allocation [8].

3. Types of Resources

The different types of IoT resources are:

a) Computing Resource: Computing resource are those resources which are present within a computer system. Internal components of a system as well as any external components connected to a system are also a resource. It includes memory, network, processor, input/output device [9]. These are also known as System Resource.
b) Networking Resource: Also known as Shared Resource [10]. As the name indicates the data, information can be shared among multiple devices that are linked or connected to each other. It is done with the help of inter-process communication. While sharing resources bandwidth, storage, congestion control needs to be taken care.
c) Storage Resource: Storage Resources are managed by Storage Resource Manager [11]. The management of these resources is done in such a way that it does not affect the efficiency and speed of device. For this it makes the use of ACID property.
d) Power Resources: The power used by a system per day deals with power resources. Power consumed for allocating resources is less than the power consumed while waiting for a resource [9]. Power consumption is disorganized so it needs to be maintained. It is divided into two groups: one for server operations and other for network communication [12].

4. Resource Allocation Activities

There are four main activities that come under resource allocation, shown in fig.4**.** It includes planning, task mapping, task scheduling and communication scheduling.

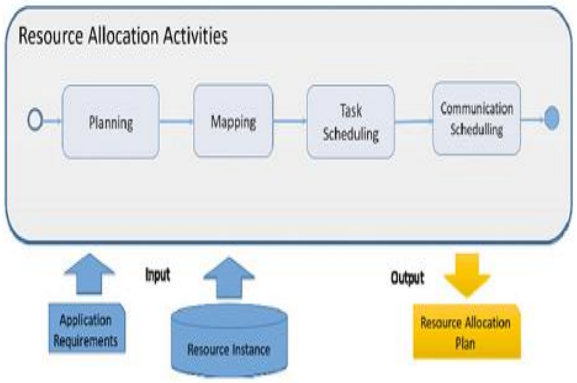

Figure 4. Resource Allocation Activities [7]

This section briefly explains all of these as:

a) Planning: It is the first activity in resource allocation. Under this phase, the complete IoT ecosystem is examined to check whether the available resources are sufficient for the application. As IoT consist of multiple tires [7], the planning phase pre decides which task is allocated to a particular tire along with the required resources.
b) Task Mapping: The next step in resource allocation is task mapping. In this, each node is assigned a particular task and sometimes nodes merge together to accomplish a particular task. Overlapping of task should be avoided.
c) Task Scheduling: After task mapping, the next activity is task scheduling. It plays a key role in resource allocation. Scheduling is done with respect to time bound [13] and based on it finds the best sequence for resource allocation. It decides which task is to be executed first so it minimize the waiting time.
d) Communication Scheduling: The final step in resource allocation is communication scheduling. It is done for the activities involved in task execution on the communication channels [14]. It should be done in an effective way, so that proper channel capacity is utilized.

4.1. Need of Resource Allocation

The IoT ecosystem consists of millions of smart objects and to make these smart objects communicate and operate effectively there is need for resource allocation.

Various reasons for resource allocation are:

a) To maintain Quality of Service (QoS), resource allocation needs to be done.
b) To manage the oddity in the system, so that it does not affect its reliability.
c) To reduce the idle time of the devices waiting for the resource to be allocated.
d) For the dynamic resource scheduling and proper utilization of open resources [15].
e) To reduce the power consumption.

5. Literature Review on Resource Allocation

A lot of research work has been done in the resource allocation field in IoT. Different researchers had given different reviews and allocation mechanisms. Some had used scheduling algorithm for dynamic allocation while some has given algorithm for hybrid resource allocation algorithm in a network. Different perspective of researchers has been explained below:

Krishnapriya.S, Jobby P.P, 2015 [16] – proposed a Load Balanced Particle Swarm Optimization technique for resource scheduling. The algorithm is used for dynamically assigning tasks and it also ensures load balancing. QoS is a major challenge in IoT. There are multiple factors on which quality depends such as latency,

reliability, proper utilization of network as well as computational resources. In this, various levels of QoS has been defined for the heterogeneous systems as shown in fig.5. The main objective of this proposed algorithm is to ensure QoS along with efficient resource allocation.

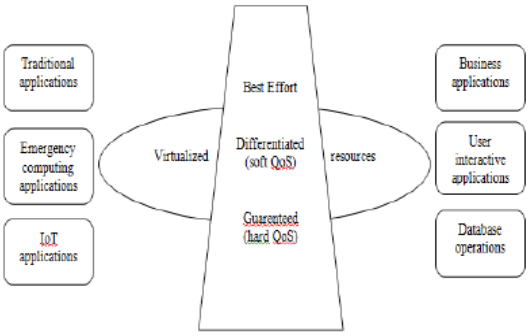

Figure 5. Levels of QoS [16]

Y. Choi, Y. Lim, 2016 [17] – describes resource allocation as a major challenge in Cloud Computing (CC) for IoT. The main issue associated with resource allocation in the CC is to meet Service Level Agreement (SLA) associated with a user.SLA is defined as a contract for QoS between service provider and end user. So, to increase the providers profit and to reduce the SLA violation constraints, it proposes a winner determination mechanism. It shows that this mechanism results in far better way than already existing ones.

J. Li, Q. Sun, G Fan, 2016 [18] – in this paper researchers had discussed how to improve network utilization. With the evolution of IoT, number of devices are getting increased day by day, which access internet and hence it immensely effects the network performance. So, to ensure better network performance uplink scheduling is done on LTE based IoT communication. It proposes a QoS constrained resource allocation algorithm for an uplink SC-FDMA. Finally, simulation model is used to show how this algorithm improves the performance of network data rate.

A. Singh, Y. Viniotis, 2016 [19] – defines the message broker service in IoT. It is basically an intermediate module between the sender and receiver and it is governed by SLA. SLA only defines the volume of the message and does not give any additional details regarding the message. In this researchers had presented a new two step SLA scheme. It is similar to the already existing one but also provide additional control for providers to enforce it. Also, they examined result with simulation that the proposed solution accord with already existing solution and also analyze various system parameters.

V. Angelakis, I. Avgouleas, E. Fitzgerald, N. Pappas, Di Yuan, 2016 [20] – in this author identifies a problem called Service - to- Interface Assignment (SIA). According to this as the number of devices are increasing on IoT and each of them uses different technologies, so it becomes difficult to assign services to each device with different as well as non- exchangeable resources. To solve this problem, a mathematical solution is given called Mixed Integer Linear Programming (MILP). This shows that the total cost for using interface resources has been reduced along with worth service requirement.

Z. Zhou, M. Dong, K. Ota, G. Wang, L. T Yang, 2016 [21] – in this paper the work is done to overcome the energy loss as well as to maintain the QoS, which gets affected during the communication on a network. Device-to-device (D2D) communication makes it possible makes it possible to establish communication between user equipments and in this paper architecture for D2D is also explained, shown in Fig.6. Its main motive is to have high throughput with best service. But the service quality gets degraded due to the interference and spectrum reuse. To overcome this problem, hybrid resource allocation algorithm has been given which is based on Cloud Radio Access Network (C-RAN). It also gave a centralized interference mitigation algorithm to maintain QoS. It is carried out in baseband unit pool. The result of simulation validates the performance of algorithm.

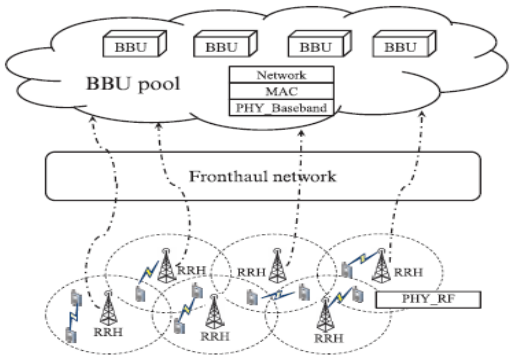

Figure 6. Architecture of D2D communication [21]

A. Singh, Y. Viniotis, 2017 [22] – describes the message broker service in an IoT cloud environment. The service is owned by SLA and it offers multiple advantages such as its simplicity. But it does not consider any information about the message except the volume of the message and hence it becomes difficult to implement it and also it arise an executing SLA problem for the providers. To solve this problem buffering, scheduling and rate limiting mechanism are used and finally evaluates result with simulation.

T.P.C. de Andade, C.A. Astudillo, N.L.S. Da Fonseca,2016 [23] – IoT environment provide machine type communication with the help of long term evolution advance (LTE-A). In this paper, the focus is on the resource allocation along with the LTE random access allocation. It explains a three Packet Downlink Control Channel (PDCCH) scheduling for the prioritization of random access control messages and the PDCHH resource allocation functional architecture, shown in fig.7. The first algorithm is baseline algorithm which allocates resources on the basis of priority scheduling and the other is resource shuffling which is used when allocation is impossible. The last one is independent of the priorities of user equipment, it allocates resources randomly. Finally it simulates to validate the PDCCH algorithm.

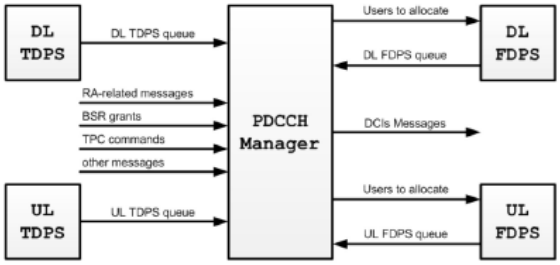

Figure 7. Resource allocation functional architecture [23]

From the different sources, we had done a brief review of various problems in resource allocation as well as how to tackle these problems. Further, future work can be done in this field with some new innovative solutions.

6. Conclusion

This paper reviews about resource allocation in IoT. QoS is one of the most important aspects in resource allocation. As we have already discussed, due to increase in heterogeneous devices resource allocation is becoming a major challenge day by day in IoT. To overcome this problem different authors have proposed several ideas, mechanisms, algorithms from their perspective. We can use these to solve the resource allocation problem and can define new schemes to overcome this problem.

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