Does Online Mobile Gaming Overcharge You for The Fun?

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***Abstract*—With the growing popularity of online mobile games, the network traffic generated by them accounts for an increasingly significant proportion of mobile Internet traffic; however, the game's traffic characteristics have not been well studied. To understand more about such traffic, we analyze the network traffic of 9 online mobile games from 3 genres, namely, first-person shooting games, role-playing games, and racing games. Our results show that small payloads, high packet rates, and an excessive number of pure TCP ACK packets incur high traffic overheads. The payloads may have redundant content, which can be properly compressed. Given the increasing number of pay-by-volume and throttling 3G/4G data plans, gamers may not realize they are being overcharged due to such overheads. We find that the game traffic can be largely compressed even with small window sizes, which indicate that the packet payload tend to be redundant and may be reduced without compromising users' gaming experience.**

I. Introduction

Online mobile games are computer games played on mobile devices, such as smartphones and tablets, via the Internet. They have been extremely popular, thanks to the rapid growth of mobile devices that are based primarily on Android and iOS. Recently, Nouch [1] reported that the number of mobile gamers surpassed the 500 million mark in 2012, and they spent more than US$9 billions. Meanwhile, Khalaf [2] found that Android and iOS users spend 32% of their time in playing mobile games, which rank first among all types of mobile applications.

Currently, it is difficult to determine if the network engines of online mobile games have been properly designed. Plus, it is not known *if such games overcharge players by sending out more traffic than necessary in order to overcome the uncertainty inherent in network transmissions*. Our objective is to determine whether current online mobile games have been carefully designed and handle network communications adequately. An inappropriate network design may cause 1) players to be overcharged, and 2) less than satisfactory game QoE due to too few updates (too conservative) or unnecessary congestion (too aggressive) and 3) congestion collapse due to non-TCP-friendly traffic.

In this paper, we study nine online mobile games from three popular genres, namely, first-person shooting (FPS) games, role-playing games (RPGs) and racing games (RCGs), on Apple's App Store (store.apple.com). Based on the results, we make the following observations:

1) The payload size of online mobile game traffic is generally rather small, which implies that the overheads of packet headers are relatively high [3].
2) Certain games, particularly those over UDP, have high packet rates, while some TCP-based games generate an excessive number of pure TCP ACK packets. Both types of games are associated with high packet header overheads.
3) Some games constantly send highly redundant packets that could be aggregated and compressed without compromising the gaming experience. Furthermore, none of the UDP-based games send TCP-friendly traffic, and that may cause congestion collapse.

TABLE I
THE 9 ONLINE MOBILE GAMES EVALUATED

Category	Abbv.	Full game title	Developer
First-Person Shooter (FPS)	ar	Archetype HD	Munkyfun
	bia2	Brothers In Arms 2 Free+	Gameloft
	sg	SHADOWGUN	Madfinger Games
Racing Game (RCG)	ah7	Asphalt 7: Heat	Gameloft
	rr2	Real Racing 2	Firemint
	sr	Sonic & SEGA All-Stars Racing	Sumo Digital
Role-Playing Game (RPG)	oc	Order & Chaos Online	Gameloft
	pl	Pocket Legends	Spacetime Studios
	wom	The World of Magic	Com2uS

II. Analysis

We selected 9 mobile games from 3 popular genres (FPS, RPG and RCG) for analysis. All the games (see Table I) can be played on Apple iPad 2 and freely downloaded from Apple's App Store (as of June 2013). Since they are online games, they can only be played whenever an Internet connection is available. Among the 9 games, the 3 RPGs send packets over TCP connections, while the rest (3 FPS games and 3 RCGs) use UDP as their transport protocol. This split is basically consistent with the following suggestions in an FAQ article on GameDev.net [4, 5]: "slow-paced games (e.g., RPGs) can use TCP, while fast-paced games (e.g., FPS games and RCGs) should use UDP."

We connected an Apple iPad 2 to a wireless AP, which is provided by a Wi-Fi capable PC with an Intel i7 920 CPU and Windows 7, and ran `tcpdump` on it to capture all the packets flowing through the computer. We asked five gamers to play each of the 9 games for more than 10 minutes, and recorded the game traffic flowing through the Wi-Fi AP. The time spent in non-game-play intervals (e.g., the login screen, the chat room, and the player matching phases) were excluded from the trace. In a total, we have collected 458 minutes of trace, which comprises 756 millions of packets and 95.8 GB of data.

TABLE II
PER-HOUR 3G DATA CHARGES FOR SELECTED GAMES

		Japan	US			UK	
		DoCoMo	AT&T	T-Mobile	Verizon	T-Mobile	Vodafone
FPS	ar	$0.78	$0.89	**$2.13**	$1.55	**$2.37**	$1.69
	bia2	**$5.06**	**$5.78**	**$13.87**	**$10.11**	**$15.44**	**$11.03**
	sg	**$3.22**	**$3.68**	**$8.83**	**$6.44**	**$9.83**	**$7.03**
RCG	ah7	$0.73	$0.83	**$2.00**	$1.46	**$2.22**	$1.59
	rr2	$0.39	$0.44	$1.06	$0.77	$1.18	$0.85
	sr	$0.61	$0.70	$1.67	$1.22	$1.86	$1.33
RPG	oc	$0.55	$0.63	$1.51	$1.10	$1.69	$1.20
	pl	$0.93	$1.07	**$2.56**	$1.87	**$2.85**	**$2.04**
	wom	$0.19	$0.21	$0.52	$0.38	$0.57	$0.41

† Currency unit is all unified to US dollars.
‡ Hourly rate higher than $2.0 is highlighted in boldface.

Under the pay-by-volume and throttling data plans now offered by major cellular Internet access providers, the high bitrates and high packet rates (and therefore the high traffic overhead) incur huge costs that will be passed on to gamers without their knowledge. Table II summarizes the cost per hour of the 9 games based on the measured bitrates of the games. We observe that certain games, such as `bia2` and `sg`, cost players higher than US$5 per hour under certain data plans; and under the T-Mobile data plan in the UK, 8 out of the 9 games cost players more than US$1 per hour. These high charges make us ponder: *Are the high packet rates and bitrates for gaming really necessary?* We will address this issue in the next section.

We find that an online mobile game, if not well tuned, tends to send more data than necessary in order to handle potential network impairments. In this case, the game's payloads would contain a high degree of *redundancy* if the payload is not encrypted or obfuscated before transmission. According to this rationale, we extract and concatenate the payload stream of each game, and use `gzip` with different-sized compression windows to compress the payloads in order to compute the *compressibility* of the stream. Figure 1 shows the compression rates (derived by dividing the size of the compressed payload by the payload's original size) for both client and server traffic with various window sizes. A lower compression rate indicates a higher compressibility and thus a higher degree of redundancy. A closer look reveals that, generally, the games with higher packet rates tend to have a higher degree of redundancy. For example, `bia2` has a high packet rate and a low compression rate, while the three RCGs and `wom` have low packet rates and high compression rates (i.e., lower redundancy). To illustrate the relationship more clearly, we plot the compression rates versus the packet rates and bitrates of the games in Figure 2. The graph shows that the payload compressibility is generally proportional to the packet rates and bitrates of the game traffic. This evidences that a game with a higher packet rate and bitrate may not be due to a more complicated game scene; the reason might simply be that *more redundancy exist in its traffic*.

III. CONCLUSION

The gaming experience is visible to players, but the network bandwidth charges are relatively "invisible" to them. Therefore, online mobile game developers tend to over use network bandwidth to ensure the network quality of online gaming regardless the overcharges for 3G/4G data plans paid by the gamers. Moreover, overuse of the bandwidth may cause

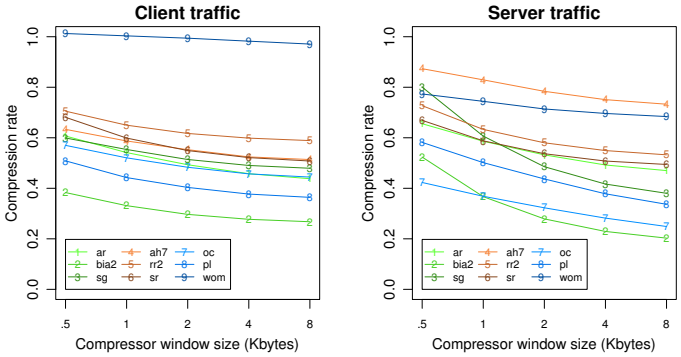

Fig. 1. The compression rate of payload streams with various compressor window sizes

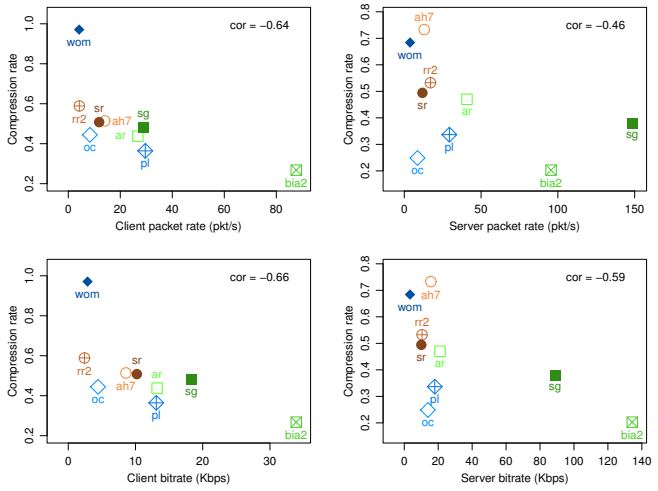

Fig. 2. The packet rates / bitrates of games vs. the payload stream compression rates (8 KB window size)

congestion collapse if the traffic is not TCP-friendly. In this work, we have identified some evidences that certain online mobile games tend to send excessive and redundant traffic during game play, which will overcharge the players if they are using mobile networks (e.g., 3G/4G) to connect to the Internet. It is hoped that this work will stimulate more research on mobile game traffic and that the future mobile game play will be more economic to the users, ISP, and the Internet and more fun.

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