Everything you Always Wanted to Know about Playing a FPS Game on a Car

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***Abstract*—This paper studies the feasibility of playing a First Person Shooter interactive online game while traveling as a passenger on a car in an urban scenario where wireless connectivity is available through WiFi Access Points (APs). Knowing in advance the positions of APs, we propose a mechanism that is capable of predicting future connectivity times while moving, so that a player may choose (or not) to begin a game round. With such estimation of connectivity time, a player can obtain a feeling regarding which parts of a game s/he could (not) accomplish and hence be put in the position of deciding for the best. We validated our approach through simulations utilizing a large set of real vehicular movement traces collected in Pisa, Italy.**

Keywords— vehicular communications; online games; first person shooter games; quality gaming times

I. Introduction

Online gaming is often thought of as an entertainment experience occurring at home through one of the mainstream consoles or high-powered PCs. Nevertheless, more and more players today normally enjoy playing networked games on the move, and this is possible thanks to the improvements that smartphones, tablets and other portable devices have experienced. Online games, hence, have entered that pool of activities that can be pursued while experiencing some spare time (e.g., reading a newspaper, solving crosswords, etc.). Although it is always possible to play "against the machine", players more and more enjoy experiencing competitions against real opponents.

Among the many different game genres, researchers and practitioners agree that First Person Shooters (FPSs) are typically those that lay down the most stringent requirements in terms of interactivity [1]. In fact, FPS games are all characterized by the fact that all the most relevant game events are related to *shootings*, representing the climax phases of the game where the most part of interactions between players take place. From the perspective of how the game develops, this means that a lot of interactions between players occur but their duration is limited in time (from several dozens of seconds to a few minutes at most). To support these patterns of interaction, evidently, even if for small intervals in time, a full network support is required.

The appearance of fully functional FPS games on mobile platforms is rather an interesting phenomenon nowadays. However, although fast and fully mobile interactive gaming may be closer in time, an important barrier still needs to be breached to enable sustainable and satisfactory experiences: this amounts to the lag and jitter introduced by 3G and 4G networks. A viable way around cellular network inadequacies exists for FPS games and for all those that require the combination of high bandwidth and low delay connections: the use of WiFi hotspots. In fact, 802.11 Access Points (APs) located at home, but also on the streets, can suitably complement the data connections offered by mobile networks: they provide higher bandwidths, they are less burdensome in terms of delays and their use is usually cheaper. Many cities already deploy or are currently deploying such dense AP networks.

However, playing while relying on WiFi APs can be very challenging, if not impossible, when moving on a car: coverage areas are typically limited and non-overlapping in space, with negative consequences on the regular advancement of any online game. However, also while driving, it is possible to experience *lucky* moments of congestion where, stopping close to an AP, connection times last long enough to be exploited to complete given stages of a game. Such connection times may be short, and hence only be sufficient to complete tasks where a very basic set of interactions is involved, or be long and thus provide the chance of finishing an entire stage of a fully functional game.

This said, we here aim at enabling the use of highly interactive online games in vehicular scenarios. In order to do this, we predict for how long a vehicle will be in the range of available APs. In fact, if informed that there is no available time to complete a given session, a player can avoid the frustration of remaining stuck while completing it. Contrarily, if sufficient time is available, a player may decide to enjoy a whole round. In essence, exploiting the prediction of how long connection times will be, a player (or a gaming platform) can proceed only her/his gaming plans that can be completed correctly. In this context, our contribution consists of the design of a mechanism that predicts the effective connection time available between a moving vehicle and a game server while under AP coverage. In essence, we quantify the connectivity region that may be supported by an AP situated along an urban road. We prove the validity of our approach with simulations, measuring the effective connection time observed between a moving vehicle and an AP. Vehicular

This work has been partially financed by the European Social Fund in collaboration with the Government of Aragon; TAMA Project, Government of Aragon; and the Italian PRIN ALTER-NET Project.

traffic patterns are drawn from real mobility traces that we collected on the road, performing over one hundred traversals of an urban street in Pisa, Italy.

The remainder of this paper is organized as follows. In Section II we review the work that falls closest to ours, whereas in Section III we describe the details of our mechanism. In Section IV we present its performance in simulation. We conclude with Section V.

II. Related Work

Multiple proposals have exploited the connections and the data transfers that can be supported between moving vehicles and roadside APs. In [2] experiments were carried out exploiting V2I connections, achieving a maximum throughput speed of 5 Mbps. Such type of connectivity was experimented also in [3], to deliver the data gathered by mobile sensors to centralized servers. The authors of [4] exploited different connection time indicators (e.g., heuristics), in order to optimize wireless data transfers between pedestrians and ambulances. The work we present in this paper differentiates from any of the described approaches in two fundamental aspects: (a) we here address the support of a real-time service such as a FPS game in vehicular environments, and, (b) we predict connection times based on the very initial information (average speed experienced on the initial part of a road) that is available while traversing a given street.

Although FPS games are at the center of a number of research efforts and initiatives, many of them concentrate on their Quality of Service (QoS) requirements and performances over fixed networks. In [5], the authors study the effectiveness of putting together, in the same arena, those players that experience similar round-trip-times and jitters, in order to reduce any unfairness. Other researches assessed the performance of FPS games under different packet loss patterns, finding very distinct behaviors [6]. The authors of [7], instead, investigated the use of FPS games under 802.11, but with a focus on competing communication traffic mitigation, rather than on user mobility. In essence, not much attention has been devoted, to this date, to FPS gaming in purely mobile scenarios. This can be explained considering that only very recently such type of games have landed on mobile platforms.

III. Prediction Mechanism

Computer gaming is an activity where gratification comes from the attractiveness and quality of a given game, but also from the concentration, the skills and the sense of control that can be exercised while being absorbed by that game [8]. For this reason an unfortunate event as an abrupt disconnection cannot but have very negative effects on the mood, as well as on the attachment that a player feels for a given tournament or adventure. For this aim, this paper proposes a mechanism able to give advice to the player about the expected time he/she may enjoy a good connectivity. It should estimate the current location of a vehicle, know the positions of available APs, and estimate the effective connection time duration between a vehicle and the gaming server (Fig. 1). Sometimes such mechanism could prevent online playing, also this being a cause of disappointment (but still less than that due to a crash or a disconnection). In addition, one could still opt for playing against the machine and hence still be entertained, although in a way that would lack that thrill and excitement that only real opponents can give.

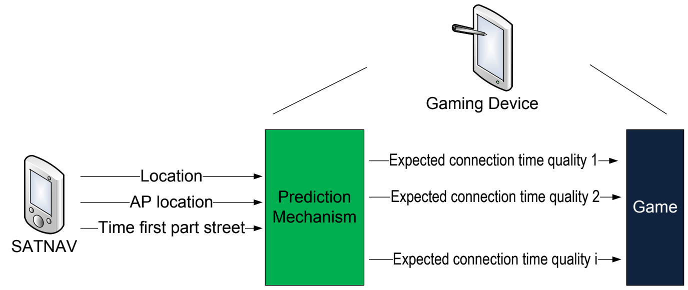


Fig. 1. Scheme of the connection time Prediction Mechanism.

The Prediction Mechanism (PM from now) should be capable of accessing the location of any available APs: to fulfill such purpose, two possible approaches could be taken. The first accounts for the fact that many commercial WiFi services already provide such information to their subscribers. If this, instead, were not the case, another option would be that of resorting to one of the many online services that provide information regarding the position of open APs [9].

Providing a correct estimate of the effective connection time duration between a vehicle and a gaming server is certainly a hard task, considering that the time a vehicle remains reliably connected to an AP may greatly vary, depending on the amount of traffic that is encountered on a given urban street. Inspired by [4], a direction to go is that of estimating the connection time between a vehicle that is traversing a given road, say *A*, and a roadside AP, as the total amount of time that would be spent on *A*. Hence, the idea is that of approximating the connection time with a given gaming server with the time spent on the road (i.e., portion of road between two intersections) where an available AP is located. Now, from a purely theoretical perspective, this may be seen as a heavy approximation, as an AP might not cover the entire road section, or the connection quality, between a moving vehicle and an AP, might not be good on that road. In practice, however, relevant literature reveals that such assumption is not unpractical, considering that the average length of a street section in western city like London, for example, amounts to about 100 m [10] and typical AP coverage radii well exceed such value.

Our PM, hence, should be capable of predicting the traversal time of a given street, once that street is entered. While finding a unique answer to this question for all streets, in all types of driving environments (e.g., in America as in Europe and in Asia) is still an open problem, we again resort to [4] where it has been experimentally observed that, for a given street in Pisa, Italy, strong correlations exist between the total time spent on that road and the time that is typically spent on a few of its subsections. This means that once a given vehicle has traversed one of those subsections, it is possible to compute with a good approximation the time that that vehicle will spend on the entire road. As an example, the portion of road where speeds are observed to vary most (i.e., highest standard deviation) provides good estimates as, intuitively, it is the segment where queues build up when a lot of traffic is present and where no queues are found, otherwise. The downside of such approach, however, is that often such segments span way down the road (e.g., computing a correct estimate requires traversing more than 50% of a road), while, instead, we require our PM to produce a connection time estimate as soon as possible, as it is more useful for a player.

The same study, along with other relevant ones, reveals that the average speed reached at the beginning of an urban road is typically higher than that experienced on the entire road [4], [11]. This means that if we measure the time $T_{10\%}$ that is spent by a vehicle on the initial 10% of a given urban road section, a conservative estimate (i.e., worst case scenario in terms of game playing) of the time that that vehicle will spend on the entire road is readily computed as $10 \times T_{10\%}$. This is a simple approach that can be easily implemented in our PM, as it requires no complex estimation or data gathering campaigns and, as we shall see from our results, can provide a way of discerning when a game can be played and when it can not.

Now, the PM should work as follows. Thanks to the information obtained from the SATNAV it can determine when a new road is entered. If that road presents an accessible roadside AP, the mechanism computes the expected traversal time. Such time could be computed, as in [4], measuring the time spent on a subsection that is highly correlated to the time spent on that given road, or, instead, as we discussed, measuring the time required to traverse the initial part of the street. Assuming the given subsection is l m long and that the time spent on that subsection equals to T_l, the road traversal time is computed by the PM as:

$$T = (L / l) \times T_l, \tag{1}$$

where L amounts to the total length of the street. Once T is available, it can be put to good use to decide whether a given game can be played or not. Clearly, if the time required to complete a given game is higher than T, playing the game will be forbidden, while, in the opposite case, the player will be encouraged to play online. We can, hence, individuate the four following situations:

(a) **Successful play**: the estimated time is higher than the effective game duration and a game can be completed.

(b) **Not allowed:** the estimated time does not suffice, the game should not be started.

(c) **Interrupted:** the estimated time is higher than the effective game duration, but is too optimistic, as the game cannot be completed.

(d) **Wrong predictions:** the estimated time is lower than the effective game duration, but is too pessimistic, as the game could have been completed.

IV. Experimental Results

Simulations have been conducted using NS2, allowing both mobility and communication patterns to be based on real traces (i.e., movement and packet flow ones, respectively), thus making it possible to accurately and reliably transpose information recorded in the real world into a simulation model. NS2 *Two Ray Ground* propagation model is used, the street width is set to 10 m, the WiFi coverage radius is 250 m and the WiFi maximum rate (802.11g) is 54 Mbps. The scheme of the simulations is shown in Fig. 2.

As far as mobility is concerned, a large set of vehicular traces has been utilized in our model: in particular, a total of 111 traces were collected at different times of the day, and during different days of the week, while traversing via Benedetto Croce, located in Pisa, Italy (~ 400 meters) [12]. These traces present a wide range of end-to-end times, which go from as low as 34 s to as high as 217 s. Clearly, 217 s is a very stringent limit for possible gaming intervals. Despite this fact, two or three minutes can be sufficient to play a round within a small FPS scenario.

A popular FPS game, *Quake IV,* has been selected as the application under study. Its traffic consists of: (a) a first stream of UDP packets sent by the client at a speed of 64 pps (packet size equals 79 bytes) and, (b) a second stream of UDP packets sent by the server at a speed of 14 pps (packet size equals 161 bytes on average). In addition, a subjective quality estimator exists for such game. This means that the Mean Opinion Score (MOS) can be computed directly, utilizing a formula, which depends on delay and jitter, and matches the average opinion that would be provided by a large group of people [13]. The score ranges from 1 (bad quality) to 5 (good quality). Values above 3 are typically considered acceptable [1].

The scenario considers that an open 802.11 AP sits midway through the street and a player, moving on a car, attempts to connect to a gaming center through that AP. We first selected a single mobility trace out of the 111 available ones. The result of this run is shown in Fig. 3, in terms of MOS. A tick of 1 s has been used. We observe that as soon as the car enters the street and gets under coverage (which happens at t = 0 s in this case), the PM begins the computation of the time required for traversing the first 10% of the street. At t = 33 s the PM computes the prediction and lets the player begin a 60 s game. In this case, the car is always inside the AP coverage, so the match can end normally. The RTT is slightly above 40 ms, which means that the wireless part does not add significant delays. Jitter presents more variability, but never exceeds 1 ms. As a result, the MOS is roughly 3.75 during the whole game, which means acceptable quality. So, based on a simplistic approach which considers a single mobility pattern, we are able to state that an acceptable subjective quality for a FPS can be provided by a WiFi AP in this scenario.

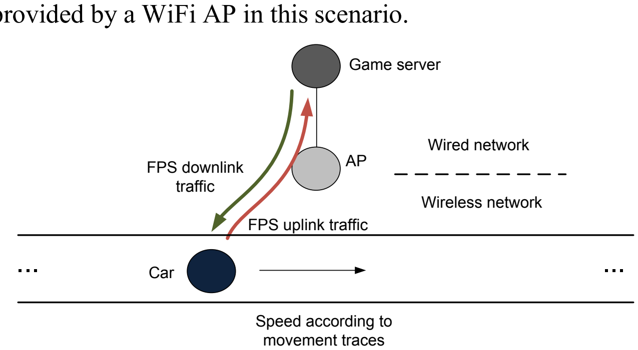


Fig. 2. Scheme of the simulations.

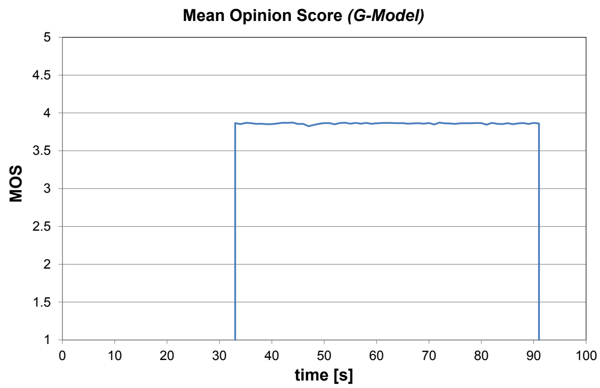


Fig. 3. MOS obtained by the player traveling in the car.

Next, we will show an example using the initial 20% of the street for obtaining the estimation. In Fig. 4 (a), we show how an **interrupted** situation looks like: a vehicle takes a long time to traverse the initial 20% of the street, but it later speeds up abruptly freezing a 60 s tournament that was started. Despite this negative result, we kept considering the option of producing an estimate using the first 10% or 20% of the street, widening the breadth of our analysis. As the estimate that the initial subsection could produce is conservative, we introduce a factor $K > 1$ that multiplies the prediction time:

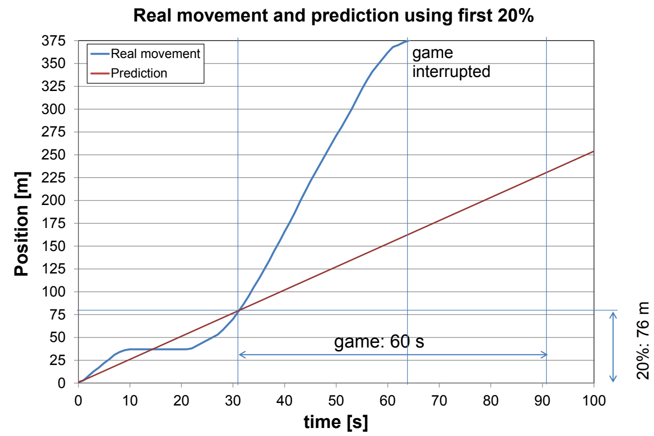
$$T_{predicted} = K \times \ (L / l) \times \ T_l \tag{2}$$

In Fig. 4 (b), we provide an example where we use two different values of K. For $K = 1$, we obtain a **wrong prediction**: a pessimistic prediction is obtained and a 120 s game is not allowed, although it could have been completed. For $K = 2$, however, the estimate is more optimistic and the game can be played (Fig. 4 (b)).

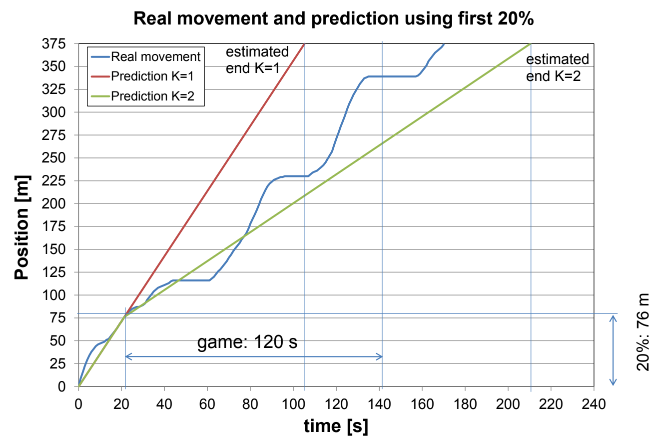
It has been found that reasonably accurate predictions (0.75 correlation) of the total time spent on via Benedetto Croce could be obtained from its 15%-36% subsection [4] (l=0.15 and L=0.36). Thus, in order to compare this option with the other prediction mechanisms that we have so far described (10% and 20%), we performed a set of simulations utilizing the whole set of 111 mobility traces and assuming two different game durations, 60 s and 120 s. The results are shown in Fig. 5.

The first set of columns show the results when using *15%-36%* prediction with the 111 car movement traces. As it can be seen (Fig. 5 (a)), a 60 s game can be completed in only 31 cases, while a 120 s long game would always be interrupted. Hence, waiting until the car is at the 36% of the street strongly penalizes the PM: too much time is wasted until the game starts. So this prediction, although accurate, clearly indicates us the way to go: a rough but fast prediction is preferable over an accurate but slow one.

In column sets 2 through 7 we can observe the results obtained when estimating the end-to-end time based on the initial 10% and on the initial 20%, for different K values. The last set of columns *(no PM)* present the results when no prediction mechanism is used: in this case, if the game does not successfully end, it is considered **interrupted**. The results, for this case, are the average over 10 simulations: the player begins



(a)



(b)

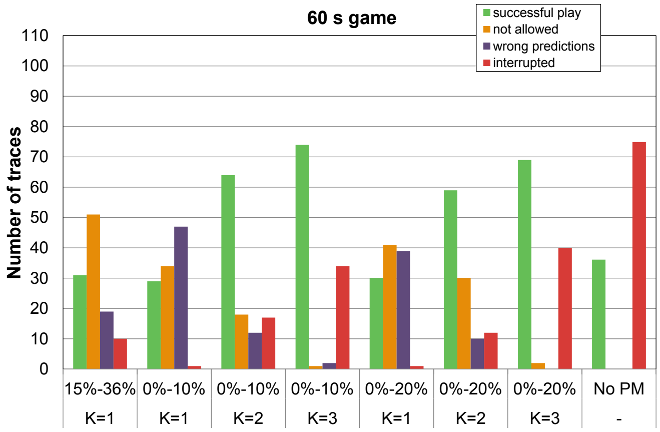
Fig. 4. Prediction and real movement examples: (a) **interrupted** ($K = 1$); (b) **wrong predictions** ($K = 1$) and **successful play** ($K = 2$).

the game in a uniformly distributed moment of the movement trace, just as it really happens when no prior information is available. The number of times that the game ends abruptly outnumbers the number of successful endings by a factor of 2, in the case of 60 s, and by a factor of 12 if 120 s are considered.

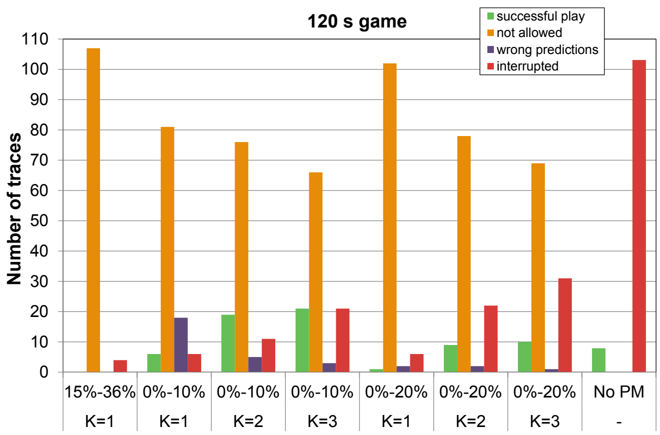
Focusing on a 60 s long game (Fig. 5 (a)), we observe that good results are obtained when predictions are based on the initial 10% of the street with a factor $K = 2$.

If, instead, predictions are based on the initial 20% of the road, results are slightly worse, since more time is spent to obtain a prediction (nevertheless, the prediction accuracy improves and the number of wrong predictions decreases). The value of $K = 3$ is too large, as predictions are too optimistic: as a result, the user always plays, behaving as if no prediction were made. As a consequence, only **successful** and **interrupted** results are obtained.

However, *no PM* returns the worst results: if no PM is available, a player not only misses any information concerning the length of a connection, but also when a connection becomes available, thus further reducing the chance of being able to complete a game, as only very rarely he or she will take advantage of a full connection window.



(a)



(b)

Fig. 5. Results of the prediction mechanism for (a) 60 s long games; (b) 120 s long games.

When a 120 s game is, instead, considered (Fig. 5 (b)), we see that the PM prevents the user from playing in a high percentage of cases. Now, predictions obtained using 10% are significantly better than 20%, since the time required to obtain a prediction becomes even more critical: if the prediction is based on the time spent over the initial 20% of the street, it may be too late to play once an estimate is available.

All in all, our results show how the prediction mechanism avoids, in most cases, the abrupt interruption of a game. Game applications, hence, could take advantage of a PM, in order to improve the user's experience.

V. Conclusion

This paper has studied the suitability of interactive FPS games when being played in vehicular scenarios including WiFi APs. A prediction mechanism for the effective connection time in which the game can be played has been proposed, to be used by game applications in order to avoid the bad experience of an abruptly interrupted game. The main contribution, in essence, has been that of providing a mechanism that could estimate the quality time available at a FPS client when at a given point along a road.

A functional scheme of the mechanism has been proposed, and simulations using real car movement traces have been conducted, showing the suitability of this approach. Tests using different predictors have been deployed, showing that the prediction should be built using the information of the time spent at the very beginning of the street.

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