TSGR1#5(99)627

TSG-RAN Working Group 1 (Radio) meeting #5
Cheju, South Korea, June 1~4th, 1999

Source: WG1 Ad Hoc2
Document for: submitted to 3GPP
Title: CWTS WG1 1999/005

Proposal:

A NOVEL FRAME STRUCTURE FOR WCDMA

Zhang Ping, Li Zexian, Wang Yuezhen
Beijing University of Posts and Telecommunications
Li YingTao
ShenZhen HuaWei Technology Company limited
Email: pzhang @bupt.edu.cn

Summary:
This document describes the new frame structure that could be used in WCDMA system. In the proposed scheme, the pilot symbols in one slot are distributed in one slot separately. Channel estimation by these pilot symbols will be more accurate than the conventional method and without adding more pilot symbols than the conventional one. As a result, if the new slot structure is adopted in practical system, it will take advantages over the conventional one.

1. INTRODUCTION

WCDMA technology that possesses the potential possibility to be used in 3rd generation mobile system holds the promise of enhanced performance of cellular and personal communications. In the system designing, the pilot symbol aided coherent demodulation is used in forward link. The pilot symbols are inserted into the data frame periodically in advance. Channel estimation is carried out by these pilot symbols without adding a dedicated channel. Coherent demodulation is obtained by using these estimation parameters. However, in the WCDMA systems of Europe and Japan [1], some parameters such as the pilot symbol numbers and so on are also undetermined. To find a solution, we proposed a new method to determine the inserting frequency of pilot symbols, which leads to a novel frame structure straightforwardly. Performance comparison between conventional and novel frame structure has been carried out by computer simulation.

2. SYSTEM MODEL

Fig. 1 shows the principal frame structure of forward link in WCDMA systems of Europe and Japan. Each frame of length 10ms is split into 16 slots ,each of length 0.625 ms. Within each slot, the DPCCH and DPDCH are time duplexed. There are pilot symbols ,transfer power control (TPC) bits , transport format indicator (TFI) and data in each slot . But the exact number and the inserting frequency of pilot symbol are yet to be determined . The frame structure of the Europe

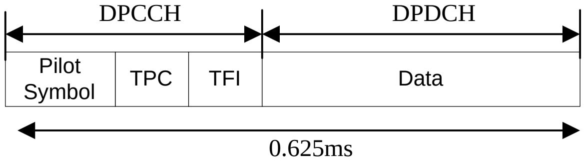


Fig.1 Slot structure for forward link dedicated physical channel

and Japan WCDMA system is used here. We propose a new method to determine the insert frequency of pilot symbol

under different conditions[2].
Consider an asynchronous CDMA system containing K users in a cell. In the transmitter, a pilot symbol is inserted in each time duration containing M+1 symbols (including the pilot symbol). This can be achieved by the M:1 multiplexer that inserts one pilot symbol followed by M data symbols. The pilot symbols are known to receiver in advance and independent of data symbols. The transmitter and the receiver can determine the state of the sequence at the same time. The signal transmitted by each user propagates through a frequency selective Rayleigh-fading channel. The baseband equivalent representation of the signal received by the *k*th user is:

$$r(t) = \sum_{k=1}^{K} \sum_{l=1}^{L} C_{k,l}(t) S_k(t - t_{k,l}) + n(t) \qquad (1)$$

At receiver the most strong L signals are received by using RAKE receiver . After despreading, the received signal samples corresponding to the pilot symbols are then compared with the known pilot symbols to achieve unbiased but noisy channel estimation . In order to reduce the estimation error a low pass filter is used . This process removes the high frequency noise components and the resulting channel estimation is more accurate. So interpolation is necessary to obtain channel estimation for each symbol if coherent detection is to be used .
Because of the inserted pilot symbols and the estimation error, performance difference exists between the ideal coherent and PSACD . The performance difference has a close relationship to the number of pilot symbol. Just because of this, a method based on the performance difference to determine the insert frequency is obtained.

3. PERFORMANCE ANALYSIS

In this section ,we shall analyze the performance loss of the pilot-symbol based channel estimation method relative to the optimal coherent receiver over such a channel. We take the flat multipath flat Rayleigh fading channel as example . After despreading , the received signal is as following :

$$r(t) = c_l(t) b(t) + n_l(t) \qquad (2)$$

wherein r (t) is the received signal, b(t) is data signal or pilot symbol, $n_l(t)$ is the additive Gaussian noise. *b((M+1)m)* and *r((M+1)m)* are the pilot symbols and the corresponding received samples respectively. By multiplying *r((M+1)m)* with the conjugate of b((M+1)m) [3], the resulting channel estimate is:

$$\hat{h}_l((M+1)m) = c_l((M+1)m) + b^*((M+1)m) n_l((M+1)m) \qquad (3)$$

where $c_l((M+1)m)$ is a lowpass random variable and the second term is the channel estimation error.

In order to reduce the estimate error, the estimate value $\hat{h}_l((M+1)m)$ is passed through a lowpass filter whose cutoff frequency is no less than the maximum Doppler frequency. The output of this filter is:

$$\tilde{h}_l((M+1)m) = c_l((M+1)m) + \tilde{n}_l((M+1)m) \qquad (4)$$

It can be seen that the variance of $\tilde{n}_l((M+1)m)$ is reduced. By comparing this result with the ideal coherent demodulation RAKE receiver [5], the loss due to estimation error can be obtained easily.

4. NUMERICAL AND SIMULATION RESULTS

We consider a CDMA mobile communication system and the carrier frequency is 1900 MHz. In Fig.2 the x-axis represents the number of data after each pilot symbol and the y-axis represents the performance difference between PSACD and ideal coherent demodulation. Different curves are the performance of different speed and the curve above has a higher speed than the lower. From these it can be concluded that the effect of speed on the performance of PSACD

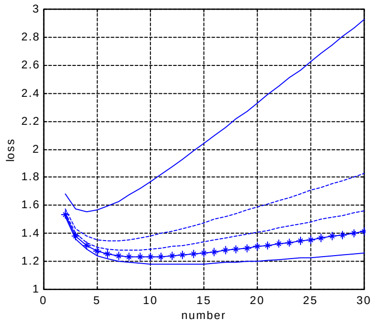


Fig.2 the effects of speed on the pilot number

can be reduced if we select an appropiate insert frequency according to the vehicle speed. It is easily obtained that if the service is detremined sert frequency of pilot symbol has an optimal value to minmize the loss due to PSACD.

From the result above, a novel slot structure is formed which is shown in Fig.3. In the new frame structure, the number of pilot symbols in one frame is same as in the conventional frame. The difference lies in the position of pilot symbol in the slot. In the new slot structure not the entire pilot symbols lie in the head of the slot. They distribute in the slot uniformly.

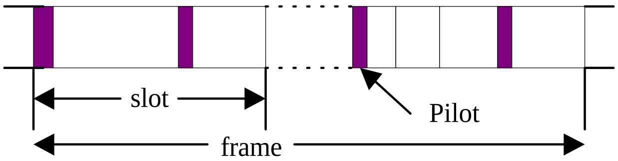
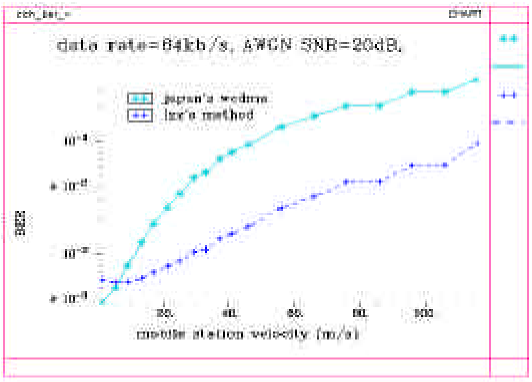


Fig.3 Novel slot structure

For evaluating this new frame structure, the system model has been designed by computer simulation.

Performance comparison between novel frame structure and conventional one by computer simulation is plotted in Fig. 4. In fig. 4 the legend of LZX's Method means the novel frame structure. In our system for simulation the SNR is fixed and the mobile speed is changed. From the figure it is easy to draw the conclusion that the higher the speed is, the more great improvement can be obtained.



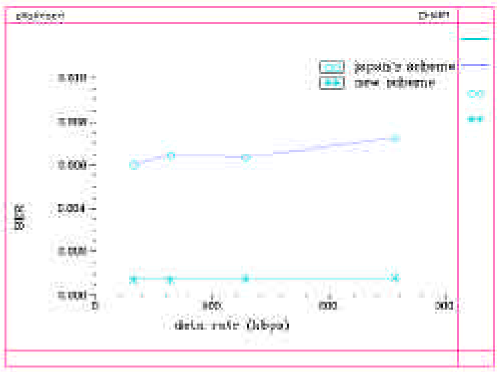


Fig.4 Performance comparison Fig. 5 Performance comparison

Performance comparison between novel and conventional frame structure under different information rate is shown in Fig. 5. The simulation system for Fig.5 is the same as that for Fig. 4, the difference is the vehicle speed is 36Km/h, but the information rate is changed. From the results it is obvious that the performance improvement has loose relationship with information rate.

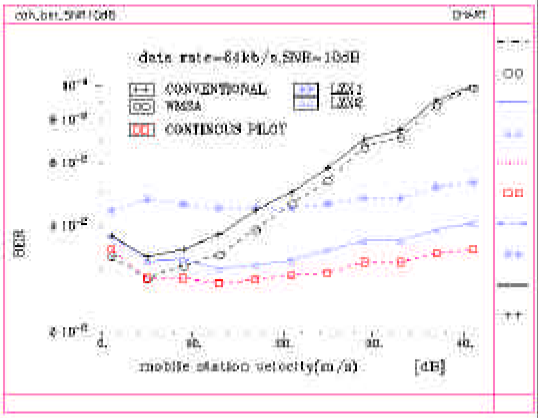


Fig.6 Performance comparison

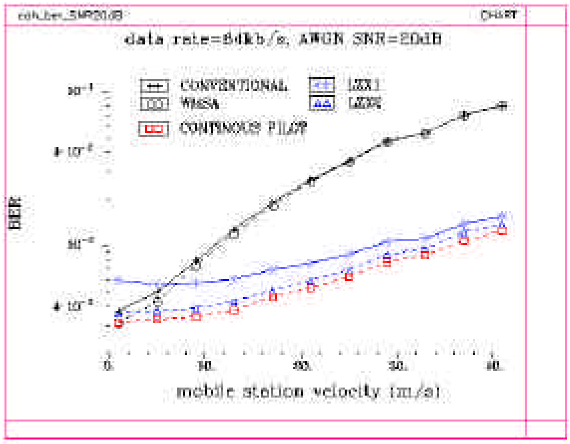


Fig. 7 Performance comparison

From the simulation results, it is clear that when the mobile station speed is high, the novel frame structure takes advantages over the conventional one.

In order to further testify our new frame structure, we have done more simulation for it.

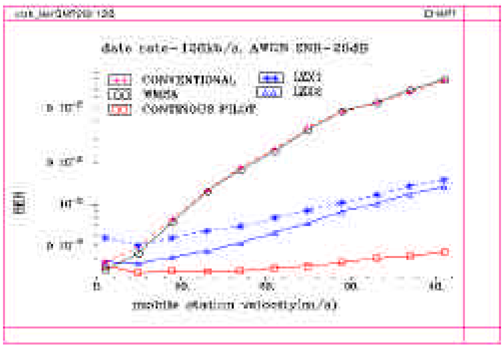


Fig.8 Performance comparison

In Fig.6,7,8, the legend “Conventional” means the common method which is used in WCDMA system, WMSA means Weight Multiple Slot Average [6] which was proposed in reference. “Lzx1” and “Lzx2” represent the performance of novel frame structure under conventional channel estimation method and **MODIFIED WMSA** channel estimation method. The difference among them lies in the date rate and SNR. In fig.9, the performance comparison is done under multipath environment (M.1225 Vehicle environment CHANNEL A).

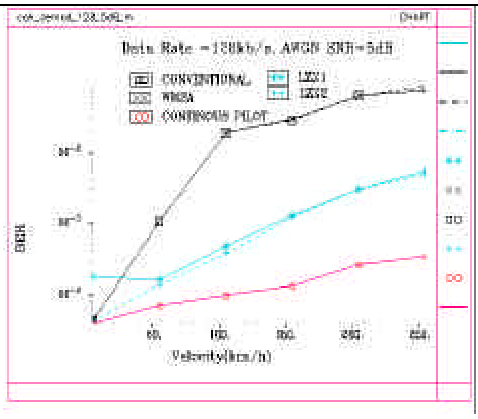


Fig.9 Performance comparison

By the results provided above, it is clear that novel frame structure takes advantages over the conventional one.

5. CONCLUSION

Here a novel frame structure is put forward. Performanmce comparsion is evaluated by computer simulation. It is clear that the new frame structure has adventages over the conventional one and possess the potenial ability to be used in the 3rd generation mobile communication system..

6. REFERENCES

[1] Tdoc SMG2 , "Concept Group Alpha-Wideband Direct-Sequence CDMA "
[2] Li Zexian, Zhang Ping, Hu Jiandong, A Novel Method to Determine the Insert Frequency of Pilot Symbol, IEEE ISCAS 99, Florida, USA.
[3] W.C. Jakes, Ed. Microwave Mobile Communications, John Wilay, NewYork, 1974.
[4] S.Y.Yoon, S.E.Hong, J.Ahn, Pilot Symbol Aided Coherent Decorrelating Detector for Up-link CDMA Mobile Radio Communication, IEE Electronics Letter, 1994,30(12): 929-930.
[5] J.G. Proakis, Digital Communications . 2nd ed. NewYork: Mc GrawHill, 1988
[6] Hidehiro ANDOH, Mamoru SAWAHASHI, Fumiyuki ADACHI, Channel Estimation Filter Using Time-Multiplexed Pilot Channel for Coherent RAKE Combining in DS-CDMA Mobile Radio, IEICE Trans. COMMUN., Vol. E81-B, No. 7 July 1998