The Anatomy of a Large Mobile Massively Multiplayer Online Game

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ABSTRACT

We describe a large-scale and long-term measurement study of a popular mobile Massively Multiplayer Online Role Playing Game (MMORPG), called Parallel Kingdom, which has over 600,000 unique users distributed across more than 100 countries. Our study covers important aspects of the game including (i) characteristics of its population, (ii) players' game usage behavior, and (iii) correlation between players' interest and the money spent by them in the game. Our measurement study spans almost the entire life of the game staring from its inception on October 31, 2008 to November 10, 2011 (1104 days in total). To perform this study, we instrumented the game's client software (iOS and Android) to interact with our measurement server. The rich dataset gathered allowed us to analyze various characteristics of this highly popular mobile MMORPG.

Categories and Subject Descriptors

C.2.0 [**Computer-Communication Networks**]: General; K.8.0 [**Personal Computing**]: Games

General Terms

Measurement

Keywords

Mobile games, MMORPG, Parallel Kingdom, Mobile applications, Characterization

1. INTRODUCTION

With the rapid growth of smartphones and Internet enabled handheld devices, an increasing number of third-party applications are being developed for them and their usage is increasing rapidly [3]. Games constitute a significant portion of these applications in the terms of popularity. For instance, recent research on mobile application usage showed that users spent more time on gaming applications compared to any other category [8].

Motivated by these observations, we study one specific mobile game called Parallel Kingdom [11], available on both Android and iPhone platforms, with over 600,000 unique users distributed across more than 100 countries. Parallel Kingdom (PK) is a multiplayer role playing and strategy game which places a player's character in a virtual game world that is superimposed on top of the real world. More specifically, the typical location of the a player's character is in the actual physical location of the mobile device, as reported by its GPS receiver or its wireless (WiFi or cellular-based) positioning system. In short, it is a real location-based, real-time, mobile Massively Multiplayer Online Role Playing Game (MMORPG). Each player can interact with other players and monsters, find treasures and trade items, often in their physical vicinity. The game client software has been written for Apple's iOS platform as well as Google's Android platform (such as the G1, DROID, and Nexus One phones).

To the best of our knowledge, this is the first large scale and long-term measurement study of a mobile based MMORPG game with a large and diverse user base. The data analyzed in this paper starts from the first day when the game was released on October 31, 2008 until November 10, 2011 (1104 days in total). To perform these measurements, we developed a measurement library (for Android and iOS platforms) that was integrated and deployed with the game. We worked closely with the game developers to instrument some of the game code while ensuring that the overhead was minimal in terms of code instrumentation and additional resource usage (CPU, memory and network). Pushing each update into the game took time as we had to coordinate with the update schedule of the game on when the updates were actually pushed into Apple App Store/ Android Market. We also had to test each update thoroughly before deployment to ensure that the game developers were comfortable with our code running within the game.

This paper covers important aspects of the game and its constituents including: (i) characteristics of the player population, (ii) players' application usage behavior, and (iii) impact of player interest on game revenues. Some of the key observations from our study of PK are as follows:

1. The players of this MMORPG game played multiple short and closely spaced sessions. Almost half of the new user sessions were started within 5 minutes since the end of the previous session. Caching data across consecutive sessions can provide savings in network usage due to such behavior.
2. The device model and platform impacts the application usage. For example, amongst the Android devices, phones with slide-out keyboards had more user interactions (involving both text and touch based interactions).
3. We find that the generation of game revenues is highly correlated with the "active period" (the number of days that a player says in the game) and interactivity. For example, the daily revenues from old players was more than 2.5 times the revenues generated from newer players.

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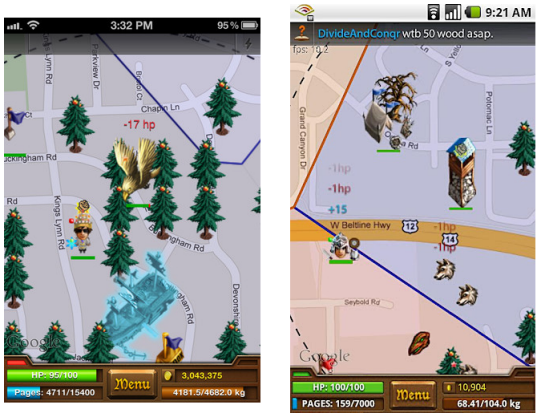

Figure 1: Screen-shots of the Parallel Kingdom game for the iOS (left) and Android (right) platforms.

2. THE PARALLEL KINGDOM GAME

In this section, we first present a brief description of the gameplay in Parallel Kingdom (PK) [11] and then briefly discuss the game data analyzed in this paper.

2.1 Game Overview

As mentioned in Section 1, PK is a Massively Multiplayer Online Role Playing Game (MMORPG) that places the character (user in the virtual gaming world) on a virtual map according to their real world location. The game uses the device's GPS/WiFi capabilities of the mobile device for tracking the real world user location. In the game, each player picks up, trades or upgrades various items, fights monsters and interacts with other players on the map or through chats and messages. Players can spend real money to buy the virtual currency in the game (Food). The game (starting with Age 1) was officially launched on October 31, 2008 and has since then gained a lot of popularity. The game is a free third party application and is available for the iOS (Apple) and Android platforms. The game uses a centralized server architecture and its servers are located in Madison, Wisconsin USA.

Over time, the game has added numerous features and pushed out updates through a few major releases of new "Ages" and several minor updates. Since the First Age, there have been three major releases (Age 2, Age 3 and Age 4). Recently, the game crossed over a million unique players worldwide, and was ranked amongst one of the most popular mobile based MMORPGs [14]. Figure 1 shows screen shots of the game for the Android and iOS platforms.

2.2 Data Collection

The data collection methodology involves a client-side library developed by us which has been integrated with the game and a measurement server that collects data from the clients that play the game. The goal of the data collection process is to capture different metrics that convey the end-users' experience and interactions when they play the game.

Table 1 describes the different metrics captured by the our system. We initially started by just capturing session length information but over time we have added new capabilities to our system. We ensured that the overhead of our library on the client's device is minimal. Table 2 shows a summary of the game related statistics used for analysis in this paper.

Platforms covered	Android, iOS
Total Unique Players	>600,000
Total Sessions	47,469,725
No. of unique IP addresses	2,676,718
No. of countries	118
Distinct device models	780
No. of ISPs observed	>1,000

Table 2: Summary of Parallel Kingdom game statistics for data collected until November 10, 2011.

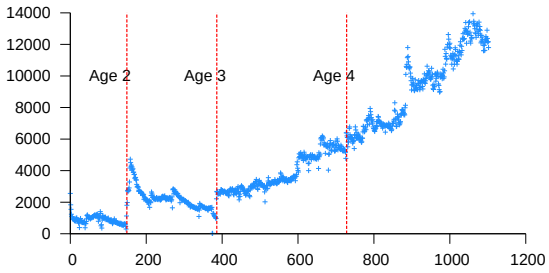

Figure 2: The daily active users for the game starting from October 31, 2008 to November 10, 2011.

3. ANALYZING USER POPULATION AND BEHAVIOR

In this section, we discuss trends related to the PK's user population (daily active users and its usage characteristics in terms of session lengths and long term variations in playing durations.

What are the long term trends in daily active usage?

Figure 2 shows the number of daily active users since the start of the game in October 2008 till November 10, 2011. As shown in the figure, the number is either steadily increasing or decreasing for most of the time except for a few days when there are sudden spikes. The sudden spike in days 149, 387, 729 correspond to the major releases of the game (called Age 2, Age 3 and Age 4 respectively). Other big spikes in the number of daily active users occurred around June 28 2010 (day 603) when the game was released on the iPad and iOS 4 platform and on day 886 due to a major update to the game. Thus, new releases and updates positively impact the number of daily active users of the game. Also, starting from Age 3, there is more consistent increase in the game's daily active usage. Some important factors causing this behavior are the improvements in gameplay, increase in the game's popularity in its category and increase in developers' efforts to advertise the game to attract new players.

What properties are exhibited by user sessions?

Figure 3 (left) shows the duration of the session lengths in the game. We find that a large fraction of sessions are short lived. For example, 55% sessions are less than 10 minutes long. Further, only 9% of sessions are more than 60 mins. Figure 3 (right) shows the CDF of the number of daily sessions per user. Around 26% of users play a single session per day while 27% of users play more than 10 sessions. Figure 4 shows the distribution of the time gaps between consecutive user game sessions per day (the difference between start time of a session and end time of the previous session for the same

Metric	Description
Session length	The duration for which a user plays the game before disconnecting from the server.
Platform	Device specific information (e.g., model, OS related information).
Location	The player's location during a session (e.g., country and state).
Actions	Game related activities such as gathering resources, fighting other players and monsters, trading items, sending messages and chats to other players etc.
Food consumption	Food serves as the virtual currency in the game. Players can purchase Food with real money or through different in-game activities (e.g., selling items).

Table 1: The description of different game related metrics used for our analysis.

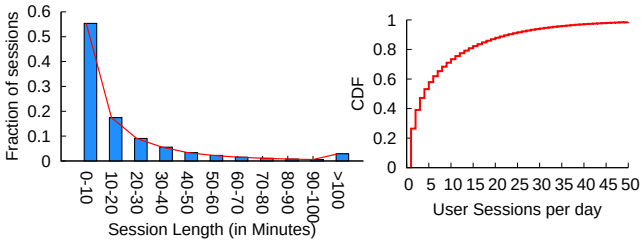

Figure 3: (left) Distribution of session lengths, (right) CDF of the number of sessions played by a user per day (Oct 20 - Nov 10 2011).

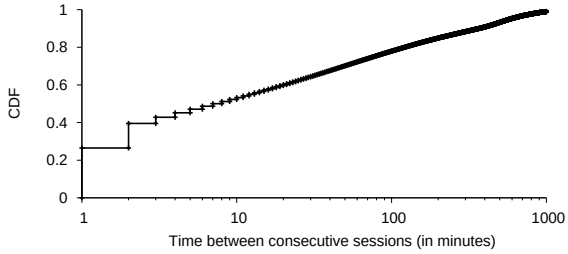

Figure 4: Distribution of time periods between consecutive user sessions per day (Oct 20 - Nov 10 2011). The X-axis is shown in logscale.

user). It is interesting to note that 47% of new user sessions tend to be within 5 minutes of the end of the previous session.

Such short and closely spaced multiple sessions are partly characteristic of application usage on smartphones as has been observed before [7]. It is normal user behavior to get distracted and close the game to use another application such as an email client or stop the game to attend a phone call and then return back to the game. Also such behavior is partly game specific as observed in desktop based MMORPGs [5]. For example, it is common for PK users to login, play for a short while (e.g., feed the dogs) and logoff. Application developers can implement optimizations based on such user behavior. For example, instead of discarding a player's state (maps, inventory information etc.) from the phone at the end of a session, it is more efficient to save and reuse it during the next session because almost half of the consecutive user sessions occur within 5 minutes of the previous session.

How does the players' game sessions and total playtime vary over time?

Figure 5 (top) shows daily average time players spent on the game per day. For the first 150 days, players spent an average of 20 minutes per day. On day 149 (March 28, 2009), when Age 2 of the game was released, we observe a sudden increase in playing time to around 80 minutes per day. This was because of a significant update

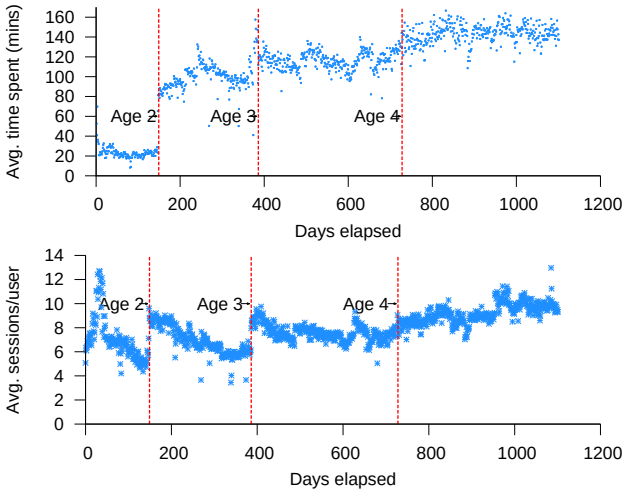

Figure 5: (top) Average time spent daily by players on the game, (bottom) Average number of daily sessions per player.

in the game's features in Age 2. We see similar increases in average play times when Age 3 and Age 4 were released on November 17, 2009 (day 380) and October 31st, 2010 (day 728) respectively. Thus, as the game becomes more popular and usable (more features and bug fixes, better UI and gameplay), it increases the average time users spend playing the game.

Figure 5 (bottom) shows the average number of daily sessions per user over a period of 1104 days. It can be seen that users usually play more sessions with the release of new upgrades to the game and play fewer sessions when time passes on after the update. For example, PK's players played an average of 9 sessions after the release of Age 2 and this decreased to 6 sessions towards the end of Age 2. Another example is day 950 (10th June, 2011) when the average sessions per player increase from around 8 to 10 due to additions of new skill levels to the game. It is interesting to note that variations in average user sessions and playtimes have decreased over time (Age 2 vs Age 4). One of the important reasons for this behavior is the increase in frequency of game updates during the recent months. These updates provide new features and activities to maintain the game's appeal and keep players interested in the game.

4. PLATFORM USAGE CHARACTERISTICS

In this section, we discuss trends for PK such as its adoption across different platforms over time and the impact of the form factor of different devices on the players' game usage behavior.

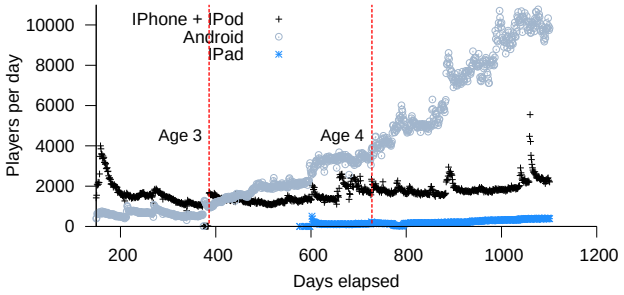

Figure 6: Platforms used by players starting from Age 2 (platform info was not recorded for Age 1).

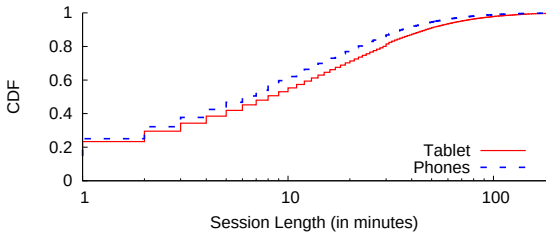

Figure 7: Session lengths for the tablet (e.g., iPad) and phone (e.g., iPhone) platforms. The X-axis is shown in logscale.

What are the long term trends in the platform usage for PK?

Figure 6 shows the platforms used by the players on each day starting from March 28, 2009 (the beginning of Age 2) to Nov 10 2011, for a total of 954 days. Starting from Age 2, we see a spike in the number of iPhone players and they were consistently more than Android players (almost double) throughout this age. However, starting from Age 3, we find an increasing trend in Android players, who eventually exceed the iPhone players. We talked to the developers about this behavior and they told us that one of the main reasons was more targeted advertising and promotion of the game on the Android platform. Another reason for this trend was due to the game being ranked the best amongst Android applications in its category in December 2009.

Besides the releases for new Ages, releases for more platforms also positively impacted the game's daily active usage. On June 28 2010 (day 603), the game was released for iOS 4 and iPad leading to more player attention towards the game. Interestingly, the release of iOS4 and iPad versions also caused a spike in the game's usage amongst the Android players.

How does usability (display screen size, availability of slide out keyboards) affect playing time and user interaction?

The game UI for both Android and iPhone platforms are very similar to each other (Figure 1). We analyzed how "usability" of different platforms may affect the application usage. In particular, we analyzed the effect of (i) size of the display screen and (ii) availability of slide out QWERTY keyboards. We studied the impact of using tablets (e.g., iPad) vs smartphones (e.g., iPhone, Droid) on the users' session lengths. Figure 7 shows that session lengths are higher for tablets (a median of 10 minutes for tablets vs 7 minutes for smartphones) which typically have larger screen sizes and higher screen resolution compared to smartphones. This shows that users' attention span towards an application can be sensitive to the form factor of the device that they use. For many actions in PK, such

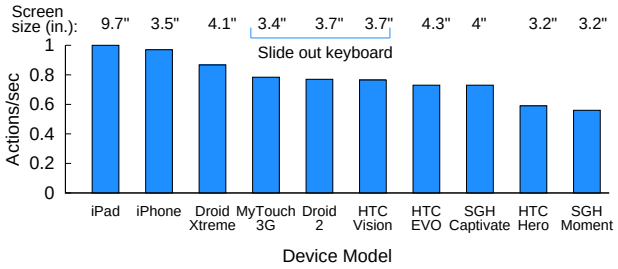

Figure 8: Normalized number of actions per unit time for tablet (iPad), and different phone models. Usability in terms of screen size and slide out keyboards are shown (May 2011).

as exploring places on the map, moving the character and attacking monsters in the vicinity of the player, the user has to perform touch related activities. In these cases, a larger touchscreen allows the user to perform these activities better and improves his/her experience. For example, players can visualize a larger area on the map on tablets compared to smartphones and interact with more objects simultaneously on the map.

We also analyzed the effect on "user interaction" by measuring the average number of user actions/sec on popular device models over a period of one week. We chose devices having diverse form factors (screen sizes and slide out keyboards) from amongst the top 20 devices at the time. Figure 8 shows some interesting results. We find that tablet (iPad) users perform the highest number of actions/sec, owing to a larger screen size (9.7" for iPad). We also find that iPhone comes a close second (despite a screen size of 3.5"), possibly indicating the superior quality of iOS user interface. Amongst Android device models, we find an interesting trend — devices with smaller screen sizes (e.g., 3.2" for Samsung Moment) experienced less user interactions compared to those with a larger screen size (e.g., 4.3" for HTC EVO). However, devices with slide out keyboards (e.g., Droid 2) exhibit higher user interaction compared to some of the devices with larger screen size (e.g., EVO), despite small screen sizes (3.4" – 3.7"). These Android devices have similar capabilities in terms of CPU and memory. This shows that a platform's ease of use can impact application usage.

5. IMPACT OF USER INTEREST ON GAME REVENUES

In Table 1, we discussed that "Food" serves as the virtual currency in the game. Food can be used to buy items from other users or merchants, upgrade buildings, train hunting dogs etc. New users are given some initial Food to allow encourage them to explore the game. The users can obtain more Food by selling items, inviting friends to start playing the game and by purchasing it using real money. Food transactions, therefore, are the main source of revenue for the developers of Parallel Kingdom. In this section, we analyze how user interest in the game translates into food consumption. We measure user interest in terms of: (i) the number of actions performed by the user in the game (Table 1), (ii) session lengths and (iii) 'user retention' which represents the number of days during which the players are active in the game.

How interactive are the different players in the game? How is user interactivity correlated with game revenues?

In the game, players perform various kinds of activities such as attacking monsters and buildings, buying/selling items and learning new skills. We recorded these different types of actions performed

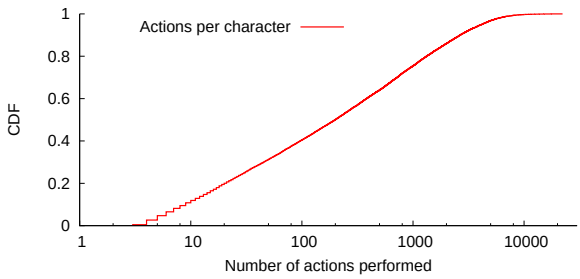

Figure 9: The CDF of the number of actions performed by different players in the game during a week in November 2011. The X-axis is shown in logscale.

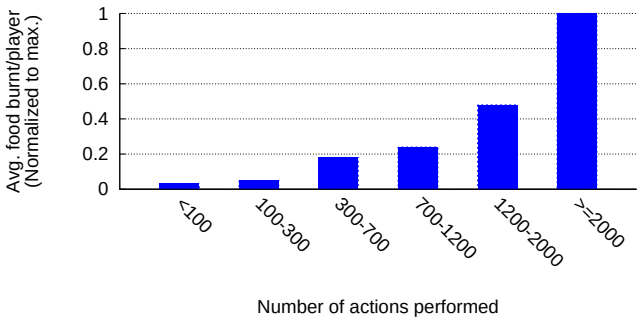

Figure 10: The average food consumed per player (normalized to maximum) depending on their interactivity.

by the players during each game session. Figure 9 shows the CDF of the total number of actions performed by players who played the game during a week in Nov 2011. This graph shows a skewed behavior with a few players who are highly active in the game. For example, around 40% of the players who played the game during this week performed less than 100 actions while 6% of the players performed more than 4000 actions during the same period.

Interactivity is a important indicator of player interest in the game. It is in the interest of the game developers if the players are more interactive as the more interactive players tend to spend more money in the game as shown in Figure 10. This is because players can spend money to buy resources to expedite their progress in the game (e.g., to learn new skills, buy virtual goods etc.). In this figure, the players are grouped based on the number of actions performed by them during a week in Nov 2011 and the average amount food consumed (normalized to maximum) by the players in each bin during this period is shown. The most interactive players (the rightmost bin) spent around 25 times the food compared to the least interactive players (the leftmost bin). Thus, developers should continuously monitor players to measure the changes in their interactivity over time. To increase the interest of the "passive" players (characterized by decreasing interactivity) in the game, the developers should provide incentives to them. For example, they can provide some free virtual currency to these passive players so that they can perform more activities in the game. As these players' interest in the game increases, they will be willing to spend more money in the game.

Do longer session lengths imply more food consumption?

We now discuss the impact of player interest in terms of sessions durations and the amount of food burnt by the players. Figure 11 shows the CDF of session lengths for sessions with non-zero Food

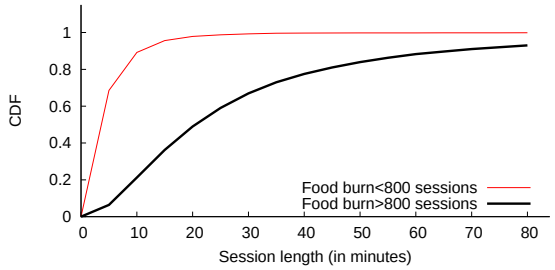

Figure 11: The CDF of the session lengths based on the food consumption behavior.

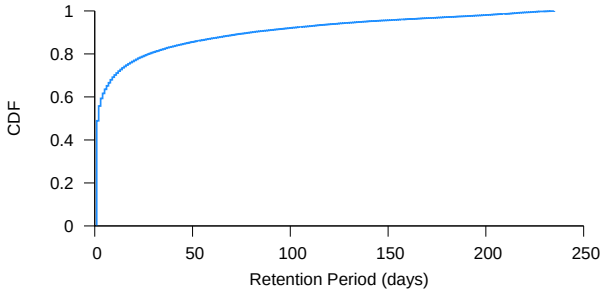

Figure 12: CDF of the player retention periods during Age 2 of the game.

spending. We divided sessions into two roughly equal sized groups: session that burned more than 800 Food and those that burned less than 800. We find that sessions during with more Food spent tend to be longer than those during which less Food is spent. Thus, it is in the interest of the developers to keep the users involved in the game so that the users are enticed to use more virtual currency in the game.

How long do users stay involved in the game, i.e., what is the distribution of retention period of the users?

To study how many days users continue to play the game, we compute the number of users joining and leaving the game during Age 2 (March 27, 2009 to November 16, 2009, a total of 235 days). If a user first played the game on day $d1$, and if we do not find the player playing the game after day $d2$, we define $d2 - d1$ as the "retention period" of the player, *i.e.*, the total number of days the player stays in the game. In Age 2, a total of 55,637 users downloaded the game and played it at least once. However, we found that most users only play for a short number of days before quitting. Figure 12 shows the CDF of retention period. We observe that around 48% of users stay in the game for only for a single day *i.e.*, these users download the game, play for a day and never play again. Many popular sites like AppBrain [2] use downloads to indicate an application's popularity in an app store. However, we observe that downloads alone might not accurately reflect the popularity or user base of an application. For example, only 11,125 users (20% of the downloads) were retained for more than one month during Age 2 in PK. Thus, it is neccessary to keep attracting new players to maintain and increase the daily active usage of these games.

How does the active user period affect application revenues?

For this analysis, we analyzed all Food transactions in the game for a total of 183 days, from November 2, 2009 to May 3, 2010.

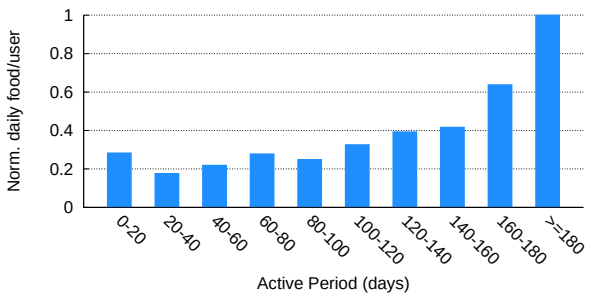

Figure 13: (left) CDF of the player retention periods. (right) Active period versus normalized average Food expenditure per player per day.

We define an "active period" of a user as the total number of days during which a player plays the game. For example, if a player plays on day 1 and again on day 5, the active period for the player is two days. We group active period into bins of 20 days. Figure 13 shows the relationship between active period and normalized daily average food spent per user. We observe an increasing trend of "food spent per day" as users play more days in the game *i.e.*, the longer a user stays in the game, the larger is the amount of Food (and therefore, money) spent *per day*. This is especially evident amongst users who played the game for more than 180 days. These users spend 2.5× more than users who have played less than 150 days. For users with active period less than 20 days, the average Food spent is slightly more than some users with longer active periods. This is because new users are given some initial Food, and many users with short active periods use up their initial allotment of Food and never buy more. The above data shows that it is crucial to retain old players as they generate more daily revenue per player for the game.

6. RELATED WORK

Chambers et al [6, 5] analyzed some popular online game workloads by concentrating on FPS genre of games (Counter-Strike) meant for a different set of users (mainly desktop and laptop users). In [9], the focus is on the analysis of third party applications for OSNs (Online Social networks), one of which is a game. This study concentrates on the underlying social networking aspects of the third party applications. In [10] the authors further studied how Facebook forward/process the requests/response from third-party OSN applications, and its impact on the overall delay performance perceived by end-users. Our study is focused on the a popular MMORPG game available for smartphones and handheld platforms (Apple's iOS [4] and the Google's Android Platform [1]).

Prior research [12, 16, 15] has studied popular MMORPGs such as World of Warcraft and EVE Online to analyze and predict the trends in player populations, distributions and game usage. [16] does a long term study of the game EVE Online but it only focuses on the issues of general MMORPG game usage predictability and player population predictability. The studies [12, 15] based on the World of Warcraft game are limited to a single realm and do not provide a snapshot of the entire game and about the different players spread across the globe. In [13], Pittman et al. continue their work on a larger dataset using two MMORPGs to create a model for analysis and simulation of the virtual world and player populations. In our study, we analyze properties such as player interactivity and factors impacting game revenues in a popular MMORPG meant for mobile devices.

7. CONCLUSION

We presented a study of Parallel Kingdom, a popular mobile MMORPG by collecting long term data from its player population. We used this data to understand the characteristics of such games and how different factors affect the usage of this game. We observed that the players played multiple consecutive sessions and were also influenced by the device's form factor in terms of their attention span and interactions with the game. Further, the players' interest in the game (determined by sessions lengths, active periods and interactivity) can be closely correlated to their virtual currency consumption within the game which has a direct impact on the game revenues for the developers.

8. ACKNOWLEDGMENTS

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9. REFERENCES

[1] Android devlopers. http://developer.android.com/index.html.
[2] Appbrain. http://www.appbrain.com/.
[3] Apple hits 25 billion app store downloads. http://www.usatoday.com/tech/news/story/2012-03-05/apple-app-downloads/53372352/1.
[4] Apple. iPhone Developer Center. http://developer.apple.com/iphone/.
[5] C. Chambers, W. chang Feng, S. Sahu, D. Saha, and D. Brandt. Characterizing online games. *IEEE TON'10*.
[6] C. Chambers, W.-c. Feng, S. Sahu, and D. Saha. Measurement-based characterization of a collection of on-line games. In *IMC '05*.
[7] H. Falaki, R. Mahajan, S. Kandula, D. Lymberopoulos, R. Govindan, and D. Estrin. Diversity in smartphone usage. In MobiSys '10.
[8] Flurry. Flurry blog. http://www.theappside.com/2012/01/10/flurry-stats-social-games/.
[9] A. Nazir, S. Raza, and C.-N. Chuah. Unveiling facebook: a measurement study of social network based applications. In *IMC '08*.
[10] A. Nazir, S. Raza, D. Gupta, C.-N. Chuah, and B. Krishnamurthy. Network level footprints of facebook applications. In *IMC '09*.
[11] PerBlue. Parallel kingdom. http://www.parallelkingdom.com/.
[12] D. Pittman and C. GauthierDickey. A measurement study of virtual populations in massively multiplayer online games. In *NetGames '07*.
[13] D. Pittman and C. GauthierDickey. Characterizing virtual populations in massively multiplayer online role-playing games. In *Advances in Multimedia Modeling*, 2010.
[14] PocketGamer.biz. Pocketgamer.biz announces its top 10 mobile game developers to watch in 2012. http://www.pocketgamer.biz/r/PG.Biz/PG.Biz+Top+50+Developers+2012/feature.asp?c=38352.
[15] P.-Y. Tarng, K.-T. Chen, and P. Huang. An analysis of wow players' game hours. In *NetGames '08*.
[16] W. Feng et al. A long-term study of a popular MMORPG. In *NetGames '07*.