Exhibit E

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Additional inventors are being named on the _____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (500 characters max)

Methods and Apparatus for Multi-carrier Communication Systems with Adaptive Transmission and Feedback

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

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ENCLOSED APPLICATION PARTS (check all that apply)

☒ Specification *Number of Pages* 9
☒ Drawing(s) *Number of Sheets* 8
☐ Application Data Sheet. See 37 CFR 1.76
☐ CD(s), Number _____
☐ Other (specify) _____

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Respectfully submitted,

SIGNATURE _____ Date 2/13/2004

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TELEPHONE 425-451-8278 Docket Number: _____

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Methods and Apparatus for Multi-Carrier Communication Systems with Adaptive Transmission and Feedback

1 Background of the Invention

Adaptive modulation and coding (AMC) has been used in wireless systems to improve spectral efficiency in a fading environment where signal quality varies significantly. By adjusting the modulation and coding scheme (MCS) in accordance with the varying signal-to-noise-plus-interference ratio (SINR), reliable communication link can be maintained between communicating devices. For example, in CDMA2000 1xEV-DO system, twelve different modulation/coding schemes are provided. AMC is also used in CDMA2000 1xEV-DV and 3GPP HSDPA systems.

In addition to MCS, other system functionalities, such as channel estimation, transmission power control (TPC), subchannel configuration, can be adjusted in accordance with state of the communication channel to improve performance. For example, channel estimation is usually carried out using so called training symbols or pilot data, which are known to both the transmitter and the receiver. For coherent modulation, the channel information can be extracted at the receiver by comparing the pilots and their corresponding received versions. For non-coherent modulation, the received samples of those pilots are used as reference for the detection of the transmitted data. Channel estimation is an important part of multi-carrier communication systems such as Orthogonal Frequency Division Multiplexing (OFDM) systems. For example, in conventional OFDM systems, such as IEEE802.11a, 802.11g, 802.16, or DVB-T system, pilots are transmitted for the channel estimation purpose. However, the number of pilots and pilot patterns are fixed, independent of other functionalities such as MCS, TPC, subchannel configuration.

Fast TPC can be used to compensate for fast fading. In a multi-cell multiple access system, TPC is also used to reduce intra-cell and inter-cell interference and conserver battery life for the mobile station by not transmitting excessive power when not needed. However, TPC is usually considered an independent function in a wireless system in that it is not related to MCA, pilot attributes, or subchannel configuration.

Subchannel configuration is normally defined and fixed in the operation. It is usually not considered as adjustable functionality of the system to adapt to user profile and/or operational environment.

2 Summary of the Invention

This invention describes the methods and apparatus to carry out adaptative transmission where modulation schemes, coding rates, training pilot patterns, TPC levels, and subchannel configurations are jointly adjusted to adapt to the channel

conditions in order to maximize the overall system capacity and spectral efficiency without wasting radio resource and compromising error probability performance. Furthermore, the subchannel composition is designed to be configurable so that it can be adjusted statically or dynamically according to user profiles or environment conditions. The methods for obtaining the channel information and for transmitting the control information in the joint adaptation scheme are also included in the present invention, and methods for reducing the overhead of messaging such as feedback of channel condition and indexing of the joint scheme are described.

The multi-carrier system mentioned in this invention can be of any special formats such as OFDM, or Multi-Carrier Code Division Multiple Access (MC-CDMA). The invention can be applied to downlink, uplink, or both, where the duplexing technique can be either Time Division Duplexing (TDD) or Frequency Division Duplexing (FDD).

3 Brief Description of the Drawings

The present invention will be thoroughly understood from the detailed description given below and from the accompanying drawings of various embodiments of the invention, which, however, should not be taken to limit the invention to the specific embodiments, but are for explanation and understanding only.

Figure 1: A representative cellular communication system: Base Station 1 is communicating with Mobile Station 1 and Mobil Station 2 in Sector A of its cell site, and Base Station 2 is communicating with Mobile Stations 3, 4, and 5 in Sector B of its cell site.

Figure 2: The basic structure of a multi-carrier signal in the frequency domain is made up of subcarriers. Data subcarriers can be grouped into subchannels in a particular way. The pilot subcarriers are also distributed over the entire channel in a particular way.

Figure 3: The radio resource is divided into small units in both the frequency and time domains: subchannels and time slots. The basic structure of a multi-carrier signal in the time domain is made up of time slots.

Figure 4 is an illustration of the control process between Device A and Device B. Device A transmits the data and the associated control information to Device B after the adaptation process. Device B measures the channel condition and feeds the CQI information back to Device A.

Figure 5 illustrates the joint adaptation process at the transmitter of an OFDM system which controls the coding, modulation, training pilot pattern, and transmission power for a subchannel.

Figure 6 is an illustration of the control messaging associated with the data transmission between the communication devices: AMCTP indicator associated with the data transmission on the forward link from the transmitter to the receiver, and CQI feedback on the return channel from the receiver to the transmitter.

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