Just-in-Time Code Offloading for Wearable Computing

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Abstract—Wearable computing becomes an emerging computing paradigm for various recently developed wearable devices, such as Google glass and Samsung Galaxy Smartwatch, that have significantly changed our daily life with new functions. To magnify the applications on wearable devices with limited computational capability, storage, and battery capacity, in this paper, we propose a novel three-layer architecture consisting of wearable devices, mobile devices and remote cloud for code offloading. Specifically, we offload a portion of computation tasks from wearable devices to local mobile devices or remote cloud such that applications even with heavy computation load can still be upheld on wearable devices. Furthermore, considering the special characteristic and requirements of wearable devices, we investigate a code offloading strategy with a novel just-in-time objective, i.e., maximizing the number of tasks that should be executed on wearable devices with guaranteed delay requirements. Because of the NP-hardness of this problem as we prove, we propose a fast heuristic algorithm based on Genetic Algorithm (GA) to solve it. Finally, extensive simulations are conducted to show that our proposed algorithm significantly outperforms other three offloading strategies.

Index Terms—wearable computing, just-in-time, code offloading, cloud

1 Introduction

Along with the popularity of various wearable devices, such as Google glass [1] and Magic Ring [2], wearable computing has attracted more and more attentions since it facilitates a new form of cyber-physical interaction comprising small body-worn devices that are always powered on and accessible [3]–[6]. Various emerging applications, such as healthy monitoring, reality augmentation, and gesture or object recognition, require wearable devices to provide fast processing and communication capability in an energy-efficient manner. On the other hand, hardware equipped on wearable devices is usually with limited size and weight, hardly to provide enough capability and power for complicated applications.

To fill the gap between resource demand and supply on wearable devices, we propose a novel architecture that offloads some codes to nearby mobile devices with stronger processing capability or a remote cloud with unlimited computation resources. Specifically, we consider a three-layer architecture as shown in Fig. 1. Wearable devices with limited computation capability forms the first layer closest to users. Several mobile devices, such as smartphones or tablets, are in the middle layer, which can communicate with wearable devices using short-range communication technologies like ZigBee or Bluetooth. Meanwhile, these mobile devices can communicate with remote cloud as the third layer via WiFi or LTE networks.

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Under this three-layer architecture, we investigate how to efficiently offload codes from wearable devices in the first layer to computation resources in the second and the third layers. In this paper, wearable applications are represented as task graphs, in which methods or functions are denoted by nodes and their relationship by edges. Note that some tasks like sensing or display cannot be offloaded, i.e., they should be executed only on wearable devices. These tasks are referred to as w-tasks in the rest of our paper. For other non-w-tasks, we propose a code offloading algorithm to schedule them on mobile devices or cloud. To guarantee a certain level of user experience, we consider a just-in-time objective for code offloading, i.e., maximizing the number of w-tasks that are executed within a given delay from their direct previous ones. It is motivated by the fact that w-tasks directly interact with users who cannot tolerate long delay between any two adjacent w-tasks.

The main contributions of this paper are summarized as follows.

- We propose a novel three-layer architecture for code offloading from wearable devices to local mobile devices and remote cloud. Different layers have distinct processing capability, and they communicate with each other using different wireless communication technologies.
- We consider an optimization problem for code offloading with a just-in-time objective with respect to user experience. This problem is proved to be NP-hard, and we develop a formulation that deals with the challenges of both task assignment