Exhibit 1030

Shared Channels for Packet Data Transmission in W-CDMA

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***Abstract**: One of the targets for a Wideband CDMA (W-CDMA) system is to provide an efficient transfer of low bit rate to very high bit rate packet data services. A shared channel concept has been proposed for both the downlink and uplink channels that is better suited for bursty packet data traffic [1][2][3][4]. The shared channels allows UEs to transmit and receive data bursts at high rates by using short leases on the radio resource thereby lowering the overall delay by taking the greatest advantage of statistical multiplexing. The high rate bursts require the network tightly manage its resources to insure that the appropriate OVSF codes are assigned on the downlink and the aggregate interference does not exceed the noise rise on the uplink. In both cases, the network must convey the new assignments on a frame by frame basis. In this paper, packet data transmission using both Downlink Shared Channel (DSCH) and Uplink Shared Channel (USCH) is discussed for a W-CDMA system.*

1. Introduction

The Shared Channel originated from the well known observation that packet call QoS is greatly enhanced by the use of fat pipe multiplexing where the scheduling of packet users is done collectively rather than stochastically. Section 2 presents the benefits of fat-pipe multiplexing for web browsing. The DSCH concept, introduced in Section 3, provides a method for fat-pipe scheduling of downlink packets by dynamically sharing the power and code resource among users thus overcoming the problem of downlink code shortage. The USCH concept, introduced in Section 4, provides a similar scheduling mechanism for the uplink. Although not code limited, the USCH requires that the network tightly manage the power resource while scheduling the uplink data packets. In Section 5, simulation results are presented comparing possible control channel options for communication assignments, either on dedicated or common channel, and the performance of continuous and discontinuous packet data transmission. Finally, conclusions are drawn in Section 6.

2. Fat Pipe Multiplexing

The benefits of fat pipe multiplexing are shown using simulation. Table 1 presents the results for Web browsing session over a 307 kbps channel scheduled together as one composite channel (i.e. a fat-pipe) or multiple dedicated channels. The results presented were for web browsing; however, FTP and email transfer have been considered as well [4].

In the simulation, the data traffic is modeled as distinct sessions with a Poisson arrival process. Each session marks a period of higher activity comprised of a number of packet calls. The number of packet calls per session is geometrically distributed while the time between packet calls is exponentially distributed. If the session modelling is for web browsing, then the packet call models a web page download, while the arrival time models the think time used to peruse the web page. Each packet call consists of one or more packets whose inter-arrival time and length are both exponentially distributed. The parameters associated with the data traffic model are summarized in Table 2.

Table 1 Simulation results for single service (Web Browsing) implementation.

Number of packet channels	Packet Channel Bandwidth kbps	Percent load	Average Queue delay (seconds)	Average Transmis-sion time (seconds)	Total delay time (seconds)
1	307	75	1.27	0.313	1.58
8	38.6	75	0.708	2.51	3.22
16	19.2	75	0.461	5.02	5.48

Table 2 Web Browsing Model.

Parameter	Mean
Session Arrival Rate	0.72 sessions/second
Packet calls per Session	5
Period between Packet Calls	120 seconds
Packets per Packet Call	25
Packet Length	480 bytes

A significant reduction in the average web page download is achieved by using fat-pipe multiplexing. Table 1 shows the system performance in terms of the average queue delays, the average packet call transmission time, and the total time the packet call is in the system for a 75% system load. The latter is the sum of the queuing delay and transmission time. The results show that as long as the utilization is under 100%, the average time[1] in the system is lower when fewer channels

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[1] The average time in the system is defined as the time from when a transmission request is made till the time the transmission is completed.

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of greater bandwidth are implemented. As one would expect, as the number of channels increases the average queue delay decreases even though the bandwidth of each channel decreases. However, the increased queuing delay is more than compensated by the decrease in transmission time on larger bandwidth channels. These characteristics hold true in general provided the channel holding time distribution is *sufficiently regular* [5]. Considering that the end users perception of Quality of Service for data applications is limited to the time interval from when the request for service is submitted to when the service has completed, the system performs better when the allocated bandwidth is configured into fewer communications channels of larger bandwidth. As a result, both downlink and uplink shared channel would provide these scheduling benefits for W-CDMA.

3. Downlink Shared Channel (DSCH)

The DSCH provides a method for sharing code and power resources to overcome a potential code shortage when bursty data traffic is typical. When assigned in a conventional manner on a Dedicated Channel (DCH), a User Equipment (UE) is reserved a portion of the Orthogonal Variable Spreading Factor (OVSF) code tree for the duration of the web browsing session based on the peak data throughput. As an example, consider the code tree in Figure 1 where seven 384 kbps UEs operating at activity rate of 10% are allocated resources. Notice that 87% of the code tree is consumed. However, if codes are re-assigned dynamically on a frame-by-frame basis only 14% of the code tree is consumed since only one OVSF code with SF=8 may be shared between seven users. This latter case is depicted in Figure 2.

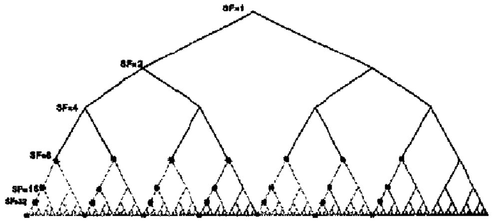

Figure 1 OVSF Code Tree for DCH.

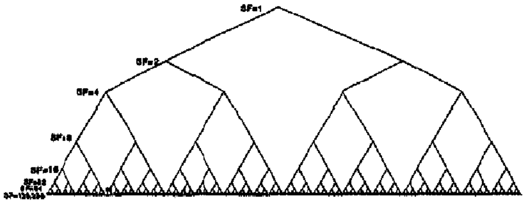

Figure 2 OVSF Code Tree for DSCH.

The OVSF codes for the DSCH can be assigned using i) multiple DCH's or ii) a DSCH control channel which is also termed as Physical Shared Channel Common Control Channel (PSCCCH). The slot structure of the DSCH when associated with a DCH is shown in Figure 3. This is a special case of multicode transmission where the low rate DCH is spread by a fixed rate OVSF code known to the UE and the spreading factor of the DSCH varies from frame to frame. The DSCH only carries the data field whereas the DCH comprises of Pilot, TPC, TFCI and Data field. The slot structure of the DSCH when associated with a PSCCCH is shown in Figure 4.

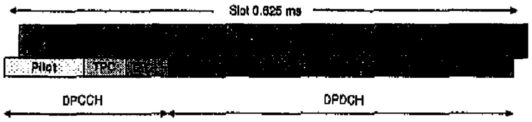

Figure 3 Slot structure of DSCH associated with DCH.

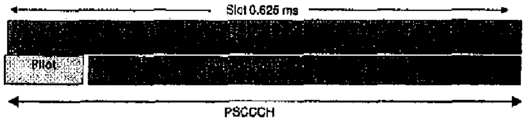

Figure 4 Slot structure of DSCH associated with PSCCCH.

4. Uplink Shared Channel (USCH)

In the case of the USCH there is no code limitation as each UE will have its own scrambling code. However, there is still a limited power resource, hence the USCH represents a shared power resource. The USCH coordinates the fast scheduling of uplink data packets so as to insure a uniform interference power profile protecting voice users. In the USCH concept, each active UE is assigned a fraction of total noise rise, which translates into a Spread Factor (SF) assignment. Similar to that of a DSCH, the data rate of the USCH can be reassigned on a frame-by-frame basis. The signaling for the USCH is conveyed on a PSCCCH. The structure of PSCCCH which aggregates the functions of power control, downlink OVSF code assignment and uplink spread factor assignment is shown in Figure 5. The PSCCCH carries Common Transmit Power Control (CTPC) information, a Dynamic Persistence Indication (DPI), Common OVSF Code Assignments and Uplink spreading factor assignments (SFA). For flexibility, it is assumed that the PSCCCH operates at multiple spreading factors and is sized appropriately depending on the traffic load in the cell. The rate and SF of the PSCCCH would be broadcast on the BCH. Each slot contains pilot information and 8 power control feedback bits for each of a maximum of 8 individual UEs transmitting on the uplink. The remaining bits per slot are encoded with a rate 1/3 convolution code and interleaved over the 10 ms frame to enhance the reliability of the DPI as well as the DSCH and USCH assignment information. The PSCCCH is not power controlled and is transmitted over the entire cell.

Since the assignment and re-assignment of the power resource to various packet data users are made on a frame by frame basis, the convergence of the fast power control loop, availability of good channel estimates, and searcher performance are critical for the operation of the USCH. A method for power control and channel

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estimations for bursty data traffic is introduced in Section 5 along with some simulation results.

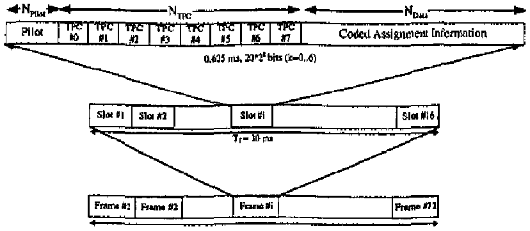

Figure 5 Structure of the PSCCCH.

5. Simulation Results

The use of PSCCCH in association with DSCH is efficient when the number of simultaneous packet data calls exceed a certain threshold. The packet data simulation that was used in Section 2 to present the benefits of a "fat-pipe" scheduling was modified to monitor the number of simultaneous packet calls. For this investigation, the simulation models the scheduling of multiple users on a 384 kbps shared channel. The model parameters are identical to those presented in Section 2. The simulations runs were conducted for 75%, 90%, 92%, and 95% shared channel utilizations based on a session arrival rate of 0.60, 0.70, 0.72, and 0.76 per second, respectively Figure 6 presents the cumulative probability of *N* or more simultaneous packet calls. Table 3 tabulates the statistics for the simulation runs. The simulation shows the dedicated control channels will be more efficient with respect to power budget for low utilizations, however, the common channel will be more efficient when resources are needed the most. Assuming a 10:1 ratio of PA resources [6] required to support one common channel versus one dedicated channel, the simulation shows that the common channel will be more efficient in terms of power budget when shared channel utilization is above 92%. The common control channel bounds the PA resources consumed by shared channel signaling bolstering the stability of the shared channel during periods of peak loading.

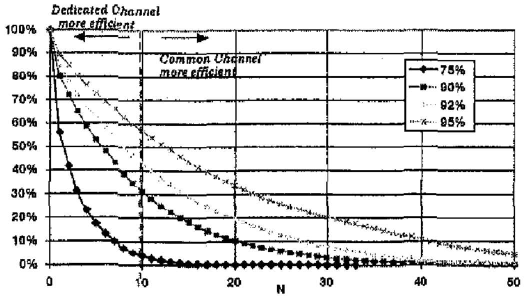

Figure 6 Probability of *N* or more Simultaneous Packet Users.

Convergence of the fast power control loop and the availability of good channel estimates at the base station are critical in the case of USCH where packets arrive in a bursty manner [8]. A simple solution is to use a low rate bi-directional link maintenance channel between the packet bursts. The link maintenance consists of power-control commands and pilot symbols needed to preserve power control and synchronization of the dedicated physical channel. However, there is a cost associated with the use of the link maintenance channel since code and power resources are consumed even though no data is being transmitted. The cost increases linearly with the number of users engaged in a packet call.

Table 3 Simulation Results for Various Shared Channel Utilizations.

Shared Channel Utilization	Session Arrival Rate	Mean number of Simultaneous Users		Likelihood a Common Channel will be more Efficient	
		Analytic	Simulated	10:1	20:1
95%	0.76	18.05	16.5	57%	34%
92%	0.72	10.58	10.9	42%	20%
90%	0.70	8.1	7.86	31%	10%
70%	0.60	2.25	2.19	7%	0.3%

Figure 10 illustrates the modified approach for discontinuous packet data transmission as in the case of the USCH. Three cases are considered, a) packets are transmitted only in the downlink using DSCH, b) packets are transmitted only in the uplink using USCH and c) packets are transmitted in both the uplink and downlink direction. In all the cases an uplink channel is maintained so as to convey the power control bits for forward link, piggybacking information and/or to carry the data using the USCH. To prime the fast reverse link power control loop, searcher and channel estimator, the transmission of preamble using DPCCH starts one frame (16 slots) prior to the scheduled uplink or downlink packet data transmission. The preamble is transmitted with an additional negative power offset from the computed open loop estimate. Further, the initial power control step size for transmitting the preamble is set at a higher value (e.g. 2dB) so that power control loop converges faster if the UE is in a deep fade. On the receipt of the first down power control command at the UE during the preamble transmission phase, the step size reverts back to normal power control (PC) step size (e.g. 1dB). It may be noted that the step size always resets to its normal setting in the beginning of actual packet data transmission.

Next, simulation results are presented using a W-CDMA reverse link simulator for the above three cases. In this simulator, the packet data source model is represented by a function that produces a random draw of a new packet transmission time along with a subsequent inter-arrival time before the next packet. If the generated inter-arrival time occurs prior to the completion of transmission of the generated packet, a concatenation process occurs. Another packet is generated and appended to the original packet. This process continues until there is time for idle

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slots to occur. In the simulation the mean packet size is assumed to be 480 bytes and a code rate of two blocks per frame is used, which translates into 144 kbps UDD service. Figure 7 shows the CDF of consecutive idle frames within a packet call for system utilization values of 75% and 92%. It may be observed from the figure that as the system utilization increases the number of consecutive idle frames within a packet call also increases. The increase in idle frames is caused by a greater reliance on time multiplexing which occurs due to the higher likelihood of multiple active packet calls sharing the channel.

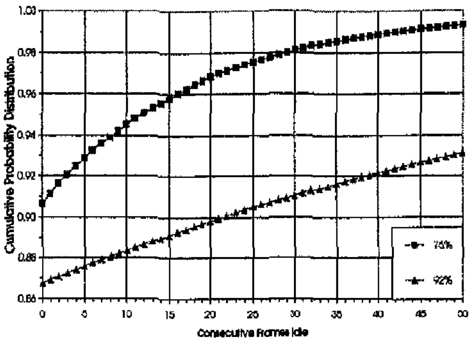

Figure 7 Consecutive idle frames within a packet call for various values of system utilization.

Table 4 Simulation Parameters.

Parameter	Value
Information Bit Rate	60.8 kbps (144 kbps UDD)
Block Size	304 bits
Turbo Code	R=1/3, K=4
Channel Estimation	Non -Ideal
Antenna Receiver Diversity	On
Inner Loop Power Control	On
Outer Loop Power Control	On
Power Control Step Size	0.5 dB
Power Control Delay	1 slot
Power Control Feedback Error	1%
DPCCH to DPDCH Power	-7dB
Pilot/TPC/TFI bits per slot	6/2/2
Searcher/DLL	Off

The W-CDMA chip level link simulator was used to evaluate the performance of continuous and discontinuous packet data transmission. The above source model was used to model the discontinuous packet data transmission. The parameters used in the simulator are shown in Table 4. The simulation was run for a chip rate of 4.096Mcps and carrier frequency of 2.0GHz for a flat fading channel. It may be noted that the simulations did not use the negative power offset or the varying step size of Figure 10. The three cases simulated were a) continuous packet data transmission, b) discontinuous packet data transmission without preamble, and c) discontinuous packet data transmission with one frame preamble transmission. Simulations were run at three values of vehicle speeds (3, 30 and 120 kmph) under flat fading channel conditions for various values of system utilization. Table 5 and Table 6 summarize the received Eb/Nt for target Frame Erasure Rate (FER) of 10% and 1% at a system utilization of 75% and 92% respectively. Figure 8 and Figure 9 give a pictorial representation of the summary.

Table 5 Received Eb/Nt at 1% and 10% at a system utilization of 75%.

Vehicle Speed (km)	Continuous (dB)		Discontinuous (dB)		Discontinuous with Preamble (dB)	
	1% FER	10% FER	1% FER	10% FER	1% FER	10% FER
3	2.2	1.2	3.6	1.5	2.4	1.4
30	5.9	3.3	6.1	3.5	6.0	3.5
120	5.1	3.3	5.3	3.3	5.3	3.4

Table 6 Received Eb/Nt at 1% and 10% at a system utilization of 92%.

Vehicle Speed (km)	Continuous (dB)		Discontinuous (dB)		Discontinuous with Preamble (dB)	
	1% FER	10% FER	1% FER	10% FER	1% FER	10% FER
3	2.2	1.2	4.1	1.7	2.5	1.4
30	5.9	3.3	6.4	3.5	6.2	3.5
120	5.1	3.3	5.4	3.4	5.4	3.4

The following observations are made from Table 5 and Table 6.

a. At high and medium values of vehicle speed the degradation due to discontinuous packet data transmission is within 0.5dB. This is due to the fact that the power control does not track the fading at high values of Doppler.

b. The performance degradation at slow speed at 1% FER and high system utilization is approximately 2dB.

c. At operating FER of 10% the loss in performance due to discontinuous packet data transmission is less than at the 1% FER operating point.

d. The performance at slow speeds is improved for discontinuous transmission with one frame preamble transmission.

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