RADIO RESOURCES STRATEGIES IN UMTS, PACKET SCHEDULING

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ABSTRACT

This article deals with some methods that are responsible for access to UMTS network and for ensuring QoS (Quality of Services) in UMTS. These methods involve access control, congestion control, packet scheduling and handover control. In this paper, a Fair throughput packet scheduling algorithm and a Fair resources packet scheduling algorithm are described.

1. INTRODUCTION

This article deals with several functions that play a very important role in UMTS system. These functions are denoted as RRM (Radio Resources Management) functions. In UMTS, all users operate on the same frequency at the same time. This causes interference, which is the key issue, because the system capacity is related to interference level. RRM functions are responsible for supplying optimum coverage, ensuring efficient use of physical resources, keeping the desired QoS and providing the maximum planned capacity.

RRM functions are: access control (AC), congestion control (CC), handover control (HC), packet scheduling (PS), power control (PC) and orthogonal spreading codes manager (CM). CC solves overloaded situations and tries to get the system to non overloaded situation. HC hands users among cells as they are moving through the area. PC is responsible for adjusting the transmitted power both in uplink and downlink. PC is very important part of RRM, because it has direct impact on interference level. PS organizes data traffics in order to satisfy various demands of users (e.g. packet delay, bit rate of traffic). AC solves system load and it decides if a new connection request will be accepted or rejected. There are many versions of AC algorithm, e.g.: interference based AC, throughput based AC, transmitted power based AC and some others. All RRM functions (especially HC, PS and AC) have to cooperate very closely to maintain optimum system capacity. For example, handover users should have the main priority in AC process to keep the QoS of existing connections. From another point of view, rejecting of a new call is from user's perspective not so disturbing than dropping out of an existing call.

2. PACKET SCHEDULING

This paper is based on information from [1] and [2]. A very briefly introduction of this topic follows. New radio link causes power increase ΔP_{Tx} that could be, according to [1], estimated by using equation:

$$\Delta P_{Tx} = \frac{\rho R}{W}\left(\frac{p_{tx\_cpich}}{\rho_c} + (1-\alpha)\cdot P_{tx\_target} - P_{tx\_tot}\right) \tag{1}$$

The meaning of separate variables: ρ is the required E_b/N_0, R is the maximum bit rate of the new connection, p_{tx_cpich} is the power of the common pilot channel in the cell, α is the orthogonality factor, P_{tx_target} is the target (planned) cell transmission power, P_{tx_tot} is the total current transmission power in the cell, W is the chip rate (3,84 Mchip/s) and ρ_c is the *CPICH* E_c/N_0 (energy per chip per noise spectral density) received by the mobile. The new packet orientated connections use power budget left by other connections:

$$P_{Allowed} = P_{Target} - (P_a + P_{i,GB} + kP_{i,DTX}) \tag{2}$$

P_{Target} is the target cell transmission power, P_a is the power of all active connections, $P_{i,GB}$ is the power of just admitted inactive guaranteed bit rate connections, $P_{i,DTX}$ is the power that needs to be reserved for discontinuous connections that are just in idle or reading periods. k is a management parameter; it ranges from 0 to 1.

2.1. FAIR THROUGHPUT PACKET SCHEDULING (FT)

This algorithm tries to fairly share (according to the throughput) unexploited power, see (2), among bearer services in every scheduling period. Each user gets such an amount of power that all users have the same bit rates (in ideal case). In reality, users get such a bit rates that sum of power estimates (1) satisfies (2). If it is necessary, this algorithm rejects users with poor priority or arrival times.

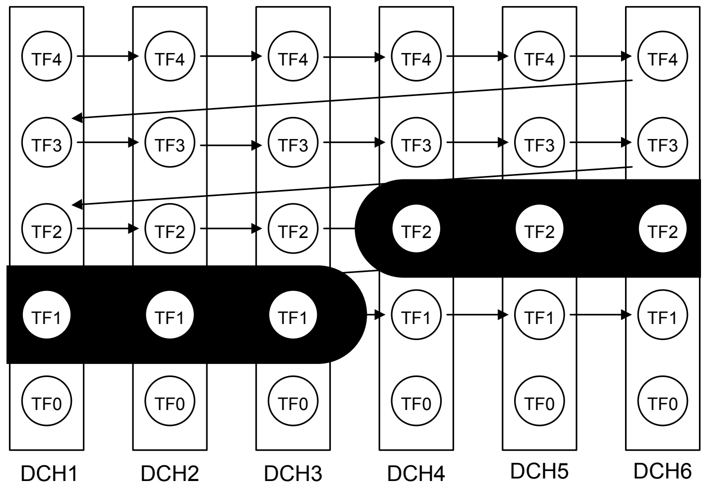

Figure 1: Selection of bit rates of several users by using a sliding window.

Algorithm implementation could be done as follows. Capacity requests (CR) of active users and possible transport formats are sorted to create a matrix of N_{TF} x N_{CR} dimension. Transport formats form rows of the matrix. They are sorted in ascending order according to bit rates. Capacity requests forms columns of the matrix. They are sorted in descending order according to priorities and arrival times.

A sliding window, whose size is equal to number of CR, is used for finding the suitable combination of bit rates. The sliding window starts sliding from left upper corner of the matrix and continues to the right bottom of the matrix. The sliding window stops when the sum of estimated power increases satisfies (2).

2.2. FAIR RESOURCES PAC KET SCHEDULINKG (FR)

This algorithm fairly shares unexploited power among users. Their bit rates depend on their SIR (signal to interference ratios), which correspond to *CPICH* E_c/N_0. If it is necessary, this algorithm rejects users with poor SIR. Power weights w_i could be used to keep the priority system. This algorithm could be implemented as follows:

- Available power, counted by using (2), is divided by number of users N: $p_{link}=P_{Allowed}/N$. This power is used for virtual rates computing, by using (3). Virtual rates are rounded upwards to the possible bit rates.
- A temporary set of TFs is constructed from rounded virtual bit rates. This set is processed by FT algorithm.

Equation 3 is used by FR algorithm for virtual bit rates computing. Power weights w_i enables to keep the system of the priority.

$$R_i = \frac{W}{\rho}\frac{\frac{w_i}{\sum_j w_j} p_{link}}{P_{tx\_target}\cdot(1-\alpha)+\frac{p_{tx\_cpich}}{\rho_c}-P_{tx\_tot}} \qquad (3)$$

3. SIMULATION

A simple simulation for algorithm examination has been done in MATLAB. Simulation parameters were set according to [1] and [4]. The following bit rates were available: 0, 32, 64, 128, 144, 256 and 384 kb/s. All simulations used the following parameters: $P_{Allowed}$ = 36 dBm, P_{tx_target} = 40 dBm, α = 0.5, p_{tx_cpich} = 33 dBm, W = 3.84 Mchip/s, ρ = 8, P_{tx_tot} = 37 dBm, CR = 12. ρ_c was different for each simulation and for each mobile station; it could vary from -24 to 0 dB. The power weights w_i were not involved in this contribution. FT (see figure 2) denotes fair throughput scheduling algorithm, FR2 denotes fair resources scheduling algorithm. FR1 is a modification of FR2, where sliding window slides only in vertical direction. Two thresholds, t_1 = 30 kb/s and t_2 = 1 kb/s, were assumed to be used for virtual bit rates rounding. Bit rates that were under theses thresholds were replaced by zeros.

Figure 2 shows comparison of aforementioned algorithms. Final bit rates allocation and *CPICH* E_c/N_o values of all users are specified in table 1. Figure 2 shows comparison of all algorithms according to number of rejected users and amount of exploited power. FR2 algorithm appears to be able to achieve better exploitation of available power and to increase number of satisfied users. FR2 algorithm rejects users with poor SIR (and high priority in this case) which have great power demands, or these users get low bit rates.

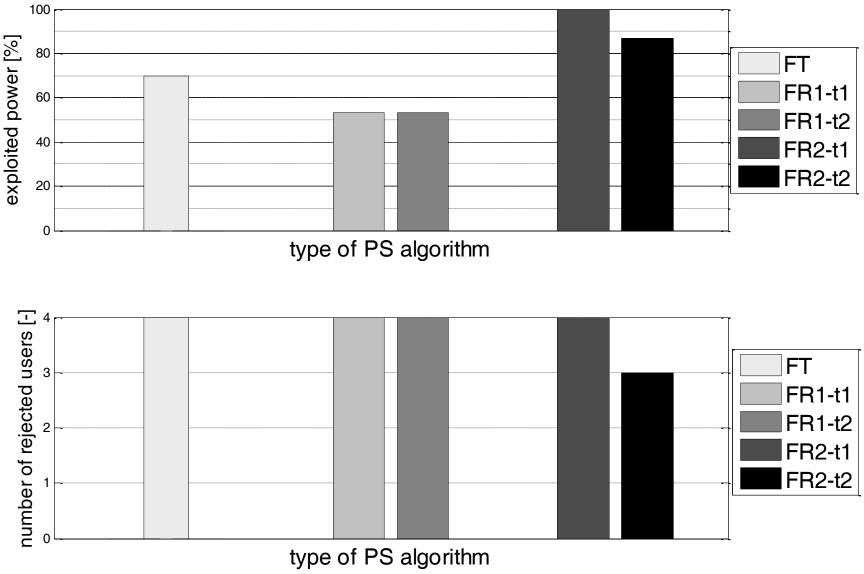

Figure 2: Comparison of investigated algorithms.

Table 1: Bit rate allocation for different scheduling algorithms.

ρ_c [-]	0,1	1,0	1,0	0,1	1,0	1,0	1,0	0,1	1,0	0,2	1,0	1,0
R(FT) [kb/s]	0	0	0	0	32	32	32	32	32	32	32	32
R($FR1_{t1\text{-}t2}$) [kb/s]	0	64	64	0	64	64	64	0	64	0	64	64
R($FR2_{t1}$) [kb/s]	0	64	128	0	128	128	128	0	128	0	128	128
R($FR2_{t2}$) [kb/s]	0	64	64	0	64	64	64	0	64	32	64	64

4. CONCLUSION

A brief description of several types of packet scheduling algorithms was introduced in this contribution. Simulations indicate that fair resources packet scheduling algorithm might be able to improve number of satisfied users in whole system. Its real impact to the system capacity and system QoS should be investigated in much more complex system model.

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