Traffic Analysis of an Internet Online Game Accessed via a Wireless LAN

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***Abstract*— The Internet has been widely adopted to allow users to share their gaming experiences. In addition, many portable gaming devices (e.g., gaming consoles) are now able to connect to one another, allowing a local gaming experience. The natural evolution of this paradigm allows portable consoles to connect to the Internet, enabling users to play with the rest of the world. Most of the time, this is exploited by using a wireless access, to guarantee the portability requirements. This letter discusses a traffic analysis of a portable gaming console when connecting to the Internet for multi-player purposes.**

***Index Terms*— On-line game, wireless networks, p2p, traffic analysis, gaming devices.**

I. Introduction

As a consequence of the wide diffusion of the Internet, different kinds of traffic patterns are now produced. Thus, being able to recognize different flows to perform differentiate operations (e.g., adjusting the forwarding disciplines), is a key issue to guarantee users' satisfaction. Anyway, the complexity of the analysis of the Internet traffic is increasing in two different aspects. On one hand, various network applications have completely different requirements and, on the other hand, the heterogeneity of the network is increasing, e.g., wireless access technologies are becoming a consistent portion of the overall Internet. Among others, network enabled gaming applications and wireless devices are becoming responsible of producing a non negligible portion of the total traffic load [1]; hence, characterizing their behavior is a mandatory step.

Briefly, modeling and understanding Internet-enabled gaming devices allows to: i) develop models to take into account different applications' behaviors to support the design of the network; ii) exploit traffic separation to ensure Quality of Service (QoS) requirements, if any, and to apply a proper billing mechanism, if needed; iii) help online game developers to test and engineer their applications in respect of the even more complex network scenario.

To the author' best knowledge, this is the first attempt to investigate traffic characteristics of portable gaming devices, operating in a mixed wireless-wired environment. However, many efforts for modeling traffic of *wired*-Internet online games have been already performed. In [2], a real-time strategy game based upon the *peer-to-peer* (p2p) paradigm, is analyzed, proving that the traffic produced by online games has different characteristics from the prevailing Internet traffic. In [3], latencies introduced by the network for a popular first-person shooter have been discussed, while [4] proposes a traffic model for the same class of games, in order to help Internet Service Providers (ISPs) to estimate bandwidth consumption. Lastly, [5] clearly shows that the traffic traces of the most popular games introduce significant challenges to the current network infrastructure.

In this perspective, this letter investigates the traffic characteristics of an online game, played from a portable console, which accesses the Internet over a standard Wireless LAN (WLAN).

The remainder of the letter is structured as follows: Section II introduces the testbed. Section III reports the analysis of the traffic being collected, and finally, Section IV contains conclusions and indications for future work.

II. Measurement Testbed

In order to carry out experiments, we employed a standard IEEE 802.11b Access Point (AP), a Nintendo DS (NDS) console and the game Mario Kart DS (MKDS). The AP was connected to a high-speed Internet access (a dedicated $10Mbit/s$ line). The Nintendo DS console is equipped with a fully compliant IEEE 802.11b air interface, but with its maximum transfer rate limited to 2 Mbit/s to cope with excessive battery drain. Regarding the selected game, we chose MKDS, owing to its high popularity among NDS users (being the first game with a full on-line support). Put briefly, MKDS allows to race against 3 opponents (for a maximum of 4 simultaneous players per session) and it is highly interactive. Each race is composed by a fixed number of laps, that is 3. As a consequence of the design, MKDS implements a synchronous game logic; thus, when a racer moves, its position within the track must be promptly updated at each remote user's console.

For what concerns the architecture of the gaming service, the system relies on the Nintendo Wi-Fi Connection (NWC) [6]. The NWC resembles a p2p infrastructure, where peers are the opponents and the centralized component deployed by Nintendo is used as a mediation point to tunnel data to consoles behind a Network Address Translation (NAT).

This system relies on TCP for log-in/out operations and to convey signaling, and it uses the following ports: 28910, 29900, 29901, 29920, 80, and 443. Conversely, for the p2p traffic, the system relies on UDP, which may be transmitted over any port. In addition, the NWC service also allows to find players circumscribed to a particular part of the world

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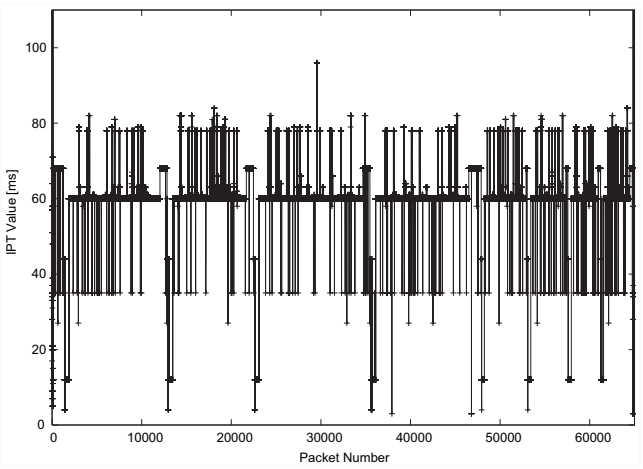

Fig. 1. Trace of the IPT for two consecutive sessions. The 1^{st} session $(1-48,000)$ is composed by 4 players, while the 2^{nd} $(48,001-64,000)$ is composed by 2 players only.

(e.g., world-wide, in the same continent, etc.), as a means of reducing *lag*[1] effects.

Regarding the trials, we analyzed the traffic by varying the number of players (i.e., 2, 3, and 4 players), while performing entire championships (i.e., a run of 4 consecutive tracks). Championship mode has been selected, because it is the preferred one. In addition, by making consecutive races, we were able to underline the repetitive patterns introduced by the game's scheme.

III. Traffic Analysis

To evaluate the traffic characteristics of this particular gaming architecture, we collected data in different gaming configurations (e.g., by varying the number of players). In this work, we assumed a user session as the time of completion of an entire championship. In addition, we noticed that after ~ 50 sessions, mean values tend to become steady. To collect the data, we used the *ethereal* sniffing tool; then, we processed the traces by using the *tcptrace* application, jointly with ad-hoc scripts.

The literature shows that a traffic model may be produced by investigating the data at different levels of abstraction. Specifically, by investigating at the levels of *application*, *transport*, or *network*. Each approach allows to highlight a particular behavior. Hence, we propose a brief investigation for each level of abstraction.

A. Inter Packet Time

The analysis of the Inter Packet Time (IPT) is useful, since many network devices (e.g., routers and APs) mostly operate by processing data *per-packet*. Also, it gives hints about how to manage buffers and taming devices' queues.

The observed average IPT within a session is equal to 58.512 ms; we did not notice any appreciable deviation in the IPT when playing in different tracks, or by varying the number of users.

[1]even if the *lag* is the latency, we adopt this term to conform to online gaming nomenclature.

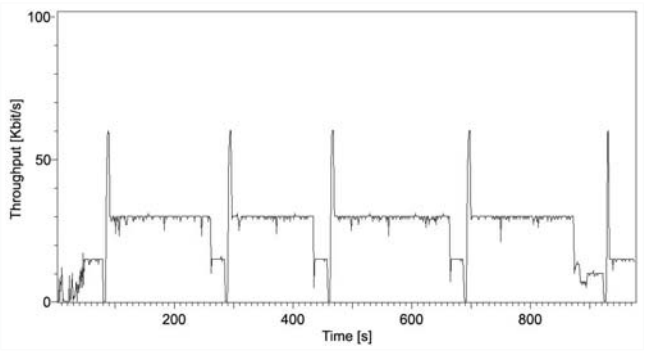

Fig. 2. Throughput of the outbound UDP traffic.

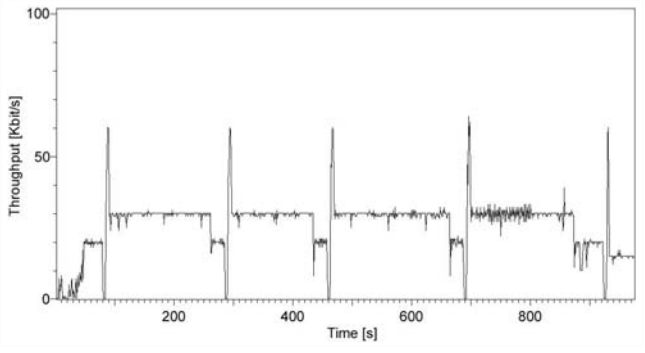

Fig. 3. Throughput of the inbound UDP traffic.

Figure 1 depicts the IPT trace of two consecutive sessions, showing the insensitivity of IPT with respect to variations in the number of players. However, the number of exchanged packets among players decreases, owing to the reduced amount of data to be exchanged.

B. Packet Size

When in the presence of a small population of users, packet size can be often neglected. However, in order to be able to face a massive adoption of this class of systems, it must be taken into account; for instance, when an AP is deployed to serve a huge amount of players. As discussed in [7], vendors engineer their network devices (e.g., APs and routers) by making assumptions on the packet size; they often expect packets to fall in the range of 125-250 $bytes$. Thus, having users to produce a burden of packets not conforming to such range can bring the device to be the bottleneck, rather than the link speed.

The observed average size of the payload of the UDP streams is equal to 30 $bits$, hence $\sim$ 4 $bytes$. Then, this constitutes a high protocol overhead. Consequently, devices that deal with a vast amount of MKDS users must have a sufficient forward capacity to avoid perception of poor performance by users, in terms of *lag* and disconnections. Lastly, packet size is constant, despite the number of players or a particular track.

C. Throughput

Figures 2 and 3, respectively, depict outbound and inbound UDP throughputs observed during a game session. Traces

TABLE I
TRAFFIC SUMMARY FOR A TYPICAL GAMING SESSION

No. of packets	66,590
Avg. packets/s	43.934
Total Bytes Exchanged	6,576,294

TABLE II
TRAFFIC PER PROTOCOL

	TCP	**UDP**
Percentage	3.69	96.31
Exchanged Packets	2,725	64,785
Data Volume in Bytes	229,219	6,537,459

clearly show the high periodicity of the system. Specifically, the first 80 s are employed for searching users and handshaking operations. Then, each burst represents a racing session (burst number 2 is shorter because the selected track was shorter than the others).

Also, it can be noticed that each burst starts with a small traffic peak. The peaks happen at the very beginning of each race to synchronize each opponent before starting. Conversely, at the end of each race, the throughput decreases, even if smoothly, and carries out information about the voting for selecting the next track. Notice that at the end of the fourth burst, hence the last race, there is a different traffic due to the presence of a short victory scene. Then, the usual pattern for selecting the next race appears again.

For completeness, at the end of the proposed traces depicted in both figures, also the throughput of a 2 opponents' race is sketched. Notice that the amount of the exchanged data decreases, while the peak for syncing remains barely unchanged.

On average, for a 4-player race, the bandwidth consumed by each contestant is 60 kbit/s. This is consistent with the requirement of having the game playable with many different Internet accesses. Thus, the wireless link (for a single player) is not the bottleneck. Further trials highlight that the bandwidth consumption varies linearly with the number of players. In this perspective, when employing a unique AP for covering a high number of players, the bandwidth is not critical as the high number of small packets and their tight timing requirements.

D. Periodicity and Predictability

The highly periodical flavor of bursts is mainly due to the repetitive game logic (e.g., it is not possible to play less than 4 races). However, non-periodical patterns can happen, for instance when all the opponents abandon the game, but this is highly unlikely and then negligible. Also, glitches in the period duration can happen, mainly due to variations in the length of the tracks (reflecting in more or less time needed to complete a race) or in players' skill (reflecting in players waiting for a slow opponent to complete the last lap).

A period can be defined by an entire race campaign and it is composed of about 46,000 UDP packets barely uniformly subdivided in 4 bursts. In this case, with periodicity comes also predictability, which can be exploited both on the WLAN and at the server side, for allocation purposes. Predictability gives also some hints for supporting some traffic policing and billing on WLANs. For instance, with the increasing availability of portable devices, public hot-spots would support some disciplines designed for online gaming. In this perspective, the system under test exhibits synchronization peaks that might be exploited for triggering some policy in the APs. A simpler solution, the game traffic being mainly carried by UDP packets, can be billing this traffic with higher prices with respect to standard patterns (i.e., HTTP) and reserving resources to avoid performance degradations.

E. Traffic Summary of a Gaming Session

In this section we propose the summary of a typical gaming session. The session was composed of 2 consecutive championships and lasted 25 minutes, including log-in and log-out procedures. Values are averages over 50 trials. Table I portraits a brief summary of the traffic produced in the session under investigation.

Moreover, Table II provides a quick breakdown of the traffic subdivided by protocol. Notice that the overall traffic is composed mainly by UDP during the entire session. Conversely, the TCP is mainly employed at the beginning and the end of the session (if the user nicely disconnects, from the NWC service). Lastly, 5% of the TCP traffic is encrypted via Secure Socket Layer (SSL).

IV. CONCLUSIONS

In this letter we presented an analysis of an online game where users access the Internet via a portable console, by using a standard IEEE 802.11 wireless access. Many aspects are consistent with previous analyses, e.g. [5]. Future work will aim at enriching the analysis and building a synthetic model to conduct more detailed simulative trials e.g., when in presence of a huge population of concurrent players and high latency accesses.

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