Triggering Wireless Network Flashes

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***Abstract*— Recent advances in wireless technology make high data rate communication in short ranges feasible. The network instances of short-range paths that may achieve high data rates are defined as *network flashes* in this paper. The characteristics and the efficiency of network flashes are discussed here.**[1]

I. Introduction

Both connectivity and data rates strongly depend on the communication range, the wireless channel and the physical layer technology. The lower the communication range, the more the partitions in the network, rendering it practically useless. On the other hand, recent advances in wireless technologies make the design of high data rate communications feasible, especially in short ranges. Rates up to hundreds of Mbps may be achieved, capable of accommodating high data rate applications, including multimedia, [1].

Until recently, short-range communication has been linked with the Wireless Personal Area Network (WPAN) paradigm to ensure private transmissions of low data rates in, basically, a peer-to-peer mode of operation where no infrastructure is required. The lack of guaranteed connectivity, the need for multi-hop communication and the vulnerability of the constructed paths are some of the reasons why short-range communication has not been employed at a local or metropolitan area scale. Nevertheless, the density of wireless users has increased in the last years, and high data rate network instances of short-range paths between potential source and destination pairs may exist and could be used to the benefit of the wireless user. We use the term *network flash* to describe these highly dynamic and temporary network instances that have the potential to achieve high data rates.

The remainder of this paper is organized as follows. In Section II, light is shed on the characteristics of the network flashes. Results from the employment of a proposed dual-mode architecture, [2], are depicted in Section III to show the potentiality of activating network flashes within the context of a Wireless Local Area Network (WLAN). Future work is commented in Section IV.

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II. Network Flashes

A. Connectivity

In ad hoc networks, various protocols have been proposed to ensure that no network partitions occur or that established paths are maintained after the loss of connectivity. Actually, more than half of the transmission capacity is spent on routing, medium access and protocol control packets in a typical ad hoc network, [3]. Ranges of 150m-250m have been considered instead of short ranges. First, because a lower number of hops are required to reach a destination and, secondly, because connectivity can be more easily guaranteed.

Three short communication ranges (6m, 8m, 15m) are studied under the constraint that the nodes are stationary and uniformly distributed in a circular area of 30m and 200m respectively around an Access Point (AP). In Table I and Table II, the mean number of neighbouring nodes as well as the mean minimum number of hops required to reach the AP (if there were neighbours to allow for the establishment of this path) are quoted for the cases of 20 and 100 nodes inside the defined area.

TABLE I
Case: 30m around the AP

Nodes	Range (m)	Neighbours	Hops
20	(6, 8, 15)	(0.8, 1.4, 5)	(3.8, 3, 1.8)
100	(6, 8, 15)	(4, 7.1, 25)	(3.8, 3, 1.8)

TABLE II
Case: 200m around the AP

Nodes	Range (m)	Neighbours	Hops
20	(6, 8, 15)	(0, 0, 0.1)	(22.9, 17.3, 9.4)
100	(6, 8, 15)	(0.1, 0.2, 0.6)	(22.9, 17.3, 9.4)

As expected, short-range connectivity is hardly achieved in a low density area. However, a greater number of nodes may allow – even temporarily – for paths towards the specified destination. Shorter-range paths require more hops (even if there is connectivity) to reach the destination and may be considered easily corrupted and, thus, useless.

B. Lifetime

Network flashes are expected to be temporary and not last long if one also considers the effect of mobility or even the variability of the wireless channel. This attribute makes short-range communication an even more inappropriate candidate for the ad hoc networking paradigm, where the routing overhead increases with the path failures.

The effect of mobility and multi-hop communication in network flashes is shown in Table III. Simulations were conducted using ns-2, [4]. 50 nodes were set to move based on the waypoint model in a 100mX100m area, and the lifetime of multi-hop paths was measured for different mobility scenarios (maximum speed of 1, 5 and 15m/sec and pause time equal to zero), number of hops (1 up to 4) and communication range (6, 8 and 15m).

TABLE III
EFFECT OF MOBILITY AND MULTI-HOP COMMUNICATION

Hops	Range (m)	Speed (m/sec)	Lifetime (sec)
1	6	(1, 5, 15)	(18.2, 7.3, 1.9)
2	6	(1, 5, 15)	(9.3, 4.1, 1.1)
3	6	(1, 5, 15)	(5.2, 2.9, 0.8)
4	6	(1, 5, 15)	(4.9, 1.4, 0.6)
1	8	(1, 5, 15)	(26.1, 9.9, 2.6)
2	8	(1, 5, 15)	(13.9, 4.6, 1.3)
3	8	(1, 5, 15)	(9.2, 2.6, 1.1)
4	8	(1, 5, 15)	(6.1, 2.1, 0.8)
1	15	(1, 5, 15)	(47.2, 18.6, 4.9)
2	15	(1, 5, 15)	(25.3, 8.7, 2.6)
3	15	(1, 5, 15)	(18.1, 5, 1.7)
4	15	(1, 5, 15)	(11.7, 3.8, 1.3)

Network flashes are short-lasting even in the case of low mobility. Especially in the case of a multi-hop, 6m-range path, achievable data rates need to be really high to alleviate the disadvantage of its short lifetime.

C. Data Rates

[1] shows the capability of network flashes to reach rates of more than 100Mbps for a single hop communication at a distance of 10m. Although it may seem that network flashes may be useless since they can be active for a short period of time, they can be quite appealing, especially when combined with the traditional networks.

III. Potentiality of Triggering Network Flashes

In order to take advantage of network flashes one could: (a) use several data channels (multiple physical interfaces) operating at different power levels achieving different data rates, [5] [6], or (b) develop a centralized network architecture that is based on the existing infrastructure to decide on whether and when to trigger network flashes (one or more physical interfaces), [2].

To show the benefits of network flashes when properly triggered, the architecture proposed in [2] has been used, where short-range communication is allowed in a new frequency band. Nodes have to switch between the different frequency channels under the control of the AP in a HiperLAN/2 cell, whereas the AP itself can operate in both frequency bands at the same time. Increased overhead is required for the control information about the shorter-range paths to be updated and for efficiently triggering network flashes. In Figure 1, the throughput gain when taking advantage of network flashes is shown, for different number of nodes (2, 6 and 10) moving at a maximum speed of 1m/sec at a close distance around the AP (no more than 15m), comparing with the traditional HiperLAN/2 network (No Trigger). Every node generates traffic destined to the AP at a rate of 10 Mbps, while the physical layer can allow for 10-90 Mbps for ranges lower than 15m, [2]. The triggering mechanism requires an extra overhead that is no more than 1,12 Mbps in the worst case of 10 nodes.

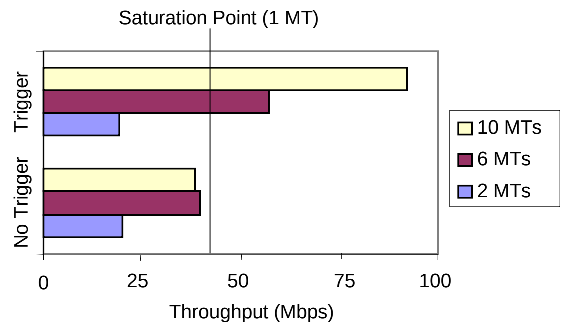

Fig. 1. Throughput Gain.

In Fig. 1, the maximum throughput achieved (41,3 Mbps) when no network flashes are triggered is depicted and denoted as the saturation point (when only one node close to the AP is active and, thus, allocated the maximum capacity allowed in traditional HiperLAN/2 at the lowest control overhead). Network flashes may not only relieve the traditional wireless networks but also contribute to the increase of their capacity in case of sufficient node density.

IV. Future Work

We will focus on a new, analytically tractable model capturing in a combined manner both the short-range communication channel behaviour and the user mobility behaviour in a WLAN/WPAN environment. Analytical results about how network flashes may affect the performance of a wireless network under the induced constraints will be provided. Since triggering network flashes requires additional overhead, conditions will be established under which this overhead is compensated for and the system becomes more efficient.

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