On the Development of IETF-based Network Monitoring Probes for High Speed Networks

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Introduction

- Currently, there is a large number of high-layer network protocols
- For each high-layer protocol, there is a growing number of applications allowing its usage
- It also exists a growing number of users that use an also growing number of applications directed to an even larger number of protocols
- The ever growing network utilization implies in:
  - constant alterations in the network infrastructure
  - upgrading or buying equipment for newer (and faster) networks

Introduction (continuing...)

Such modifications involve costs, which must be justified

The IETF (Internet Engineering Task Force) has been making efforts to standardize mechanisms that allow characterization and measurement of both protocols and networked applications behavior

Since the end of the 90's, the *rmonmib* working group has been working on MIBs (Management Information Base) which provide accurate network information to the network manager, giving him means to justify investments

These standard MIBs also help in capacity planning, traffic characterization and network optimization

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Project Goals

Our major goal is to provide the network community with a RMON2 compliant monitoring agent, designed to be used in GNU/Linux environments, which should be:

- Efficient, so it can be deployed on shared `x86` workstations or dedicated low-end x86 stations
- Fast, so it can monitor links such as Fast Ethernet, which operates at 100Mbps, with low or even no packet loss at all
- Open and free software, as there is no such implementation available, on the hope of basing other network researches

The Challenge of Network Monitoring

Ethernet is the most widely used network type, whose speed may reach 10Gbps currently

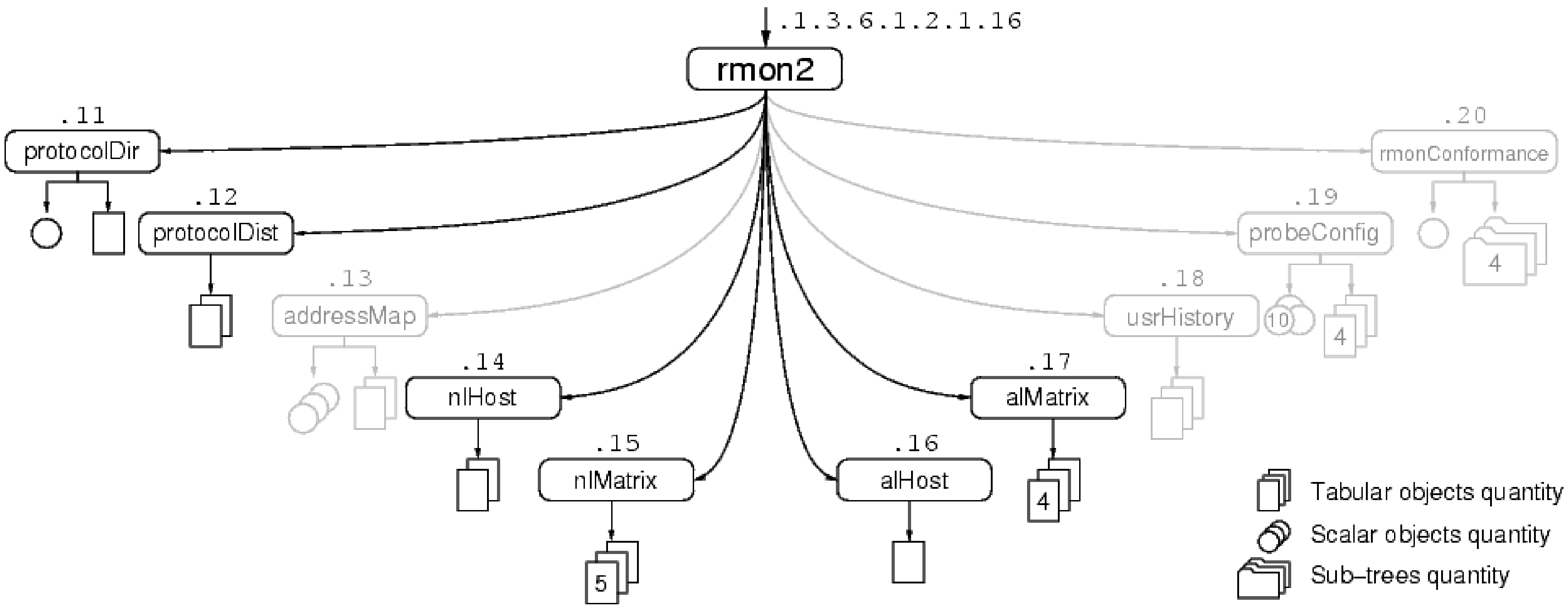
On a 100Mbps Fast Ethernet link, we have:

- packet rates from 8,127 to 148,810 packets per second

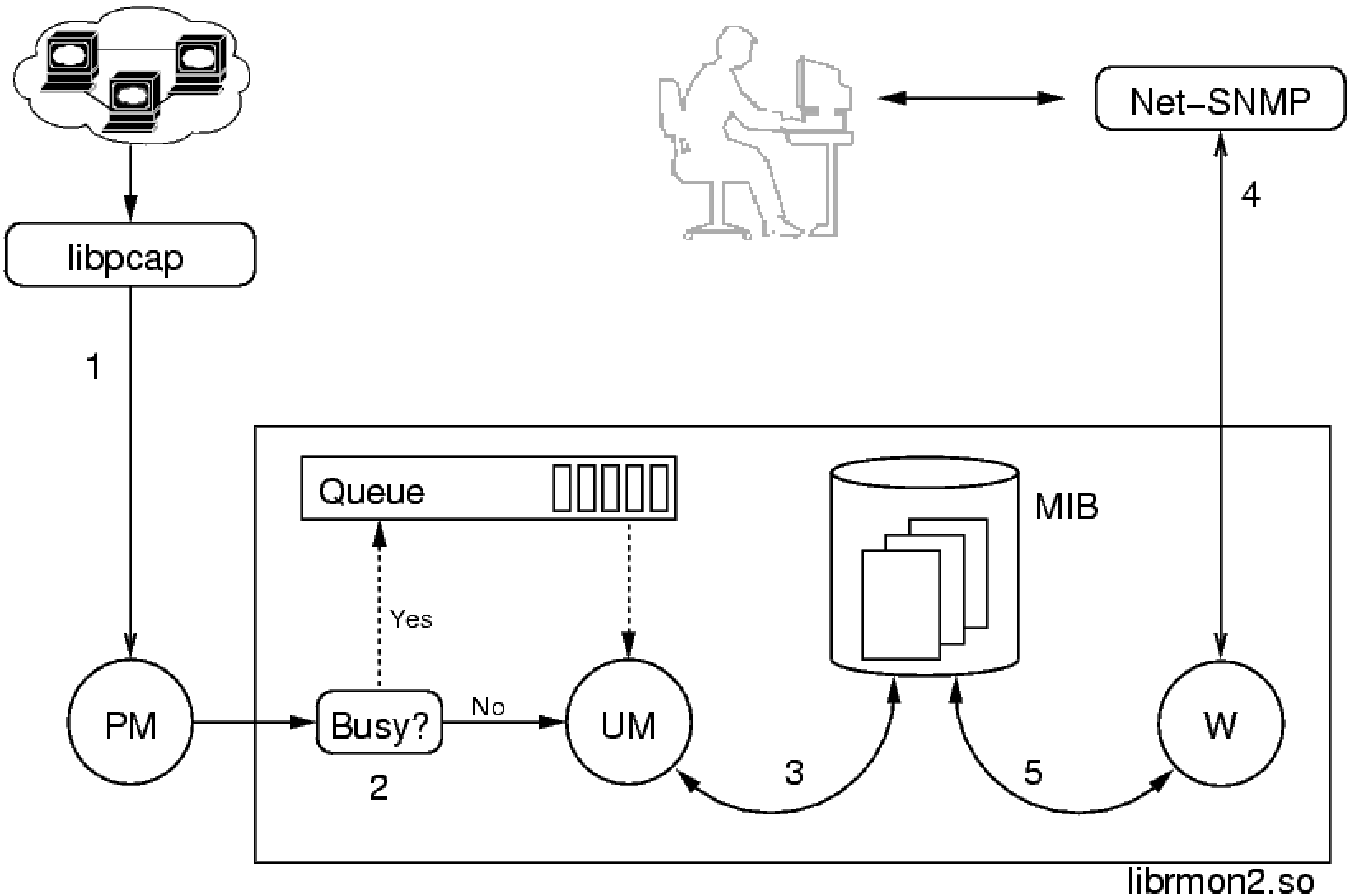
Thus, we have:

- best case of 123.05μs to process a single packet at 8,127 packets per second
- worst case of 6.72μs to process a single packet at 148,810 packets per second

Brief RMON2 Review



Agent’s Architeture



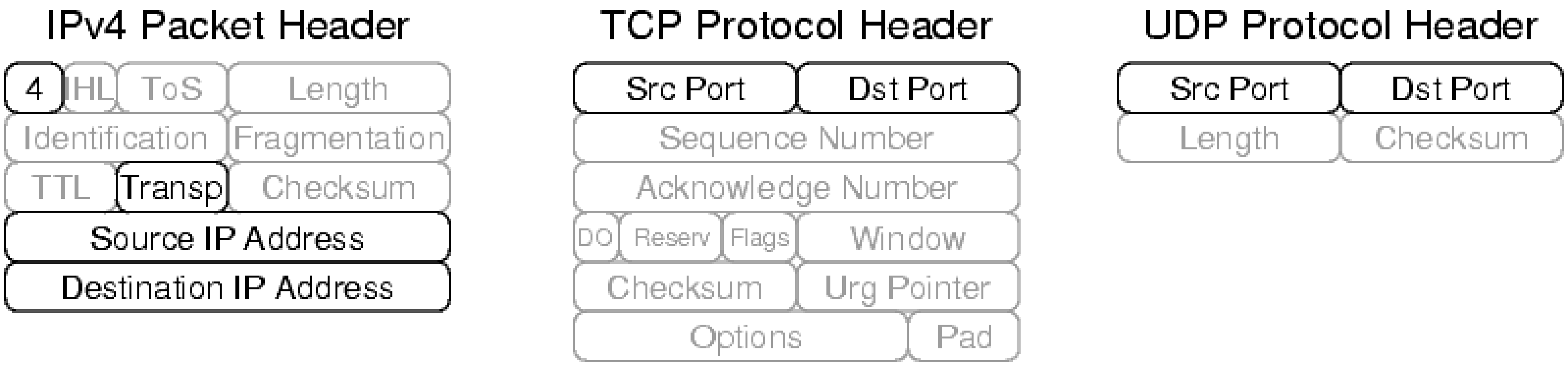
What Does the Agent Collect?

The agent recognizes and analyses only IP over ethernet packets

If so, it looks for IP version 4, discarding the packet if not

Being an IPv4 over ethernet, the agent collects the relevant data: network source and destination addresses, application source and destination ports

Additional info is not on the packet itself, such as network interface and system uptime on packet’s processing



How Does the Agent Store Collected Data?

Simple and small structures are implemented over **array of pointers**, as happens with the **control tables**. They are so simple that any other data structure imposes too much overhead.

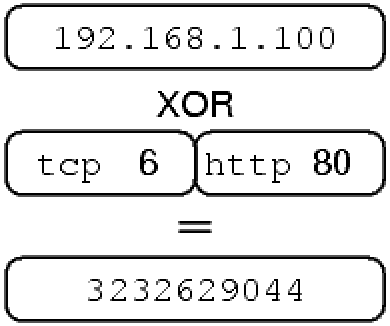
Larger structures (simple or not) are implemented over **hash tables**, as happens with the **data tables**. These structures take advantage from the fast recovery times inherent to hash tables.

The agent uses a hash function known as “double hashing”, which deals better with collisions.

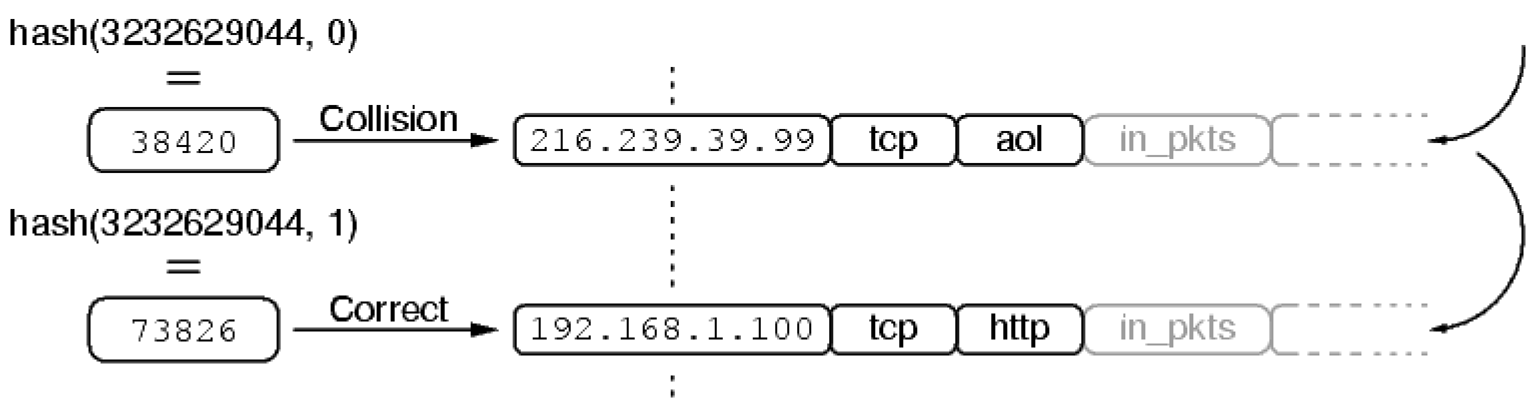
While simpler hash functions deal with collisions by probing another table position within some prefixed range (generally 1, n or n^2), double-hashing probes key-dependant positions, which are almost random. This greatly reduces the chance of a second collision for the same key.

Hash Tables Revisited

First, we create the key to be used in the hash function. We need to pick data which is very intimate to the packet that is very unlikely to be present on other packets, such as the network address. To get better results, we mix some data, like transport and application protocols



Then we apply the hash function over the key, with an initial **offset** of zero to get the first **possible** data index. This index is used to access the hash table, and the position must be checked to see if it's the wanted one. In case of **collision**, the **next** offset is probed.



Example of hash table used in the `alHost` subtree

Performance Analysis of the Agent

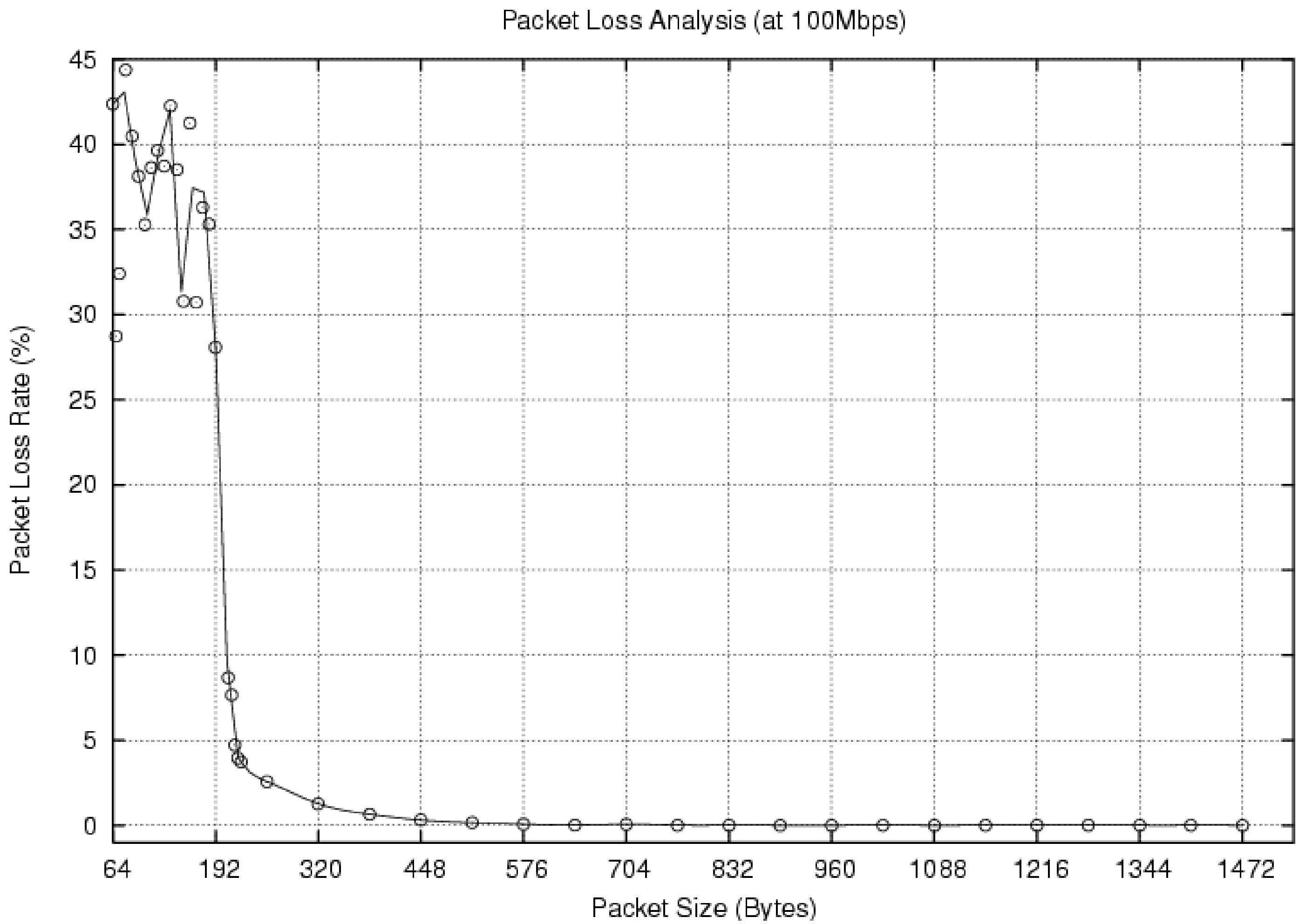
Simple setup, connecting 2 hosts through a crossover UTP cable, at 100Mbps, full-duplex

Agent host is a 1.7GHz Intel Pentium 4, running GNU/Linux Slackware Linux 8.1, with a 2.4.21 Linux kernel (compiled with architeture-specific optimizations enabled)

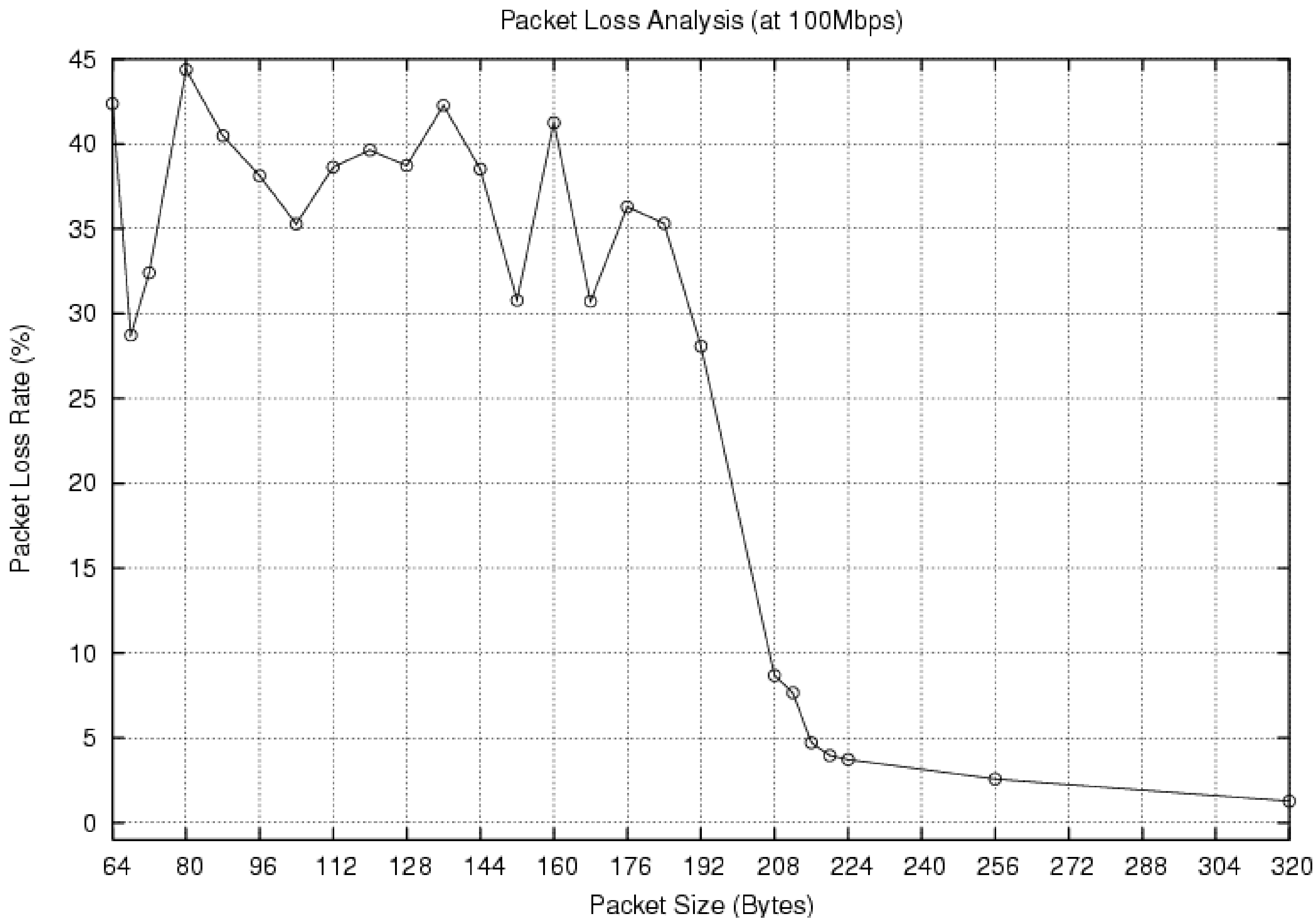
Two test types:

- Stress test to measure agent's limits, consisting in the transmission of the same UDP packet one million times, varying only packet size and without any delay between packets. Linux kernel **packet generator** was used.
- Realistic test, to verify how the agent would behave under real network traffic. A **tcpdump** trace file, containing one million packets (duration of about 30 seconds) was used and replayed at nominal rate.

Stress Test Results



Stress Test Results - Detail



Realistic Test

The test was run 20 times, and the average packet loss was of 23.9608%

We found several factors which contributed to this significative packet loss rate:

- The `protocolDir` cache mecanism still imposes too much CPU usage
- Under heavy network load, the Linux kernel uses a considerable amount of CPU. Measurements showed that this usage can get as high as 48%, due to network card interrupt handler. This was improved on Linux kernels 2.5, and will de available on 2.6.
- `libpcap` default installation presents a small buffer, insufficient to cope with high network load
- The agent is still under optimization to be able to handle this standard MIB efficiently and with lower CPU usage

Conclusions and Future Work

Passive network monitoring demands high CPU power, and thus, any further processing must be very efficient to avoid considerable packet loss rate

As happens with other MIBs standardized by IETF, the large quantity of objects demands a high computacional effort in order to keep these data real-time updated, which turns into a complex task

Althought not tested again, the RMON2 agent is expected to deal a lot better with realistic traffic, due to the `protocolDir` table conversion to hash table

Modifying libpcap is planned, giving it larger buffers to support heavy network load while we design a better solution

Questions?

Thank you!

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The RMON2 Agent is ready to be downloaded!
Please contact us so we can provide instructions