Performance Comparison of MIMO Technology over LTE-A System

Khalid Hussein Rashid, Ashwaq Q.Hameed
Department of Electrical Engineering, Technology University

khalidhussein24@yahoo.com, aza-2004r@yahoo.com

Abstract

Third generation partnership project (3GPP) has been introducing The Long Term Evolution (LTE) (release8) and LTE advance (LTE-A) (release 10)fourth generations as a new access technology to mobile communication in order to meet the tremendous requirement of data traffic. LTE-A have adopted modern techniques such as Multiple-Input Multiple Output (MIMO)and Orthogonal Frequency Division Multiplexing OFDM to satisfy all the requirements and meet the tremendous growth of data.

LTE-A with MIMO system scheme based on transmission mode Close Loop Spatial Multiplexing (CLSM).CLSM transmission modes used for doubling the bit stream and consequently increased the data rate with Adaptive modulation schemes. In this paper, The performance metrics considered are throughput. These are used to evaluate the performance of LTE-A in (AWGN) channel and Rayleigh Fading channel with detection schemes for CLSM with different band width (3, 5 and 10 MHz) and the following results has been obtained : at the same bandwidth (10 MHz) for 8x8 MIMO channel and AWGN at SNR (25dB) the maximum throughput equal(224.3 Mb/S) while in Rayleigh the throughput equal(203.8 Mb/S) . A MATLAB simulation version R2013a has been used to complete the analysis and comparison.

Keywords: MIMO, close loop spatial multiplexing ,LTE-A, Signal to Noise Ratio, Adaptive Modulation and OFDM.

Paper History:

1. Introduction

The fourth generation which is the first release of LTE (release 8) is called 4G and developed level 4G is LTE (release 10) is know LTE-advance because increase level of commutation system this generation based OFDM [1]. LTE-Advanced System is the advanced technology for the fourth generation (4G) wireless networks [2]. It is an International Mobile Telecommunication-Advanced (IMT-A) standardized by the LTE-A. The development of wireless broadband networks with very high data rates. The data rate of LTE-A system should be target a downlink maximum data rate of 1 Gbps and an uplink maximum data of 500 Mbps [3]. It provides high-speed data transmission. The low Latency can be defined by Control-plane (C-plane) and User-plane (U-plane) ,LTE-A system reduced U-plane latency when compared with LTE system and high quality mobile services which in turn are considered the key considerations of mobile broadband technology [4, 5].

LTE-A works different bandwidths ranging from 1.4MHz to 20MHz, can operate provides a high data rate [6]. As one of the most important techniques of meeting the LTE-Advanced goals, the MIMO technology which increased data rates and system level performance. The enhanced Multiple -In and Multiple -Out (MIMO) technology is very important as this is a major enhancement technique that uses multiple antennas at both transmitter and receiver.

The main components of the MIMO technology used in the LTE -A . CLSM Is a method that provides high data rates based on number of antennas used. The key CLSM is based on that multiple divided data streams can be transmitted in parallel through a number of antennas and should be divided at the receiver region [7]. As a result the received signals can be expressed as in

$$Y = HS + W \qquad (1)$$

H: channel matrix. S: transmit data.

W: noise system

In this paper MIMO channel 8x1 , 8x4 and 8x8 and this channel has been presented as shown below.

$$H_{8x1} = \begin{bmatrix} h1,1 \\ h2,1 \\ h3,1 \\ h4,1 \\ h5,1 \\ h6,1 \\ h7,1 \\ h8,1 \end{bmatrix}, \quad H_{8x4} = \begin{bmatrix} h1,1 & h1,2 & h1,3 & h1,4 \\ h2,1 & h2,2 & h2,3 & h2,4 \\ h3,1 & h3,2 & h3,3 & h3,4 \\ h4,1 & h4,2 & h4,3 & h4,4 \\ h5,1 & h5,2 & h5,3 & h5,4 \\ h6,1 & h6,2 & h6,3 & h6,4 \\ h7,1 & h7,2 & h7,3 & h7,4 \\ h8,1 & h8,2 & h8,3 & h8,4 \end{bmatrix}$$

$$H_{8x8} = \begin{bmatrix} h1,1 & h1,2 & h1,3 & h1,4 & h1,5 & h1,6 & h1,7 & h1,8 \\ h2,1 & h2,2 & h2,3 & h2,4 & h2,5 & h2,6 & h2,7 & h2,8 \\ h3,1 & h3,2 & h3,3 & h3,4 & h3,5 & h3,6 & h3,7 & h3,8 \\ h4,1 & h4,2 & h4,3 & h4,4 & h4,5 & h4,6 & h4,7 & h4,8 \\ h5,1 & h5,2 & h5,3 & h5,4 & h5,5 & h5,6 & h5,7 & h5,8 \\ h6,1 & h6,2 & h6,3 & h6,4 & h6,5 & h6,6 & h6,7 & h6,8 \\ h7,1 & h7,2 & h7,3 & h7,4 & h7,5 & h7,6 & h7,7 & h7,8 \\ h8,1 & h8,2 & h8,3 & h8,4 & h8,5 & h8,6 & h8,7 & h8,8 \end{bmatrix}$$

2. Simulation Model

The model used for simulation is MATLAB based and it is a standard LTE-A model developed by MATLAB. The LTE-A with CLSM model is also based on different antennas (8x1, 8x4 and 8x8)configurations. The model generates changeable sized data with the size based on a combination of parameters which consist of channel bandwidth ,AWGN, Flat Rayleigh channel and MIMO configuration. Figure 1 shows a block diagram of a typical OFDM based system.
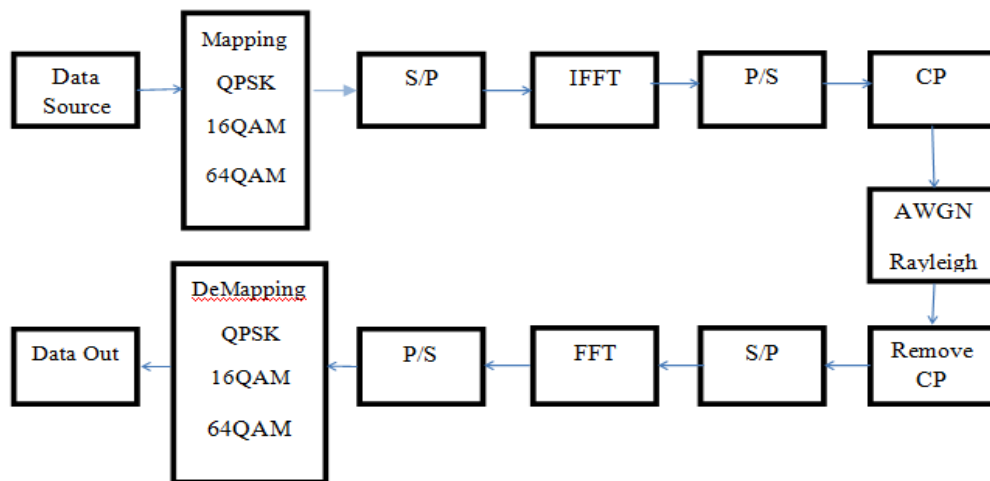

Figure 1:Block diagram of OFDM system

Firstly, the input data will be generated using the uniform distribution unsystematic number generation. The input data will be mapped into one of LTE-A (QPSK ,16QAM and 64QAM) modulation schemes are used as adaptive modulation according to CQI (Channel Quality Indicator). These higher modulation or constellation schemes are essential to provided bandwidth efficiency and high data rates in LTE-A while lower modulation achieve low data rate according to the system used. This will change the data to related value of M-ary constellation which is real and imaginary parts [8].

The Inverse Fast Fourier Transform(IFFT) stage generates OFDM symbols and converts these difficult data symbols into time domain and. In OFDM technique the high data rate serial stream is divided into a number of parallel streams and then these low-rate parallel streams are transmitted over unlike subcarriers at the same time [9].

In LTE-A systems, the OFDM uses two types of cyclic prefix (CP) that are extended CP and normal CP. The extended CP for lower frequencies (rural areas) and The normal CP is used for high frequencies (urban areas) .

Cyclic prefix addition is an important role during OFDM signal generation. A cyclic prefix is essential to prevent overlap from before transmitted OFDM symbols. [9].

At the receiver side ,the first step has to remove the guard period so that it reduce the ISI at the same channel and reduce the ICI between two adjacent channels. This process is also called de-cyclic prefix.

The de-cyclic prefix is followed by the Fast Fourier Transform (FFT) process which convert modulated symbols time domain into the frequency-domain for all sub-carriers.[9].

3. Simulation Results and Discussion

The performance metrics which could be used of communication systems include throughput . This paper focused on the throughput performance of CLSM antenna configurations. The parameters varied included SNR, number of antennas and channel bandwidth. Simulations were performed for these models show the throughput performance based on by increasing the number of antennas at both transmitter and receiver.

Table 1 The parameters used in the simulation are given below.

Parameter	Values
Bandwidth	3,5,and10 MHz
Cyclic Prefix (CP)	Normal
Channel Estimation Techniques	Perfect
Channel Type	AWGN and flat Rayleigh
Receiver Detection Type	Zero Forcing (ZF)
No. of Transmit Antenna (s)	8
No. of Receive Antenna (s)	1, 4,8
Transmission Schemes	Closed Loop Spatial Multiplexing (CLSM)

LTE-A system depended OFDM technology and MIMO technology of different antenna configurations (8x1,8x4 and 8x8). In Figure 2, the throughput considerable metric for three different bandwidth at antennas configurations. When we take a high range of SNR in order to achieve high stability for the system .
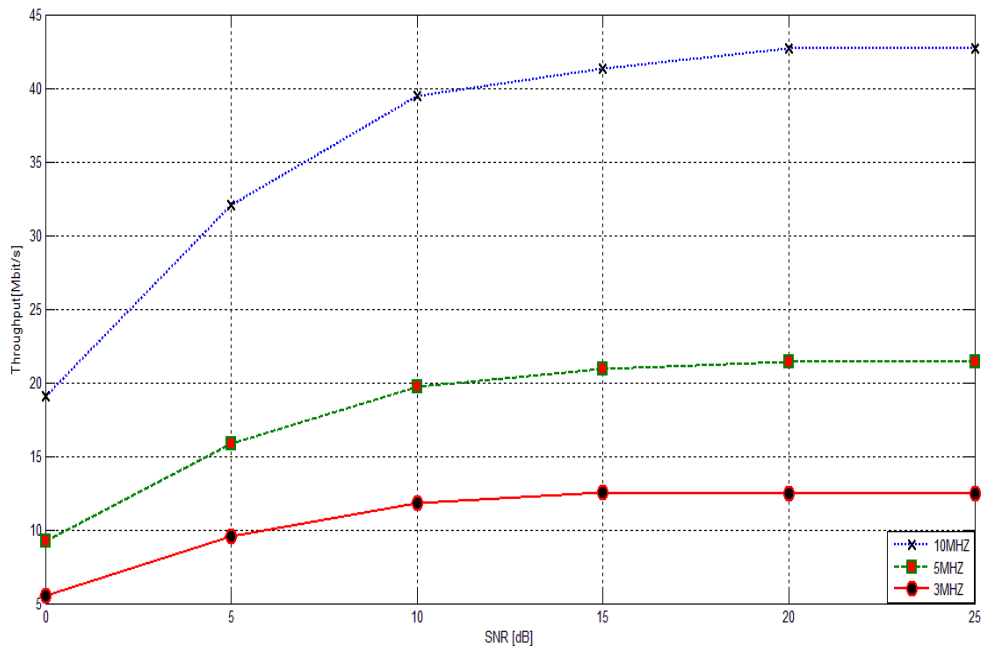

Figure 2: Performance throughput under different bandwidth of 8x1 MIMO channel with AWGN

Figure 3 describes the Throughput performance of(8x1)MIMO this figure clearly describes that with the increase of SNR, throughput increases gradually. The different bandwidth and SNR show that AWGN better than Flat Rayleigh when compare results because Flat Rayleigh is the real noise which affected by the Doppler shift, scattering and reflection. For example the comparison between Figure 2 and Figure 3 at 10 MHz with SNR equal 10dB the throughput equal (39.46 Mb/S) for AWGN while the throughput equal (30.82 Mb/S) for flat Rayleigh.
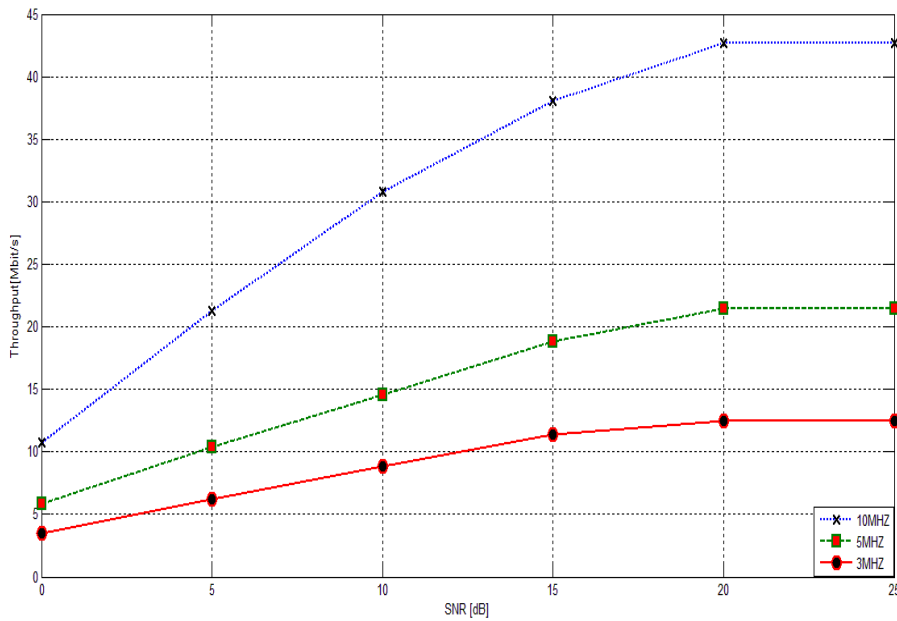
Figure 3: Performance throughput under different bandwidth of 8x1 MIMO channel with flat Rayleigh

Figure 4 explains that the throughput performance for MIMO 8X4.The throughput for greater than with compress in case 8x1.

When increasing the number of antenna it can be get increasing in the throughput and this obtain LTE-A to work transmission high throughput.
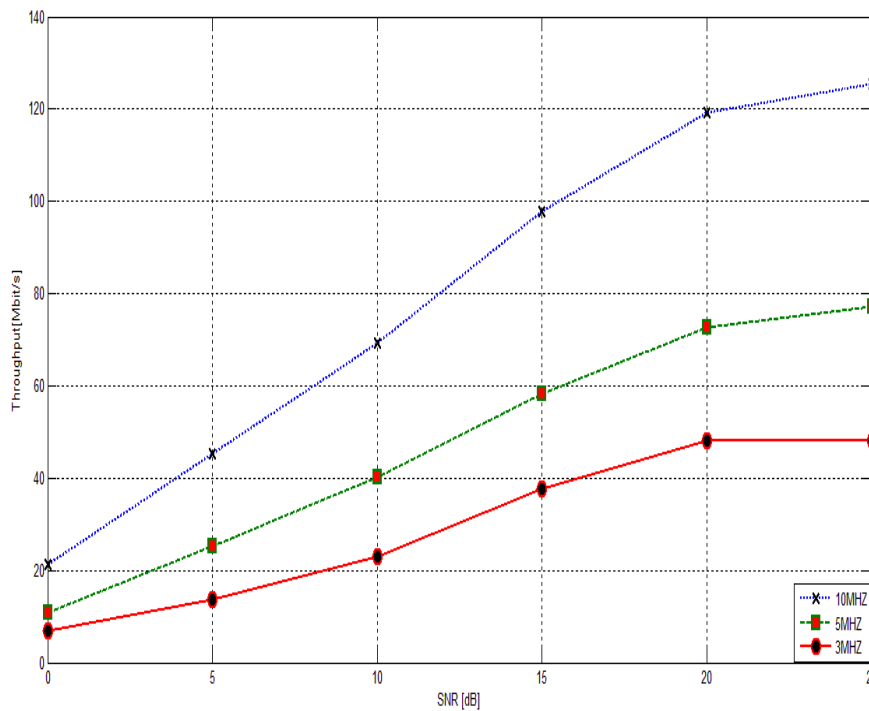

Figure 4: Performance throughput under different

bandwidth of 8x4 MIMO channel with AWGN It is clear that Figure 5 show that AWGN better than Flat Rayleigh of throughput transmission. For example the comparison between Figure 4

and Figure 5 at 10 MHz with SNR equal 10dB the throughput equal (69.41 Mb/S) for AWGN while the throughput equal (58.61 Mb/S) for flat Rayleigh
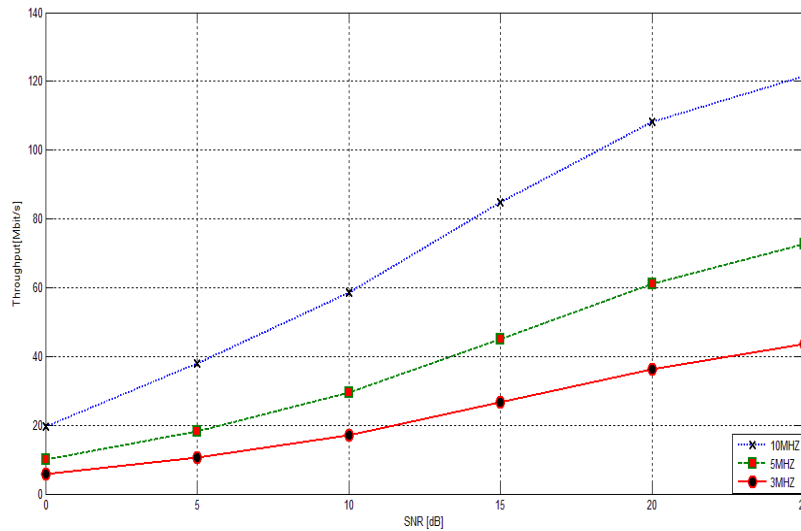
Figure 5: Performance throughput under different bandwidth of 8x4 MIMO channel with flat Rayleigh

It is clear that Figure 5 show that AWGN better than Flat Rayleigh of throughput transmission. For example the comparison between Figure 4 and Figure 5 at 10 MHz with SNR equal 10dB the throughput equal (69.41 Mb/S) for AWGN while the throughput equal (58.61 Mb/S) for flat Rayleigh.

The best cases to maxim throughput when used 8x8 antenna, compares resulted with 8x1 and

8x4, Figure 6 displays the relation between the SNR and throughput for different bandwidth. The throughput of a MIMO (8x1) system is lower than the throughput of a MIMO (8x4) system. It is clear that the throughput of a MIMO (8x8) system is higher than the throughput of a MIMO (8x4) system and the throughput of a MIMO (8x4) system is also higher than the throughput of a MIMO (8x1) system.
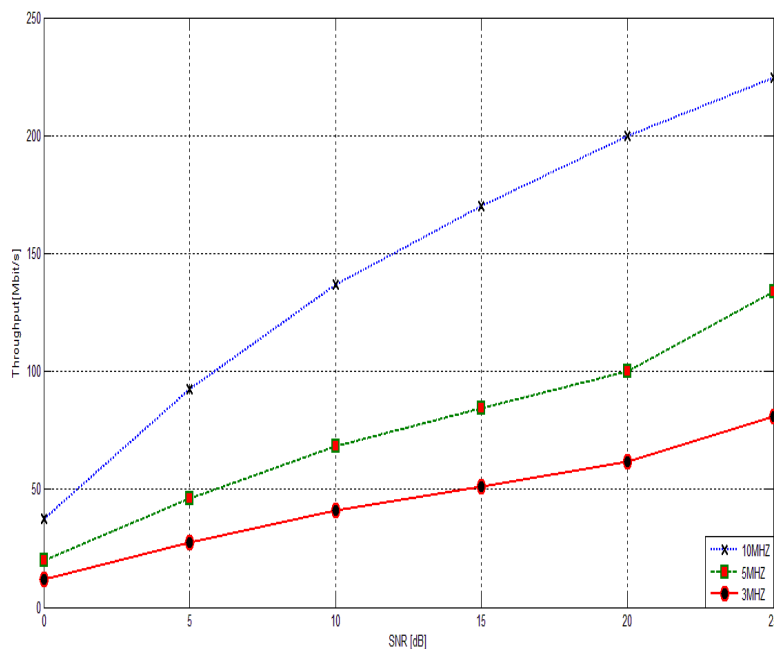

Figure 6: Performance Throughput under Different bandwidth of 8x8 MIMO channel with AWGN

It is clear Figure 7 also show that 8x8 MIMO channel maximum throughput but AWGN is better in 8x8 as we show the reason in previous cases. For example the comparison between

Figure 6 and Figure 7 at 10 MHz with SNR equal 10dB the throughput equal (137 Mb/S) for AWGN while the throughput equal (85.22 Mb/S) for flat Rayleigh.
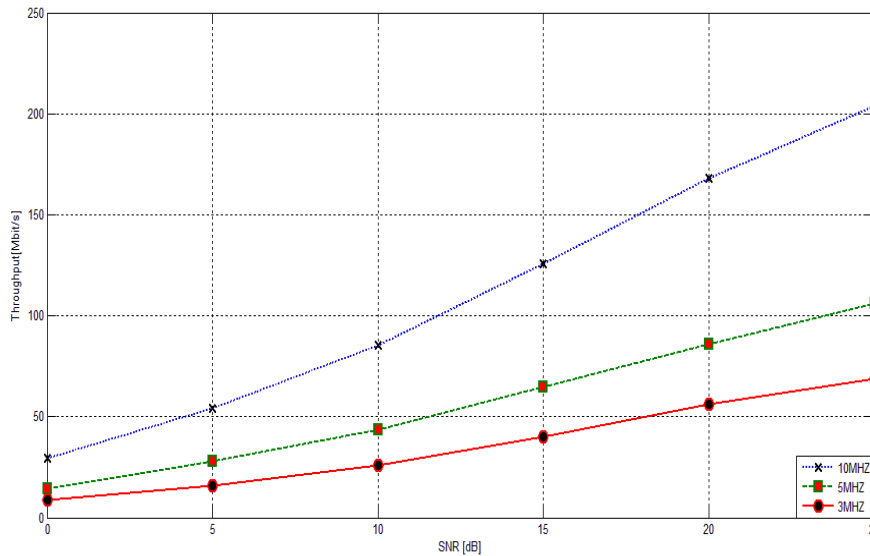
Figure 7: Performance throughput under different bandwidth of 8x8MIMO channel with flat Rayleigh

4. Conclusions

In this paper a number of transmission mode for LTE-A system which contain of MIMO type CLSM, as well as diffrent band width and with diffrent channel model are used.

1. Performance of LTE-A of maximum throughput when used 8x8 MIMO channel of AWGN.
2. When using wider bandwidth at 10 MHz high throughput is acheived as compared with (3 and 5) MHz.
3. AWGN gives better results as compared with flat rayleigh.

References

[1] Cox, Christopher, An introduction to LTE: LTE, LTE-advanced, SAE and 4G mobile communications, John Wiley & Sons, 2012.

[2] Mogensen, Preben E., et al. LTE-Advanced: The path towards gigabit/s in wireless mobile communications, Wireless Communication, Vehicular Technology, Information Theory and Aerospace & Electronic Systems Technology, 2009. Wireless VITAE 2009. 1st International Conference on. IEEE, (2009).

[3] Unknown, Author, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (Release 10), Technical Specification 36, 2010.

[4] Rindani, M. N., and A. A. Bavarva, BER performance comparison of 4X4 extended alamouti scheme for different fading channels, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), 2, (2013) and performance of 4G-LTE networks: A practical approach, John Wiley & Sons,

[5] Dahlman, Erik, et al, 3G evolution: HSPA and LTE for mobile broadband, Academic press, 2010.

[6] Uyoata, Uyoata E., and James M. Noras, BER Performance of 2x2 and 4x4 Transmit Diversity MIMO in Downlink LTE, International Journal of Computer Applications 108.9 (2014).

[7] Akyildiz, Ian F., David M. Gutierrez-Estevez, and Elias Chavarria Reyes, The evolution to 4G cellular systems: LTE-Advanced, Physical communication 3.4, (20100, pp 217-244.

[8] Litwin, Louis, and Michael Pugel, The principles of OFDM" RF signal processing 2, (2001), pp 30-48.

[9] Osman, Ammar, and Abbas Mohammed, Performance evaluation of a low-complexity OFDM UMTS-LTE system, Vehicular Technology Conference, 2008. VTC Spring 2008. IEEE   .