Design of A Downlink Power Control Scheme in Unequal Error Protection Multi-Code CDMA Mobile Medicine System

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Abstract - *In this paper, we propose a downlink power control scheme to apply in the unequal error protection multi-code CDMA mobile medicine system. The mobile medicine system contains (i) blood pressure and body temperature measurement value, (ii) ECG medical signals measured by the electrocardiogram device, (iii) mobile patient's history, (iv) G.729 audio signal, MPEG-4 CCD sensor video signal, and JPEG2000 medical image. By the help of the multi-code CDMA spread spectrum communication system with downlink power control scheme and unequal error protection strategy, it is possible to transmit mobile medicine media and meet 'the quality of service. Numerical analysis and simulation results show that the system is a well transmission platform in mobile medicine.*

Keywords: multi-code CDMA, downlink power control, unequal error protection, mobile medicine

1 Introduction

Mobile medicine is a new application in the wireless multi-media communications[1-2]. In previous works[3-5], we have study multi-code CDMA in wireless multi-media communication and mobile medicine system. In this paper, we further consider a downlink power control scheme with unequal error protection and apply in mobile medicine system. By the help of the multi-code CDMA spread spectrum communication system with downlink power control and unequal error protection strategy to make it possible for transmission media in this system to meet the quality of service of mobile medicine system, and achieve the purpose of the maximum resource utilization. In different media, the power is controlled and unequal error protection is used according to the demand for bit error rate. Higher transmission power and higher error protection strategy is given to the media requesting lower bit error rate. In this paper, we also simulate related mobile medical signal transmission.

2. A Multi-Code CDMA Transport Architecture in Unequal Error Protection Mobile Medicine System

The multi-code CDMA system is one of the various multiple access techniques for beyond 3G. It provide multirate multimedia services by varying the number of spreading codes assigned to each user in order to meet the throughput requirement. In this paper, we consider the case when each sub-channel can tolerate different bit error rate. In this situation, we then discuss the transmission power allocation and unequal error protection among these sub-channels based on the requirement of different bit error rate. The advantage of such a system is that less power and low error protection strategy are required for sub-channel that can tolerate higher bit error rate. Less power means less interference, so under a given total interference, more channels can be used. Thus, we can trade bit error rate for transmission capacity. With unequal power allocation and unequal error protection, more channels can be used for less secure media. Figure 1 shows our downlink transport architecture with unequal error protection based on multi-code CDMA spread spectrum communication system. For every patient, the blood pressure, body temperature measurement value, and ECG signal input to the OCPN model. The blood pressure, body temperature measurement value, and ECG signal are integrated to data bit streams. These data bit streams give higher error protection strategy and input to the OCPN model. The 64kbps microphones audio signal is compress by G.729 and output 8kbps audio bit streams. These audio bit streams give lower error protection strategy and input to the OCPN model. The 600kbps CCD sensor video signal is compress by MPEG-4 and output 64kbps video bit streams. These video bit streams give mid error protection and input to the OCPN model. Presentation of pre-orchestrated medicine information requires synchronous playback of time-dependent medicine data according to some prespecified temporal relations. At the time of creation of medicine information, a patient needs a model to specify temporal constraints among various data objects which must be observed at the time of playback. A well-known model called Object-Composition Petri- Net(OCPN)[3] is able to describe the temporal relationships of the various components of a medicine document include its type, size, throughput requirements,

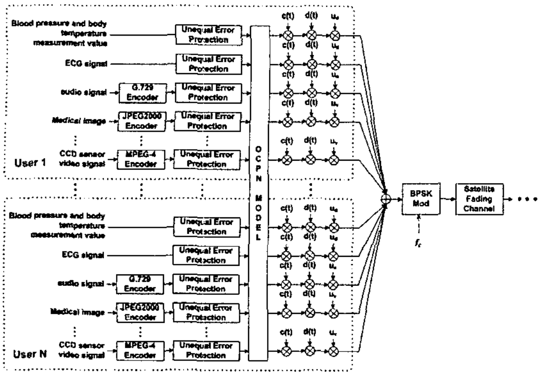

Figure 1. A multi-Code CDMA spread spectrum communication transport architecture with downlink power control and unequal error protection mechanism in mobile medicine.

the duration of its presentation. There are three kinds channel in our transport architecture in order to transmit audio, video, and data bit streams. They are data, video and audio channels. The channel number of total audio,video and data channels is calculated from OCPN model. Due to the OCPN model indicate transmission throughput of concurrent multimedia objects. The length of Walsh Code c(t) is 1024 concatenated $2^{42}-1$'s PN Code d(t). The transmitted medical signals contain electrocardiogram output result of electrocardiogram detector, blood pressure, body temperature value. Patients can consult doctors through microphones, CCD sensor video signal, and mobile medical platform in interactive ways. We use a down-link power control mechanism for different media's virtual channel with different transmission power weighting ua, uv and ud, to keep a good transmission quality. The transmission power weighting parameters ua, uv and ud of audio, video and data virtual channels with unequal error protection are discussed in the following.

3. Downlink Power Control in Unequal Error Protection Multi-Code CDMA Mobile Medicine System

Base station assigns different transmission power and error protection strategy to all virtual channels according to the type of the media to be transmitted such as audio, video, data and channel condition. In the following, we will derive the relation between the transmission power, unequal error protection and the given requirement on the bit error rate. We assume that there are total K users in our system, and the kth user has N_k virtual channels. The transmitting signal $s_{km}(t)$ of the *m*th data stream (virtual channel) belonging to the *k*th user is expressed as

$$s_{km}(t)=\sqrt{2P_{km}}a_{km}(t)b_{km}(t)\cos(w_c t+\theta_{km}) \qquad (1)$$
$$=\sqrt{2\mu_{km}P}\,a_{km}(t)b_{km}(t)\cos(w_c t+\theta_{km})$$
$$1\le m\le N_c, 1\le k\le K,\ 0<u_{km}\le 1$$

Where u_{km} is the weighting factor of the *m*th virtual channel belonging to the *k*th user. This factor is dynamic assigned according to our power control mechanism in order to achieve maximum resource utilization at the acceptable quality of multimedia presentation services. The constant *P* is the reference transmission power of the base station; and θ_{km} is the random phase angle, uniformly distributed between 0 and 2π , $b_{km}(t)$ is the data signal, which consists of a sequence of rectangular pulses of duration *T*. The concatenated spreading code $a_{km}(t)$ is the concatenated spreading sequence, which is equal to the product of an Walsh code sequence $c_m\in\{1,-1\}$ assigned to its *m*th sub-channel and a PN sequence $d_k\in\{1,-1\}$ used by the *k*th user. Thus, the received signal at the input to the matched filter in the mobile receiver is given by

$$r(t)=\mathrm{Re}\{\int_{-\infty}^{\infty}h_{km}(\tau)\tilde{s}_{km}(t-\tau)\exp(jw_c t)d\tau\}+n(t) \qquad (2)$$
$$=\sum_{k=1}^{K}\sum_{m=1}^{N_k}\sum_{l=1}^{L_{km}}\sqrt{2\mu_{km}P}\beta_{lkm}a_{km}(t-\tau_{lkm})b_{km}(t-\tau_{lkm})\cos(w_c t+\varphi_{lkm})+n(t)$$
$$\varphi_{lkm}=-w_c\tau_{lkm}+\phi_{lkm}+\theta_{lkm}.$$

Where $\tilde{s}$ (t) is complex envelope of s(t) ; $Re\{\cdot\}$ denotes the real part of complex number; n(t) is white Gaussian noise process with two-side power spectral density $N_o/2$. For simplified analysis, the first virtual channel of the first user is chosen as the reference for calculating the probability of error of the data symbol b_{11}. The receiver is able to coherently recover the carrier phase φ_{lkm} and τ_{lkm} locking to the *l*th path as a reference path between the transmitter and its corresponding receiver. All other paths constitute interference. That is, we assume without loss of generality that $\varphi_{l11}=0$ and $\tau_{l11}=0$. Moreover, since all the signals including the desired signal and the interfering signals caused by the other virtual channels relative to reference virtual channel (virtual channel 1 of user 1) are transmitted to the 1st mobile receiver from the same base station (downlink) and have the identical propagation environment between the base station and the receiver for reference virtual channel, it can be shown that $\overline{\beta}_{lkm}=\overline{\beta}_l$. The envelope of the matched-filter output at the *j*th sampling time instant (t=*j*T) is denoted by $Y_{11}^{(j)}$ and can be expressed as

$$Y_{11}^{(j)}=\int_{(j-1)T}^{jT}r(t)a_{11}(t)\cos(w_c t)dt$$

$$= \beta_{l11}\sqrt{\frac{\mu_{11}PT^2}{2}}b_{11}^{(j)} + Int_1 + Int_2 + Int_3 + v \quad (3)$$

Where $v = \int_{(j-1)T}^{jT} n(t)a_{11}(t)\cos(w_c t)dt$, Int_1 is intra multi-user interference (self-interference) indicating the interference introduced by the other virtual channels of reference user; Int_2 is intra multi-path interference; Int_3 denotes inter multi-user interference. These derivations of the signal-to-noise plus interference ratio for audio, video and data $\overline{\gamma}_{b,audio}$, $\overline{\gamma}_{b,video}$, and $\overline{\gamma}_{b,data}$ had also been shown in [4,5]. Thus, the signal-to-noise plus interference ratio for audio, video and data are given by

$$\overline{\gamma}_{b,audio} \approx \left[\frac{(\mathrm{N_a u_a + N_v u_v + N_d u_d})\upsilon}{3N_c u_a} + \frac{N_o}{2\mu_a \overline{E}_b}\right]^{-1} \quad (4)$$

$$\overline{\gamma}_{b,video} \approx \left[\frac{(\mathrm{N_a u_a + N_v u_v + N_d u_d})\upsilon}{3N_c u_v} + \frac{N_o}{2\mu_v \overline{E}_b}\right]^{-1}$$

$$\overline{\gamma}_{b,data} \approx \left[\frac{(\mathrm{N_a u_a + N_v u_v + N_d u_d})\upsilon}{3N_c u_d} + \frac{N_o}{2\mu_d \overline{E}_b}\right]^{-1}$$

Where $\overline{E}_b = (\overline{\beta}_l^2 PT)$ represent the received energy per information bit via the lth path (reference path). $N_{k,audio}$, $N_{k,video}$ and $N_{k,data}$ are the total number of virtual channels for transmitting audio, video, and data media for the kth user, and N_a, N_v, and N_d are the total number of virtual channels for transmission audio, video, and data media in the multi-code mobile medicine communication system. And u_a, u_v and u_d are the weighting factor denoting transmission power weighting for audio, video, and data media. $\upsilon = \sum_{q=1}^{L}\left(\overline{\beta}_q^2 / \overline{\beta}_l^2\right)$. Proakis [6]showed that the BER for both the non-diversity coherent receiver and a receiver with maximal ratio combining (MRC) of order L can be expressed in terms of $\overline{\gamma}_b$

$$p_e = p_e(\overline{\gamma}_b) = \left(\frac{1-u}{2}\right)^L \times \sum_{s=0}^{L-1}\binom{L-1+s}{s}\left(\frac{1+u}{2}\right)^s \quad \text{for MRC of } L \quad (5)$$

In (5), for MRC, $\mu = \sqrt{\frac{\overline{\gamma}_c}{1+\overline{\gamma}_c}}$. Where $\overline{\gamma}_c = 2R\overline{r}_b d_{\min}$, R is the convolution code rate, and $d_{\min}$ is the free distance of convolutional code. And the weighting factor u_a u_v u_t can be obtained by substituting the value of η_a, η_v, η_d, and is given by

$$u_d = \frac{\frac{N_o}{2E_b}\frac{3N_c}{\alpha\upsilon\eta_a}}{-\frac{N_d}{\eta_a} - \frac{N_a}{\eta_d} + \frac{3N_C}{\alpha\upsilon\eta_a\eta_d} - \frac{\eta_v}{\eta_a}\frac{N_a}{\eta_d}} \quad (6)$$

$$u_a = \frac{-\frac{N_o}{2E_b}\frac{3N_C}{\alpha\upsilon} - N_d u_d}{N_a - N_v\frac{\eta_v}{\eta_a} - \frac{1}{\eta_a}\frac{3N_c}{\alpha\upsilon}}$$

$$u_v = \frac{\eta_v}{\eta_a}u_a$$

where η_a, η_v, and η_d are the minimum signal to interference plus noise ratio to satisfy the BER requirement for different media.

4. Numerical Analysis and Simulation Results

In Figure 2, we consider the restriction data, video, and audio channel bit error rate are 10^{-7}, 10^{-4}, and 10^{-3} according to reference[2]. Each virtual channel transmission power is calculated by our downlink power control scheme in unequal error protection multicode CDMA mobile medicine system. 1/3 (557,663,771) convolution code[7] is used to protect data virtual channels and 1/2 convolution (561,753) is used to protect video and audio virtual channels. We based on the requirement of bit error rate in different transmission media, and channel condition such as signal to adaptive white Gaussion noise at that time to adjust different transmission power in various transmission media virtual channels. We suppose that at that time, there were 200 video and 100 audio virtual channels transmission, and the number of data virtual channels increase from 50 to 65. The length of Walsh Code c(t) is 1024 concatenated $2^{42}-1$'s PN Code d(t). The transmission power weighting of the audio, video and data virtual channel ua, uv and ud are shown in figure 2. The multipath gains we consider are [1 0.5 0.25 0.125]. The red sign (*), blue sign (*), and green sign (*) are the data virtual channel transmission power weighting ud when signal to adaptive white Gaussion noise are 3dB, 5dB and 7dB. The red circle, blue circle, and green circle are the video virtual channel transmission power weighting uv on when signal to adaptive white Gaussion noise is 3dB, 5dB, and 7dB; The red triangle, the blue triangle, and the green triangle are the audio virtual channel transmission power weighting ua on when signal to adaptive white Gaussion noise is 3dB, 5dB, and 7dB. The transmission power weighting of audio, video, and data channels are decreased when signal to adaptive white Gaussion noise is larger. The simulation result also shows that the bit error rate of audio channel is 0.00097, the bit error rate of video channel is 9.83×10^{-5} and the bit error rate of data channel is 9.31×10^{-8} in our downlink power control scheme. It is close to the theoretical value 10^{-3},10^{-4} and. 10^{-7}. The length of Walsh Code is 1024 concatenated $2^{42}-1$'s PN Code and the transmission bit rate of every virtual channel we designed is 10kbps.. Figure 3 shows the results of the electrocardiogram signals simulation tested in multicode CDMA mobile medicine system with downlink power control. The mean square error of original electrocardiogram signal and received signal is 0.009. It is suitable to use in medicine. Figure 4 shows the transmission results of audio signals tested in multicode

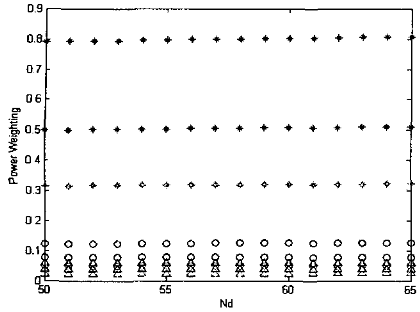

Figure 2 each virtual channel transmission power weighting calculated by our downlink power control scheme.(*:data virtual channel, *O* :video virtual channel, Δ : audio virtual; Red : signal to adaptive with Gaussian noise is 3dB, Blue : signal to adaptive white Gaussian noise is 5dB, Green :signal to adaptive white Gaussian noise is 7dB)

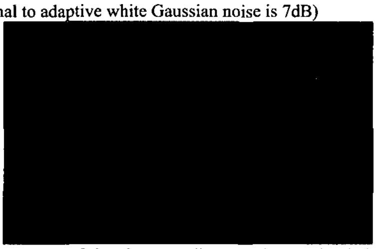

Figure 3 the results of the electrocardiogram signals simulation tested in unequal error protection multi-Code CDMA mobile medicine system with downlink power control.

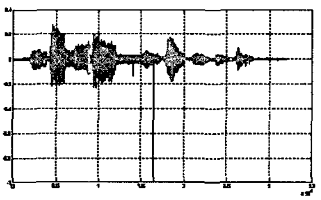

Figure 4 the transmission results of G.729 audio signals simulation tested in unequal error protection multi-Code CDMA mobile medicine system with downlink power control. (Green :original audio signal ; Blue : received and decoded G.729 audio signal with power control)

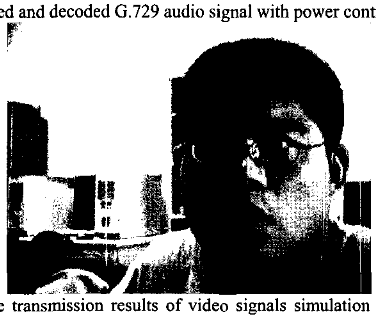

Figure 5 the transmission results of video signals simulation tested in unequal error protection multi-Code CDMA mobile medicine system with downlink power control.

CDMA mobile medicine system with downlink power control. The mean square error of the original transmission audio signal and received decode G.729 audio signal is 3.63×10^{-4}. The audio signal is very clear. Figure 5 showsthe transmission results of MPEG-4 CCD sensor video signals simulation tested in multi-code CDMA mobile medicine system with downlink power control. The received average PSNR values of CCD sensor MPEG-4 video signal are 37.11dB. The transmission platform proves to be good.

5. Conclusions

In this paper, we propose a downlink power control scheme in unequal error protection multi-code CDMA mobile medicine system. Numerical analysis and simulation results show that our power control scheme can combat multi-user interference, channel fading and achieve the maximum resource utilization. The multi-code CDMA in the mobile medicine communication system with downlink power control scheme and unequal error protection strategy is a well platform Detailed discussion and comparison data for received audio, video, and medical image signal simulation results in unequal error protection multi-code CDMA mobile medicine system without power control will present in ICCCS2005.

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