Relative Performance Comparison of Time Slot Selection Criteria for DCA Scheme to FCA Scheme in a UTRA-TDD System

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Abstract: When interference in a channel is too high, the user channel has to be reallocated. The paper describes the selection criteria for time slots in a UTRA-TDD system during Dynamic Channel Reallocation. The investigated criteria include looking at the total interference in each time slot in the cell, the total packet losses in all the time slots and finally the number of users in each time slot. Further analysis is carried out to take a time average of the investigated criteria before deciding the reallocated time slot. The goal of the simulation is to do a relative performance comparison for individual user packet losses with the above algorithm relative to the Fixed Channel Allocation scheme.

1 Introduction.

WCDMA (Wideband Code Division Multiple Access) air interface, as specified by 3GPP [1], (3rd Generation Partnership Project) consists of two complementary interface modes for deployment in terrestrial networks: UTRA Frequency Division Duplex (FDD) and UTRA Time Division Duplex (TDD) mode. The existence of the TDD band is partly because of the allocation of the spectrum consisting of one paired and two unpaired bands. As a result of this, the ETSI [2] proposed not one but two access technologies. Hence FDD is to be used in the paired band and TDD in the unpaired band.

Historically, network access has been optimised for voice traffic. As data traffic continues to increase in the network, data rates are becoming more asymmetrical. The TDD system supports asymmetrical traffic and is designed mainly for high-density areas with low mobility requirements compared to the FDD system where symmetrical traffic is required for both the uplink and the downlink. TDD also operates by toggling transmission directions in time intervals. This toggling is seamless to the user. Hence TDD supports voice and other symmetrical services other than asymmetric services. FDD is well suited for symmetrical services since each channel has a fixed bandwidth and the channel capacity of each frequency is also fixed and equal to that of all other channels in the frequency band.

Another important feature of TDD in comparison to FDD is its Dynamic Channel Allocation (DCA) Scheme. Since TDD operates in the time domain, unpredictable data conditions that vary in time can be transported efficiently through dynamically allocating traffic channels for the upstream and downstream based on required traffic. Dynamic Channel Allocation is also used when a user with varying interference conditions in a particular channel is reallocated to a different channel with lower interference. This paper investigates a DCA scheme when the interference is high for a user channel where a selection algorithm is carried out to select the best channel to reallocate the user. The paper is organised as follow; section 2 and 3 shall describe background information about the UTRA-TDD System and different Channel Allocation Schemes supported by the TDD system followed by the proposed idea in section 4 and finally results and conclusion in section 5 and 6.

2.Time Division Duplex (TDD) System.

The frame structure as illustrated in Figure 1 of a TDD frame is 10 ms long [4,9]. It is broken into 15 time slots each of 667μs. The time slots are shared between the uplink and downlink depending on the traffic conditions. Each time slot consists of up to 16 spreading codes. The combination of a single code in one time slot at a single operating frequency is called a Resource Unit (RU). Therefore one TDD frame has a total 240 Resource Units (RUs). The chip rate of a TDD frame is 3.84Mcps. Each time slot has 2560 chips with chip duration of 260.4ns.

The downlink physical channel of a TDD frame only uses the maximum spreading factor of 16 to facilitate the implementation of low cost terminals. Therefore to support higher data rates, multiple channel uses a varying spreading factor from 16 to 1. This leads to a smaller peak-to-average transmission power ratio and thereby lower battery consumption for the mobile unit in comparison to multicode operation.

Power Control of a TDD mode is performed on frame base i.e., an update interval of once every 10ms. This makes the TDD unsuitable for a fast moving vehicular environment. Two different types of power control are adopted for the uplink and the downlink [3]. The uplink uses an open loop technique. It works by taking into account the reciprocity of the uplink and downlink channel with the assumption that the path loss of the uplink and downlink are equivalent. Closed-loop power control is used for the downlink where the mobile unit compares the estimated received SIR-to-SIR target.

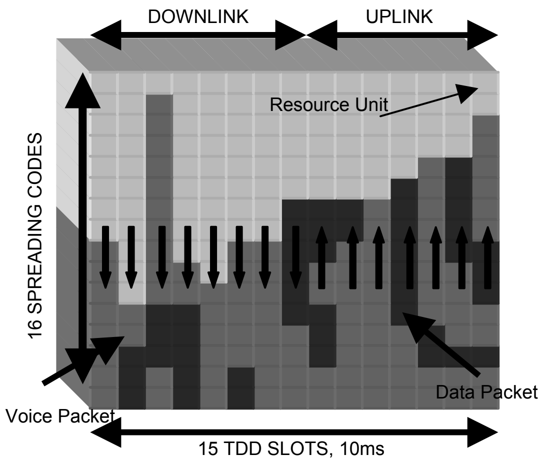

Figure 1 - TDD Frame Structure

One of the key requirements of TDD is efficient handover. TDD only supports hard handover, which means that the mobile unit is only connected to one base station at a time. The handover decision is done on measurements carried in its idle time slots. Each base station sends a list to the mobile unit. This list contains information to facilitate the identity of the cells and the measurements required. The measured received power provides information about the relative distance and potential quality of the mobile unit to its surrounding base stations and this is used in the handover algorithms.

3. Supported Channel Allocation Schemes for UTRA-TDD System.

The FCA [6] works by allocating RUs to a user for the duration of the service. The allocation of the RUs to the user is random and independent of the link quality and required Quality of Service. The user uses the same channel for the duration of the call. Although it can be assumed that interference is spread uniformly in all time slots in the TDD frame, FCA lacks the ability to adapt to the link quality.

Depending on the measurement, DCA [6] tends to assign RUs to users based on the best available transmission quality. The reallocation of RUs varies dynamically depending on the algorithm it uses. TDD supports two types of DCA scheme, slow DCA and fast DCA [5].

Slow DCA allocates resources to cells where time slots are allocated to the uplink and downlink dynamically depending on the amount of traffic required in each link and also traffic in the adjacent cells. By using slow DCA, handover can be made quickly and interference levels can be minimised. Fast DCA allocates traffic to the bearer service itself. It acquires and releases RUs by resource pooling in the code domain or the time domain. A combination of both methods is also possible. For real time service, RUs are allocated to the user for the duration of the service but allocated RUs may vary according to the reallocating procedure. The reallocation procedure can be measured based on the varying interference conditions experienced by the user. However, for non real time service, channels are allocated only for the duration of the transmission.

4. Proposed Scheme.

The modelling approach used for signalling channel reallocation is described in [9] where three parameters are introduced to trigger the optimum moment for channel reallocation. Once signalling takes place, the base station will decide to which time slot the user should be reallocated. Described in

[10] is one such algorithm where different grading is given to time slots with the best possible channel for channel reallocation. This paper describes the selection for the best time slot to which a user can be reallocated based on three investigated parameters:

- least interference in a time slot.
- least number of packet losses in a time slot.
- least number of users in a time slot.

The first selection involves calculation of the total interference from the intra-cell and inter-cells. This is carried out by summing the received interference power in each time slots contributed from users in the same cell and neighbourhood cells with the same transmission time. When DCA is initiated, the user is reallocated to the time slot, which has the lowest received interference power. The second idea initiates a packet loss count of the total packets lost in each time slot when the channel signals channel reallocation. The users in the same time slots with high interference will also have packet loss. The second idea investigates reallocating users to time slots, which have the least packet losses at the time. The final investigation involves reallocating users to time slots with least number of users. This is based on the assumption that time slots with the least users have the least interference.

The proposed investigation method involves taking the measurement only at the instantaneous time period. However, in situations where the received interference power is always fluctuating, a further investigation is carried out to take an average of the above parameters within a time period before deciding which time slot a user should be allocated.

Figure 2 describes the simulation environment used.

Cell Size	300 meters
Cells	1 intracell and 6 intercells
User Speed	3.6km/h (1m/s) in a straight line
Path Loss Model	Outdoor to Indoor and Pedestrian Environment [7]
Obstacle Model	Log Normal Fading Margin 11.3 dB [7, 8]
Traffic Capacity	32 Erlangs
Data Rate	Speech (12.2kbps) / 2RUs
Activity Factor	45-55%
Power Control	+/- 2dB [3]

Figure 2 – Simulation Environment

5. Results.

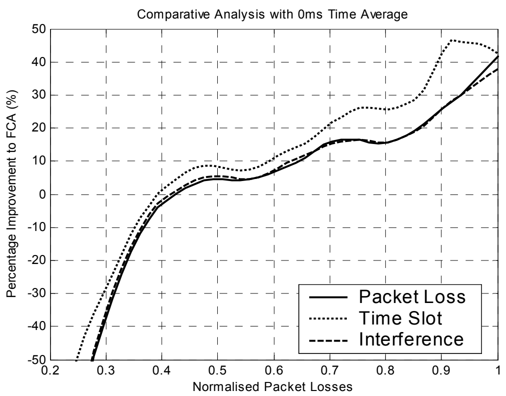

Figure 3 - 0ms Time Average Simulation

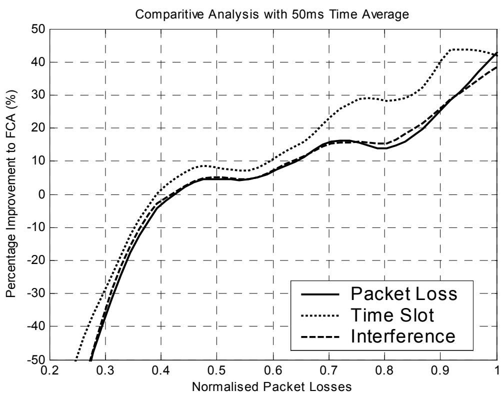

Figure 4 – 50ms Time Average Simulation

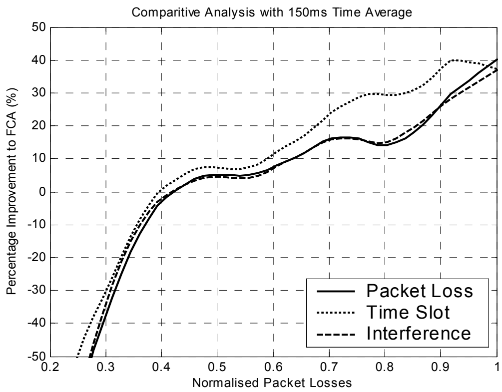

Figure 5 - 150ms Time Average Simulation

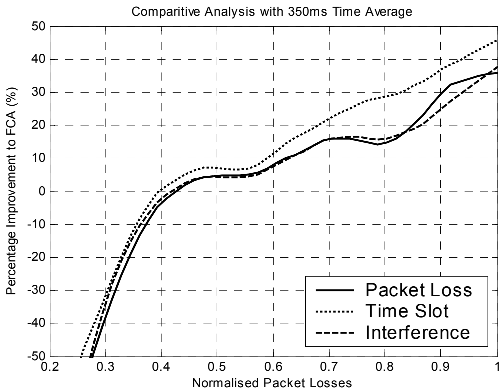

Figure 6 – 350ms Time Average Simulation

Figures 3-6 describe simulation results for time slot selection criteria packet loss, time slot and interference with variable time average from 0ms to 350ms. The x-axis displays the normalised distribution of packet loss using FCA and the y-axis displays the percentage improvement of packet loss when DCA is used.

Users with low packet loss using FCA show a decrement in performance when DCA is used. However, towards the high packet loss end of the graph, DCA out-performs the FCA scheme, showing a reduction of up to 45% in the number of packet losses. Least number of users in a time slot selection criteria breaks even earlier compared to least number packet loss and interference based selection criteria. Averaging the time period of the three parameters shows very little performance difference. However towards the high end of the packet loss graph, time slot selection criteria shows a steady improvement with higher time average.

6. Conclusion.

The above simulation was to investigate fast DCA in a UTRA-TDD system for most suitable time slot when a user channel is reallocated due to interference conditions. Selection criteria for least number of users in a time slot is shown to outperform interference and packet loss based selection. Also from the results it is shown that time averaging plays very little affect on the performance of the system. The simulation has been carried out at 50% cell loading. Further simulation has to be performed to investigate the three parameters with low and high cell loading.

References

[1] http://www.3gpp.org/

[2] http://www.etsi.org/

[3] 3GPP, Dec 2001, UTRA UE TDD Radio Transmission and Reception, TSG, 25.102.

[4] 3GPP, Dec 2001, Physical Channels and Mapping of Transport Channels onto Physical Channel (TDD), TSG, 25.221.

[5] 3GPP, Sept 2001, Radio Resource Management Strategies, TSG, 25.922.

[6] Katzela I, Naghshineh M, June 1996, Channel Assignment Schemes for Cellular Mobile Telecommunication Systems: A Comprehensive Survey, IEEE Personal Communications, Vol 3, 3, 10-31.

[7] ETSI, April 1998, Universal Mobile Telecommunications (UMTS), Selection Procedures for the Choice of Radio Transmission Technologies of the UMTS, UMTS 30.03.

[8] Gudmundson M, 1991, Correlation Model for Shadow Fading in Mobile Radio Systems, Electronic Letters, 27, 2145-2146.

[9] K.Sivarajah, H S Al-Raweshidy, 2003, Dynamic Channel Allocation (DCA) Initiation Analysis in a UTRA_TDD System, 4th International Conference on 3G Mobile Communication Technologies, 364-368.

[10] Kriengchaiyapruk T, Forkel I, 2001, Dynamic Allocation of Capacity in UTRA TDD System, 2nd International Conference on 3G Mobile Communication Technologies.