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NOVEL ENERGY-SAVING CELL SELECTION FOR MULTIMEDIA SENSOR ROUTING NETWORKS

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Abstract:
Energy issue of cellular access wireless network has drawn much attention in the recent years. In this paper, we propose a Energy-Saving Cell Selection Mechanism (ESCSM) including the energy-saving triggering conditions determination and a regional cell selection algorithm based on traffic enabling smart services in ubiquitous computing environments. The new architecture is called multimedia sensor network (MSN). ESCSM selects the BSes which can be switched off without any negative effects to the radio coverage and service provisioning. Simulation results show that ESCSM can save nearly 23% energy one day at most and guarantee the coverage. A routing scheme named multimedia geographic routing (MGR) is specially designed to minimize energy consumption and satisfy constraints on the average end-to-end delay of specific applications in MMSNs performance to satisfy QoS and capacity quality while saving energy.
Keywords- Energy-saving; trigger condition; cell selection

I. INTRODUCTION

Greenhouse effect has drawn much attention in the last decades, and the Information and Communication Technologies (ICT) industry in 2007 consumed 2% of total world energy consumption [1], which still causes 2% of the CO2 emissions over the world.

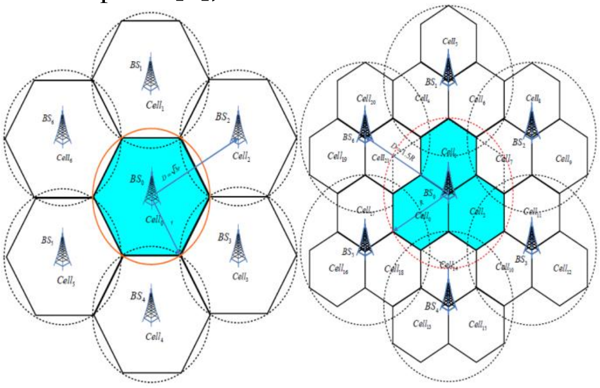

Figure 1. The cell layout of different BS

Recent advances in the fields of wireless technology, multimedia communications and intelligent systems have exhibited a strong potential and tendency on improving human life in every facet, including entertainment, socialization, education, and healthcare. To enable smart multimedia services in a mobile and ubiquitous environment, video surveillance system may interface with other wireless technologies, such as wireless sensor networks (WSNs), wireless multimedia sensor networks (WMSNs), and body area networks etc.

In cellular networks, such as GSM and UMTS (the Universal Mobile Telecommunications System), A Base Station (BS), such as BTS, Node-B, consumes around 1500W, and quantities of these devices contribute up to 80% of the whole network energy consumption [2]. So, if we can find a way to save energy of BS, a considerable energy cost will be saved. Temporary, one BS can serve for one cell or three cells, which is shown in Figure 1. Thus, cell or BS will be considered as the smallest object in this paper.

Cellular networks in an urban environment are normally dimensioned to cope with peak time traffic demand and may be under-utilized in off-peak times (e.g., at certain hours of the night), an example can be seen in Figure 2. Thanks to this feature, we can save energy by switching off some cells if the radio coverage and service provisioning can be taken care of by the cell that remains active. How to choose the cells to be closed and how to save more energy are import research issues of this paper.

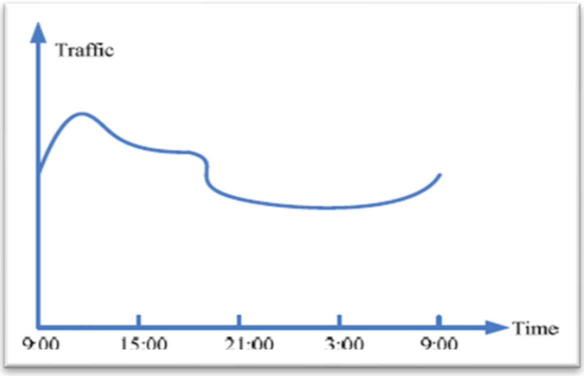

Figure 2. Traffic distribution of a cell in one day

In this paper we discuss the trigger conditions and a novel energy-saving cell selection mechanism (ESCSM). In section 2, we will introduce the related work of energy-saving. Section 3 elaborates the ESCSM, which including two parts: research of energy-saving trigger and implementation of the energy saving algorithm. Then we will simulate the algorithm in UMTS networks and analysis the result in section 4. Finally section 5 summarizes our work and provides future directions. In particular, we will employ some powerful sensor node with both mobility and multimedia functionalities, which can be controlled by contextual information collected by other systems to enable interactive multimedia services. The new architecture is called multimedia sensor network (MMSN) in this paper. A routing scheme named mobile multimedia geographic routing (MGR) is specially designed to minimize energy consumption and satisfy constraints on the average end-to-end delay of specific applications in MMSNs. Simulations verify the MGR's performance to satisfy QoS requirement while saving energy for MMSNs.

II. RELATED WORK

In this paper, we start our expatiation with traffic load, then bring up the concept of energy-saving trigger and illustrate the criteria of triggering briefly. When the traffic load of the network descend to a certain level, a algorithm of energy-saving will be triggered and works out which BS can be switched off without any negative effects to the radio coverage and service provisioning.

a) Analysis of Delay-Energy Tradeoffs

Notation

1) Analysis of One-Hop Delay:

In this section, we analyze the latency between two neighboring nodes, which is the summation over the queuing, processing, propagation, and transmission delays:

Queuing delay: For the sake of simplicity, we assume a stable packet rate in our network. Then, queuing delay is considered to be a constant for each hop, which is denoted by Tq•

Processing delay: With respect to processing delay, we assume that each node incurs similar delay to process and forward one packet with constant length. The processing delay is denoted by Tp.

Propagation delay: This parameter can be neglected when compared to the other delays.

Transmission delay: We assume that the size of a data packet does not change between a source-sink pair, its transmission delay (denoted by Ttx) remains constant between any pair of intermediate sensor nodes.

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Therefore, the delays taking place between any pair of intermediate nodes are considered to be similar in this paper, which can be estimated simply by

Thop = Tq + Tp + Ttx.

Consequently, the delay between current node to the sink node is proportional to the hop count between the two nodes.

2) Energy-Delay Tradeoff: Typically, a geographic routing mechanism (e.g. , GPSR [5]) intends to maximize packet progress at each hop in a greedy fashion. Since such a distance-based scheme introduces nearly maximal hop distance, the end-to-end delay could be minimized while more energy will be consumed based on our energy model.

However, achieving minimum delay is not beneficial for some delay sensitive applications when the minimum delay is smaller than the application specific QoS delay boundary(i.e., TQos). In the case that the earlier arrival of a data packets is not necessary, an intermediate sensor node can reduce the transmission power with a smaller transmission range for delivering packet to next hop in order to reduce energy consumption, but not too small to still be able to guarantee the delay objective.

B. End-to-end Delay Objective

Let D denote the distance between source and sink. Let Rmax denote the maximum transmission range of a sensor node. Then, the minimum end-to-end delay is equal to which is realized by the use of the shortest path with maximum progress at each hop. Then, for a certain network topology, an multimedia application is allowed to adjust application-specific end-to-end delay TQos subject to the following constraint at least:

TQos>Tmin,

Otherwise the QoS delay cannot be achieved.

C. Calculating the Desired Hop

Distance at Current Node current node. Let tcurrent denote the current time when the routing decision is being made; let tcreate denote the time when the packet is created at the source node. Then, tS-4hcan be easily calculated by the difference between tcurrent and tcreate. Then, the reserved time credit for the data delivery from current node to the sink node, Th-4t, can be calculated by:

III. A NOVEL ENERGY-SAVING CELL SELECTION MECHANISM（ESCSM）

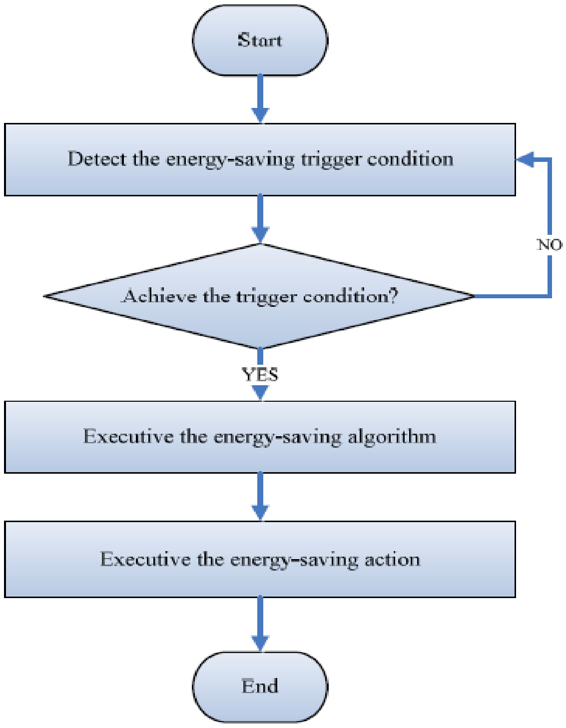

Figure 3. The procedure of energy-saving execution

In cellular networks, BSes will periodic report some useful information to the core network on time, such as the traffic load information. In this paper, firstly, basing on this information, we propose the concept of trigger condition under which the network can execute energy-saving algorithm.
Then, when this trigger condition is satisfied, after the implement of our energy-saving algorithm some BS can be switched off with the phones assigned to neighbor BSes. Figure 3 shows the overall procedure of energy-saving.

A. Trigger condition

The definition of trigger condition for a BS should include the following two aspects:
a) The traffic of the BS under a threshold, at which the network can execute energy-saving actions, and is named as ηb, the value of ηb will be given in section 4.
b) The duration of which having current traffic load
below b is longer than t To achieve better energy efficiency, we should select the above two conditions carefully, any of which can affect the ultimate energy-saving result. The choice of condition a) and condition b) are similar, both of which are approximate projections based on historical data, and b) is also considered as an empirical value. So we just choose condition a) to discuss in detail. The energy-saving threshold ηb is not a constant value, and it is trained by the old threshold and the average traffic in the ES-Compensate state last day. We refer to the method of calculating acknowledgement arrival times in computer networks [7]. Let $\eta' b$ be old energy-saving threshold, the new threshold be ηb,
and M be the average traffic in the ES-Compensate state last day, then

$$\eta b = \alpha \eta b' + (1-\alpha) M \quad \text{----------} \quad (1)$$

Where α is a smoothing factor that determines how much weight is given to the old value. Typically $\alpha = 7/8$.
Selection of condition b) requires some skills. If the value is set too short, it will be likely to cause frequent switching between states; however, if the value is set too long, it will reduce the effect of energy saving. In practice, we tend to set the value as a larger number. After all, frequent switching is more headaches.

B. Energy-saving algorithm

When the current situation in the network satisfies the trigger conditions, the energy-saving algorithm can be implemented. The algorithm will determine how many BSes can be switched off, and then the saving power can be evaluated. A reasonable assumption is that the adjusting of antenna tilt or transmit power by remaining active BSes is able to compensate the regional coverage, and the power of switched off BS is 0.
Before the energy-saving algorithm, some parameters would be introduced firstly: let m be the number of BS, and the ith cell is denoted by BSi, n is the number of phone, the ith phone is denoted by Pj, The maximum traffic load (the total bandwidth available) of BSi is Cmaxi, the current traffic load is
Ci, and the power consumption is Pi, the maximum coverage radius is Rmaxi, the current coverage radius is Ri. The mobile terminal i require ci bandwidth, and the distance between Pi and BSj is Dij. We define relationship matrix as Q={qij}, when Pj have connection with BSi, then qij=1, one phone can only connect with one BS.
We are trying to design an algorithm to obtain optimal energy efficiency, but it is usually a difficult task in real telecom network. In the following algorithm, we adopt a greedy method to get a good result.

Energy-saving Algorithm(To be edited)

In the start of this algorithm, we sort {BS} in ascending order according to traffic load at first, then check every BS in order, if all phones in the BS can be assigned to other BS (must be the neighbor of the checked BS), the BS can be switched off and assigned to {BSsaving} . Because the capacity of the BSes have change if one BS is switched off (some phones are assigned to other BS), we should sort {BS} in ascending order according to traffic load again before the next BS is checked.
When the algorithm is executed, the energy saving action is adopted, that is, turning different BSes into the states from the results of the algorithm. Some BSes are converted to ESaving state, several are

converted to ES-Compensate state, and a few still keep in No-ES state. This region begins into the energy-saving mode.

Let Non, Noff and Ncom denote the number of BS in No-ES state, ESaving state and ES-Compensate state, the distribution period of regional traffic is T, and the energy-saving execution time is t, we adopt a indictor Es to evaluate the energy efficiency:

$$E_S = \frac{P_{BS} \times N_{off} \times t}{P_{BS} \times m \times T} \times 100\% = \frac{N_{off} \times t}{m \times T} \times 100\% \qquad (2)$$

IV. PERFORMANCE EVALUATION

• End-to-end Packet Delay: It includes all possible delays during data dissemination, caused by queuing, retransmission due to collision at the MAC, and transmission time.

• Energy Consumption: the energy consumption for a successful data delivery, which is calculated according to Eqn.(I).

• Average Energy Consumption: it is a running mean of ordinate values of input statistic, which is obtained by the statistics collection mode of "Average Filter" in OPNET simulation [7].

• Lifetime: It's the time when the first node exhausts its energy.

V. CONCLUSIONS

In this paper, we utilize the unbalanced distribution of traffic, propose a energy-saving algorithm, and implement the algorithm when network traffic satisfy the trigger condition, the result is to switch off some BSes to reduce the energy loss. Then, the trade offs of end-to-end delay and energy consumption for supporting multimedia service with delay QoS requirement are discussed. By utilizing location information, we design a routing algorithm named mobile multimedia geographic routing (MGR) for QoS provisioning in MMSNs. When MMN moves in the network, MGR is designed to minimize energy consumption and satisfy constraints on the average end-to-end delay of specific applications. Verified by the simulation, the algorithm here in is practicable and meets our expectation with at most 23% energy saving.

In the future work, we will pay more attention to the problem of radio coverage, how to avoid the blind spot in coverage and how to reduce the overlap in coverage are very meaningful topics.

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