Project 2

Swiss Army Knife Network Sniffer

Course of study	Bachelor of Science in Computer Science
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Abstract

One-paragraph summary of the entire study – typically no more than 250 words in length (and in many cases it is well shorter than that), the Abstract provides an overview of the study.

Contents

1 First Thesis Chapter

1.1 Introduction

What is the topic and why is it worth studying? – the first major section of text in the paper, the Introduction commonly describes the topic under investigation, summarizes or discusses relevant prior research (for related details, please see the Writing Literature Reviews section of this website), identifies unresolved issues that the current research will address, and provides an overview of the research that is to be described in greater detail in the sections to follow.

2 Network Environments

Each environment represents a practical setup in which the Network Swiss Army Knife (nsak) can be deployed for traffic analysis, performance testing, or security evaluation.

2.0.1 Category I: Basic / Local

E 1: Point-to-Point

Diagram: Laptop ↔ nsak ↔ Router

Figure 2.1

Description: Direct inline bridge between client and router. Used for basic LAN capturing, latency and throughput testing.

E 2: Home Network

Diagram: Laptop, Smart Devices, Printer ↔ nsak (inline) ↔ Router

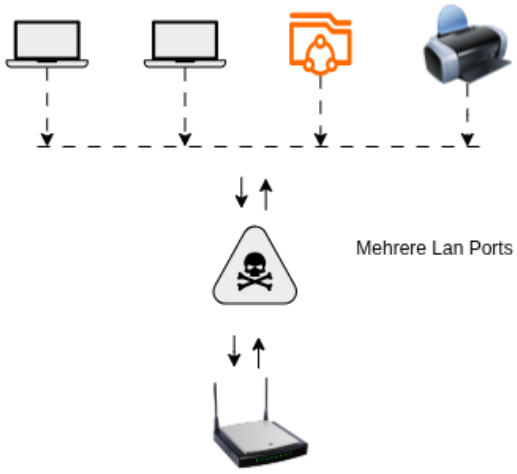

Figure 2.2

Description: Captures typical home traffic. WLAN interface required for Wi-Fi analysis. Useful for IoT discovery and local broadcast observation.

E 3: Business Network

Diagram: Devices ↔ Switch ↔ nsak (inline) ↔ Server / Router

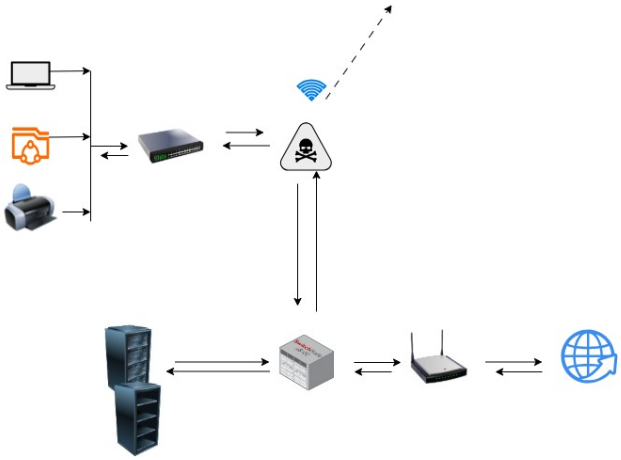

Figure 2.3

Description: Represents a small office LAN. nsak placed at uplink or server edge to monitor internal traffic, VLANs, and broadcast domains.

2.0.2 Category II: Mobile / Wireless

E 4: Access Point Mode

Diagram: Wi-Fi Device ↔ AP-nsak ↔ Internet

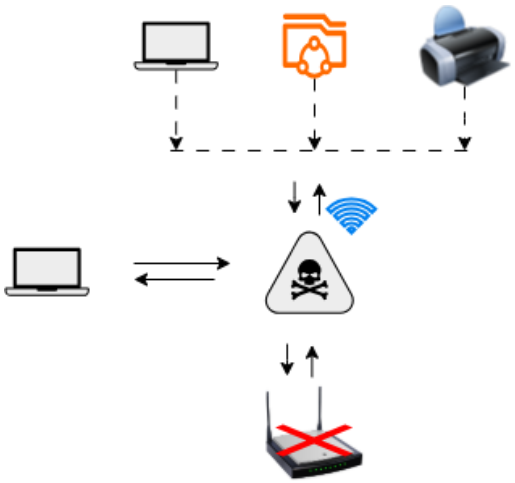

Figure 2.4

Description: nsak acts as Wi-Fi AP, providing connectivity and packet capture. Captures management and data frames for WLAN analysis.

E 5: Mobile Hotspot

Diagram: Smartphone ↔ nsak ↔ LTE/5G
Description: Mobile tethering or hotspot scenario. Focus on NAT behavior, encryption overhead, and power constraints.

2.0.3 Category III: Secure / Advanced

E 6: Data Center / Server Rack

Diagram: Servers ↔ Switch ↔ Firewall ↔ nsak
Description: High-performance setup for 2.5G–10G traffic capture. Focus on throughput, buffering, and VLAN-tagged traffic.

E 7: VPN Gateway

Diagram: Router ↔ nsak (VPN Endpoint) ↔ Remote Peer
Description: nsak configured as WireGuard gateway. Measures encrypted vs.

unencrypted traffic, tunnel stability, and CPU load.

2.0.4 Category IV: IoT / Special Purpose

E 8: VLAN-Segmented Enterprise Network

Diagram: Switch + Router + Multiple VLANs ↔ nsak
Description: Used to verify VLAN isolation and detect inter-segment leaks or misconfigurations.

E 9: IoT Sensor Network

Diagram: IoT Devices ↔ Local Gateway (Broadcast) ↔ nsak
Description: Passive capture of local IoT or broadcast-based communication. Identifies timing, protocol use, and unsecured traffic.

2.0.5 Category V: Virtual / Simulation

E 10: Attack Simulation Network

Diagram: Virtual Attacker ↔ Target VM ↔ nsak **Description:** Virtual lab for testing detection systems, malware traffic, and replay scenarios.

E 11: Remote Management Environment

Diagram: Admin ↔ VPN/SSH ↔ nsak (headless) **Description:** Remote-controlled nsak for automated capture and monitoring in unattended operation.

E 12: Dual-Sniffer Setup

Diagram: nsak-A ‖ nsak-B (same link) **Description:** Two synchronized devices capture the same traffic path. Used for timestamp comparison and hardware validation.

3 Hardware Selection

3.1 Requirements

The following requirements were defined for the hardware platform used in this project:

- At least two native Ethernet interfaces for inline packet sniffing
- Support for 2.5 GbE or higher
- Onboard Wi-Fi with access point (AP) and monitor mode support
- Low power consumption suitable for 24/7 operation
- Compact form factor for laboratory and prototype setups
- Strong community and software support
- Affordable cost (below 150 CHF)

3.2 Evaluated Boards

Several boards were considered as potential variants. Their main specifications relevant to the project are listed in Table 3.1.

Table 3.1: Comparison of Board Variants

Board	SoC / CPU	RAM / Storage	Ethernet Ports	Power (typ.)	Wireless (onboard)
Banana Pi R3 Mini	MT7986A, Quad-core ARM Cortex-A53 @ 1.3 GHz	2 GB DDR4, 8 GB eMMC, microSD	2 × 2.5 GbE	5–7 W	MT7976C, Wi-Fi 6 (AP/Client/Monitor)
Banana Pi R3	MT7986A, Quad-core ARM Cortex-A53 @ 1.3 GHz	2–4 GB DDR4, eMMC, microSD	1 × 1 GbE, 2 × 2.5 GbE, 4 × 1 GbE	7–10 W	MT7976C, Wi-Fi 6
Banana Pi R4	MT7988A, Quad-core ARM Cortex-A73	4 GB DDR4, NVMe option	4 × 2.5 GbE, 2 × 10 GbE (SFP+)	10–15 W	None (M.2 Wi-Fi module required)
Banana Pi R5	MT7988B, Quad-core ARM Cortex-A73	4 GB DDR4, NVMe option	2 × 10 GbE, 2 × 2.5 GbE	12–18 W	None (M.2 Wi-Fi module required)
Raspberry Pi 4	BCM2711, Quad-core ARM Cortex-A72 @ 1.5 GHz	2–8 GB LPDDR4, microSD	1 × 1 GbE (second via USB dongle)	6–8 W	Wi-Fi 5 (AP/-Client only)
Raspberry Pi 5	BCM2712, Quad-core ARM Cortex-A76 @ 2.4 GHz	4–8 GB LPDDR4X, microSD	1 × 1 GbE (second via PCIe card)	8–12 W	Wi-Fi 5 (AP/-Client only)
NanoPi R76S	Rockchip RK3588S, Octa-core (4× Cortex-A76 @ 2.4 GHz + 4× Cortex-A55 @ 1.8 GHz)	16 GB LPDDR4X / LPDDR5, NVMe (option via M.2)	3 × 2.5 GbE (RJ45)	10–15 W	None (M.2 Wi-Fi 6E module recommended)

Table 3.2: Requirements Fulfillment by Candidate Boards

Requirement	R3 Mini	R3	R4	R5	RPi 4	RPi 5	NanoPi R76S
≥ 2 native Ethernet interfaces	✓	✓	✓	✓	✗	✗	✓
RAM > 4GB	✗	✗	✓	✓	✗	✓	✓
≥ 2.5 GbE support	✓ (2×)	✓ (2×)	✓✓ (4×)	✓ (2×)	✗	✗	✓
Onboard Wi-Fi with AP & Monitor mode	✓	✓	✗	✗	✗	✗	✗
Low power consumption (<10 W)	✓	✓/▲	✗	✗	✓	▲	✓
Compact form factor	✓	✗	✗	✗	✓	✓	✓
Strong community & software support	✓	✓	▲	▲	✓ (general)	✓ (general)	✓
Suitable for inline packet sniffing	✓	✓ (overkill)	▲ (overkill)	▲ (expensive)	✗	✗	✓

Legend: ✓ = Requirement fulfilled, ✗ = Requirement not fulfilled, ▲ = Partially fulfilled / limited

3.3 Decision

Based on the defined requirements and the evaluation of alternatives, the **Banana Pi R4** and the**NanoPI R76S** are most suitable hardware platform for this prototype implementation.

The Banana Pi R4 offers two native 2.5 GbE interfaces for inline sniffing the board is compact, affordable, and supported by a strong community. In Addition, the two 10 GbE SFP+ ports provide flexibility for extensions as fiber-based packet capturing. A drawback of the R4 is the weaker CPU and a larger size compared to the NanoPI R76S

The NanoPi R76S is more compact and provides up to 16GB of RAM, which is advantageous for memory intensive processing and buffering tasks. While it lacks built-in Wi-fi, it can be expanded via the M.2 Wi-Fi 6E module. It can not host both a Wi-Fi card and NVMe SSD simultaneously. Consequently, data storage must be provided via microSD card or external USB SSD

Alternative boards such as the Banana Pi R3 Mini, R3 are limited overall performance. Rasberry PI 4 or 5 offer higher single core performance but were ultimately discarded because they provide only a single native Ethernet interface, requiring external adapters that reduce performance for inline sniffing scenarios.

4 Second Thesis Chapter

4.1 Implementation

4.1.1 Architecture

Declaration of Authorship

I hereby declare that I have written this thesis independently and have not used any sources or aids other than those acknowledged.

All statements taken from other writings, either literally or in essence, have been marked as such.

I hereby agree that the present work may be reviewed in electronic form using appropriate software.

October 9, 2025

Frank Gauss (gausf1) and Lukas von Allmen (vonal3)

Bibliography

List of Figures

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Listings

Glossary

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  ```
  \usepackage[automake]{glossaries-extra}
  ```

- Run the external (Lua) application:

  ```
  makeglossaries-lite.lua "documentation"
  ```

- Run the external (Perl) application:

  ```
  makeglossaries "documentation"
  ```

Then rerun LaTeX on this document.

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.1 First Appendix Chapter

.1.1 Project 2 Proposal