

# Characterizing User Behavior and Data Service Patterns in Cellular Networks<sup>+</sup>

Chong-Wook Kwon<sup>1</sup>, Yae Hoe Kim<sup>2</sup>, Hyoung-Kee Choi<sup>3</sup>

*School of Information and Communication Engineering  
Sungkyunkwan University, Seoul, Korea*

*E-mail: <sup>1</sup>ckwon@ece.skku.ac.kr, <sup>2</sup>weawen@ece.skku.ac.kr, <sup>3</sup>hkchoi@ece.skku.ac.kr*

**Abstract:** This paper analyses billing records from the CDMA 1x EV-DO networks. The billing records were obtained from the largest commercial mobile service provider in Korea. We analyze the billing records that include useful information in order to understand the features of the entire network. Since it is impossible to check all the network data, billing information gives insight into user behavior and characteristics of the packet core network. The aim of this study is to proffer understanding of user behavior and service patterns that are valuable for the management of commercial cellular networks.

## 1. Introduction

Cellular networks are increasingly being used to carry internet traffic, enabling users to stay connected to the internet wherever they are, without the restricting need for a wired network. Advanced communications technology and development of mobile phones provide sufficient bandwidth for many typical internet applications. These include Email, multimedia messaging service (MMS), audio/video streaming, and external internet connection service.

Analysis of traffic traces in cellular networks shows that GPRS, CDMA and small-scale of WLAN are suitable for carrying data traffic. These observations are in the main limited to small scale packet measurement running at the two end hosts. The research mostly concentrated on measuring TCP performance metrics, rather than understanding user behavior and data service patterns with entire network.

In this paper we analyze long term statistical data and billing records obtained from a commercial mobile service provider. This is the first research based on billing records in a CDMA 1x EV-DO network.

The results of this research may aid researchers to model network traffic with respect to user behavior and to estimate workload models for commercial PCN (Packet Core Network) service providers.

<sup>+</sup> This research was supported by the MKE(Ministry of Knowledge Economy), Korea, under the ITRC(Information Technology Research Center) support program supervised by the IITA(Institute of Information Technology Advancement)" (IITA-2008-C1090-0801-0028)

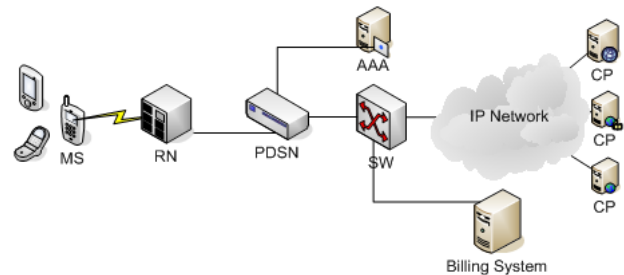


Figure 1: CDMA network configuration and the billing system

## 2. Related Works

There are few published measurement studies on packet data network traffic in the literature. Previous work has examined the variation of characteristics according to the cellular network.

Tamas and his teams [1] discussed the characteristics of WAP traffic. The paper extended the understanding of WAP traffic patterns and provided a traffic model based on long-terms, live measurement. However, the research did not reflect characteristics of the various applications from the current network, because this research based on initial network.

Young [2] studied the mobile data traffic traces of a CDMA network and presented its characteristics compared to wired internet traffic. They showed the uneven up/downlink traffic utilization nature in packet data networks, along with small packet sizes. In this research, we find similar features.

Milosh [3] suggested the traffic model using traces

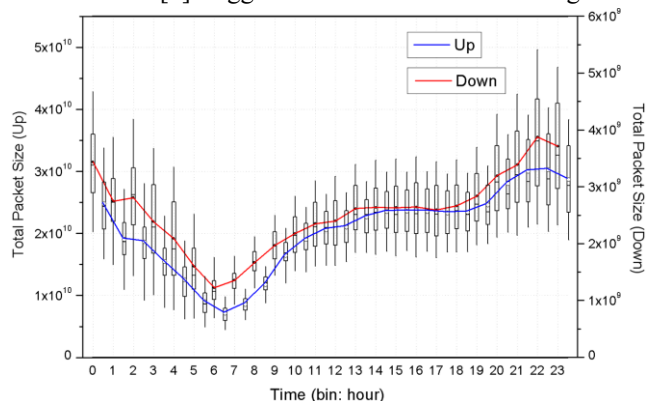


Figure 2: The user data traffic pattern in time series

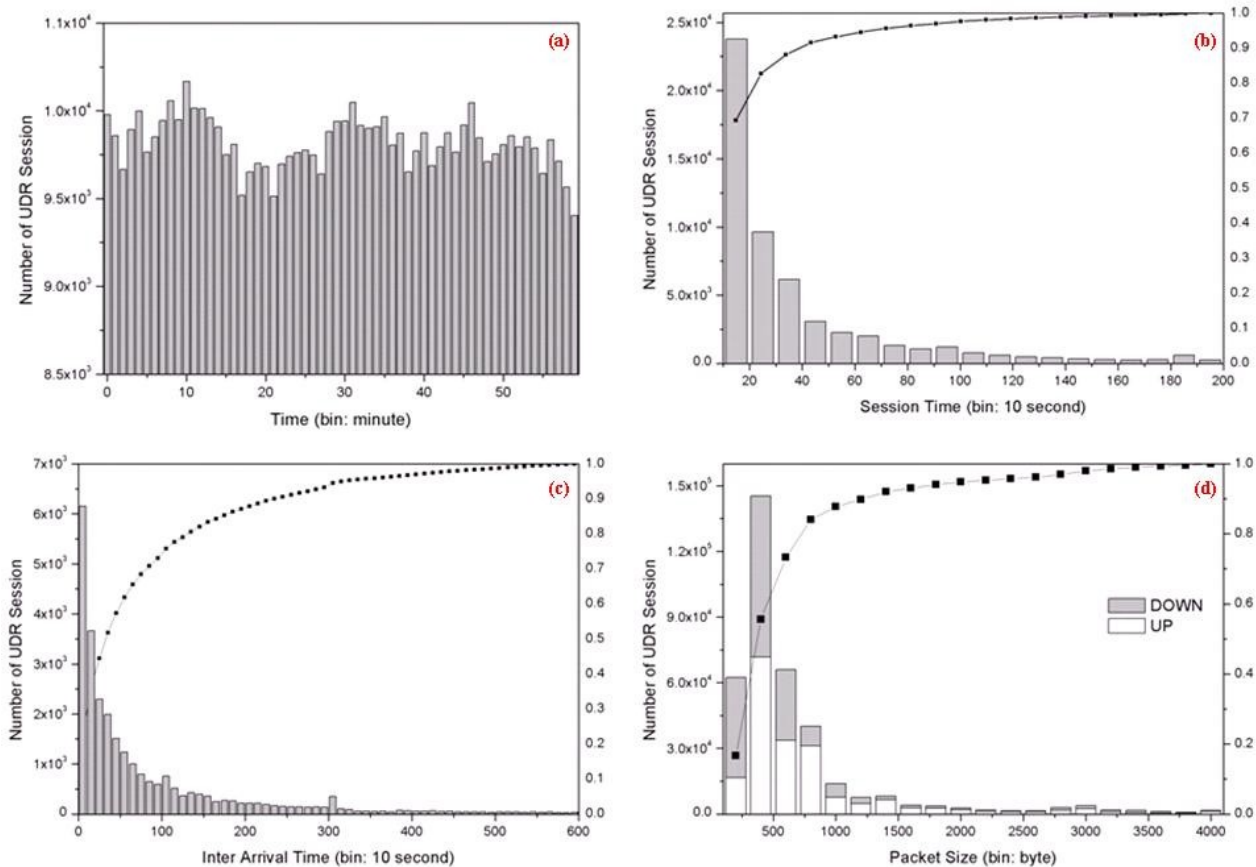


Figure 3: The analyzed result of user sessions by UDR

collected from the GB interface on a GPRS network. Rather than analysis using individual user traffic, they used the aggregate method for workload statistics. In order to analyze the characteristics of the entire network, we use a clustering method.

Youngseok lee [4] researched performance analysis of the transport layer protocols to understand the property of the entire network.

Guanghui he and Jennifer [5] indicated the behavior of individual wireless users by modeling several important stochastic properties.

All these research efforts focused on modeling individual features and analyzing a narrow range of network applications. In this paper, we aim to leverage the actual billing traces and study the properties of the entire cellular network in several aspects.

### 3. Methodology

Figure 1 shows the CDMA 1x EV-DO network configuration and billing system. The billing records are collected from the billing system. Packet Accounting parameters are divided into radio specific parameters collected by the RN (Radio Node), and IP network specific

parameters collected by the PDSN (Public Data Service Node)[6]. The PDSN merges the radio specific parameters for a given user session with the IP network specific ones to form a Usage Data Record (UDR). After merging, the PDSN will send the UDR to a local RADIUS Server (AAA). The PDSN will formulate one UDR per IP address per mobile station (MS). The RADIUS server (AAA) will support RADIUS attribute formats as defined in RFC 2138 [7] and RFC 2139 [8].

The data for analysis was collected in two ways. First, statistical information was collected for one year (January, 2007 ~ December, 2007). Second, the billing records were collected at the peak time of day, starting at PM 10:00 for an hour for 7 days (March 13, 2008 ~ March 19, 2008).

The billing records consisted of two parts. One is UDR-generated from PDSN and the other is CDR (Content Detail Record)- generated from the billing system collecting the packets from the mirroring switch. The billing records are used by service providers to charge their customers network usage.

UDR contains information useful to understand user sessions. CDR contains information about detailed user service sessions. It contains separated fields for each service type [6]. There are forty service types. We

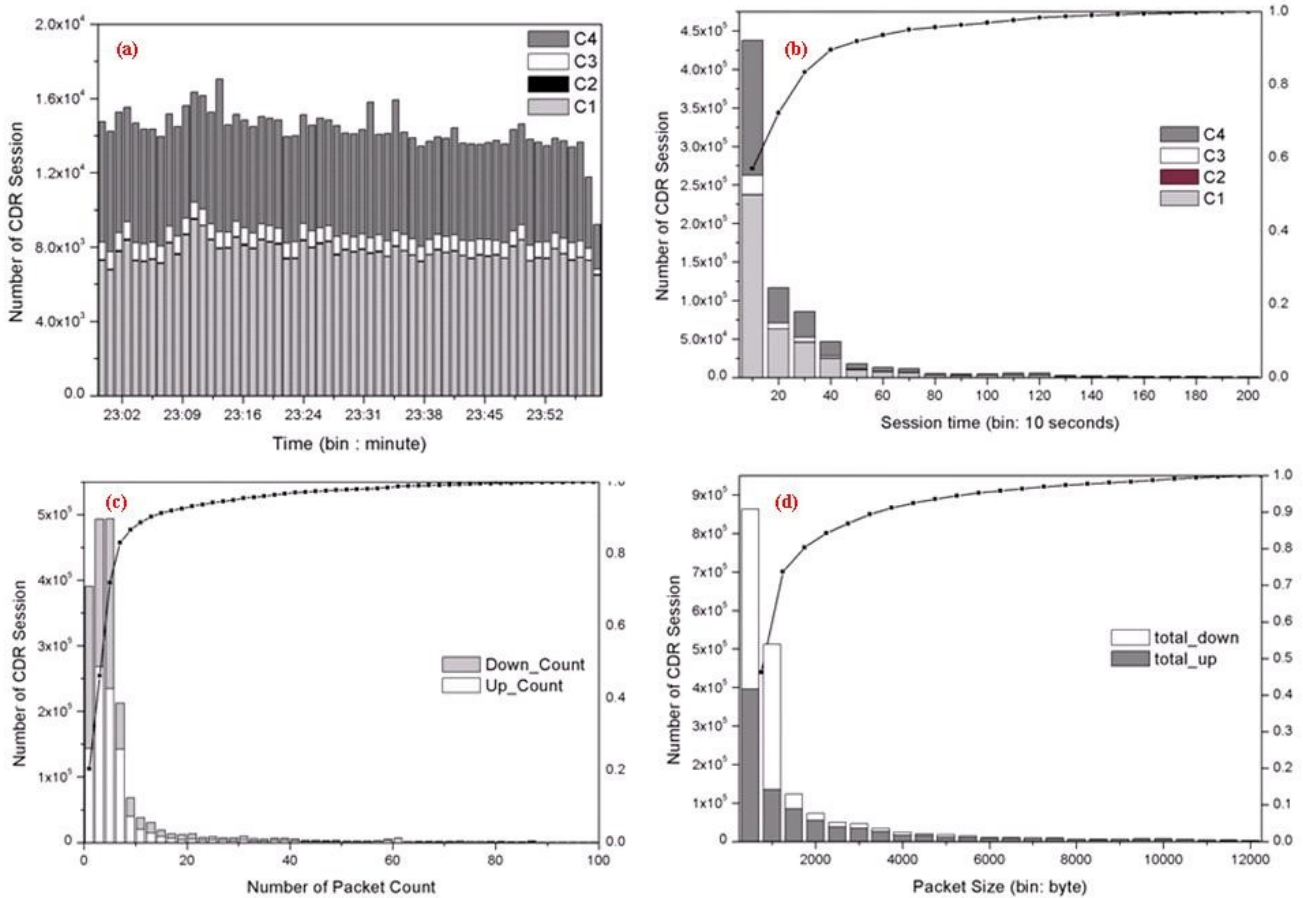


Figure 4: The analyzed result of service sessions by CDR

classified these into four categories for ease of understanding. Category 1 is WAP service, Category 2 is small-sized multimedia service, Category 3 is large-sized multimedia service and Category 4 is internet connection service.

#### 4. Analysis Result

The traffic distribution was measured over one year. Figure 2 shows the results analyzed over time. The analysis shows similar distribution of pattern regardless of date. Generally, peak times of data traffic are between 22:00 and 0:00 and its off-peak times are between 5:00 and 8:00 that is the morning rush hours. The pattern of data traffic corresponds to user's life pattern.

##### 4.1 Analysis of User Sessions

Figure 3 shows a detailed analysis of user sessions by UDR. According to the detailed analysis over time, the number of user sessions was equally distributed (a). We examined the usage patterns of the user's session time. More than 70% of

total user sessions were shorter than 200 seconds (b). Over 90% of user sessions were terminated within 400 seconds. 80% of the entire session's Inter Arrival Times between user sessions were 1000 seconds or less (c). 90% of the data were less than 1kb in packet size (d). In general patterns followed a Pareto Distribution for most factors (user session time, session inter arrival time and packet size).

##### 4.2 Analysis of Service Sessions

Billing data was collected in peak time for one week for more detailed analysis. Figure 4 shows a detailed analysis of each service type using CDR data.

WAP service sessions (Category 1) account for 50% of the total number. This indicates that that WAP is the major service type. Web browsing sessions for internet access services (Category 4) account for approximately half of the total session. Category 4 is gradually increasing (a). This result shows a current trend whereby a subscriber does not utilize the service provided by a service provider, but utilizes the direct service through external internet access,

**Table 1: The analyzed result of statistical data**

View of user session (UDR)					
Number of session	418987				
Average Session Time	37.86				
Average Inter arrival Time	113.31				
Average Packet Size (total up/down)	3653.94 / 25206.55				
View of service session (CDR)					
Category	C1	C2	C3	C4	OTHER
Average Number of Session	467086	2756	50913	346597	104028
Average Session Time	37.25 (148.74)	65.54 (82.37)	298.38 (368.06)	173.47 (190.65)	13.23 (161.12)
Average Packet Size per Session (total up/down)	751.3/ 4552.3	2675.3/ 65665.9	5100.1/ 126070.9	1174.5/ 4227.0	353.7/ 1061.4
Average Packet size per Packet (total up/down)	107.9/ 713.7	55.3/ 1312.8	158.2/ 661.1	80.5/ 362.3	137.8/ 692.7

with the cellular network as an access medium. This feature will increase in the future. More than 80% of total service sessions were transmitted within 300 seconds (b), 90% of the service sessions were less than 10 packets (c), 90% of the entire service sessions were around 2kb or less (d). They also followed a general Pareto Distribution for most factors (service session time, number of packet count, packet size).

Table 1 provides a comparative view of user sessions from UDR and service sessions from CDR. A subscriber can enjoy different kinds of service in one user session. There are distinct features according to the service type of user requests. Hence, it is more appropriate to analyze data on the basis of service type, rather than user session.

## 5. Conclusion

Analysis of the statistical data and billing record yielded some significant data, despite the fact that they contain only a high-level description of the network usage. Our analysis shows cyclic behavior of the CDMA network users. The traffic pattern corresponds to the user's life pattern. A few unique traffic characteristics were observed: Uneven up/down traffic utilization, low average packet size and short average session length. We analyzed the billing record with respect to the service session. It provides useful information about network operation and predictions for commercial networks.

## References

- [1] Tamas Varga, Bert Haverkamp, Bart Sanders, "Analysis and Modeling of WAP Traffic in GPRS Networks," Proceedings of ITCSS, Antwerp, Belgium, September 2004
- [2] Young J. Won, Byung-Chul Park, Seong-Cheol Hong, "Measurement Analysis of Mobile Data network," Passive and Active Network Measurement, pp.223-227, LNCS 4427, April 2007
- [3] Milosh Ivanovich, Jonathan Li, Timothy Neame, "Modelling GPRS Data Traffic," Proceeding IEEE Communication Society Globecom, November 2004
- [4] Youngseok Lee, "Measured TCP performance in CDMA 1x EV-DO network," Proceedings of Passive and Active Measurement Conference, March 2006
- [5] Guanghui He, Jennifer C. Hou, Wei-Peng Chen, "Characterizing Individual User Behaviors in WLANs," ACM MSWiM 10<sup>th</sup>, Greece, October 2007
- [6] TR-45, Wireless IP Network Standard, TIA/EIA/IS-835, June 2000
- [7] RFC 2138, Remote Authentication Dial In User Service, April 1997, <http://www.faqs.org/rfcs/rfc2138.html>
- [8] RFC 2139, RADIUS Accounting, April 1997 <http://www.faqs.org/rfcs/rfc2139.html>