TrackMania Nations Forever network traffic - a preliminary study

Roxanne R Pashaei
Centre for Advanced Internet Architectures. Technical Report 091202A
Swinburne University of Technology
Melbourne, Australia
rpashaeidariani@swin.edu.au

Abstract-**This paper presents our deployment of the online game TrackMania Nations Forever (TMNF) and its network traffic behaviour. The game is based on client-server mode and the data analysed is taken from a TMNF game server and its corresponding clients at CAIA in real-life scenarios. Measuring the packet length and inter-arrival times in both direction, this paper describes the traffic characteristic of TMNF as well as the impact of different condition such as number of player and client hardware on traffic generated by this game. The goal is to observe the statistics of TMNF game which may lead us to simulate its traffic and eventually estimate the potential future impact of TMNF traffic over the network.**

Keywords- Traffic trace, TrackMania Nations Forever (TMNF), Game Traffic Characterisation

I. Introduction

In recent years Internet based computer games have become more and more popular and the traffic associated with these games constitutes a significant part of internet traffic [1] [2] [4]. Game characteristics impose some impact on the network traffic which have a substantial influence on the packet size distribution and inter-arrival times which are important elements in network traffic shaping. It is important to understand how the traffic varies as the number of players increases and how this traffic affects and is affected by other traffic.

Previous research has already looked at the traffic characteristics of different First Person Shooter (FPS) online games to provide game traffic analysis and modeling [1] [2] [3] [4] [5]. As a result the general model of game statistic for interactive FPS game traffic has been illustrated and developed. Modeling traffic generated by these multiplayer online games has attracted a great deal of attention in the past few years [1] [2]. Modeling online games traffic can be achieved after deploying and analysing the game characteristic in an appropriate test environment under a real condition. In attempting to understand traffic generated by online games, we need to look and analyse the general game characteristics in different experimental conditions [1] [2] [3] [4] [5].

Prior work has shown that game behaviour for small number of players allow us to predict its features for larger number of players. Understanding how the game traffic varies as the number of users increases allows us to predict what happens to packet lengths and packet inter-arrival times. Previous research has been done for some interactive multiplayer games and the detailed game characteristics are obtained in controlled trials with the small number of players (typically less than ten) and then its model extrapolated to much larger numbers of players [2].

In this paper we focus on the traffic generated by the multi-player online game TrackMania Nations Forever (TMNF). Our goal is to configure an appropriate test-bed for the TMNF game and differing number of players to measure its traffic behaviour for correlation with the player numbers. In particular we are interested in the packet inter-arrival times and packet lengths of messages transmitted to and from the game server and game clients and to see whether these parameters vary as the number of players varies.

The rest of the paper is structured as follows. Section two introduces the TMNF game. Section three describes the test-bed and experiment methodology. Section four explains how the data was collected. Section five presents packet lengths, inter-arrival times characteristics, with their dependencies on number of players or hardware. We see that there is a simple relation between this traffic and Server-to-Client packet length. The final section provides assumption and conclusion.

II. Bckground

TrackMania is a series of arcade racing games which was desined and developed by the French team Nadeo for Nintendo DS and Windows PCs. The TrackMania series lets the player race a track as many times as they want until time runs out. They can also choose to respawn at any time possible. Although in multiplayer mode multiple cars race on the same track, they cannot actually collide or otherwise interfere with each other. Hence no collision happens between players and they compete for the best time and point in each run [7] [8] [14].

TrackMania Nations Forever is a client-server based game with client software running on standard PCs. It mostly uses UDP for transport and adjusts packet transmission rates.

This report deals with traffic captured during networked sessions of the TMNF game in real-life scenarios. In this case, the traffic traces concern network traffic generated by the TMNF game running on a central dedicated server with between two to seven players and three different maps. Player actions are transmitted from the client to the server. The server constructs a game state for distribution to all players based on these actions. The game state is then distributed to all players. The game state may be different for players. In general for all players, traffic in the Client-to-Server direction usually consists of few fixed packet length whose distribution is independent of the number of players on a given server. On other hand, traffic in the Server-to-Client direction usually shows distinct variation as the number of players increases [1].

III. Methodology

A. Game testbed

Figure 1 illustrates our topology of testbed.

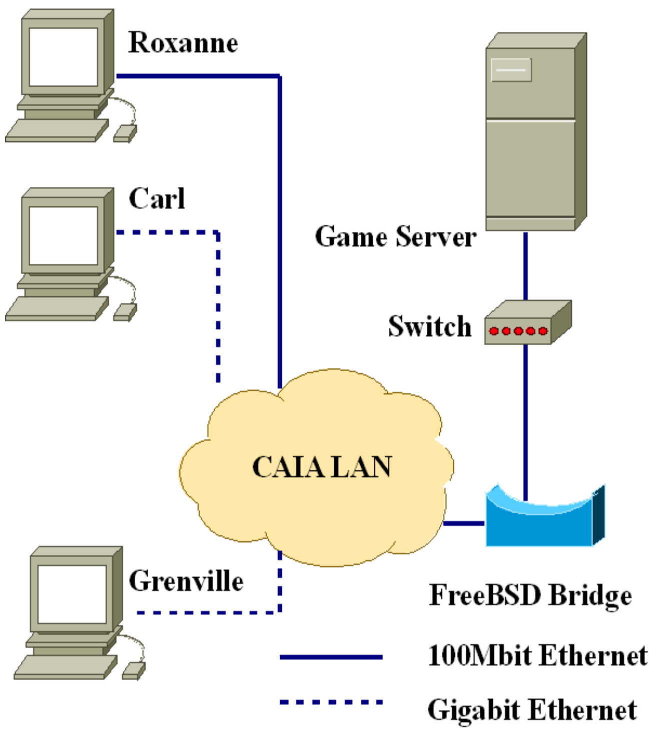

Figure 1. Test-bed diagram

In the Client-Server model, up to seven different client machines were involved in six different trials. The client software ran on Windows operating system on standard PCs. The server was run from a Live-CD on a Unix platform on top of a FreeBSD machine. TrackMania Server in Box v2.0.3 (TMSiaB v2.0.3) is bootable Linux-CD (140 MB, based on PuppyLinux) which contain all requirments to start, configure and administer a Dedicated Server [9][10].

The server manages the game state for distribution to all players. The FreeBSD-based bridge was located between server and the CAIA LAN switch to capture data traffic. The game was deployed across CAIA with a mixture of Gigabit and and 100 Mbit switched Ethernet links.

B. Platform Configuration

Table 1 to 8 list the configuration of all computers involved in the trial. Figure 2 and Figure 3 describe the TMNF configuration used by all clients.

Server Platform	
IP	136.86.229.102
CPU	Celeron D 2.8 GHz
RAM	1 GB
HDD	80 GB
OS	FreeBSD 7.1

Table 1. Server Configuration

Bridge	
CPU	Intel P4 1.60 GHz
RAM	512 MB
Kernel tick-rate	1000
OS	FreeBSD 7.2

Table 2. Bridge Configuration

In /etc/rc.conf of FreeBSD we added these parameters to configure the bridge:

```
cloned_interface=”bridge0”
ifconfig_bridge0=”addm fxp0 addm faxp1 up”
ifconfig_fxp0=”up”
ifconfig_fxp1=”up”
```

Roxanne Desktop	
IP	136.86.229.98
CPU	Intel P4 2.8GHz
RAM	786 MB
Video Adapter	NVIDIA GeForce4 MX 440 with AGP8X
Network Adapter	Intel PRO/1000 MT
OS	Windows XP SP3
Game Resolution Mode	1280x960

Table 3. Client Hardware Configuration (Roxanne)

Carl Desktop	
IP	136.86.229.136
CPU	Intel Celeron CPU 2.4 GHz
RAM	512 MB
Video Adapter	NVIDIA GeForce 6600
Network Adapter	Intel PRO/100 VE
OS	Windows XP SP3
Game Resolution Mode	1280x960

Table 4. Client Hardware Configuration (Carl)

Granville Desktop	
IP	136.86.229.37
CPU	Intel Core 2 Duo 6300 1.86GHz
RAM	2GB
Video Adapter	NVIDIA GeForce 7900 GS
Network Adapter	Realtek RTL 8168/8111 PCI-E Gigabit Ethernet NIC
OS	Windows XP SP3
Game Resolution Mode	1600x1200

Table 5. Client Hardware Configuration (Grenville)

Mattia Desktop	
IP	136.86.229.224
CPU	Intel P4 2.67GHz
RAM	1 GB
Video Adapter	Intel 82845G/GL/GE/PE/GV Graphic Controller
Network Adapter	Intel PRO/1000MT
OS	Windows XP SP2
Game Resolution Mode	640x480

Table 6. Client Hardware Configuration (Mattia)

Fazl Desktop	
IP	136.86.229.106
CPU	Intel P4 2.8GHz
RAM	1 GB
Video Adapter	Intel 82845G/GL/GE/PE/GV Graphic Controller
Network Adapter	Intel PRO/1000MT
OS	Windows XP SP2
Game Resolution Mode	640x480

Table 7. Client Hardware Configuration (Fazl)

Soung Desktop	
IP	136.86.229.117
CPU	Intel P4 2.8GHz
RAM	1 GB
Video Adapter	Intel 82865G Graphic Controller
Network Adapter	Intel PRO/1000MT
OS	Windows XP SP2
Game Resolution Mode	640x480

Table 8. Client Hardware Configuration (Soung)

Roxanne Laptop	
IP	136.86.229.104
CPU	Intel Core 2 Duo 6300 1.67GHz
RAM	2 GB
Video Adapter	NVIDIA GeForce 8600M GT
Network Adapter	Broadcom 440x 10/100 Integrated Controller
OS	Windows Vista SP2
Game Resolution Mode	1440x900

Table 9. Client Hardware Configuration (Roxanne)

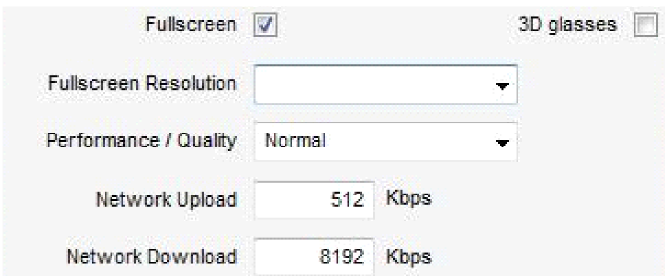

Figure 2. Configuration options

All Clients used full screen mode (Figure 2) and the screen resolution is set as per player (Table 3 to 9). For all clients, the upload rate (the rate in which data is sent to server by client) is 512 Kbit/s and the download rate (the rate in which data is received by client from server) is 8192 Kbit/s.

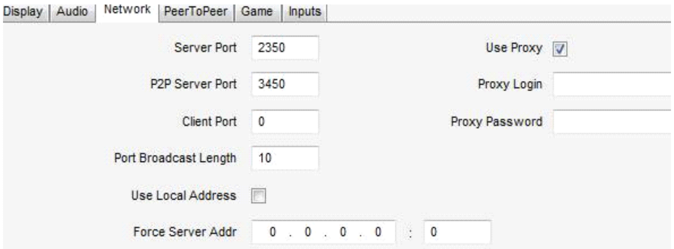

Figure 3. Network option

As shown in Figure 3 the dedicated server is reachable on main port TCP and UDP (default 2350), optionally on p2p port TCP (default 3450) [13].

Figure 4. Internet option

Figure 4 shows that the game can be palyed either offline in a particular LAN or can be connected to the internet. In this experiment we have chosen the "stay offline" option in all trials.

The rest of setting used the default configuration value for TMNF game client.

IV. Data Collection

There are three main phases of interaction between client and server that impact on network traffic.

1. A client initially connects to the server, and receives data from the server to update the client's local virtual world information (map definitions).
2. The client is connected to the server and game is in progress (players driving the car and competing on speed).
3. The client is connected to the server, and the game has been paused as the server changes maps.

The goal is to obtain statistics of traffic during active game play-phase2. The start-up phase of the game involves the exchange of many small 'keep-alive' packets while all players join the game. A sufficiently large number of statistics need to be captured. For the two-to-seven players games, we analysed active game play statistics for three minutes, corresponding to approximately 2500 packets per client [1].

Traffic is captured at the bridge (Figure 1) using tcpdump. This is then further analysed using wireshark [10][19].

All games were run using the same game environment for a set 3-minutes duration. Each trial involved a different number of players who participated on a game since the start-up till the end.

V. Packet length and inter-arrival statistics

In this section we present plots showing synthetic and empirically derived distributions for the six and seven players games. As the actual game traffic happens while client and server both are in progress we use the packet range of 1300-3800 which is roughly three minutes of actual playing time.

We will review the raw results and describe what our data reveals about TMNF behaviour as well. We will categorize our result in two modes; Client-to-Server and Server-to-Client. We consider the facts and based on the data we collected in each trial, we can have some assumption of TMNF behaviour and its dependency. It then may lead us to create a traffic modeling for TMNF game in future.

For all scatter plots and CDFs we have used scilab-5.1.1 and scilab 4.1.2. Due to space constrains we only show a representative sample of CDF and scatter plots [11].

The vast majority of inter-arrival are less than 100-150 ms. As a result, we are analysing the 99% of packets which are in less than 150ms range.

A. *Client-to-Server Packet inter-arrival times*

In Figure 5 and 6 we show the statistics of the inter-arrival times from each Client-to-Server for TMNF in a six players game and a seven players game.

As shown in Figure 5 and 6 the packet inter-arrival times for each individual client differs slightly depending on the client machine (graphic card, CPU and Network adapter).

(20ms to 70ms). One assumption for this kind of behaviour is differences in kernel tick rate.

In Figure 7 and Figure 8 we compare inter-arrival times of each trial for two specific players in Client-to-Server mode. (Roxanne and Carl)

As shown in Figure 7 and Figure 8, the inter-arrival times for an individual client in all trials is similar regardless of the number of players in a given trial. The inter-arrival times are distributed between 20ms to 70ms values, which means clients update the server with their current information.

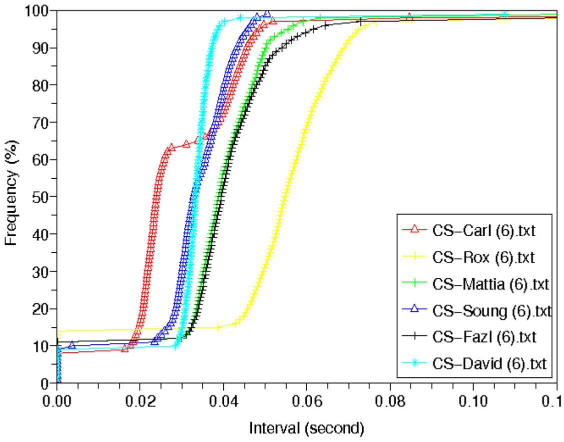

Figure 5. All players' inter-arrival time in a six players game (Client-to-Server)

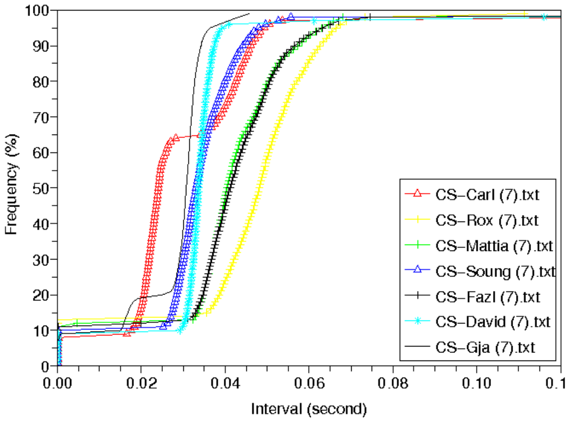

Figure 6. All players' inter-arrival time in a seven players game (Client-to-Server)

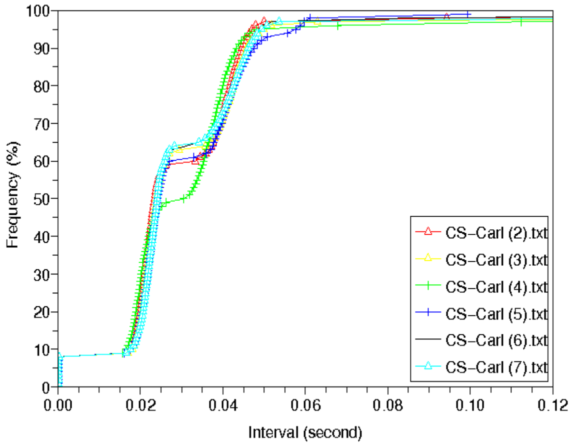

Figure 7. Carl's inter-arrival time in two to seven trials (Client-to-Server)

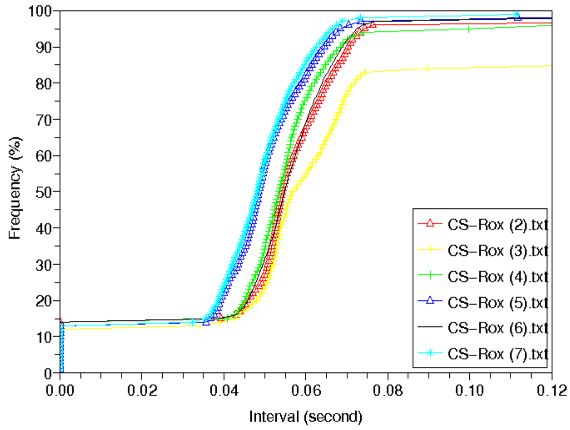

Figure 8. Roxanne's inter-arrival time in two to seven trials (Client-to-Server)

Identical client hardware and configuration result in identical inter-arrival times (Mattia and Fazl). We assume that clients send their updates to server frequently to inform the server of their current activity. Traffic analysis for First Person Shooter games suggests that if one client reports its update to server less frequently than the others, then there is a potentially unfair advantage for that player. Fairness dictates that clients should report their location and action at a frequent rate with the possible exception of when the client is inactive [2]. In TMNF, clients need to update the server with their information such as position, speed, direction and acceleration. Hence the same assumption of fairness applies. As a result although the number of client increases, the distributions of packet inter-arrival times of all clients are similar and it varies between 20ms up to 60 ms.

There are some unexpected behaviour in two client machines (Carl and Gja). The packet inter-arrival times for these two clients are distributed between two separate values (20ms to 30ms and 40ms to 60ms), however, the distribution for all other clients are similar

Figure 9, Figure 10, Figure 11 and Figure 12 illustrate the scatter plot of packet inter-arrival time for three clients in a seven players game. For better understating of the pattern and the correlation between adjacent packets we are zooming in each plot and analysing the 300 packets (packets 2500-2800). We are plotting the packet inter-arrival times for Roxanne and Mattia to represent the common Client-to-Server game behaviour and Carl and Gja as the exception representative behaviour.

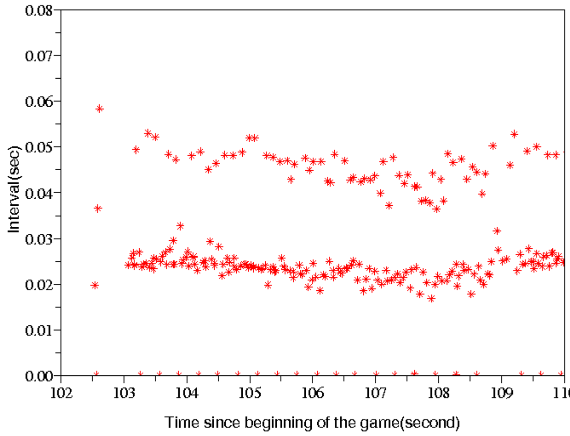

Figure 9. Scatter plot of packet inter-arrival time for packets between 2500 to 2800 (Carl)

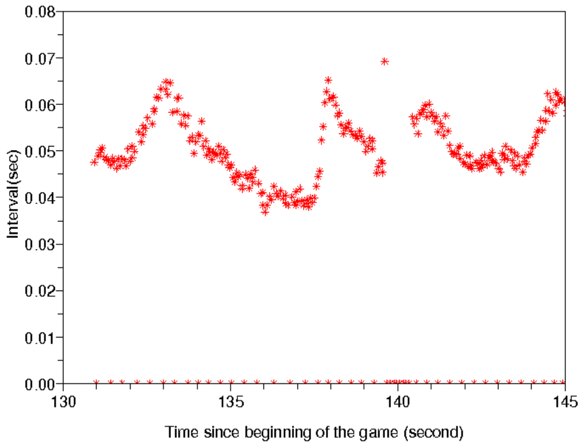

Figure 10. Scatter plot of packet inter-arrival time for packets between 2500 to 2800 (Roxanne)

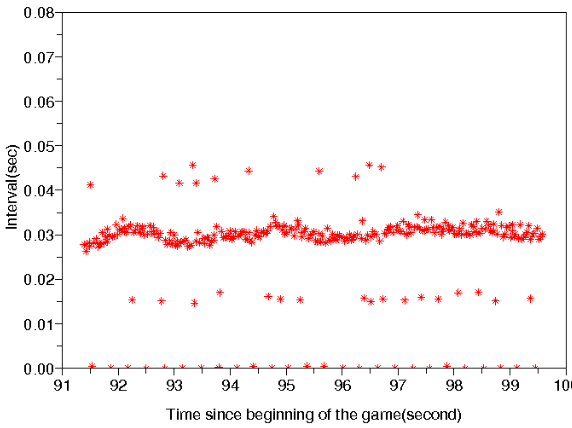

Figure 11. Scatter plot of packet inter-arrival time for packets between 2500 to 2800 (Gja)

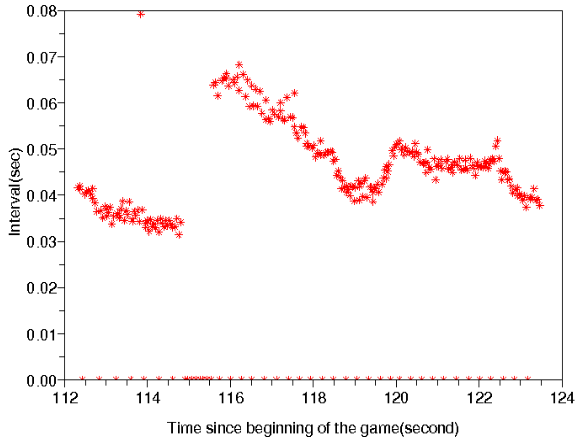

Figure 12. Scatter plot of packet inter-arrival time for packets between 2500 to 2800 (Mattia)

Figure 9, 10, 11 and 12 show that, although the majority of packet inter-arrival times for each clients is limited in a specific range (20ms to 70ms), there is no particular pattern in inter-arrival times distribution and they vary randomly.

B. Client-to-Server Packet Length

In Figure 13 and Figure 14 we illustrate the distribution of the packet lengths from each client to server for TMNF in a six players game and a seven players game. The packet length we are considerring is IP packet in addition to 14 bytes ethernet header (excluding ethernet CRC).

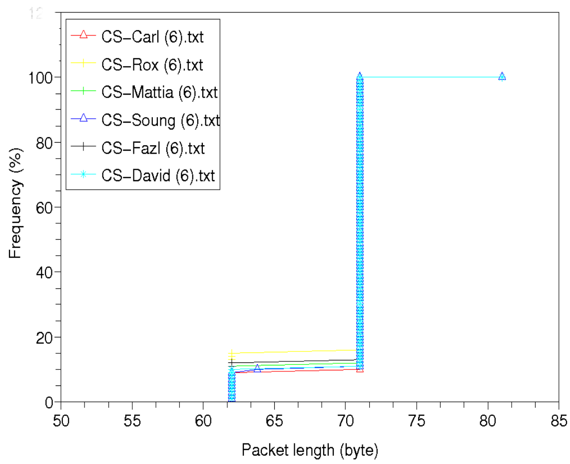

Figure 13. All players' packet length distribution in a six players game (Client-to-Server)

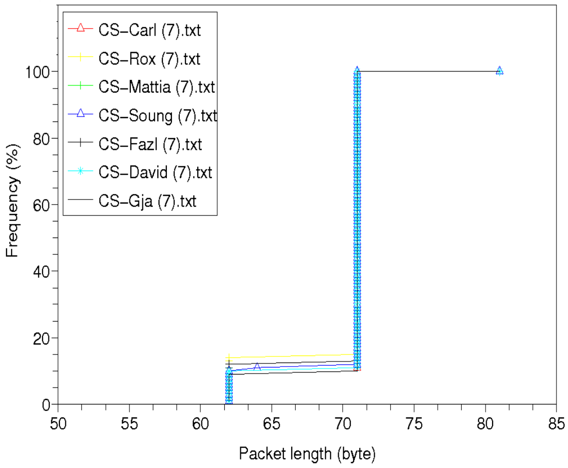

Figure 14. All players' packet length distribution in a seven players game (Client-to-Server)

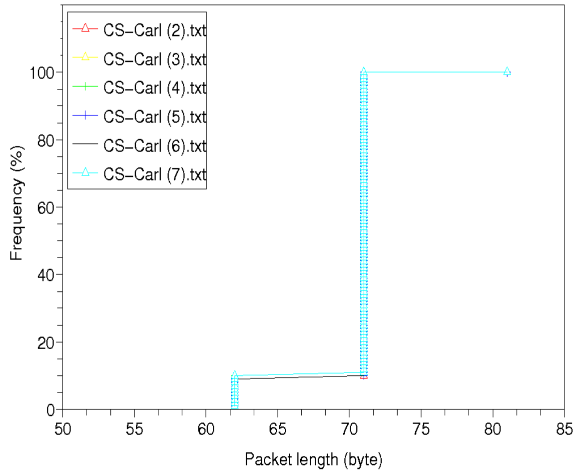

Figure 15. Carl's packet length distribution in two to seven trials (Client-to-Server)

As shown in Figure 13 and Figure 14 the Client-to-Server packet lengths variation is precisely the same for all clients in each trial regardless of the client configuration and number of players in the game. All Client-to-Server packet lengths have one of two values ; 62 and 71. This holds true for two through seven players. We can assume it also holds true for N players. Although this is an assumption, considering some facts based on previous experiment in FPS games, we can prove our assumption. We can expect that Client-to-Server messages will usually fall into a few different categories, with a few different parameters. The action that a player can perform and hence the information that needs to be transmitted back to server about those actions will usually be quite limited [2]. It will include information as how fast players are moving, position of the player on a track, the direction which the player driving toward and is player accelerating or is in brake-age position. No other data will be collected from client in TMNF game. Consequently, we would expect packets to be same for all clients in term of size.

For TMNF we make the following simplifying assumptions in showing how the larger number of players can be predicted from games played by smaller number of players:

- The nature of game play for individual player does not significantly change as the number of players changes. Each player spends same amount of time in engaging in a race regardless of the number of players.
- Players have similar behaviour. They engage in similar activities in much the same way as each other.

Based on these assumptions, we can say that packet lengths distribution for N number of players in TMNF games have one of two values; 62 and 71.

In Figure 15 and 16, we compare packet size distribution of each trial for two specific players.

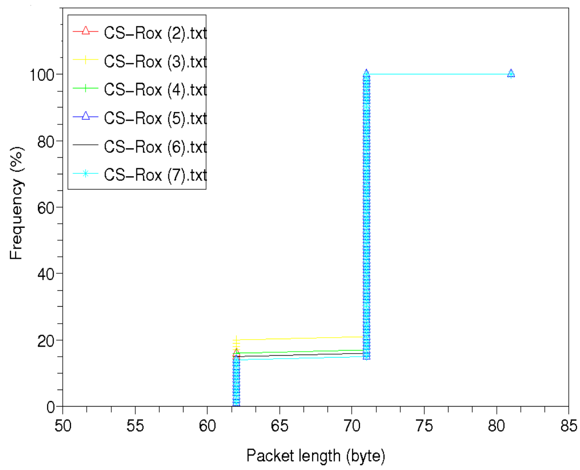

Figure 16. Roxanne's packet length distribution in two to seven trials (Client-to-Server)

As shown in Figure 15 and Figure 16, for a client involved in each game, the packet size distribution is identical in all trials and has no dependency to the number of players.

In Figures 17 and Figure 18 we plot the packet length for two specific clients in a seven players game. We are analysing the 300 packets (packets 2500-2800) to observe whether there is any particular pattern in packet length distribution for all small packets and large packets and their correlation with each other.

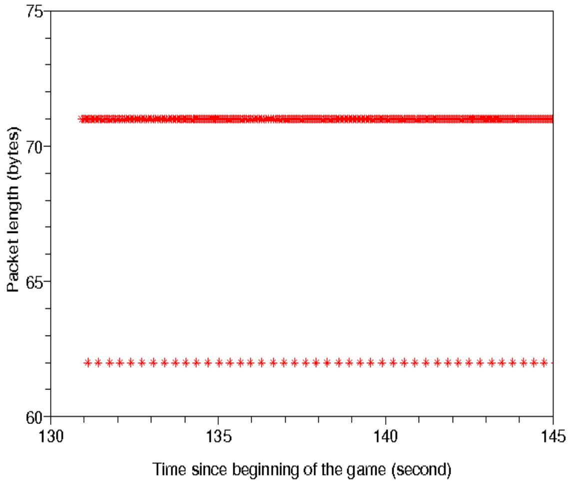

Figure 17. Roxanne's packet length distribution in a seven players game for packets between 2500 to 2800 (Client-to-Server)

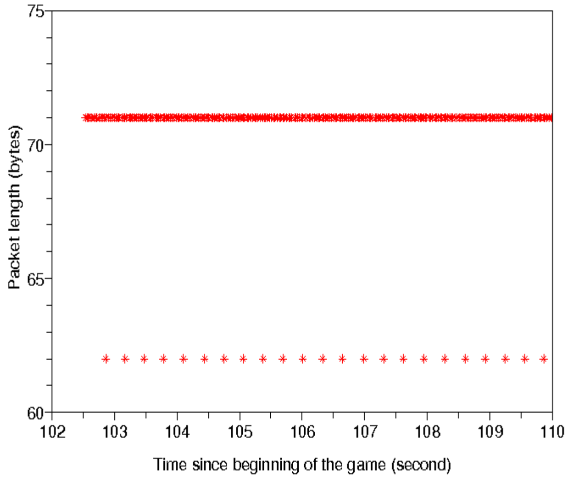

Figure 18. Carl's packet length distribution in a seven players game for packets between 2500 to 2800 (Client-to-Server)

Figure 19 and Figure 20 show the 62 and 71 bytes packet distribution in a closest view for one player (Roxanne). We observe that there is a specific pattern for packet length intervals. Packets with the length of 71 are sent to server more frequently than packet with the length of 62. The intervals between each 71 length packets are approximately 40-50 ms, however, the 62 length packet are sent in every 300-400 ms. Both are sent roughly in a regular intervals.

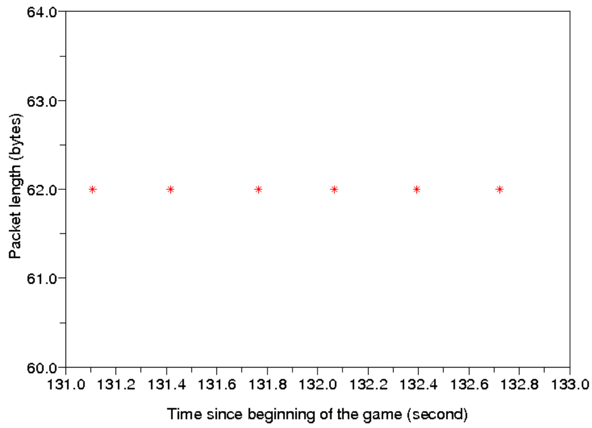

Figure 19. Roxanne's 62 bytes packet length distribution in a seven players game (Client-to-Server)

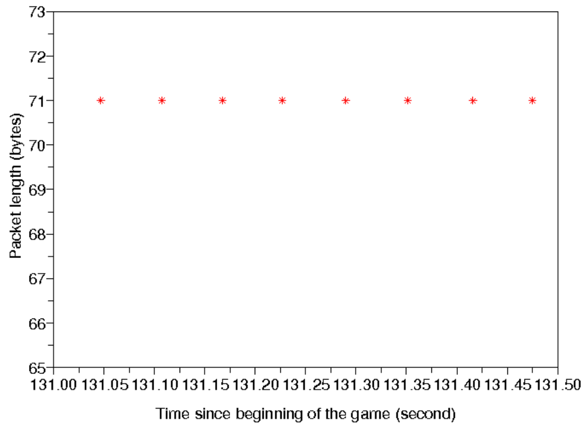

Figure 20. Roxanne's 71 bytes packet length distribution in a seven players game (Client-to-Server)

Figure 21, Figure 22, Figure 23 and Figure 24 demonstrate the 62 and 71 bytes packet inter-arrival times.

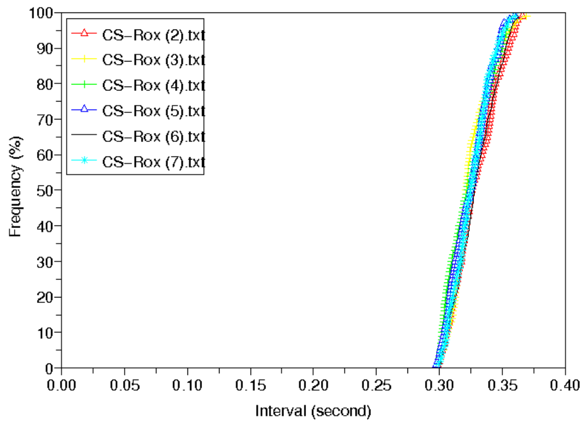

Figure 21. Roxanne's inter-arrival time for 62 bytes packets in two to seven players game (Client-to-Server)

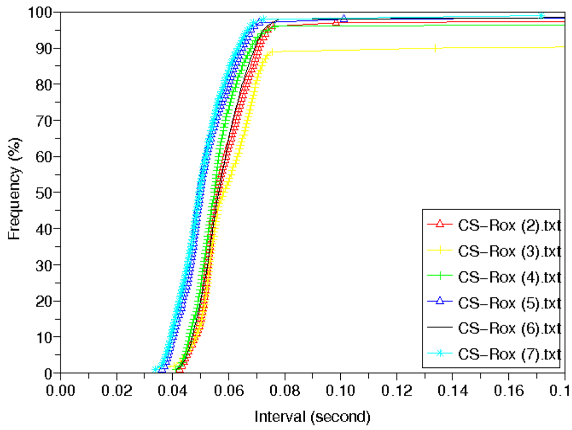

Figure 22. Roxanne's inter-arrival time for 71 bytes packets in two to seven players game (Client-to-Server)

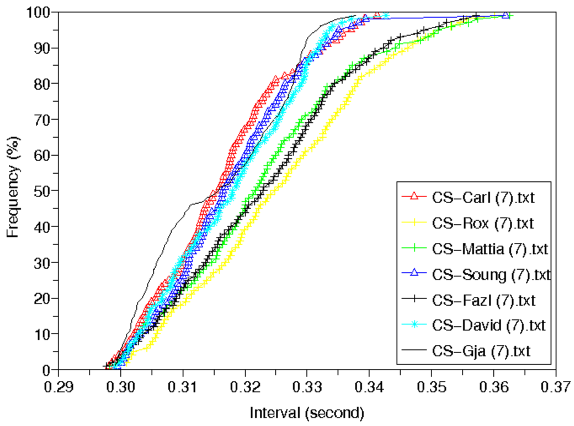

Figure 23. All players' inter-arrival time for 62 bytes packets (Client-to-Server)

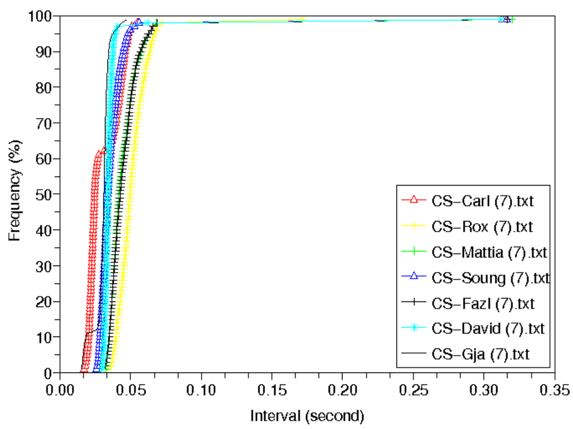

Figure 24. All players' inter-arrival time for 71 bytes packets (Client-to-Server)

We assume that bigger packets (71 bytes) contain the detailed information of clients which is sent to server to update the server. These packets make the server aware of the clients condition (such as speed and position and so forth) and need to be sent more frequently. The smaller packets (62 bytes) has general information. We can consider these packets as the keep alive packets.

We can summarize the Client-to-Server traffic procedure into the following points:

- The packet length distribution follow specific pattern and all clients have the fixed packet length regardless of number of player and client configuration.
- All clients have the same packet length distribution due to parameters which a packet contain.
- The inter-arrival times for one client is almost consistent in all trials regardless of number of players and it varies over a range of 20 ms to 70 ms.
- Different clients configuration exhibit different ranges of inter-arrival times. It is possibly based on Video Card, CPU and Network Card.
- Traffic behaviour consists between two similarly configured clients.

C. *Server-to-Client inter-arrival times*

Figures 25 and Figure 26 illustrate the statistics of the packet inter-arrival times from server to each client in a six and seven players game.

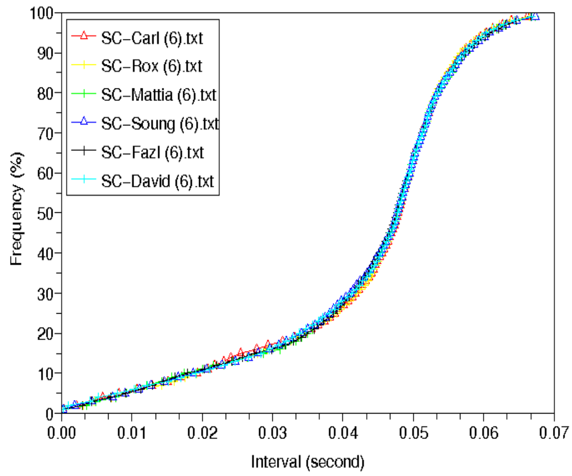

Figure 25. All players' inter-arrival time in a six players game (Server-to-Client)

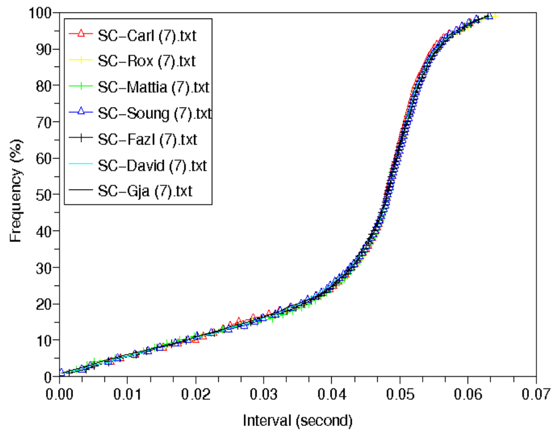

Figure 26. All players' inter-arrival time in a seven players game (Server-to-Client)

We can observe that the Server-to-Client packet inter-arrival times are very regular for all clients in each individual trial(Figure 25 and Figure 26). The overlap shows that packet inter-arrival times are pretty much identical and it is not varying depending on the number of players. Again, applying the fairness assumption we would expect the inter-arrival times between messages to be closed to constant. For the game to be fair to all players the server needs to treat each client similarly and propagate updates to all players frequently at the same rate. Consequently, we would expect the CDF of Server-to-Client inter-arrival times to be approximately overlapped [2].

In Figure 27 and Figure 28 we plot the inter-arrival times for two specific clients in a seven players game for packets 2500-2800. Although there is no particular pattern in packet inter-arrival times distribution, we observe that majority of packets are sent to clients with inter-arrival time ranges between 40 to 60 ms.

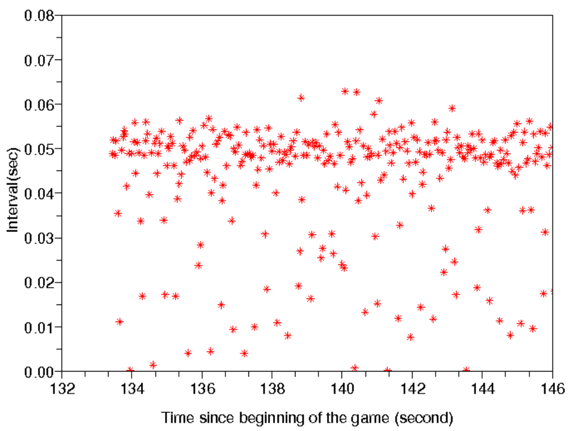

Figure 27. Packet inter-arrival time distribution for packets between 2500 to 2800 in a seven players game (Carl)

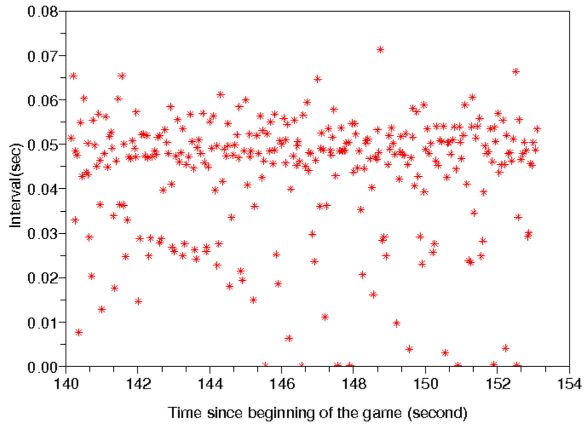

Figure 28. Packet inter-arrival time distribution for packets between 2500 to 2800 in a seven players game (Roxanne)

We observe that there are a small number of packets with inter-arrival time less than 40 ms and very short number of packets with more than 60 ms intervals. This is similar for all clients in a Server-to-Client mode which shows that there is no dependency between Server-to-Client inter-arrival times and number of players in each game as well as players configuration.

In Figures 29 and Figure 30, we observe the Server-to-Client packet inter-arrival times for two particular players in all seven trials. It shows that as the number of players increases the Server-to-Client inter-arrival time for each individual player is decreasing which means the probability for server to send updates within 60ms is getting higher. We can also observe that 30% of packets in each trial are sent in less than 40ms.

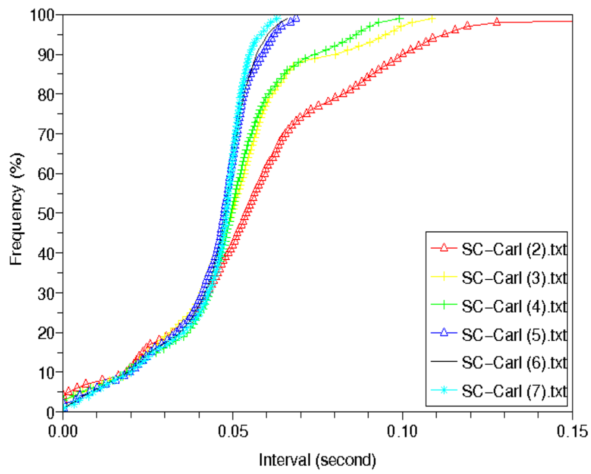

Figure 29. Carl's inter-arrival time in two to seven trials (Server-to-Client)

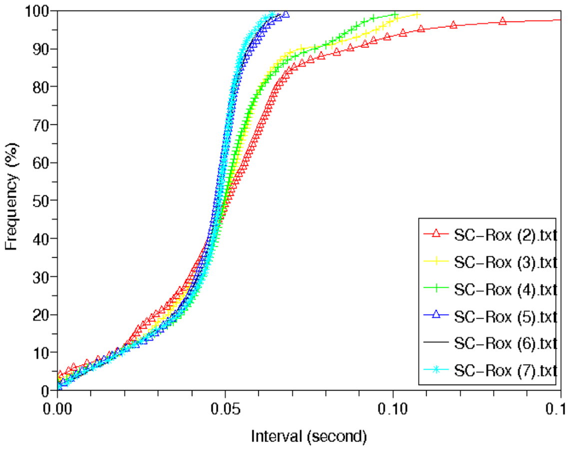

Figure 30. Roxanne's inter-arrival time in two to seven trials (Server-to-Client)

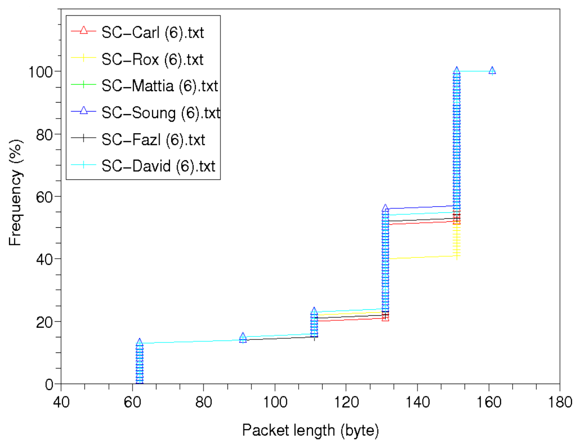

Figure 31. All players' packet length distribution in a six players game (Server-to-Client)

As the number of players increases the information which has to be sent to the clients by server is increasing. This information can contain players' time ranking. Players compete with each other in terms of speed and time and this is critical for each player to know the other players' information. Based on the fairness theory, we assume that in each game server tries to respond to all clients similarly. As a resulet with more number of players, server should respond to each individual client faster to make them aware of other players' recent information. Therefore, with larger number of players, the packet inter-arrival times for an individual client is shorter than the time when we have less number of players.

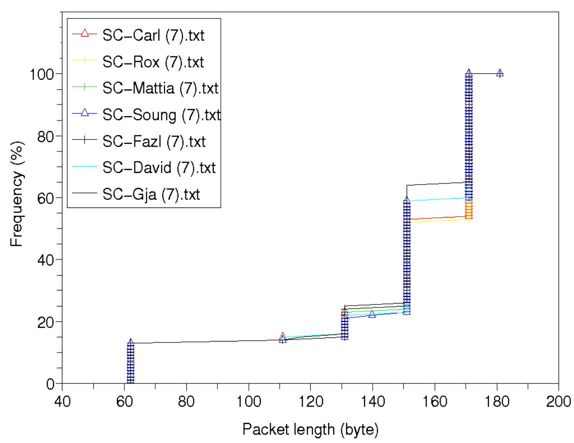

Figure 32. All players' packet length distribution in a seven players game (Server-to-Client)

D. Server-to-Client Packet Length

Figure 31 and 32 illustrate the distribution of the packet size from the server to each client for TMNF with six and seven players. By comparing Figure 31 and 32, we can see that the number of players impact on the distribution of packet length. Packet length values are more widely distributed for a bigger number of players. As the number of clients increases, when the number of clients is more than two, the packet size transmitted by server linearly rises about 20 bytes with an additional client. Server transmits the updated packets containing each client's information to all other players, so the number of sent packets by the server to each client is almost equals and as the players' informations are quite similar, the packet size for each clinet is similar.

A summary of packet length distribution for two to seven players game is illustrated in table 10.

	62	71	91	111	131	151	171
Two	X	X					
Three	X	X	X				
Four	X	X	X	X			
Five	X	X	X	X	X		
Six	X	X	X	X	X	X	
Seven	X	X	X	X	X	X	X

Table 10. Packet length distribution vs Number of player in game

It would be interesting to see the impact of N number of player on a trial. We assume that there may be N different variation of packet lengths but we do not have the information about the maximum number of players that TMNF game can support.

We know that the Maximum Transmission Unit (MTU) for Ethernet Frame is 1518 bytes which is the IP packet length (1500 bytes) in addition to MAC header (14 bytes) and CRC (4 bytes) [12][13]. In our experimet we considered ethernet packet length excluding CRC. With this knowledge we can estimate the maximum number of players which TMNF can support based on the packet length. The first packet length is 62 and next one is 71 and then it is increasing by 20 byte for each additional player. Below shows the maximum number of player estimation:

1514 – 71 = 1443

When the number of players is minimum two plyares the first 71 bytes will be definitley used and therfore, 1443 bytes will be left. For any additional players length of packet transmits by the server rises about 20 bytes.

1443 / 20 ~ 72+2 = 74

Hence the maximum number of players in one game can be approximately 74 players. We can assume for N number of players (N~74) packet length would be distributed in N (74) different values.

As shown in Figure 31 and Figure 32 and also Figure 33 and Figure 34 (which compare the packet lengths distribution of all trials for two specific players) in an active game the packet length are distributed mostly on last two values regardless of its value and the number of players and has the least amount of distribution in first few values.

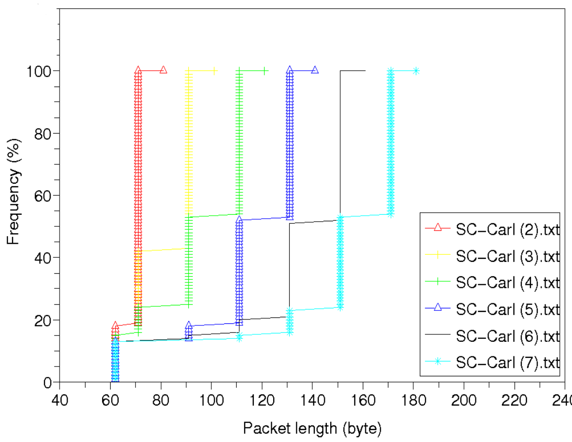

Figure 33. Carl's packet length distribution in all trials (Server-to-Client)

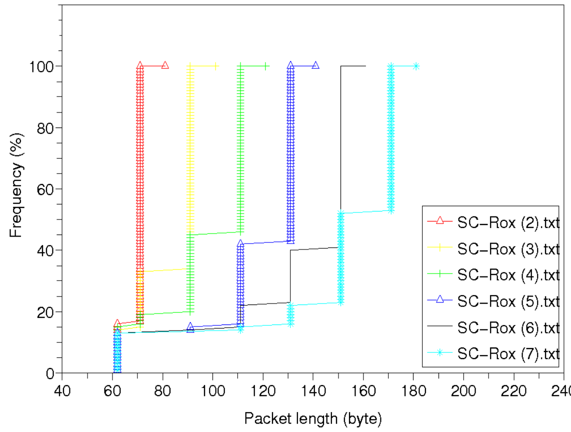

Figure 34. Roxanne's packet length distribution in all trials (Server-to-Client)

Prior research on FPS games has shown that propagating details about game-state where players have interacted (shot at each other) will require more data than where players have not interacted [2]. In TMNF during the active game, players compete for the best time and points. The time ranking of all players has to be seen all the times during the active game as well as the ghost view of the other players. As the number of clients increases these parameter will increase and eventually the parameters that should be sent to clients in a packet increases. As a result server sends updates to clients more frequently through a range of larger packets and the general information is sent less frequently in smaller packets.

In Figures 35, 36 and 37 we are illustrating the scatter plot of packet length distribution for three clients in a seven players game to discover whether there is any particular pattern in packet lengths distribution.

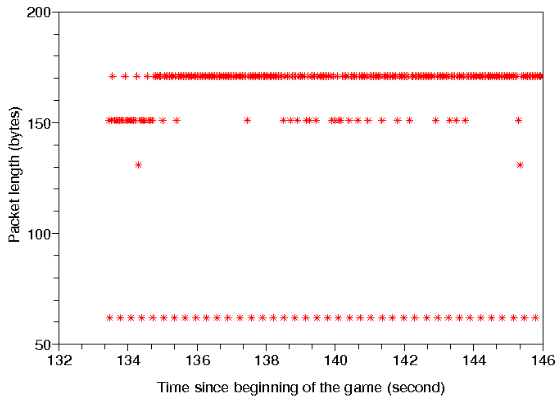

Figure 35. Carl's packet length distribution for packets between 2500 to 2800 in a seven players game (Server-to-Client)

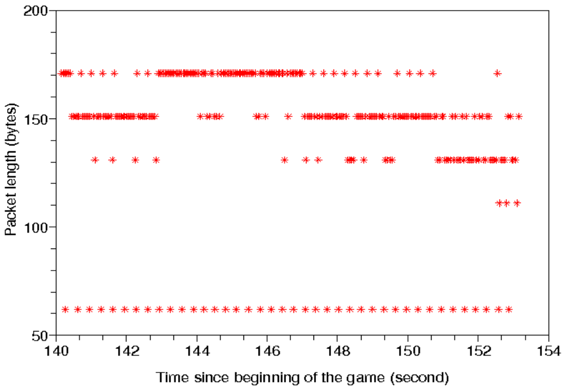

Figure 36. Roxanne's packet length distribution for packets between 2500 to 2800 in a seven players game (Server-to-Client)

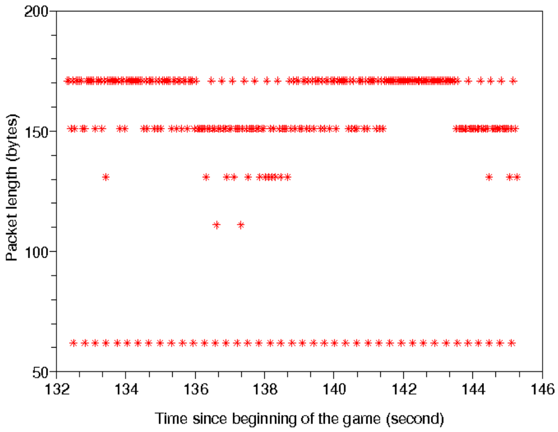

Figure 37. Gja's packet length distribution for packets between 2500 to 2800 in a seven players game (Server-to-Client)

Figure 38 demonstrate the scatter plot of 62 bytes packets for one client (Roxanne).

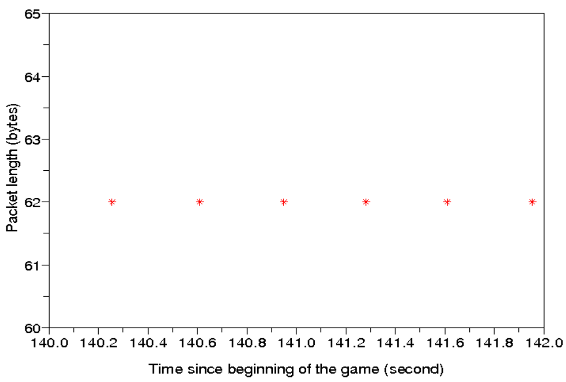

Figure 38. Roxanne's 62 bytes packet length distribution in a seven players game (Server-to-Client)

In Figure 38, we can discover that the 62 length packets are sent to a client in a particular sequence (every 400 ms). We assume these are the keep alive packets which are sent to clients in a regular intervals.

Figure 39 shows that there is no pattern for packets with the size of above 62.

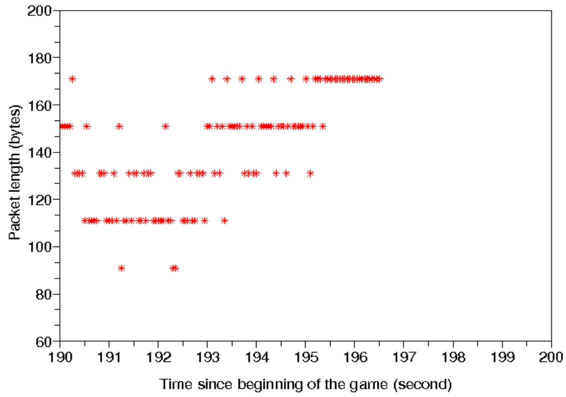

Figure 39. Roxanne's above 62 bytes packet length distribution in a seven players game (Server-to-Client)

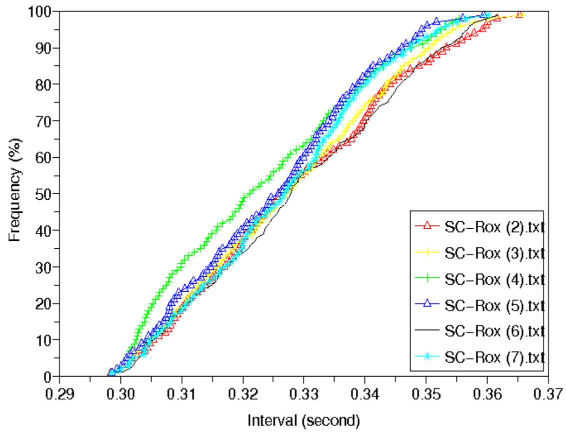

Figure 40. Roxanne's packet inter-arrival time in two to seven players games for 62 bytes packets (Server-to-Client)

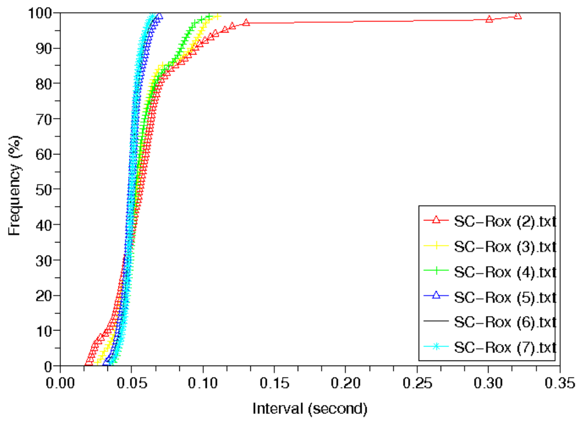

Figure 41. Roxanne's packet inter-arriaval time in two to seven players games for above 62 bytes packets (Server-to-Client)

Figure 42 illustrate the 62 bytes packet inter-arrival times in Server-to-Client mode in a seven players game.

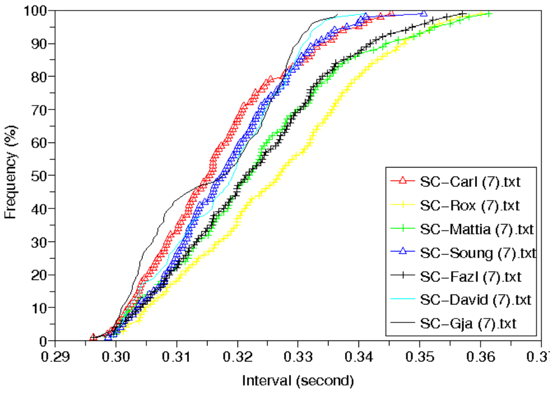

Figure 42. All players' packet inter-arrival time in two to seven players games for 62 bytes packet (Server-to-Client)

As we can see that the 62 length packets are sent to clients in every 300 to 400 ms.

Figure 43 illustrates the packet intervals for packet with 62 bytes size in Server-to-Client mode in a seven players game.

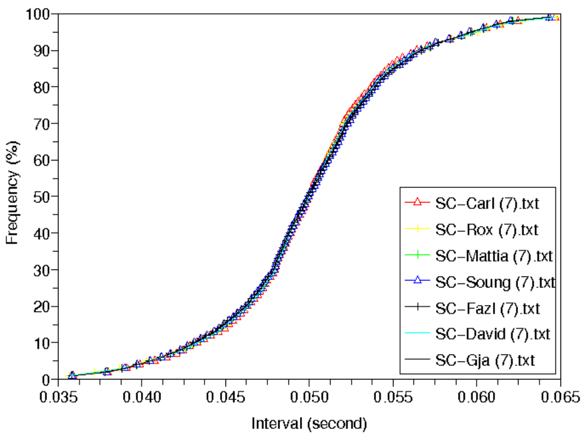

Figure 43. All players' packet inter-arrival time in two to seven players games for above 62 bytes packets (Server-to-Client)

In Figure 43 we can see that packets with the size above the 62 bytes are sent to client more frequently. (35 to 55 ms)

We can summarize the Server-to-Client traffic procedure into the following points:

- The packet inter-arrival time for each client varies based on the number of player in a game. It decreases when the number of players is increasing.
- The packet inter-arrival times for all clients is similar in particular game regardless of the number of player due to server fairness.
- All clients have the same packet length distribution based on the number of players.
- As the number of client increases when the number of clients is more than two, the packet size transmitted by server linearly rises about 20 bytes with an additional client.

VI. Conclusion

This paper was motivated by earlier work on the impact of interactive network games, in particular, First Person Shooter games. Interactive network games are popular and are promising source of revenue [5][15][16][17]. But these are not the only games which can impact the traffic network. There are some other online games in which the traffic characteristics associated with them are important and have to be considered as a influential source of network traffic.

In this paper, we analysed TrackMania Nations Forever. We characterized TM traffic in terms of packet inter-arrival times and packet rates from Server-to-Client and Client-to-Server based on real traffic data obtained on the bridge connected to server in CAIA Ethernet Switched LAN.

Based on the observed characteristics we explored that the Client-to-Server inter-arrivals differs slightly regarding to number of players but the packet size distribution is fixed and is the same for all clients regardless of the the number of player in each given trial and clients hardware configuration.

This paper also provided Server-to-Client game characteristic which showed server acts similar for all clients in terms of inter-arrival times in an individual trial. It is also illustrates that Server-to-Client packet length distribution depends on the number of player and can be restricted by huge number of player. It showed that by each additional game player the packet length is distributed in a wider range which is previous range plus 20 bytes.

Future work can be directed to the exploration of the network performance limitation of the TMNF game as well as its traffic prediction and modeling for N players.

Acknowledgement

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