TSG-RAN Working Group 1 Meeting #18 ***TSGR1#18(01)0102***

Boston, USA
January 15-18, 2001

Source:	**NTT DoCoMo**
Title:	**Multipath Interference Canceller (MPIC) for HSDPA and Effect of 64QAM Data Modulation**
Agenda Item:	**AH24 (HSDPA)**
Document for:	**Discussion**

1. Introduction

In this contribution we show the link level simulation results for multi-level data modulation such as 16QAM and 64QAM in case that UE employs multipath interference canceller (MPIC) in multipath fading environment. The results show that

(1) MPIC can mitigate the severe multipath interference (MPI) and keep high-throughput in multipath environments.
(2) 64QAM data modulation can be effective in increasing maximum throughput if MPI (and MAI) is effectively eliminated with MPIC.

2. Method of Improving Throughput in Multipath Fading Environment

By increasing the modulation level of the data modulation, the peak throughput of HSDPA can be increased in theoretically assuming no multipath channel. However, in an actual propagation channel, multipath (frequency-selective) fading appears in a 5-MHz W-CDMA bandwidth. Although the multipath interference (MPI) of high-speed packet channel is suppressed to 1/SF on average (SF denotes spreading factor), severe MPI degrades the SIR, and consequently the throughput performance since the equivalent SF must be nearly 1 to achieve throughput higher than 10 Mbps. Note that when multipath fading occurs even when the received signal power is sufficiently high, the throughput of a high-speed packet channel is degraded not by the background noise, but by its own severe MPI. Thus, efficient amplitude/phase data modulation such as 16QAM and 64QAM is ineffectual in multipath fading channel because the required SIR is higher than that with QPSK modulation. Thus, the area in which high-speed data services are provided using an equivalent low SF and high-level data modulation is very limited to the rare line-of-sight environment in the immediate vicinity of the base station. One possible solution is implementing MPIC to the receiver. MPIC effectively can make use of multi-level amplitude/phase modulation especially for 64QAM and can improve throughput performance of high-speed packets even in a multipath fading channel, thereby results in extension of the coverage area of high-speed packet service.

3. MPIC

Figure 1 shows the structure of the MPIC that we employed in this evaluation. We assumed two-branch antenna diversity reception. MPIC comprises several channel estimation and interference replica generation units (CEIGUs), the number of which corresponds to the number of stages. On and after the second stage, the MPI replica estimated in the previous stage is removed from the received signal for the input signal of

CEIGU. The structure of the CEIGU is illustrated in Fig. 2. In each CEIGU, the input sample sequence of each antenna is despread by a matched filter. The channel variation due to fading of each resolved path is estimated by coherently averaging the despread in-phase and quadrature component of the common pilot symbols over one-slot length. Then, the phase variation of each path is compensated and coherently Rake-combined. The tentative hard-decision of data sequence of the Rake combiner output is performed to estimate the data modulation. The MPIC replica is generated using the decision data sequence, channel estimate, and received power of each path.

Let $\tilde{\xi}^{(p)}_{b,l}(t)$ be the estimated complex channel variation and $\tilde{d}^{(p)}_{k}(t)$ be the estimated data modulation for the l-th path ($1 \le l \le L$) of the b-th antenna ($1 \le b \le 2$) of the k-th code channel ($1 \le k \le 20$) at the p-th stage ($1 \le p \le 4$). Then MPI replica $\hat{I}^{(p)}_{b,l}(t)$ of the p-th stage is expressed as

$$\hat{I}^{(p)}_{b,l}(t-\hat{\tau}_l) = \sum_{l=1}^{L} \tilde{\xi}^{(p)}_{b,l}(t)\left\{\sum_{k=1}^{K} \tilde{d}^{(p)}_{k}(t-\hat{\tau}_l)\cdot c_k(t-\hat{\tau}_l) + d_{cpich}(t-\hat{\tau}_l)\cdot c_{cpich}(t-\hat{\tau}_l)\right\} \qquad (1)$$

where $c_k(t)$ and $c_{cpich}(t)$ are the spreading modulation for the k-th code channel and common pilot channel, respectively. Term $d_{cpich}(t)$ is the known pilot channel modulation and $\hat{\tau}_l$ is the estimated delay time of the l-th path. By using $\hat{I}^{(p)}_{b,l}(t)$ and received signal $r_b(t)$, the input signal, $r^{(p+1)}_{b,l}(t)$, of MF in the CEIGU for the l-th path of the b-th antenna at the (p+1)-th stage is represented as

$$r^{(p+1)}_{b,l}(t) = r_b(t) - \alpha \sum_{\substack{j=1 \\ j \ne l}}^{L} \hat{I}^{(p)}_{b,j}(t-\hat{\tau}_j) \qquad (2)$$

where α is the real-valued interference rejection weight ($0 \le \alpha \le 1$), which alleviates the impact of generation error of the MPI replica. Since the updated MPI is removed from the received signal, and the channel estimation and tentative data decision are repeatedly performed in each canceling stage, the accuracy of the regenerated MPI replica is improved as the number of stages increases. Since the MPIC removes MPI of one high-speed packet channel, the increase of signal processing complexity from conventional Rake receiver is not so large.

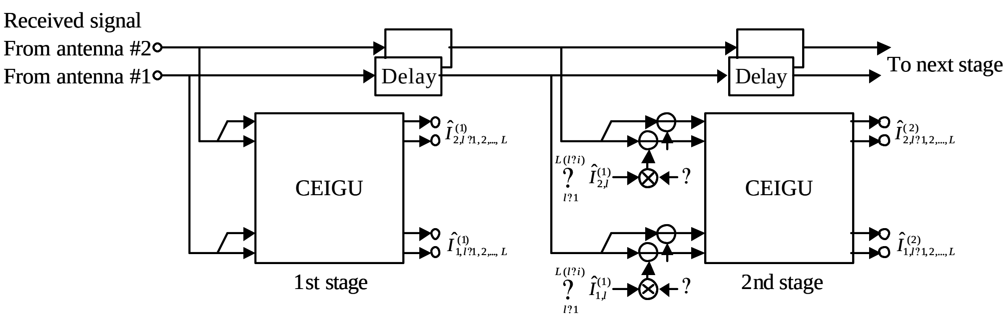

Fig. 1 MPIC structure

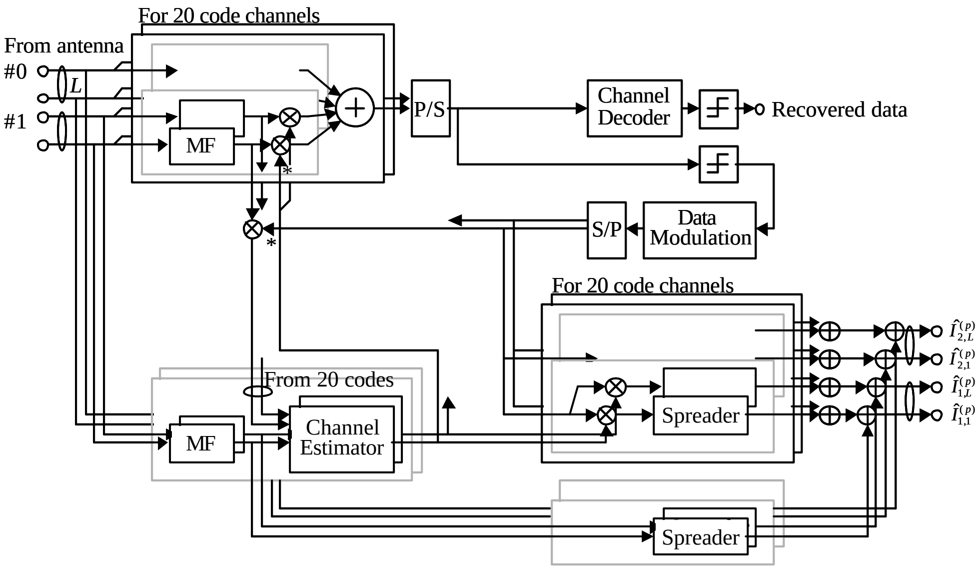

Fig. 2 CEIGU structure

4. Simulation Assumptions

The simulation assumptions are listed in Table. 1.

Table. 1 Simulation assumptions

Chip rate		3.84 Mcps
Spreading factor (SF)		32
Number of multicodes for HS-DSCH		20
Modulation	Data	16QAM, 64QAM
	Spreading	QPSK
HSDPA frame length		0.667 msec (1 slot length)
CPICH Ec/Ior		-9.54 dB (11% of Ior)
DSCH Ec/Ior		-0.51 dB (89% of Ior)
Channel coding / decoding		Turbo coding (R = 3/4, k = 4) / Max-Log-MAP decoding (8 iterations)
Channel estimation		CPICH-assisted (1 slot averaging)
Antenna diversity reception		2-branch
Channel model		1 or 2-path Rayleigh f_D = 80 Hz
Number of stages of MPIC		4
TPC		Off

MCSs used in the simulation are shown in Table 2.

Table. 2 MCS used in the simulation

MCS	Info. Rate (Mbps)	Number of Info. Bits in Packet	Modulation	Coding Rate
1	7.2	4800	16QAM	3/4
2	10.8	7200	64QAM	3/4

5. Simulation results

Figure 3 shows the throughput performance as a function of $I_{or}/(I_{oc}+N_0)$ in 1- and 2-path fading channel. In 2-path fading channel, throughput performance with and without proposed 4-stage MPIC were plotted. In single-path channel, MCS2 which employs 64QAM can achieve higher maximum throughput compared with MCS1 with 16QAM in enough high $I_{or}/(I_{oc}+N_0)$ region. However in 2-path fading channel, throughput with MCS2 were severely degraded due to the severe MPI of its own channel without MPIC. As a result, MCS2 cannot improve throughput compared to that with MCS1 in any $I_{or}/(I_{oc}+N_0)$ region without MPIC in 2-path fading channel. On the other hand, when MPIC was applied, almost the same or higher throughput can be obtained in 2-path fading channel compared to that in single-path channel owing to accurate MPI cancelling and Rake diversity effect. Therefore 64QAM data modulation combined with MPIC can increase the maximum throughput even in multipath fading channels.

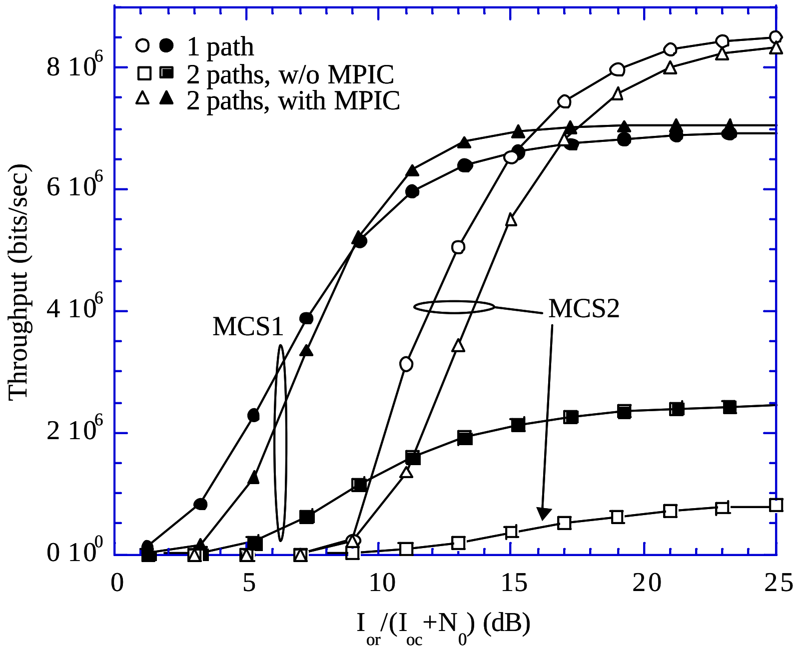

Fig. 3 Throughput performance

6. Conclusion

We showed the link level simulation results for multi-level data modulation such as 16QAM and 64QAM in case that UE employs multipath interference canceller (MPIC) in multipath fading environment. The results show that

(1) MPIC can mitigate the severe MPI and keep high-throughput in multipath environment.
(2) 64QAM data modulation can be effective in increasing maximum throughput if MPI (and MAI) is effectively eliminated with MPIC.

According to these results, we propose that

(i) MPIC should be considered in AH24.
(ii) 64QAM data modulation should not be excluded from AMC.

In this contribution, MPIC removed MPI of one high-speed packet channel within a cell. Further, we can extend the application of MPIC to remove MPIs of high-speed packet channels from several contiguous cells in addition to own cell, thereby increasing throughput performance further the by suppressing dominant interference from other cells.

References

[1] Motorola: "High Speed Packet Access", TSGR1#13(00)0727, May. 2000
[2] Ericsson, Motorola, Nokia: "Common HSDPA System Simulation Assumptions" TSGR1#15(00)1094, Aug. 2000