Enhancement of Power Consumption Efficiency and Channel Resource Utilization for Mobile Communication

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Abstract — Unlike wired networks, data transmissions on wireless channels are often subject to burst errors which results in retransmissions and unnecessary battery power consumption in the mobile terminals. In this paper, we study a reservation based, power efficient access control scheme for mobile data transmissions. The proposed procedure monitors and assigns channel resources to the mobiles that are experiencing good channel conditions, and defers channel access of those mobiles that are in bad channel condition for a period of time (dormant period). We simulate different scheduling policies and analyzes one of them. The channel condition is characterized by first order Markov model. We introduce the Throughput per Power Unit as a performance metric for battery power consumption efficiency with respect to data transmission. Both theoretical and simulation results show the proposed control scheme outperforms the non-adaptive data transmission control scheme with respect to both throughput per power unit and the channel resource utilization.

I. INTRODUCTION

We propose a power efficient Channel Condition Adaptive Resource Assignment (CCARA) procedure. CCARA, the proposed reservation based access protocol performs slot-by-slot channel condition estimation. CCARA assigns channel resources to the mobiles that are in good channel condition, and suspends channel access of those mobiles that are in bad channel condition for a period of time (dormant period). Ideally, the channel resources can be efficiently utilized by encouraging mobiles in good channel condition to transmit data, and battery energy can be conserved for those mobiles that are in bad channel condition by not transmitting data during the burst error period. However, the length of burst error period is unknown, therefore, the proposed protocol allows the dormant mobiles to send data packet periodically to probe the channel condition. Longer dormant period saves power but increases delay. Hence, the length of dormant period should be properly chosen to conserve mobile battery power and to meet the system delay requirement.

II. PROTOCOL DESCRIPTION

To implement the CCARA procedure, the base station maintains two operating lists, the Active list and the Dormant list. The Active list contains those mobiles that are eligible for channel resource assignment. Whereas the Dormant list contains mobiles that are waiting for their corresponding Dormant Period to expire. The value of Dormant Period Expiration Timer (DPET) decrements by one for each elapsed time slot. When a dormant mobile's DPET reaches 0, it is moved from the Dormant list to the Active list by the base station.

III. RESOURCE SCHEDULING POLICIES

To schedule mobiles in the Active list for resource assignment, we have studied and performed simulations based on five different scheduling policies, Randomly Pick (RP) policy, Round Robin (RR) policy, Longest Queue First (LQF) policy, Shortest Queue First (SQF) policy, and Hybrid policy. The RP policy chooses mobiles randomly from the Active list for channel assignment, the RR policy chooses mobiles from the Active list by using Round Robin scheme, and both the LQF and the SQF policies choose mobiles from the Active list based on their respective queue length. As for Hybrid policy, it is a mix of RP policy and SQF policy, RP policy is used when the average queue length is less than a predetermined threshold $T_1$, once the average queue length exceeds $T_1$, SQF policy is used instead, whenever the standard deviation on fairness exceeds $T_2$, the scheduling policy is switched back to RP. In the case of dormant period $n = 0$, the SQF policy has the best performance on average packet delay in heavy traffic load, but has the worst performance on fairness. As for Hybrid policy, with $T_1 = 10$, and $T_2 = 0.2$, it maintains the same average packet delay as that of the RP policy for packet arrival rate less than 5.2, and outperforms the RP policy for packet arrival rate greater than 5.2. The $SDF$ of Hybrid policy is as good as that of RP policy in light traffic load, and outperforms the SQF policy in heavy traffic load. The differences in delay and fairness for the different scheduling policies diminish as $n$ increases. Furthermore, the throughput per power unit increases as we increase $n$, and the throughput per power unit of different scheduling policies are very close to one another. Hence, we perform analytical evaluation on the proposed protocol by using the least complex policy, Randomly Pick (RP) policy.

IV. RESULTS

The length of dormant period $n$ is an important design parameter, it affects the efficiency of mobile battery power consumption on data transmission as well as average packet delay. Our results showed the proposed CCARA scheme outperforms the non-adaptive resource allocation scheme in both the throughput per power unit and the channel resource utilization by properly choosing $n$. Furthermore, the larger the length of error bursts, the better the improvement in using the proposed CCARA scheme. For a channel characteristic modeled by the first order Markov chain with transition probability $p_{BG} = 0.92, p_{BG} = 0.08, p_{BB} = 0.2, p_{BB} = 0.8$. If the system's average packet delay criteria is 40 slots, choosing $n = 2$ instead of $n = 0$, on average, we can reduce power consumption by 17%, and increase system capacity (channel resource utilization) by 18%.