Power Control Optimization of Code Division Multiple Access (CDMA) Systems Using the Knowledge of Battery Capacity Of the Mobile.

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Abstract:-Power Consumption has become most important criteria in the design of wireless portable devices. The proposed work is on the study of the power control methods for different optimization objectives given the knowledge of battery power capacity. The target is planned to set on the single cell multi rate code division multiple access (CDMA) system with perfect successive interference cancellation (SIC) as our specific system. Different orderings for the SIC lead to different power control mechanisms. This is to develop some simple ordering schemes for SIC so that we can maximize the minimum transmission time for a group of users within the same cell. T the same time, which can increase the total amount of data that a group of users can transmit within the same cell before they all run out of battery power.

Keywords*: co- channel interface, near- far effect, matched filtering, K- demodulation and signal recovery, channel estimation, tentative symbol decision and replica generation of users etc.*

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1. Introduction

The demand of ubiquitous information access and manipulation has created significant challenges and opportunities for the semiconductor industry. The revenue from wireless voice handset is expected to exceed that from PCs in the future, and the use of wireless internet acess is expected to overtake fixed internet access in the next few years.

The above trends make it important for semiconductor vendors, electronic system design houses and tools companies to focus their efforts on addressing the challenges encountered in the design of mobile wireless communication systems. One of the most important criteria in the design of such systems is to maximize the battery life, since it directly impacts the duration and extent of mobility. The increasing complexity of wireless commucation protocols, increasing performance requirements due to the need for bandwidth, and relatively slow growth in battery technology, make it critical to consider power conumption issues during the design of the protocols and system architecture.

Mobile Wireless communication show an incredible growth, it is estimated that by the year 2010, wireless phones will surpass wire line phones, each having a world wide penetration of more than 20%.

In CMOS circuit, there are three kinds of power dissipation, the dynamic short circuit and leakage power consumption. Dynamic and short circuit power is dissipated when there is switching activity in the circuit. Leakage power is dissipated once the circuit is connected to the power supply.

2. Dynamic Power Dissipation

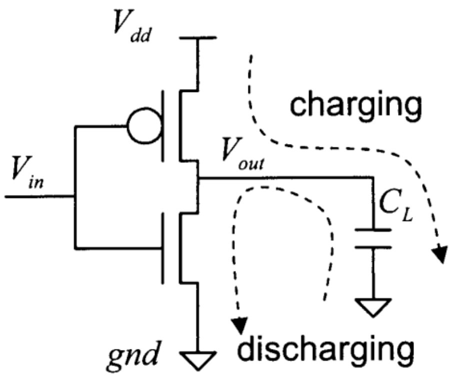

Figure 2.1

Dynamic power dissipation is due to the charging and discharging of the output load capacitance (C_L) as in above figure. When he input is changed from high to low the CMOS of the inverter turns on and charges up the load capacitance from low to high. The charging of load capacitance consumes ½ C_LV^2 of the energy using PMOS

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and ½ $C_L V^2$ energy is stored in load capacitor. When the input changes from high to low the NMOS of the inverter turns on and discharges ½ $C_L V^2$ of the energy stored in the load capacitance.

Hence, the total dynamic power dissipates when the input changes from low to high to low can be written as:

$$P = C_L V^2 / T_S^2 = C_L V^2 f_s$$

Where T_s and f_s are the period and frequency of the switching of the inverter respectively.

Due to the fact that the inverter may not be switching at every system clock cycle f_s may not be equal to the operating frequency 'f'. The term called "switching activity" can be defined to express f_s in terms of 'f', i.e, $f_s = \alpha_{0\to 1} f$. The total power dissipation will be:

$$P = C_L V^2 \alpha_0 \to 1 f$$

Where $\alpha_{0\to 1}$ is the total number of 0- >1 transitions over the whole period of operation.

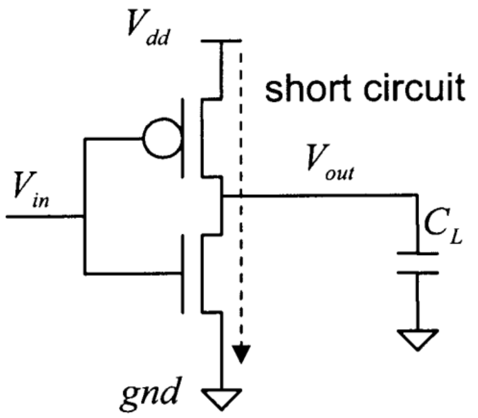

Figure 2.2 Short Circuit Power Dissipation

3. A Methodology for Power Consumption Analysis

In this section, the methodology we are proposing is discussed in general and a layout of the rest of the dissertation is provided. The framework of the methodology we are proposing is illustrated in Figure **The Methodology**

Formal specifications of protocols have for a long time been used for the prediction of the performance measures of protocols based on the OSI basic reference model. As mentioned in Section 3.1 herein, the network architecture is one of the contributing factors to the energy-efficient design of wireless communication systems. In addition, there is a considerable amount of power consumed during the operations of the aforementioned. Though it is

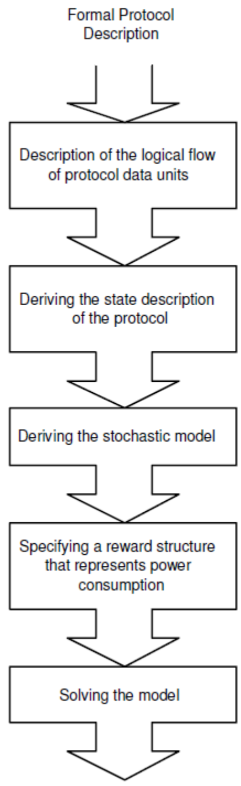

Figure 3.1

The Methodology procedure in outline

a significant subsystem, the network architecture poses a more difficult challenge in determining the empirical data associated with their power consumption because of the way the different layers interface with the hardware. We propose a methodology for analyzing the power consumption of a wireless communication system based on the functions and operations documented in the formal specification of their radio interface protocols. The following discussion describes the different parts of our methodology illustrated in Figure

real protocol system during a given period of time is characterized by the probability distributions of a stochastic process. The state transition diagrams in this case, indicate the evolution of the system in time and can be represented by the finite-state stochastic process which characterizes the dynamics of the protocol system.

1. The evolution of any protocol with finite memory can be modelled as a Markov chain
2. The freedom to modify the reward structure allows the modeller to represent a wide variety of operating conditions.

Model Solution

Once we have the MRM, we are able to solve it using the performability tool available in MATLAB. The tool allows us to solve different MRMs based on the specification of reward rates and reward structures. In particular, the tool can be used to predict the following results over an interval of time:

1. Power consumption in a protocol state, and

2. Power consumption of the protocol layer.

4. Power Control Optimization Of CDMA System

Introduction:

A method for successive interference cancellation in code division multiple access (CDMA) systems is provided that uses variable interferer weights. This method allows interfering signals to be cancelled in order to recover a transmitted data signal. This method involves receiving the data signal subject to interference from at least one interfering signal. A first interfering signal is identified. Then an interferer weight coefficient associated with the first interfering signal is generated. This allows the first interfering signal to be cancelled from the received data signal using the interferer weight coefficient. These processes may then be reiterated for other interfering signals. It is then possible to recover the transmitted data signal from the received data signal.

Successive Interface Cancellation: (Power Optimization):

To formulate the optimization problem, we defined the following notation for the useful parameters:

N: the number f users in the cell.

W: the bandwidth of the system

E: the remaining battery capacity vector of the users $[E_1, E_2, \ldots, E_n]$

V: the normalized charge per minute vector of the users $[V_1, V_2 \ldots, V_n]$

R: the rate requirement vector of the users $[R_1, R_2, \ldots, R_n]$

Q: the QOS requirement vector of the users $[Q_1, Q_2 \ldots, Q_n]$

P: the transmit power vector of the users $[p_1, p_2 \ldots, P_n]$

H: the channel power gain vector of the users $[h_1, h_2 \ldots, h_n]$

E_b: bit energy

N_o: additive white Gaussian noise (AWGN) with one side power spectrum density.

The expression of E_b / N_o of the i^{th} user in the SIC is given by:

$$(E_b/N_0) = W/R_i \times h_i P_i / \sum_{j=i+1}^{N} h_j P_j + N_0 W \quad i=1,2\ldots\ldots N$$

Minimizing the total transmission power: (Given the rates and all the QOS requirement)

The objective of the power control is to minimize:

$$\sum_{i=1}^{N} P_i$$

Subject to the constraints:

$$(E_b/N_0) \geq Q_i \quad ; i=1,2\ldots\ldots N$$

<u>**Proposition 1**</u>**:** "Given any decoding order of users in the SIC scheme, the optimal power control solution which minimizes the total transmission power system always meets all the QOS requirements with equality."

Maximizing the minimum transmission time:

To ensure that all the users are connected the same time for as long as possible.

Objective: The minimum transmission time of all the users is maximized given knowledge of the remaining battery capacity of each user.

Given the rate, the QoS requirement, the remaining battery capacity of each user, the objective of this power control scheme is to maximize.

$$\text{Min}(E_1/P_1 \ldots\ldots\ldots E_N/P_N)$$

Subject to constraint of $(E_b/N_o) \geq Q_i \quad i=1,2,\ldots\ldots,N$

The solution for minimizing the total transmission power does not generate an optimum solution for this optimization problem because the remaining battery life of the users has not been accounted for.

The Ordering Schemes:

The remaining battery life changes with time for different detection orders. The ordering schemes to predict the battery life can be divided into two categories as given in Figure

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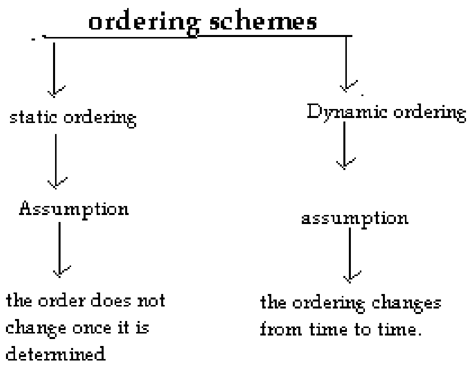

Classification of Ordering Schemes

Static Ordering Scheme (SOS):

Proposition 2: "Given any static decoding order of the user in the SIC scheme one of the optimal power control solution which maximizes the minimum transmission time meets all the QoS requirements with equality.

5. Simulation Results And Discussion

Simulation Results:

For every simulation, we randomly generated the location of each user (*d*) which was uniformly distributed between 50m to 500m, the battery capacity (*E*) which was uniformly distributed between 0 to 1, the Raleigh fading factor (r) which was Raleigh distributed with the minimum value set to 0.001, and the log-normal factor (X_{σ_s}) which was log-normal distributed with standard deviation equal to 5 db.

The averaged values of the minimum transmission time, the total transmission power, the outage probability, and the number of re-ordering required are summarized in Figures 5.1 to 5.4, respectively. Here, S, G, and R represent the static, gain, and rate ordering schemes, respectively. D_0.1 represents the dynamic ordering scheme where the threshold value is equal to 10% of Δt_1 which is computed from the initial ordering result. D_0.05 represents the same dynamic ordering scheme except that the threshold value is set at 5% of Δt_1.

Average Normalized Minimum Transmission Time

For comparison, we normalized the minimum transmission time of all the schemes using the value obtained for the rate ordering scheme. In Figure 5.1, a summary of the average results of 1000 different simulations are given. It can be seen that the average normalized minimum transmission time increases when there are an increasing number of users in the cell. If there are 24 users in the cell, the minimum transmission time can be extended more than 30 times using static ordering scheme.

Using dynamic ordering scheme, an additional 17% improvement can be achieved compared with the results obtained when using static ordering when there are 24 users in the cell. For smaller number of users such as six, the improvement is reduced to about 3%. Compared with the gain ordering which minimized the total power consumption, both the static and dynamic order schemes have significant improvement in extending the minimum transmission time.

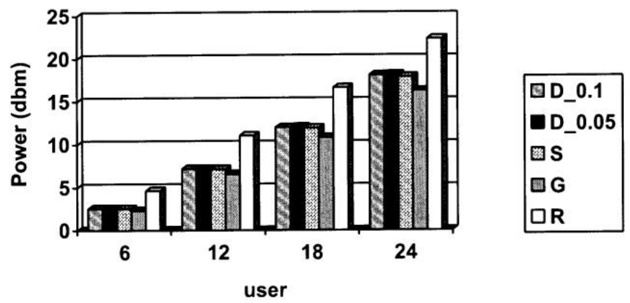

Figure 5.1 Average Transmission Power in dbm under Different Schemes

In Figure above, a summary of the total transmission power of all the users is presented. It is clear that the gain ordering is the best ordering scheme for minimizing the total transmission power. About 50% to 30% power reduction can be achieved in comparison with that when using rate ordering. Using dynamic or static ordering schemes, the total transmission power is increased by about 8% to 10% in comparison with that of gain ordering. However, this is still much less than that when using rate ordering.

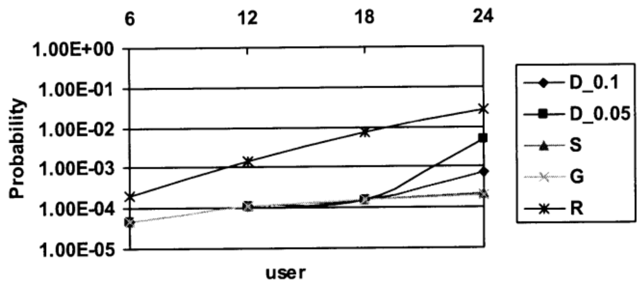

Figure 5.2 Average Outage Probability

In terms of the average outage probability, shown in Figure 5.3, the gain ordering has the lowest outage probability as it actually tries to detect the users with the worse channel conditions as late as possible in order to reduce their required transmission power. Using dynamic or static ordering schemes, users with worse channel conditions may still be detected first if they have a lot of battery capacity. The outage probability, thus, increases in comparison with that when using gain ordering. However, the rate is still quite low compared with that using rate ordering.

Average Numbers of Re-ordering Required

Re-ordering is needed when using the dynamic scheme. Figure 5.4 shows the number of re-orderings required for the dynamic ordering scheme under different threshold values. It is clear that the number of re-orderings required increases as the threshold values. It is clear that the number of re-orderings required increases as the threshold value decreases. From the results, it can be seen that the number of re-orderings is small

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