Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	Downlink switched beam support in IEEE802.16e	
Date Submitted	2005.1.	
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Re:	P802.16e Ballot Resolution Committee Recirculation Announcement	
Abstract	Definition of new information element (IE) and MAC management messages to support switched beamforming in downlink.	
Purpose	Optional support of new switched beam selection mechanism in downlink.	
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Optional Closed-loop Downlink Switched Beam Selection Mechanism

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1. Introduction

Smart antennas are widely used to steer the beam patterns toward individual users. Since smart antenna technologies yield not only the enhanced antenna gain but also the co-channel interference reduction, systems with antenna arrays can provide better network performance than those with omni or sector antennas do. Switched and fully adaptive beamforming are two major applications of the smart antenna systems and each has it's own advantages and disadvantages. In many cases transmit switched beam forming is widely used in the downlink and receive adaptive beam forming is widely used in the uplink. In this contribution an efficient beam selection algorithm of downlink transmit switched beam smart antenna system is proposed. In order to support the proposed algorithm, we don't need any physical changes or additions. We can reflect this contribution by defining a new information element (SBF_DL_Support_IE) and TLVs.

2. Algorithm

The most important task in designing the switched beam system is to develop an efficient method of beam selection, in such a way that the base station (BS) can quickly and accurately switch to the correct beam, which covers the area where the target mobile subscriber station (MSS) belongs. The conventional methods of selecting the beam are based on the BS's measurements such as the received signal strength indicator (RSSI) and the direction of arrival (DOA) using the uplink signal. But this contribution

proposes a new switched beam selection algorithm in which MSS determines the best beam and informs the beam index to BS so as for the BS to steer it to the corresponding MSS. The criterion of selecting the best beam at MSS side is the maximization of received signal-to-noise ratio (SNR) and in this case in order to evaluate received SNR individual channel estimation between each array element constituting the smart antenna and MSS is required.

Fig. 1 illustrates the linear array antenna configuration for switched beam forming. The h_i in Fig. 1 represents the channel between the ith antenna element of array and the MSS. In order to support K fixed switched beams the BS uses N element array antenna and preset K weighting vectors. For the switched beam of index k, the BS shall apply the weighting vector, W_k.

$$W_k = \begin{bmatrix} w_{k,1} \\ w_{k,2} \\ w_{k,3} \\ \cdots \\ w_{k,N} \end{bmatrix}, \quad k = 1, 2, \ ..., K \tag{1}$$

For a downlink switched beam of index k formed by N element array antenna at BS, the received signal at MSS side is given by

$$r = \sqrt{\gamma} H W_k x + n, \tag{2}$$

where H is $[h_1 \quad h_2 \quad \cdots \quad h_N]$, r, x, n, γ represent the received signal, transmitted signal, thermal noise and the input SNR, respectively. In order to obtain downlink channel vector H, we need to define downlink pilot signals identifying array elements. Equation (3) represents the instantaneous SNR of the received signal at the MSS.

$$SNR = \gamma \left(W_k^H R W_k \right), \quad R = H^H H. \tag{3}$$

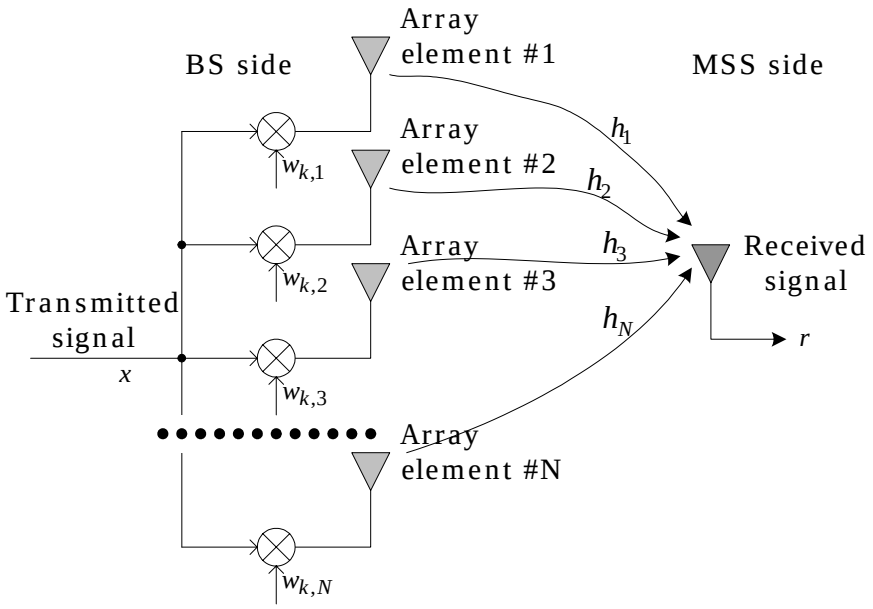

Fig. 1. Linear array antenna for switched beam forming.

Using the channel measurements and the preset K weighting vectors, the MSS selects the beam, which maximizes the received SNR. Therefore the selection is made in such a way that the MSS estimates the SNR for each weighting vector using (4) and finds the best one which gives the best SNR:

$$BeamIndex = \arg\max_{k} \left\{ \gamma\left(W_k{}^H R_L^i W_k \right) \right\}, \quad R_L^i = \rho R_L^{i-1} + (1-\rho) R^i, \tag{4}$$

where R^i and ρ represent the i th-calculated $H^H H$ in the time sequence and an averaging parameter, respectively. And the selected switched beam index at the MSS shall be informed to the BS using the feedback channel.

3. Advantages

Followings are the advantages of this algorithm:

- In the DOA-based algorithm there is a limitation to assign enough power to uplink signal for reliable DOA measurement because MSS is powered by battery. On the other hand in this algorithm BS can assign enough power to downlink pilot signals for the MSS to measure downlink channel vector.
- Since the downlink channel estimation takes into account the discrepancies associated with each antenna element, the proposed switched beam selection algorithm does not need BS array transmitter calibration. Also this is very useful for FDD applications.

- In the conventional downlink switched beam algorithms, the BS is responsible for selecting the appropriate downlink beam for each target MSS based on such uplink signal measurements as DOA and RSSI. But in the proposed algorithm every MSS selects the downlink switched beam based on the channel measurement using the common downlink pilot signal. So the proposed algorithm needs not to assign individual bandwidths in the uplink to MSSs for the dedicated measurements of DOA and RSSI

4. Proposed text changes

Two text changes are proposed to support this contribution:

- In order to support the proposed switched beam selection mechanism, we need to define SBF_DL_Support_IE using extended DIUC to indicate the allocation for the transmission of orthogonal sequences. The MSS uses these orthogonal sequences to obtain downlink channel responses depending on array elements at BS.
- In order for the MSS to notify beam index to BS, new TLVs are appended for REQ_REQ and AAS_Beam_Select messages.

Make section 8.4.5.3.10 in Page 239 and insert the following text

--- Begin text ----------

8.4.5.3.10 Optional Downlink Switched Beam Support IE

An extended IE with an extended DIUC value of SBF_DL_Support_IE is issued by the BS to indicate the allocation for the transmission of orthogonal sequences. The MSS uses these orthogonal sequences to obtain downlink channel responses depending on array elements at BS. The purpose of this IE is to support closed-loop downlink transmit switched beam selection in which the best beam among the downlink fixed steered beams is selected by MSS using the downlink channel responses and already known weighting vectors for preset fixed beams. The MSS shall feed the selected beam index to BS.

Eighteen orthogonal sequences are defined by matrix *M* based on the 9-point DFT, which is already used in the AAS preamble. If we denote the generated matrix from 9-point DFT as h_9, then the matrix *M*, which is 18-by-18, is defined by:

$$M = \begin{bmatrix} h_9 & h_9 \\ h_9 & -h_9 \end{bmatrix}. \qquad (5)$$

Every row of matrix *M* is used as orthogonal sequence. The *n-th* array element transmits the *n-th* row of *M*. The *n-th* row is denoted by *n-th* sequence.

The SBF_DL_Support_IE allocates some AMC bands to transmit orthogonal sequences. The *n-th* element in the array at BS shall transmit the *n-th* orthogonal sequence twice using the specified band as in Fig. xxx.

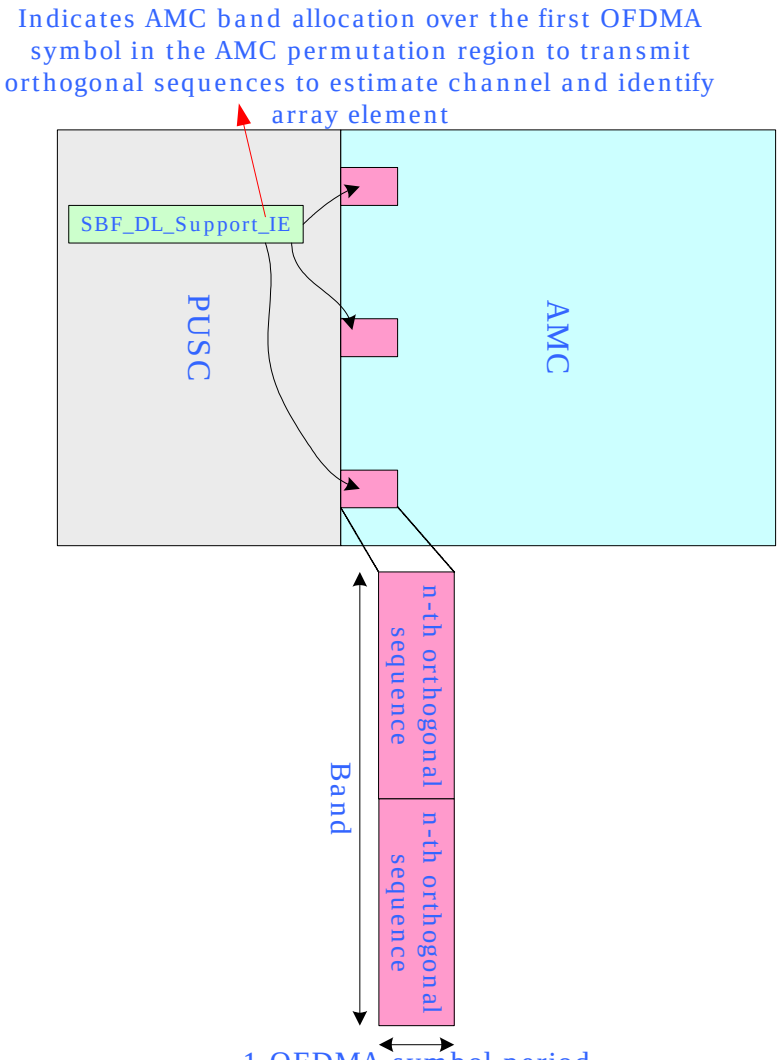

Fig. xxx: AMC band allocation to transmit orthogonal sequence transmission for *n-th* array element.

Table xxx – SBF_DL_Support_IE format

Syntax	Size	Notes
SBF_DL_Support_IE() {		
Extended DIUC	4 bits	SBF_DL_Support_IE
Length	4 bits	
No of array elements at BS (*N*)	5 bits	The value of this field specifies the number of array elements. The maximum value of *N* is 18. Only first *N* orthogonal sequences among the 18 shall be used.
Reserved	3 bits	Shall be set to zero.
Number of preset switched beams	8 bits	The value of this field specifies the number of preset switched beams in a sector or cell.
AMC band allocation	Band BITMAP	If the *n*-th LSB of the Band BITMAP is set to 1, then the *n-th* band of the first OFDMA symbol in AMC permutation region shall transmit the corresponding orthogonal sequence twice as in Fig. xxx.
}		

--- End text ----------

The selected switched beam index by MSS may be sent using AAS Beam Select message already defined in IEEE Std 802.16-2004.

Make section 11.8.3.7.12 at Page 410 and insert the text

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11.8.3.7.12 Downlink Switched Beam Forming Support

In order to support downlink transmit switched beam selection, the MSS notifies the best switched beam index and the AMC band number on which it estimated the downlink channel to evaluate the best beam to BS.

Type	Length	Value	Scope
xxx	2	Bits#0-7:Request beam index by MSS Bits#8-15: AMC band number on which MSS evaluated the downlink channel to evaluate the best switched beam	REG-REQ

In order to support downlink transmit switched beam selection, the MSS notifies the AMC band number on which it estimated the downlink channel to evaluate the best beam to BS.

Type	Length	Value	Scope
xxx	1	Bits#0-7: AMC band number on which MSS evaluated the downlink channel to evaluate the best switched beam	AAS_Beam_Select

--- End text ----------