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Wireless Access Method and Physical Layer Specifications

Title: **On the GRAP - A Proposed MAC Protocol**

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Abstract

GRAP is introduced in [1] as the possible MAC for wireless LANs. We introduce more considerations to answer some general questions about the GRAP, espcially the 21 criteria for MAC.

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I. Introduction

A medium access control protocol, GRAP (group randomly addressed polling), was proposed as a candidate for the IEEE 802.11 MAC protocol [1]. As the MAC subgroup has listed 21 criteria (actually 20) to evaluate MAC protocols, we intend to explain more details about GRAP based on these 21 criteria in this documentation.

We briefly summarize GRAP as follows:

II. Responds To Criteria

Unauthorized Network Access Impact on Throughput

The only chance for new arriving (mobile/remote) nodes to join the network is to send a registration packet in group p uplink period. Any unauthorized attention can be rejected by the base station automatically and no effective polling from the base station will ever happen. The effect on throughput will be limited only in group p uplink and be minor.

Establish Peer-to-peer Connectivity Without Priori Knowledge

In [1], only the networks with infrastructure have been discussed. However, this does not imply any contradition with ad-hoc networking (peer-to-peer connection). In order to establish the ad-hoc networking, we just have to distinguish the network operating modes (infrastructured or ad-hoc) at the very beginning of running networks. If the mode has been selected as ad-hoc and no infrastructure can be supported, the construction of ad-hoc networks will start.

Ad-hoc networking is somewhat similar to packet radio networks in general. However, for wireless LANs, the connection topology of ad-hoc wireless LANs may be more close to fully connected LANs than common packet radio networks. A straightforward way to set up an ad-hoc network is to use some kind of SEA (spokesman election algorithm) to pick up a mobile/remote node as a temperary base station to execute GRAP protocol.

Throughput

In [1], we demonstrated that the up-link throughput can be 88% or higher and down-link operates in contention-free situation. The overall performance with 80% down-load and 20% up-load is around 97% or higher channel utilization.

Delay

Simulations shown in [1] demonstrated that the delay for GRAP is pretty low comapred with sloted-ALOHA and carrier sense protocols, especially in heavy load situations.

Maximum Number of Nodes

GRAP is designed for a large numbers of mobile nodes in multi-cell environments. Its grouping feature can divide nodes into several groups in polling. Only the active nodes in a group will be polled.

Ability to Serve Data, Voice, And Video (Time Bounded Services)

In addition to serving data packets (or messages), time bounded services' packets have also been considered and supported. Once a mobile node has any packet from time bounded services, it can join the polling of any group. If such a packet is from interactive voice service, the node may drop the packet once the life of the packet is too long. Furthermore, if a time bonded service packet can not transmit in regular polling after some re-polling procedures, it can go into the group p polling where the new arriving nodes should be a small number in each superframe cycle time., though regular data packet can be done in this way too (however, regular data packets can endure longer delay.).

Transparent to PHY Layers

The key step for GRAP to be transparent to different PHYs is the orthogonal signaling to transmit random address. Since there are typically only very limited random numbers from GF(p) where p is typically a relatively small number such as 5 or 7, such signaling can be embeded in frequency components according to different PHYs. For IR, this can be the period of codes. For DS-SS, this can be the period of symbols. For FH-SS, this can be certain combination of tones (or levels of FSK).

Robustness with respect to Colocated Networks

The mobile nodes will transmit only after receiving [READY] from the base station. Different wireless LANs' identities should be embeded in this [READY]. Without unfriendly prupose, nodes registering in different wireless LANs should not try to get in even if reachable. As far as unfriendly break-in, this is a security issue. At least, the base station's management should check necessary control information and GRAP can definitely match this purpose. As far as the MAC to provide security capability is still under discussion, however, we do not see any difficulty specific to GRAP to prohibit applying typical public/private key techniques.

Battery Power Consumption

One of the advantages of GRAP protocol is that the mobile nodes do not need to monitor the base station if there does not exist intention to communicate. Consequently, the battery power consumption can be greatly saved. Only when the mobile nodes intend to transmit, receive, or keep time bounded services, the nodes have to be in the active or waiting mode.

Any Critical Delay Which Limits Large Area Coverage

Since GRAP is basically a polling scheme fro wireless LANs raher than extremely long distance communication networks such as geostationary ssatellite communication networks, delay is not a significant issue here. Furthermore, according to simulations, the delay for GRAP is pretty low and typically in the range of several packet transmission time. The simultaneous transmission of random addresses does not require being synchronous. Therefore, in the most conservative case, it can tolerate at least several microsecond propagation delay difference which is equivalent to at least several thousands of feet.

Fairness of Access

GRAP has an advantage to support priority or no-piority at all. As the random addresses are actually generated by mobiles themselves, fairness of access is for sure. In the mean time, in case the reception of two active nodes at a base station differs quite a lot, and even worse that the stronger one keeps transmission a series of packets, GRAP can still resolve this situation since the node with stronger received transmission will change to another goup according to its newest successful random address (number) with large probability and quickly with probability near 1. Thus, the fairness of access is basically guarnteed.

MAC Needs to Enforce Insensitivity to Capture Effects

As discussed in previous item, there is no need to enforce insensitivity to capture effects. Strong transmission will tranfer to another group in probabilistic way to avoid dominance.

Support for Priority Traffic

As in the description in [1], GRAP is also designed for priority traffic. If the base station polls according to certain order of random numbers, we can arrange priority by restricting random numbers generated by mobile nodes.

Ability to Support Non-reciprocal Traffic

Since it is flexible on the length of superframe, frames, and broadcasting duration, there will be no difficulty to support non-reciprocol traffic.

Time to Market and Complexity

The implementation of GRAP does not really need lots of extra work. The simultaneous random addresses detector is also straightforward to implement. Complexity in hardware and time to the market will not cause problems.

Ability to Work in Simple, Small, Large Systems

To work with different scales of networks is pretty flexible for GRAP. In general, the larger number of nodes in a cell, we can use a larger p to accomodate more active nodes. Or, we can increase the number of cells (thus, decrease the cell-size) while GRAP is suitable for multi-cell structure and we can reduce the transmission power for mobile nodes.

N/A

This item has been left open.

Ability to Support Handoff/Roaming Between Service Areas

As in [1], we clearly demonstrated this capability as an advantage for GRAP. No handoff is required nd soft handoff for time bounded services.

Implication on Complexity of PHY

There is no implication on complexity of PHY since it only requires to transmit some orthogonal signaling such as frequency components. For all kinds of possible transmissions, this can be easily controlled by data sequence.

Ability to Support Broadcast (Multi-cast)

For down link, it is a natural. For up link, once the packet can go to the base station, it can be handled by the backbone network.

Preservation of MSDU's Order

GRAP does not change the order of MSDUs. For any node, only the previous packet went through, then the following one can transmit in next cycle.

Theoretical Analysis and Implementation

Theoretical analysis of randomly addressed polling has been conducted [2] and the numerical results pretty coincide with the simulations in [1]. More detailed analysis is under working. Real implementation to justify this protocol has begun under the support of the National Science Council.

References:

[1] K.C. Chen, "GRAP - A Proposed Medium Access Control Protocol for Wireless LANs", *IEEE P802.11/92-131.*

[2] K.C. Chen, C.H. Lee, "RAP - A Novel Medium Access Control Protocol for Wireless Data Networks", *submitted for publication.*