Improved Performance of 3G1X CDMA2000 Wireless Packet Data System in a Simulated Field Environment

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Abstract: The Third Generation (3G) CDMA2000 wireless telecommunication network standard has been designed to provide high speed data services on both forward and reverse link traffic's. In addition to the increased voice capacity, system performances and high-speed packet data services, it also supports quality of service for various end-user applications. However, the forward packet data link in 3G systems are time multiplexed among all of the mobile users. This paper precisely addresses both the forward and reverse link packet data throughput performances in a simulated Additive white Gaussian noise (AWGN) environment and compare the results with the benchmarked 3G field data.

Keywords: **MS, BTS, RAN, AWGN, FCH, SCH, PPP, GRE, SDU, PCF, FTP, AAA, PDSN.**

1. Introduction

The evolution of first commercial third generation (3G) wireless standard typically known as CDMA2000 provides high-speed packet data services alongside with the voice services [1] – [4], [6]. The initial design principle of the packet data rate system is flat channel that serves multiple users in a time-division multiplexed pattern, eventually the base transceiver station transmits to a unique mobile user with a specified data rate which is used for that radio link. In this paper the overall performance of the wireless packet data system in a simulated field environment is addressed. This paper precisely aims at throughput measurements carried out at PPP layer. The paper is structured as follows. In section 2, the system overview of the wireless high speed packet data services with illustration about the Network architecture for 3G1X packet data system, the channel structure for both forward and reverse link are described. The forward link throughput performance results are presented in section 3, while the reverse link throughput performance results are presented in section 4 and finally the conclusions are drawn in section 5.

2. System Overview

The wireless packet data system supports the packet data services as per the 3GPP2 CDMA2000 1X standard [1], [2]. The key air interface channels, the burst mode of traffic channel and network architecture elements for the packet data services are addressed in subsequent paragraphs. The paper highlights on the improvements made in the throughput of the packet data system as compared with the legacy systems deployed in the field which had Solaris OS whereas the current packet data system is ported with RedHat Linux based intel architecture with efficient generic routing encapsulation (GRE) tunneling scheme. In this simulated field environment scenario of the wireless packet data system, the physical radio link traffic channels are supported and are used for a packet data transmission that performs coding, modulation, spreading and scrambling of the physical channels.

There are two sets of logical channels in the packet data structure one being the Fundamental Channel (FCH) and the other is Supplemental Channel (SCH) on both reverse and forward links. FCH maintains the physical layer connectivity and carries both signaling as well as packet data traffic, whereas SCH carries high speed packet data traffic allocated randomly based on the traffic demand. The range of SCH data rate varies based on the Radio Configuration (RC). Currently, RC3 has been implemented as per standard which includes a 9.6 Kb/s FCH and the available data rates for SCH are 9.6, 19.2, 38.4, 76.8, 153.6, and 307.2Kb/s [5], [7]. Henceforth, in the physical layer standard, the peak data rate for a mobile data user can be maximum of 307.2 Kb/s supporting with 1SCH and 1FCH.

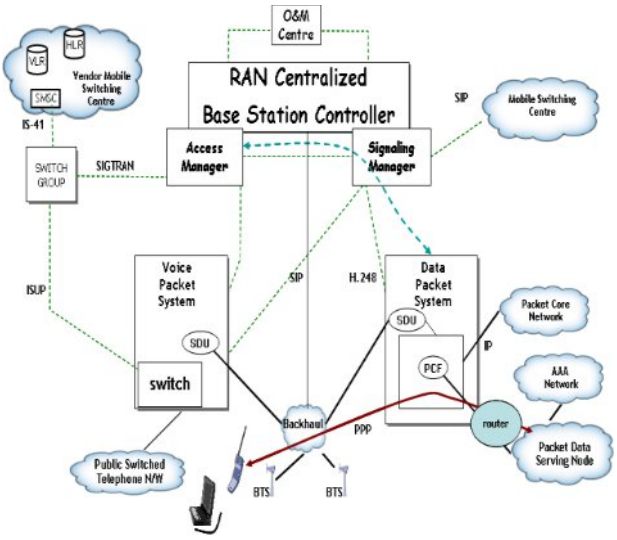

Figure 1. CDMA2000 3G1X Hybrid Network Architecture

The overall data throughput is expected to be burst in nature due to the randomly allocated SCH data rates. During the data call setup and when the call is active for a period of time and as per the defined session time configured in the network, the forward and reverse FCH are in use for transporting data and signaling control messages. Typically when the transmit buffer size goes beyond 1K bytes, a burst traffic gets generated to increase the in use transmission rate and results in the allocation of a desired SCH at the highest possible rate for which the physical link

layer can accommodate. In a burst traffic environment, both the FCH and SCH are used to transport data, providing a system level capacity to the user. Once burst traffic is established, it maintains till all data has been transmitted and the maximum burst threshold duration is reached or expired. The benchmarked user data rates as measured at the PPP layer that assumes 1% frame error rate (FER) for both FCH and SCH channels, with radio link protocol (RLP) retransmission scheme, and with a burst duration of 10sec and a 1sec interval between subsequent bursts, and with a compressed packet size of 1K bytes. It is expected that the user data rates vary when they are actually transmitted over the fading environments.

The present wireless packet data system network architecture as illustrated in figure 1 supports user data applications on a typical IP backhaul of the radio access network (RAN) over point-to-point protocol (PPP). As per the protocol stack architecture shown in figure 2, where a packet pipe in the user plane traditionally known for PPP link is established between the MS which is connected to Laptop and to that of the packet data serving node (PDSN).

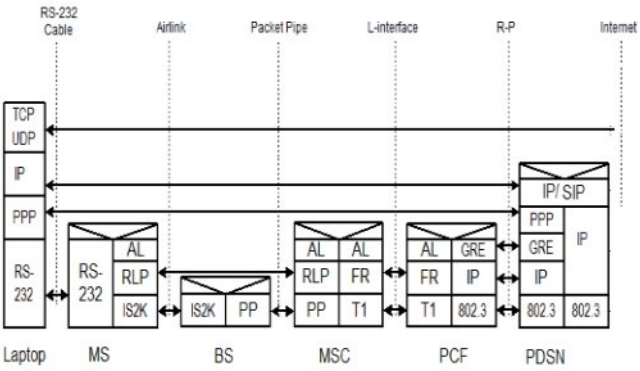

Figure 2. Network Protocol Stack Architecture

The Packet Control Functionality (PCF) serves as an interface between the MS and the packet network world. Traditionally the PCF maintains the active or dormant states of the radio resources connections to the MS. A connection to the MS is described as an active session, whenever a radio traffic channel resources are assigned and a connection to the MS is described as a dormant session, whenever the connection exists but the radio traffic channel resources are hardly available and withdrawn. The PCF also talks to BTSs for managing the radio resources and then conveys the same to the PDSN. As mentioned in table 1 of the interface specifications, the PCF communicates with the base station controller that manages the BTSs (BSC) using A8/A9 interface and at the same time talks to PDSN over A10/A11 interfaces for establishing both signaling and bearer information accordingly. The PCF transmits and receives these IP packets using the packet Gateway interface. At the same time the IP Datagram's are transmitted and/or received on the same PPP link.

The selection and distribution unit (SDU) maintains the radio link protocol connectivity with the mobile user for an active packet data session and also the Handoff information for all the active legs between the base transceiver stations.

Table 1. Interface Specifications for the Data Call

I/F	IOS Model
A8	Traffic channel between BSC and PCF
A9	Traffic channel signaling between BSC and PCF
A10	User traffic between PCF and PDSN
A11	Signaling info between PCF and PDSN

The packet data serving node (PDSN) establishes bearer connection and terminations for the link layer protocol connection with the MS via PPP. Hence the PDSN assigns dynamic IP address to the MS after successful registration. In this context, the PDSN maintains a pool of user/subscriber IP addresses on the simple IP (SIP) network. In the process of the data call setup, the PDSN performs the functions of the subscriber/user validation using local authentication-authorization-accounting (AAA) or remote AAA authentication which basically acts as billing server for the subscribers. The choice of the AAA is primarily based on the selection algorithm defined at the PDSN. Therefore the PDSN serves as the bridge between the wireless network and the external internet world for catering simple IP based packet data services. Here, the data service initially maintains a dormant PPP session. Additionally the PDSN performs quality of services profiles for the end-subscribers for ensuring the reliability of the data traffic in the network. Hence the traffic measurements at the PPP layer are carried out at both Mobile user and at the PCF Gateway Router such that the packet losses, delays and errors if any are determined.

Table 2. System Level Parameters

Parameters	Value
Number of BTS-sectors	3
Carrier Frequency	1900 MHz
BTS TX Power	-75 dBm
Mobile TX Power	-25 dBm
Frame Error Rate (FCH & SCH)	1 %
FTP Get/Put size	10 MB
FTP Delay (Dormant Timer)	10 Sec
PDSN/FTP Server	1

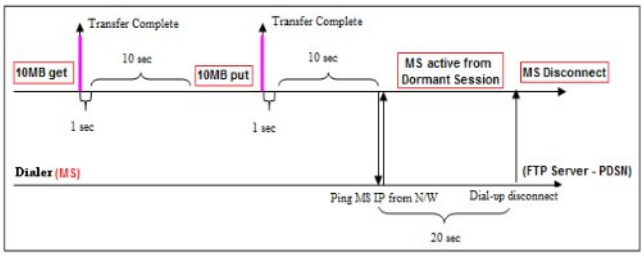

Figure 3. 3G 1x Packet Data Call Flow for Forward and Reverse Link User Traffic

3. Forward Link Performance

The forward link tests based on the system level parameters mentioned in table 2 were carried out by using an FTP get of a large file from the laptop (MS) to an FTP server on the external packet data network typically a PDSN as illustrated in figure 3. For obtaining the base-lined data in the forward link (FWD) performance measurement, with the radio frequency link balanced environment, the data burst traffic over an additive white Gaussian noise is measured and are benchmarked as indicated in table 3. Usually the application file transfer protocol (FTP) that generates steady state data traffic will look as if a series of continuous burst with fixed data rate for the particular duration of time. The user throughput for an FTP uses TCP/IP for reliable data transmission using the SCH under stable RF conditions in AWGN.

Table 3. Average Forward PPP Throughput Data

	Measurement	Field Data
Forward Link	10842132 bytes sent in 724.03Sec **14.97KBytes/sec**	**115 Kbps**

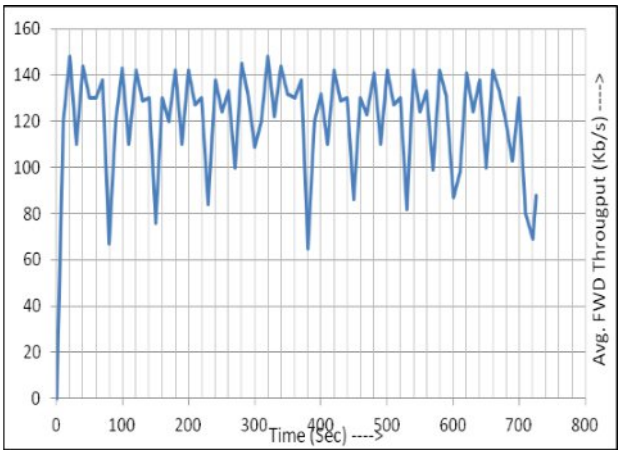

Figure 4. Average Forward PPP Throughput

Hence, the forward link throughput at 1% FER values was measured by downloading >10 MB file via FTP. It can be observed that average forward link throughput of "~120 Kb/s" is achieved with 153.6 Kb/s SCH and 9.6 Kb/s FCH transporting data concurrently as illustrated in figure 4.

4. Reverse Link Performance

Similarly the reverse link tests based on the system level parameters depicted in table 2 were carried out by using an FTP put of a large file from the laptop (MS) to an FTP server on the external packet data network typically a PDSN as illustrated in figure 3. For obtaining the base-lined data in the reverse link (RVS) performance measurement, with the radio frequency link balanced environment, the data burst traffic over an additive white Gaussian noise is measured and are benchmarked as indicated in table 4. Usually the application (FTP) that generates steady state data traffic will look as if a series of continuous burst with fixed data rate for the duration of time. The user throughput for an FTP uses TCP/IP for reliable data transmission using the SCH under good RF conditions in AWGN.

Table 4. Average Reverse PPP Throughput Data

	Measurement	Field Data
Reverse Link	10842132 bytes received in 2224.75Sec **4.87KBytes/sec**	**36 Kbps**

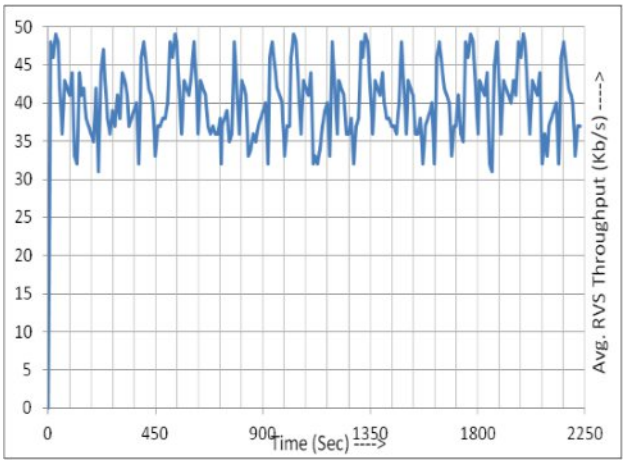

Figure 5. Average Reverse PPP Throughput

Hence, the reverse link throughput at 1% FER values was also measured by uploading >10 MB file via FTP. It can be observed that average reverse link throughput of "~40 Kb/s" is achieved with 38.4 Kb/s SCH and 9.6 Kb/s FCH transporting data concurrently as shown in figure 5.

5. Conclusions

In this paper, the simulated results for the packet data call performances in a typical field environment is addressed. The performances of the wireless packet data system under simulated AWGN channel environment signifies highly remarkable quality packet data service. Moreover the observations from the graphs clearly indicates that the PPP throughput performance data shows us an improvement of almost ~4.35% on the forward link and ~11.1% in the reverse link as compared to the field trial data. This essentially will provide the wireless network operators the most efficient way to handle the packet data services.

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