Searching for invariants in network games traffic*

[Extended Abstract]

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ABSTRACT

Even if Internet traffic analysis and characterization is a fertile research area, a lot of work still must be done to study and understand the traffic characteristics of new emerging multimedia applications. Among them, an interesting category is that of multiplayer network games. This paper aims at demonstrating that, at packet level, spatial and temporal invariants exist in the traffic of such applications. For this purpose, we study *Counter-Strike*, a popular client/server network game, comparing results from two different networks. The effectiveness of the proposed approach is evaluated by studying statistics of both packet size and inter-packet time. Results provide a view on packet-level game traffic and they confirm that the main traffic dynamics present properties that can be generalized, independently of the observation point and time.

Categories and Subject Descriptors

C.4 [**Performance of Systems**]: Miscellaneous

Keywords

Measurement, Traffic Analysis, Networked games

1. INTRODUCTION

Multi-player network games are rapidly becoming significant contributors to overall Internet Traffic and they are one of the most popular examples - along with *VoIP* and *VoD* applications - of real-time, interactive, and multimedia commercial Internet applications. The authors of [1] reported that about 4% of all packets in a backbone could be associated with only 6 popular games, worthing - in the USA alone - a significant fraction of the 7 billion computer games industry [2]. In this paper we focus on *Counter-Strike*. As of May 2002, there were more than 20.000 *Counter-Strike* servers active [3]. In 2000, measurements [1] indicated that the Half-Life/Counter-Strike application was generating a large percentage of all observed UDP traffic behind DNS and RealAudio.

Also, the amount of Internet traffic generated by computer games can be expected to increase fast, especially because the new players are entering the Internet with game consoles (e.g. *Microsoft's Xbox*, *Dreamcast* (from *Sega Corp.*), and *Sony's Playstation II*) supporting wired and wireless network connections.

Providing premium service to the increasing on-line gaming community could be a promising source of revenue for ISPs. Thus, ISPs must have knowledge of the traffic load and profile related to games to provision their networks accordingly. Interactive games traffic has indeed different characteristics from other Internet traffic (WWW, e-mail, VoIP etc) and therefore imposes different requirements on the underlying network. Hence, for appropriate network planning and dimensioning, traffic characterizations and models are required.

In this paper, by applying a packet-level approach, we study multi-player network games traffic presenting our first attempt to the *search for spatial and temporal invariants* [9], and sketching similarities and differences with other Internet traffic.

2. OBJECTIVES

The key idea of this work is that traffic related to the same applications/protocols presents interesting properties of temporal and spatial invariance when it is studied at packet level. In this work, we investigate the statistical properties of Inter Packet Time (IPT) and Packet Size (PS) of a well known client/server network game, *Counter-Strike*. More precisely, first we provide a characterization from a WAN traffic trace collected at server-side [5].

Second, to study the invariance properties, we compare our results against those from the analysis performed in [6], which is related to LAN traffic collected at client-side.

We show how e.g. it is possible to see packets Inter-Arrival Times (IAT) at the server, as the aggregation of Inter-Departure Times (IDT) from a number of clients.

To the best of our knowledge, we extend the results present in literature in that: (I) we present a traffic characterization

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of Counter-Strike in terms of marginal distributions, fitting quality, tail analysis, autocorrelation study, and Hurst parameter evaluation; (II) we provide a time/frequency analysis to study the periodical behavior in game traffic; (III) we study the global and local dependencies between IPT and PS; (IV) we provide a first look at the invariants of both first order statistics and properties like tails behavior, autocorrelation, and Hurst parameter;(V) we provide freely available at [4] the statistical tools used in this work.

2.1 Packet-level approach

Packet-level traffic characterizations express network traffic in terms of Inter Packet Time (IPT) and Packet Size (PS). We adopt a *packet-level* approach for the following reasons: (i) simple and at the deepest point of view; (ii) switching devices typically operate on a packet-by-packet basis; (iii) most network performance problems (e.g. Delay, Jitter, Loss) happen at packet level; (iv) independent of protocols evolution and applicable to different applications; (v) usable in traffic generation and simulation; (vi) traffic at packet level remains observable after encryption (e.g. SSL or IPSec); (vii) results are robust to traffic profiling for anomaly detection. When traffic traces make it possible, the packet-level approach is adopted conjointly with flows, connections, sessions, and aggregate traffic analysis.

2.2 On the considered scenarios

Our work is based on the comparison of the analysis of the same game in two very different contexts. In the case of the WAN scenario we used the traffic trace available at [8]. Traffic was captured at a Counter-Strike server of one of the most popular on-line gaming communities in the Northwest region of USA, mshmro.com [5]. The server is configured with a maximum capacity of 22 players (which is the average number of players in fact). It is worth noting that even if the trace collection was limited to 20 millions of packets (ca. 8 hours), traffic from and to the server exhibits similar behavior even for the rest of the day [7].

While in this trace the point of observation is from the server, the other considered scenario is related to traffic captured at client side in a LAN environment. The use of data from two distinct gaming sessions - happened at different times, in two different kinds of network (WAN vs LAN), and observed from a *server* point of view on one scenario, and from the *clients* point of view in the other one - allows to search for invariant characteristics peculiar to the game.

The results from the second scenario, which we used for the comparison, have been presented in [6]. In that work Faerber, by analyzing empirical distributions of IPT and PS of packets flowing in and out clients, proposed a simple model of Counter-Strike traffic.

3. DISCUSSION AND CONCLUSION

Due to space constraints of this abstract we do not provide all the results of our analysis. We will present and comment them in the live poster session. Here we just summarize the main findings and we show two representative examples of the invariants we found.

As for *Counter-Strike* traffic characterization, we characterize the IPT and PS (inbound and outbound) variables. We report both marginal probability distributions and the related first order statistics. Also, we studied the samples temporal structures and their mutual dependencies. Finally, for each variables we study the tails behavior. After the characterization, we focus on the search for invariants between the two considered traffic traces by comparing the incoming/outgoing traffic of the server with that of the clients. In Fig.1 we show the PDFs of both the IDT observed at client-side in the LAN scenario and the IAT of aggregate client traffic captured at server side in the WAN scenario. We found that the average value - 41.7 ms which correspond to ca. 23 $pkts/s$ - of the IDT samples reported in [6] is consistent with the mean of the server IAT (from all the 22 clients): $0.002\ s \longrightarrow 506\ pkts/s = 22\ players \times 23\ pkts/s$.

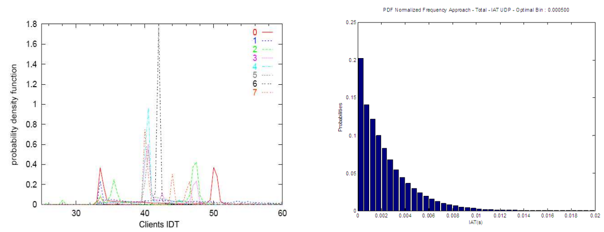

Figure 1: IPT PDF: client-side IDT (left) [6], server-side IAT (right)

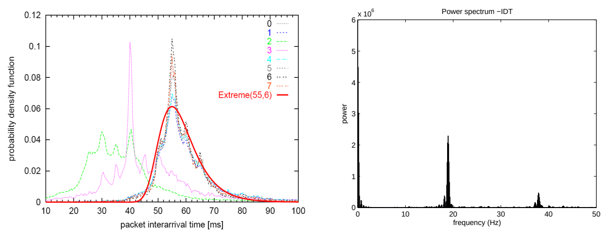

Figure 2: Client-side IAT PDF (left) [6], Frequency spectrum of Server-side pkt rate (right)

In Fig.2 the PDFs of the IAT at clients (in the LAN scenario), and the frequency spectrum of the packet rate of server-to-clients packets (in the WAN scenario) are depicted. From the frequency analysis we found a notable peak around 19 Hz, probably connected to regular game updates (ca. each 53 ms) sent from the server to the clients. Indeed, looking at the PDFs in the left diagram we see that most distributions are centered around 55 ms.

4. REFERENCES

[1] S. McCreary, k. Claffy, “Trends in Wide Area IP Traffic Patterns: A View from Ames Internet Exchange,” 13th ITC Specialist Seminar on Measurement and Modeling of IP Traffic, Sep 2000

[2] D.S. Jackson, “Video Games: A room Full of Doom,” Time Magazine (US Edition), vol. 153, n. 20 May 24, 1999.

[3] `http://www.counter-strike.net/`

[4] `http://www.grid.unina.it/Traffic/`

[5] `http://www.mshmro.com`

[6] J. Faerber, “Network game traffic modelling”, ACM workshop on Network and System Support for games, Apr. 2002

[7] Wu-chang Feng, Francis Chang, Wu-chi Feng, Jonathan Walpole.“A Traffic Characterization of Popular On-line Games”, IEEE/ACM Transactions on Networking, Jun 2005.

[8] W. Feng, cs.mshmro.com CounterStrike Server Traffic Trace”, www.ogiworks.org/files/tcpdump.11Apr0855.04 - Apr 2002.

[9] S. Floyd, V. Paxson, “Difficulties in simulating the Internet”. *IEEE/ACM Trans. on Networking*, Vol. 9 , Issue 4, pp. 392-403, Aug. 2001