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Agenda Item:
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To: TSG RAN WG1
Title: Smart Antenna technolgy for low chip rate TDD option
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Introduction

A smart antenna system is composed of an array of multiple antenna elements and coherent transceivers with advanced digital signal processing algorithms. Instead of a single fixed beam pattern from a traditional antenna, the smart antenna can dynamically generate multiple beam patterns, each of them is pointed to a particular UE, and such beam patterns can adapt to follow any UE intelligently. On the Rx side of Node B, such a feature, i.e., spatially selective Rx (uplink) beamforming, can greatly minimize co-channel interference from the co-channel UEs at different locations, thus increase the Rx sensitivity and lead to higher capacity. It can also effectively incorporate multipath components to combat multipath fading. On the Tx side of Node B, intelligent spatially selective Tx (downlink) beamforming can also greatly reduce the interference to other co-channel UEs, then dramatically save the output power requirement and lead to higher capacity.

Smart Antenna

Smart antenna structure in Node B

The low chip rate option is mainly based on the smart antenna technology as described. Generally speaking, a smart antenna based Node B should be that shown in Figure 1. The smart antenna array is composed of N antenna elements, N related feed cables and N coherent RF transceivers in RF part. By use of the A/D converters or D/A converters in analog baseband (ABB), the Rx and Tx analog signals are interfaced to the digital baseband (DBB) part over the high-speed data bus. In this model, all antenna elements related feed cables and coherent RF transceivers will be calibrated before operating.

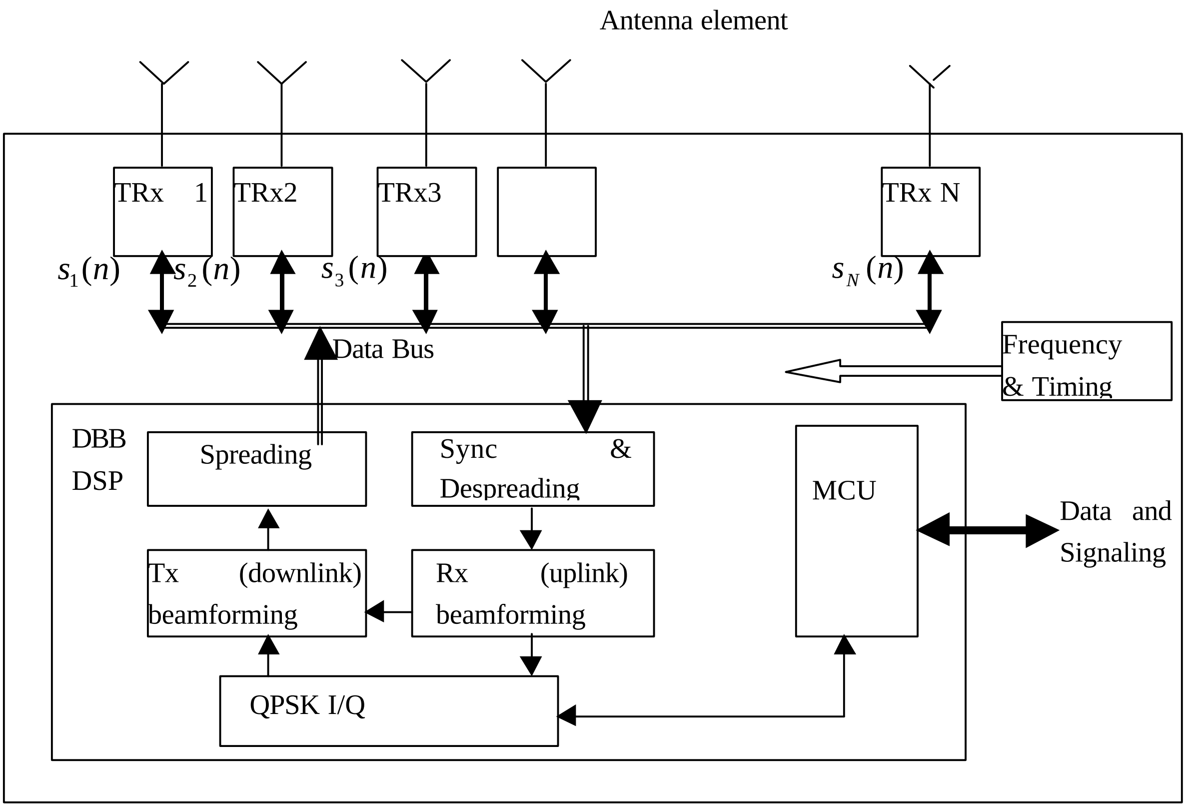

Figure 1 Block diagram of Node B with Smart Antenna

Beamforming

Reference to Figure 1, the Node B is equipped with smart antenna array and DBB DSP. When a signal comes from one UE within the coverage of the Node B, each antenna element and coherent RF receiver will get it. Because of the different location of the different antenna element, the phase of the Rx signal will be different. In case of multipath propagation, each path will come from different directions with different amplitude and delay. Then the Rx signal at each antenna element will show different phase and amplitude. After the front-end processing in RF part and A/D converters processing in ABB, digitized Rx signal with the phase and amplitude information will be sent to DSP in DBB part. After despreading in the DBB processor, the Rx data of each code channel may be obtained. The purpose of smart antenna in uplink is to find the best E_b/I_0 after the combination,Theoretically, the uplink beamforming can add up all useful signals while canceling all multipath interference.Next step is to realize downlink beamforming. The Tx signal of the each code channel is got by some algorithms that enable the UE to obtain the best E_b/I_0 .In TDD system, because of the symmetrical performance in wave propagation, it is possible to directly use the uplink beamforming results to downlink beamforming.

An example of the beamforming algorithm is described in Annex A.

Conclusion

In this document, a basic description for the structure of smart antenna system in Node B and the beamforming principle are provided. Smart antenna is one of the most important parts in TD-SCDMA Node B,it's proposed to include this new feature for low chip rate TDD option in new clause 8.4 of TR 25.928

---------------------------------- changes to 25.928 begin -------------------------------------

8.4 Smart Antenna

8.4.1 Smart antenna structure in Node B

The low chip rate option is mainly based on the smart antenna technology as described. Generally speaking, a smart antenna based Node B should be that shown in Figure 1. The smart antenna array is composed of N antenna elements, N related feed cables and N coherent RF transceivers in RF part. By use of the A/D converters or D/A converters in analog baseband (ABB), the Rx and Tx analog signals are interfaced to the digital baseband (DBB) part over the high-speed data bus. In this model, all antenna elements related feed cables and coherent RF transceivers will be calibrated before operating.

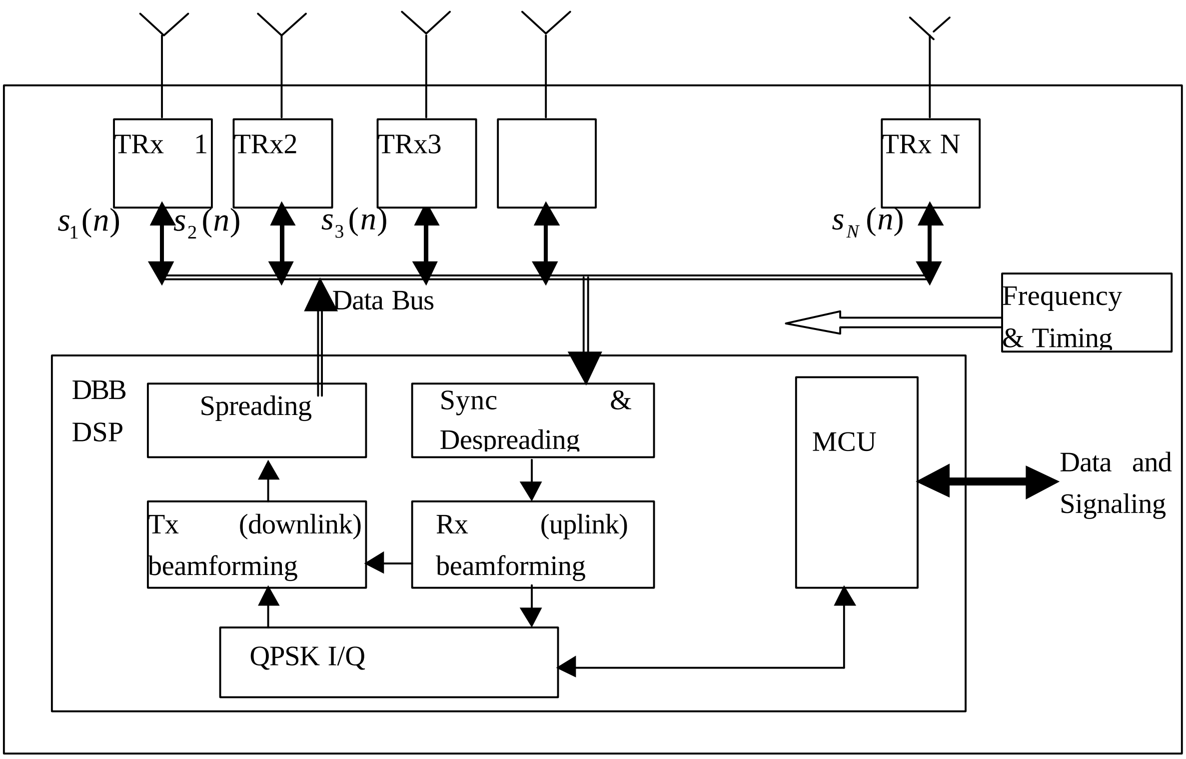

Figure 1 Block diagram of Node B with Smart Antenna

8.4.2 Beamforming

Reference to Figure 1, the Node B is equipped with smart antenna array and DBB DSP. When a signal comes from one UE within the coverage of the Node B, each antenna element and coherent RF receiver will get it. Because of the different location of the different antenna element, the phase of the Rx signal will be different. In case of multipath propagation, each path will come from different directions with different amplitude and delay. Then the Rx signal at each antenna element will show different phase and amplitude. After the front-end processing in RF part and A/D converters processing in ABB, digitized Rx signal with the phase and amplitude information will be sent to DSP in DBB part. After despreading in the DBB processor, the Rx data of each code channel may be obtained. The purpose of smart antenna in uplink is to find the best E_b/I_0 after the combination,Theoretically, the uplink beamforming can add up all useful signals while canceling all multipath interference.Next step in smart antenna is to realize downlink beamforming. The Tx signal of the each code channel is got by certain algorithms that enable the UE to obtain the best E_b/I_0 .In

TDD system, because of the symmetrical performance in wave propagation, it is possible to directly use the uplink beamforming results to downlink beamforming.

An example of the beamforming algorithm is described in Annex A.

ANNEX A

The following is an example of one beamforming algorithm.

Let the output of the i-th receiver be $s_i(n)$ at the time n. After despreading, one may obtain the Rx data of each code channel as $x_{ji}(l)$ for the l-th symbol, where j means the j-th code channel. The purpose of smart antenna in uplink is to find the best E_b/I_0 after the combination, The signal of the l-th symbol in the j-th code channel is denoted as $X_j(l)$, then

$$X_j(l) = \sum_{i=1}^{N} x_{ji}(l) w_{ij}(l)$$

(A-1)

where W is the uplink beamforming matrix with element $w_{ij}(l)$.

Many beamforming algorithms can be found in published papers. Theoretically, the uplink beamforming can add up all useful signals while cancelling all multipath interference.

Next step in smart antenna is to realize downlink beamforming. The Tx signal of the j-th code channel is denoted as $Y_j(l)$ for the l-th symbol. Let the UE obtain the best E_b/I_0, then it can be obtained that

$$y_{ij}(l) = \sum_{i=1}^{N} Y_j(l) u_{ji}(l)$$

(4)

where

$y_{ij}(l)$ is the Tx signal on the i-th antenna for the l-th symbol in the j-th code channel;

U is the downlink beamforming matrix with element $u_{ji}(l)$.

In TD-SCDMA system, the uplink and downlink are operated at the same frequency but in different time slots. This make it possible to directly use the uplink beamforming results (W in equation (A-1)) to downlink beamforming (U in equation (4)) because of the symmetrical performance in wave propagation. The reciprocal principle in electro-magnetic theory provides the theoretical foundation.

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