ISSN:2348-2079

Volume-5 Issue-2

IJIAREC

International Journal of Intellectual Advancements and Research in Engineering Computations

A cooperative clustering protocol for energy saving of mobile devices with wlan and bluetooth interfaces

[1]Mr S.Sambasivam M.C.A., M.Phil.,Associate Professor,
[2]Mr T.ImthiyajFinal MCA.,
Department of MCA, Nandha Engineering College(Autonomous) Erode-52
E-Mail ID:Sammy2173@gmail.com, ahamedimthiyaj.ia@gmail.com

Abstract - One of the most widely used wireless communication standards is a Wireless Local Area Network (WLAN) (IEEE 802.11). However, WLAN has a serious power consumption problem. In this paper, we propose a novel energy saving approach that exploits the multiradio feature of recent mobile devices equipped with WLAN and Bluetooth interfaces. Unlike previous approaches, our work is based on clustering. In our work, a cluster is a Bluetooth Personal Area Network (PAN), which consists of one cluster head and several regular nodes. The cluster head acts as a gateway between the PAN and the WLAN, enabling the regular nodes to access the WLAN infrastructure via low-power Bluetooth.

1.INTRODUCTION

MOBILE ad hoc networks (MANETs) have been an important class of networks, providing communication support in mission critical scenarios including battlefield and tactical missions, search and rescue operations, and disaster relief operations. Group communications has been essential for many applications in MANETs. The typical number of users of MANETs have continuously increased, and the applications supported by these networks have become increasingly resource intensive. This, in turn, has increased the importance of bandwidth efficiency in MANETs. It is crucial for the medium access control (MAC) protocol of a MANET not only to adapt to the dynamic environment but also to efficiently manage bandwidth utilization.

In general, MAC protocols for wireless networks can be classified as coordinated and uncoordinated MAC protocols based on the collaboration level [1]. In uncoordinated protocols such as IEEE 802:11, nodes contend with each other to share the common channel. For low network loads, these protocols are bandwidth efficient due to the lack of overhead. However, as the network load increases, their bandwidth efficiency decreases. Also, due to idle listening, these protocols are in general not energy efficient. On the other hand, in coordinated MAC protocols the channel access is regulated. Fixed or dynamically chosen channel controllers determine how the channel is shared and accessed. IEEE 802.15.3 [2], IEEE 802.15.4 [3], and MH-TRACE [4] are examples of such coordinated protocols. Coordinated channel access schemes provide support for quality of service (QoS), reduce energy dissipation, and increase throughput for dense networks. Extensively deployed cellular networks also use a coordinated MAC protocol in which the channel access is regulated through fixed base stations.

Unlike these previous works, our approach is based on clustering. Clustering is commonly used in sensor networks for network scalability, load balancing data aggregation or energy efficiency [9], In our work, clustering makes nodes (i.e., mobile devices) that share their WLAN interfaces with each other. Fig. 1 depicts the concept of our approach and compares it to the previous approaches. As shown in Fig. 1b, a cluster is a Bluetooth Personal Area Network (PAN) that consists of one cluster head (CH) and several regular nodes (RNs). CHs are responsible for coordination among the nodes within their clusters and the forwarding of packets from the PANs (clusters) to the WLAN, and vice-versa.
This paper presents a distributed clustering protocol, Cooperative Networking protocol (CONET). CONET has four main objectives:

1. improving the energy efficiency of wireless net-works by exploiting a secondary radio,
2. dynamically configuring clusters to meet the band-width requirements of all nodes,
3. producing well-distributed cluster heads, andminimizing control overhead.

The final goal of our CONET is to reduce the power consumption in wireless networking applications. For this purpose, we first classify popular applications into two types: group networking and individual networking. Next, we propose a general clustering protocol that considers both application types.

Group networking. In this case, a group of nodes have a common goal and need to prolong the grouplifetime to achieve that goal. The group lifetime canbe defined as the time elapsed until the first node in the group depletes its battery. For example, let us assume that some friends are playing network games together using their nodes. In this case, the maximum time during which they can play together will depend on the node with the lowest remaining battery.

Individual networking. In this case, we consider unrelated individuals running their own applications (i.e., no common goal), even when they are geometrically close to each other. In a subway train, for example, many people may use their mobile nodes simultaneously, but each of them is likely to have different purposes: one may visit websites or one may just wait for incoming messages while keeping her usingwearable computers [20] to evaluate its performance on real hardware systems. We also simulate CONET for large networks of more than 100 CONET dynamically clusters the network according to

2.PROBLEM STATEMENT

The mobile devices that we consider in this paper are popular user terminals, such as smart phones or wearable computers. For the rest of this papersimply refer to a mobile device as a node. We assume the following proper-ties about the nodes and wireless networks:
each node’s bandwidth, energy, and application type. We have implemented the CONET prototype
mobile nodes and evaluate the performance. Both results demonstrate that CONET is effective in reducing the power consumption of WLAN-based commu-nicationsystems.wireless interface on. member of each cluster is the cluster head itself. Like these clusters, a cluster which has no RNs is called a trivial cluster, and the head of the trivial cluster is called a trivial clusterhead (tCH). Therefore, tCHs do not need to use Bluetooth forpacket forwarding, but only for advertising. Note that tCH is a subset of CH.

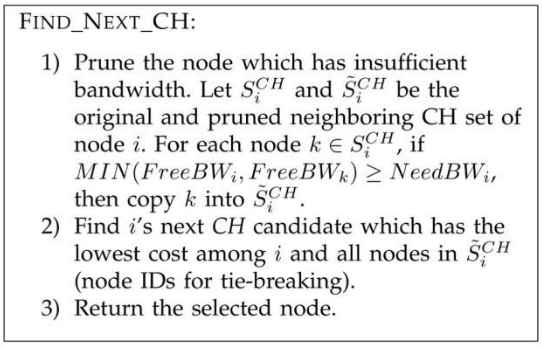
2.1.1 .Responding to JOIN Requests

In stage (B) of Fig. 2, each CH waits for JOIN requests from other nodes for a short time (say, 1 second). The JOIN message of node i includes the amount of required bandwidth $NeedBW_i$. Upon receiving a JOIN message, the CH goes to stage (C) and compares its FreeBW with the sender’s NeedBW. If the CH has a sufficient amount of free bandwidth for the sender (i.e., F reeBWNeedBW), it will accept the request, but, otherwise, reject it. After responding to the request, the CH returns to the initial stage. The sentence, “Become a CH,” in stage (A) means “keep the CH role” for the nodes that are already CHs. At the initial moment shown in Fig. 3a, because no node has sent a JOIN message yet, all the nodes go down to stage (D).

2.1.2. Cluster Head Election

When there is no JOIN request, the CH counts the number of RNs within its clusters (stage (D) in Fig. 2). If there is at least one RN in the cluster, the CH returns to the first step and keeps its current role. This allows RNs to select their next CHs by themselves, which is necessary for network stability: If CHs stop their roles of packet forwarding regardless of the associated RNs, the RNs will occasionally lose their links to the WLAN access point. Furthermore, clusters will be reformed quite frequently if CHs ignore the status of each RN, such as the first association time (the time at which the RN has joined).

The chance for energy saving is given to trivial CHs (tCHs), which turned out to have no RNs within their clusters at the end of stage (D). A tCH selects its next CH by itself. In stage (E), each tCH calls the FIND_NEXT_CH procedure, which presents the CH election process of CONET. Assume that node i calls FIND_NEXT_CH. It then executes the following procedure:



FIND_NEXT_CH:

1) Prune the node which has insufficient bandwidth. Let S_i^{CH} and $\tilde{S}_i^{CH}$ be the original and pruned neighboring CH set of node i. For each node $k \in S_i^{CH}$, if $MIN(FreeBW_i, FreeBW_k) \geq NeedBW_i$, then copy k into $\tilde{S}_i^{CH}$.
2) Find i's next CH candidate which has the lowest cost among i and all nodes in $\tilde{S}_i^{CH}$ (node IDs for tie-breaking).
3) Return the selected node.

Even though all nodes estimate F reeBW using (3), the estimation results of two neighboring nodes could be different due to the limited radio range. For example, let us assume that there is a hidden flow on the left side of node 1 in Fig. 3a, which is in node 1’s radio range, but out of nodes 2’s radio range. In this case, F $reeBW_1$ will be estimated to be smaller than F reeBW$_2$ because the flow only interferes the idle channel time of node 1.

2.1.3. Role Switching

It is necessary to rotate the CH role regularly to balance the energy consumption among all nodes. To do so, each RN has a timer, RN_Timer, which expires every T_{RN} seconds. When the timer expires, the RN goes to stage (E) again and calls the FIND_NEXT_CH procedure to elect its next CH. Depending on the election result, the RN itself becomes a new CH or joins one of the existing clusters, including its current cluster.

The transition from Figs. 3b and 3c shows the cluster reformation due to the timer expiration. Let us assume that since the first cluster is created (Fig. 3b), the RNs, nodes 2 and 3, have consumed 30 Joules, while the CH, node 1, has consumed 60 Joules, regardless of their data rates.[3] As RN_Timerindependently expires in the RNs, they movefrom stage (G) to stage (E) in Fig. 2. Then, node 3 finds out that it has the lowest cost among the nodes. Thus, it becomes a CH and node 2 joins the new cluster. At thismoment, node 1 eventually becomes a trivial CH because no node is associated to it. Then, node 1 goes to stage (E) and finds out that node 3 is the lowest cost CH. Thus, it joins node 3, resulting the new cluster structure, as shown in Fig. 3c. By regularly switching roles in this manner, energy consumption can be distributed.

3.PERFORMANCE EVALUATION

In this section, we evaluate the performance of CONET. First, we present experimental results from the prototype that we have implemented using customized wearable computing platforms.

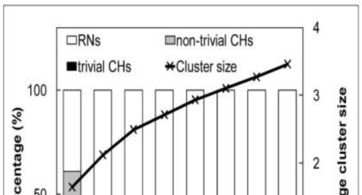
3.1.Evaluation with Prototype

Ubiquitous Fashionable Computers (UFCs) are used as mobile nodes. UFC is a wearable computing platform (Fig. 5) that has three kinds of wireless interfaces: WLAN, Bluetooth, and ZigBee (IEEE 802.15.4). Table 1 summarizes the specifications of these interfaces. In the prototype evaluation, ZigBee is removed from the UFCs. The main processing module of UFC is based on the Intel XScale processor, PXA270, and runs Linux 2.6. We measured the power consumption of major components. The power breakdown for a UFC in idle mode is presented in Table 2. Observe that the WLAN interface consumes about 880 mW which is almost half of the total power consumption (1,780 mW).

TABLE 1
Specification of the Three Wireless Interfaces of UFC

Type	ZigBee	Bluetooth	WLAN
H/W	Crossbow MICAz (CC2420)	CSR BlueCore03	3COM 3CRUSB 10075
Standard	Not used	Bluetooth 1.0	802.11b
Maximum data rate	Not used	1 Mbps (440* kbps)	11 Mbps (5.1* Mbps)

Values marked with are measured. We measured the effective maximum rate of Bluetooth and WLAN using an FTP download workload.



To make each UFC aware of its residual energy, we removed its battery and directly connected the Agilent E3648A power supply to the UFC, as shown in Fig. 5. This equipment is capable of measuring the power consumption in real time and feeding back the measurement result via an RS-232 serial interface. We connected the power supply and the UFC with an RS-232 cable and wrote a simple logging program that updates the residual energy based on the reported power consumption. With this hardware/software setup, we can set the initial energy of each node to any value and measure the fine-grained power consumption and residual energy. Currently, we set in (5) to 0.2 to estimate the future power consumption. The choice of this value is based on empirical analysis of sensitivity.

In the prototype evaluation, we used the NAT-based switching technique to manage handoffs, which is described in Section 4. All nodes were stationary and close to each other (i.e., within the Bluetooth range) during the experiments. Unless otherwise specified, we set the default role switching period T_{RN} to 120 seconds for all experiments. The effect of these time values will be discussed in Section 5.2.2.

3.1.1 Node Role and Power Consumption

To understand the effect of node roles on power consump-tion, we organized a two-node cluster using two UFCs. The initial energies of both nodes were set to be equal. Neither of them generated network traffic, i.e., all nodes were idle, during the experiment. We assumed a group networking scenario in this experiment: thus, the cost function of (4) is used. Since the UFCs were set to have exactly the same conditions, they just rotated their roles every 120 (T_{RN}) seconds. We measured the time-varying behavior of the power consumption of the two UFCs (UFC1 and UFC2) according to their roles.

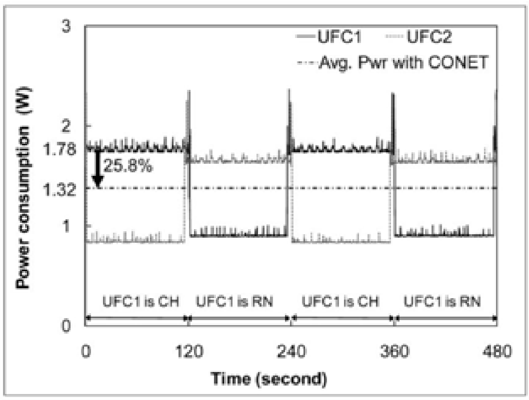


Fig. 6.Time-varying power consumption according to the node roles.

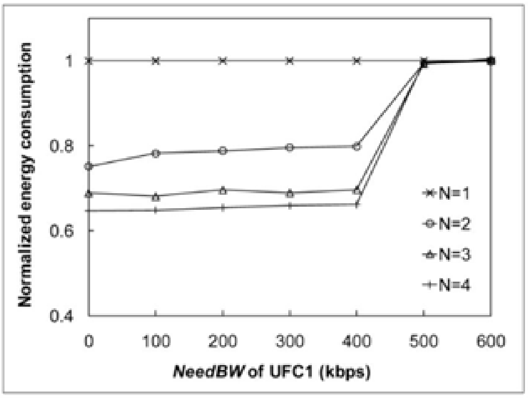


Fig. 7. Effects of the number of nodes (N)

Fig. 6.Time-varying power consumption according to the node roles.

UFC1 cannot be the RN because its requirement cannot be satisfied by other nodes. As presented in Table 1, the effective maximum data rate of Bluetooth is 440 kbps. Therefore, when UFC1's NeedBW is 500 or 600 kbps, it should always use its WLAN regardless of N, consuming as much energy as the baseline.

energy. Fig. 10 shows that activating the WLAN interface of a UFC takes about 3.8 seconds and consumes about 3,620 mJ of additional energy. Fig. 11 shows the power consumption when a CH becomes an RN. Turning off the WLAN interface also includes time and energy overhead for disabling the WLAN interface, unloading the WLAN device driver, and modifying NAT and route configuration. For a UFC, the time to completely switch from CH to RN is about 1.4 seconds, and the amount of additional energy is about 830 mJ.

3.2.Evaluation with Simulation

In this section, we evaluate the performance of CONET via simulations. Unless otherwise specified, we assume that 100 nodes are uniformly dispersed into a 70 70 meter field. Because it is unrealistic to assume that all 100 nodes have the same purpose (like sensor networks) of prolonging the group lifetime, we only consider individual networking in this simulation. An ordinary WLAN access point is located at (0, 0). We assume that the WLAN and Bluetooth

the overhead in role switching from RN to CH. In the ideal role switching from CH to RN, the WLAN interface is enabled immediately without any preparation processes, and the power curve rises vertically (like a step pulse). In the real case, however, several seconds of time are required to activate the WLAN interface and load the corresponding

Fig. 7. Effects of the number of nodes (N) and the bandwidth requirement (NeedBW) on energy efficiencole with UFC2 every 120 seconds, UFC1 consumed about 1.32 watts on average. Compared to the traditional WLAN-only communication, both UFC1 and UFC2 can reduce energy consumption by 25 percent.

3.1.2 Number of Nodes and Data Rates

To evaluate the effects of the number of nodes (N) on the performance, we varied N from 1 to 4. All nodes are sufficiently close (i.e., within the Bluetooth range) to each other: thus, they could be grouped into the same cluster. We also investigated the effects of bandwidth requirements (NeedBW). A traffic generator, D-ITG, was ported on UFC1 and generated Poisson distributed TCP traffic of various data rates to the test server. The test server is directly connected to the AP with an Ethernet cable; thus, the data rate is not limited by any external networks. We varied the data rate of UFC1 from 0 to 600 kbps. Other UFCs stayed in the idle state during the experiments. We performed experiments on group networking scenarios with the same initial energies for all nodes. Therefore, clustered nodes rotated their roles every 120 (T_{RN}) seconds in a round-robin manner. We measured the energy consumption of UFC1 for 16 minutes for each case. The experiment results are shown in Fig. 7. Each curve was normalized to energy consumed by UFC1 when there was no other nodes with which to cooperate (i.e., N is 1).

When the number of nodes (N) is 1, UFC1 should use its WLAN interface from that point on, as it does in traditional networking. This case is a baseline for comparison. As N increases, the energy consumption of UFC1 decreases if its NeedBWdoes not exceed the bandwidth limit of Bluetooth.For example, when its NeedBW is 200 kbps, UFC1 consumes only 78 percent (N¼ 2), 70 percent (N¼ 3), and 65 percent (N¼ 4) of the baseline. This is because, as the number of cooperating nodes increases, UFC1 can spend more time as an RN. However, when its NeedBW exceeds the Bluetooth limit,

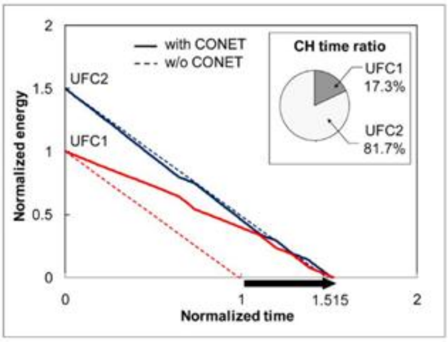


Fig. 8.Extension of the group lifetime of a two-node cluster.

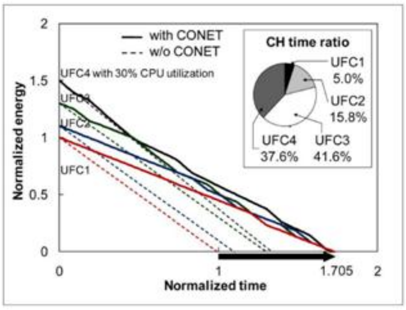


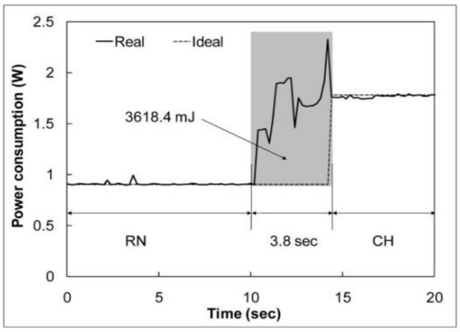
Fig. 9.Extension of the group lifetime of a four-node cluster. UFC4 has an extra CPU load

Traditional lifetime of UFC1. The result shows that CONET extends the group lifetime by about 52 percent. During the experiment, UFC2 became the CH more frequently than UFC1 because of UFC2's higher initial energy. The pie diagram shows that UFC2 was the CH for 82 percent of the total lifetime, while UFC1 for only 18 percent. It is important to note that although UFC2 spent most of the time as the CH, its lifetime was also slightly lengthened by about 1.5 percent. This is because the energy saved by turning the WLAN off for a few periods is much larger than the overhead of clustering operations, such as role switch-ing. Section 5.1.4 discusses the overhead in detail.

Next, we increased the number of UFCs to four and performed the same experiment. An additional CPU-intensive load that requires a 30 percent CPU usage, on average, was given to UFC4, whose initial battery is the largest among the UFCs; therefore, UFC4's battery will be consumed more rapidly than others. The CPU load reflects a situation where one of the UFC users in the same group performs another task, such as watching a movie or listening to music with her UFC, while playing an online game simultaneously. Fig. 9 shows the results. Because the future lifetime of each UFC is estimated by using both the current and past power usage, even when UFC4 has the highest energy, UFC3 was frequently selected as the next CH. This experiment proves that the implemented CH election mechanism works correctly according to the algorithm described in Section 3.2.1. As a result, the group lifetime of this cluster is extended by about 70 percent.

3.1.3. Switching Overhead

When an RN becomes a CH, it should turn on its WLAN interface, load the appropriate software, such as a devicedriver, and modify its network settings. This sequence of jobs incurs overhead in terms of time and energy. Fig. 10 shows software mdules.



.

Fig. 10.Overhead of switching from RN to CH.

Fig. 13 illustrates the relation between the node density and energy saving. It shows the cluster organizations and average cluster sizes (the average number of nodes in a cluster) according to the total number of nodes. When the number of nodes is 25, the portion of trivial CHs is about 31 percent, which means that only 69 percent of the nodes cooperate with other nodes on average. This is because when the nodes are sparsely distributed, each node is likely to find no neighboring nodes for cooperation. As a result, the

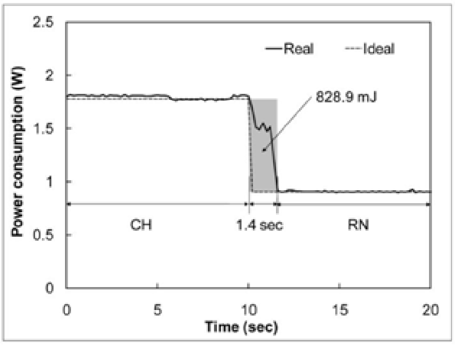


Fig. 11.Overhead of switching from CH to RN.

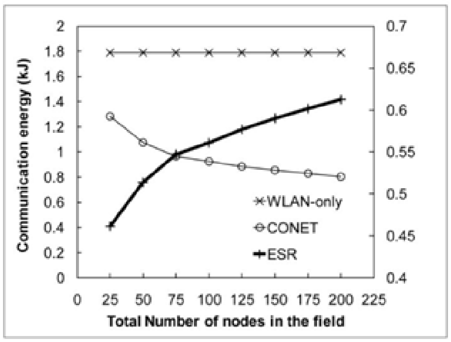


Fig. 12.Effects of the node density on the average communication energy and energy saving ratio (ESR).

Communication ranges are 100 and 10 meters, respectively. Therefore, all nodes can communicate with the access point anywhere in the field using their WLAN interfaces. We do not consider the multirate support of WLAN, i.e., the maximum bit rate of WLAN is constant (54 Mbps).

The motion of the nodes follows the Random WaypointMovement with Pause model . In the beginning, nodes areuniformly distributed over the entire field. Then, each node randomly chooses a location as a next destination (way point). The distribution of the way points is uniform. At the same time, the node randomly picks a velocity between 0.5 and 2.0 m/s. Then, it moves to the destination with the chosen speed. After arriving at the destination, the node pauses for a random period between 30 and 600 seconds. Every node repeats the above procedure until the simulation ends.

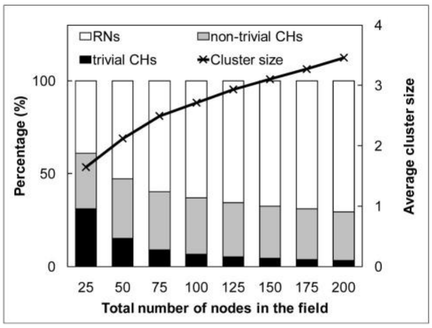
At the beginning of each pause period, a node triggers the CBR traffic of a random data rate between 0 and 1,000 kbps. This CBR traffic lasts for a random period between 0 and 120 seconds. The node then has a random think time between 0 to 60 seconds. If the node is still in the pause period after the think time, it initiates more random CBR traffic. Note that a node can have traffic while it is moving if its last traffic is not terminated before the pause period ends. This procedure is repeated until the simulation ends. The parameter values used in the simulation are summarized in Table 3. The simulation time is 1,800 seconds for each experiment.

3.2.1 Effects of Node Density

We vary the number of nodes in the field from 25 to 200 to study how CONET works with low to high node density. Fig. 12 shows the effects of the node density on the communication energy consumption and the energy saving ratio (ESR). In traditional WLAN-only networking, each node consumes about 1.79 kJ on average, regardless of the number of nodes. In CONET, on the other hand, energy consumptiondecreases as the node density increases because more nodes can be grouped into a cluster and share WLAN interfaces. A node belonging to a larger cluster can spend more time as an RN.

For example, when there are 100 nodes using CONET, the average energy consumption of each node is about 0.93 kJ.

This is only 52 percent of the energy consumed in WLAN-only networking, showing an energy savings of approxi-mately 48 percent. Observe that the ESR value, which is 56 percent (0.56) for the 100 nodes case, is slightly higher than 48 percent. This is because, as discussed in Section 3.2.2, the ESR is calculated using only energy consumed during cooperation with at least one node, i.e., energy consumed when the node is a trivial CH is removed from the ESR calculation. As the number of nodes increases from 100 to 200, the ESR also increases from 0.56 to 0.61 because each node can spend more time as an RN.



4.CONCLUSION AND FUTURE WORK

In this paper, we have presented CONET, a bandwidth-aware and energy-efficient clustering protocol for multi-radio mobile networks. CONET uses Bluetooth to reduce the power consumption of WLAN in mobile devices. It dynamically reconfigures the clusters based on the band-width requirements of applications to avoid the performance degradation. We have classified the applications into two cases: group networking and individual networking. CONET runs the same election algorithm for both cases, but uses different cost functions. CONET maximizes the group lifetime for the group networking case and fairly distributes the energy gain among all nodes for the individual networking case. One key feature of our approach is that it does not require modifications to existing wireless environments, paving the way to easy deployment. Although this paper describes CONET based on WLAN/ Bluetooth, we believe that it can be easily extended to other interface combinations, such as WiMAX/Bluetooth.

CONET can be applied to advanced types of sensor networks in which nodes have multiple radio interfaces [10]. Although we have only provided algorithms for one-hop clustering, we can extend our protocol to support multihop clustering. This can be achieved by applying general multihop clustering algorithms, such as Max-Min D-Cluster formation.

REFERENCES:

[1] E. Shih, P. Bahl, and M.J. Sinclair, “Wake on Wireless: An Event Driven Energy Saving Strategy for Battery Operated Devices,”
Proc. ACM MobiCom, pp. 160-171, 2002.

[2] P. Bahl, A. Adya, J. Padhye, and A. Wolman, “Reconsidering Wireless Systems with Multiple Radios,” ACM SIGCOMM Computer Comm. Rev., vol. 34, no. 5, pp. 39-46, 2004.

[3] Y. Agarwal, R. Chandra, A. Wolman, P. Bahl, K. Chin, and R. Gupta, “Wireless Wakeups Revisited: Energy Management for VoIP over Wi-Fi Smartphones,” Proc. ACM MobiSys, pp. 179-191, 2007.

[4] Y. Agarwal, C. Schurgers, and R. Gupta, “Dynamic Power Management Using on Demand Paging for Networked Embedded Systems,” Proc. Asia South Pacific Design Automation Conf., vol. 2, pp. 755-759, 2005.

[5] S.M. Kim, J.W. Chong, B.H. Jung, M.S. Kang, and D.K. Sung, “Energy-Aware Communication Module Selection through ZigBee Paging for Ubiquitous Wearable Computers with Multiple Radio Interfaces,” Proc. Int’l Symp. Wireless Pervasive Computing, pp. 37-41, 2007.

[6] T. Pering, Y. Agarwal, R. Gupta, and R. Want, “CoolSpots: Reducing the Power Consumption of Wireless Mobile Devices with Multiple Radio Interfaces,” Proc. ACM MobiSys, pp. 220-232, 2006.

[7] Y. Agrawal, T. Pering, R. Want, and R. Gupta, “SwitchR: Reducing System Power Consumption in a Multi-Client, Multi-Radio Environment,” Proc. IEEE Int’l Symp. Wearable Computers, pp. 99-102, 2008.

[8] M. Anand and J. Flinn, “PAN-on-Demand: Building Self-Organizing WPANs for Better Power Management,” Technical Report CSE-TR-524-06, Dept. of Electrical Engineering and Computer Science, Univ. of Michigan, 2006.

[9] A. Chaman and S. Pierre, “On the Planning of Wireless Sensor Networks: Energy-Efficient Clustering under the Joint Routing and Coverage Constraint,” IEEE Trans. Mobile Computing, vol. 8, no. 8, pp. 1077-1086, Aug. 2009.

[10] D. Lymberopoulos, N.B. Priyantha, M. Goraczko, and F. Zhao, “Towards Energy Efficient Design of Multi-Radio Platforms for Wireless Sensor Networks,” Proc. ACM Int’l Conf. Information Processing in Sensor Networks, pp. 257-268