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A Review on Resource Allocation Techniques for Internet of Things

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Abstract:
One of the remarkable technical revolutions is IoT, which promises the future of communications and control at a higher level. An IoT ecosystem has millions of heterogeneous devices which are connected through a network. Efficient resource management is required to raise the quality of services. This paper addresses one of the issues of resource management that is resource allocation. Network heterogeneity and diversity of IoT devices makes resource allocation as a challenging task, many efficient algorithms and techniques are being proposed and used to solve the resource allocation problem. This paper reviews few of the algorithms and techniques used to allocate resources for Internet of Things.

Keywords: Internet of Things, Resource Management, Resource Allocation.

1. INTRODUCTION

Internet of things is the integration of several technologies and also sometimes called as the Internet of Everything (IoE), contains web based components that gather, transfer and process the data they obtain from their ecosystem using implanted sensors, processors and communication hardware. IoT is predicted to be the next big revolution in the communication world. The aim of IoT is to create a flawless network of billions of wireless devices that can communicate over the Internet. IoT ecosystem has millions of components with enormous diversity ranges from small sensors to large, powerful data center nodes, the dynamic execution environment, unambiguous nature of the data generated by smart objects, all these made IoT ecosystem as an atypical ecosystem. Acquiring physical data and transforming it into valuable information and/or services include many processes, such process need a resource from the IoT ecosystem. For instance, some applications are latency sensitive and some need complicated processing like data and time series analysis [1]. IoT components like sensors have limited computing and energy resources, and they are not capable of storing the large data and to carry out the complicated task. So there is need of powerful components to carry out transformation process required by IoT applications. Such components may be smartphones, gateways and data centres. So it's better to consider IoT ecosystem with cloud platform and some powerful devices like gateways, edge nodes.

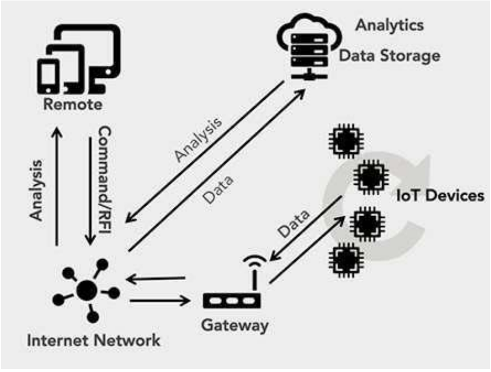

Figure.1. The IoT ecosystem

From the above Fig. 1, resource can vary from physical resources to software resources. Physical resources are storage, processor, bandwidth and energy and many more, software resource can be procedures to perform information fusion, virtualization function etc. Identifying and analyzing such resources from IoT ecosystem makes resource allocation as challenging task [1].

2. RELATED LITERATURES

For IoT networks, resource allocation is an open issue. Heterogeneous nature of the network makes resource allocation as a challenging task. In this paper, different resource allocation techniques are discussed.

In [2], a genetic algorithm is proposed to allocate service resources that give rough calculation for the feasible solution to the resource allocation problem. An author considers IoT ecosystem with IoT resources, gateways, and the connections between them [3]. Proposed resource allocation method reduces data transmission between gateways and hence it is possible to address the limitations of mobile devices [2][3].DCMST algorithm was customized so that resource allocation problem can be addressed by using genetic algorithm[4] and that defined a new schemes and functions for encoding and to check the fitness. With the genetic algorithm, dynamically changing edge weights could be considered effectively during the resource allocation process. The proposed approach is experimented and compared with the brute force approach; feasible solution can be produced within 40 trials with short running time.

In adaptive resource algorithm, signal's frequency domain characteristics are considered to assign network bandwidth and priority to the components. In [5], the experiment was carried out by developing UGV path tracking test-bed and error signals were measured in the simulation to evaluate the performance. An adaptive multiple sampling rate scheduling (AMSRS) algorithm was proposed to improve the performance of IoT with network bandwidth constraints. This algorithm dynamically detects the transmitted signal's frequency domain characteristics and adjusts the weighting factors among different sensing or actuating components, and allocates network resources according to the component's individual need and improves the overall performance of the IoT system. An author developed three-UGV path tracking IoT test-bed. The AMSRS algorithm as compared with the static algorithm that reduces sums of the accumulated errors and maximum errors by 73.87% and 66.48% respectively.

In [6], a software-defined network architecture for IoT is defined and inquired for the resource allocation problem in the proposed SDN-based IoT network. The problem was formulated as a semi-Markov decision process (SMDP) with the objective of maximizing the expected average reward of the network. The feasible solution to the SMDP problem is attained by using a relative value iteration algorithm that decides, to transmit MTC packet whether to select MTCGs or eNB and number of resources to be allocated for each wireless link. Simulation is used to demonstrate the proposed scheme and is proved as a superior to the referenced scheme with the numerical results.

In [7], author compared resource allocation in network to Stackelberg game and explains how to reach the stable state with different participants. To allocate the resources to different components in an IoT ecosystem, WLAN, WiMAX are considered as types of networks. In WLAN network, bandwidth and load are proportional to each other, load increases with bandwidth and then slowly it decreases until it becomes stable. The load in the network WiMAX is monotonically increasing. WLAN network capacity is less so WLAN and WiMAX are used in two different load conditions so that WiMAX is saturated earlier. Mean while, cost increases with network congestion so to improve the gain, portion of the WiMAX network bandwidth is transferred with lesser load. The users of WLAN and WiMAX network request for bandwidth change that can be done in the iterative process. [7] Explains how iterative process of WLAN network bandwidth acquisition by users increases to the maximum after 30 iterations and then gradually becomes smaller until it reaches a steady state. After this both WLAN and WiMAX achieves perfect Nash equilibrium in Stackelberg sub-game of heterogeneous wireless networks at some point of time.

In [8], LTE is utilized for sensor networks and that investigates possible number of sensor nodes can be transmitted and per Resource Block(RB) how many bytes are transmitted. Hypothetical estimatation says that sensor nodes transmit 10kb data per Resource Block. The findings are significantly different when carried out simulation in OMNET to create sensor network scenario. [8] Demonstrates results with 29 sensor nodes transmitting 1 Kb. Here Simulation was carried out using SimuLTE in OMNET by considering real world parameters for sensor networks. The LTE network shows that a maximum of 1 Kb data can be transmitted by 29 sensor nodes per second with less than 1% of packet loss which is equals to 21 bytes of data being transmitted per resource block, but it is 181 bytes per resource block for the continuous transmission.

Paper [9], IoT devices can be a set of many heterogeneous network interfaces and services may require available resources. Assigning services with heterogeneous and non interchangeable resource demands to multiple network interfaces of an IoT device and at the same time reduces the cost of using the interfaces. Mixed-integer linear programming (MILP) is given to assign services to interfaces with various resources. Main aim is to reduce the total cost of using resource interfaces to fulfil the service requirements. In [9], stated Service to-Interface Assignment (SIA) problem that calculates the total cost. Cost of using each resource including the activation cost of each interface to serve a required service is collectively calculated as total cost. Author proved NP-Completeness for the SIA problem. In this paper they presented two cases, in first case interfaces have sufficient resources to serve the requests in first attempt and second case serves the request in multiple rounds that is it serves part of the request in each round. Author developed two different algorithms to estimate the optional solution for huge number of instances. In first case there will be enough resources so services with high demand will be allocated in one round and their average cost will be considered. In second case algorithm estimates the required shares of resources and allocates randomly among equally demanding shares [9]. Simulation results are given for both the cases that shows how the service splitting over different interfaces.

3. Features Of Different Resource Allocation Methods

Below table gives features of the different resource allocation methods reviewed in this paper.

Table .1. Features of Resource Allocation Methods

Techniques	**Special feature**
Genetic Algorithm	DCMST algorithm is modified to define new encoding scheme and fitness functions, which are used in resource allocation process.
AMSRS	1. Dynamic detection of the transmitted signal's frequency domain characteristics. 2. Adjusts the weighting factors among different sensing or actuating components. 3. Individual need based resource allocation improves the overall performance of the IoT system.
Relative value iteration algorithm	Resource allocation for packet transmission through appropriate wireless links.
Distributed Iterative Algorithm	Iterative algorithm for proper resource distribution among the sensor nodes.
LTE	Sensor node communication with best possible utilization of Resource Block(RB).
MILP	Assigning services to interface with different resources and this algorithm is defined for two different cases.

4. CONCLUSION

This paper reviews different techniques used for resource allocation for Internet of Things. Degree-constrained minimum spanning tree algorithm is modified to make use of the genetic algorithm. An adaptive multiple sampling rate scheduling (AMSRS) algorithm was proposed and used to improve the performance of IoT with network bandwidth constraints. Relative value iteration algorithm used for SDN based IoT network that decides whether to select MTCGs or eNB to transmit MTC packet and number of resources to be allocated for each wireless link. Distributed iterative algorithm shows how WLAN and WiMAX network bandwidth acquisition by users increases to the maximum after few iterations and then gradually reaches the steady state. By using LTE technology calculated amount of data that can be transmitted per Resource Block. Mixed-integer linear programming (MILP) is given to assign services to interfaces with various resources. There are many resource allocation techniques like above reviewed ones, according to requirement appropriate method can be used.

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