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Radio resource management for a mobile network with TD-CDMA

Yin-Fu Huang *, Tsung-Yi Chiu

Institute of Electronic and Information Engineering, National Yunlin University of Science and Technology, 123 University Road, Section 3, Touliu, Yunlin 640, Taiwan, ROC

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Abstract

In the paper, we proposed a resource allocation method employing maximal compatible cliques to make use of channel bandwidth as efficiently as possible in a TD-CDMA system. Furthermore, the strength of beacon signals was also measured to decide whether or not to reserve resources for hand-off users, in order to reduce their dropping probabilities. Finally, we conducted several experiments to validate that our method could make use of the finite resources efficiently, thereby revealing better blocking probabilities and dropping probabilities than other methods.

Keywords: TD-CDMA; Radio resource management; Resource reservation; Hand-off; Maximal clique

1. Introduction

Since the third-generation (3G) mobile radio systems will provide us from low to high data rate services with a maximum data rate of 2 Mb/s, it can be used in several multimedia applications such as voice, audio/video, graphics, data, Internet access, and e-mail. These services, regardless of based on packet switched or circuit switched, have to be supported by the radio interface and the network subsystem. In January 1998, the 3GPP (Third-Generation Partnership Project) has agreed on the UMTS (Universal Mobile Telecommunication System) for 3G mobile radio systems. The UTRA (UMTS Terrestrial Radio Access) consists of two modes, the FDD (Frequency Division Duplex) mode and the TDD (Time Division Duplex) mode. The UTRA FDD using WCDMA (Wideband Code Division Multiple Access) can be applied in paired bands, whereas the UTRA TDD using TD-CDMA (Time Division-Code Division Multiple Access) is applied in unpaired bands [6]. The minimum spectrum of UTRA used for operations is 2×5 MHz for the FDD mode and 5 MHz for the TDD mode. Both of them have been harmonized with respect to the basic system parameters such as carrier spacing, chip rate, and frame length. Therefore, FDD/TDD dual modes can be operated well in the UTRA system.

Recently, some papers were proposed to explore radio resource management on CDMA systems. (1) In the WCDMA downlink, the relevant elements influencing downlink radio resource management (RRM) were identified and presented, including the admission threshold and the importance of establishing some limits on the maximum power per connection [16], and the radio resource allocation and management schemes with scheduler were proposed to guarantee a certain QoS level for different users according to their traffic conditions [9]. (2) In the WCDMA uplink, a new RRM to accommodate high data rate traffic gradually in several frames was proposed to reduce the signal quality deterioration in the beginning of a frame [7], and an integrated power control and rate allocation approach was proposed to enhance system throughput [18]. (3) On the DS-CDMA systems, the distributed constrained power control (DCPC) algorithms employing two evolutionary computation (EC) techniques to solve linear systems of

* Corresponding author. Tel.: +886 5 5342601x4314; fax: +886 5 5312063.
E-mail address: huangyf@el.yuntech.edu.tw (Y.-F. Huang).

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equations for power update were designed and they significantly enhance the optimization and calculation speed of power control [17]. Another utility-based radio resource management scheme for mobile multimedia DS-CDMA systems was proposed to maximize the system overall utilities [3]. (4) In the cellular CDMA system, the resource management scheme consisting of a combination of power distribution, rate allocation, service scheduling, and connection admission control was proposed to achieve both effective QoS guarantee and efficient resource utilization [12]. Then, a resource allocation strategy in an integrated voice/data cellular CDMA network was presented and analyzed [10]. Finally, an adaptive RRM in a CDMA-based hierarchical cell structure was proposed to improve call blocking, call dropping, and utilization of radio resource compared with conventional schemes [19].

Here, we focused on the radio resource allocation and management over TD-CDMA. Several researchers have proposed resource allocation methods to service user requests [5,11,14,15]. In the paper [14], they proposed the zone concepts, and then used the best packing strategy based on *structure matrix* and *resource management matrix* to allocate resources to users in a zone. In the paper [15], also based on the zone concepts, two interference policies – polite policy and aggressive policy were proposed to avoid an unacceptable increase of inter-cell interferences. In the paper [11], a *time slot scoring algorithm* was proposed to allocate time slots to users where different slots have their own scores, according to their interferences and unallocated resources.

In the paper, we also used the zone concepts, *structure matrix*, *resource management matrix*, and the interference policies. However, different from previous researches, we considered multiple user requests in multiple zones in order to meet a real environment. In the environment, different users in different zones can use the same time slots if there are no interferences between them. Here, we proposed an algorithm to find out *maximal compatible cliques* (MCCs), and then used them to allocate the same slots to different users as far as possible. Besides, based on multimedia services and user mobility, we considered six request classes in the system model, and each one has its own priority. For a hand-off user, we also proposed a resource reservation scheme to reduce the dropping probability in the system.

The remainder of the paper is organized as follows. In Section 2, we described the system model used in the paper, including the frame structure of UTRA TDD, bunch and zone concepts, the resource reservation scheme, and request classification. In Section 3, the resource allocation involving the resource reservation was proposed. In Section 4, a simulation model based on the Manhattan-like structure in UTRA TDD was given, and several experiments were conducted to show our results. Finally, we made conclusions in Section 5.

2. System model

2.1. Frame structure of UTRA TDD

The system model we investigated here is the UTRA TDD mode that has been selected for operations with unpaired spectrum allocation by ETSI in January 1998. The UTRA TDD mode uses a combined time division and code division multiple access (TD-CDMA) scheme where the different user signals are separated in both time and code domain. For the UTRA TDD frame structure as shown in Fig. 1, a 10 ms frame is divided into 15 time slots and each of them can have 1–16 different codes. Each time slot can be allocated to either uplink or downlink directions. The most characteristic in the UTRA TDD mode is the flexibility that TDD can use different switching point configurations to adapt itself to different environments and deployment scenarios. The details about the UTRA TDD mode can be found in [6,8].

In our system, we defined the ⟨frequency, time slot⟩ pair as an SRU (soft resource unit), and ⟨frequency, time slot, code⟩ triple as an RU (resource unit). Thus, there are 15 SRUs in a frame and 16 RUs for an SRU in our system. Users can request one or more RUs in either uplink or downlink directions within a frame. Since the resource allocation strategies for both uplink and downlink directions are similar, we only considered the uplink direction in our model.

2.2. Bunch and zone concepts

The concept of a bunch is based on a locally centralized resource allocation management. It consists of a radio network controller (RNC) connected to a cluster of remote

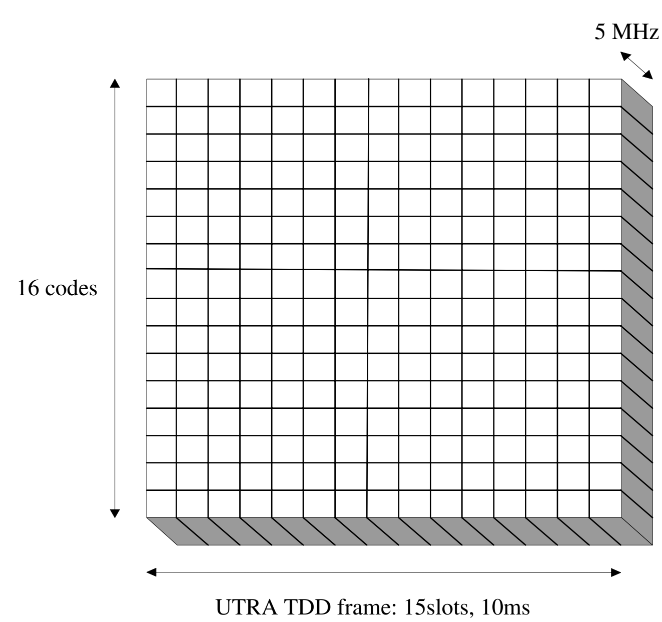

Fig. 1. Frame structure of UTRA TDD.