Enemy Territory Traffic Analysis

Julie-Anne Bussiere*, Sebastian Zander
Centre for Advanced Internet Architectures. Technical Report 060203A
Swinburne University of Technology
Melbourne, Australia
julie-anne.bussiere@laposte.net, szander@swin.edu.au

***Abstract*- We analyse the network traffic of the online multi-player first person shooter game Enemy Territory. The game is based on the Quake 3 game engine but has more complex gaming rules. The data analysed is taken from a public game server run at CAIA, and corresponds to real gaming traffic. Measuring the packet length, inter-arrival time and bandwidth in both directions, this paper describes the impact of map, number of players or client hardware on the traffic. We find the traffic characteristics of Enemy Territory are very similar to the characteristics measured for Quake 3. However, there are some slight differences we point out. We also introduce activity as a new parameter that influences the traffic statistics such as packet length distributions.**

***Keywords*- Enemy Territory, Game Traffic Characterisation**

I. Introduction

Interactive network games have become more and more popular and their traffic constitutes a significant part of Internet traffic. This paper provides a traffic analysis of the on-line multi-player game Enemy Territory (ET) [1]. This game was developed as a Quake 3 (Q3) game modification (mod) but has more complex gaming rules. While Q3 is a pure deathmatch first person shooter game, ET is team based and missions need to be accomplished. This has an influence on the overall game characteristics, for example the duration of maps depends on how quickly players accomplish the mission.

Section 1 explains how the data was collected. Section 2 presents packet length, inter-arrival time and bandwidth characteristics, with their dependencies on map, number of players or hardware. The final section provides a comparison with Quake 3 traffic characteristics, which were analysed in a previous paper [2].

II. Data collection

The data we analyse is taken from a tcpdump trace measured at the public CAIA game server, which is running the standard '6 map campaign' [1]. The packet data has been filtered in order to only focus on CAIA players statistics over 24 hours. We used pkthisto [3] to obtain statistics on packet length, packet inter arrival time, packet and data rates. We always use a histogram size of 2000 packets and the bin size is 1byte for packet length and 0.25ms for inter-arrival time statistics. Our data does not come from particular experiments corresponding to precise game scenarios. External players and CAIA players were able to connect, disconnect and play at any time on the server. Therefore, in our dataset the number of players is varying. Because of this and the standard map cycle running on the server we can only evaluate the traffic characteristics for certain combinations of player numbers, maps etc. On the other hand, the traffic we analyse reflects real-life scenarios and still provides interesting results about Enemy Territory traffic characteristics. Table 1 describes the different hardware configurations of CAIA players.

***Table 1:* Player hardware features**

	Processor	*Clock speed*	*RAM*	*Graphics card*
Player 1	Pentium4	2.66GHz	256MB	Intel 82845G
Player 2	Intel Celeron	2.4GHz	1.24GB	Nvidia GF6600
Player 3	Pentium4	2.66GHz	512MB	Nvidia FX5200TV
Player 4	Pentium4	2.8GHz	256MB	Nvidia GF6600
Player 5	Pentium4	2.8GHz	512MB	Intel 82845G
Player 6	Pentium4	1.6GHz	256MB	Nvidia GF6600

III. Traffic analysis

A. *Packet Rate and Data Rate*

Server to client

The packet per second (pps) rate from server to individual clients is fairly constant at 20±0.28 packets/second. The data rate from server to individual clients (Figure 1) is varying between 12 and 30kbps.

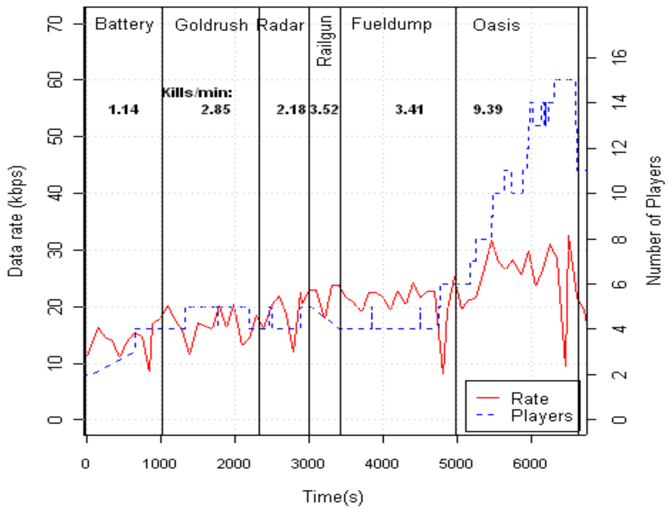

***Figure 1:* Data rate from server to an individual client**

* Julie-Anne Bussiere performed this work while a visiting research assistant at CAIA in 2005.

We observe the packet and data rate for a duration of about 1 hour and a half. All standard ET maps had been played once during this period. The total number of players is varying from 3 to 5, except for the map *Oasis* where people keep on connecting to the game and the number of players goes up to 15. For the map *Battery*, 3 clients are playing at the beginning and another one connects in the middle of the game. Besides the number of players the average kills per minute is given as an activity indicator. It is obviously directly related to the number of players. However, the activity is not the only parameter impacting on the data rate. Comparing the values of *Goldrush* and *Radar* shows that a higher activity does not necessarily result in a higher data rate. The map played is important as well.

Client to server

The packet per second rate for each client to server dependents on the client's frame rate which depends on the map as well as the client machine (graphics card, CPU) and game configuration. It is important to note that each player can choose its game configuration (e.g. screen resolution). These parameters are not known but can also have an impact on the data we analyse.

Figure 2 shows the packet rate from each client to server, grouped by graphics cards and maps played. Whereas the mean pps rate is quite similar for the Nvidia FX5200TV and the Intel 82845G with a CPU speed of 2.66GHz, the mean pps rate is between 10pps and 20pps higher for the Nvidia Gforce 6600 with 2.4GHz or 2.8GHz CPU frequency. The GF6600 has a higher packet rate compared to the other graphic cards even on a machine with 1.6GHz CPU frequency. The impact of the particular map is important as well: the difference in packet rate is about 20pps between the maps *Battery* and *Goldrush*. The difference between maps is due to different features that impact on the client's frame rate for example rain, snow or huge outdoor environments.

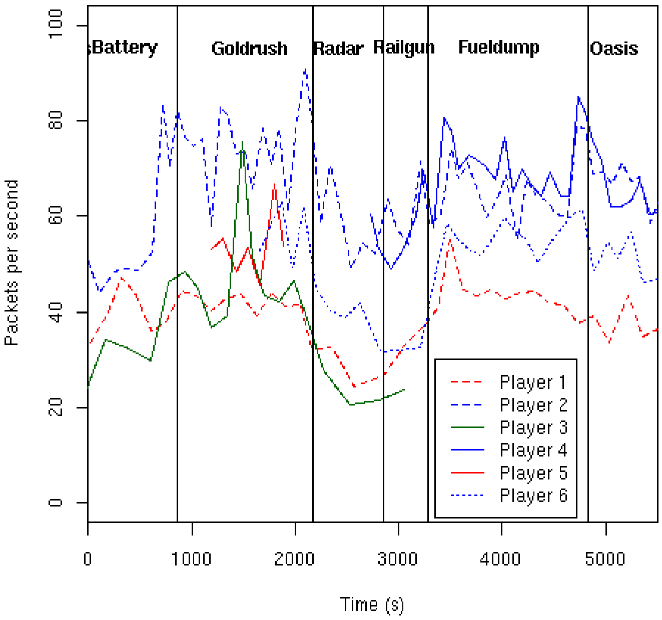

***Figure 2:* Packet rate from clients to the server**

The data rate (not shown) has very similar shape and dependencies on map and client as the packet rate. It varies between 10kbps for player 3 on map *Goldrush*, up to 45kbps for player 4 on map *Radar*.

B. *Packet length*

Server to client

Figure 3 shows the packet length distribution from the server to an individual client (player 2). It covers 1 hour and a half and all 6 maps are successively played. The distribution is seen from the top, with brighter colors for higher percentages. The name of the map is given with the number of clients playing.

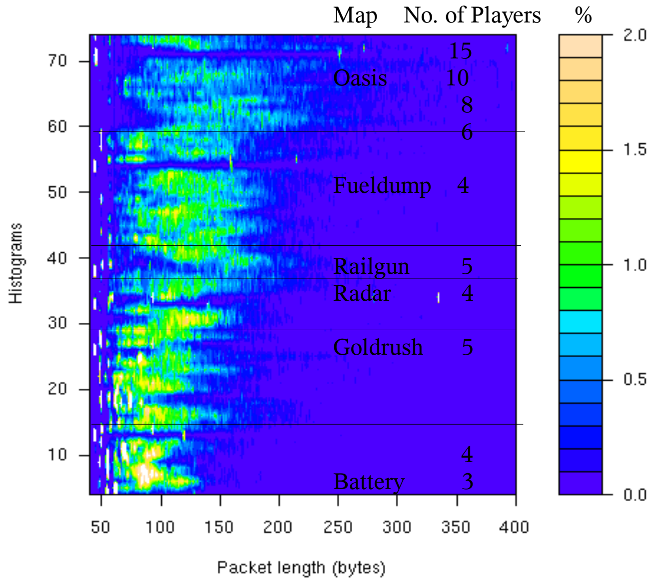

***Figure 3:* Packet length distribution from server to player 2**

Figure 4 shows the map and number of players impact on the server to client packet length distribution on the map *Battery* (player 2). It obviously gets wider with more players. We can see the packet length is varying according to the combination of map and number of players.

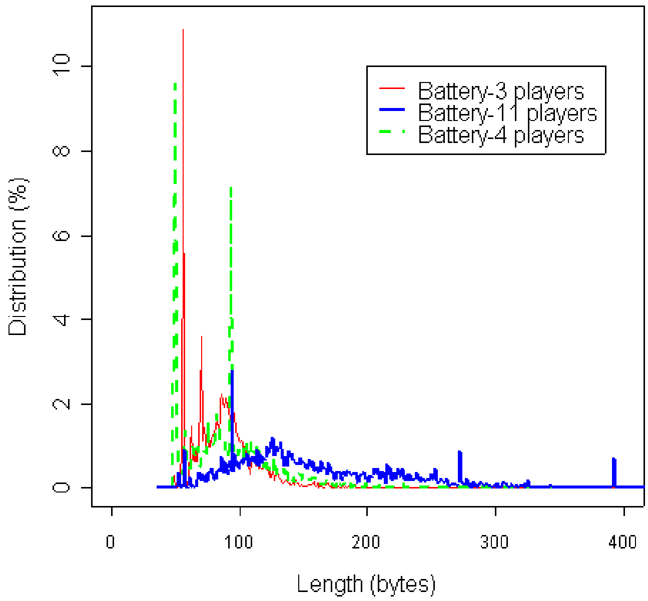

***Figure 4:* Number of players impact on server to client packet length distribution (player 2)**

The number of players impacts on the average packet length value (respectively 85, 98 and 127 bytes) and on the distribution as well: packet lengths values are more widely distributed for a bigger amount of players. The distributions for 3 and 4 players have a peak around 50 bytes, which are caused by temporary inactivity of player 2. (The player actually changed client configuration settings during the game.) It would be interesting to see the impact of each independently, but we do not have data for all configurations of map / number of players.

Concerning map impact, we compare the packet length distribution on the maps *Goldrush* and *Railgun* with the same number of players (Figure 5). The distributions are sums of the individual player distributions.

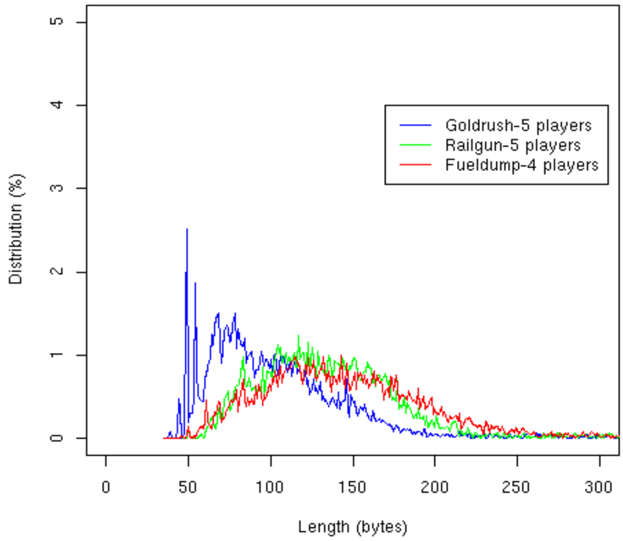

Figure 5: **Server to client packet length distribution for several maps**

For *Goldrush,* the average packets size is about 100 bytes, and the distribution shows most of the packets are below the average value. For *Railgun*, the average value is 140 bytes and values are more widely distributed. But considering the activity on each map, it appears that on *Goldrush* the mean kills per minute is 2.85 whereas it is 3.52 on *Railgun*. We added the packet length distribution for a map with a similar level of activity (*Fueldump* with mean kills per minute 3.41). This distribution is much closer to the one of *Railgun*, but the number of players is different (4 players). It seems that sometimes an activity indicator would be more appropriate as model parameter than just the number of players (although activity certainly depends on the number of players).

Client to server

The packet length distribution from individual clients to the server is basically constant between 55 and 72 bytes, but the distribution differs slightly between players. Figure 6 shows the packet length distribution for players 1, 2 and 3 on the map *Railgun* (5 players in total). We can see two peak values at about 62 and 67 bytes, but the distribution between these peak values is different. The mean size for players 1, 2 and 3 is 64.6, 62.6 and 64.2 bytes respectively. It seems that height and location of the peaks depends on the clients. This is different to what was found in the Q3 study [2], but as shown in Figure 6 the difference is only slight.

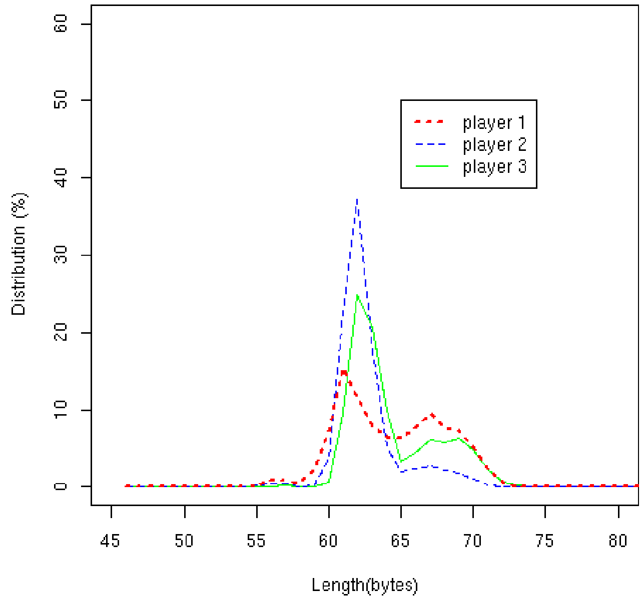

Figure 6: **Client to server packet length distribution for several players**

In Figure 7 we plot the packet sizes over a duration of 1 hour and a half, covering the different maps, for an individual client (player 2) to the server. On the map *Battery*, we can see that packet lengths are smaller at the beginning with a peak at 57 bytes. It corresponds to a period of time when the player was connected but did not play (idle). When the player starts playing, we see the packet sizes increasing with a peak around 62 bytes. This shows that client to server packet lengths are dependent on the behavior of the player.

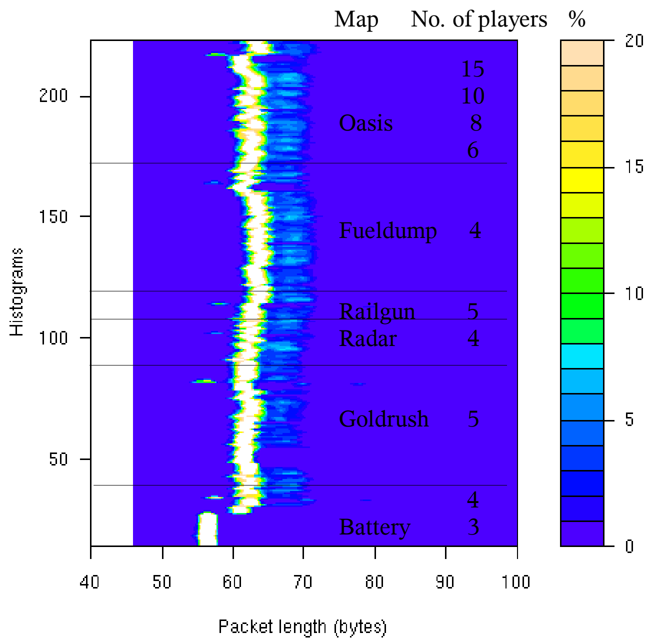

Figure 7: **Packet length distribution from player 2 to the server**

Overall the packet length varies slightly over different histograms but it does not seem to have a strong relation to the map or the number of players. The larger packet lengths appearing at the end of *Oasis* could be due to an increasing of activity, with a mean of 9.4 kills/minute on this map in comparison to about 3 kills/minute for the other games. Plotting the same graph for player 1 gives a wider distribution between 60 and 70 bytes as we would expect it considering Figure 6.

C. Packet inter arrival times

Figure 8 shows packet inter-arrival time from server to all individual clients. The histograms were summed over all the duration of the game. The server to client inter-arrival times are fairly constant 50ms.

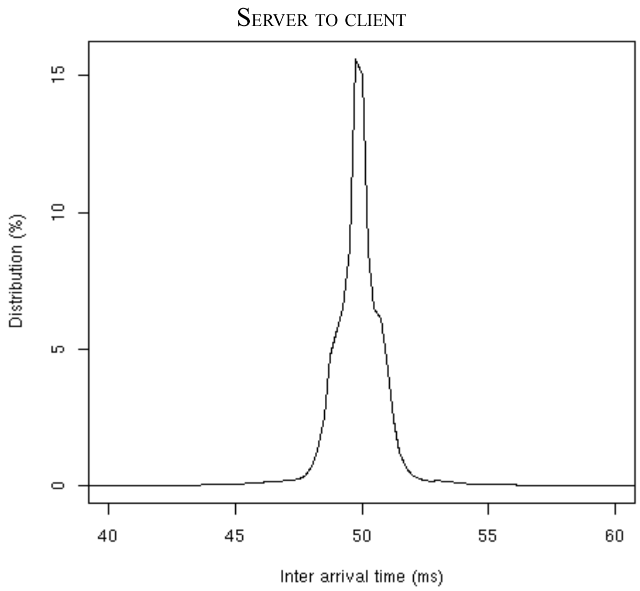

Figure 8: **Server to client inter arrival time distribution**

CLIENT TO SERVER

Client to server inter-arrival times are dependent on the maps as well as the client hardware (graphics card, CPU). We show the inter arrival-times for players 1, 2 and 3 who have different graphic cards. Figures 9-11 present the inter-arrival time distribution over the different maps played. As previously, this is a view from top, cut at 2%, which allows to see the low values as the distributions for players 1 and 3 are very wide with no high peaks.

In figure 11, as seen previously for client to server packet length, player 2 is inactive at the beginning which explains why the inter arrival times are about 20ms. Across all maps there is a peak value at 10ms, and we can see that the distribution gets wider depending on the map. For *Radar* and *Railgun*, where there is snow or rain (which requires more graphical resources), the inter-arrival time goes up to 30ms. Other clients with this graphic card (GF6600) have the same general distribution, with a peak value at 10ms. However we notice longer inter arrival times (up to 55ms) with a slower CPU clock speed (player 6 with only 1.6GHz).

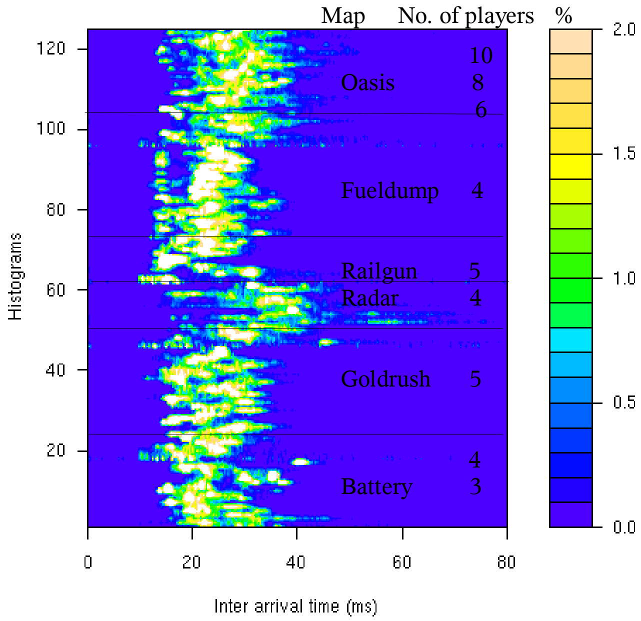

Figure 9: **Inter Arrival time distribution from player 1 to server**

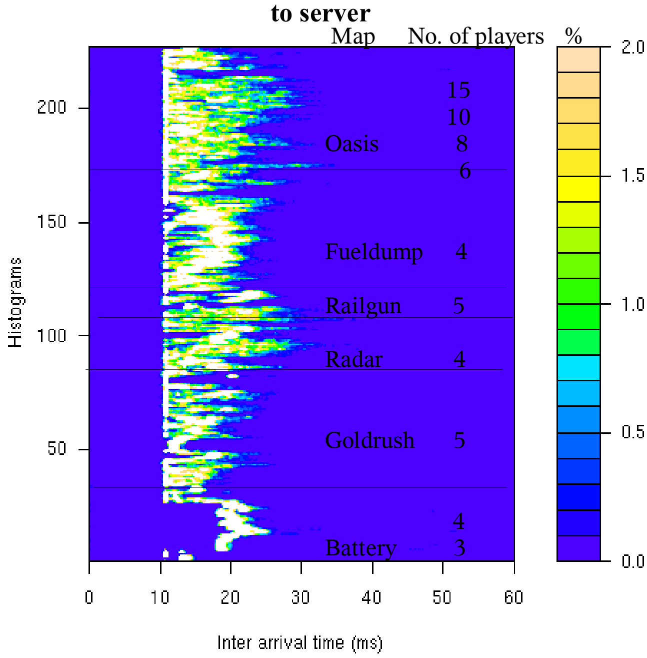

Figure 10: **Inter Arrival time distribution from player 2 to server**

For players 1 and 3 the distribution is wider and more irregular. There is no dominant peak value. The minimum value is 10ms for all players.

Figure 12 shows the distributions summed over all histograms for the 3 players. Whereas Figures 9-11 show the distributions from the top this figure shows the distribution from the side. As mentioned before for player 2 there is a significant peak at 10ms while for player 1 and 3 the distributions have no single very high peak.

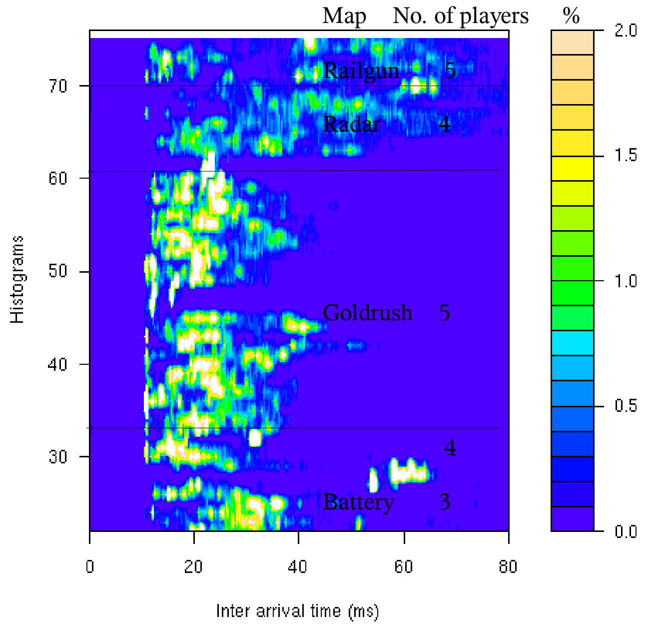

Figure 11: **Inter-arrival time distribution from player 3 to server**

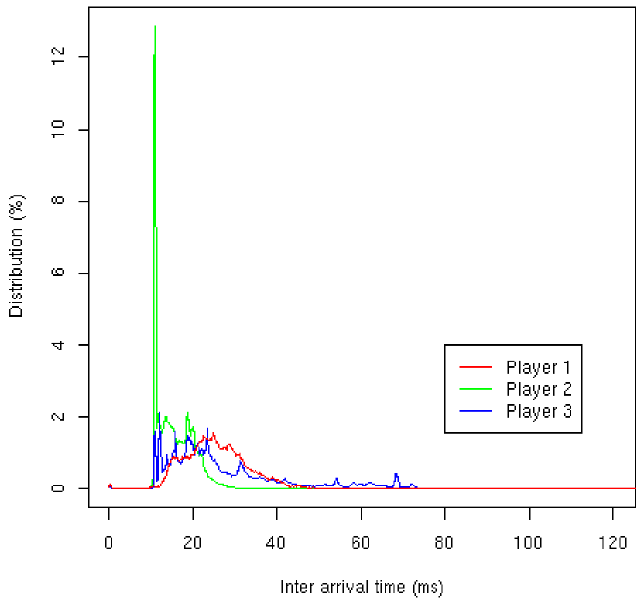

Figure 12: **Client to server inter-arrival time distribution**

IV. Comparison with Quake 3 traffic analysis

As Enemy Territory (ET) is based on the Quake 3 (Q3) engine (it actually is a Q3 server modification), it is interesting to compare their traffic characteristics. The Q3 traffic analysis is described in detail in [2]. The following tables compare the range of values of all traffic statistics for both games. It should be noted again that the ET traffic analysis was not done under the same gaming conditions as the Q3 analysis in [2] (concerning the number of players and client hardware). In the table, the character "*" indicates a dependency on game conditions.

Table 2: **Comparison of ET and Q3 traffic statistics**

Server to client	***ET***	***Q3***
Packet length *	40-300 bytes	40-250 bytes
Inter arrival time	50±5 ms	50±15 ms
Packet rate	20 packets/s	20 packets/s
Data rate *	12-30 kbps	15-40 kbps

Client to server	***ET***	***Q3***
Packet length	55-72 bytes	55-72 bytes
Inter arrival time*	10-70 ms	10-60 ms
Packet rate*	20-90 packets/s	20-90 packets/s
Data rate*	10-45 kbps	12-45 kbps

The server to client packet length is impacted by the number of players. For ET, the number of players reaches 15 on map *Oasis*, whereas the maximal number for Q3 is 8 players. This explains why we have larger packets of 300 bytes for ET and not for Q3. The inter-arrival time distribution of server to client packets is wider (larger variance) for Q3. This could be because the Q3 server had a slower CPU and therefore it might not have been able to produce as accurate inter-arrival times as the ET server. Concerning the data rate from server to client, Q3 reaches 40kbps on a specific map (pigskin) with 8 players. On other maps it does not exceed 30kbps with 8 players as well, which is similar to what we measured for ET. The client to server traffic characteristics are all very similar. The larger range of inter-arrival times for ET comes from the Nvidia FX5200TV graphics card. No values are given for this graphic card for Q3 traffic, but we can expect (considering its bad performance) that we would have some larger inter-arrival times of 70ms as well.

However, the ET client to server packet length distribution was shown to be different for different clients. This is an important difference, as this phenomenon was not observed for Q3. But the difference observed was only slight and further investigation is needed to identify if it is caused by different client hardware or different player behavior. We also showed that the number of players and map seems to be not the only parameter impacting the server to client packet length and data rate. The amount of activity during the game is important as well.

Obviously, activity is a direct consequence of the number of players, and is also related to the map. The activity indicator we used takes in account only the kills per minute, and we can see it is as correlated to the data rate as well as the number of players. It could be interesting to create an activity indicator which would take in account all the actions occurring during the game (for example building, healing, chatting etc.). This new metric could be a better model parameter than just the number of players for games such as ET, where the activity is more loosely correlated to the number of players (due to game tactics) than for pure deathmatch games.

V. Conclusion

This paper provides an analysis of Enemy Territory traffic characteristics based on real traffic data obtained on the public CAIA game server. We analysed packet and data rates, packet length and packet inter-arrival times in both directions. We compared the results with previous findings for Quake 3 [2]. As Enemy Territory is a game based on Quake 3, we find many similarities in their traffic characteristics. One difference is that for ET we observed slightly different client to server packet length distributions. Further investigations are needed to identify whether this is due to different client hardware or different player behavior. So far the observed difference in the packet length distributions is very small so the approach in [2] to use one model for client to server packet length would still be feasible.

This paper also shows that traffic characteristics are dependent on the level of activity. It suggests to introduce an activity indicator for future game traffic analysis, which could be a better model parameter than just the total number of players for more complex first person shooter games such as ET.

Furthermore, for a more comprehensive analysis it would be useful to create game scenarios with various predetermined map and number of player configurations or alternatively investigate a large number of different traces from the public server (which probably cover a lot of different scenarios under realistic conditions).

Acknowledgments

Thanks to all the CAIA members who dedicated a lot of their after work time to playing Enemy Territory.

References

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