Bachelor's thesis: Medium Access Control for Wireless Regional Area Network

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Outline

Introduction WRAN[1] project

HAMNET[2][1]

- TCP/IP based Wide Area Network
- Operated by radio amateurs
- User access provided in 13 cm band (2.3 - 2.4 GHz)
  - LOS (line of sight) for longer distance data transmissions required

WRAN project [2]

- Initiated by the Austrian Amateur Radio Society ÖVSV[3]
- Novel communication system for providing last-mile access to HAMNET
- Usage of Sub-GHz frequency bands
  - Connections in NLOS (non line of sight) conditions possible
- Radio interface according to IEEE 802.22

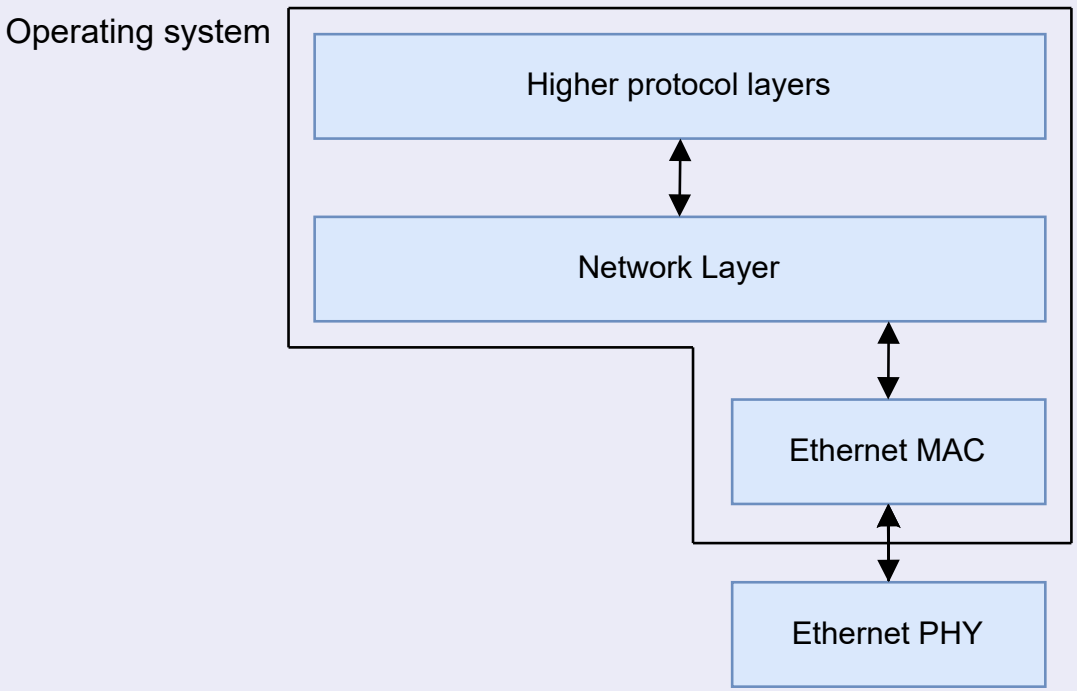
[1] Wireless Regional Area Network
[2] Highspeed Amateur Radio Multimedia NETwork
[3] Österreichischer Versuchssenderverband

Introduction WRAN project

WRAN project implementation [2]

- Implementation on Linux-based Single-board computer
- SDR (Software-defined radio) for signal processing

High-level system architecture



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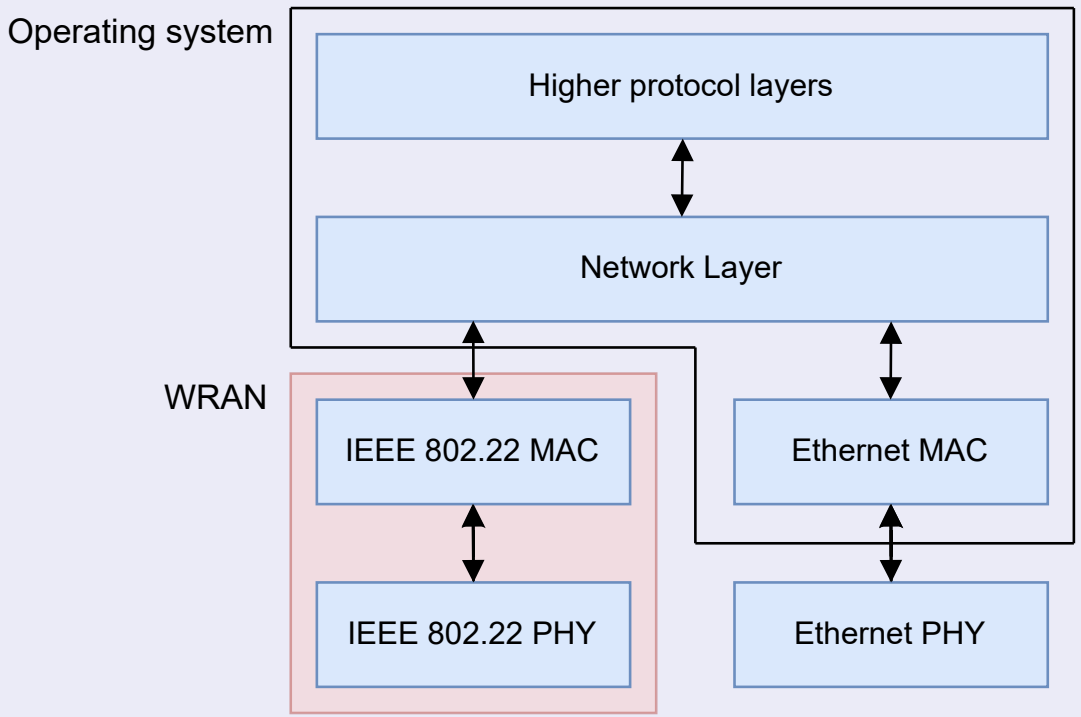

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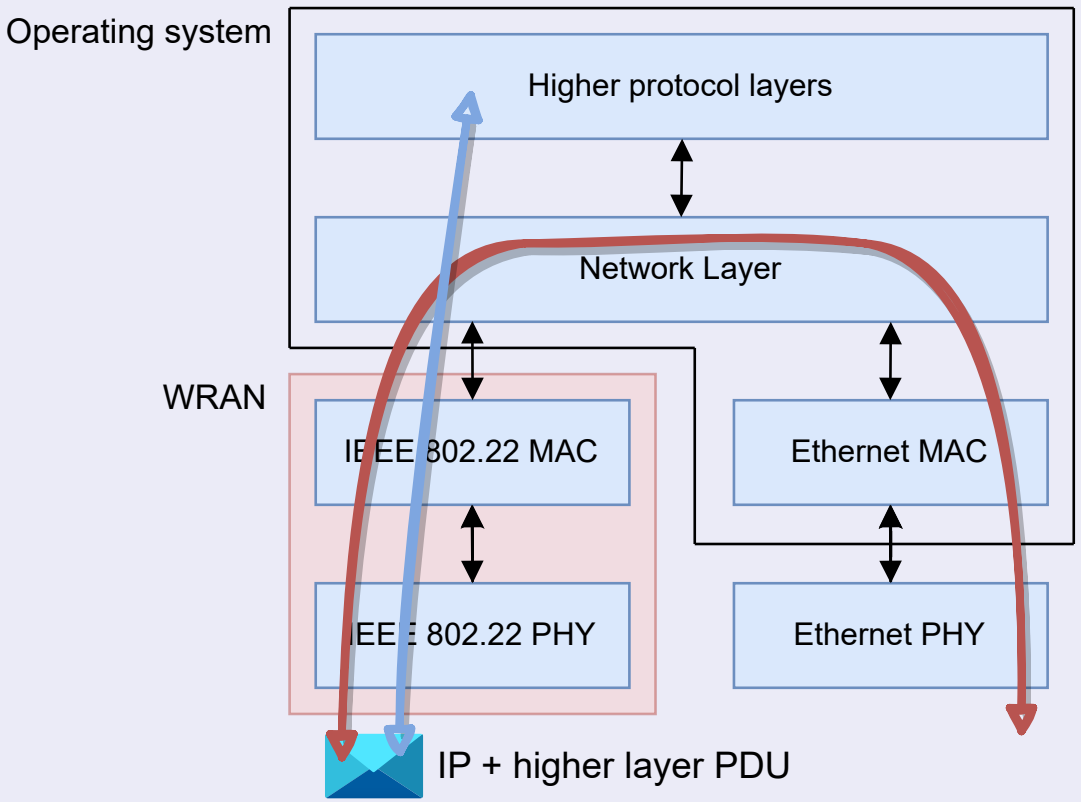


Introduction IEEE 802.22 [3]

IEEE 802.22

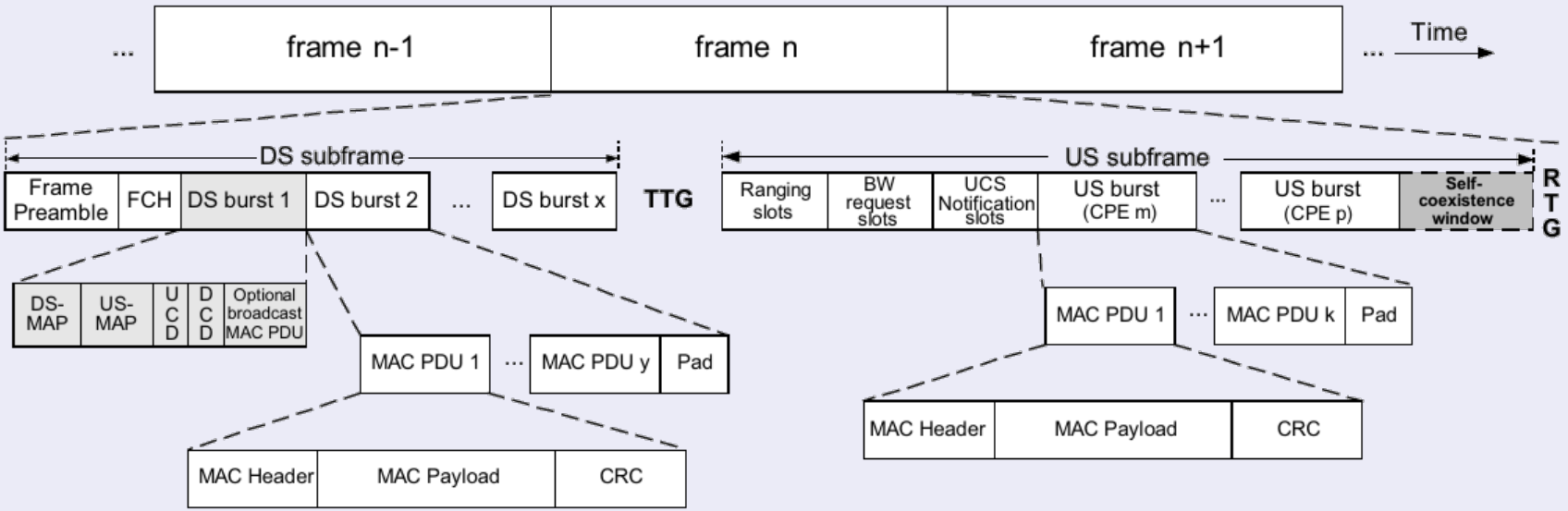
- Point-to-multipoint wireless communication standard
  - Central base station (BS), up to 255 connecting nodes (CPEs)
  - Range typically 17..30 km
- Intended for usage in VHF and UHF frequency bands
  - Cognitive radio features for ensuring coexistence alongside licensed transmissions
- Specifies MAC and PHY

Medium Access Control Layer (MAC)

- Connection-oriented
  - Persistent connection between BS and CPE
- Medium access controlled by BS
- MAC receives higher-layer PDUs and generates fixed-length MAC frames
- PDU fragmentation

Introduction IEEE 802.22 [4]

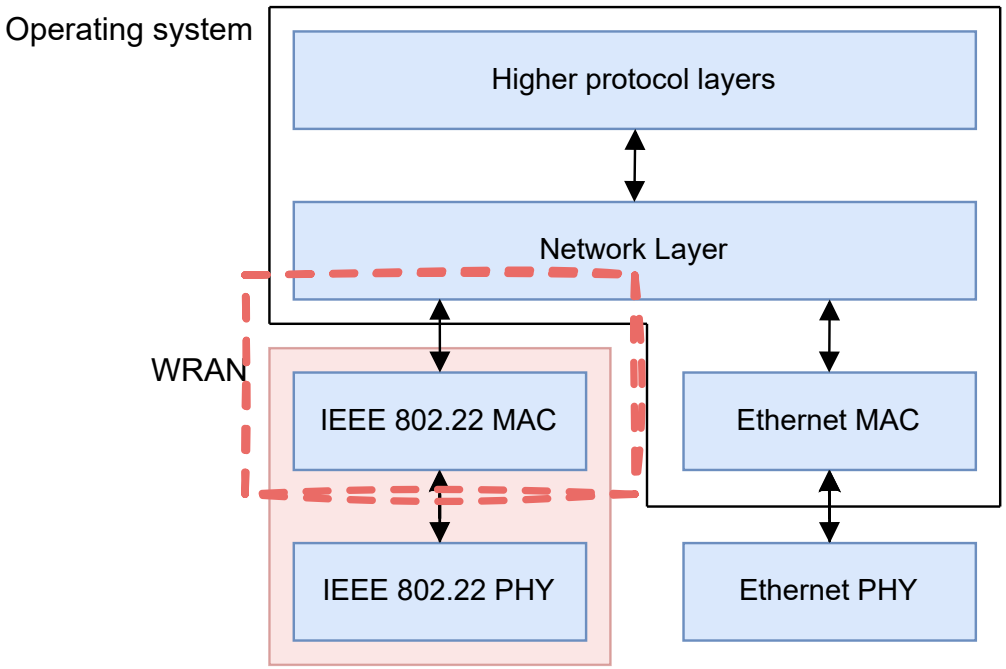
Frame structure



- MAC frame
  - Constant length
  - DS (downstream) and US (upstream) subframe
- DS / US burst
  - Length defined by BS in DS-MAP / US-MAP
- MAC PDU
  - MAC payload: User data or management messages
  - 8-bit CRC over header, 32-bit CRC over entire MAC PDU

Scope of the thesis

- Simple MAC Layer
  - Interface to network stack of the operating system
    - ★ Via TUN interface on OSI Layer 3
    - ★ Transmission of IP packets (SDU of the MAC Layer)
  - Fragmentation
  - Generation of MAC PDUs and DS / US bursts
- Implemented in *Framer* application



Implementation

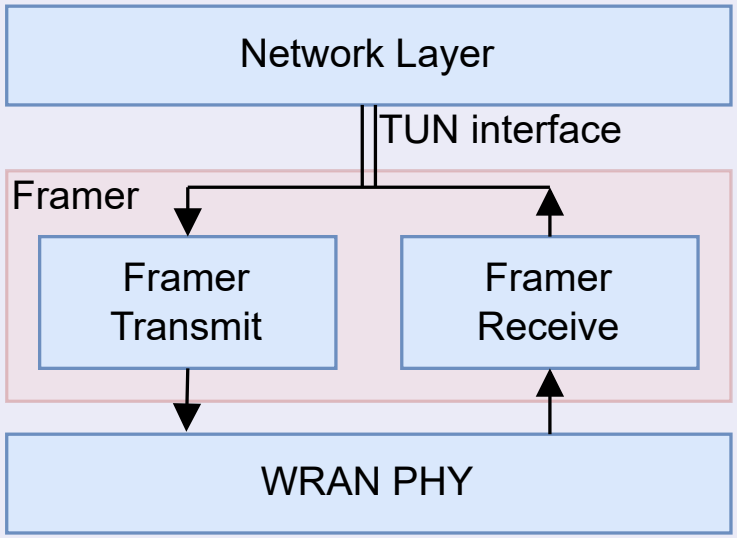
Deviations from the standard

- Data plane
  - Only fragmentation implemented
  - No ARQ, Packing, Encryption
- Management plane & cognitive plane
  - Not implemented

Implementation

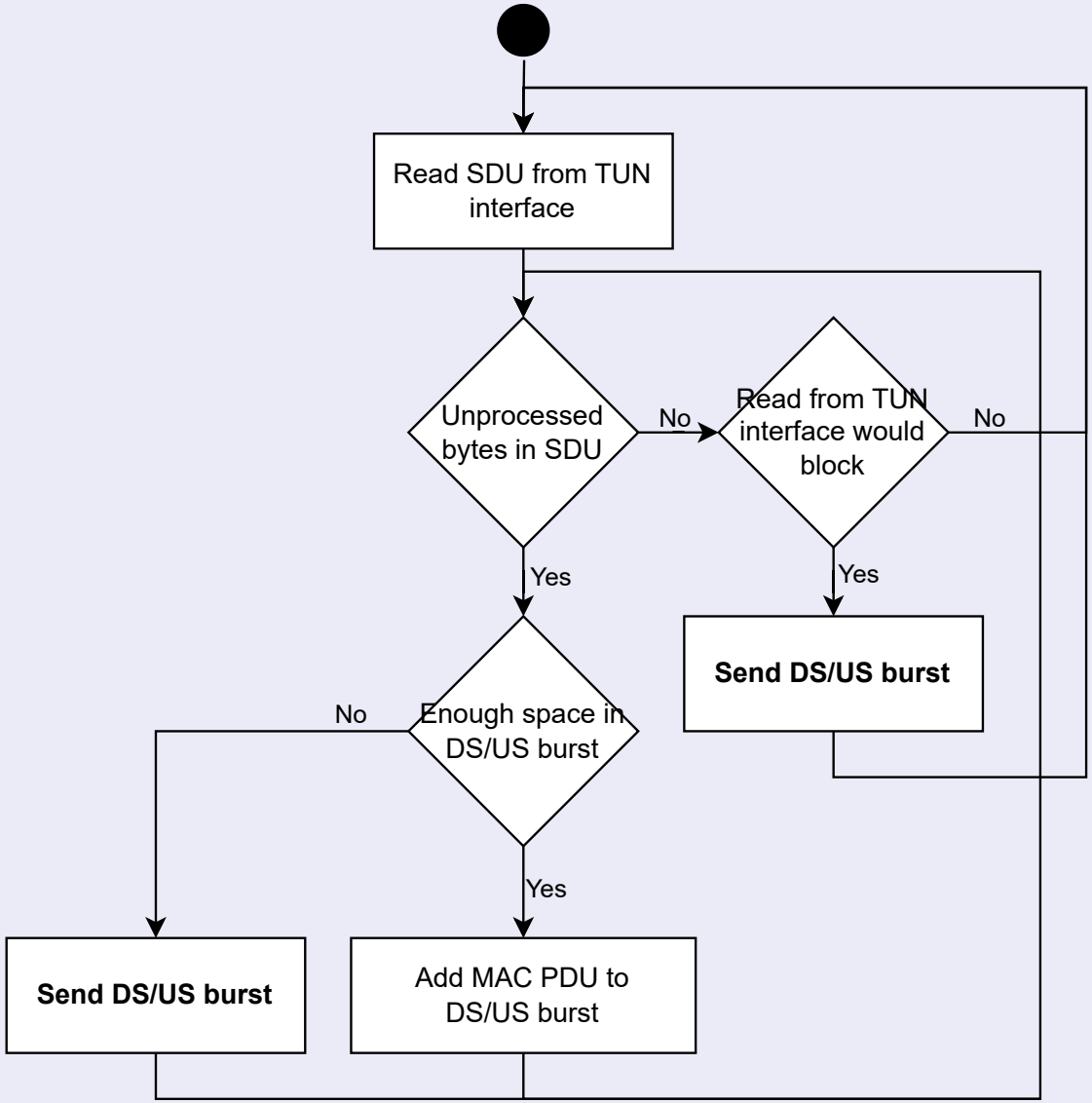
Framer application

- `framer.cpp`
  - Contains `main()` function
  - Initializes TUN interface
  - Creates transmitter and receiver thread
- `framer_transmit.cpp`
  - Reads IP packets from TUN interface
  - Fragmentation of IP packets
  - Generates DS / US bursts
- `framer_receive.cpp`
  - Decodes received DS / US bursts
  - Reassembles fragmented IP packets
  - Writes IP packets to TUN interface



Implementation

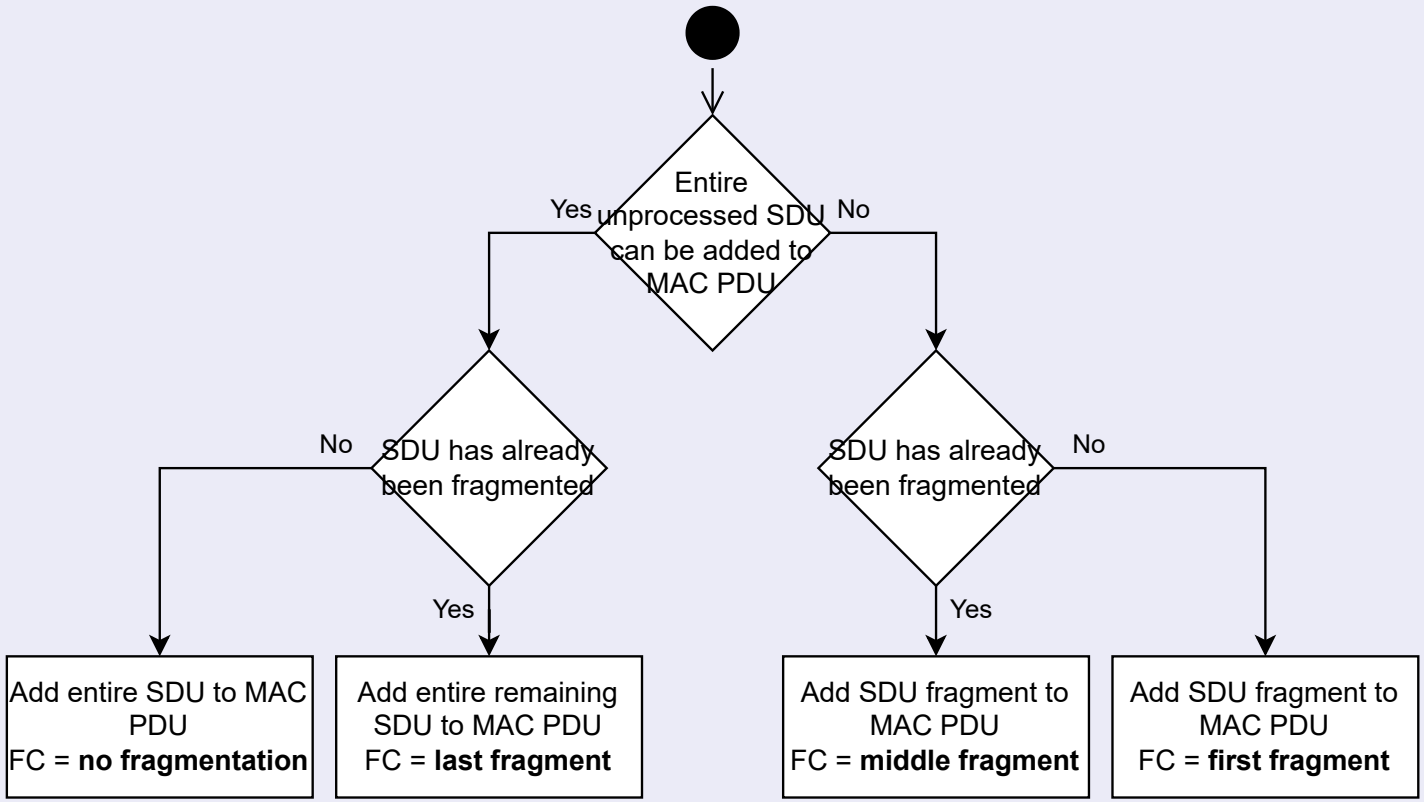
Transmitter



Implementation

- Fragmentation subheader contains required information
  - Fragmentation state (FC field) of MAC PDU
  - Sequence number

Fragmentation state

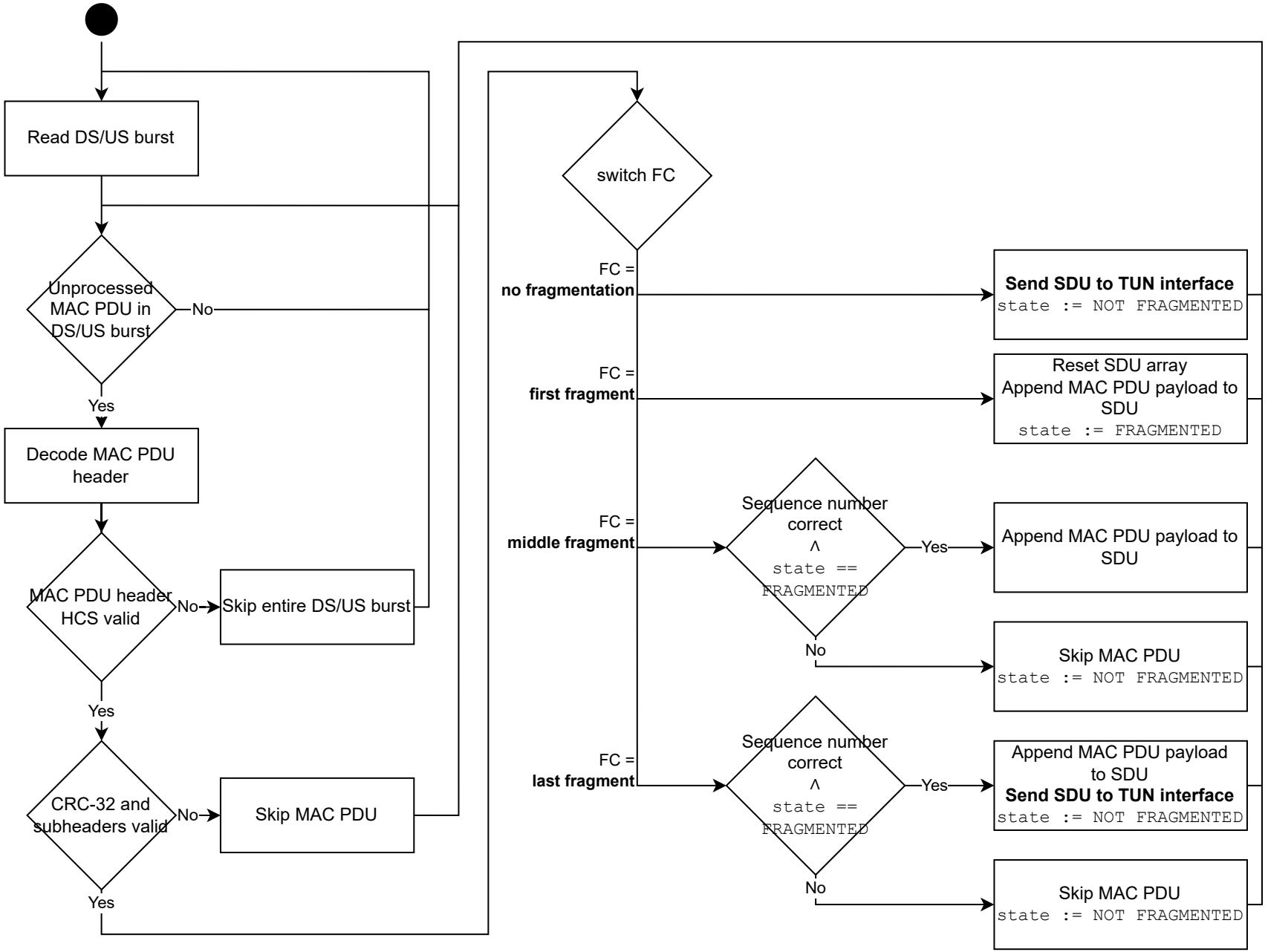


Implementation

Receiver

- Maintains internal state
  - Fragmentation state of last received MAC PDU (`FRAGMENTED` / `NOT FRAGMENTED`)
  - Sequence number of last received MAC PDU
- Internal SDU array to which received fragments are added

Implementation



Implementation

TUN interface

- Created and initialized via systemd-networkd
  - Configuration of IP address, MTU
  - User is granted access to TUN interface
- No root privileges for Framer required

Interface to WRAN protocol stack

- Not implemented
- Prepared interface in the Framer exists

Toolchain

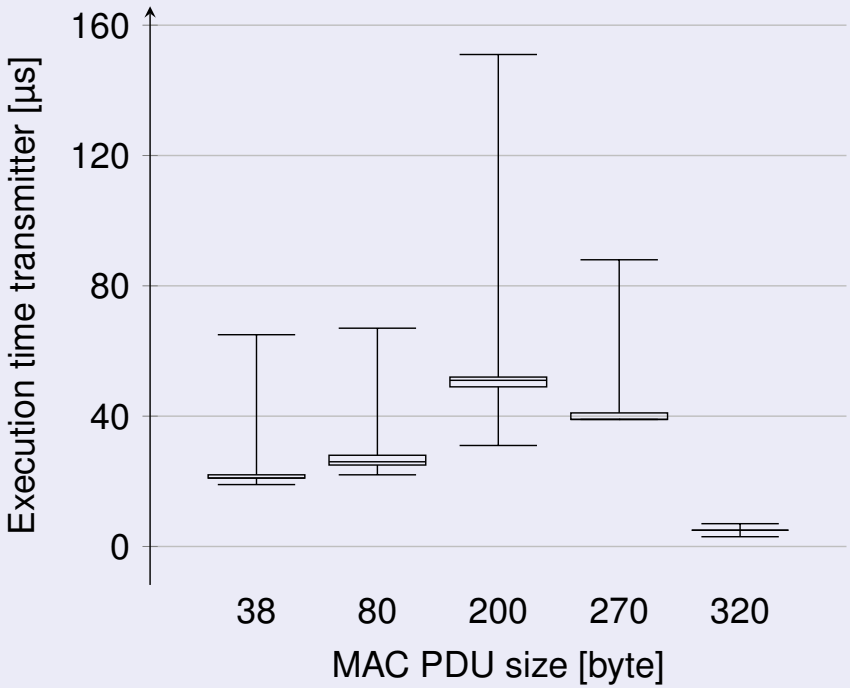
- Programming language: C++
- Compiler: GCC

Evaluation

Execution time

- Duration required to generate/decode a MAC PDU
- DS / US burst length = 320 byte

Transmitter



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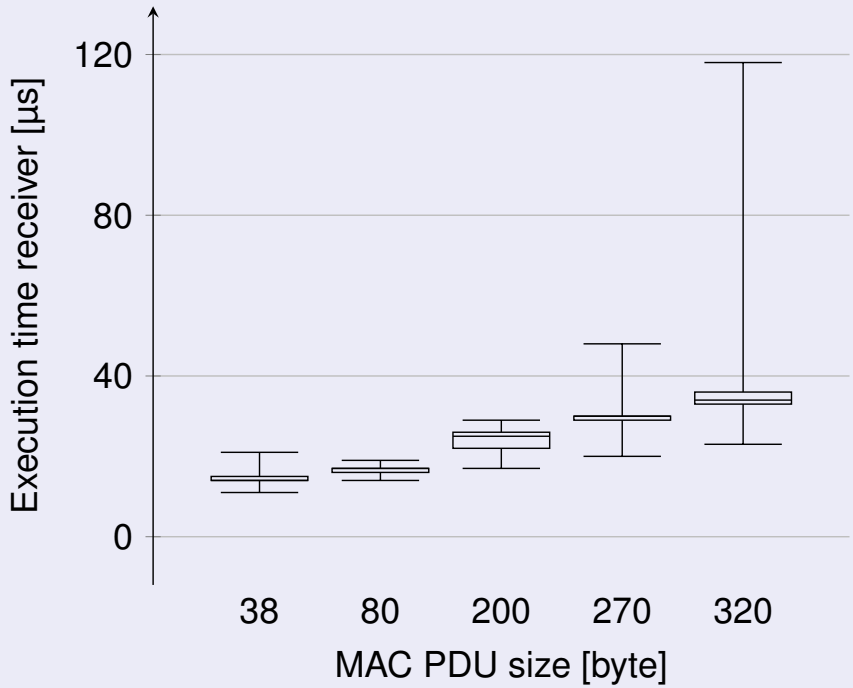
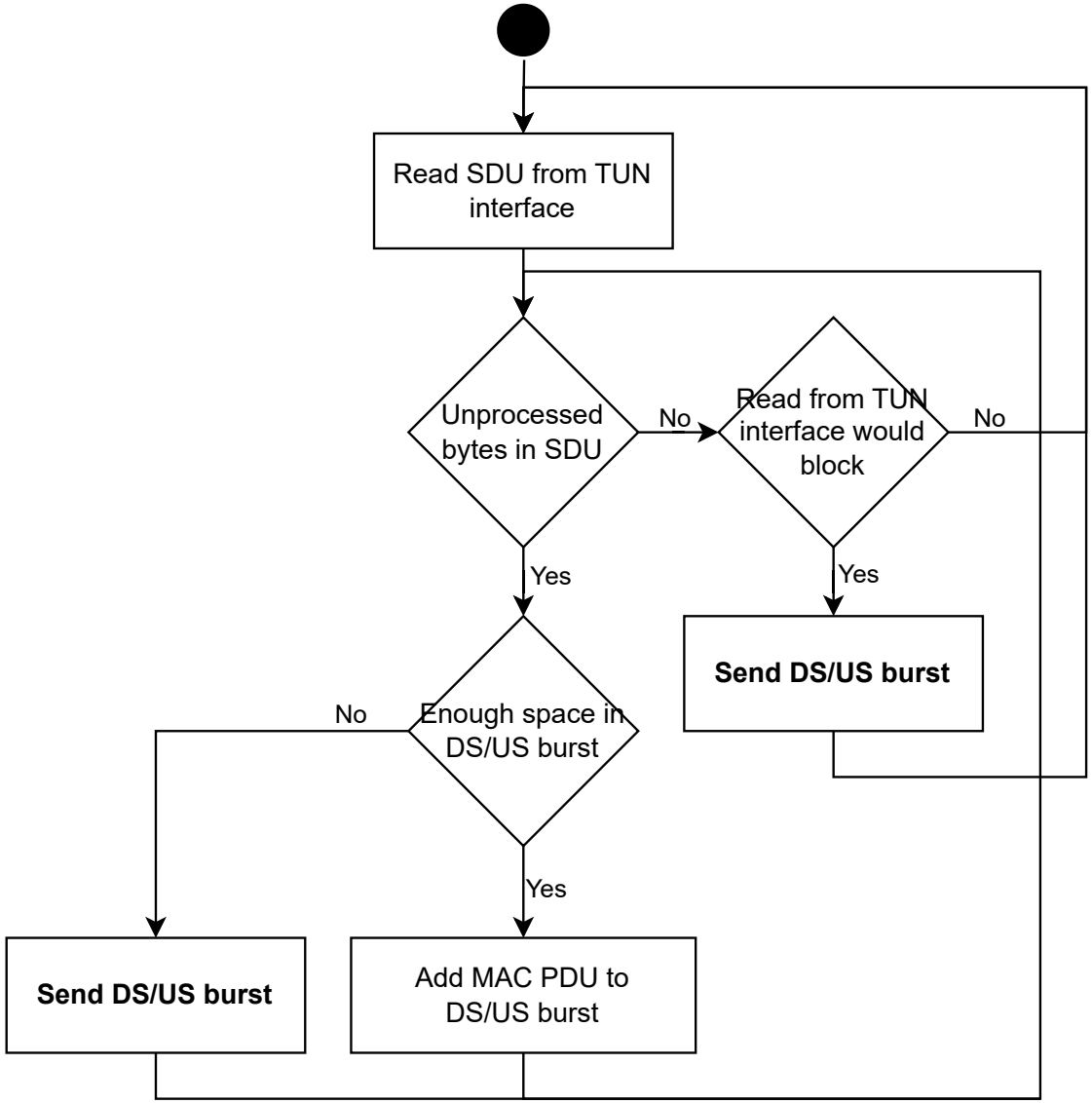


Implementation



Evaluation

TUN interface

- Interface to network stack on Layer 3
  - IP packets are exchanged via the radio link
  - Payload does not contain destination MAC address
  - BS cannot determine target CPE for incoming data
- Alternative: TAP interface
  - Interface on Layer 2
  - Ethernet frames are exchanged via radio link
  - Source/Destination MAC address included in SDU

Conclusion

Conclusion

- Current MAC Layer only provides basic features
  - Simple implementation of the data plane
  - No management and cognitive plane
- Management plane required for intended use case
  - Connection-oriented MAC
  - Ranging
  - US bandwidth scheduling
- TUN interface problematic

References[1]

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[1] References used in the presentation