TSG-RAN Working Group 1(Radio) meeting #12 ***TSGR1#12(00)0487***
Seoul, Korea 10-13 April, 2000

Agenda Item: **Radio link performance enhancements**

Source: **LG Information & Communications, Ltd.**

Title: **Time offset for multiple scrambling codes**

Document for: **Discussion**

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1. Introduction

"Radio link performance enhancements" had been adopted as work item in TSG RAN#7 (13-15, March, 2000, Madrid, Spain) [1]. The purpose of this work item is to work on the radio link performance enhancements. As a candidate for Release 2000 for improved radio link performance, we propose the enhanced modulation method for multiple scrambling code which introduces time offset between physical channels on different scrambling codes. This technique reduces the interference from different scrambling codes and improves the link performance. In this contribution, time offset between physical channels is defined as the transmission time difference between physical channels. This technique was proposed as Release99 item and discussed in TSG RAN WG 1 meeting #7 (30 Aug. – 3 Sep., 1999, Hannover, Germany) [2][3] and #8 (12-15 New York, USA) [4][5], and it was postponed to Release-2000 item.

The contents of this contribution are as follows. In Section 2, we review the complexity increase due to the proposed method. In Section 3, we show new simulation results. The theoretical study of the performance gain is investigated in [2][4] in detail. So, we avoid duplication in this contribution. Finally, the summary is given in Section 4.

2. Review of the Complexity

2.1. Current Method

Figs. 1-2 show the transmitter and receiver of the current method, respectively. In Fig. 2, L is the under-sampling ratio defined as the sample rate divided by chip rate. In the current method, all downlink physical channels are transmitted on the same time offset as illustrated in Fig. 3.

The downlink physical channels on the same scrambling code should be transmitted on the same time offset in order to preserve the orthogonality of orthogonal variable spreading factor (OVSF) codes. However, the orthogonality of OVSF codes between physical channels on different scrambling codes is not preserved. Moreover, the MAI between non-orthogonal physical channels has the maximum value when time offset between physical channels is zero [6]. So, we introduce non-zero time offset between physical channel on different scrambling codes.

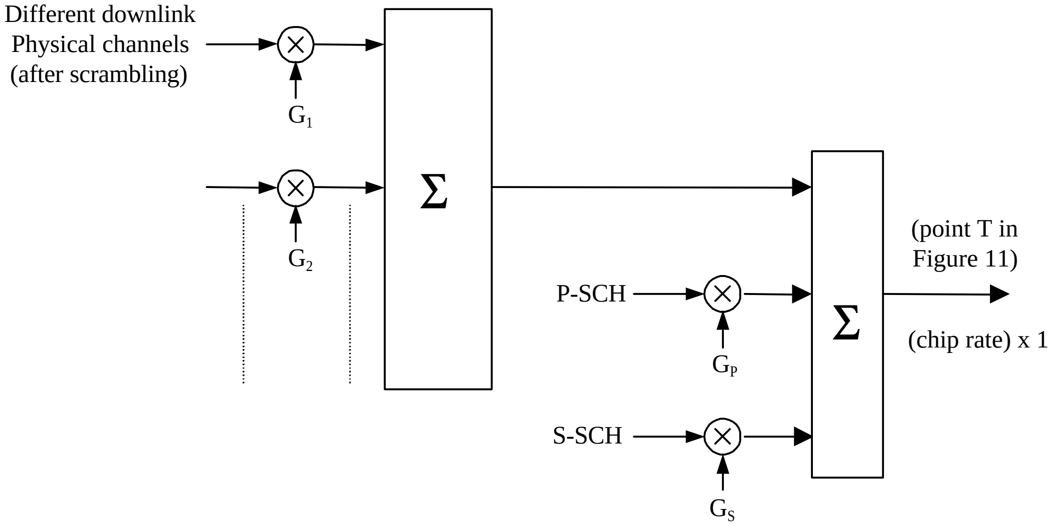


Figure 1. Transmitter of the current method

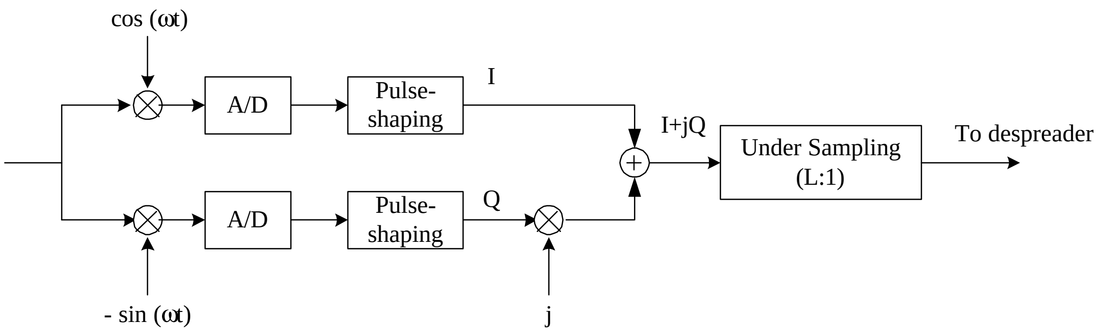


Figure 2. Receiver of the current method

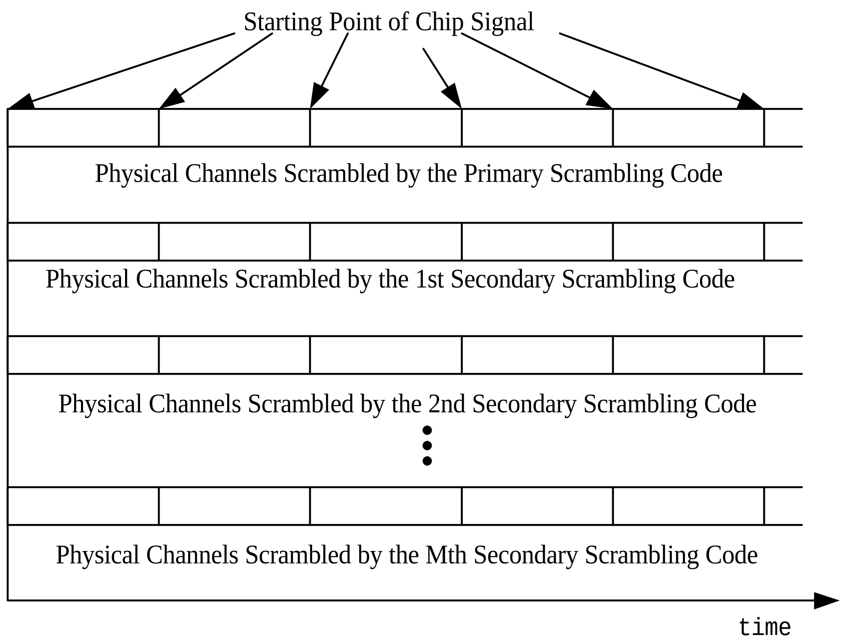
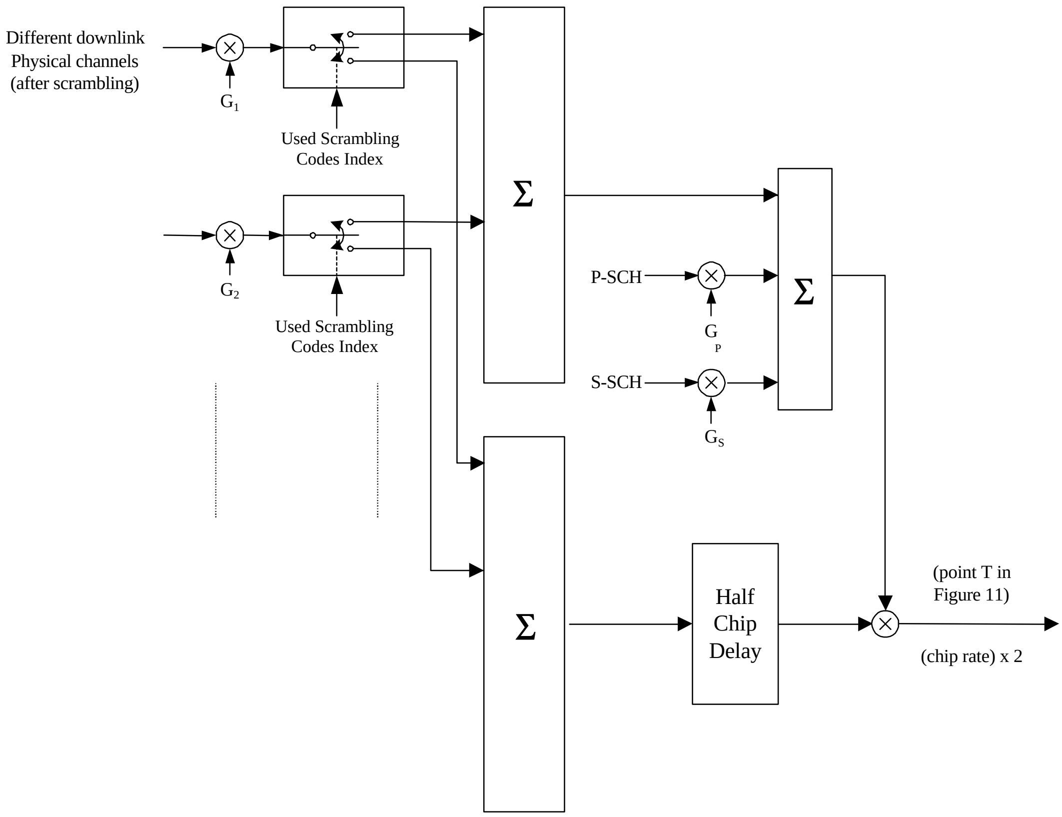


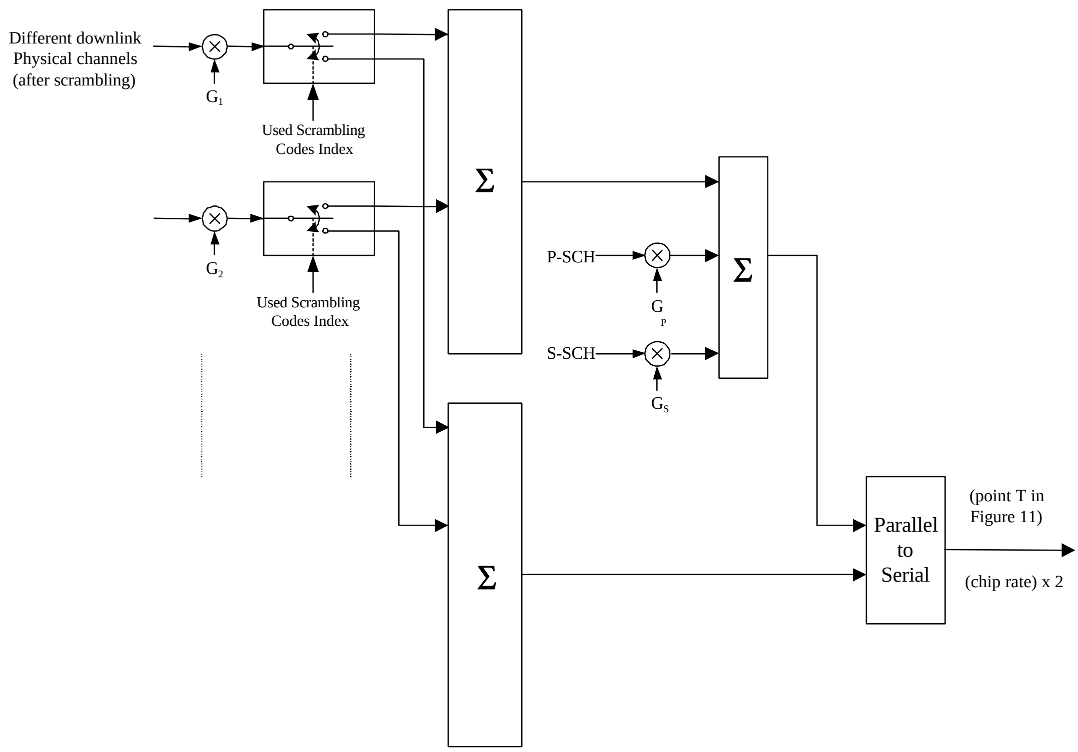
Figure 3. Timing relationship between physical channels of the current method

2.2. Proposed Method

Figs. 4 and 5 show the transmitter and receiver of the proposed method, respectively. The output of scrambling coder is time-delayed for zero chip duration or a half chip duration according to the used scrambling codes index. The timing diagram of physical channel of the proposed method is illustrated in Fig. 6. In Fig. 6, M is the number of secondary scrambling codes (SSCs). Pre-defined value of time offset for each SSC should be used, otherwise signalling of time offset should be transmitted to UE from UTRAN.



(a)



(b)

Figure 4. Transmitter of the proposed method ((a) and (b) are equivalent form)

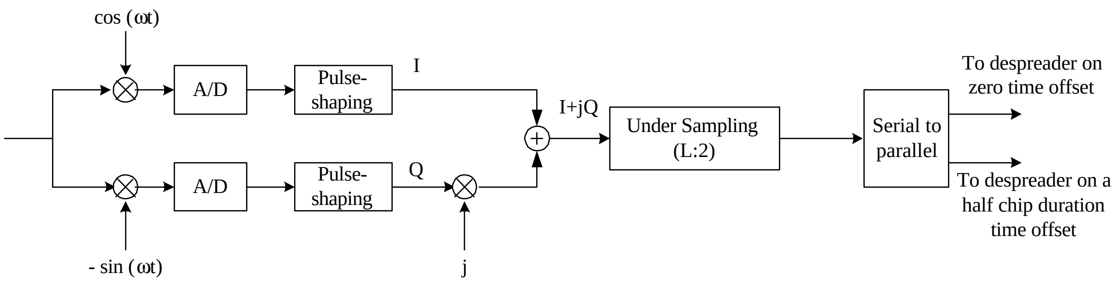


Figure 5. Receiver of the proposed method

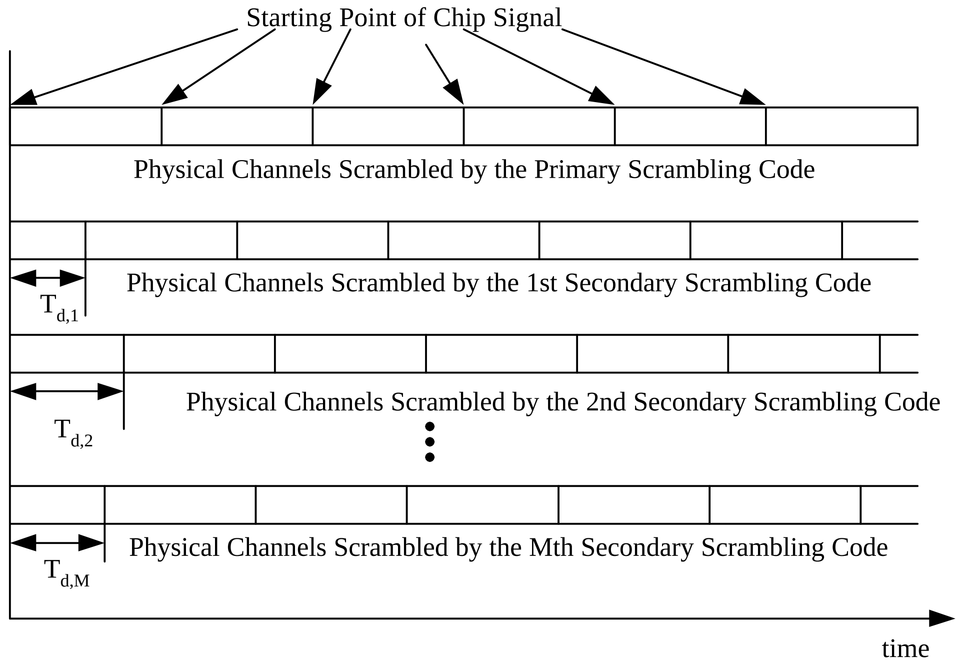


Figure 6. Timing relationship between physical of the proposed method (where $T_{d,j}$ = 0 or $T_c/2$)

2.3. Complexity Increase Due to the Proposed Method

Now, we describe the increase of the complexity in transmitter and receiver due to the proposed method. As we can see from Figs. 1 and 4(b), numbers of switchers, one adder and one parallel-to-serial converter are additionally necessary in transmitter, and, one serial-to-parallel converter is additionally necessary in receiver as we can see from Figs. 2 and 5. Table 1 summarizes the complexity increase in transmitter and receiver. As we can see from Table 1, the complexity increase due to the proposed method is very small.

Table 1. Complexity increase

Part	Additonal unit	Number of units
Transmitter	Switcher	# of physical channels
	Adder	1
	Parallel to serial convertor	1
Receiver	Serial to parallel convertor	1

3. Simulation Results

In [2], we show that the proposed method reduces the in-path interference power from different scrambling codes by 10.9% by theoretical analysis. But, the proposed method does not reduce the interference from other cells and other-paths. So, the performance gain of the proposed method depends on channel type and the ratio of other-cell interference. The other-cell interference power is a function of the position of the user equipment (UE) in the home cell. The peak value of the ratio of other-cell interference power, P_{inter}, at the UE to the home cell power, P_{intra}, at the UE is plotted in [7] as a function of the normalized distance, r/R_c, where R_c is the cell radius. The peak value of P_{inter}/P_{intra} is about -16.3dB, -0.93dB, and 2.5dB at r/R_c = 0.4, 0.8, and 1, respectively. In the simulation, we consider various channel types (AWGN, indoor, and vehicular) and various value of ratio P_{inter}/P_{intra}. The other cell interference is modeled as AWGN. The system parameters used in the simulation are listed in Table 2. In Table 2, PSC means primary scrambling code.

Table 2. Simulation Parameters

Parameters	Current Method	Proposed Method
Number of scrambling codes	2 (one PSC and one SSC)	
Time delay	PSC: zero time offset SSC: zero time offset	PSC: zero time offset SSC: a half chip duration Time offset
Spreading Factor	64	
Number of users	PSC: 63 users and CPICH, SSC: 20 users on SSC	
Transmit Power	Transmit powers are set to have the same received SIR for all users (fast TPC is not used.) CPICH: 5% of total system power	
Over-sampling ratio (L)	4	
Pulse shaping filter	Root-raised cosine filter with roll off 0.22	
Channel estimation	Practical channel estimation	
Channel	AWGN, Indoor, and vehicular	
$P_{inter}/(P_{intra} + P_{inter})$ (%)	3, 20, 40, and 60	

In Fig. 7, the received signal-to-interference ratio (SIR) is plotted as a function of the ratio, $P_{inter}/(P_{intra} + P_{inter})$, of other-cell interference power to other-cell interference power plus home cell power. The ratio, $P_{inter}/(P_{intra} + P_{inter})$, is about 3%, 45%, and 65% at r/R_c = 0.4, 0.8, and 1, respectively. Fig 7 shows the performance gain of the proposed method over the current method for all channel type and other cell interference power ratio.

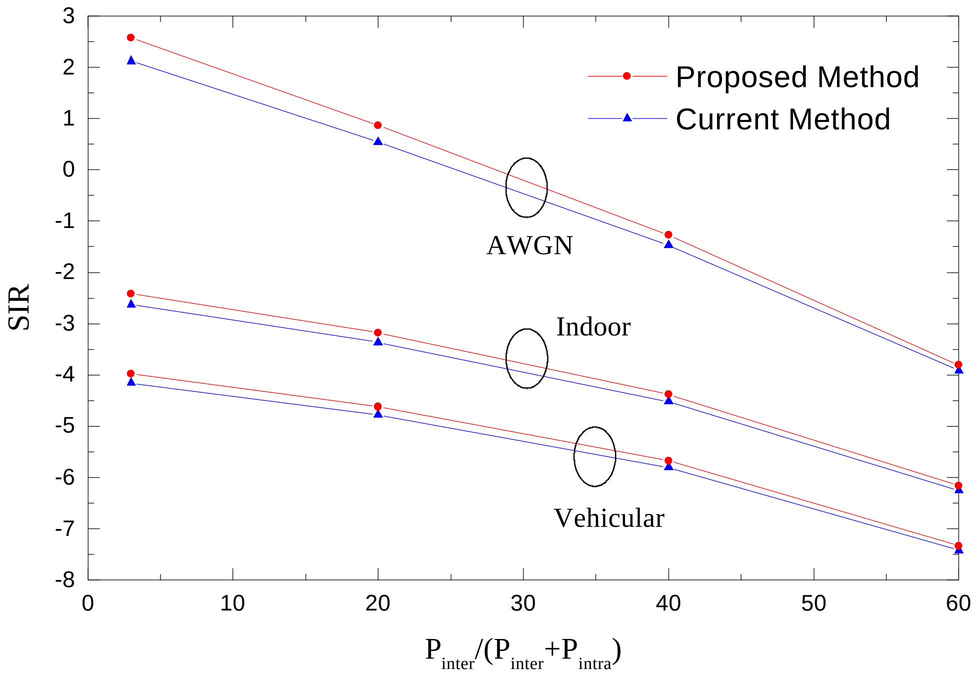


Figure 7. Received SIR (63 users and CPICH is on PSC, and 20 users is on SSC)

The performance gain of the proposed method originates from the reduction of the interference from difference scrambling codes. The interference reduction by using the proposed method is plotted in Fig. 8. Fig 8 shows that the interference reduction ratio of the proposed method is proportional to the ratio of in-path interference from home cell to total interference.

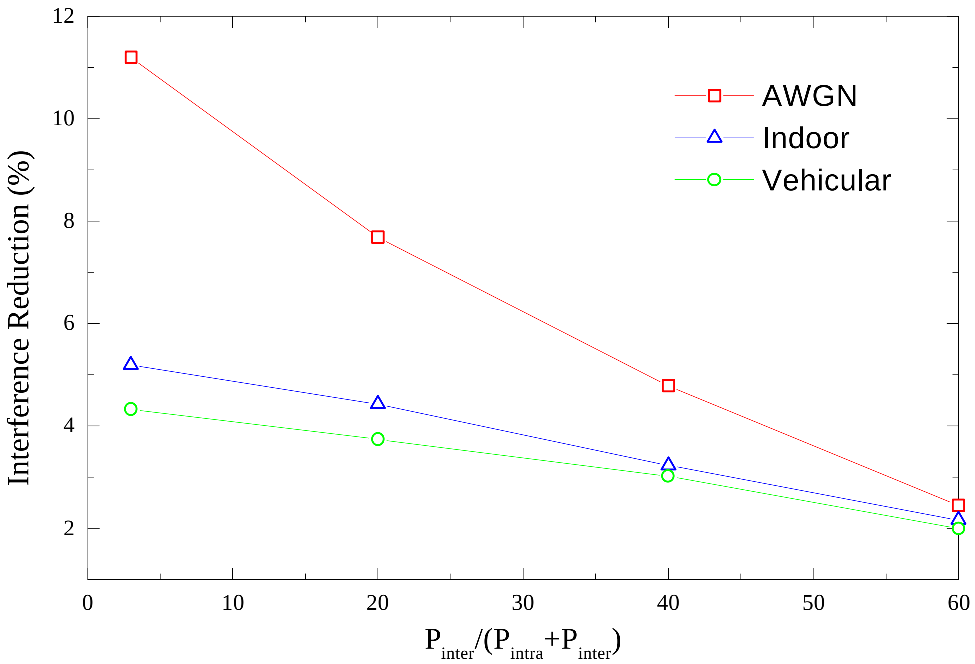


Figure 8. Interference reduction by using the proposed method (63 users and CPICH is on PSC, and 20 users is on SSC)

In Figs. 9 and 10, the received signal-to-interference ratio (SIR) and interference reduction ratio are plotted as a function of the number of users on the SSC, respectively. In Figs 9 and 10, the value of P_{inter} /(P_{intra} + P_{inter}) is set to be 3% which is correspond to $r/R_c = 0.4$. The interference reduction ratio will be decrease as the UE goes away from the center of cell. For AWGN channel, interference reduction ratio is about 11%, and it has no relation to the number of users on SSC. For indoor channel, interference reduction ratio is about 5% when the number of users on SSC is larger than 20.

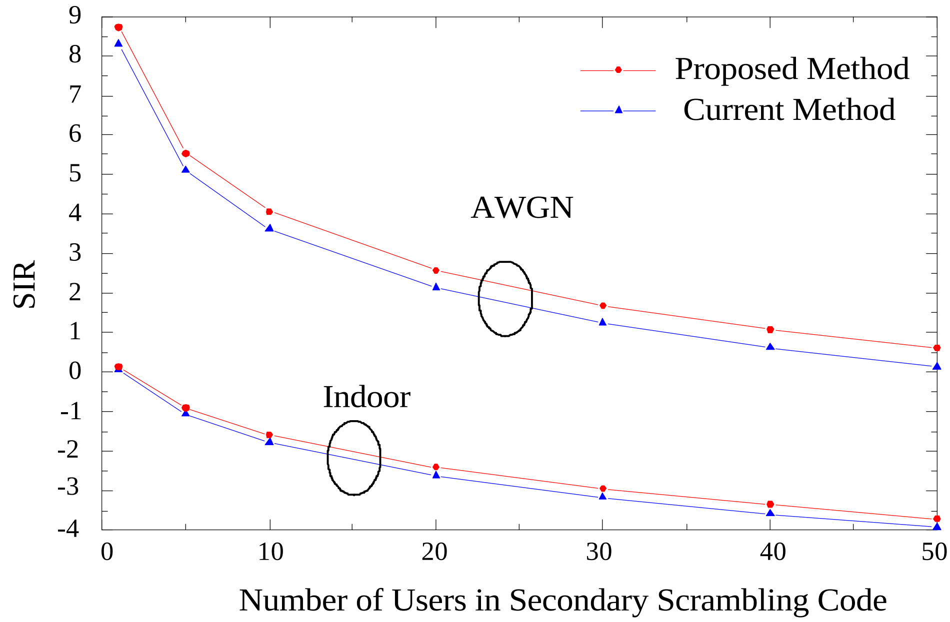


Figure 9. Received SIR (r/R_c = 0.4, 63 users and CPICH is on PSC)

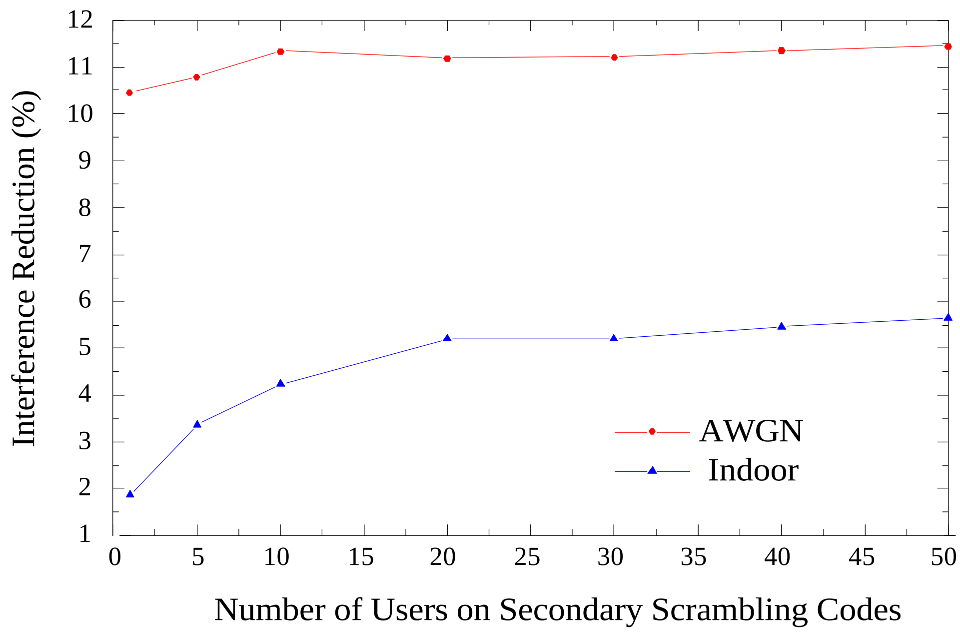


Figure 10. Interference reduction by using the proposed method (r/R_c = 0.4, 63 users and CPICH is on PSC)

4. Summary

In this contribution, we investigate the complexity and performance gain of the proposed method newly. The implementation burden of the proposed method is very small. The proposed method reduces in-path interference power from different scrambling codes by 10.9%. But, the proposed method does not reduce the interference from other cells and other-paths. So, the performance gain of the proposed method depends on channel type and the ratio of other-cell interference.

For the conceptual ideal of the performance gain, we will compare the proposed method with OVSF codes. The proposed method and OVSF codes do not reduce the interference from other cells and other-paths. OVSF codes reduces the in-path interference from home cell by 100%. So, the performance gain of the proposed method is about 10.9% performance gain of OVSF codes.

5. References

[1] Nokia, "Work item for rel'00: radio link performance enhancements," TSG RAN#7 (00)0181, Madrid, Spain, 13-15 March 2000.
[2] LGIC, "Time delay between physical channels of different scrambling codes," TSGR1#7(99)b53, Hannover, Germany, Aug. 30-Sep. 3, 1999.
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[4] LGIC, "Questions and answers about time delay between physical channels of different scrambling codes," TSGR1#8(99)g31, New York, USA, 12-15 Oct., 1999.
[5] Ad Hoc 10, "Conclusion for R1-99g31 titled questions and answers about time delay between physical channels of different scrambling codes," TSGR1#7(99)h18, New York, USA, 12-15 Oct., 1999.
[6] M. B. Pursley, "Performance evaluation of phase-coded sperad-spectrum multiple-access communication-part I: system analysis," IEEE Trans. Commun. vol. COM-25, no. 8, Aug. 1977, pp. 795-799.
[7] J. S. Lee and L. E. Miller, *CDMA Systems Engineering Handbook*, Boston · London: Artech House, 1998.

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