



Faculty of computer science

Course of study Master of computer science

Wi-Fi for time critical applications: Practical measurements and  
evaluation of influencing variables on real time capability

Master Thesis

by

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Rosenheim, the June 25, 2025

Jakob Hasche

# Kurzfassung

text

Schlagworte:

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# **1 Introduction**

## **1.1 Problem description**

## **1.2 Objective**

## **1.3 Motivation**

## **1.4 Layout of the work**

## **2 Basics**

### **2.1 Used Hardware**

### **2.2 Yocto Linux**

### **2.3 Wi-Fi standards**

#### **2.3.1 Quality of Service**

#### **2.3.2 Scheduling**

#### **2.3.3 IEEE 802.11n**

#### **2.3.4 IEEE 802.11ac**

#### **2.3.5 IEEE 802.11ax**

#### **2.3.6 IEEE 802.11be**

### **2.4 Medium Access Mechanisms**

### **2.5 Disruptive factors in Wi-Fis**

### **2.6 Real Time Capability of Wi-Fi**

## **3 Related Work**

### **3.1 RT-Wi-Fi**

### **3.2 Quality of Service in Wi-Fi**

### **3.3 Disruptive factors in Wi-Fi's**

### **3.4 Categorization of this work**

# 4 Test Environment

## 4.1 Test concept

### 4.1.1 Requirements

### 4.1.2 Used Technologies

### 4.1.3 Server and Client Implementation

### 4.1.4 Monitoring

### 4.1.5 Test Automatization

### 4.1.6 Access point configuration

## 4.2 Operating System

### 4.2.1 Requirements

- As less background noise on the system as possible
- Capable for hard real time
- For my test environment the programming languages Python, Rust and the bpftrace library
- Capability to use the Wi-Fi Card
- Network tools, to manage my Wi-Fi interface and generate the workload

### 4.2.2 Implementation

- local.conf
  - set machine to raspberrypi 5
  - set variable *RUST\_LIBC*
  - set preferred linux version to 6.12
  - activated license synaptics-killswitch
- distro (version 5.2.1 on the walnascar branch)
  - for mt7925e is a kernelversion of at least 5.7 necessary
  - walnascar was the newest one to the time of june 2025
- image
  - hostapd

## 4 Test Environment

- dnsmasq
- python3, python3-pip
- net-tools, iproute2, wpa-supPLICANT, iw und networkmanager (Als Netzwerktools um interfaces, etc steuern zu können)
- werden mittels *IMAGE\_INSTALL* hinzugefügt
- Other Layers
  - Poky
  - meta-openembedded (oe, python, networking)
  - meta-raspberrypi
  - meta-rust in layer.conf the branch walnascar had to be added and the *RUST\_LIBC* has to be replaced with `${@d.getVar('RUST_LIBC').lower()}`, and the variable had to be set in the local.conf
- Own layer
  - bb and bbappend files like normal
  - higher priority
  - set layer compatability to walnascar
- RT-Patch
  - from meta-raspberrypi layer only Linux 6.12.1 is given
  - the normal patch is 6.12.28, this is not working
  - from older patches 6.12.8 is working, but QA had to be added
  - also the kernel config needed to be updated, especially the preemt rt and rcu boost, to read copy update and synchronization in the kernel for rt behaviour
- device-tree overlay
  - download pcie-32bit-dma-pi5.dtbo from <https://github.com/raspberrypi/firmware/tree/master/bo>
  - write own recipe which installs the file at `/boot/overlays/`
  - License file has to be created, because it's an own recipe, so the md5 checksum has to be added
  - since Distro 5.1 for `S WORKDIR/sources` has to be set, in this path the files are saved
  - with do install first the folder is created and then the file is saved in the temporary root file system D with the rights 644
  - With `Files:$PN` the file is set from the temporary file system to the final one
  - in the local.conf with *RPI\_USE\_OVERLAYS* and *RPI\_EXTRA\_CONFIG* the overlay is added to the config.txt
  - in meta-raspberrypi/conf/machine/include/rpi-base.inc it has to be added in the *RPI\_KERNEL\_DEVICETREE\_OVERLAYS*
- Custom Files

#### 4 Test Environment

- hostapd
  - \* bbappend in recipes-connectivity/hostapd
  - \* all configs are located in /etc/hostapd
  - \* same procedure like for the device tree overlay
  - \* files are not located in workdir, but in workdir/sources-unpack

---

```
1 def hallo():  
2     print("Hallo Welt")
```

---

## **5 Wi-Fi Modifications**

### **5.1 Quality of Service**

### **5.2 Change of Wi-Fi Standards**

### **5.3 Frequency**

### **5.4 Bandwidth**

## **6 Evaluation**

### **6.1 Test procedure**

### **6.2 Results of low disturbance test**

### **6.3 Results of normal use test**

### **6.4 Results of high disturbance test**

### **6.5 Discussion**



## **7 Conclusion**

## **A Erstes Kapitel des Anhangs**

Wenn Sie keinen Anhang benötigen, dann bitte einfach rausnehmen.

## **Bibliography**