LOW POWER NETWORK LAYER DESIGN FOR WCN APPLICATIONS

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Abstract- Vitality effective remote correspondence arrange configuration is a significant and testing issue. Its trouble lies in the way that the general execution depends, in a coupled way, on the accompanying subsystems: radio wire, power enhancer, tweak, blunder control coding, and system conventions. Also, given a vitality imperative, improved activity of one of the previously mentioned subsystems may not yield better by and large execution. Consequently, to enhance execution one must record for the coupling among the above subsystems and at the same time advance their activity under a vitality constraint. In this article we present a nonexclusive coordinated structure technique that is appropriate for some sorts of versatile frameworks and accomplishes worldwide improvement under a vitality requirement. By calling attention to some significant associations among various layers in the structure strategy, we clarify why our coordinated plan approach is superior to conventional plan methodologies. We present numerical consequences of the utilization of our plan philosophy to a situational mindfulness situation in a versatile remote system with various portability models. These outcomes outline the improvement in execution that our incorporated plan strategy accomplishes over conventional structure techniques, and the tradeoff between vitality utilization and execution.

Keywords*: wireless, energy,DC,power*

I.INTRODUCTION

Energy-efficient wireless communication network design is an important and challenging problem. It is important because mobile units operate on batteries with limited energy supply. It is challenging because there are many different issues that must be dealt with when designing a low-energy wireless communication system (e.g., amplifier design, coding, modulation design, resource allocation, and routing strategies strategies), and these issues are coupled with one another. Furthermore, the design and operation of each component of a wireless communication system present trade-offs between performance and energy consumption. The key observation is that constraining the energy of the nodes in a wireless network imposes a coupling among the design components that cannot be ignored in performing system optimization. Therefore, the challenge is to exploit the coupling among the various components of a wireless communication system and understand the trade-off between performance and energy consumption in each individual component/subsystem in order to come up with an overall integrated system design that satisfies an energy constraint and has optimal performance with respect to some performance metric.

Traditional design methodologies that optimize each layer separately may not be appropriate in terms of overall system optimality. The purpose of this article is to present a methodology for the design, simulation, and optimization of wireless communication networks that achieves maximum performance under an energy constraint. The presentation of our methodology also gives some insight as to why traditional design methodologiesmay not achieve overall system optimality.The integrated design methodology is applied to two scenarios of mobile ad hoc networks.

The results show that significant gains are possible with an integrated design approach over traditional designs.Before we proceed, we illustrate through simple examples the coupling among the different components of a wireless communication system, and highlight the trade-off between performance and energy consumption at individual components of the system. To illustrate the coupling among different components of a wireless communication system, we first need to describe some key features of the amplifier's operation. Consider the design and operation of an amplifier. The amplifier boosts the power of the intended transmitted signal so that the antenna can radiate sufficient power for reliable communication. However, typical power amplifiers have maximum efficiency in converting DC power into RF power when the amplifier is driven into saturation. In this region of operation, the amplifier voltage transfer functionis nonlinear. Because of this nonlinearity, the amplifier generates unwanted signals (so called intermodulation products) in the band of the desired signal and in adjacent bands.

When the amplifier drive level is reduced significantly (large backoff), the amplifier voltage transfer characteristic becomes approximately linear. In this case it does not generate intermodulation products. However, with large backoff the amplifier is not able to efficiently convert DC power into RF power. Thus, there is considerable wasting of power at low drive levels, whereas at high drive levels the amplifier generates more interfering signals.We can now illustrate the coupling among individual components arising in the design of a wireless system.

Consider packet routing in a wireless network that contains no base stations (i.e., an ad hoc network). For simplicity, consider a network with nodes A, B, and C, as shown in Fig. 1. If node A wants to transmit a message to node C, it has two options: Transmit with power sufficient to reach node C in a single transmission, or transmit first from A to B with smaller power, and then from B to C. Since the received signal power typically decays with distance as $d\alpha$, for α between 2 and 4, there is significantly smaller power loss due to propagation in the second option because $d\alpha\, AC > d\alpha\, AB + d\alpha\, BC$. However, even though node A transmits with smaller output power, it does not necessarily proportionally decreases the amount of power actually consumed because of the amplifier's effect discussed above. Furthermore, besides the energy required for packet transmission, there are energy requirements for packet reception and information decoding. The probability of packet error that is achieved depends on the energy allocated to the receiver. Thus the optimal network protocol (direct transmission from A to C or routing from A to B to C) depends on the amplifier characteristics as well as the energy needed to demodulate and decode a packet. Consequently, there is a coupling among amplifier design, coding and modulation design, decoding design, and routing protocols.

To highlight the tradeoff between energy consumption and system-wide performance, consider the situational awareness problem in a mobile wireless network. In this problem, the objective of each node is to be aware of the position of every other node during a given time period. If energy consumption is ignored, and the overall performance metric is the average (over all nodes and over time) position estimation error, this error is minimized when all nodes continuously communicate their positions with one another. Such a strategy requires significant energy. If, on the other hand, the objective is to minimize the average position estimation error under an energy constraint, the nodes will have to jointly decide when to communicate and whom to communicate to during the given period, since a continuous communication strategy would use all the available energy too quickly and could lead to large average position estimation error subsequent to the energy depletion of the battery.Traditional design methodologies for wireless communication systems that attempt to optimize each layer separately may achieve global system optimality only by coincidence. However, through an understanding of the interactions and coupling among the functions at the different layers, it is possible to design a wireless communication system in a manner that truly integrates the functions of all layers.

Therefore, we propose a methodology that decomposes the system into coupled layers and exploits the interactions among them to come up with an energy-efficient design. The goal of the decomposition, besides better understanding of the design procedure for global system optimality, is to obtain a computationally tractable approach to quantifying system performance with respect to different optimization criteria. Tackling such a problem can be a formidable task. We first present a methodology for system design that incorporates the effect of the different layers on system performance. This methodology is fairly general and can be applied to many different applications besides the situational awareness scenario we consider later in this article. We next describe the component models for the amplifier, propagation, coding, modulation, and network protocols for the system under investigation. After that we explain how global optimization works together with each system layer and present optimization results for the situational awareness application. We conclude the article with a summary and discussion about potential applications.

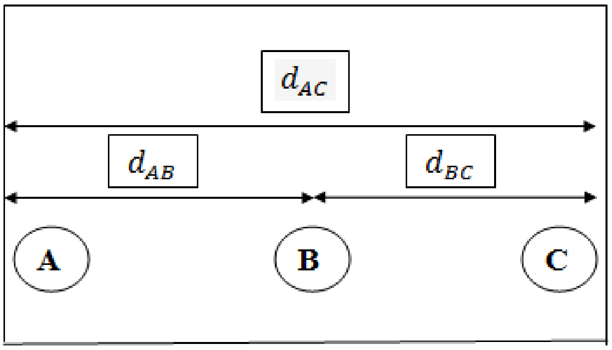

Fig .1. Three nodes in a network

II.PROPOSEDMODELS FOR SYSTEM DECOMPOSITION

We apply our integrated design methodology to a particular network design problem, namely, the situational awareness problem in wireless mobile networks. In the situational awareness problem a number of mobile nodes desire to keep track of the location of each other over some time duration.The nodes operate with batteries and thus have a finite energy constraint. The transmission of information by a node requires a certain amount of energy as does the processing of any received signal. The goal of the design is to minimize the mean absolute error of the position estimates. There is a plethora of parameters that could be considered for optimization. We focus on a small set of parameters to illustrate the design and simulation methodology. In addition, we describe the system decomposition and justify our choice of the coupling parameters among different layers. We present the system optimization in a later section. We proceed to describe each layer in a bottom-up manner.

2.1 The Device Layer

We present the model for the device layer and the coupling parameters between the device and processing layers. We justify why the coupling parameters we choose are appropriate for the wireless communication systems under investigation. While not all the components of a transmitter and a receiver have been considered in the model of this article, we have chosen a few parameters that have an important effect on the coupling among different layers and illustrate the trade-off between performance and energy consumption. At the device layer, we assume each node has an omnidirectional dipole antenna and a small power amplifier. Because the power amplifier is a major source of energy consumption and our global objective is to achieve high-precision situational situational awareness (i.e., low estimation errors) for every node under an energy constraint, it is important to understand the role of the amplifier power added efficiency in the overall optimization problem. Let *Pin* denote the input power, *Prf* the radiated power, and *Pdc* the consumed DC power. The power added efficiency is defined as

$$\text{Power added efficiency} = \frac{P_{rf} - P_{in}}{P_{dc}}$$

we consider the following parameters associated with an amplifier's operation: the total consumed power

Ptot, the output power *Pout*, and the AM-to-AM voltage characteristics [7]. We note here that the intermodulation interference also depends on the modulation scheme chosen and consider a nonconstant modulation scheme. For such a modulation scheme, we characterize the relation between the average amplifier output.power and the energy constraint *Ect* for transmitting
a packet by

$$Pout = g1(Ect).$$

This relation is tabulated for use by higher layers. In certain situations it is possible that the actual consumed energy at the transmitter, *Eta*, is less than the constraint on the consumed energy at the transmitter. In this case we define a function *Eta* =*g*2(*Ect*) that maps the energy constraint to the actual energy.

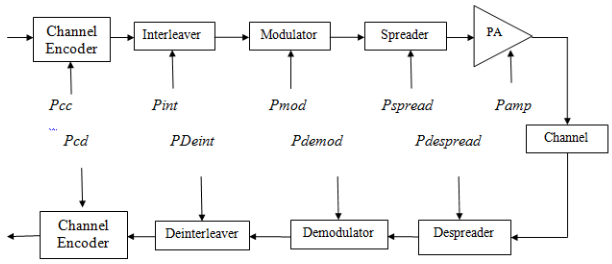

Fig.2. A processing layer block diagram

2.2 The Processing Layer

We describe the model used at the processing layer, discuss the coupling between the device and processing layers, and between the processing and network layers. More details about the specific design choices can be found in [8]. Our goal is not to model every part of this system but to understand the coupling between layers and the trade-off between performance (global and local) and energy. We first describe the basic block diagram of the processing layer, and discuss the performance-energy trade-offs of several elements in the block diagram. Finally, we describe precisely the optimization at the processing layer, and the coupling between the processing and network layers. The basic block diagram of the processing layer is shown in Fig. 2.

A block of information is presented to the channel encoder. The channel encoder adds redundancy to protect against channel errors. The output of the channel encoder is interleaved, modulated, and spread in bandwidth. The resulting signal is amplified by a power amplifier (PA) and transmitted. At the receiver the inverse operations are needed to accurately recover the block of information.While each of these operation described consumes power in order to process the data or signal,we focus on the energy being consumed by the power amplifier, demodulator, and channel decoder. We focus on these elements since generally they consume much more energy than other elements in the system. The performanceenergy trade-off of the amplifier was discussed previously. Thus, we focus on the performanceenergy trade-off of the demodulator and decoder.

2.3 Network Layer

We describe the model for the network layerand the parameters of the network protocolsthat affect global performance. We explain why these parameters are appropriate for the wireless communication systems under investigation.We consider a network of nine nodes. All nodes move according to a specific mobility model. In the situational awareness problem,each node attempts to keep track of the positions of all the other nodes. This is accomplished by communication and estimation. All nodes share their respective position information according to a specific communication protocol.In the rest of this section we present the mobility models, propagation models, communication protocols, and estimation schemes used by the nodes. We refer the reader to for further technical details regarding these various models.

2.4 Mobility Models

We describe two mobility models that we use in the various optimization problems we consider. In both mobility models, each node in the network moves to a new location at the end of every *Tm* s. In the examples considered in this article *Tm* = 1. In mobility model 1, we consider a region of size 6 km × 6 km and a group of nine nodes initially deployed in an area. All nodes travel toward the same destination which is located at *G* = (6000, 6000) m. Each node travels at average speed *v*, where *v* = 1m/s. At each step, each node's motion is subject to a random disturbance in *x* and *y* coordinates. In mobility model 2, all nodes are initially deployed region of size 1332 × 1332 m and move within this region .The mobility of each node is characterized by a twostate discrete-time Markov chain, where the two states are labeled *stay* and *move*. In each of these states, each node's motion is subject to random disturbance in the x and y coordinates, where the disturbance is parameterized by a scaling factor of 1 m in the stay state and 10 m in the move state.

2.5 Propagation Model

The transmitted signal from each node experiences propagation loss and fading. In the results that follow, we assume a twopath propagation model. Table 1 shows the variables and their typical values needed to explain the model. The two-path propagation model consists of a direct path and a path reflected off the ground with 180° phase change at the reflection point from the transmitter to the receiver. The cumulative effect of both paths determines an attenuation *A* between received power and transmitted power.where the approximation is valid when $d >> \max\{ht, hr\}$. The two-path propagation model characterizes the large-scale propagation loss of many fading channels reasonably well, which is why we adopt it in our network layer simulation.

III.PROPOSED SYSTEM DESIGN METHODOLOGY AND RESULTS ANALYSIS

We first describe the system decomposition and optimization, both of which form the constituent parts of our design methodology. We then comment on the decomposition and optimization.We consider a wireless network consisting of mobile nodes that need to communicate with one another in order to take some action or to share information, such as their respective positions. The overall goal is to characterize and optimize some performance metric under an energy constraint.

As pointed out in the first section, in order to develop a systematic and computationally tractable design methodology, we divide the problem into interacting design layers as shown in Fig.3. The system decomposition consists of three layers: the device layer, the processing layer, and the network layer. Each layer interacts with layers above or below it in a well-defined manner (described below). At the device layer, we consider physical components at each node, including the antenna, amplifier characteristics, and circuit. At the processing layer, we consider the signal processing operations, including the modulation, coding, demodulation, and decoding algorithms. At the network layer, we consider the collective operation of all mobile units, including the routing protocol, information distribution issues, communication environment, mobility modeling, and overall performance measure. Some of these parameters also describe the coupling among the different layers; thus, they necessitate the development of an integrated design methodology. The integrated design methodology we propose is described by the following steps:

Step 1: Identify the direct interactions (key coupling parameters) among layers; indirect interactions will “trickle through” the model.For example:–The packet error probability, provided by the processing layer, is a key coupling parameter that directly affects network layer performance. –Certain receiver parameters, such as the numbers of bits of quantization for the equalizer input data, the equalizer coefficients, and the decoder, affect network layer decisions indirectly through packet error probability.

Step 2: At each layer consider a local performance measure that captures the contribution of that layer to the systemwide (global) performance criterion. Such a performance measure is a function of three types of parameters:–Those that directly affect only the local performance criterion of the individual layer –Those that are controllable and directly affect the performance of multiple layers–Those that are uncontrollable and directly affect the performance of multiple layers Fix the parameters of the second and third types, and optimize the local performance criterion with respect to the parameters of the first. For example, at the processing layer, the packet error probability is a possible local performance criterion. It is a function of the three types of parameters described above. The first type parameters include the receiver parameters mentioned in step 1. The second type parameters include the energy constraints for transmitting and receiving a packet.

Step 3: Using the results of step 2, construct a model of each individual layer that is a function of only the parameters of the second and third types. Optimize the global performance criterion with respect to the parameters of the second type under an energy constraint. For instance, consider the situational awareness problem where the systemwide (global) performance criterion is the position estimation error of the network nodes averaged over the third type parameters from different layers (e.g., the distance between each pair of nodes.

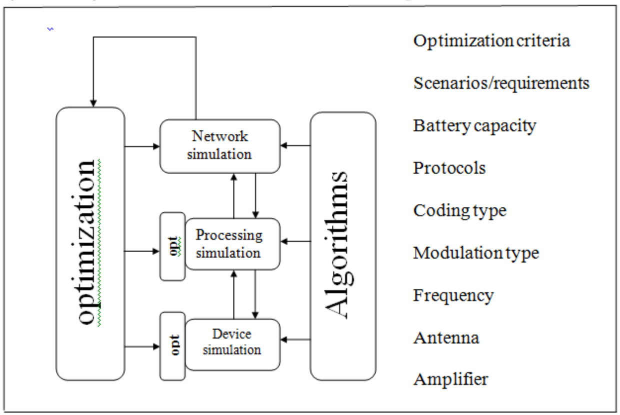

Fig .3. Layered design/optimization

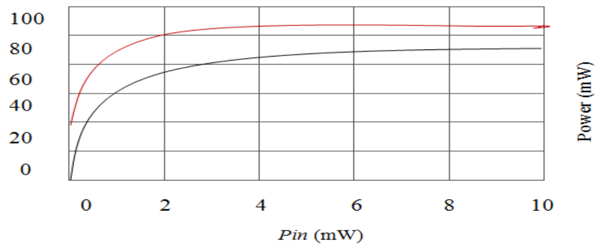

Fig .4. Characteristics of the power amplifier of radiated and DC power

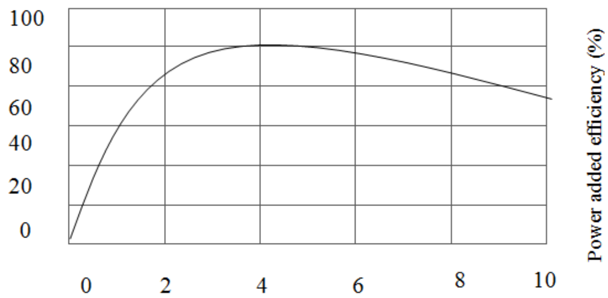

Fig.5. Characteristics of the power amplifier of power added efficiency.

IV.CONCLUSIOSN

We propose an integrated design methodology and applied it to the optimization of the situational awareness problem in ad hoc mobile wireless networks. We give evidence of why the integrated design methodology outperforms other design methodologies that do not account for or exploit coupling among layers. This evidence is supported by simulation experiments. Since the optimization and simulation at the processing and device layer are done offline, the complexity and scalability of integrated design are almost the same as those of network layer design. Therefore, integrated design can beapplied to any network layer design as long as such network layer design is feasible. In future research, it would be of interest to classify other cases where an integrated design approach leads to large performance gains over traditional approaches.

REFERENCES

[1] J. H. Chang and L. Tassiulas, "Energy Conserving Routing in Wireless Ad-hoc Networks," INFOCOM, 2000, pp. 22–31.

[2] R. Ramanathan and R. Rosales-Hain, "Topology Control of Multihop Wireless Networks using Transmit Power Adjustment," Proc. IEEE INFOCOM, 2000.

[3] V. Rodoplu and T. Meng, "Minimum Energy Mobile Wireless Networks," IEEE JSAC, vol 17, no. 8, Aug. 1999.

[4] K. Scott and N. Bambos, "Routing and Channel Assignment for Low Power Transmission in PCS," IEEE ICUPC, 1996, pp. 498–502.

[5] S. Singh, M. Woo, and C. S. Raghavendra, "Power- Aware Routing in Mobile Ad Hoc Networks," Proc. ACM/IEEE MOBICOM, Oct. 1998, pp. 181–90.

[6] J. E. Wieselthier, G. D. Nguyen, and A. Ephremides, "On the Construction of Energy-Efficient Broadcast and MulticastTrees in Wireless Networks," IEEE INFOCOM, Mar. 2000.

[7] V. Borich et al., "Nonlinear Effects of Power Amplification on Multicarrier Spread Spectrum Systems," Int'l.Microwave Symp., vol. 1,1998, pp. 323–26.

[8] W. Stark et al., "Low Energy Wireless Communication Network Design," Univ. of MI EECS CSPL tech. rep., 2001.

[9] J. M. M. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall PTR, 1995.

[10] S. Hong and W. E. Stark, "Power Consumption vs. Decoding Performance Relationship of VLSI Decoders for Low-Energy Wireless Communication System Design," Proc. IEEE Int'l. Conf. Elec., Cir. Sys., 1999, pp. 1593–96.

[11] S. Hong and W. E. Stark, "Design and Implementation of a Low Complexity VLSI Turbo-Code Decoder Architecture for Low Energy Mobile Wireless Communications," J. VLSI Signal Processing, Feb. 2000, pp. 43-57.

[12] T. Rappaport, Wireless Communications: Principles and Practice, Englewood Cliffs, NJ: Prentice Hall, 1996, pp. 69–122, 139–96.