

# Project 2

Swiss Army Knife Network Sniffer

Course of study

Bachelor of Science in Computer Science

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# Abstract

We describe the NSAK as an embedded, modular, open source, scenario-based network sniffing and security framework. We provide an overview of the system design, emphasizing the functionality of a Swiss Army Knife in a networking context. The attack scenario includes drills that configure or target a specific task to observe or open an attack vector in the system. Nsak is based on a core backend part that manages specific environments, scenarios, and drills. The whole concept is based on containerization, where each container builds or prepares a scenario that can be triggered in a network environment. In the analogy of the Swiss Army Knife, the right knife with the proper drills for the necessary task can be selected. Modularity comes into play when a drill is selected across multiple scenarios.

Keywords Network intrusion detection, Network Monitoring, Red/Blue Team

## Rules to apply

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.

Mit Regeln von Abstract gegenchecken und querlesen

Inhalt Abstract – Hintergrundinformationen wie Ausgangslage, Relevanz, Forschungskontext in ein bis zwei Sätzen zusammenfassen. – Fragestellung und Ziel explizit formulieren. – Die wichtigsten Eckpunkte zum methodischen Vorgehen angeben, bei empirischen Studien auch Angaben zu den Daten wie etwa die Charakteristika der Stichprobe. – Im Hauptteil des Abstracts die relevanten Ergebnisse und deren Bedeutung mit wichtigen Kennzahlen aufführen (ca. zwei Drittel des Abstracts). – Mit wichtigen Schlussfolgerungen oder Anwendungsmöglichkeiten das Abstract abrunden. – Das Abstract enthält keine Quellenverweise



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# 1 First Part Thesis

2.2 Einleitung Die Einleitung führt einerseits zum Thema hin (Ausgangslage), und informiert andererseits darüber, warum (Fragestellung/Problem) und wozu (Ziel/Zweck) es die Arbeit gibt sowie ggf. wie sie zustande gekommen ist (methodisches Vorgehen). Die Einleitung kann je nach Umfang und Thema mit oder ohne Unterkapitel verfasst werden. Sie umfasst ca. 5-10 Einen Überblick über die Kapitel der Arbeit gibt es höchstens bei sehr langen Arbeiten (beispielsweise Masterarbeit). Die Ausgangslage beschreiben – Relevanz: Warum ist dieses Thema überhaupt bedeutsam? Schon hier gilt es, nicht einfach etwas zu behaupten, sondern Fakten und Aussagen mit Fachliteratur zu belegen. – Aktualität: Gibt es einen aktuellen Bezug? – Zusammenhang: Wie lässt sich das Thema einordnen? In welchem fachlichen Kontext steht die Arbeit? – Forschungsstand: Was ist schon erforscht? Gibt es bereits Untersuchungen? (Ist-Zustand und Zusammenhang mit dem eigenen Thema.) Je nach Art und Umfang der Arbeit gibt es zum Wissensstand ein separates Kapitel (siehe 2.3). – Wenn vorhanden externe Auftraggeber, Auftraggeberinnen: Wer sind die beteiligten Partnerinnen oder Stakeholder? – Den Kurs bzw. das Modul, in dem die Arbeit entsteht, erwähnt man auf dem Titelblatt (siehe 4.1). 8 Das Problem und das Ziel darstellen – Zweck der Arbeit: Welche Aufgabe, Herausforderung, welches Problem soll gelöst werden? Warum sollte man die Arbeit lesen? – Fragestellung: Auf welche konkrete Hauptfrage (evtl. mit konkretisierenden Unterfragen) soll im Schlusskapitel eine fundierte Antwort gegeben werden? Ist die Fragestellung genügend eingegrenzt? Gibt es Hypothesen? – Abgrenzung: Wo liegen die Grenzen der Untersuchung (zeitlich, geografisch, thematisch, methodisch, in der Auswahl der Hilfsmittel usw.)? Was wird nicht untersucht? Was kann die Arbeit nicht leisten? – Ziel: Was soll die Untersuchung genau bewirken? Was ist die Absicht hinter der Arbeit? – Erwartung: Was möchte die Arbeit leisten (Nutzen der Untersuchung, Soll-Zustand)? Für welche konkrete Zielgruppe sind die Ergebnisse der Arbeit von Nutzen? Was ist zu erwarten? Was ist nicht zu erwarten? Das methodische Vorgehen andeuten Wie man methodisch vorgeht, wird ausführlich im Methodenkapitel beschrieben (siehe 2.4). Oft erwähnt man aber in der Einleitung bereits in ein bis zwei Sätzen, mit welcher Methode man arbeitet (Literaturarbeit, Umfrage, Entwickeln eines Prototyps, Variantenstudium usw.).

## 1.1 Current State of Research

Der «Stand der Forschung» beantwortet folgende Fragen: – Was wurde zum Thema der Arbeit bereits erforscht (Forschungsstand)? – Auf welche Forschungsarbeiten stützt sich die Arbeit ab? – Welche Theorien oder Konzepte sind für die Beantwortung der Fragestellung relevant? – Welche Begriffe müssen definiert werden? – Welche Normen spielen für die Untersuchung eine Rolle

## 2 Hardware Selection

### 2.1 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)

## 2.2 Evaluated Boards

Several boards were considered as potential variants. Their main specifications relevant to the project are listed in Table 2.1.

Table 2.1: Comparison of Board Variants

Board	SoC / CPU	RAM / Storage	Ethernet Ports	Power (typ.)	Wireless (on-board)
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/Clien-t/Monitor)
Banana Pi R3	MT7986A, Quad-core ARM Cortex-A53 @ 1.3 GHz	2–4 GB DDR4, eMMC, mi-croSD	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 re-quired)
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 re-quired)
Raspberry Pi 4	BCM2711, Quad-core ARM Cortex-A72 @ 1.5 GHz	2–8 GB LPDDR4, microSD	1 × 1 GbE (sec-ond 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 (sec-ond 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 rec-ommended)

Table 2.2: 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	✓ (2x)	✓ (2x)	✓✓ (4x)	✓ (2x)	✗	✗	✓
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

## 2.3 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. Raspberry 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.

## 2.4 Specification

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.

### 2.4.1 Category I - Inline:

**Diagram:** Laptop ↔ nsak ↔ Router

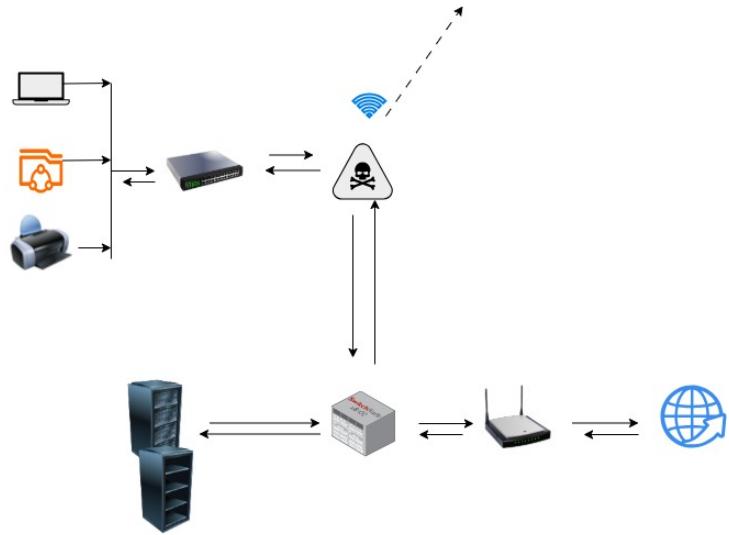


Figure 2.1

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

#### 2.4.2 Category II Wireless:

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

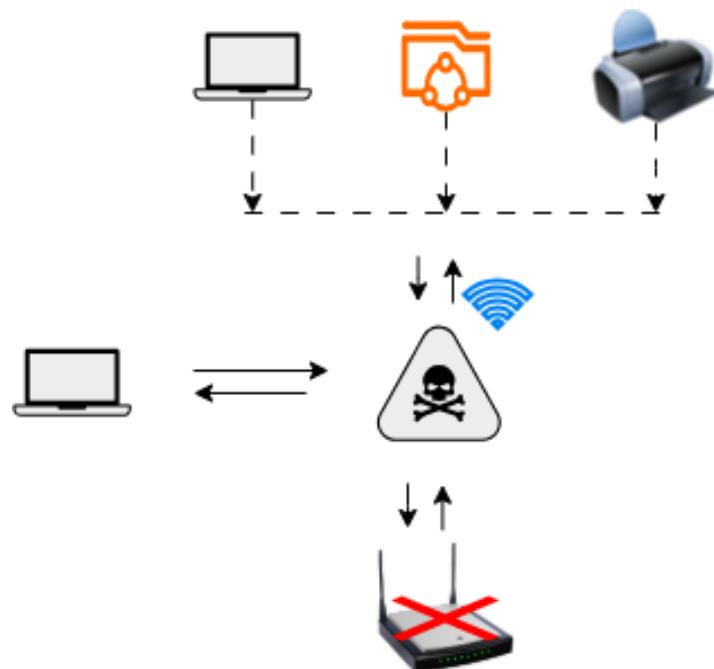


Figure 2.2

**Description:** The nsak is inline and let traffic pass but intercepts as Rouge AP and captures data



# 3 Architecture and Design

## 3.1 Use-Cases

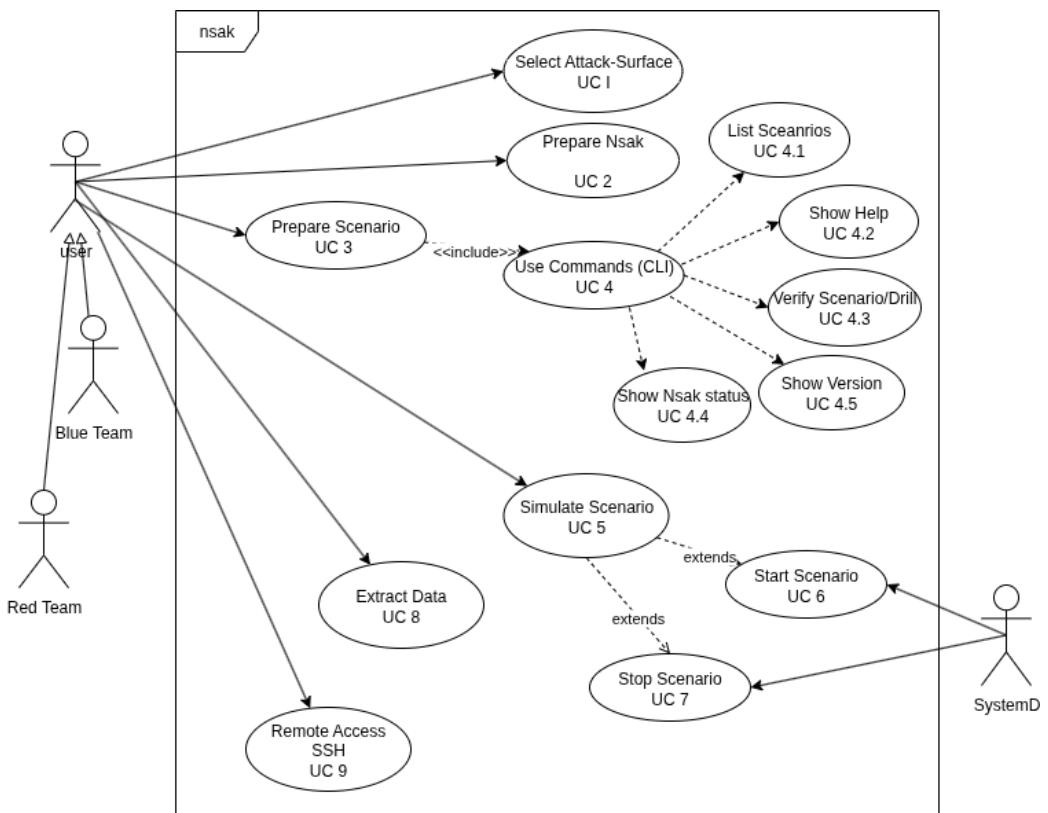


Figure 3.1

Table 3.1: Use Cases Specification (nsak)

NR	Details
UC-02	<p><b>Use-Case:</b> Select Scenarios</p> <p><b>Description:</b> From the chosen environment, the user selects which scenarios (and related drills) shall be executed and orders them by mission priority / noise level.</p> <p><b>Actor:</b> User</p> <p><b>Trigger:</b> User wants to define a mission plan.</p> <p><b>Preconditions:</b> Environment selected (UC-0001); scenario list available.</p> <p><b>Main Scenario:</b></p> <ol style="list-style-type: none"> <li>1. User requests list of scenarios.</li> <li>2. System displays available scenarios with metadata (impact, noise).</li> <li>3. User selects one or more scenarios and sets execution order.</li> <li>4. System validates selection and stores it.</li> </ol> <p><b>Alternative Scenarios:</b> No scenarios available → inform user.</p> <p><b>Error Scenarios:</b> Conflicting resources between scenarios</p> <p><b>Result:</b> Selected scenarios recorded.</p> <p><b>Postconditions:</b> Mission plan saved; ready for preparation (UC-03).</p>

NR	Details
<b>UC-03</b>	<p><b>Use-Case:</b> Prepare Scenario  <b>Description:</b> Load, validate and prepare the selected scenarios: collect drills, resolve dependencies, build container.  <b>Actor:</b> User  <b>Trigger:</b> nsak prepare &lt;scenario&gt;.  <b>Preconditions:</b> Environment + scenario selection available (UC-01/02).  <b>Main Scenario:</b></p> <ol style="list-style-type: none"> <li>1. System fetches referenced drills and their drill.yaml.</li> <li>2. System validates configuration (includes UC-04.3 Verify).</li> <li>3. System aggregates APT/Pip dependencies and resolves conflicts.</li> <li>4. System builds container image / prepares runtime.</li> <li>5. System marks scenario as <i>prepared</i> and logs results.</li> </ol> <p><b>Alternative Scenarios:</b> CI pipeline performs the same steps.  <b>Error Scenarios:</b> Validation or dependency failure → preparation aborted with diagnostics.  <b>Result:</b> Prepared scenario image / runtime available.  <b>Postconditions:</b> Scenario state = <i>prepared</i>.</p>
<b>UC-04</b>	<p><b>Use-Case:</b> Use Commands (CLI)  <b>Description:</b> Unified CLI to manage scenarios (list, prepare, start, stop, verify, status, help, version).  <b>Actor:</b> User  <b>Trigger:</b> User runs nsak &lt;subcommand&gt;.  <b>Preconditions:</b> nsak installed  <b>Main Scenario:</b></p> <ol style="list-style-type: none"> <li>1. CLI parses args and dispatches to subsystem.</li> <li>2. Command executes and writes logs.</li> <li>3. CLI prints structured output and exit code.</li> </ol> <p><b>Alternative Scenarios:</b> Machine-readable output via --json.  <b>Error Scenarios:</b> Invalid args → help; subsystem error → non-zero exit.  <b>Result:</b> Requested action performed or error reported.  <b>Postconditions:</b> State updated accordingly.</p>

NR	Details
UC-04.1	<p><b>Use-Case:</b> List Scenarios</p> <p><b>Description:</b> Show available scenarios for an environment with key metadata.</p> <p><b>Actor:</b> User</p> <p><b>Trigger:</b> nsak list [--env &lt;env&gt;].</p> <p><b>Preconditions:</b> Environment known or provided.</p> <p><b>Main Scenario:</b></p> <ol style="list-style-type: none"> <li>1. System reads scenario manifests.</li> <li>2. System prints table/list (name, desc, noise).</li> </ol> <p><b>Alternative Scenarios:</b> ?</p> <p><b>Error Scenarios:</b> ?</p> <p><b>Result:</b> Scenarios visible to the user.</p> <p><b>Postconditions:</b> User can select scenarios (UC-02).</p>
UC-04.2	<p><b>Use-Case:</b> Show Help</p> <p><b>Description:</b> Provide manual information and examples for CLI/subcommands.</p> <p><b>Actor:</b> User</p> <p><b>Trigger:</b> nsak help</p> <p><b>Preconditions:</b> CLI available.</p> <p><b>Main Scenario:</b></p> <ol style="list-style-type: none"> <li>1. System displays cmd in ordered form.</li> </ol> <p><b>Alternative Scenarios:</b> -</p> <p><b>Error Scenarios:</b> -</p> <p><b>Result:</b> List of all cmds</p> <p><b>Postconditions:</b> —</p>
UC-04.3	<p><b>Use-Case:</b> Verify Scenario / Drill</p> <p><b>Description:</b> Validate scenario.yaml/drill.yaml structure and declared dependencies (syntax + semantics).</p> <p><b>Actor:</b> User</p> <p><b>Trigger:</b> nsak verify &lt;scenario drill&gt;.</p> <p><b>Preconditions:</b> Files present and accessible.</p> <p><b>Main Scenario:</b></p> <ol style="list-style-type: none"> <li>1. System parses YAML and required keys.</li> <li>2. System checks referenced drills and dependencies.</li> <li>3. System reports validation result and diagnostics.</li> </ol> <p><b>Alternative Scenarios:</b> Verification in CI on PRs.</p> <p><b>Error Scenarios:</b> Missing files / invalid YAML → error with line/col.</p> <p><b>Result:</b> OK or detailed error.</p> <p><b>Postconditions:</b> Decision basis for preparation.</p>

NR	Details
<b>UC-04.4 needs to be discussed</b>	<p><b>Use-Case:</b> Show Nsak Status  <b>Description:</b> Present runtime status: prepared/running/stopped scenarios, container ids, last errors.  <b>Actor:</b> User  <b>Trigger:</b> nsak status [&lt;scenario&gt;]  <b>Preconditions:</b> State file prepared ??????  <b>Main Scenario:</b>            1. System reads state file and inspects container runtime.            2. System prints summary and optional details.  <b>Alternative Scenarios:</b> --json for monitoring.  <b>Error Scenarios:</b> Corrupt state → warning + fallback inspection.  <b>Result:</b> User sees current state.  <b>Postconditions:</b> —</p>
<b>UC-04.5</b>	<p><b>Use-Case:</b> Show Version  <b>Description:</b> Display nsak CLI/image version, build meta (commit, build time) and core component versions.  <b>Actor:</b> User  <b>Trigger:</b> nsak version.  <b>Preconditions:</b> CLI installed.  <b>Main Scenario:</b>            1. System prints CLI version, git commit/tag.            2. System prints base image + key tools versions.  <b>Alternative Scenarios:</b> -  <b>Error Scenarios:</b> Return a report.  <b>Result:</b> Version info available for troubleshooting/reporting.  <b>Postconditions:</b> —</p>

NR	Details
UC-05	<p><b>Use-Case:</b> Simulate Scenario</p> <p><b>Description:</b> Run a prepared scenario, monitor runtime and record outputs.</p> <p><b>Actor:</b> User</p> <p><b>Trigger:</b> nsak simulate &lt;scenario&gt;.</p> <p><b>Preconditions:</b> Scenario prepared.</p> <p><b>Main Scenario:</b></p> <ol style="list-style-type: none"> <li>1. System starts containers and services.</li> <li>2. User monitors progress.</li> <li>3. System stores logs and results.</li> </ol> <p><b>Alternative Scenarios:</b> Dry-run with test data.</p> <p><b>Error Scenarios:</b> Container startup failure.</p> <p><b>Result:</b> Simulation finished.</p> <p><b>Postconditions:</b> Results stored</p>
UC-06	<p><b>Use-Case:</b> Start Scenario</p> <p><b>Description:</b> Start a prepared scenario manually or automatically (SystemD).</p> <p><b>Actor:</b> User, SystemD</p> <p><b>Trigger:</b> nsak start.</p> <p><b>Preconditions:</b> Scenario prepared.</p> <p><b>Main Scenario:</b></p> <ol style="list-style-type: none"> <li>1. System reads configuration.</li> <li>2. Launches containers and logs IDs.</li> <li>3. Marks scenario as running.</li> </ol> <p><b>Alternative Scenarios:</b> Auto-start at boot.</p> <p><b>Error Scenarios:</b> Start failure or missing dependency.</p> <p><b>Result:</b> Scenario running.</p> <p><b>Postconditions:</b> State = running.</p>
UC-07	<p><b>Use-Case:</b> Stop Scenario</p> <p><b>Description:</b> Stop a running scenario and persist results.</p> <p><b>Actor:</b> User, SystemD</p> <p><b>Trigger:</b> nsak stop.</p> <p><b>Preconditions:</b> Scenario running.</p> <p><b>Main Scenario:</b></p> <ol style="list-style-type: none"> <li>1. System sends stop signal.</li> <li>2. Saves results and logs.</li> <li>3. Marks scenario as stopped.</li> </ol> <p><b>Alternative Scenarios:</b> Forced stop on timeout.</p> <p><b>Error Scenarios:</b> Process hang.</p> <p><b>Result:</b> Scenario stopped safely.</p> <p><b>Postconditions:</b> Logs persisted, state updated.</p>

NR	Details
<b>UC-08</b>	<p><b>Use-Case:</b> Extract Data  <b>Description:</b> Export logs, pcap files and reports from completed simulations.  <b>Actor:</b> User  <b>Trigger:</b> nsak extract.  <b>Preconditions:</b> Simulation/ mission finished.  <b>Main Scenario:</b>            1. System locates and verifies artifacts.            2. Exports data to chosen directory or archive.            3. Reports export result.  <b>Alternative Scenarios:</b> Filtered export by time or type.  <b>Error Scenarios:</b> Missing artifacts  <b>Result:</b> Data exported.  <b>Postconditions:</b> Export Files created.</p>
<b>UC-09</b>	<p><b>Use-Case:</b> Remote Access SSH  <b>Description:</b> Allow secure SSH access to the nsak host or container for diagnostics.  <b>Actor:</b> Admin / Red Team  <b>Trigger:</b> SSH login attempt.  <b>Preconditions:</b> Authorized key configured; network reachable.  <b>Main Scenario:</b>            1. User connects via SSH.            2. System verifies public key.            3. Access granted to restricted shell.  <b>Alternative Scenarios:</b> Jump host or port forwarding enabled.  <b>Error Scenarios:</b> Authentication failure / blocked key.  <b>Result:</b> Secure shell established or denied.  <b>Postconditions:</b> Access logged; keys remain intact.</p>

## 3.2 Component-diagram

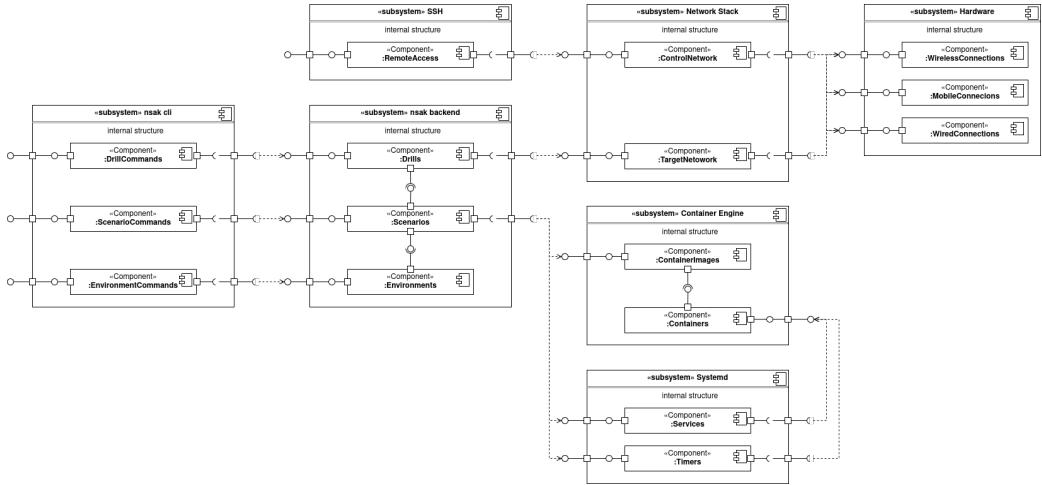


Figure 3.2

## 4 Second Part Thesis: Method

2.4 Methoden Im Methodenkapitel wird aufgezeigt, was (Material, Daten) wie (Methode) untersucht wurde, um die Fragestellung zu beantworten. Das Ziel des Kapitels ist dabei, die Nachvollziehbarkeit und Überprüfbarkeit der Untersuchung für spätere oder weiterführende Arbeiten zu gewährleisten. Dafür muss das methodische Vorgehen wiederholbar festgehalten werden. Das Methodenkapitel hat dabei einen ebenso hohen Stellenwert wie das Ergebniskapitel, denn nur nachvollziehbar erhobene Ergebnisse sind verlässliche Ergebnisse. Was genau im Methodenkapitel festgehalten wird, hängt stark von der methodischen Ausrichtung der Arbeit ab. Je nach gewählter Methodik sollten folgende Inhalte festgehalten werden:

- Welches Material wurde untersucht? (Proben, Prüfkörper, Objekte, Bauteile, Elemente, Software usw.)
- Mit welchen Geräten, Vorrichtungen, Werkzeugen usw. wurde gearbeitet?
- Welcher Probenumfang wurde untersucht? (Stichprobe, Gewährspersonen usw.)
- Wie wurden die Daten erhoben?
- Wie wurden die Daten ausgewertet? (statistische Testverfahren, Software usw.)
- Wo und wie wurde Literatur gesucht, welche wichtigen Quellen wurden verwendet, wie und warum wurden sie ausgewählt?

### 4.1 Implementation

### 4.2 Conclusion



# 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.

December 23, 2025

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## Bibliography



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## Listings



# Glossary

This document is incomplete. The external file associated with the glossary ‘main’ (which should be called `documentation.gls`) hasn’t been created.

Check the contents of the file `documentation.glo`. If it’s empty, that means you haven’t indexed any of your entries in this glossary (using commands like `\gls` or `\glsadd`) so this list can’t be generated. If the file isn’t empty, the document build process hasn’t been completed.

If you don’t want this glossary, add `nomain` to your package option list when you load `glossaries-extra.sty`. For example:

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

Try one of the following:

- ▶ Add `automake` to your package option list when you load `glossaries-extra.sty`.  
For example:

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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 L<sup>A</sup>T<sub>E</sub>X on this document.

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## .1 First Appendix Chapter

### .1.1 Project 2 Proposal