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A Survey on Dual-Radio Opportunistic Networking for Energy Efficiency

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Abstract— over the past few years the concept of Traffic-Aware Techniques for energy reducing in Wireless network is an important issue. A large portion of the energy is consumed by unnecessarily keeping the mobile device's radio in its "Active" mode even when there is no traffic. The 3G\LTE wireless interface is a very significant contributor in the field of energy efficient battery drain devices. Since many years researchers have been contributed their efforts to study the energy related issues in the field of DRONEE. Here in this paper we have described the dual-opportunistic networking for energy efficiency which is very much useful in the field of uplink transmission. In this paper we have discussed about the power consumption optimization techniques which are applicable to the smart phones as they have become an indispensable component of our daily life activities. In this paper we have presented a novel scheme that is called DRONEE that dramatically make the uplink transmissions very much energy efficient and energy efficient, while achieving near-optimal throughput and high fairness levels in cellular networks.

Keywords— LTE, Wi-Fi Direct, Virtual Machine, Hybrid Networks, Opportunistic Networking

I. Introduction

The study benefits of a quantitative is that mobile relays can provide to the wireless infrastructure – namely, extension of base station coverage and enhancement of wireless connection throughput. For connect directly to a base station, or, as an alternative, the end user can choose to establish a two-hop link using a relay. With random motion there is a two Relay locations are modeled as realizations of dimensional Poisson process and their availability is analyzed to forward as such messages received from a base station or from an end user. To the usual diffusion of the signal wave front PATH loss is indication attenuation appropriate, absorption, and diffraction. Apart from for very individual scenarios (e.g., a propagation environment resembling a waveguide), among the transmitter and the receiver indicator reduction is comparative to at least the square of the distance. In low throughput or poor reliability, or possibly both the Remote receivers can know-how severe signal attenuation, consequential. Relaying – when applied prudently into several shorter and thus less attenuated paths – can break one severely attenuated signal propagation path. Relaying is not always beneficial; it is worth noting, why fewer, longer hops may (depending on the scenario) be preferable to more, shorter hops is Haenggi considers some reasons. However, in the recent literature the potential advantages of relaying have motivated many papers. For wireless local area networks and 802.16j networks, optimal relay placement, respectively. One hop versus two hop routing was compared, and the author characterized the area in the two-dimensional plane where a deployed relay could provide an improvement in spectral efficiency, the relative advantages. In the design phase the relays are "fixed" in that their locations are either predetermined or optimized. In the literature Mobile relays have been less well studied. Wireless infrastructure using Enhancements to the mobile relays have been considered. However, these results are based on simulation and apply only to the particular cases considered. Mobile phones are ubiquitous today with an estimated cellular subscription of over 4 billion worldwide. Most phones today support one or more of 3G, GSM, and Wi-Fi for data transfer. For example, the penetration of 3G is estimated at over 15% of cellular subscriptions worldwide and is over 70% in some countries. How do the energy consumption characteristics of network activity over 3G, GSM, and Wi-Fi on mobile phones compare with each other? How can we reduce the energy consumed by common applications using each of these three technologies? To investigate these questions, we first conduct a detailed measurement study to quantify the energy consumed by data transfers across 3G, GSM, and Wi-Fi. We find that the energy consumption is intimately related to the characteristics of the workload and not just the total transfer size, e.g., a few hundred bytes transferred intermittently on 3G can consume more energy than transferring a megabyte in one shot. Below is a summary of the key findings of our measurement study, which remain consistent across three different cities, diurnal variation, mobility patterns, and devices [1].

The 3G/LTE radio consumes significant amounts of energy; on the iPhone 4, for example, the stated talk time is "up to 7 hours on 3G" (i.e., when the 3G radio is on and in "typical" use) and "up to 14 hours on 2G".1 On the Samsung Nexus S, the equivalent numbers are “up to 6 hours 40 minutes on 3G” and “up to 14 hours on 2G”.2 That the 3G/LTE interface is a battery hog is well-known to most users anecdotally and from experience, and much advice on the web and on blogs is available on how to extend the battery life of your mobile device[2]. In this paper we have presented many techniques related to the power consumption optimization.

II. Analysis of Power Consumtion Optimization Techniques

The sensor output is usually an analog signal. After signal conditioning (amplification, filtering) and digitization, data are processed locally in the node. As a result, a packet is eventually sent to the network using a transmitter circuit. The signal level needs to be amplified before reaching the antenna and propagated through a dispersive medium, such as water or air (which does not generate as many losses as water). This guarantees an acceptable signal level at the receiver input. In addition, adequate modulation techniques should be implemented in order to minimize the loss of information. The inverse system is implemented at the receiver node. The first stage is an amplifier or attenuator that sets the input level at the receiver circuit. The receiver applies the appropriate demodulation to obtain the original bit sequences, which are interpreted by the node. A first, obvious measure consists of adjusting the transmission power to the characteristics of the propagation path, like attenuation and range. Other more sophisticated techniques can be used, like preventing the duplication of packets in the network by using specialized routing protocols. A frequently used approach is to control the node activity, switching the operation mode between active, idle and sleep modes. The processor consumes the most amount of energy in the active mode. In this mode the device can receive and send data and control packets and can perform data processing. Equation 1 represents this energy value as Ptx_e and Ptx_e. In sleep mode, a device consumes the least amount of energy as the transmitter is turned off, the frequency of the main processor may be reduced and it is not possible to realize any processing operation. A considerable amount of time is required to enter and exit this mode. An intermediate state for a node, between active and sleep, is the idle state. In this mode, a device consumes less energy than in the active mode, as no data processing can take place. The device can quickly enter and exit this mode.

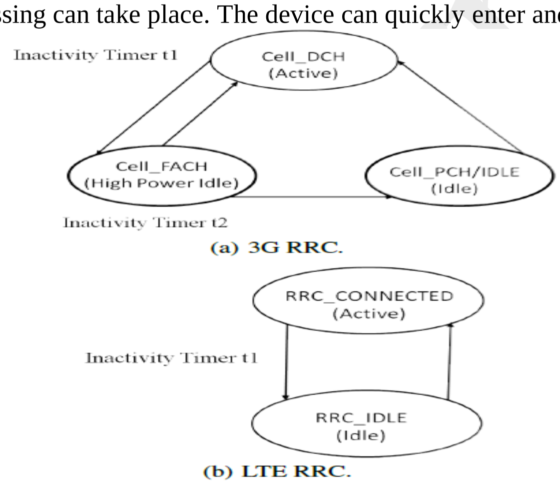

Fig. 1. Radio Resource Control (RRC) State Machine

In this section, we will review the most well-known routing protocols for WSNs that are related to energy saving techniques

A. Energy Aware Routing protocol –

EAR Energy aware routing protocol is a reactive protocol that aims to increase the lifetime of the network. This protocol seeks to maintain a set of paths instead of maintaining or enforcing one optimal path at higher rates, although the behaviour of this protocol is similar to directed diffusion protocols. These routes are selected and maintained by a probability factor. The value of this probability depends on the lowest level of energy achieved in each path. Because the system has several ways to establish a route, the energy of a path cannot be determined easily. Network survivability is the main metric of this protocol. The protocol assumes that each node is addressable through a class-based addressing scheme which includes the location and the type of nodes. When the protocol starts, there is a process of flooding, which is used to discover all the routes between various source/destination pairs and their costs. This will allow creating routing tables, where high-cost paths are discarded. By using these tables, data is sent to its destination with a probability that is inversely proportional to the cost of the node. The destination node performs a localized flooding in order to maintain the paths that are still operative. Compared to other protocols, the energy aware routing protocol provides an overall improvement of 21.5% in energy savings and increases the network life by about 44%.

However, having to collect location information, and the establishment of the steering mechanism for nodes, complicates the path settings.

B. Low Energy Adaptive Clustering Hierarchy – LEACH

A hierarchical clustering algorithm for sensor networks called Low Energy Adaptive Clustering Hierarchy (LEACH). It is a clustering based protocol that includes the formation of distributed groups. It randomly selects a few nodes as cluster heads (CHs) and rotates this role to evenly distribute the energy load among the nodes of the network. In LEACH, CH nodes compress the data arriving from the nodes in their respective groups, and send summary packets to the base station. This reduces the amount of information transmitted to the base station. Data collection is centralized and is carried out periodically. Therefore, this protocol is appropriate when constant monitoring of the WSN is needed. The operation of LEACH is separated into two phases, the setup phase and the steady-state phase. In the setup phase the groups are organized and certain fraction of nodes are elected as CHs. In the steady-state phase, data transfer to the base station occurs. All elected CHs announce to the other nodes of the network, through a broadcast message, that they are the new CHs. All non-CH nodes, after receiving this notice, choose the group they want to belong to. This decision is based on the intensity of the warning signal. Non-CH nodes inform the appropriate CHs that it is a member of their group. After receiving all messages from the nodes that wish to be included in the cluster, the CH node creates a TDMA program and assigns to each node a time slot to transmit data. This program is broadcasted to all nodes in the cluster. During the steady state, the sensor nodes can sense and transmit data to the CHs. The CH node, after receiving all data, adds its information and sends it to the base station. After some time, which is determined a priori, the network returns to the setup phase again and starts another round of new CHs election. Each group communicates using different CDMA codes in order to reduce interference with nodes that belong to other groups.

C. Hybrid Energy-Efficient Distributed clustering- HEED

HEED (*Hybrid Energy- Efficient Distributed clustering)* periodically selects the Main nodes in the cluster according to a set of parameters such as residual energy and a secondary endpoint. It also seeks to extend the network lifetime by distributing energy consumption. It also tries to reduce high control on the network. The authors explain the grouping process and the determination of the responsible node. System does not take care of the type of technology used. This work compares HEED protocol with others. HEED optimizes the use of resources according to the network density and the application requirements.

D. Hierarchical Power-Aware Routing (HPAR)

The Hierarchical Power-Aware Routing (HPAR) protocol bases its operation on the division of the network into groups of sensors. Each group is formed by geographically close sensors covering a zone. Each zone is treated as an entity. In order to perform the routing between nodes, each zone is allowed to decide how a message is routed through the other areas, so maximizing the battery life of the nodes. Messages are routed along the path that has the maximum value on all the remaining minimum power values. This route is called max-min path. In order to send a message through an area, the route through the area and the sensors involved in estimating the power level of the area should be found. Each message is routed through the areas with the information about the estimation.

III. PRIOR STUDY

Balasubramanian et al. [1] presented a measurement study of the energy consumption characteristics of three widespread mobile networking technologies: 3G, GSM, and WiFi. They find that 3G and GSM incur a high tail energy overhead because of lingering in high power states after completing a transfer. Based on these measurements, they develop a model for the energy consumed by network activity for each technology. They also develop Tail Ender, a protocol that reduces energy consumption of common mobile applications. For applications that can tolerate a small delay such as e-mail, Tail Ender schedules transfers so as to minimize the cumulative energy consumed while meeting user-specified deadlines.

Deng et al. [2] described the design of methods to reduce this portion of energy consumption by learning the traffic patterns and predicting when a burst of traffic will start or end. They develop a technique to determine when to change the radio’s state from Active to Idle, and another to change the radio’s state from Idle to Active. In evaluating the methods on real usage data from 9 users over 28 total days on four different carriers, they find that the energy savings range between 51% and 66% across the carriers for 3G, and is 67% on the Verizon LTE network. When allowing for delays of a few seconds (acceptable for background applications), the energy savings increase to between 62% and 75% for 3G, and 71% for LTE.

Huang et al. [3] developed the first empirically derived comprehensive power model of a commercial LTE network with less than 6% error rate and state transitions matching the specifications. Using a comprehensive data set consisting of 5-month traces of 20 Smartphone users, they carefully investigate the energy usage in 3G, LTE, and WiFi networks and evaluate the impact of configuring LTE-related parameters. Despite several new power saving improvements, they find that LTE is as much as 23 times less power efficient compared with WiFi, and even less power efficient than 3G, based on the user traces and the long high power tail is found to be a key contributor. In addition, they perform case studies of several popular applications on Android in LTE and identify that the performance bottleneck for web-based applications lies less in the network.

Garcia-Saavedra et al. [4] provided an in-depth experimental investigation of the per-frame energy consumption components in 802.11 Wireless LAN devices. To the best of their knowledge, their measurements are the first to unveil that a substantial fraction of energy consumption, hereafter descriptively named cross-factor, may be ascribed to each individual frame while it crosses the protocol/ implementation stack (OS, driver, NIC). Their findings, summarized in a convenient new energy consumption model, contrast traditional models which either neglect or amortize such energy cost component in a fixed baseline cost, and raise the alert that, in some cases, conclusions drawn using traditional energy models may be fallacious.

Sendonaris et al. [5] presented a new method of transmit diversity for mobile users: user cooperation. The type of cooperation they focused on was the cooperation of active users, that is, users who have information of their own to send, and thus, do not want to simply be another user's relay. Results indicate that user cooperation is beneficial and can result in substantial gains over a non cooperative strategy. These gains are two-pronged; a higher data rate and a decreased sensitivity to channel variations.

Bandyopadhyay and Coyle [6] proposed a distributed, randomized clustering algorithm to organize the sensors in a wireless sensor network into clusters. They then extend this algorithm to generate a hierarchy of cluster heads and observe that the energy savings increase with the number of levels in the hierarchy. Results in stochastic geometry are used to derive solutions for the values of parameters of their algorithm that minimize the total energy spent in the network when all sensors report data through the cluster heads to the processing center.

Ramabhadran et al. [7] illustrated a novel packet scheduler called Stratified Round Robin, which has low complexity, and is amenable to a simple hardware implementation. Stratified Robin Robin exhibits good fairness and delay properties that are demonstrated through both analytical results and simulations. In particular, it provides a single packet delay bound that is independent of the number of ows. This property is unique to Stratified Round Robin among all other schedulers of comparable complexity.

Gummeson et al. [8] argued that the pairing of two complementary radios with heterogeneous range characteristics enables greater range and interference diversity at lower energy cost than a single radio. They make three contributions towards the design of such multi-radio mobile sensor systems. First, they present the design of a novel reinforcement learning-based link layer algorithm that continually learns channel characteristics and dynamically decides when to switch between radios. Second, they describe a simple protocol that translates the benefits of the adaptive link layer into practice in an energy-efficient manner. Third, they present the design of Arthropod, a mote-class sensor platform that combines two such heterogneous radios (XE1205 and CC2420) and their implementation of the Q-learning based switching protocol in TinyOS 2.0.

Han and Srinivasan [9] proposed an energy efficient device discovery protocol, eDiscovery, as the first step to bootstrapping opportunistic communications for smart phones, the most popular mobile devices. They chose Bluetooth over WiFi as the underlying wireless technology of device discovery, based on their measurement study of their energy consumption on smart phones. EDiscovery adaptively changes the duration and interval of Bluetooth inquiry in dynamic environments, by leveraging history information of discovered peers.

Wirtz et al. [10] presented a truly spontaneous, broadcast, and ubiquitous communication channel, enabling association-less data exchange concurrent to bandwidth-intensive purpose-driven or incumbent 802.11 networking. Flexible addressing and message aggregation enable efficient co-existence of multiple applications for heterogeneous ubiquitous mobile communication. CA-Fi presents a tradeoff between preserving up to 70% of 802.11 throughput and association-less data rates of up to 30 kB/s without 802.11 networking time overhead.

Aditya et al. [11] introduced EnCore, a mobile platform that builds on secure encounters between pairs of devices as a foundation for privacy-preserving communication. An encounter occurs whenever two devices are within Bluetooth radio range of each other, and generates a unique encounter ID and associated shared key.

Lymberopoulos et al. [12] demonstrated that a proper pairing of processor and radio is crucial for taking the full advantage of the energy efficiency of higher bandwidth radios. The processor/radio pairing affects the energy balance of a sensor node, thus making the design of dynamic switching among multiple radios more challenging. Second, they demonstrate and quantify the impact of network traffic on energy consumption of a sensor node while varying network parameters, and illustrate the deficiency of existing energy-optimizing protocols.

IV. Research Issues

Saving energy and the communication of the data sensed by the nodes are two major issues in the wireless networks. Each node must consume little power and should work on low operating and system cost to maintain a large scale deployment of wireless sensor networks. Antenna and radio frequency transceiver are used for communication of sensor nodes with other nodes. Sensor nodes contain a memory unit, a CPU, the sensor unit, and the power source which is usually supplied by batteries. Many applications need sensor nodes to be designed as tiny as possible to create a small network suitable for any location. The small size of sensor nodes is beneficial for many situations but the small space also means the availability for battery capacity is small. A small network structure also provides another benefit of a reduced transmission range between nodes. The main focus for wireless sensor networks is mostly on energy conservation through various optimization techniques. These techniques should concentrate on communication and operation management as the power consumption needed for communication typically dominates a node’s power budget. In some applications there is a minimum need for sensing activity for most of the time and sometimes there is a need for strong sensor processing at particular instants. In such cases, there will be large variation of workloads. Energy awareness must be included into groups of communicating sensor nodes of the entire network as well as into the individual nodes in such applications

V. Conclusion

In this research paper we have presented and described a new concept of seamlessly interwork LTE and WiFi in hybrid networks. What approach we have taken that brings significant improvement not only in terms of energy efficiency, but also in terms of throughput and fairness. We have also shown that our proposal could be implemented in a real system using LTE and WiFi technologies. It is shown that our proposal is effective in several scenarios, spanning from single cell scenarios to multiple cells, with variable cell populations and with variable and heterogeneous distributions of user qualities. In particular, DRONEE-W has very desirable properties compared to other schemes. DRONEE-

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