Banishing Patch-Cables from LAN Parties
Using Ad-hoc P2P Multicast as a Substitute?

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Abstract. Although playing real-time multi-player games online over the Internet became more and more popular in the past few years, people still enjoy meeting for so-called *"LAN Parties"* because of higher social interaction. As the number of participants increases, the deployment of the required infrastructure (i.e. the LAN) however gets more and more bothersome. With the current availability of computers featuring WLAN support, substituting the LAN by an infrastructureless ad-hoc network seems a long awaited and time-saving step. This paper investigates how the wireless environment, its scarce bandwidth and the strong requirements of multi-player games regarding packet latencies constrain the number of a WLAN party's participants.

1 Introduction

With increasing bandwidth available in private Internet connections, online and real-time multi-player games (such as first person shooters) became more and more popular in the past years. A major and well-known drawback of these games however is the lack of social interaction, since players never get a true impression of their opponents. Although a regression is noticeable, the convenience of private Internet connections could not cause online games to fully supersede so-called *LAN Parties*. Here, people actually *meet* in one locality and run their favourite game over a locally deployed infrastructure, i.e. a *local area network* (LAN).

Although they get more and more cumbersome to deploy for an increasing number of participants, LANs have been the standard communication infrastructure of LAN parties for more than a decade. Interestingly, however, the devices interconnected within the LAN have evolved: Indeed, with the increasing performance of notebook computers, people have welcomed the relief of carried weight and required space. As they are commonly equipped with WLAN adapters, notebooks however can, with their WLAN adapters switched to *ad-hoc mode*, communicate without the need of any infrastructure. To provide an adequate support for games one must, on the one hand, bear in mind the traffic emitted by typical applications and, on the other hand, understand the differences when migrating from a fixed to a wireless network.

In current multi-player games, one dedicated node usually acts as a *server node* which in a first step gathers *position and velocity updates* as well as *event information* (use of weapons or "respawns") from all player nodes. In a second step, this data is sent equally to all player nodes. For achieving accurate movements in the game both steps are performed 25 times per second.

With a (semi-)broadcast medium becoming available in a wireless environment, the resulting number of medium accesses (possibly several hundreds per second) has a key impact on the success of data forwarding and thus affects the gaming experience. Indeed, with the information requiring to be delivered to other players within about 150*ms* [1], colliding medium accesses and resulting exponential back-off times used by WLAN adapters for resolving collisions can quickly lead to rising latencies and, thus, a worsening gaming experience.

In the following section we propose a strategy for keeping the number of medium accesses needed for data forwarding as low as possible. We then evaluate the strategy within standard LAN party scenarios by referring to network simulations: We thus study the wireless medium's impact on the feasibility of WLAN parties and investigate the effect of different MAC configurations. Eventually, we conclude the paper by giving a short summary.

2 Ad-hoc P2P Multicast as a Patch-Cable Substitute

For enabling communication within the wireless environment we rely on P2P multicast approaches, since these can easily be deployed and do not require operating system extensions as multicast routing protocols would. With P2P multicast protocols, an *overlay network* (such as [2,3]) is set up between all player nodes using standard transport links as e.g. provided by UDP. The overlay network is used for forwarding a player's periodic updates to all player nodes. As shown in Fig. 1.a), this "standard" overlay forwarding causes data dissemination to be highly inefficient: This results from the consecutive medium accesses that are required for forwarding a single update to all player nodes. Since in LAN party scenarios, however, player nodes usually find themselves very close to each other, the communication's efficiency can be improved by using the wireless medium's broadcast capability. To do so, we employ our technique of *Local Broadcast Clusters* (LBCs, [4]), which works as follows.

Whenever a player node joins the game, it attempts to detect a so-called *virtual server* by listening for the latter's periodic heartbeats. On a successful detection the player node becomes an *LBC player node* and uses the virtual server for data dissemination as detailed below. If, however, the server detection fails, the player node declares itself as a new virtual server. By periodically emitting heartbeats via broadcasts the new virtual server creates its LBC and, hereby, provides access for other joining player nodes. Note that, in contrary to LBC player nodes, virtual servers *do* join the overlay network. They, thus, become *overlay player nodes* that are interconnected via overlay links.

When an LBC player node emits a position and velocity update, the information is sent to the nearby virtual server. The latter, using a broadcast, forwards the update to other LBC player nodes in its vicinity. Additionally, the virtual server sends the information via potentially existing overlay links to distant virtual servers. These then take care of broadcasting the information to their respective LBC player nodes. As a consequence, this technique does not require all player nodes to be within each other's transmission range: Given the existence of a multi-hop routing protocol, we also provide support for fully distributed, multi-hop WLAN parties.

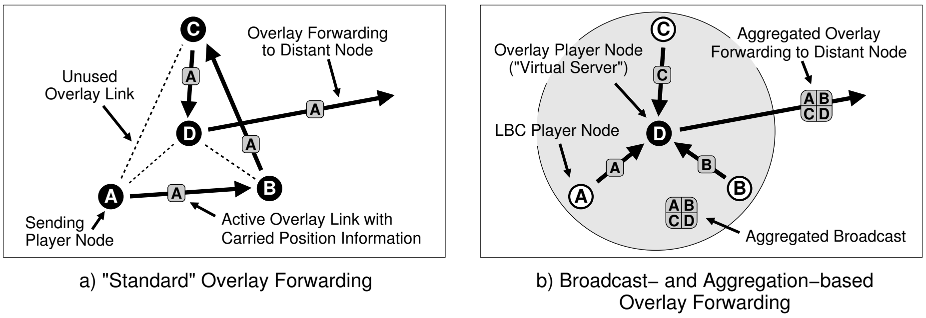


Fig. 1. Standard vs. broadcast and aggregation-based overlay forwarding.

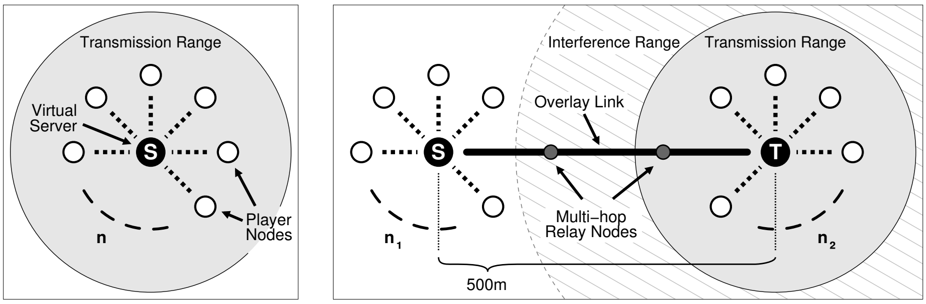
To further reduce the number of required medium accesses we apply a special data aggregation strategy: A virtual server receiving an update from an LBC player node not immediately forwards the information. Instead, the information is buffered until the virtual server sends its next own update. Note that the delay implied by buffering is included in the forwarded updates: This enables player nodes to extrapolate the movement of other players according to the latter's position and velocity information. The entire mechanism of broadcast and aggregation based data forwarding is depicted in Fig. 1.b). Also note that the buffering delay of up to 40*ms* constrains the number of times updates can be buffered before reaching the critical latency of 150*ms*.

3 Scenario Modelling

In this paper we study two different WLAN party scenarios. For the first scenario, visible in the left of Fig. 2, player nodes are placed, as in a typical LAN party scenario, within an area of 20x20m^2. The player node in the area's centre is the first to join the game. It, thus, becomes a virtual server and provides access to all other nodes which, hence, become LBC player nodes. As we increase the number of players, we expect the latencies of player updates to rise and, at some point, reach the critical threshold of 150*ms*. Since we ascribe this to an increasing number of colliding medium access and ongoing MAC retransmissions, we in this paper investigate a second, distributed scenario.

As shown in the right of Fig. 2, the distributed scenario reduces the number of medium accesses around the server by splitting a large WLAN party into two smaller clusters. The resulting scenario, thus, consists of two virtual servers which gather player updates from their respective LBC player nodes. Using the (multi-hop) overlay link each virtual server then forwards the gathered and aggregated information to the distant virtual server which, then, broadcasts the information to its LBC player nodes with its own, next update.

We assume a constant size for position and velocity information and a variable size of additional event information. We thus model traffic by letting each player node send a packet with a size randomly chosen between 32 and 48 bytes every 40*ms*. Depending



a) Single−hop Scenario b) Distributed Scenario

Fig. 2. Single-hop and distributed scenario as modelled for the investigations.

on the actual number of participating players, the resulting size for aggregated player information reaches several hundred bytes and potentially more than 1 KByte.

The simulation experiments were conducted with GloMoSim [5] featuring IEEE 802.11b with 2 MBit/s as MAC and AODV for establishing routes in the distributed (multi-hop) scenario. Unless otherwise stated, transmission power is set to 3.9*dBm*, resulting in a transmission range of 175*m* and an interference range of 353*m* respectively. While the interference range shows to be uninteresting for the first scenario, it is of major importance in the distributed scenario. Indeed, when splitting the WLAN party, it must be guaranteed that the communication inside each cluster does not affect the distant cluster. Considering the transmission and interference range we, thus, place the virtual servers 500*m* from each other. We bridge the distance using 2 multi-hop relay nodes (resulting in a 3 hop overlay-link) which only forward traffic and do not join the game.

4 Simulation Results

The results of our simulation experiments are obtained using 40 random number generation seeds and shown in Fig. 3. While we plot the number of participating players on the x axis, we show the percentage of updates with a latency beyond 150*ms* (classified as "not delivered in time") on the y axis including 95% confidence intervals.

As can be seen for the single-hop scenario, the amount of updates that are delivered with a latency above 150*ms* can be neglected for up to 21 players. With the 22nd player joining, however, about 5% of all updates are no longer delivered in time, perceivable through a worsening gaming experience. With more players joining delays drastically increase, resulting in an unacceptable game performance.

Despite the reduction of medium accesses around the virtual servers, the distributed scenario shows a performance far worse than the original single-hop scenario. While this observation at first seems surprising, it can be ascribed to the wireless (semi-)broadcast medium and its well-known hidden terminal problem [6]. Indeed, although both clusters are clearly separated and do not influence their opposite's communication, the forwarding of aggregated data along the multi-hop overlay link suffers from heavy

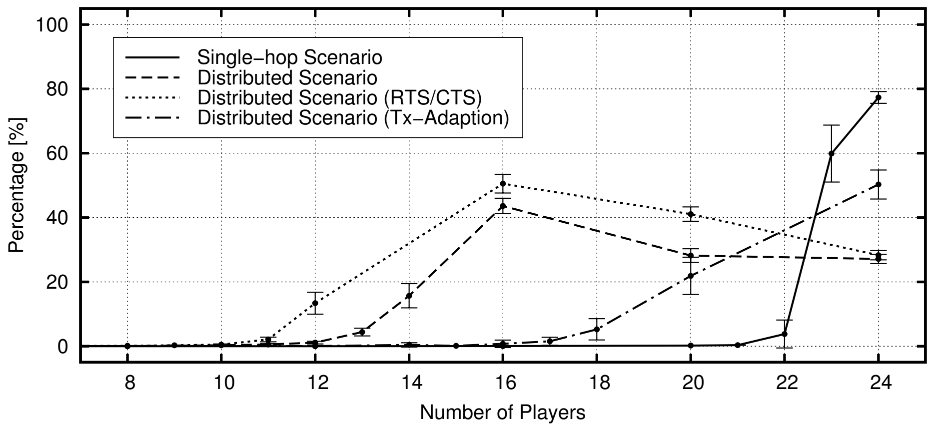


Fig. 3. Percentage of updates not delivered in time.

interference implied by the communication within the clusters. Because of resulting exponential back-off increases and ongoing MAC retransmissions, latencies quickly rise and thus lead to unacceptable performance for 13 (and more) players.

Activating the RTS/CTS extension introduced for the IEEE 802.11 standard does not lead to a performance increase, but results in a further decrease of supported players: Indeed, the sending of RTS and CTS packets implies additional medium accesses, resulting in heavier interferences and degrading performance. The percentage of updates not delivered in time, thus, already shows a slight increase for 10 players.

A possible option for reducing the extent of interferences and facilitate the communication along the overlay link is to lower the transmission power of LBC player nodes. Indeed, the latter are located within a few meters from their virtual server and, hence, do not require a full transmission range of 175*m*. As a consequence, we for the final evaluations set the transmission power of LBC player nodes to -13*dBm*, which results in a transmission range of 25*m* and an interference range of 79*m* respectively. As can be seen from the diagram, this leads to a drastic performance increase in the distributed scenario: The percentage of updates not delivered in time only starts rising slowly with 16 players. However, the results achieved in the single-hop scenario can still not be matched.

5 Summary and Conclusion

We in this work investigated, whether 802.11b WLAN adapters operated in ad-hoc mode in combination with P2P multicast protocols can substitute a bothersome to deploy LAN infrastructure, which has been a long time standard for LAN parties. To do so, we introduced an efficient data forwarding scheme using broadcast and aggregation based overlay forwarding. Using a network simulation environment, we investigated the scalability of the proposed scheme in different WLAN party scenarios.

While our simulations were conducted with low bandwidth (2 MBit/s) adapters, results show to be satisfactory for supporting WLAN parties with up to 21 participants. Using modern WLAN adapters featuring higher data-rates with up to 54 MBit/s, better results can be expected.

We in this work also investigated, whether a concept of spacial bandwidth reuse can be applied by interconnecting two distant WLAN parties using a multi-hop overlay link. Here, however, the hidden terminal problem shows to have a high impact on communication within the overlay link and thus heavily constrains the number of supported participants. While we also show that the RTS/CTS extension worsens the results because of additional medium accesses, we observe an increase of performance by reducing the transmission power of LBC player nodes: We although provide evidence that results from single-hop scenarios cannot be matched.

Concluding, we can say that, for moderately sized LAN parties (i.e. *"meeting at a friends home"*), the approach investigated in this paper shows to be a proper alternative to a true and bothersome to deploy LAN. It is, however, inadequate for bigger parties which can feature several hundred participants and, therefore, rely on a professionally deployed and costly infrastructure.

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