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RECORDS: a Remote Control Framework for Underwater Networks

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Scenario

- underwater sea trials
- underwater acoustic nodes
- nodes deployed at
  - sea surface
  - sea bottom
  - floating
- no cabled or wifi connection
  - mobile nodes
  - distances of several kilometers

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Introduction

- how to acquire real-time information?
  - status of the node
  - residual battery
  - disk space available
  - SNR of a given link
- how to reconfigure the nodes / network?
- how to start a network experiment?

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RECORDS

- open source framework
- makes it possible to remotely monitor and control a heterogeneous network
- exploits acoustic communications to deliver control messages
- avoids the need to deploy cabled or wireless connections to control each node

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RECORDS

- ready-to-use, lightweight, robust and reliable tool
- very cheap in terms of hardware resources
- easily portable on several embedded systems
- manages in real time network experiments by using the DESERT Underwater framework

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RECORDS

- is composed of four modules
  - remote control
  - startup
  - system profiler
  - log files processor
- the framework has been written using scripting languages
  - Tcl
  - Expect
  - Bourne Shell

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STARTUP module

- watchdog daemon
- reads the parameters passed by the user
- checks that the required network ports are available
- starts other modules in the correct order
- starts the system profiler
- restores other modules in case of errors

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PROFILER module

- keeps track of the CPU and RAM consumption of each component of the framework

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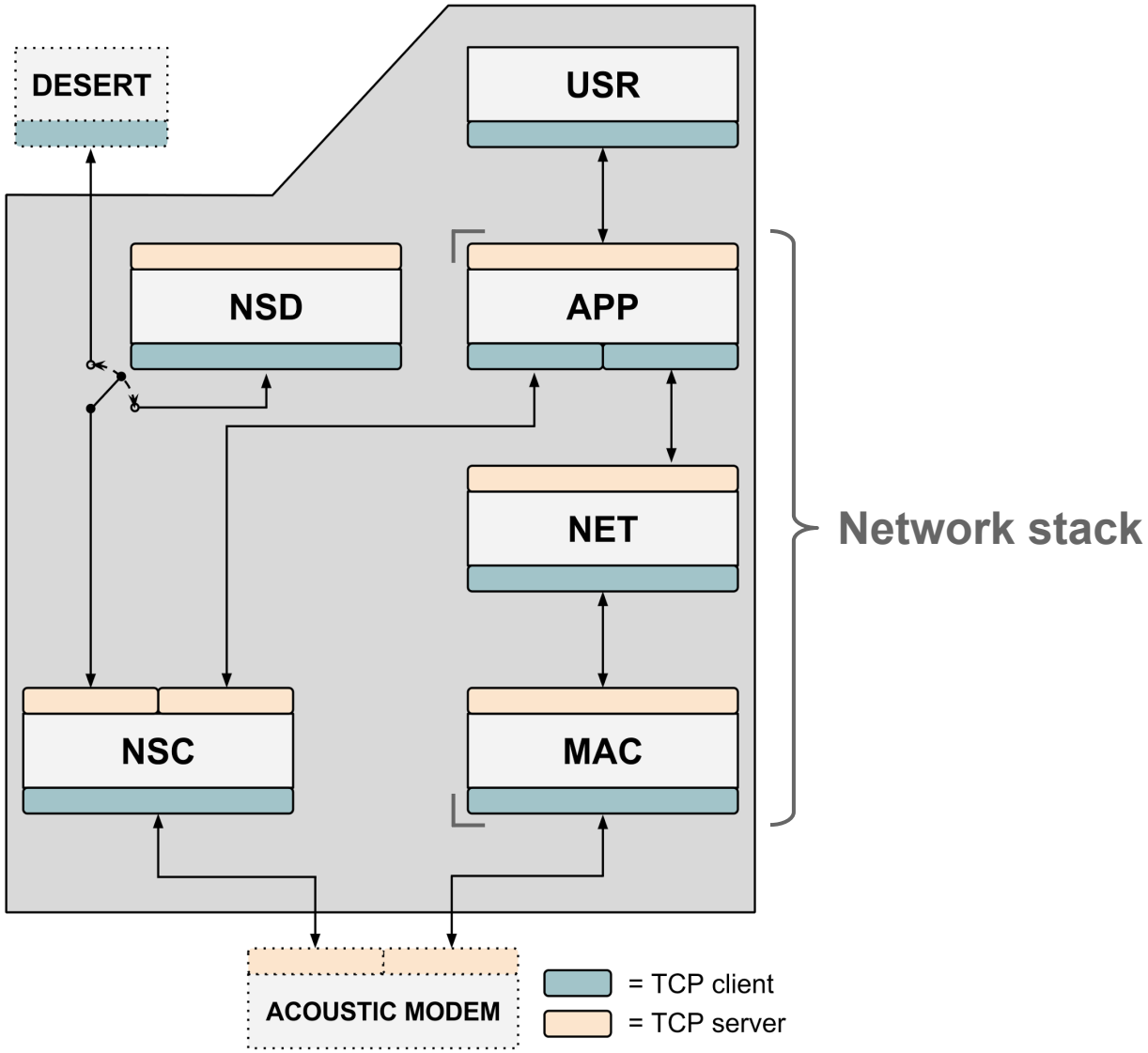
CORE modules



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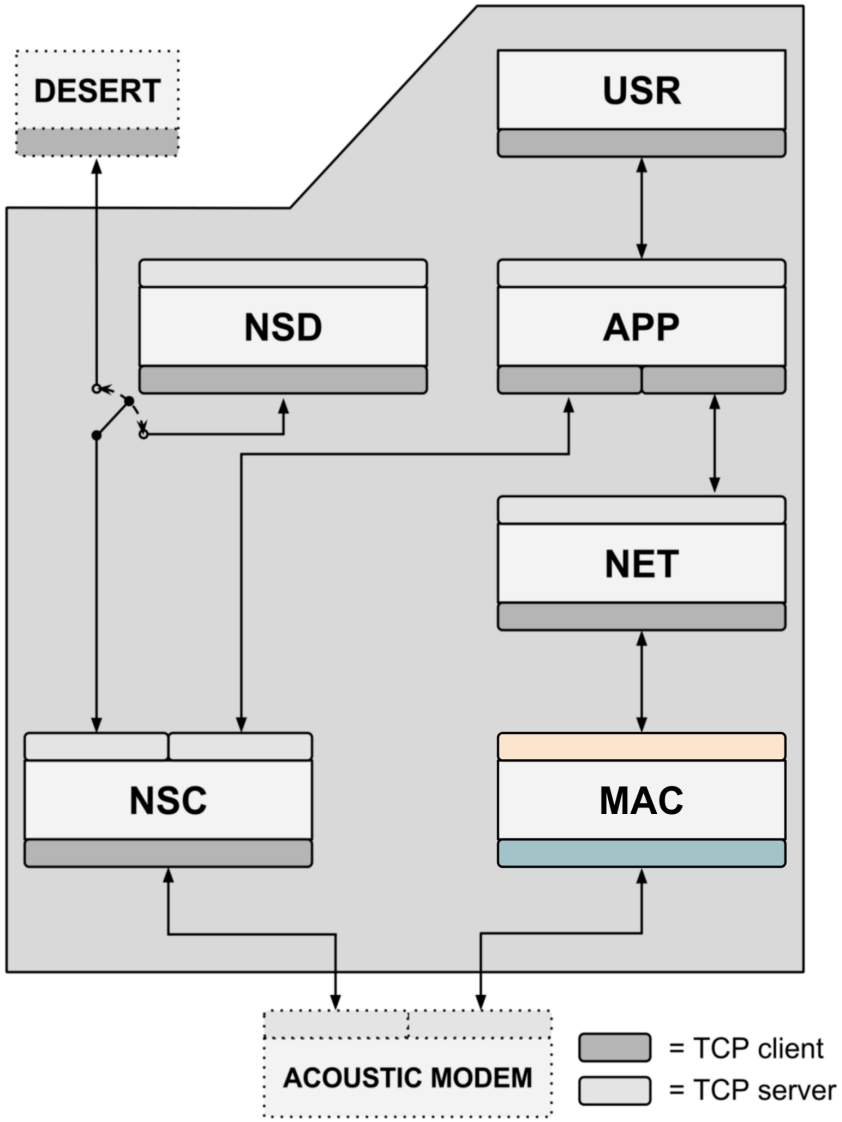
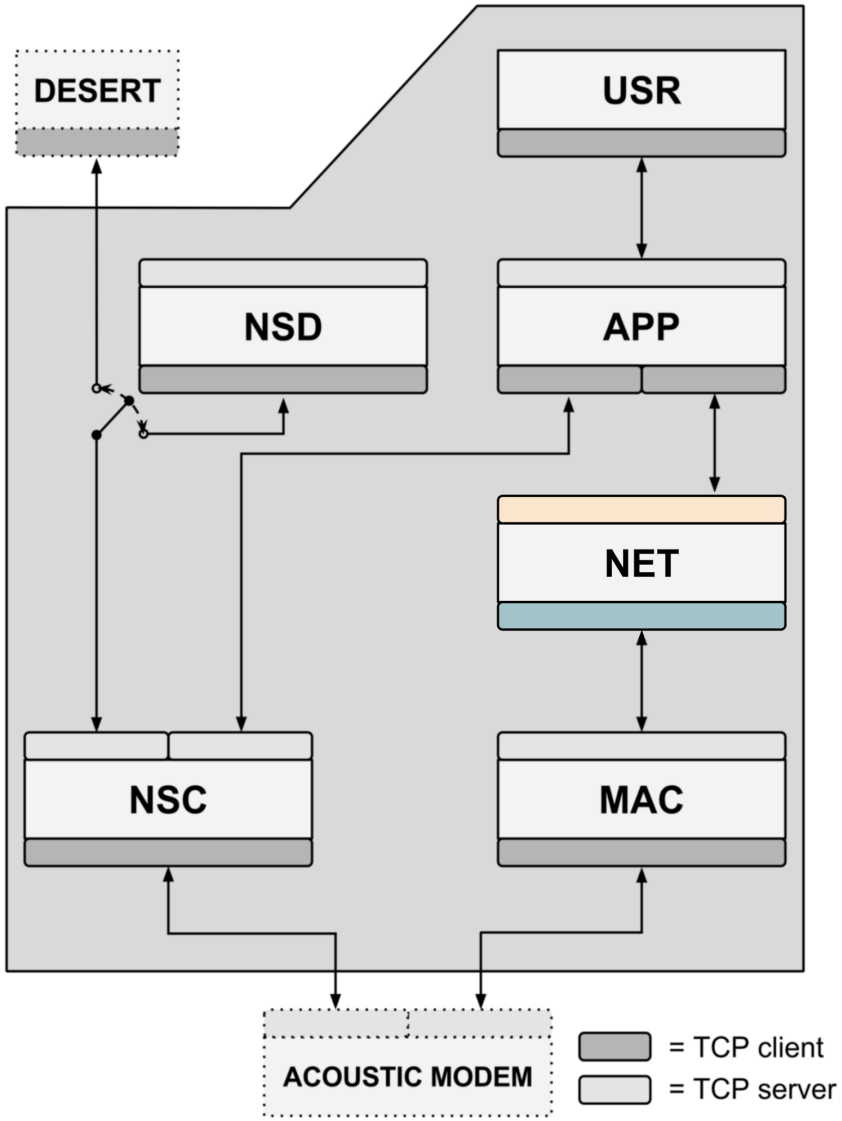
CORE module (MAC)



- interacts directly with the modem to deliver the messages coming from the upper layers and vice-versa
- provides basic multiple access interference mitigation through random back-off delays
- retrieve the multipath structure of the channel and logs it

CORE module (NET)



- implements two routing protocols:
  - static source routing
  - flooding
- each packet can be sent in broadcast, unicast or multicast, using either protocols
- packets sent via different protocols can coexist simultaneously in the network

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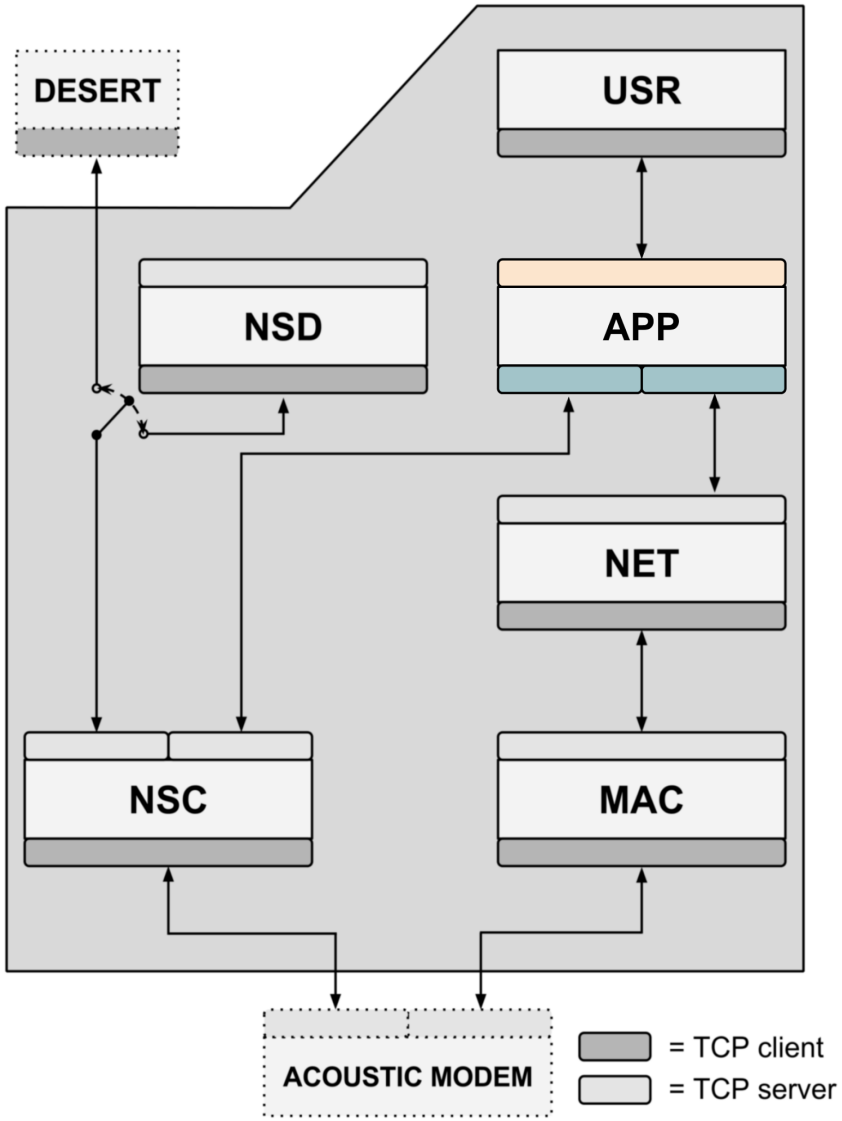
CORE module (APP)



- makes it possible to remotely start or kill instances of DESERT and keeps track of them
- acts as an abstraction layer for the modem
- creates end-to-end acknowledgement messages
- interacts with the operative system to run any system command

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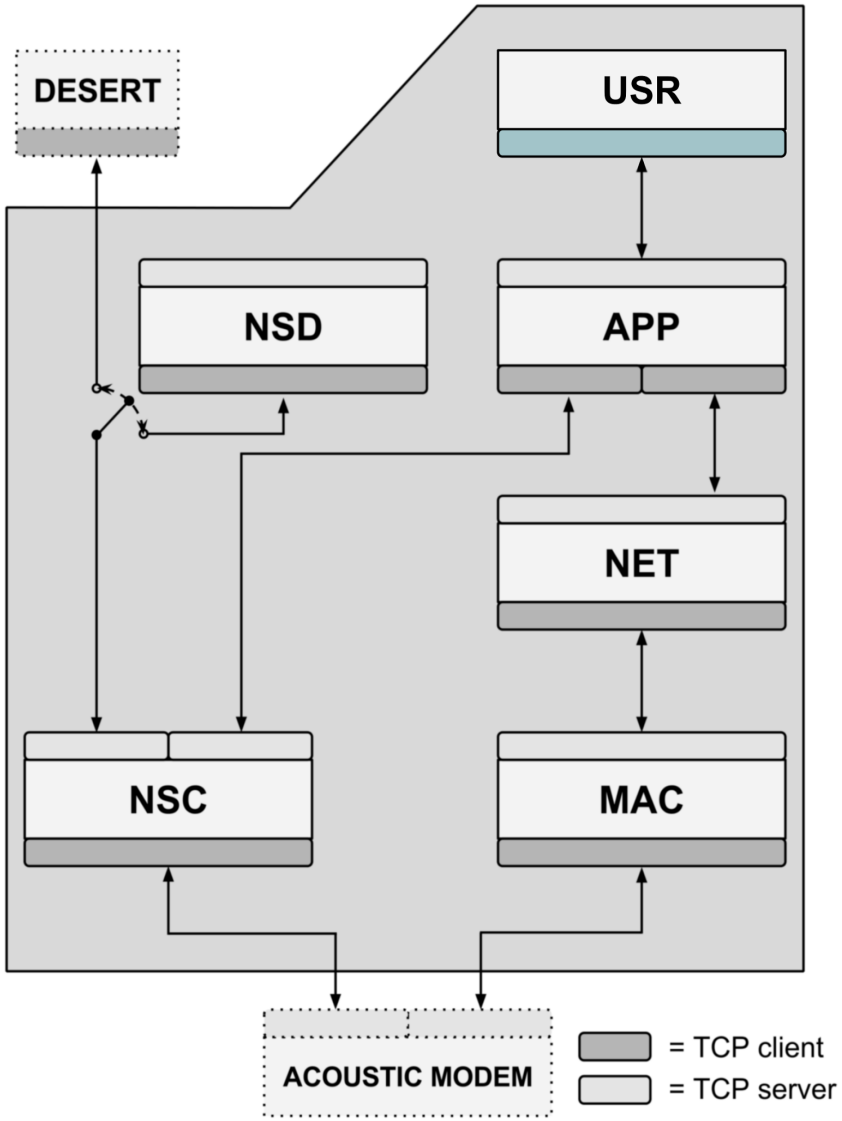
CORE module (USR)



- used to mimic the behavior of an actual user
- can query the modem by mimicking a human user
- the settings can be issued at boot time, after a predetermined period, or also periodically
- it makes it possible to send periodic heartbeat messages

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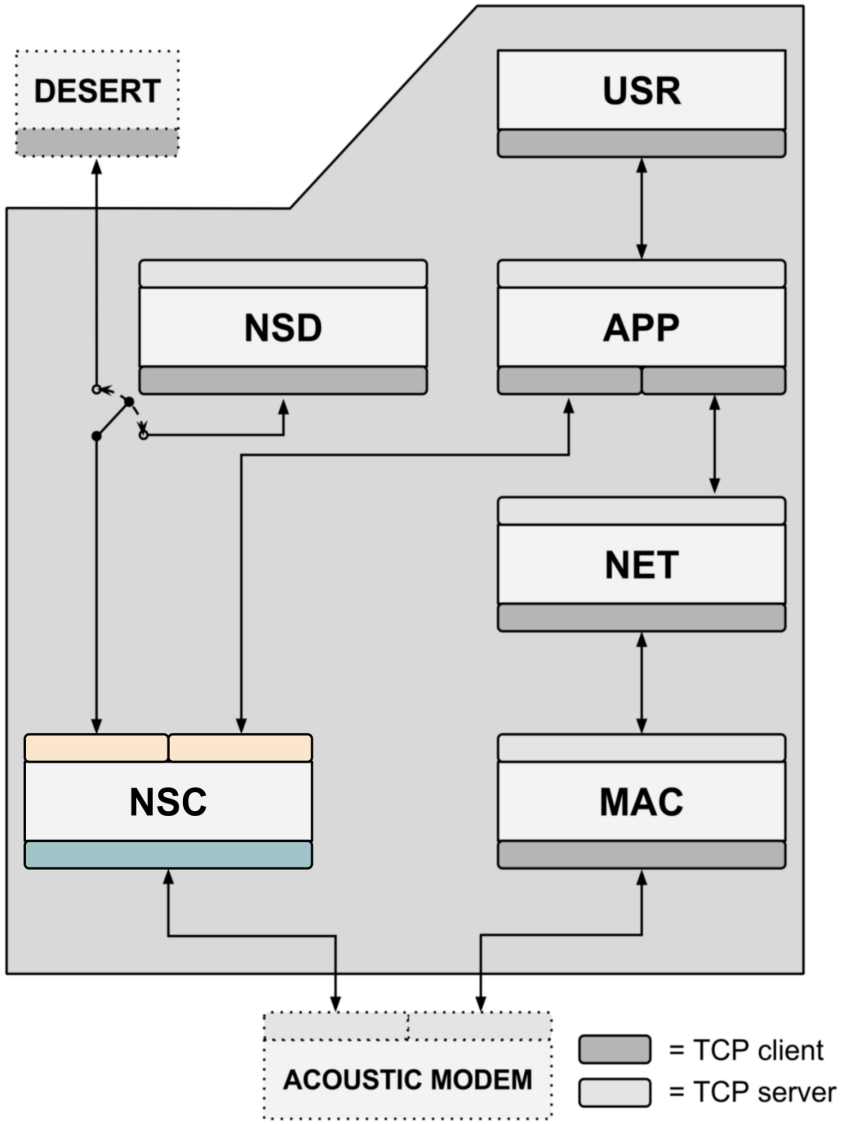
CORE module (NSC)



- resides between an instance of the DESERT framework and the modem
- forwards messages from the DESERT software to the modem and vice-versa
- simulates a desired PER value over a given source-destination link
- retrieve the multipath structure of the channel and logs it

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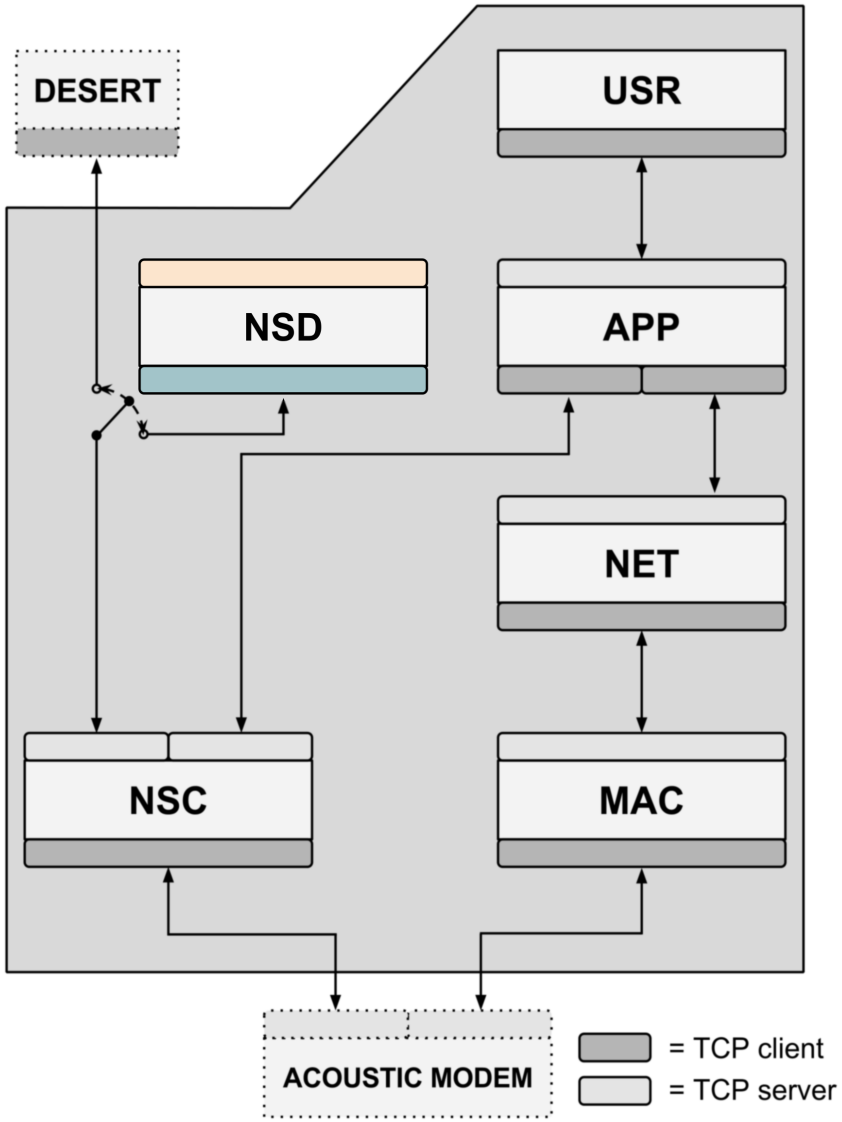
CORE module (NSD)



- provides a random traffic generator
- can started/stopped remotely on demand
- can be configured to send random ASCII strings, the length, the destination and the period can be programmed remotely

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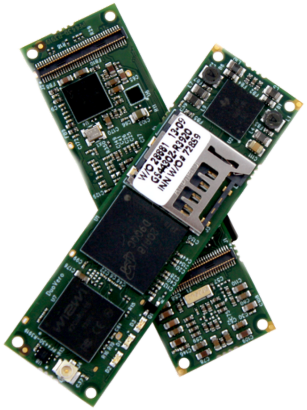
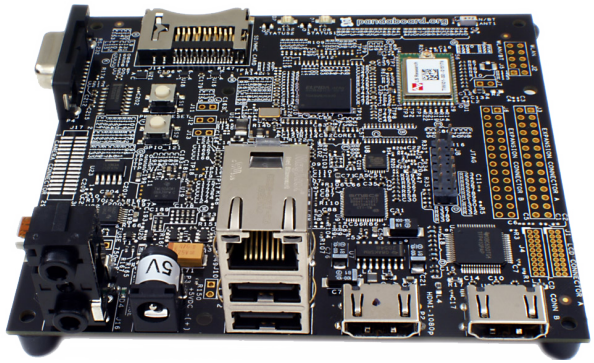
ANALYZER module

- processes the logs and produces a human-readable output
- used to obtain statistics on the fly and in real time
- generates plots

Hardware

- S2CR White Line Science Edition (WiSE)
- S2CR 18/34
- IGEPv2 DM3730
- Pandaboard
- Gumstix FIREstorm + Tobi/Tobi-Duo
- Raspberry Pi Model B
- PC (x86 and x86_64)





Experiments

- testbed
  - CPU and RAM usage
  - delivery and execution latency for remote commands
- sea trial
  - CommsNet'13 (La Spezia, Italy)

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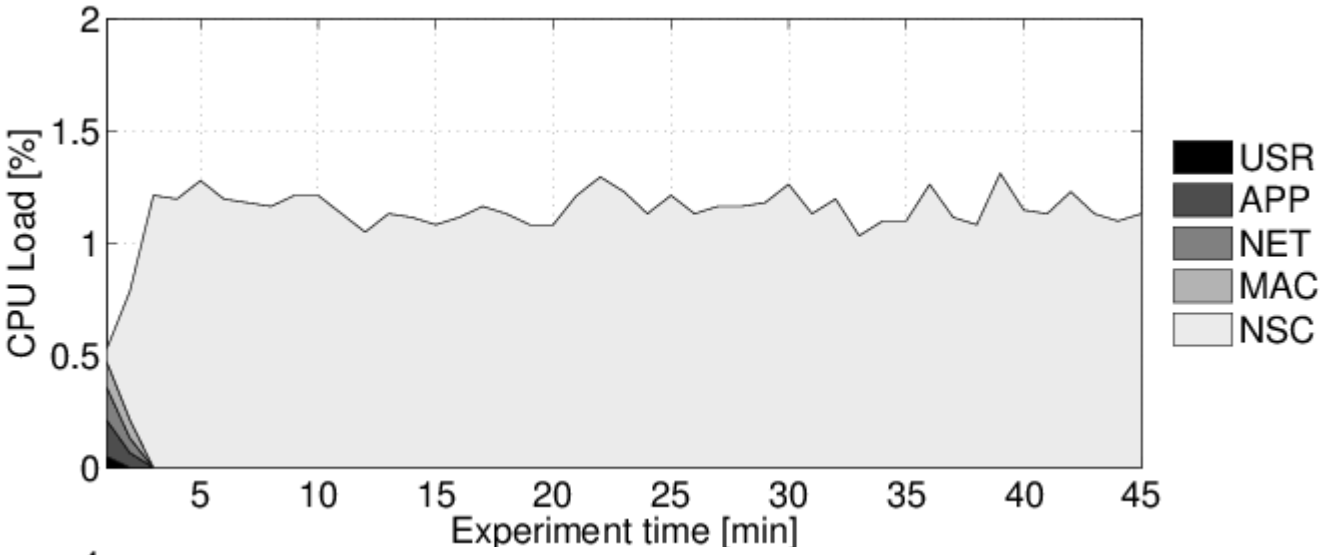
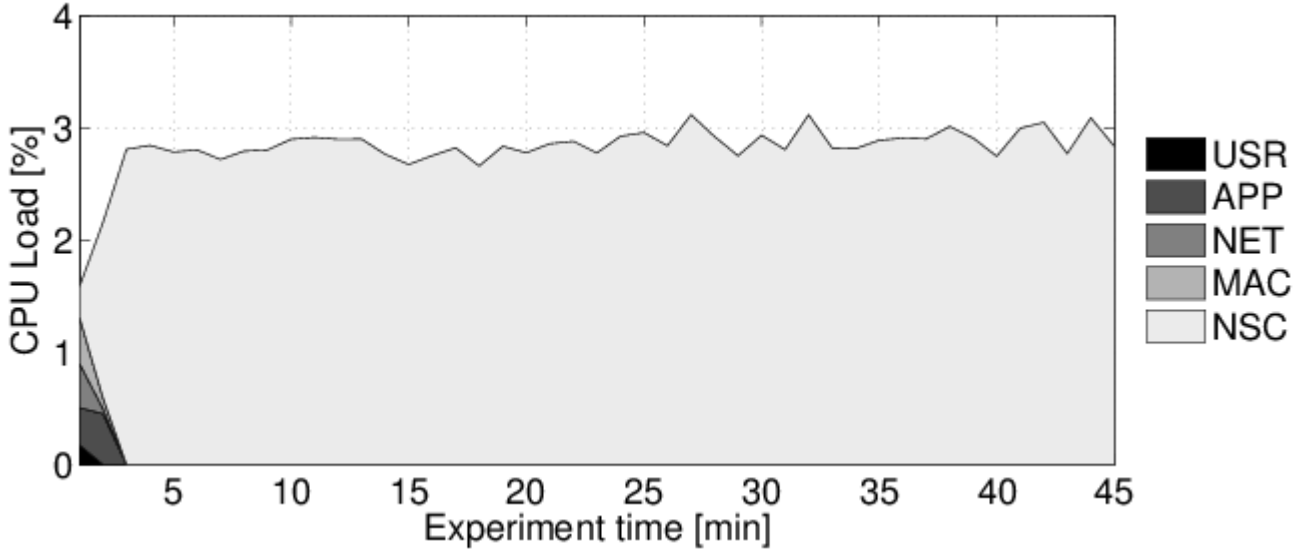
CPU usage (high traffic T = 2s)

Gusmtix



Raspberry



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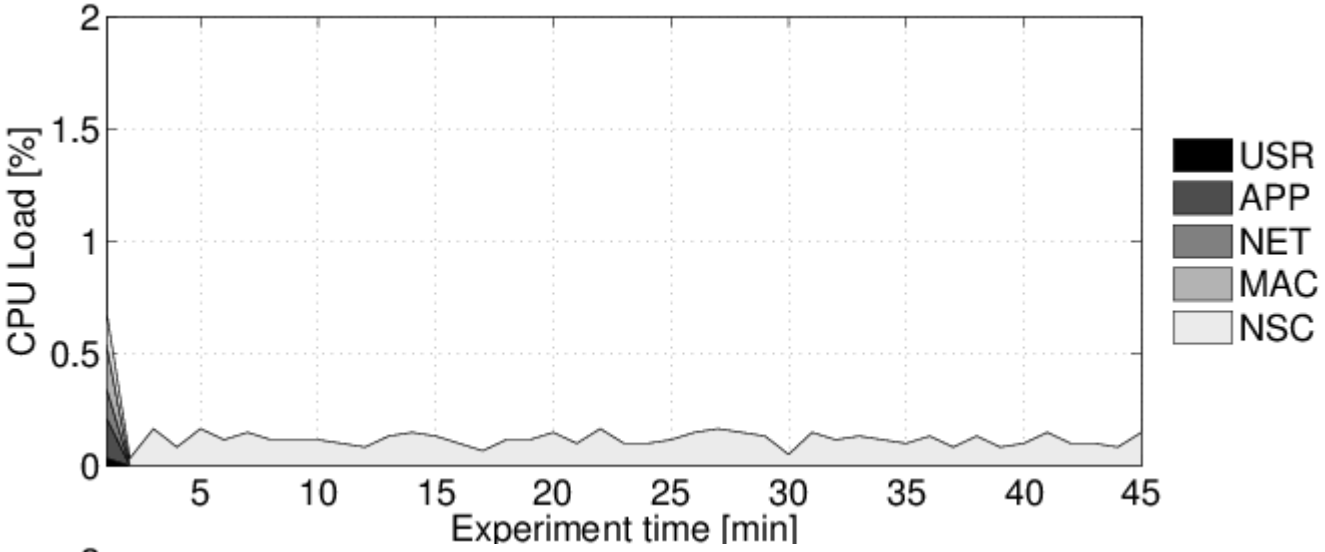
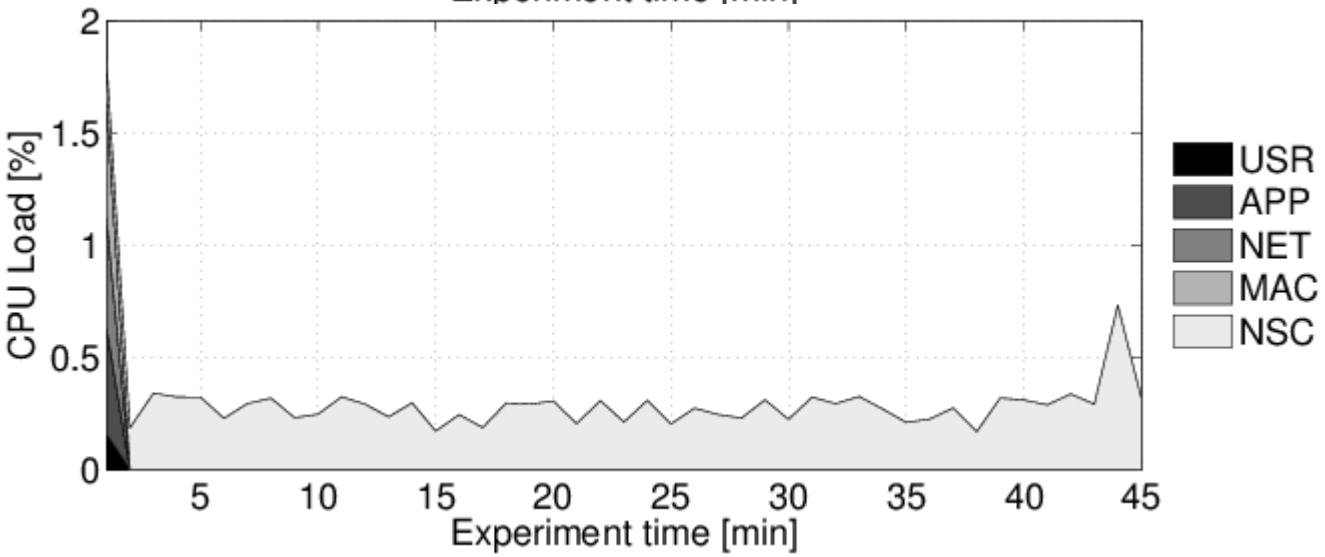
CPU usage (low traffic T = 30s)



Gusmtix



Raspberry

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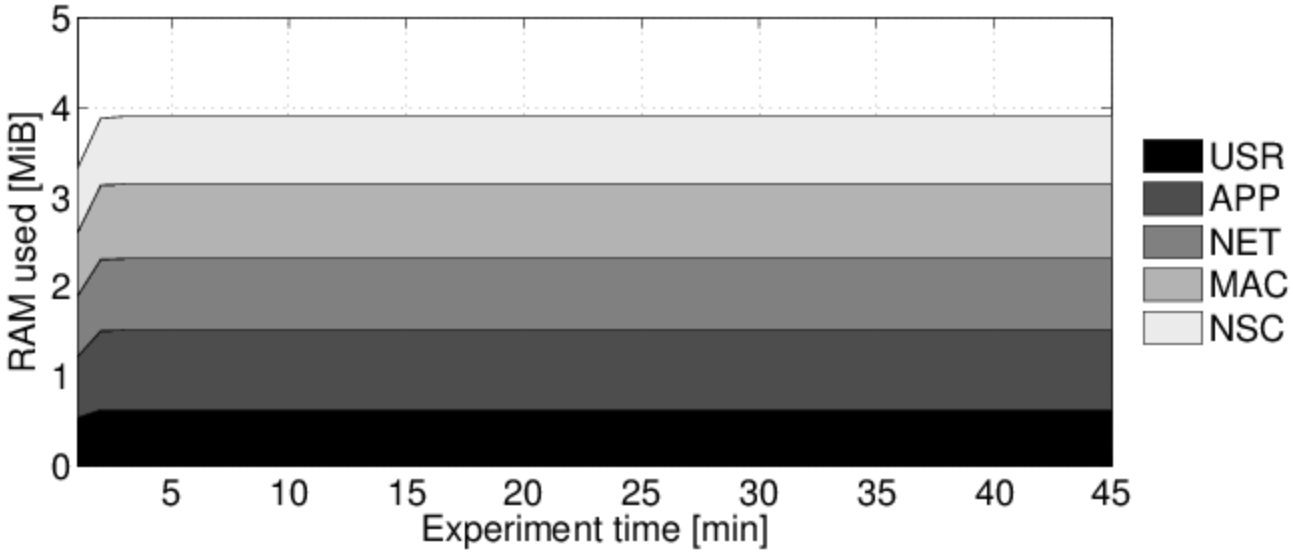
RAM usage (high & low traffic)



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Testbed

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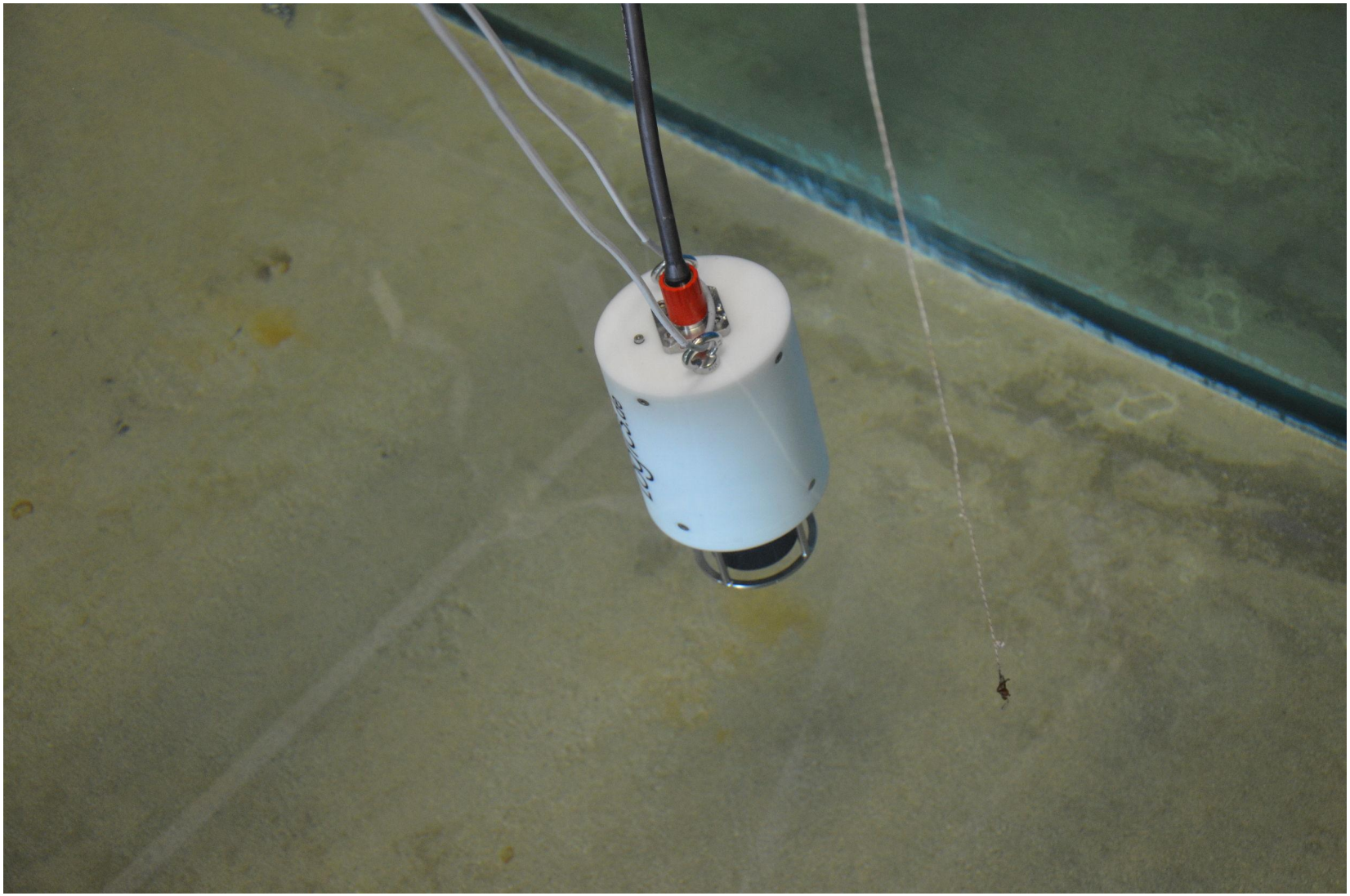
Testbed



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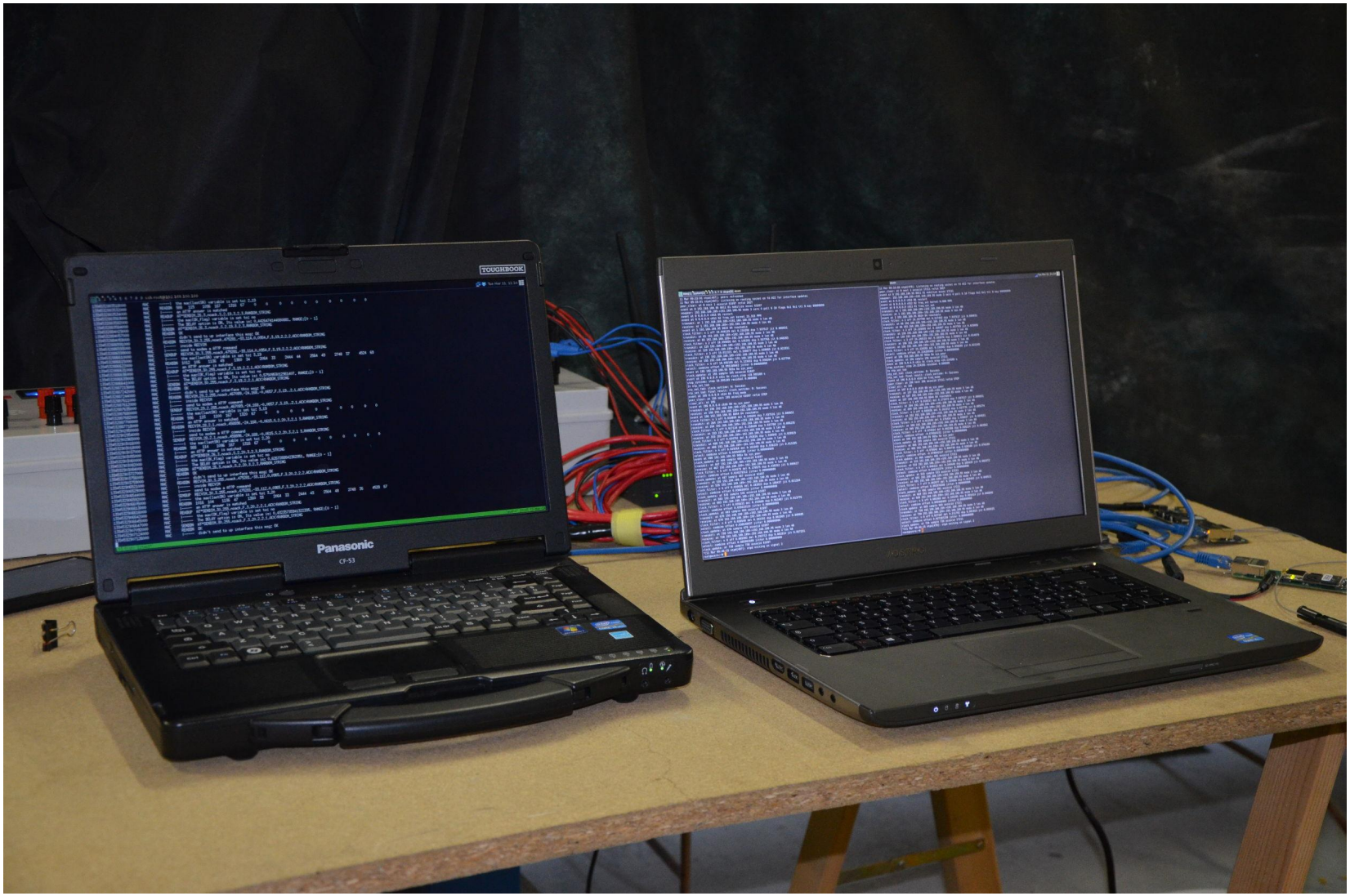
Testbed



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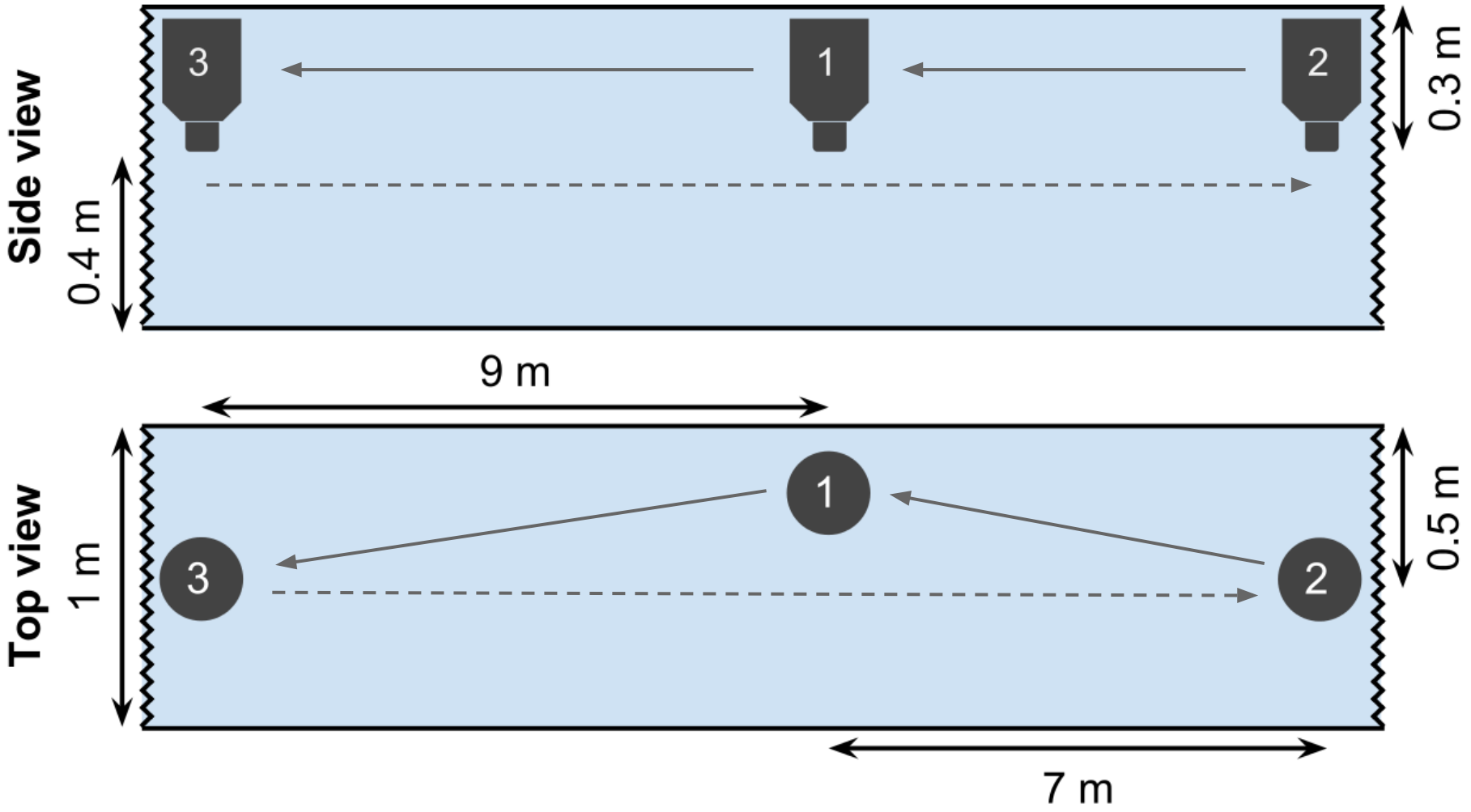
Testbed



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Delivery and execution latency

- 1.33 s for the command without ACK
  - **0.73** -> RECORDS
  - **0.60** -> MODEM + acoustic communication
- 3.75 s for the command with ACK
  - **1.60** -> RECORDS
  - **0.54** -> system processing time
  - **1.61** -> MODEM + acoustic communication
- 4.76 s for command to start network simulation with DESERT
  - **1.67** -> RECORDS
  - **1.48** -> system processing time
  - **1.61** -> MODEM + acoustic communication

* the nodes clock were synchronized through NTP

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Sea Trial

- Sep 9th–22nd, 2013
- CommsNet'13 sea trial in La Spezia, Italy
- collaboration with the NATO STO CMRE
- several types of nodes: bottom, mobile and floating
- not all the nodes were reachable via a cable or radio link
- we could only reconfigure them and check their status via the RECORDS framework
- more than 30 experiments

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Sea Trial

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Sea Trial

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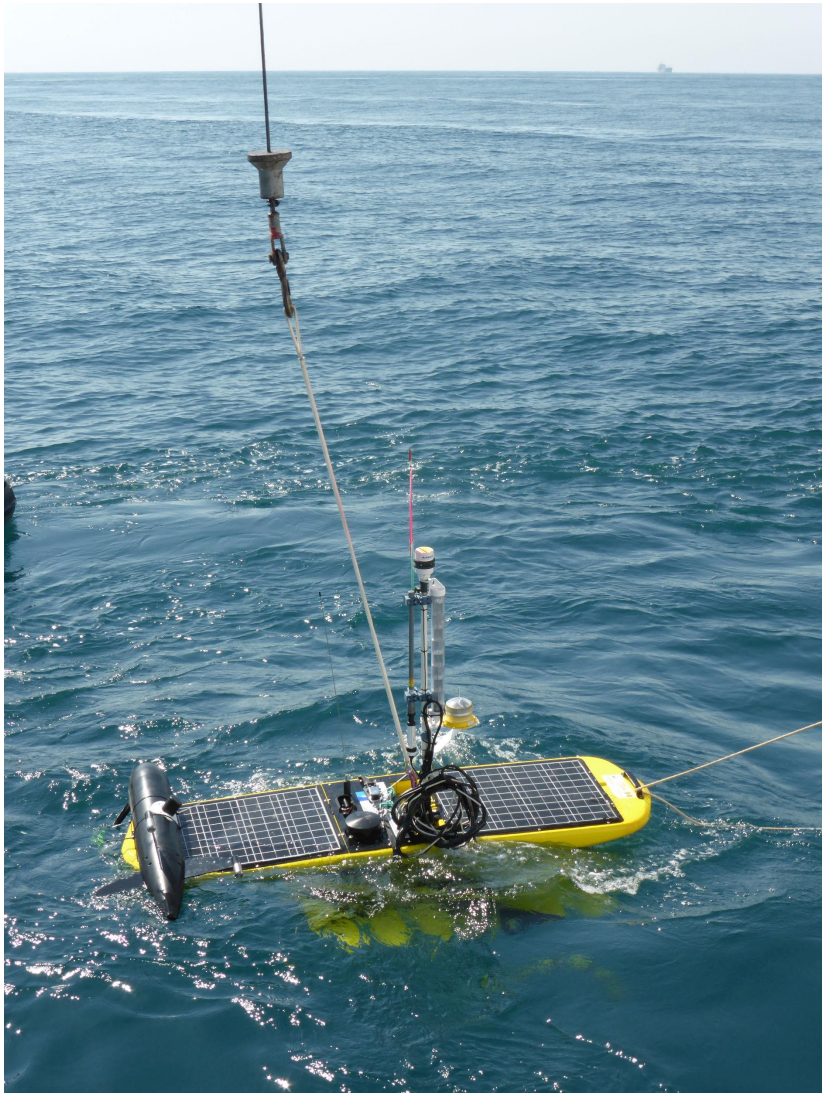
Sea Trial



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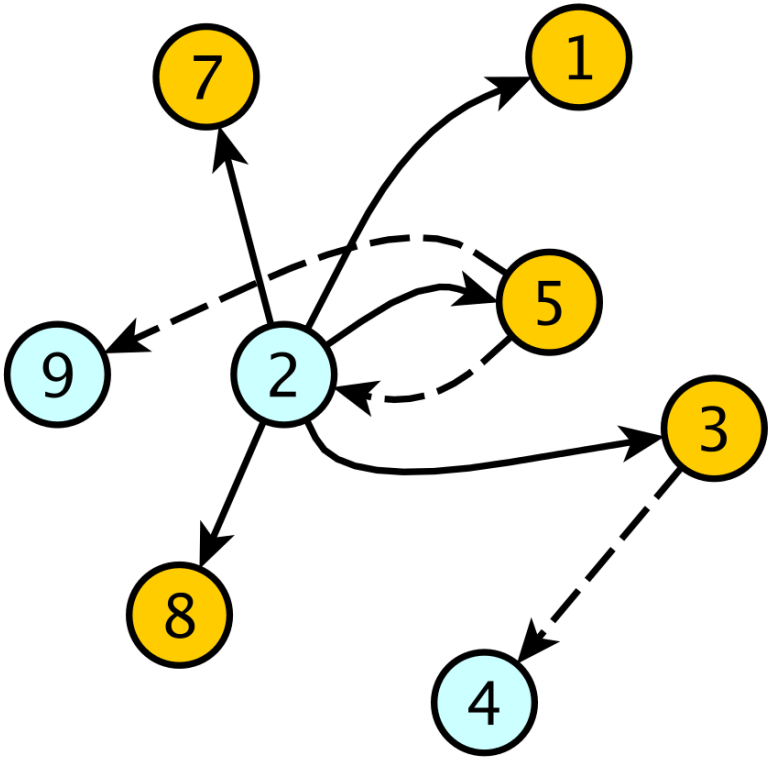
Sea Trial



- experiment with ID 53
- 8 nodes available
- direct access to node 2
- configuration command:

```
SEND,F,255,4,NS 53 M
60 240 36000 4 1 0 15
48 120 2 7 8 3
```

- flooding + TTL = 4
- nodes 1, 3, 5, 7 and 8 received it directly
- node 4 from node 3
- nodes 2 and 9 from node 5

Conclusion

- we presented RECORDS, an open source framework to remotely control underwater modems via acoustic messages
- RECORDS is modular
- we conducted several field experiments to test the framework
- the results show that RECORDS is a stable, lightweight and robust solution to control underwater networks

Conclusion

- we measured both the impact of RECORDS on the system resources of different embedded platforms and the latency
- the results confirm that RECORDS can be employed extensively in real world experiments

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- the NATO STO CMRE for involving the authors in the CommsNet' 12 and CommsNet'13 campaigns
- the partners of the EDA RACUN project for allowing us to experiment the MSUN protocol

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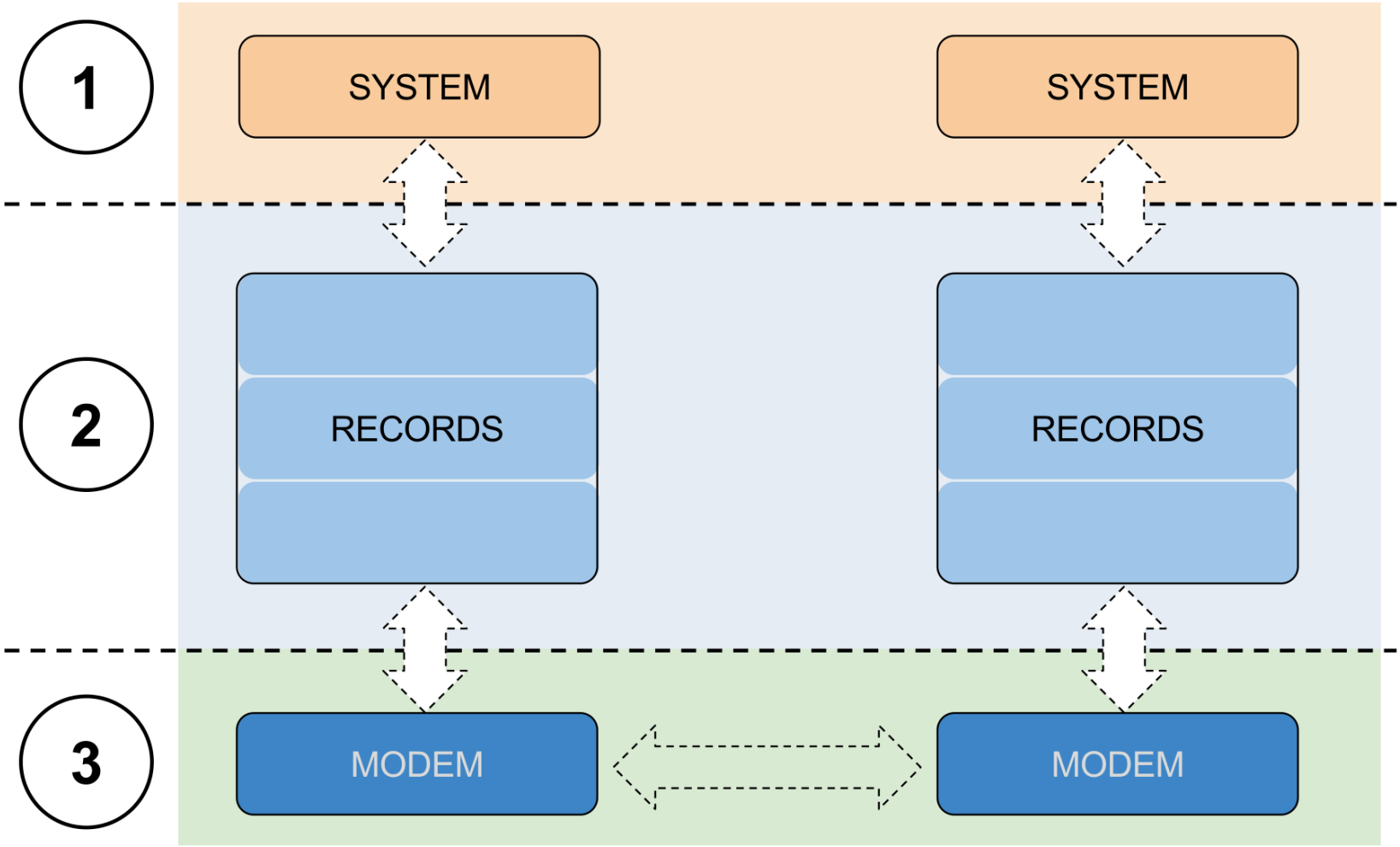
Delivery and execution latency



Sea Trial

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Testbed

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Delivery and execution latency

- we evaluated the time required to execute remote commands
  - commands without ACK
  - commands with ACK
  - commands to start network simulation with DESERT
- nodes clock synchronized through NTP
- 2 -> 1 -> 3 (16 meters between the external nodes)