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Task offloading and resource allocation for edge-of-things computing on smart healthcare systems☆

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ABSTRACT

Impelled by prevalent smart devices and omnipresent wireless communication networks, Edge-of-things transpires as a captivating paradigm to accommodate power-sensitive or compute-intensive applications over resource-constrained smart devices. In this research, we focus on flexible compute-intensive task offloading to a local cloud (i.e., cloudlet) saving energy, which aims to optimize the energy consumption, the operation speed, and the cost. A fruit fly optimization based task offloading algorithm (FOTO) is proposed, which improves offloading and resources allocation to acquire the nominal energy consumption under the existing restraints. Performances are evaluated regarding energy consumption, execution time and cost, which are compared with the cooperative multi-tasks scheduling based on ant colony optimization algorithm (CMS-ACO) and heuristic queue based algorithm (GA-ACO). The experimental results prove the effectiveness of proposed FOTO algorithm by comparing with existing algorithms.

1. Introduction

The eruptive growth of mobile phones and smart devices accompanying with the swift development of wireless networks and mobile computing technologies have moved the emergence of numerous novel computing models, such as fog computing, mobile cloud computing (MCC), edge computing etc. [1]. Edge computing refers to the empowering technologies allowing computations to be performed at the edge of the network, upon down streaming and up streaming data on behalf of cloud services and internet-of-things (IoT) services, respectively. For example, a smart device is an edge between body things and cloud; a gateway in a smart home is an edge between home things and cloud; finally a cloudlet [2] is an edge between a smart device and cloud. By using the cloud as a centralized server just rises the frequency of communique between user devices, (e.g. smart devices, tablets, wearable devices, and gadgets) we denote these as edge devices, and physically faraway cloud data centers. This limits the applications requiring real time acknowledgement. Mobile edge computing in a fanatic-dense network is anticipated to be an efficacious explanation which meets the little latency demands [3,4].

Healthcare organizations are strongly adopting analytic solutions as a part of their health information technology (HIT) infrastructures to provide better healthcare services. To identify invalid signatures more efficiently, a batch recognition game system in wireless mobile networks was developed allowing nodes to discover invalid signatures with rational delay irre-

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spective of if the game scenario contains comprehensive information or inadequate information [5]. Edge computing has been becoming more famous in healthcare since organizations introduced the number of linked medical devices into their HIT ecosystem. The aim of edge computing is to reduce the latency by bringing the public cloud abilities to the edge [6,7]. Offloading is an explanation to enhance these mobile schemes competences by relocating computation to added ingenious computers (i.e., servers). This is disparate from the traditional client-server infrastructure, where a thin client continuously migrates computations to a server [8,9]. In mobile devices, the goal of computation offloading provides the cost minimization. In this study, the computation offloading as the service and the key of computation offloading as a service for mobile devices (COSMOS) enables the intermediate service between the mobile devices and the corresponding cloud service provider [10]. The communication resources are transparent to the mobile devices to recognize the resources cost-effectively, hence satisfying the demand for mobile devices. A mobility aware content positioning infrastructure was presented by Chen et al. [11], where precise caching policies were established for SBSs in 5G and smart device leverage user movement, aiming to enlarge the cache hit ratio.

The proposed offloading model addresses the problem of resource constraint. The proper allocation of cloud resources to the smart devices is important because of the low resource capacity in smart devices. The proper allocation provides better throughput of the applications. Therefore, a new multi-objective mechanism is proposed for resource scheduling. At first, a regression algorithm is presented to reformulate the user requests in order to avoid the repeated request of the same user. Secondly, a mathematical model is defined to solve the resource allocation problem. Finally, the performances are evaluated and compared with existing offloading algorithms. Three objective functions are used in this proposed algorithm to enhance the novelty of the work in task offloading. The main contributions of this article are as follows:

- Proposing edge-of-things computing based task offloading and resource allocation for smart devices in healthcare systems.
- Providing the shortest task completing time, lowest energy consumption and minimum cost while comparing with the existing task offloading approaches in the healthcare systems.
- Giving a pragmatic approach to take benefit of edge-of-things computing in smart healthcare systems.
- Depicting the characteristics of edge-of-things computing based healthcare systems and its assistance from different perspectives.
- Demonstrating system model with three layered architecture in healthcare system
- Providing an efficient methodology for the task offloading approach in the smart devices and healthcare system as well.

The remainder of this paper is organized as follows: A brief discussion about related work is made in Section 1, which gives the explanation of task offloading using various approaches. Later, Section 3 presents problem formulation and system model to study the schematic representation of proposed work. Then, Section 4 gives the proposed methodology in which the mathematical model is designed and the objective functions are defined to solve the task offloading problem. Finally, Section 5 gives the evaluation of results and analysis of proposed work with other existing methods. Lastly, Section 6 brings the conclusion.

2. Related work

The cloud resource allocation was described by Chunlin et al. [12]. The energy consumption is optimized by the mobile cloud resource allocation approach. The resource allocation was performed on the public and local cloud level. The performance was evaluated in the experimental environment, for that the algorithm of resource allocation was proposed and the compared results were analyzed. In mobile devices, the battery is considered as the main component, and it was limited to modern mobile devices. It mainly occurred in video application and was pointed out by Zhang et al. [13]. This was very complicated with bandwidth and delay constraints. In state of the art and wireless network channel platform, the energy efficiency and the performance were examined. The opportunities and the challenges were identified for real-time video application. In dynamic wireless network conditions, the scheduling algorithm made the offloading decision over the trace-driven simulations.

In healthcare industries, to deliver a more suitable service and environment, a cyber-physical scheme for patient centric healthcare applications and facilities, known as Health-CPS was constructed on cloud and big data analytics skills by Zhang et al. [14]. This system was contained of a data gathering phase with a united standard, a data organization phase for dispersed storage and parallel computing along with a data-oriented service phase which shows that the skills of cloud and big data can be cast-off to boost the performance of the healthcare system, so that humans can relish numerous smart healthcare applications and services. A smart personal health advisor (SPHA) for comprehensive and smart health monitoring and supervising system was developed by Chen et al. [15]. The SPHAS core infrastructure was proposed to evaluate the overall health status of the user. The energy consumption issues had caused a stir in cloud computing. In this consolidation, multi-core processors and virtualization were important. This study has enhanced the model of green cloud scheduling to exploit the resource and heterogeneity of tasks to allocate the scheduled tasks.

None of the previous works had devised a proper solution to energy constraint in healthcare devices. Hence, we proposed a novel cloudlet embedded edge-of-things paradigm having better task offloading algorithm which focuses on three key parameters; energy consumption, execution time and data center cost. The proposed task offloading algorithm has shown that it is beneficial and enhances the smart devices abilities in healthcare systems.