IEEE 802.11
Wireless Access Method and Physical Layer Specifications

Title: **High Load Novell Network Performance using Wireless Spread Spectrum.**

Presented by:

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Abstract: This document has been presented in the Ad-Hoc working group about PHY-experience. However this presentation provides performance information for the PHY-MAC combination.

Introduction:

This document describes two High Load traffic models. The first model is a high load peer-to-peer model, with packet size distribution as can be expected in a Novell environment. The access method used here is CSMA/CA, for a 2 Mbps Spread Spectrum Radio Modem as implemented in the Wavelan product.
Test results are provided for the total network throughput as function of the number of active workstations In addition the results show the percentage of lost packets. This model can be compared with the classical offered load versus throughput curves normally shown in literature. The results show that although the lost packets percentage increases more or less linear with the offered load (# of Ws), the total network throughput remains more or less stable, even with very high load.
This is however not representative for real Novell Network traffic, because in a Novell environment the vast majority of traffic is between a workstation and a Network Server according to a Client Server model.

The second traffic model is relevant for this kind of environment and models in particular one of the Novell supplied network performance tests, Perform3.
The results again show a total throughput versus offered load (# of Ws), but now only the net application data throughput is measured, so it excludes the Novell overhead of 64 Bytes per packet. The big difference here is that there is a Server station that generates 50% of the total number of packets because of the way the Novell (file access) protocol is organized. The best way to describe this protocol is: It is a windowed protocol with a window size of 1. This means that each "Data" packet transfer requires to follow a request response handshaking between the workstation and the server.
The results show that again the throughput is stable for very high loads. However the lost packet percentage is much smaller than in the peer-to-peer test, and shows a more asymptotic behavior. This can be explained by the fact that given the Novell request response protocol, there are always a number of workstations waiting for the response of the Server before they can generate the next request frame. Also the %lost definition needs to be changed, so that it represents the situation that both the request packet from the workstation, and the response from the Server need to be error free for a successful transfer. Any packet lost cannot be recovered until after a time-out which in this case is set to 300 msec.
More detailed information show that 80-85% of the medium is occupied by valid data during these high traffic load circumstances, which shows that CSMA/CA is fairly efficient.

The Model:

The results shown are from a simulation, which is verified with actual field test data. The simulation model includes the traffic model, the CSMA/CA access protocol, and Server input and output Queuing system. One of the inputs for the model are the physical locations of the different workstations as shown on the result pages, with location 0 representing the Server location, and 1-15 representing the individual workstation locations. The model calculates all the attenuation paths between all stations, for the wanted signal, and possible interference signals. This means that capturing effects are included, so not all collisions will result in both packets going wrong.

Measurement Results:

The next pages show the actual measurement results for the Perform3 test for 3 different numbers of workstations engaged in the test. The results show a Max and Average throughput, in this case based on a 1024 Byte "Data" size. The actual Perform3 test use multiple test runs with ever decreasing file sizes, so that not all "Data" packets have the full length. This explains the difference between average and maximum throughput. The simulation model described above does not take a variable "Data" packet size into account, so that the results should read as Max. throughput.

Wavelan Performance Comparison.

The last page shows a comparison of the average throughput results of the following three configurations using the Perform3 test.

- Ethernet 10 Mbps based on WD Ethernet cards.
- The same Ethernet 10 MBps cards but now with the Motorola Altair using one Command Modules and two User Modules.
- Wavelan 2 Mbps

This chart shows that the performance difference between Wavelan and Ethernet is as can be expected given the raw bitrate differences.
With Altair the performance of the Ethernet network is reduced significantly.

Performance Model

* Peer to Peer traffic Model

Traffic Generator per Workstation
Random delay between consecutive packets is:
1.25 +/- .25 msec

- 60% Short packets:
  64 Bytes = 20 Bytes MAC overhead + 44 Bytes Network Operating System overhead.

- 40% Long Packets:
  576 Bytes = 512 Bytes data encapsulated in 20 Bytes MAC + 44 Bytes Network Operating System overhead.

- Random destination

Measurements: As function of number of workstations.

- Total KBytes per second successfully transferred including all overhead.

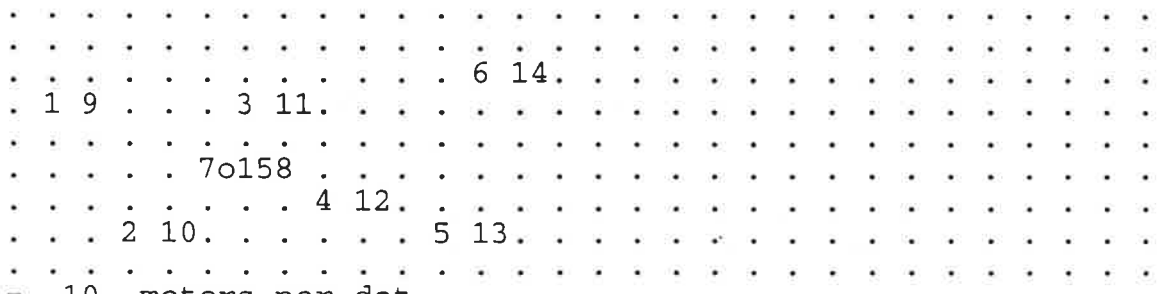
- Percentage Lost packets due to Collisions and dropped packets due to MAC retry limit reached.

Note: Includes effect of capturing.

IPXLoad Test (Peer-to-Peer)
Date: 11-08-1991 Time:15:06:29 File: Perfr14 .dat

********** Separate S/MM Loops

Performance test 1 Networks with 15 Workstations each
Attenuation Coefficient = 3.5
Fading Margin = 5 dB Normal Distributed
Extra noise outage = 0 %
SIR = 10 dB
Carrier Sense level = -82 dBm
Server delay = .5 msec + random .5 msec
Workstation delay = 1 msec + random .5 msec
Packet Data length = 512 Bytes
Lost Packet Timeout = 0 msec
Test time = 5 sec
Attenuation offset between Networks = 0 dB



Scale = 10 meters per dot.

# of WS's	Network-1 Throughput	%Lost	Network-2 Throughput	%Lost	Total
1.0	69.2	0.0	0.0	0.0	69.2
2.0	118.8	0.0	0.0	0.0	118.8
3.0	136.2	2.1	0.0	0.0	136.2
4.0	144.0	2.8	0.0	0.0	144.0
5.0	145.6	4.4	0.0	0.0	145.6
6.0	149.5	5.5	0.0	0.0	149.5
7.0	150.7	6.4	0.0	0.0	150.7
8.0	155.0	6.8	0.0	0.0	155.0
9.0	153.6	8.9	0.0	0.0	153.6
10.0	154.8	11.0	0.0	0.0	154.8
11.0	156.4	11.9	0.0	0.0	156.4
12.0	152.6	15.0	0.0	0.0	152.6
13.0	155.4	16.0	0.0	0.0	155.4
14.0	156.8	17.1	0.0	0.0	156.8

Performance Model

* Network Operating System traffic Model

Traffic Generator per Workstation
Random delay between consecutive packets is:
1.25 +/- .25 msec

- Every Workstation generates a Short 64 Bytes "request" packet addressed to the Server (20 Bytes MAC + 44 Bytes Network Operating System overhead) and waits for a 300 msec time-out period for a Server response.

- Upon reception of a Workstation packet, the Server will after a server processing time generate a 512 Byte data + 64 Byte overhead "response" packet.

Measurements: As function of number of workstations.

- Total KBytes per second successfully received data Bytes from the Server (excluding overhead), so the net application data.

- Percentage Lost packets viewed from the Workstation.

$$PLost = \frac{\#\text{ of "Request"} - \#\text{ of "Response"}}{\#\text{ of "Requests"}}$$

This will be due to Collisions and dropped packets due to MAC retry limit reached of both the traffic to the Server and all traffic from the Server.

Note: Includes effect of capturing.

PERForm3 Test (Continuous read Server)
Date: 11-08-1991 Time:14:05:15 File: Perfr26 .dat

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********** Separate S/MM Loops
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Performance test 1 Networks with 15 Workstations each
Attenuation Coefficient = 3.5
Fading Margin = 5 dB Normal Distributed
Extra noise outage = 0 %
SIR = 10 dB
Carrier Sense level = -82 dBm
Server delay = .5 msec + random .5 msec
Workstation delay = 1 msec + random .5 msec
Packet Data length = 512 Bytes
Lost Packet Timeout = 300 msec
Test time = 5 sec
Attenuation offset between Networks = 0 dB

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. . . . . .
. . . . . 6 . 14. . . . . .
. 1 . 9 . . 3 . 11. . . . . .
. . . . . .
. . . . . 7 0 158 . . . . . .
. . . . . 4 . 12. . . . . .
. . . 2 . 10. . . . . 5 . 13. . . . . .
. . . . . .
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Scale = 10 meters per dot.

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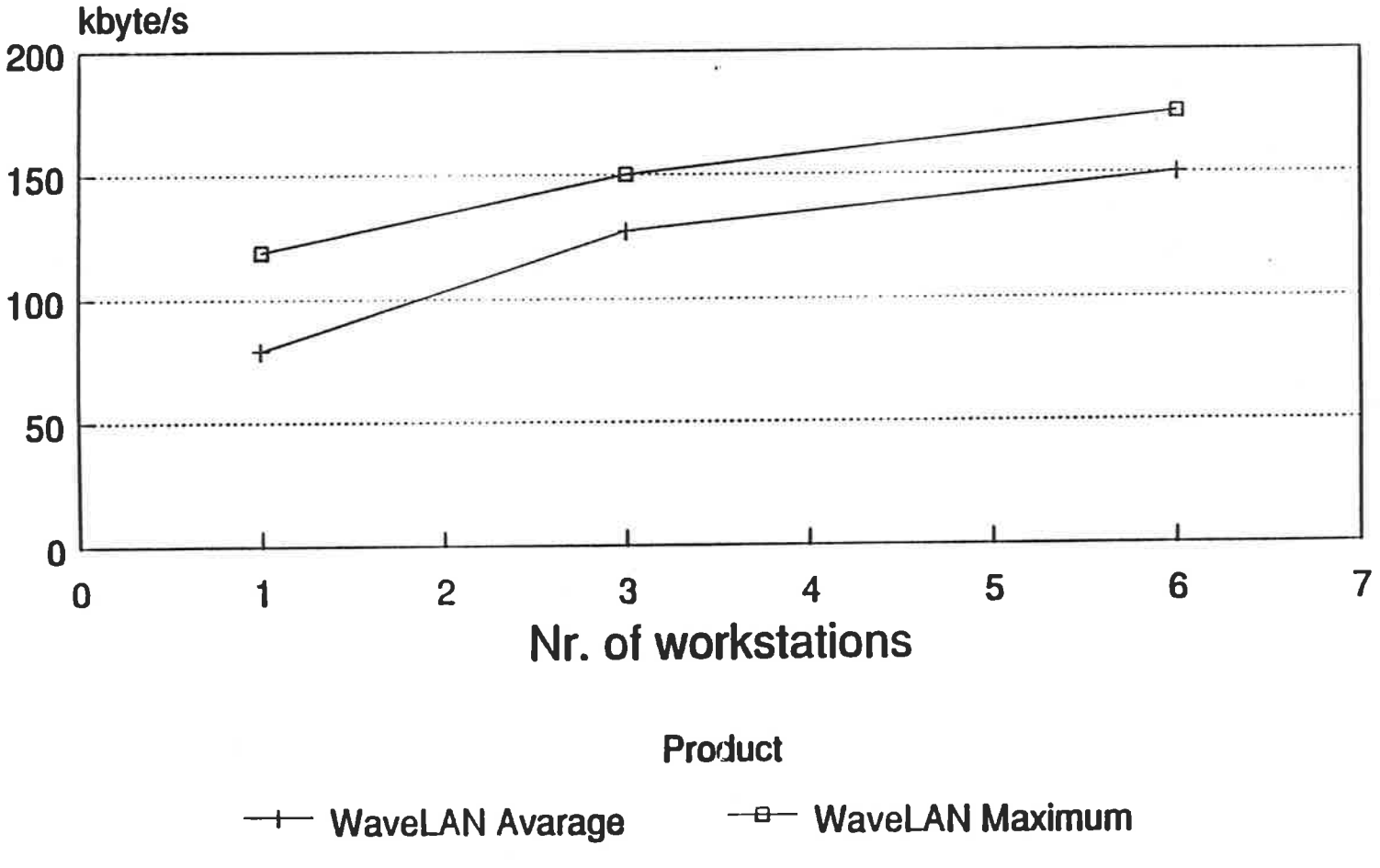
Network-1 # of WS's	Throughput	%Lost	Network-2 Throughput	%Lost	Total
1.0	102.5	0.0	0.0	0.0	102.5
2.0	107.4	0.6	0.0	0.0	107.4
3.0	124.2	1.4	0.0	0.0	124.2
4.0	119.2	2.3	0.0	0.0	119.2
5.0	128.1	2.5	0.0	0.0	128.1
6.0	137.5	2.0	0.0	0.0	137.5
7.0	141.0	1.8	0.0	0.0	141.0
8.0	141.7	2.4	0.0	0.0	141.7
9.0	141.6	2.4	0.0	0.0	141.6
10.0	141.1	4.0	0.0	0.0	141.1
11.0	141.6	3.9	0.0	0.0	141.6
12.0	142.8	2.5	0.0	0.0	142.8
13.0	141.6	3.5	0.0	0.0	141.6
14.0	142.5	2.8	0.0	0.0	142.5
15.0	143.2	1.6	0.0	0.0	143.2

WaveLAN Performance comparison

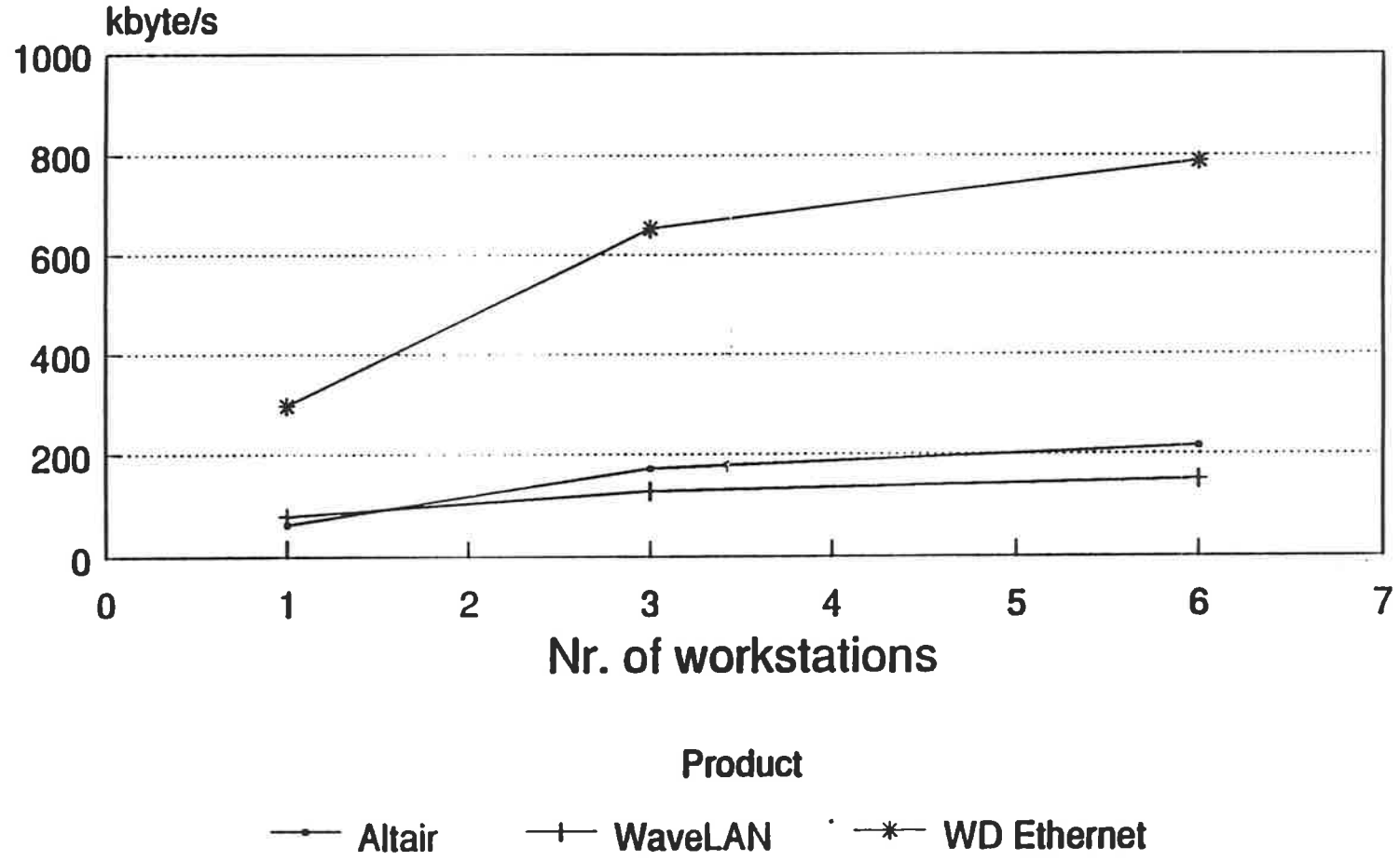
Network throughput



Based on Netware Perform 3

WaveLAN Performance comparison

Network throughput



Based on Netware Perform 3