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# Rapid Cross-Layer Prototyping of Wireless Sensor Networks Using USRP-RIO

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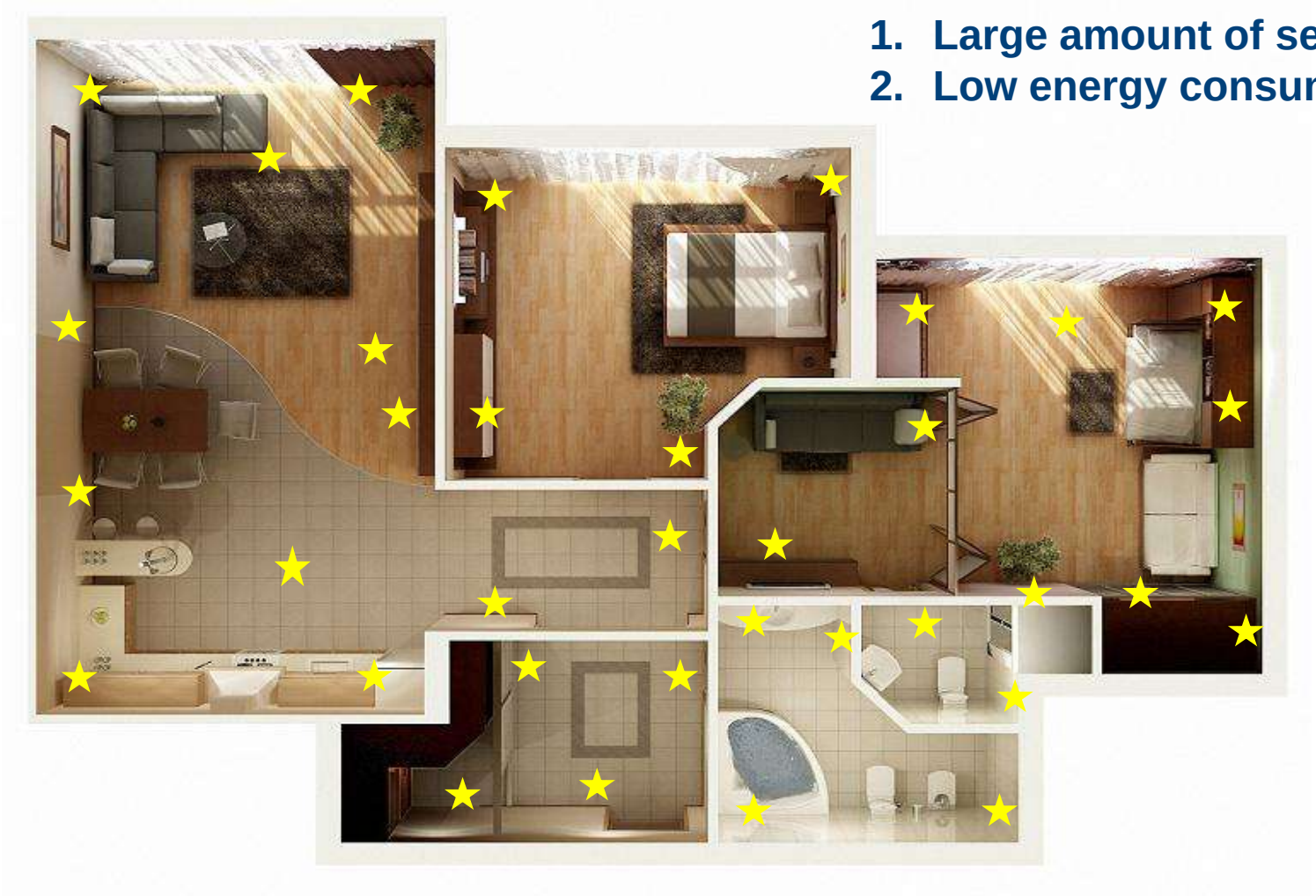
# What are wireless sensor networks?

1. **Large amount of sensor**
2. **Low energy consumption**



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# Current prototyping solutions are fixed to one layer

## (MAC &) network layer testing

- **Real-time** network testing possible
- PHY (and MAC) are fixed in chip

**Flexible, real-time PHY, MAC and network layer test possible**

## Physical layer testing


- Very **flexible** PHY testing possible
- Not real-time

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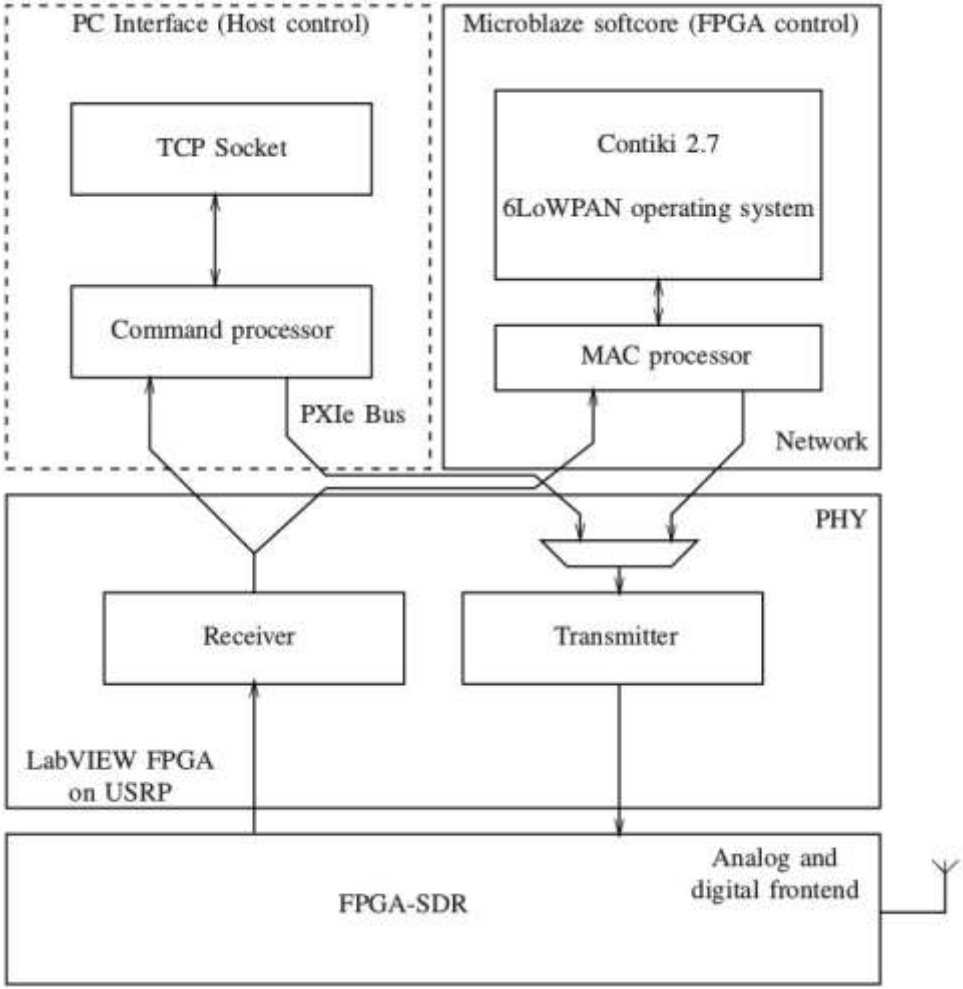
# Our solution enables cross-layer prototyping

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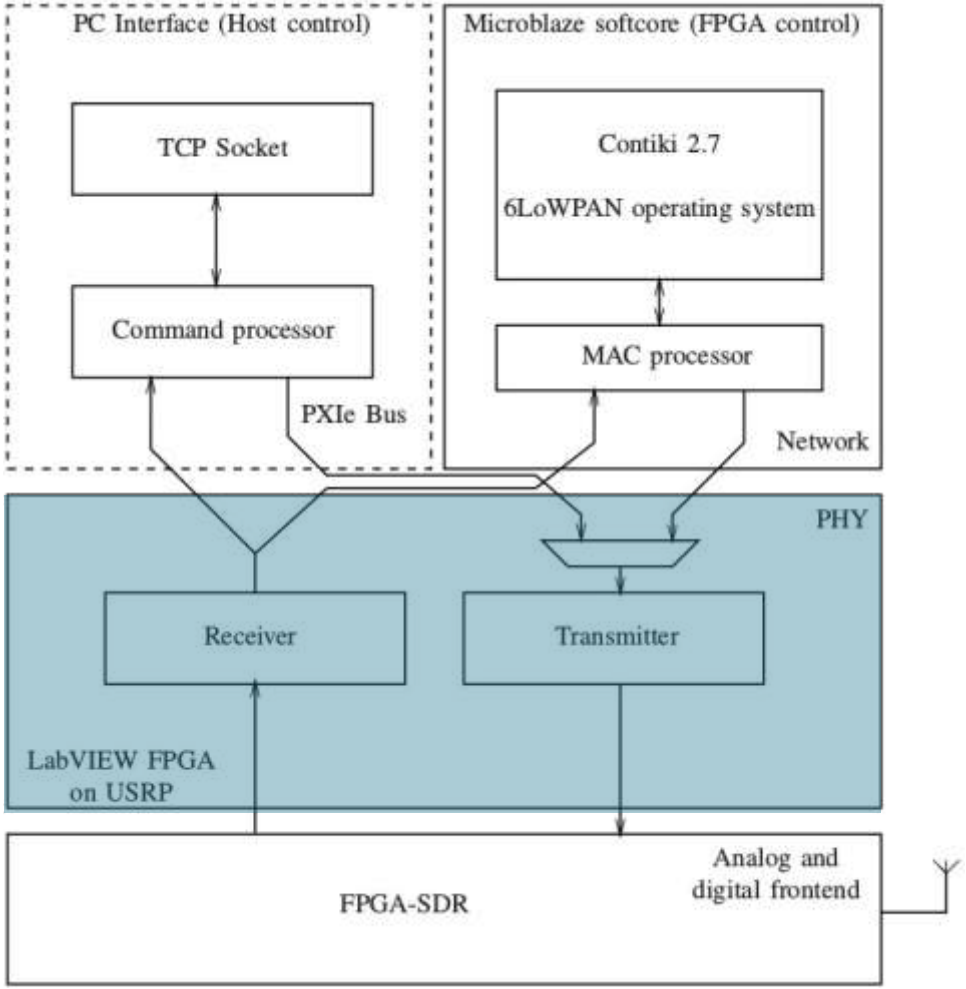
# Adaptable and flexible baseband PHY




Baseband PHY:

- LabVIEW FPGA
- IEEE 802.15.4-compliant
- Very flexible
  - Add new functionality
  - Large parameter set configurable from host:
    - Modulation
    - Pulse shape
    - Bandwidth
    - Frequency
    - …

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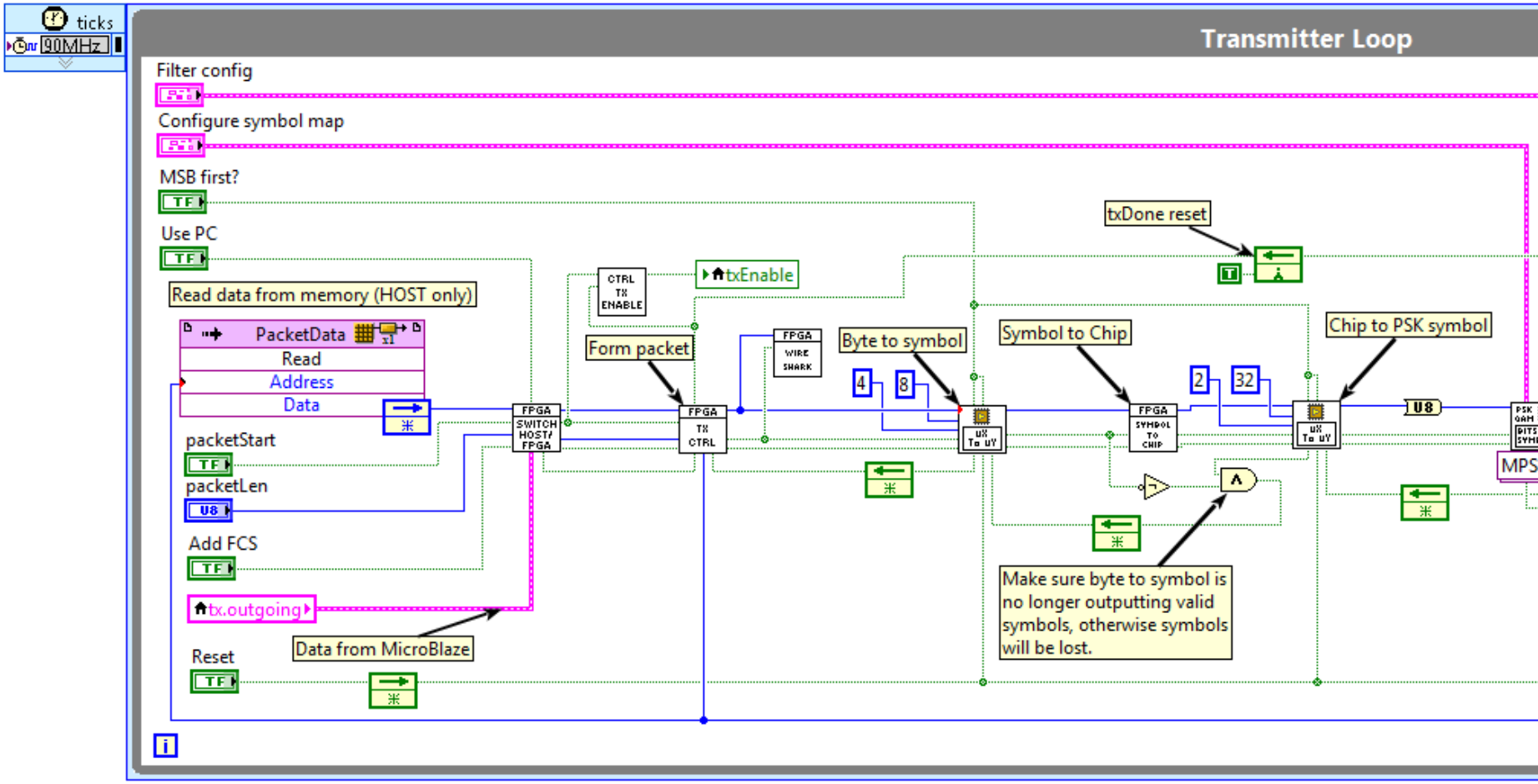
# Transmitter PHY implementation on FPGA

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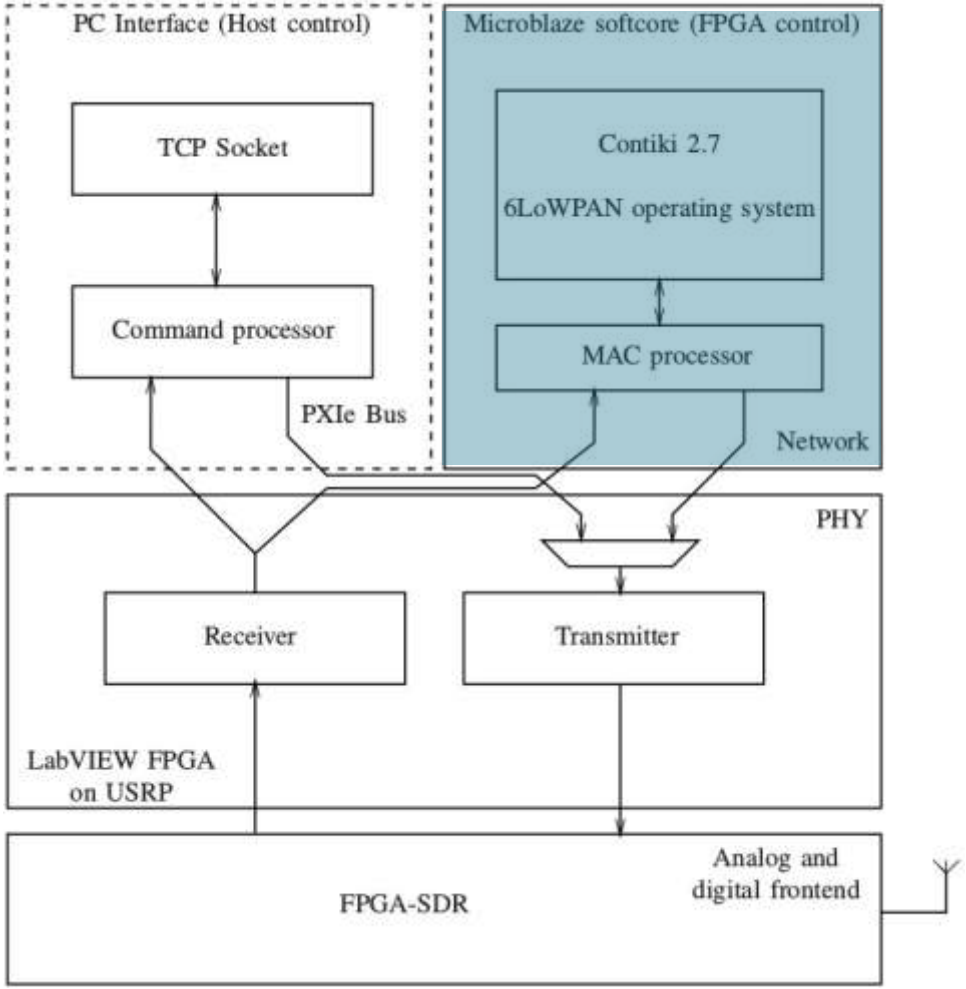
# Full network stack is available on the FPGA




FPGA control:

- Microblaze 32-bit softcore ported to USRP-RIO
- Contiki OS running 6LoWPAN network layer
- Custom MAC processor
- Very flexible
  - No full recompile needed
  - Contiki OS loaded from LabVIEW or JTAG

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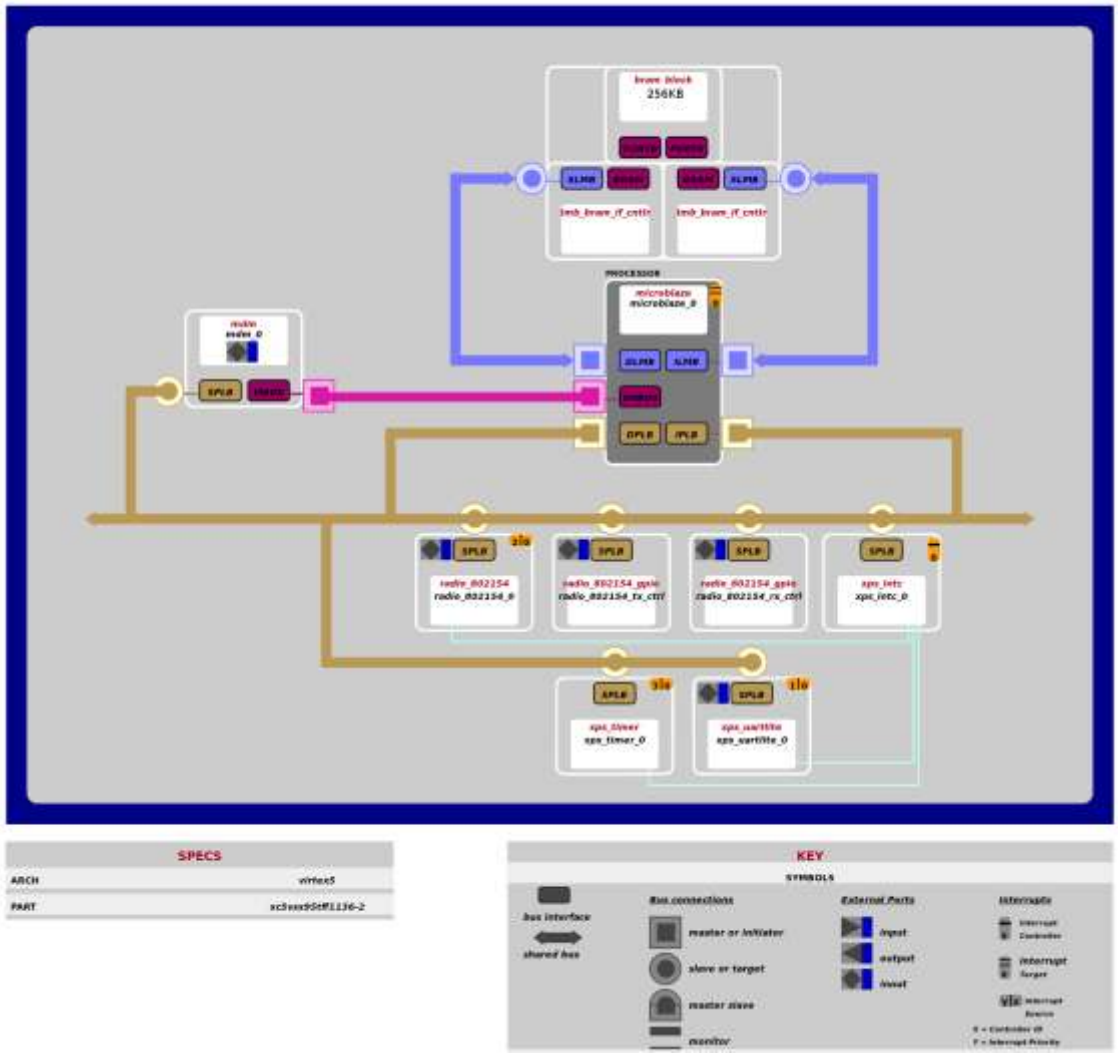
# Microblaze softcore: architecture overview

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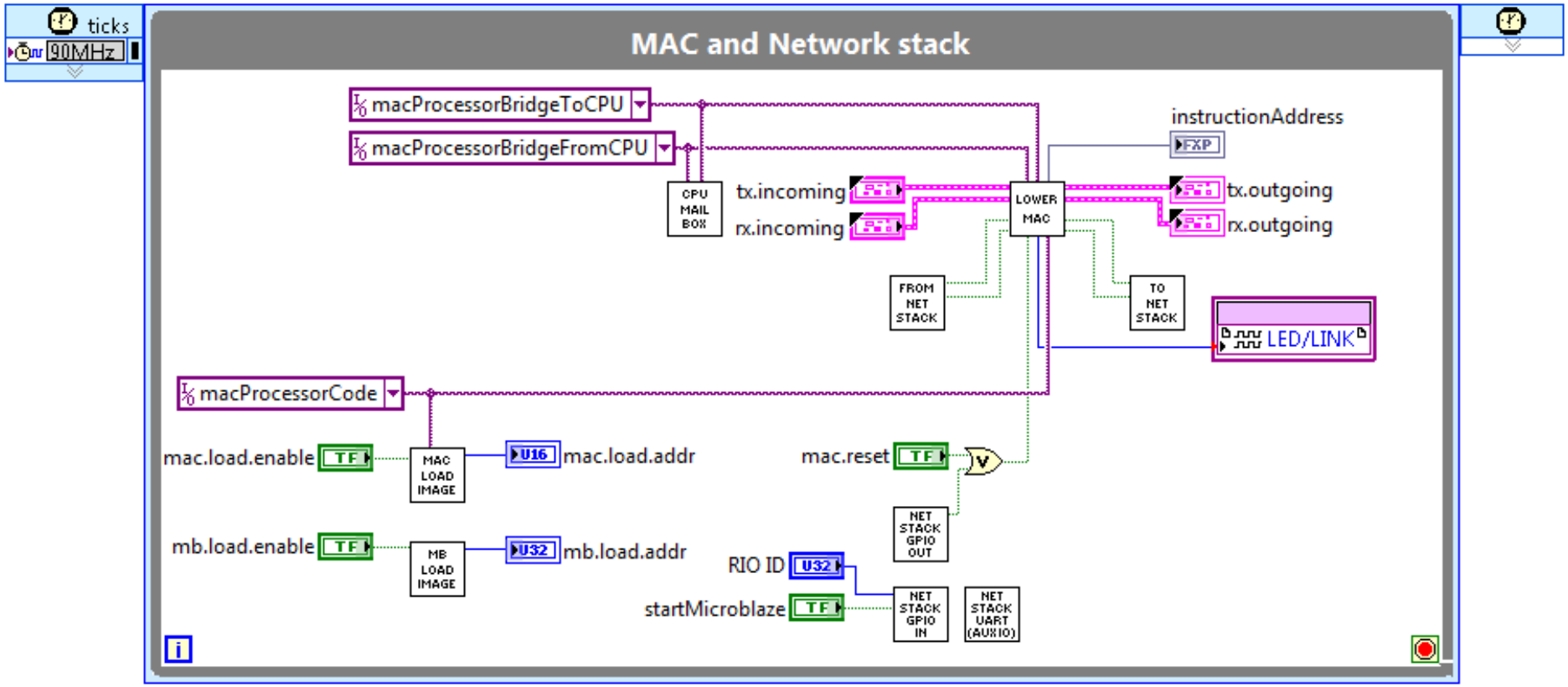
# Microblaze softcore: LabVIEW FPGA interface

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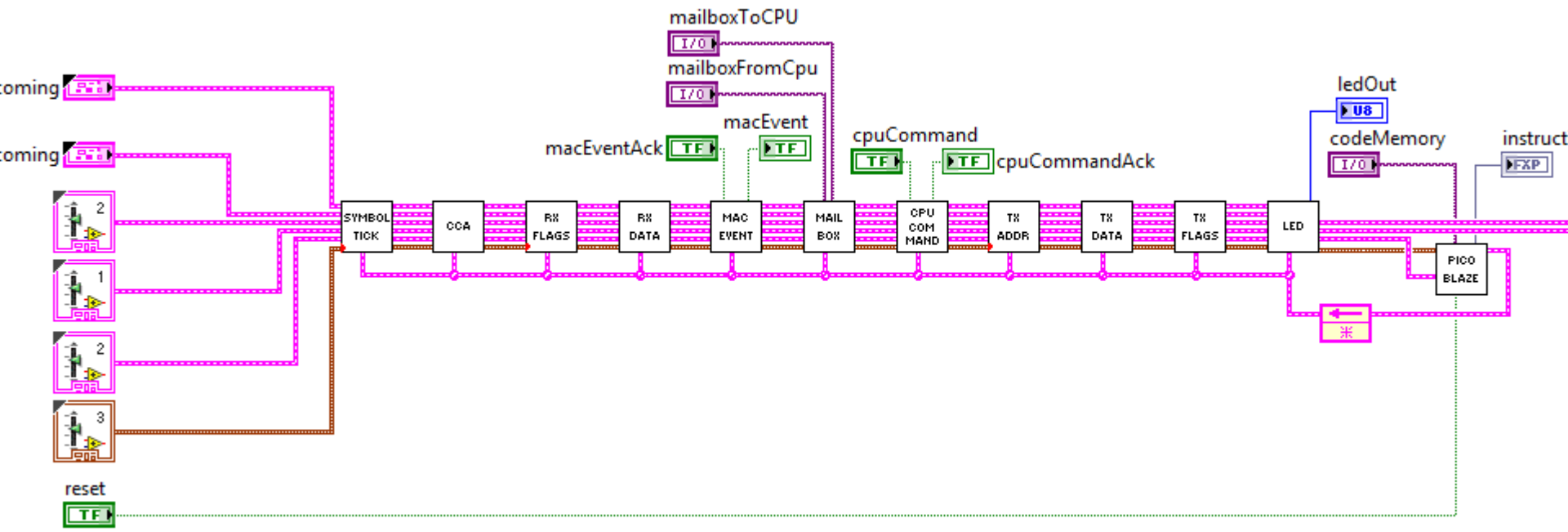
# PicoBlaze implements MAC protocol

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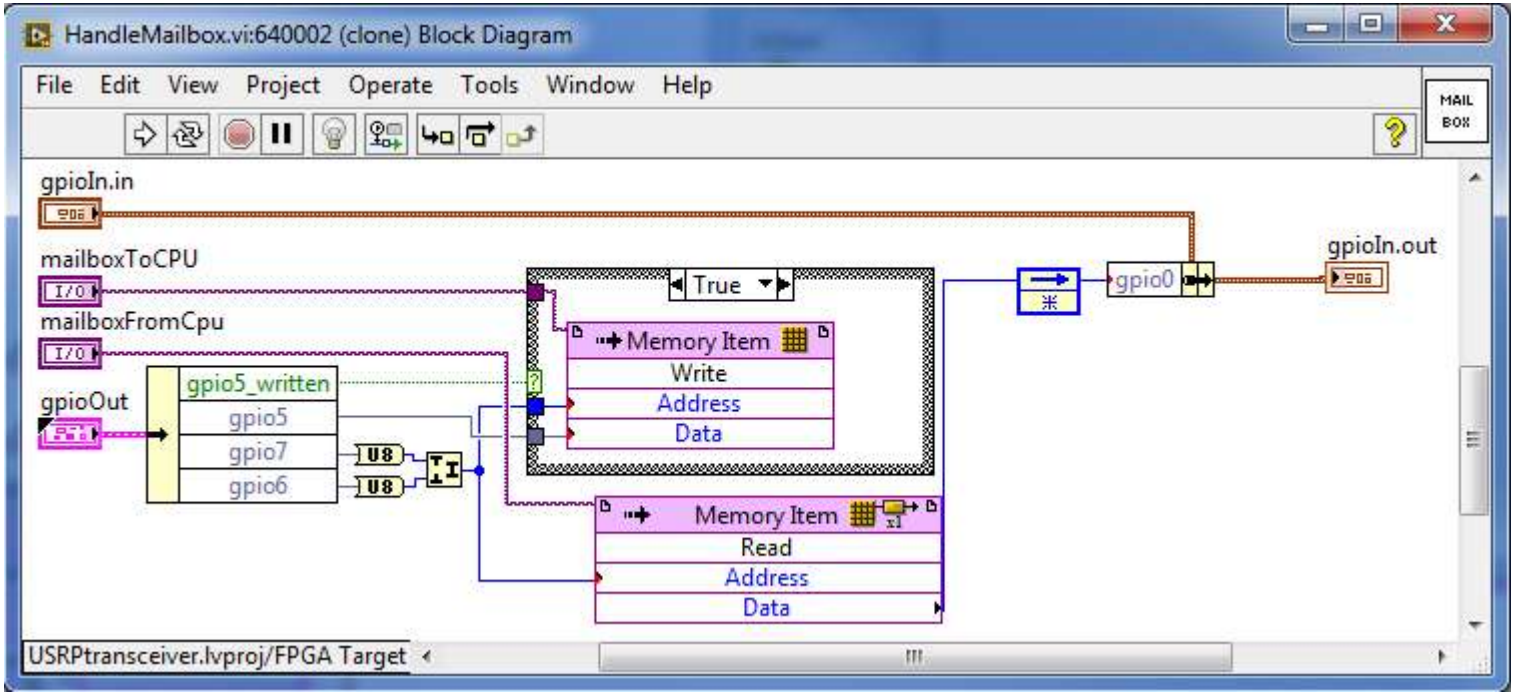
# Interface between PicoBlaze and MicroBlaze

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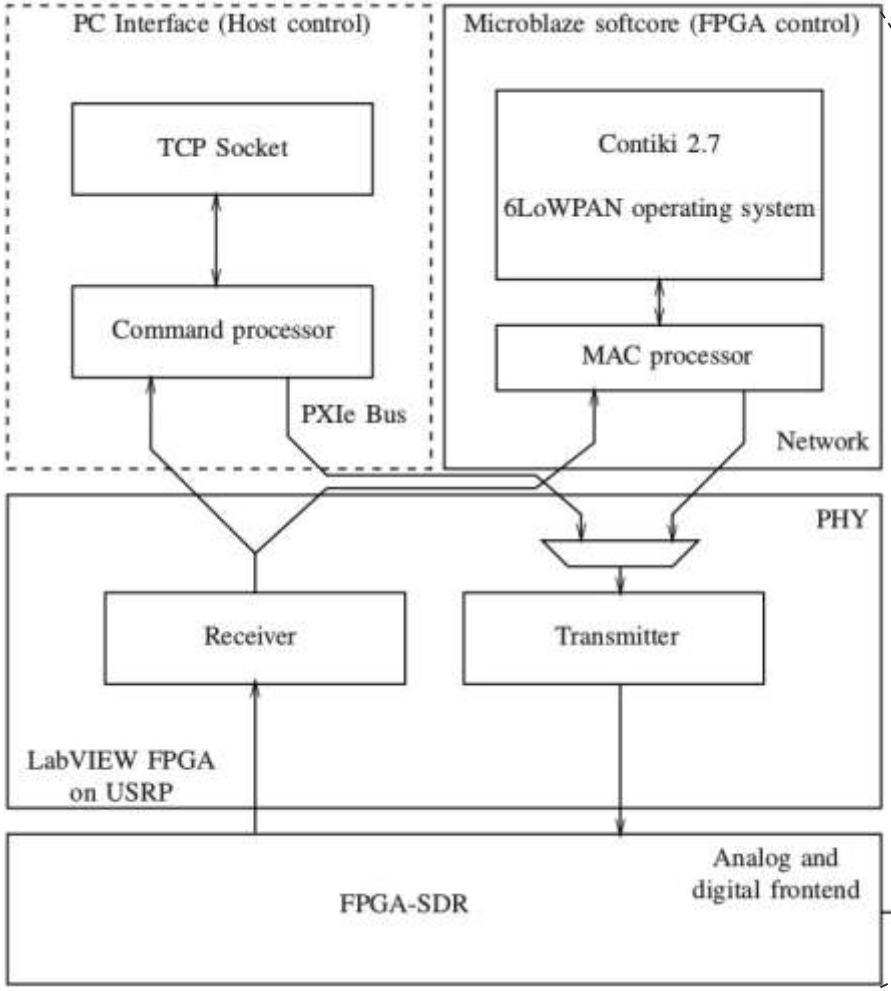
# This all fits on the FPGA of the USRP-RIO




Slice Registers: 11.6%
Slice LUTs: 11.7%
Block RAMs: 17.1%
DSP48s: 10.5%

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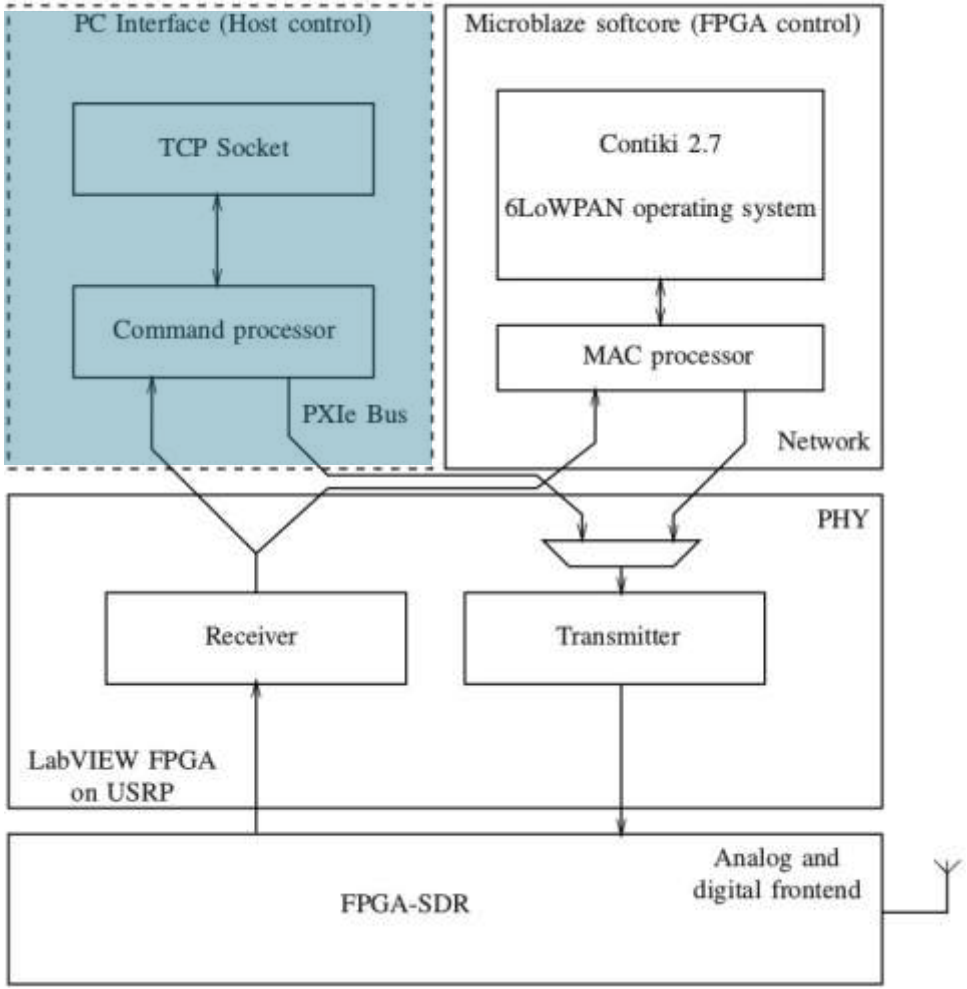
# Host control enables easy PHY customization




Host control:

- Fine-grained PHY parameter customization
- Ability to load new MAC and network layer without recompilation
- TAP interface for wireshark
- TCP Socket for automated PHY testing
- Command processor

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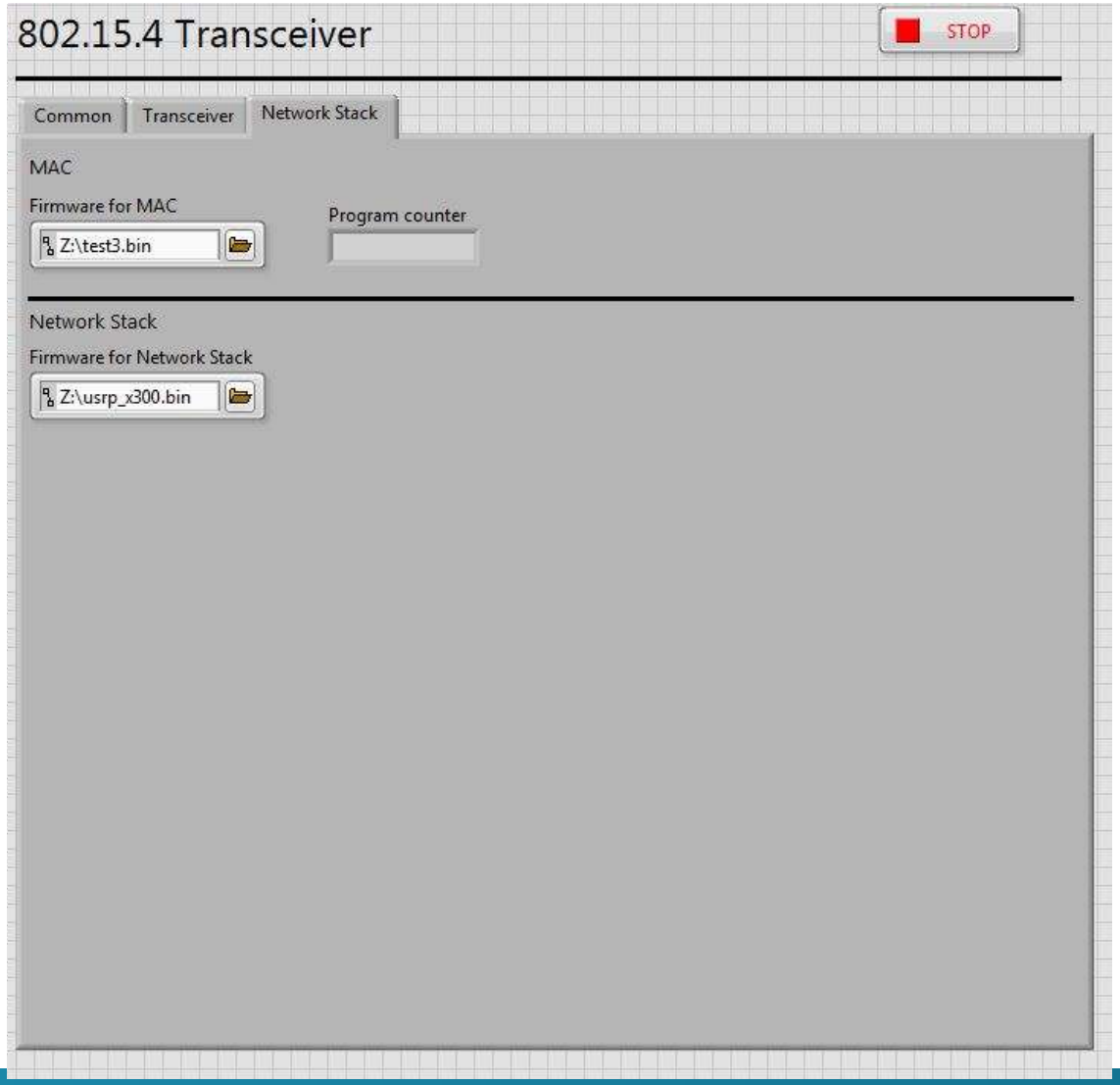
# PHY layer testing are possible using the host

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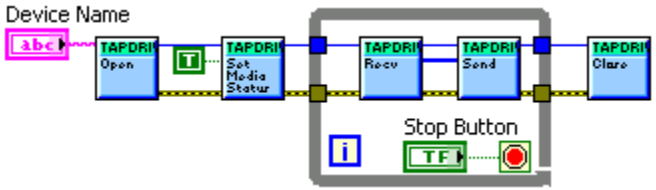
# TAP Interface: Virtual Ethernet

- Custom LabVIEW library for creating a virtual ethernet interface
- Reusable for many applications:
  - Wireshark
  - Cool communication demos
  - Raw ethernet




Easy LabVIEW interface:
Open, receive, send, close


Custom interface library (C DLL)

TAP-Windows kernel driver

'Fake' network port

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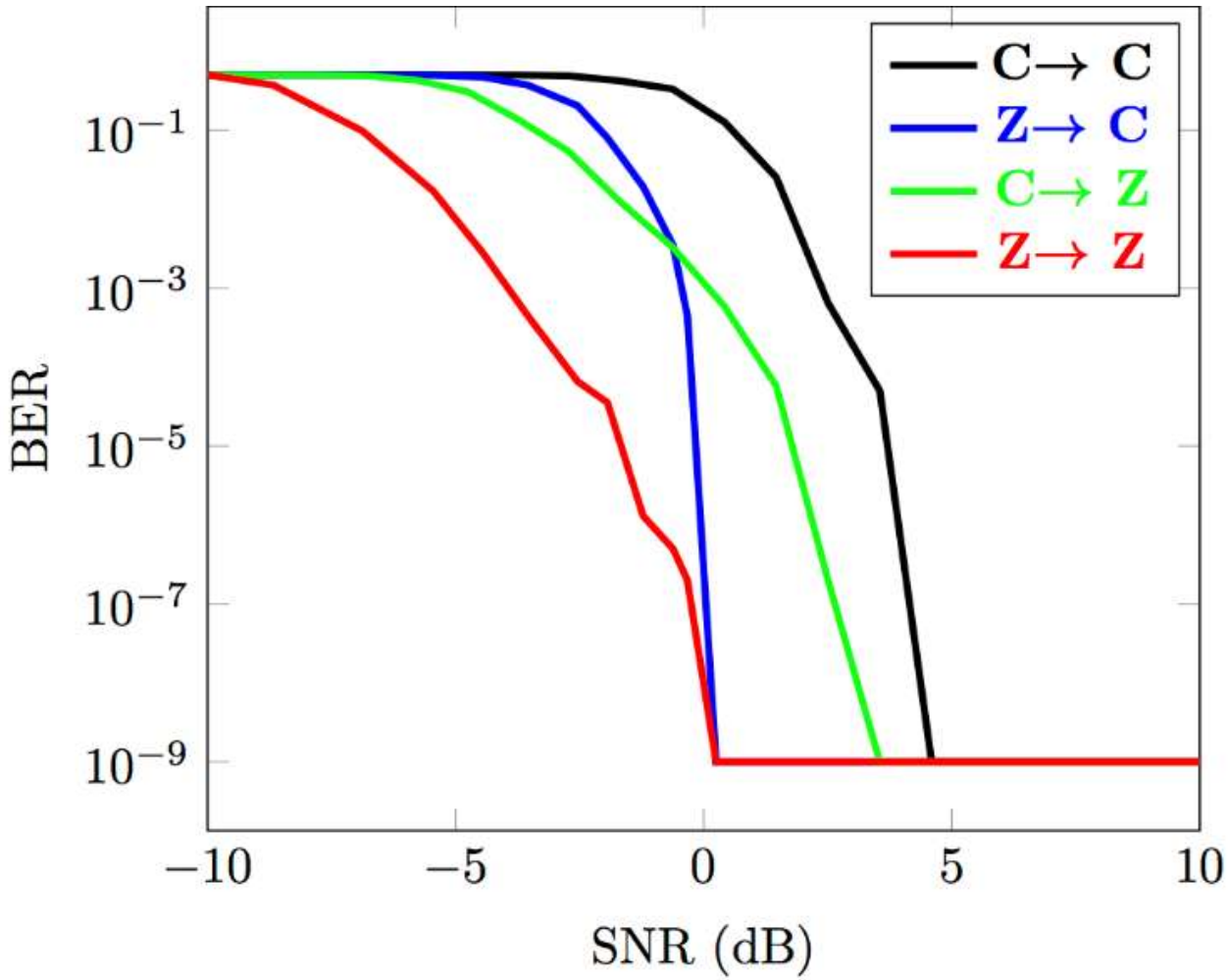
# Performance is on par with off-the-shelf nodes




C = CLAWS, Z = ZIGDUINO