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Integration of Wireless Sensor Network with Mobile Cloud Computing using Efficient Collaborative Location Based Sleep Scheduling Schemes

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Abstract :- Recently, much research has proposed to integrate mobile cloud computing (MCC) with wireless sensor networks (WSNs) so that powerful cloud computing can be exploited to process the data gathered by ubiquitous WSNs and share the results with mobile users. However, all current MCC-WSN integration schemes ignore the following two observations: 1) the specific data mobile users request usually depend on the current locations of mobile users 2) most sensors are usually equipped with non-rechargeable batteries with limited energy. In this paper, motivated by these two observations, two novel collaborative location-based sleep scheduling (CLSS) schemes are proposed for WSNs integrated with MCC. Based on the locations of mobile users, CLSS dynamically determines the awake or asleep status of each sensor node to reduce energy consumption of the integrated WSN. Particularly, CLSS1 focuses on maximizing the energy consumption saving of the integrated WSN while CLSS2 considers also the scalability and robustness of the integrated WSN. Theoretical and simulation results show that for WSNs integrated with MCC, both CLSS1 and CLSS2 can prolong the WSN lifetime while still satisfying the data requests of mobile users.

Keywords:- *Mobile cloud computing, wireless sensor networks, integration, location, network lifetime, sleep scheduling.*

I. INTRODUCTION

A. Mobile Cloud Computing (CC)

Cloud computing is a novel computing model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, services) [1]. By further integrating CC into a mobile environment, mobile cloud computing (MCC) can offload much of the data processing and storage tasks from mobile devices (e.g., smart phones, tablets, etc.) to the cloud. MCC is widely considered to not only greatly relieve the processing, storage and energy capacity limitations of mobile devices, but also provide users with many new mobile services (e.g., mobile cloud learning, mobile cloud gaming, mobile cloud healthcare) [2], [3]. For instance, regarding mobile cloud learning, traditional mobile learning may encounter various issues (e.g., high storage cost, low processing speed and limited education resources) on mobile devices. By moving the learning platform to the cloud, learners and teachers can achieve much faster processing speed as well as much richer learning and teaching resources in terms of available information, using just a simple client on the mobile device.

B. Wireless Sensor Networks (WSNs)

Wireless sensor networks are networks consisting of spatially distributed autonomous sensors to cooperatively gather various physical or environmental information (e.g., temperature, sound, pressure) [4], [5], [6]. Because it changes the traditional way for people to interact with the world, WSNs have been the research focus of both academic and industrial communities to explore their great potentials in military, industrial, and civilian applications (e.g., battlefield surveillance, air pollution monitoring, landslide detection, water quality monitoring) since the late 1990 s. For example, regarding landslide detection, a WSN can be utilized by the landslide detection system to detect the slight movements of soil as well as other changes in various parameters that may occur before or during a landslide, and thus it is possible to predict the occurrence of a landslide long before it actually happens. In addition, with respect to water quality monitoring, a number of distributed sensor nodes can be deployed at various points in dams, rivers or lakes to monitor the water quality, and thus a very accurate map of the water status can be created without the need of manual data retrieval, particularly for locations with difficult access.

C. Integration of MCC and WSNs

Recently, integration of MCC with WSNs has been proposed in several research works [7], [8], [9], [10], [11], [12],[13], [14], [15]. This trend is induced by the advantages of incorporating the powerful data storage and data processing abilities of MCC as well as the ubiquitous data sensing and data gathering capabilities of WSNs for mobile users.

The main contributions of this paper are summarized as follows.

- his paper is the first work that considers sleep scheduling in WSNs to support location-based mobile cloud applications. This clearly distinguishes our work from existing MCC-WSN integration schemes.

- This paper further proposes two novel CLSS schemes aimed at sleep scheduling of WSNs integrated with MCC. Both the location based characteristic of mobile applications as well as the energy concern of WSNs are taken into account by the CLSS schemes. CLSS1 focuses on the energy consumption of the integrated WSN, while CLSS2 further considers the scalability and robustness of the integrated WSN. The remainder of this paper is organized as follows.

Section 2 introduces the MCC-WSN integration model and Section 3 presents the proposed CLSS schemes for WSNs integrated with MCC. The proposed CLSS schemes are analyzed theoretically in Section 4 and evaluated numerically and by simulations in Section 5. Section 6 concludes the paper.

II. PROPOSED SYSTEM

In this section, we first show the mechanisms to obtain the mobile user location list and then present our proposed CLSS schemes.

A. Mobile User Location List

- Mobile User Location History List

To achieve the location list L of mobile user u, the location history of u is extracted by the cloud c based on the StarTrack service. Specifically, StarTrack in [27] is a mobile client application and it periodically captures the user's current location (e.g., with GPS) and relays the location information to the Star Track server which runs as a service in the cloud c. Further, the StarTrack server processes these location data and decomposes them into various tracks (i.e., discrete representations of trips taken by the mobile user). The points of these tracks are operational and retrievable through a high-level application programming interface and they make up the location history list named as Lh.

- Mobile User Predication Location List

To obtain the mobile user predication location list Lp, we utilize the following method that is similar with the Place Transition Graph utilized as in [21]. The key idea is that the future locations of the mobile user would be associated with the frequently visited locations of the mobile user, thus it is likely that the future track of the mobile user will be constituted by these frequently visited locations. For instance, if a mobile user goes to restaurant A and gym B from office C very often, it is obvious that the mobile user will go to gym B from restaurant A, or go to restaurant A from gym B someday in the future. Particularly, we compute a frequently visited location list Lf first. This Lf is obtained by iterating over all the retrieved tracks and selecting the end points of the retrieved tracks of the mobile user. Then Lf is updated by further removing the end points of the tracks that only appear once. With that, an adjacency matrix in which the numbers of rows and columns correspond to the number of the elements in the updated Lf is constructed. Finally, the match of each element in the row and the column except the match with two same points becomes a new track (i.e., the prediction track). All points without repetition excluding the starting and end points of the prediction tracks constitute the mobile user predication location list Lp. The mobile user location history list Lh and mobile user predication location list Lp constitute the location list L of the mobile user.

B. CLSS Schemes

There are two collaborative location-based sleep scheduling schemes for the integrated WSN and the pseudo codes of these two CLSS schemes (i.e., CLSS1 and CLSS2) in each time epoch TP are shown as follows.

- CLSS1

Regarding CLSS1 scheme, cloud c first obtains the current location lu of mobile user u (Step 1 of CLSS1). Then according to whether lu is in the location list L or not, a flag A or Z is sent to base station s by cloud c (Step 2 of CLSS1).

Base station s further broadcasts the flags. At last, each sensor node i determines its awake or asleep state according to the flag it receives in each time epoch TP (Steps 3 to 5 of CLSS1).

- CLSS2

In terms of CLSS2, the first four steps are the same as that of CLSS1. The difference between CLSS2 and CLSS1 lies in Step 5.

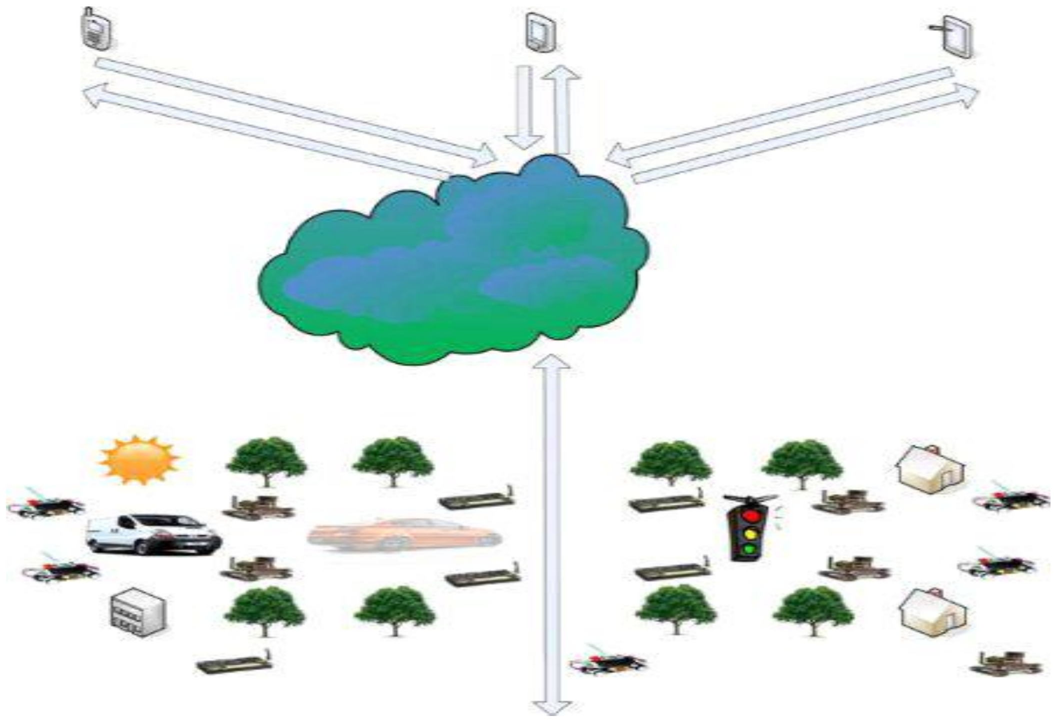

Fig 1. System Architecture

III. MAIN NOTATION DEFINITIONS

Symbol Definition

j j : Number of elements in a set c Cloud

M : Number of mobile users or WSNs u Mobile user

S: Base station

T : Time

TP :Time epoch

t :Time epoch interval

N: Total number of sensor nodes in WSN

A :Area of WSN

I: Set of sensor nodes

I: Sensor node

B: Set of links

Tr: Transmission radius

Et: Energy consumption of transmitting a byte

Er: Energy consumption of receiving a byte

Ea: Energy consumption of power amplification of one byte to cover a 1 m distance h: Packet length

d: Transmission distance

ET: Energy consumption of transmitting a packet

ER: Energy consumption of receiving a packet Average event rate

pXY ðx; yÞ Independent probability distribution of events

q: Number of packets transmitted from a node to each neighbor node if an event is detected

Lh: Mobile user location history list

Lp: Mobile user predication location list L: Mobile user location list

R: Node density

K: kin EC-CKN

Eo: Node initial energy

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NL: Network lifetime

NL0: Network lifetime of AO

NL1: Network lifetime of CLSS1

NL2: Network lifetime of CLSS2

NWR: Network work rate

NWR0: Network work rate of AO

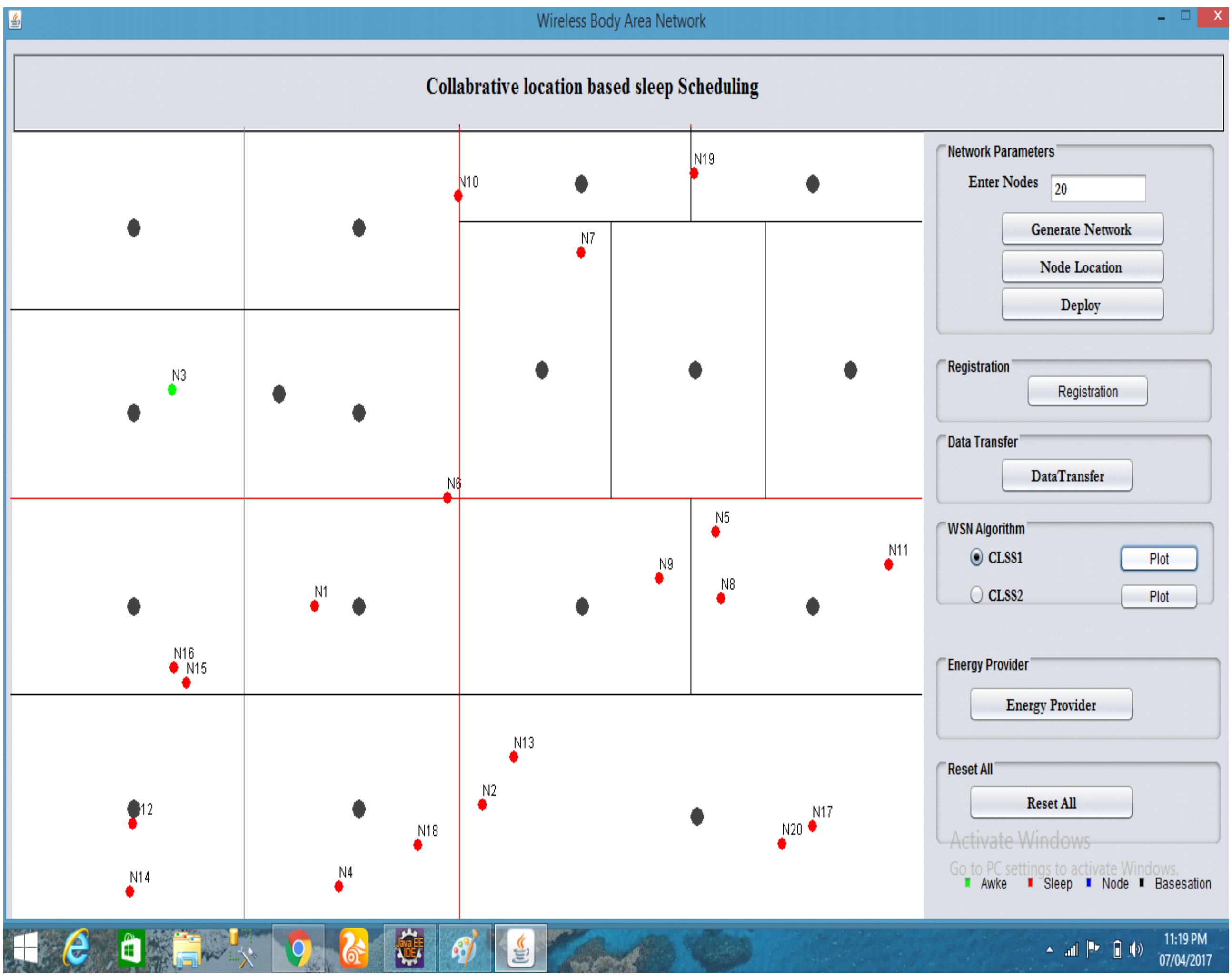
NWR1: Network work rate of CLSS1

NWR2: Network work rate of CLSS2

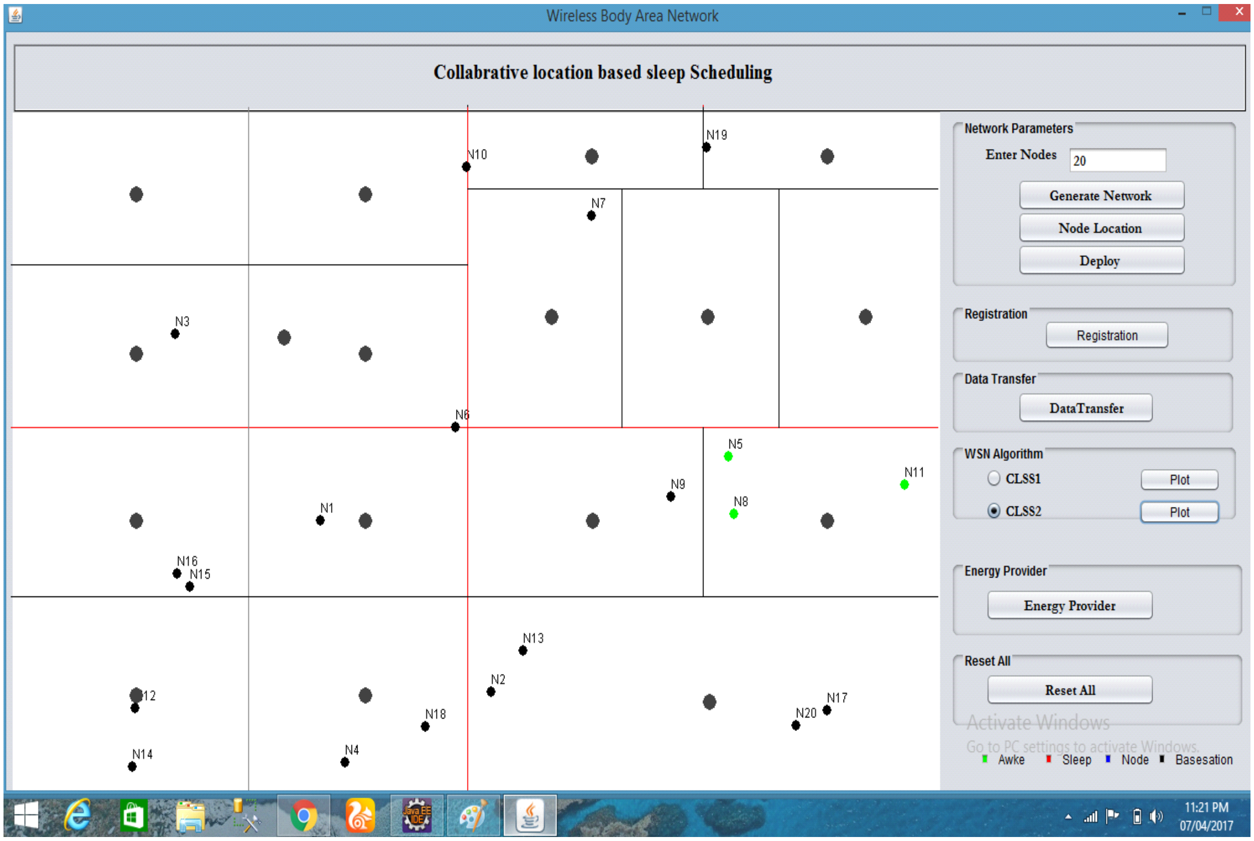
IV. CONCLUSION

In this paper, we have proposed two CLSS schemes (i.e.CLSS1 and CLSS2) for WSNs integrated with MCC. CLSS schemes involve both the WSN and the cloud and then dynamically change the awake or asleep status of the sensor node in the integrated WSN, based on the locations of mobile users. CLSS1 focuses on saving the most energy consumption of the integrated WSN and CLSS2 further pays attention to the scalability and robustness of the integrated WSN. For the integration of MCC and WSNs, both theoretical and simulation results are shown and they demonstrate that CLSS1 and CLSS2 could prolong the lifetime of the integrated WSN while still satisfying the data requests of mobile users.

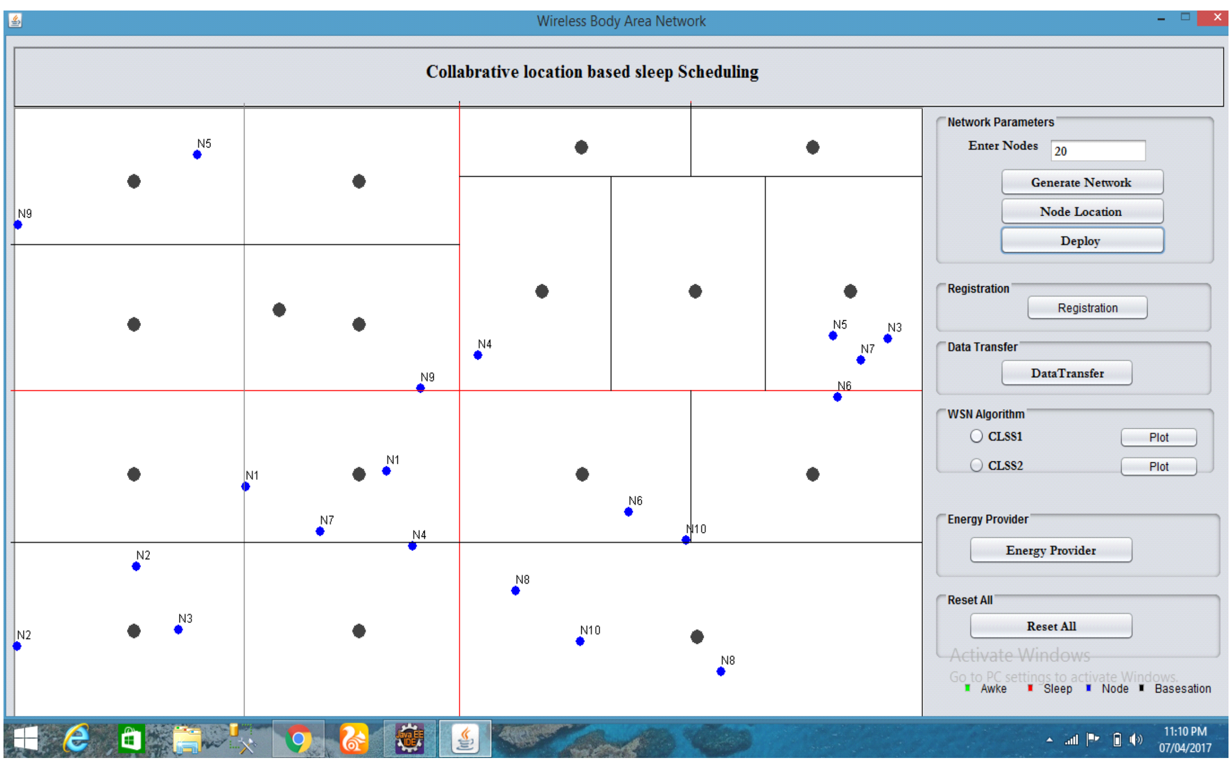
Output:



Picture 1: Snapshot of CLSS1 running



Picture 2: Snapshot of CLSS2 running



Picture 3: Snapshot of node-deployment

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