Secure SmartHome

SoC Architectures and Modelling

2016

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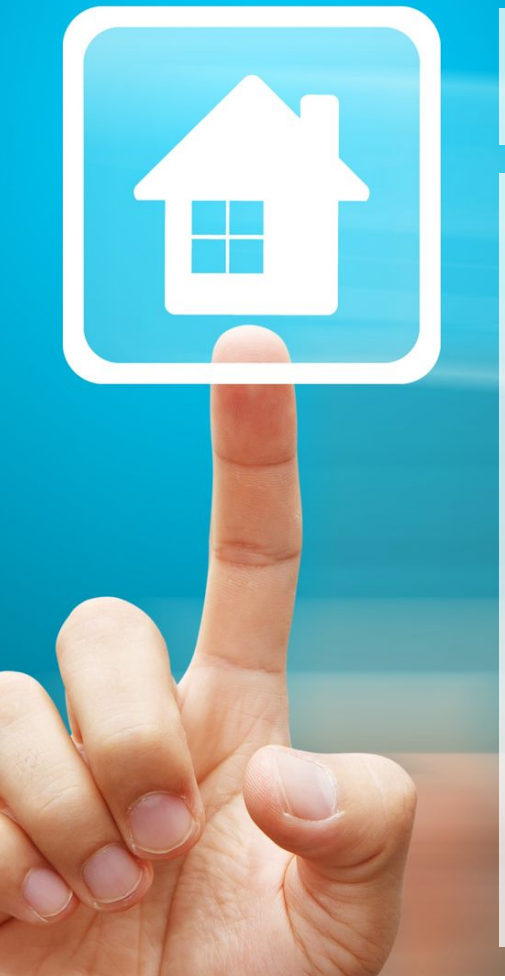
TU Graz

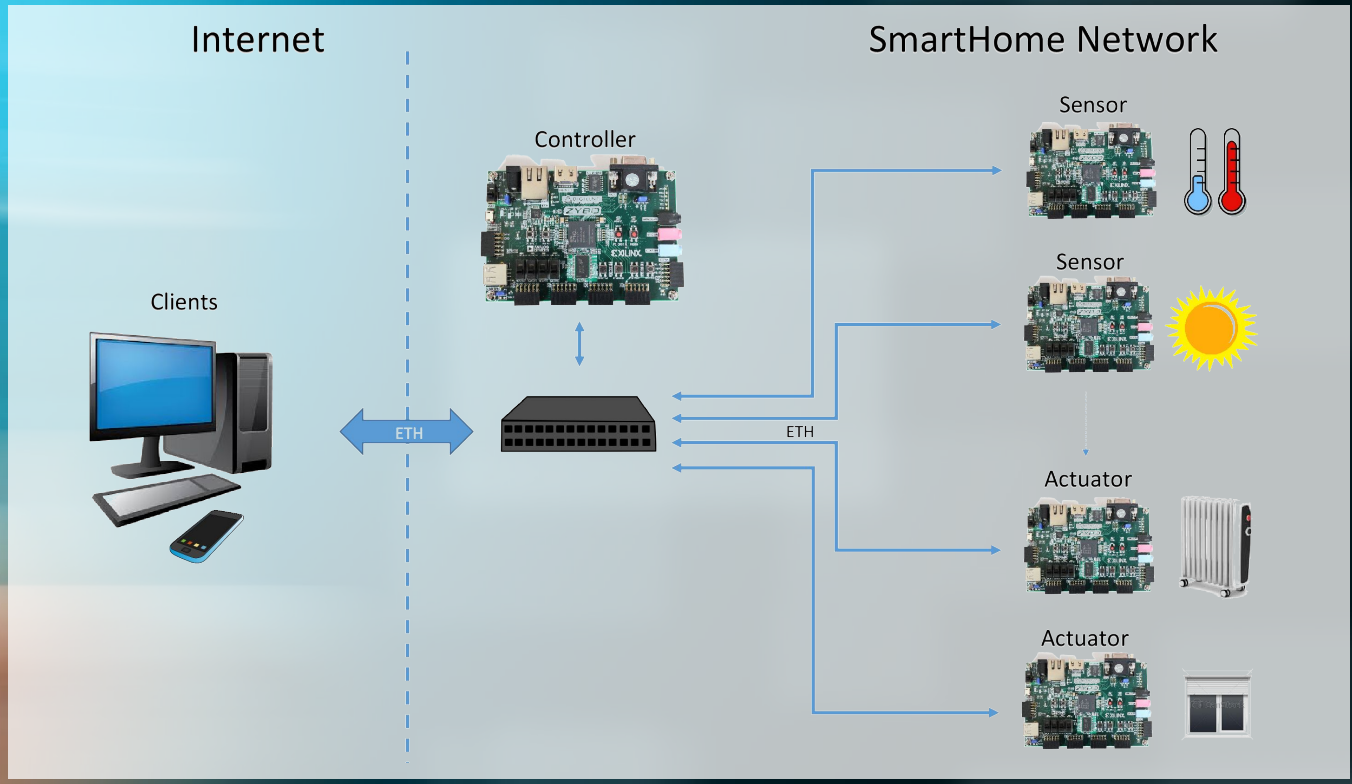
Motivation

Most home automation systems are insecure!

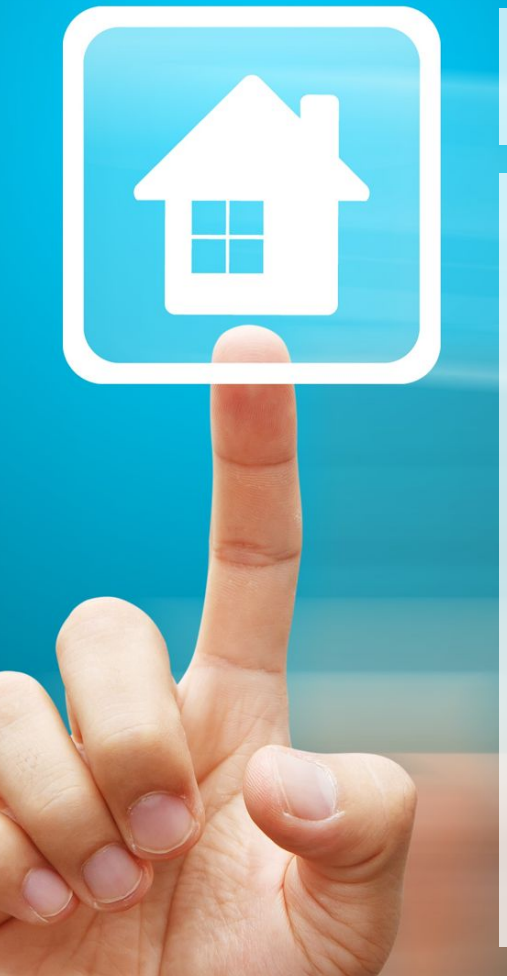
- Connected to the internet
- Sensors and actors connected via local network
- Easy to access the network
- No data encryption
- Manipulate sensor data
- Get control of the house
  - Burglary attacks
  - Military attacks

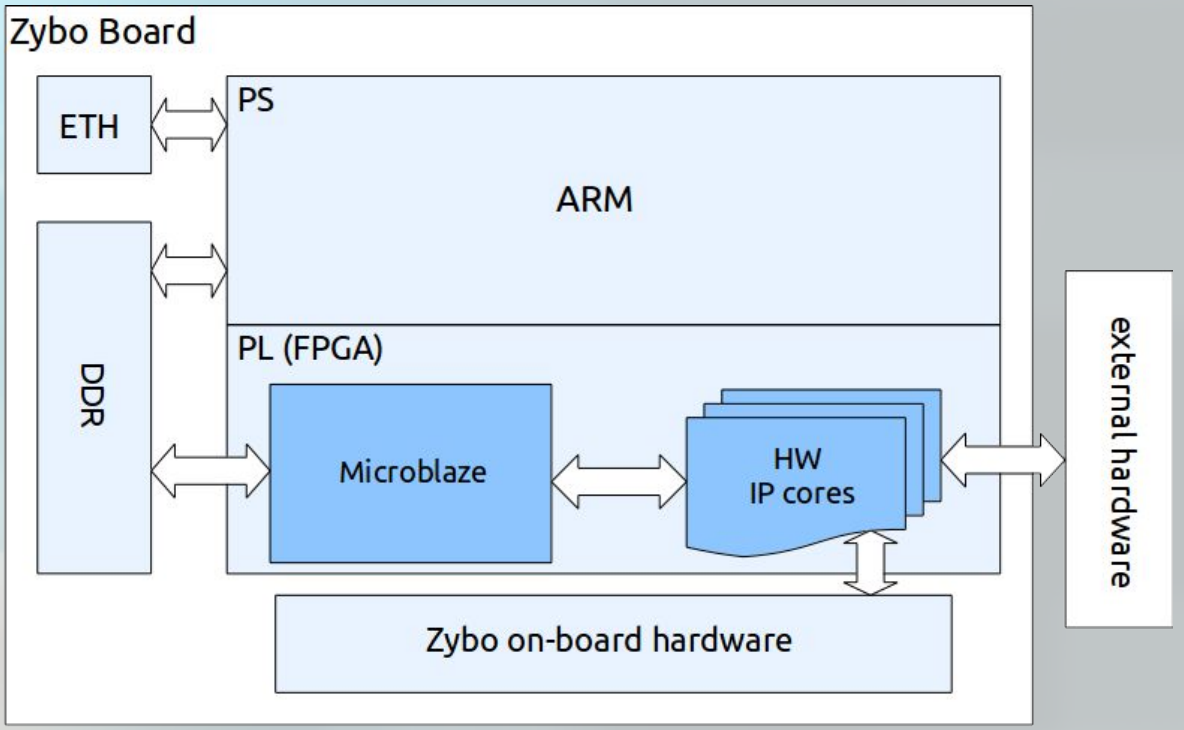
Design Overview



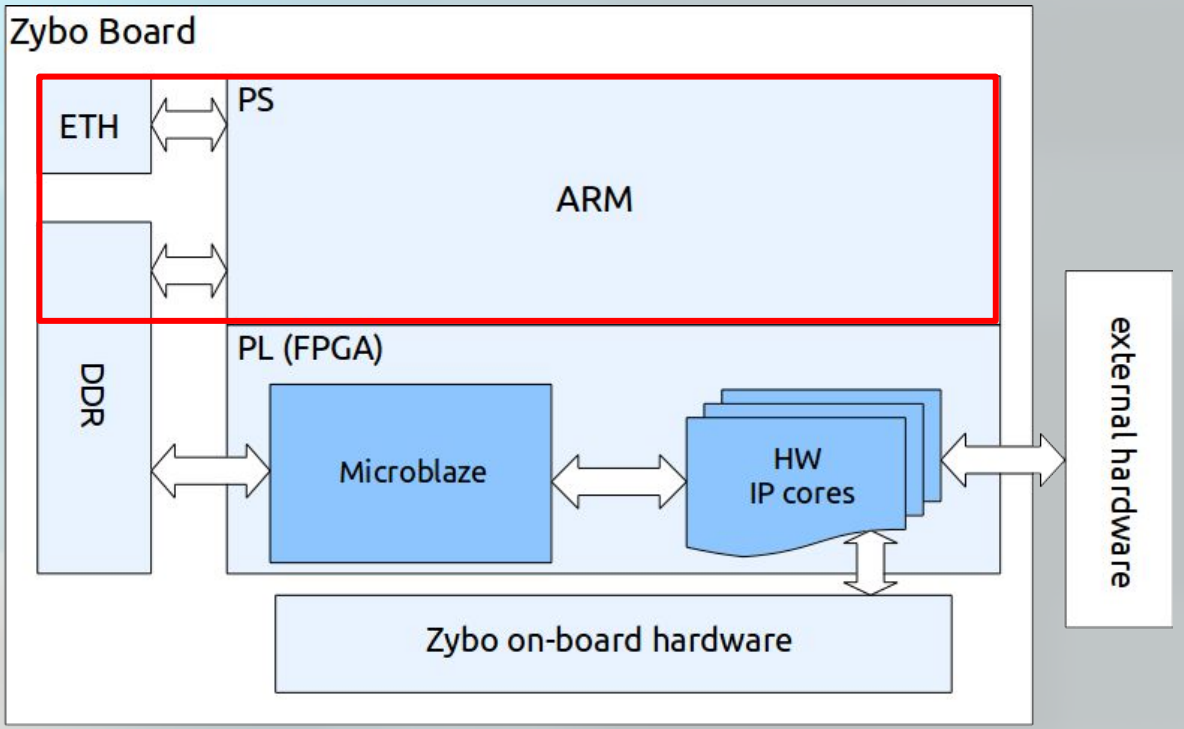


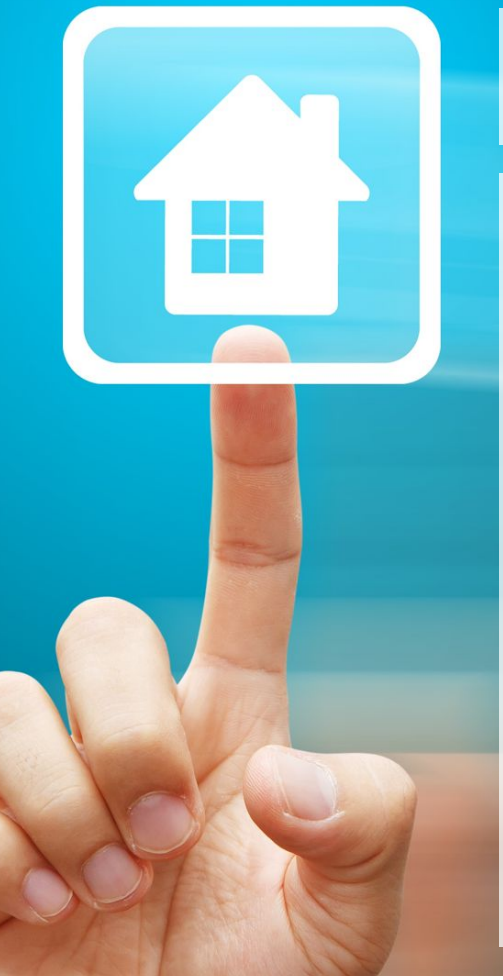
Board Overview





SW/Linux

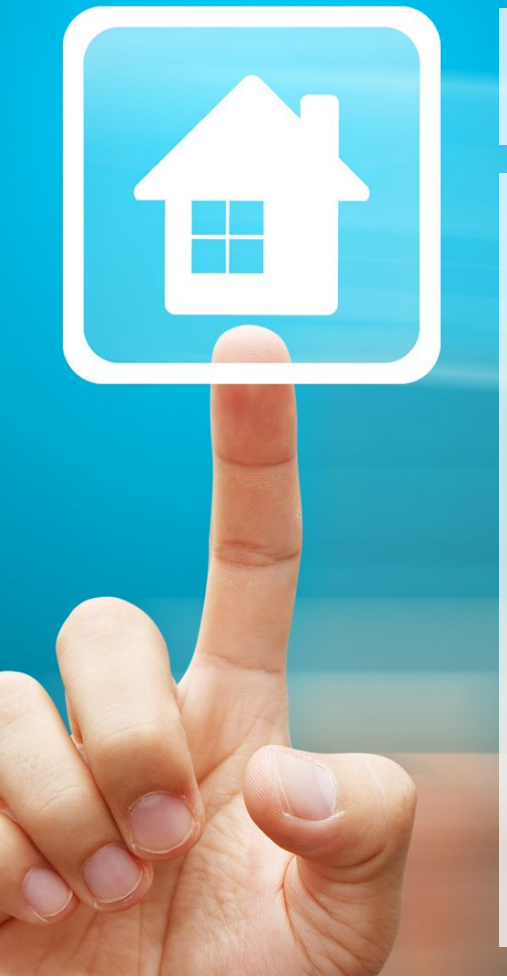

Zybo Board
ETH
PS
ARM
PL (FPGA)
DDR
Microblaze
HW
IP cores
external hardware
Zybo on-board hardware

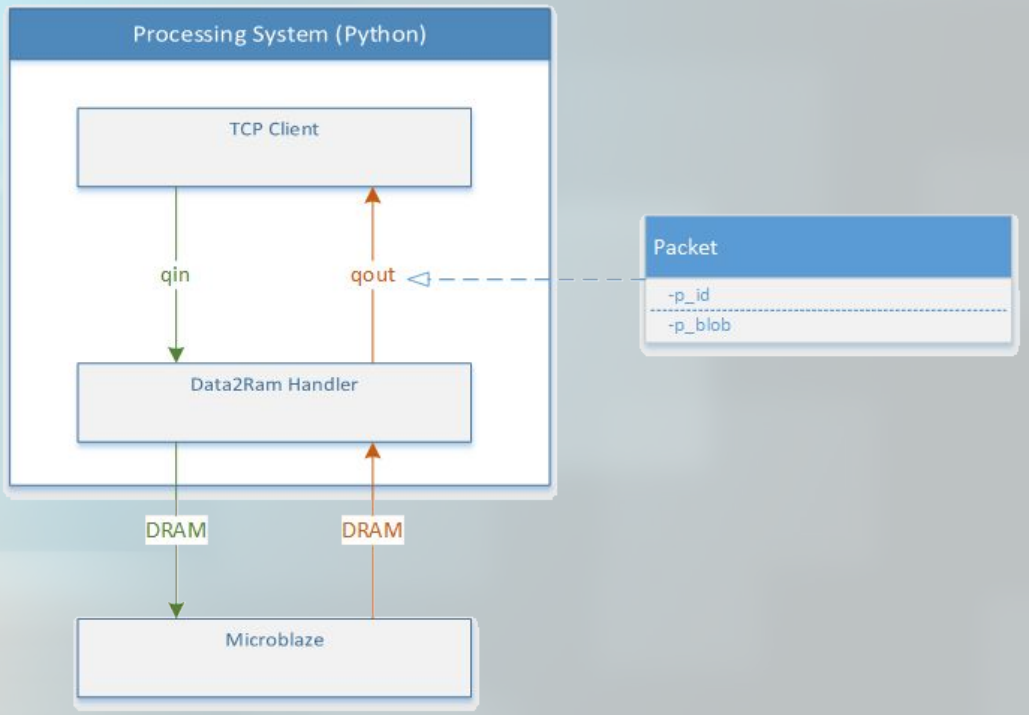


SW/Linux

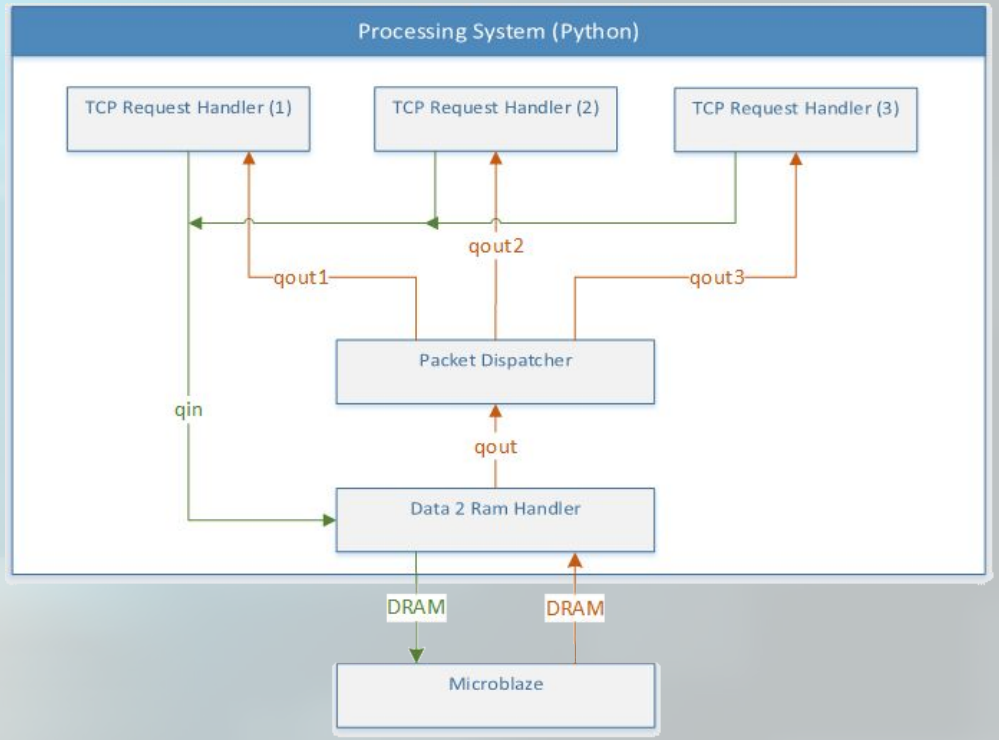
- Buildroot
  - Kernel (version Xilinx-4.4)
  - Rootfs
  - U-Boot
- Python 3.5
  - Node
    - Sensor
    - Actuator
  - Controller
- Data2Ram driver

Communication

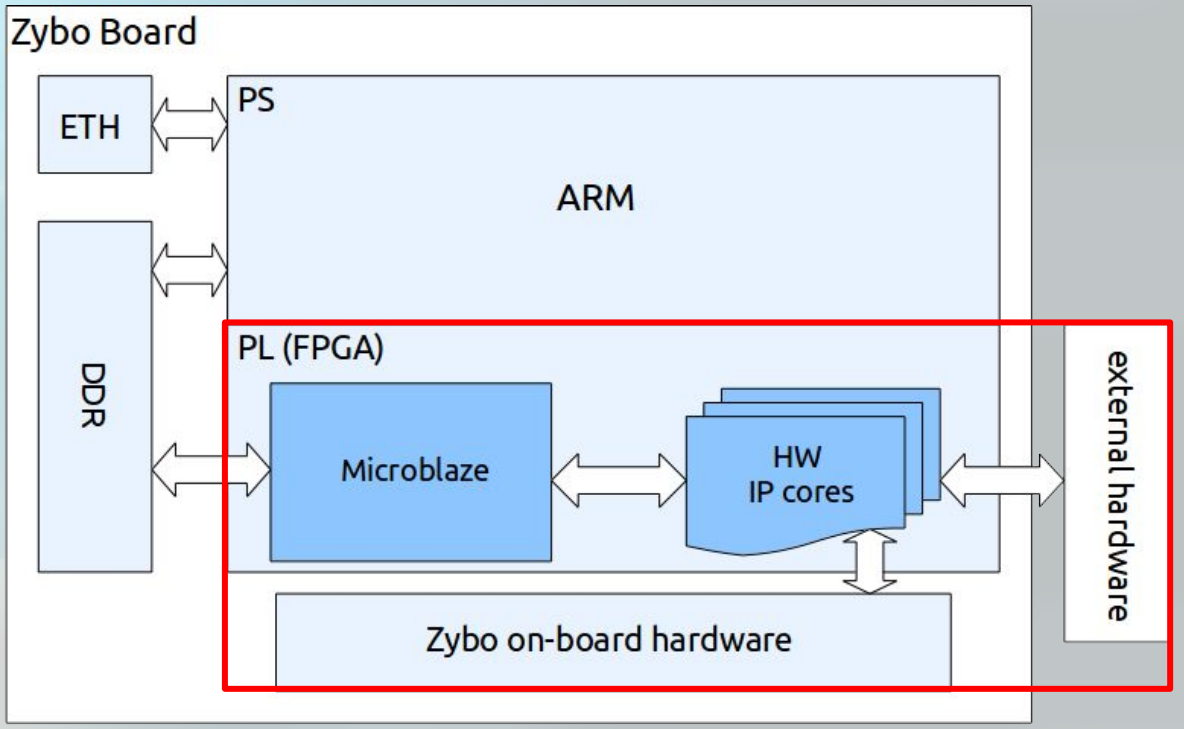




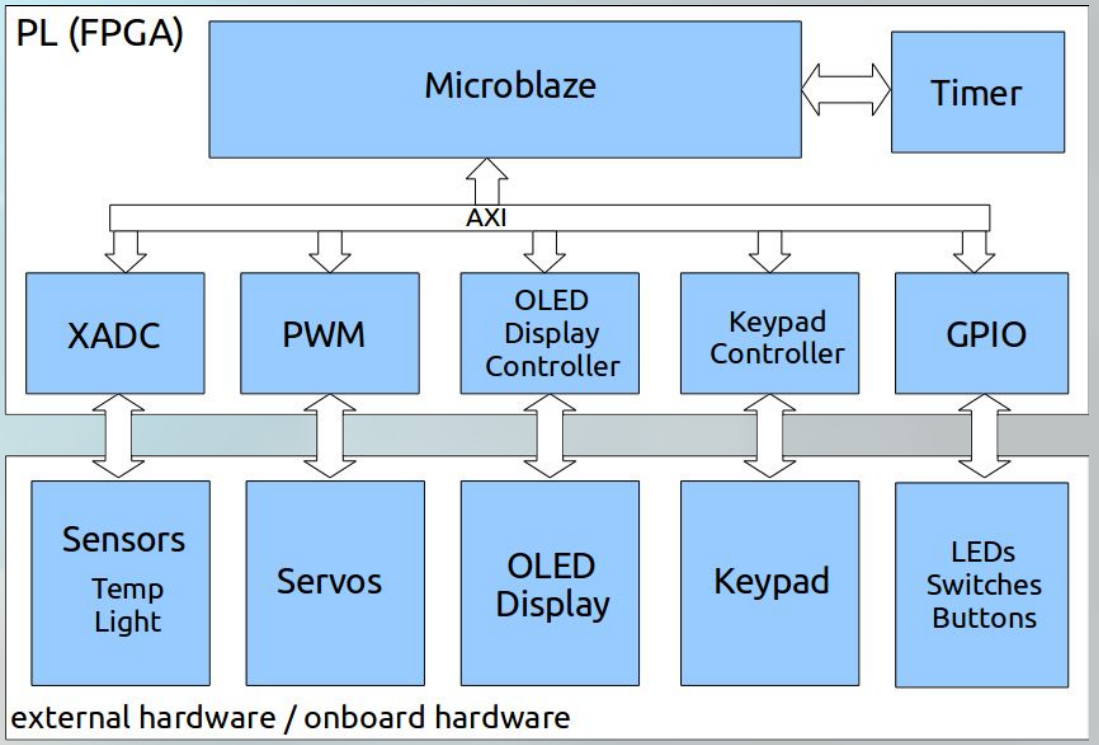
Communication



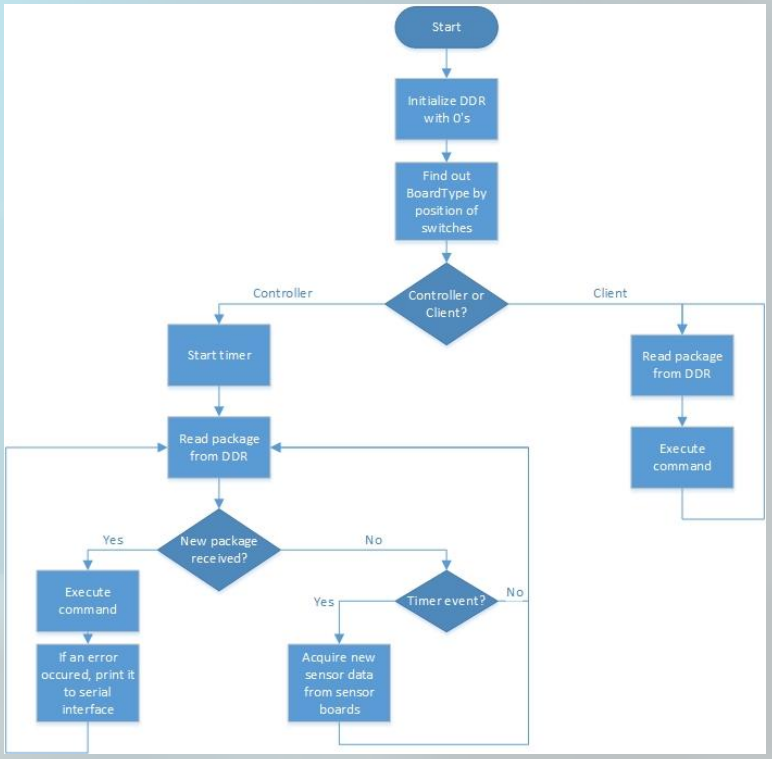
HW/Block Design



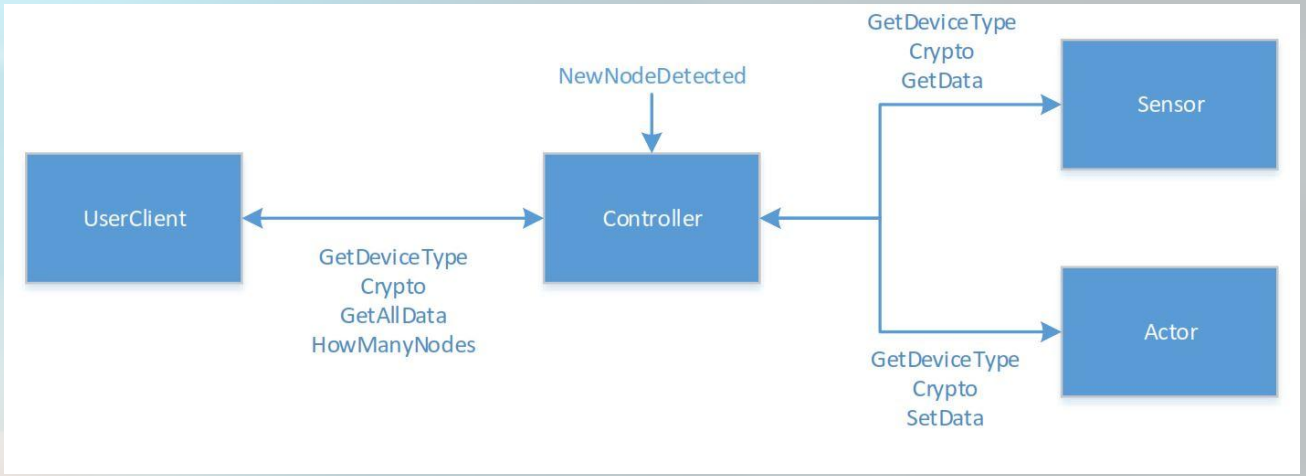
HW/PL and Hardware



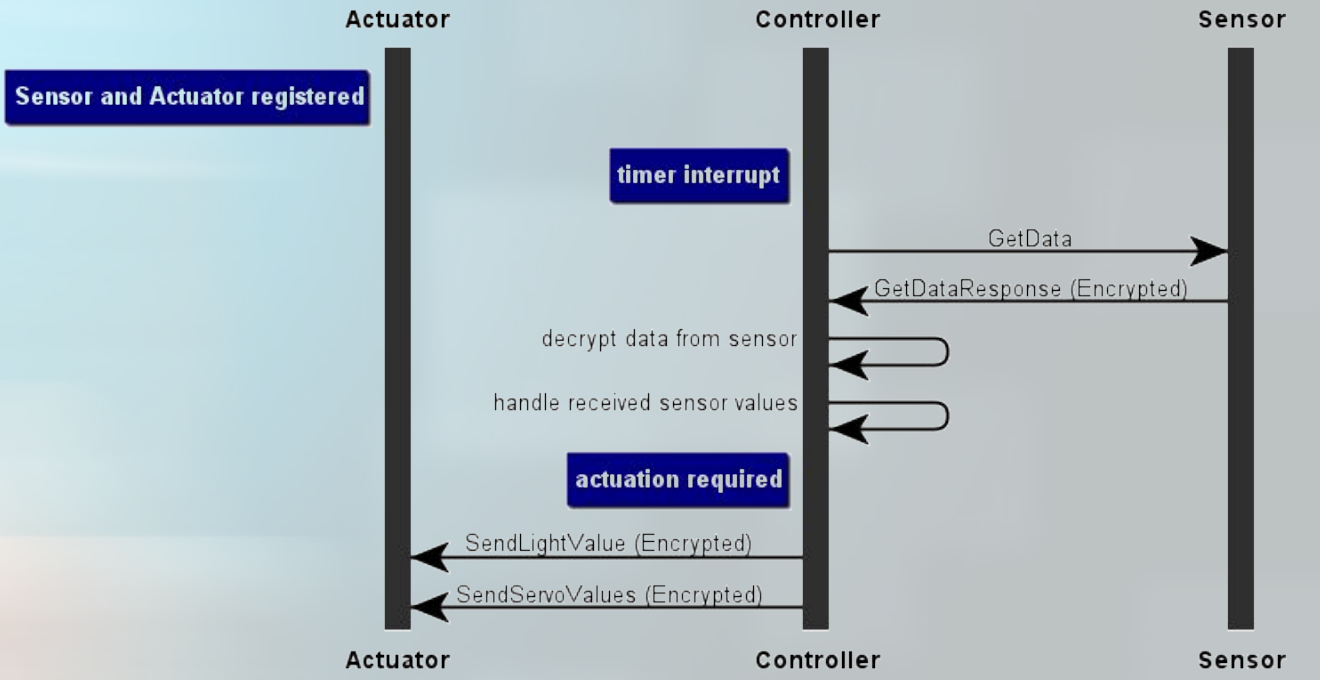
SW/MicroBlaze - Software Flow

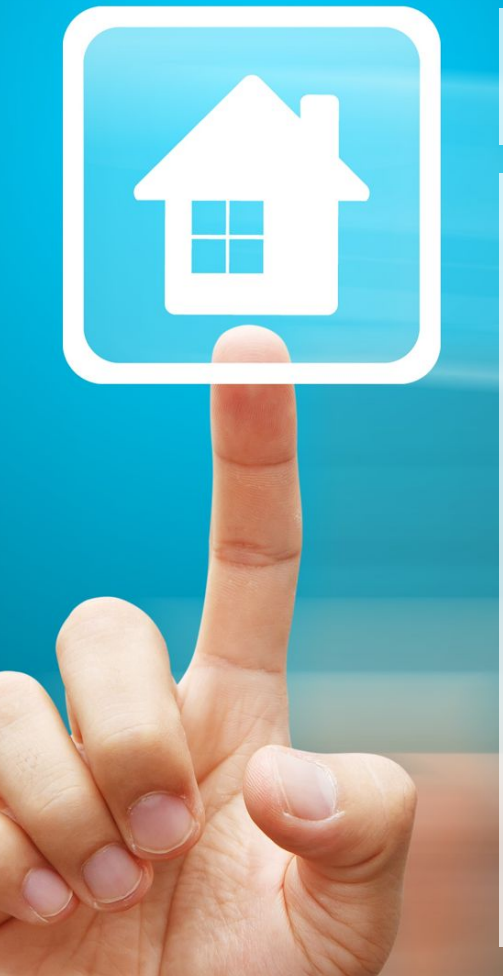


SW/MicroBlaze - Commands



SW/MicroBlaze - Timer Event

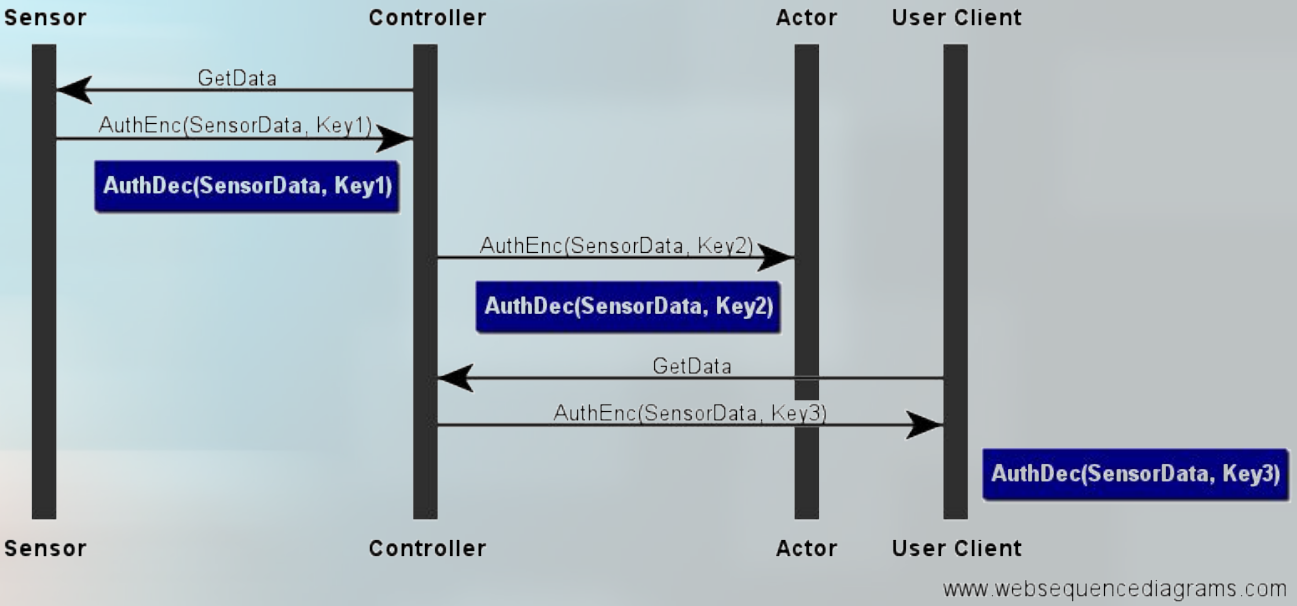


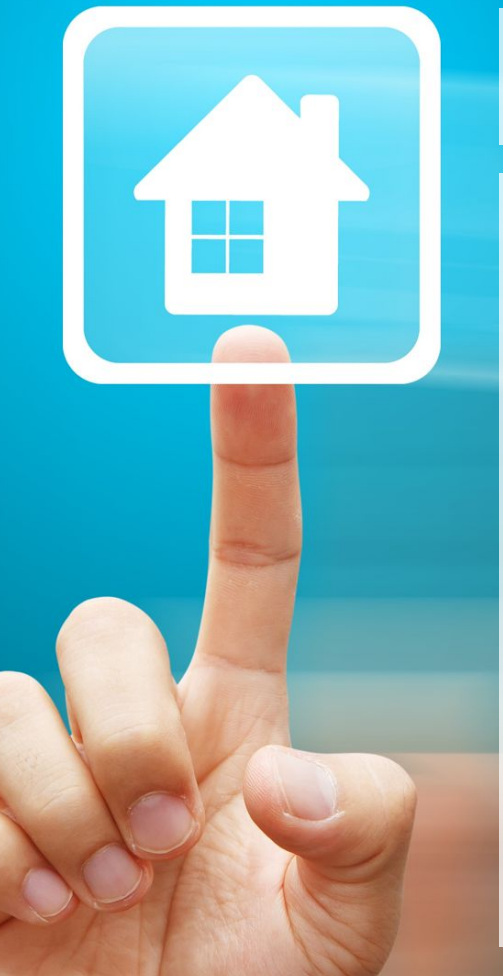


SW/Encrypted Communication

- Private-key cryptography
- Authenticated encryption
- Used algorithm: Ascon-128 v1.2
- Different key per client
- Whole communication via controller

SW/Encrypted Communication

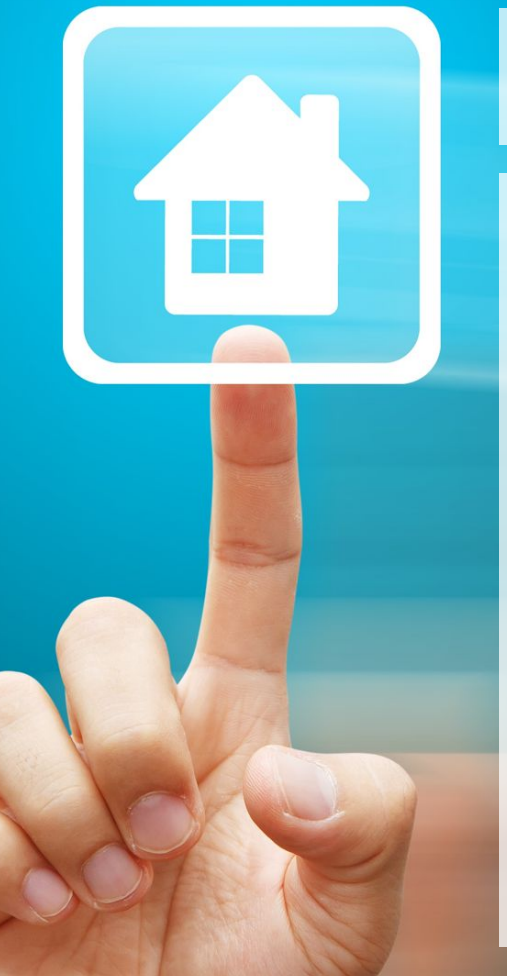


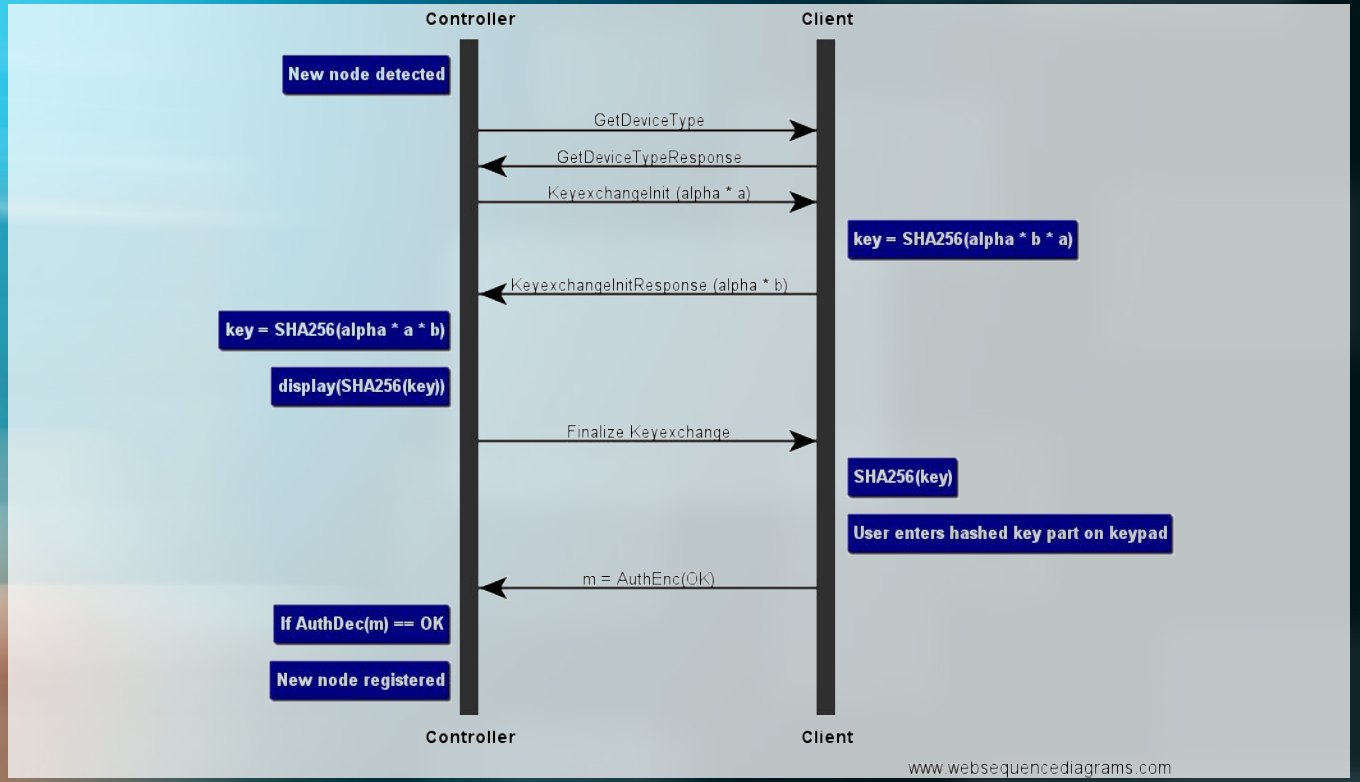


SW/Key Exchange

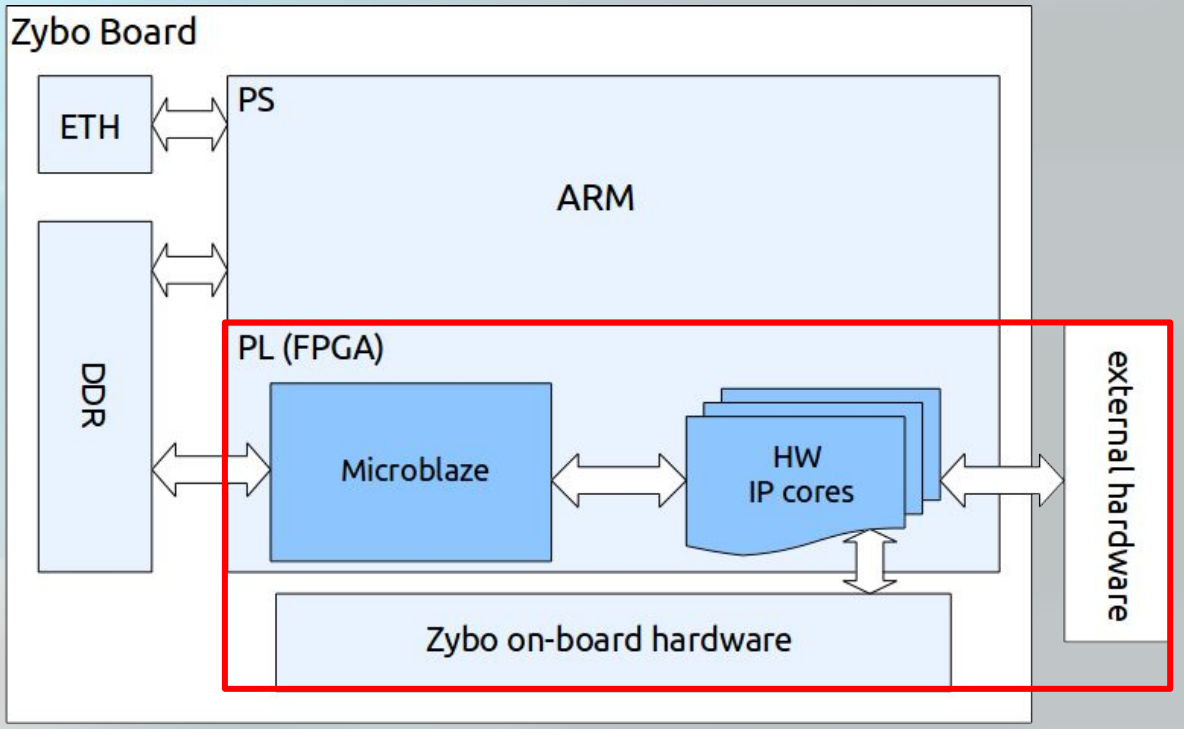
- Public-key cryptography
- Elliptic curve Diffie-Hellman (ECDH)
- SHA256
- Used curve: SECP256R1
- Used library: FLECC
- Man in the middle attack?!
  - User action: display + keyboard

SW/Key Exchange





HW/Extern


Zybo Board
ETH
PS
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HW
IP cores
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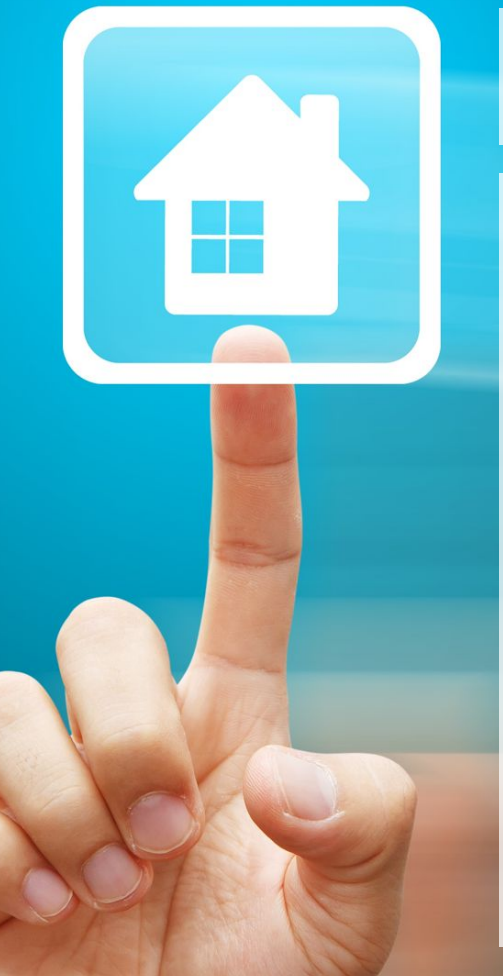
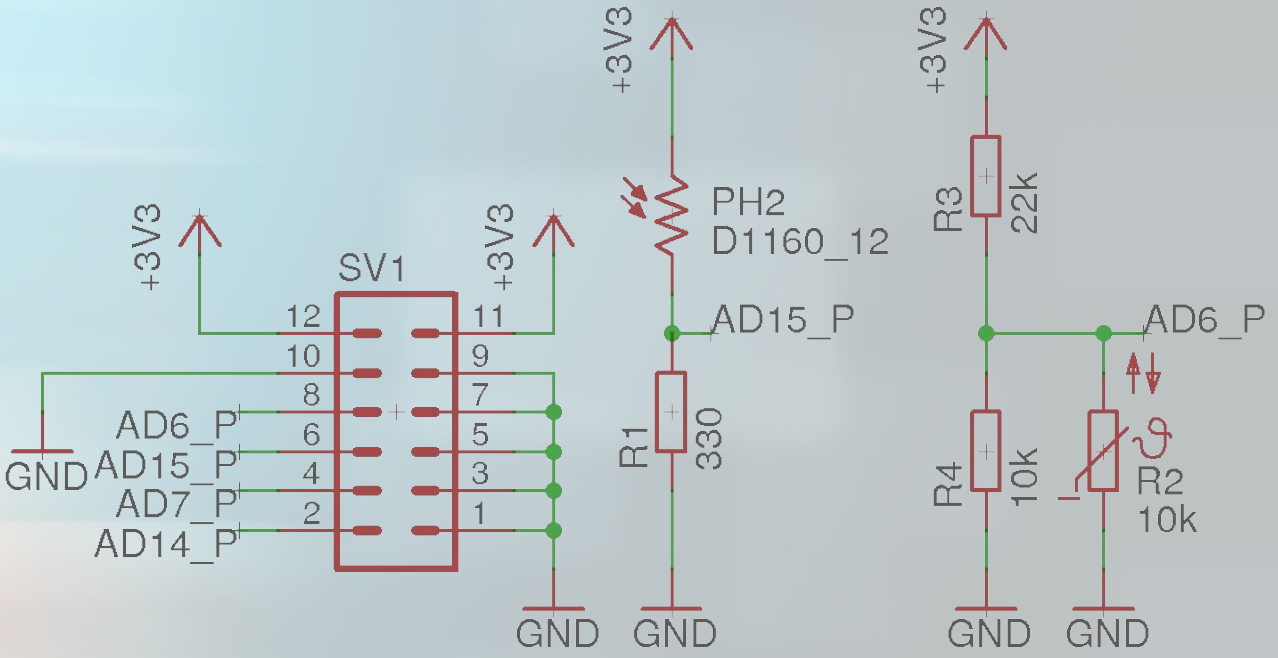
Zybo on-board hardware



HW/Light and Temp Sensors

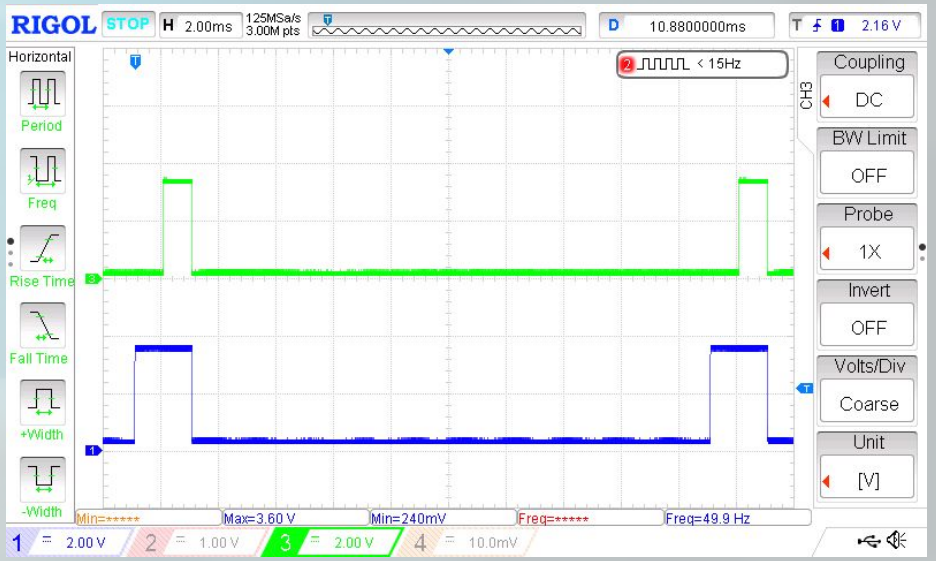
- XADC (embedded part of the FPGA)
- NTC temperature sensor
  - Calibrated with look-up-table
- Photoresistor as light sensor

HW/Light and Temp Sensors

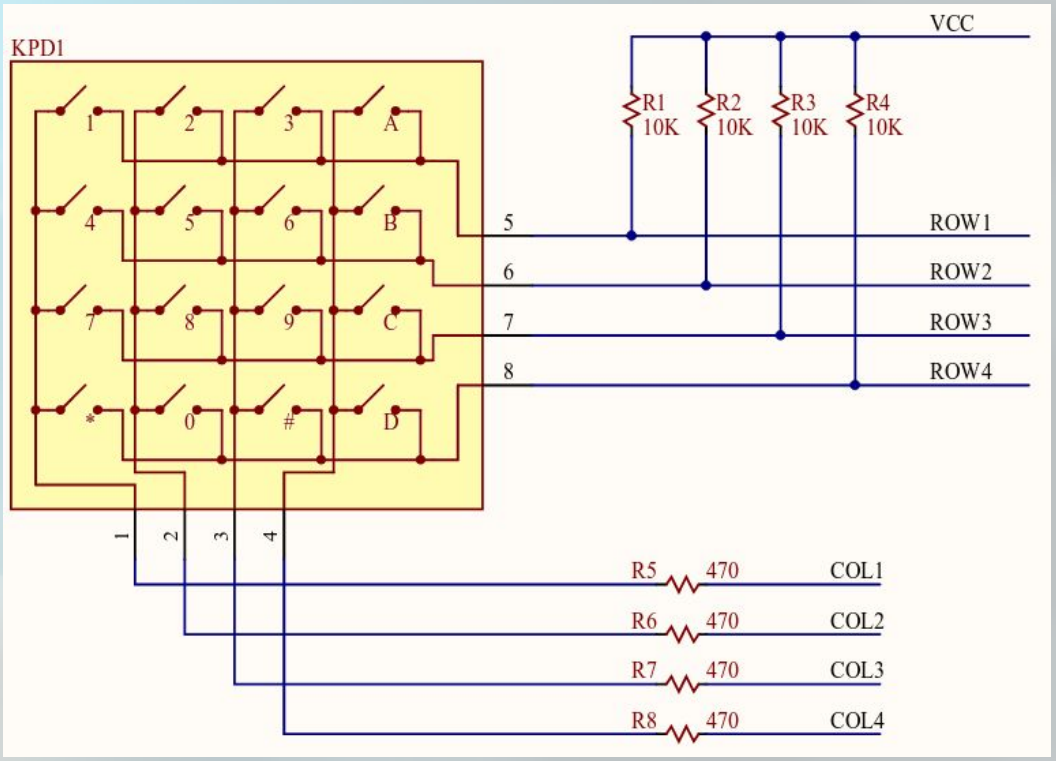


HW/Servos

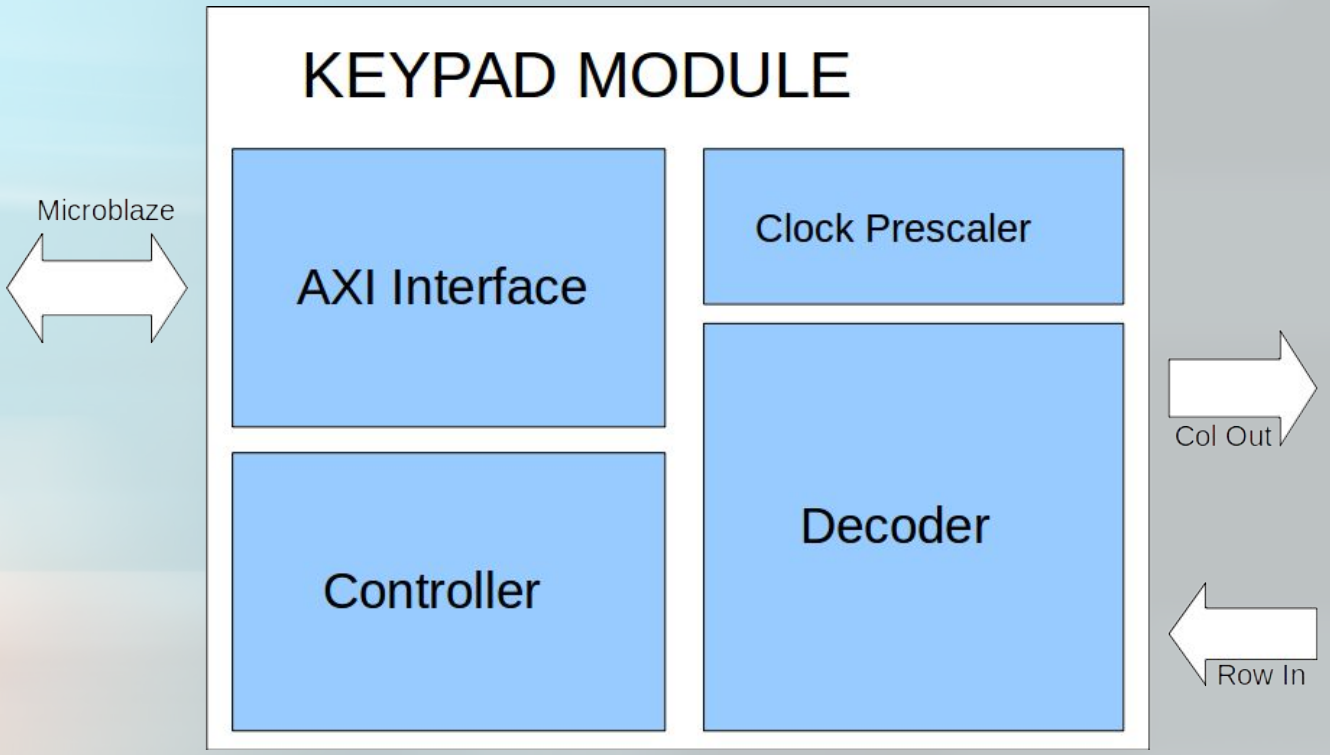
- Controlled using PWM typical 50Hz
- Pulse width 1-2ms

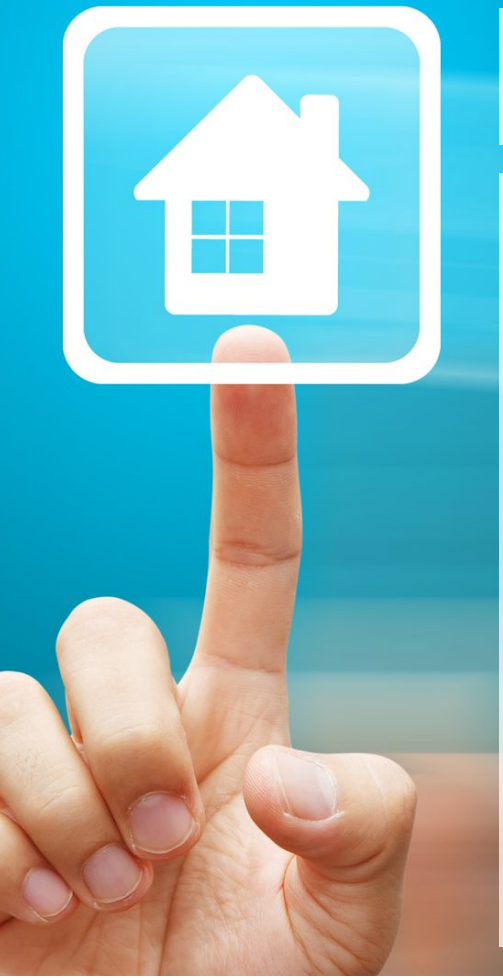


HW/Keypad - Schematic



HW/Keypad - IP

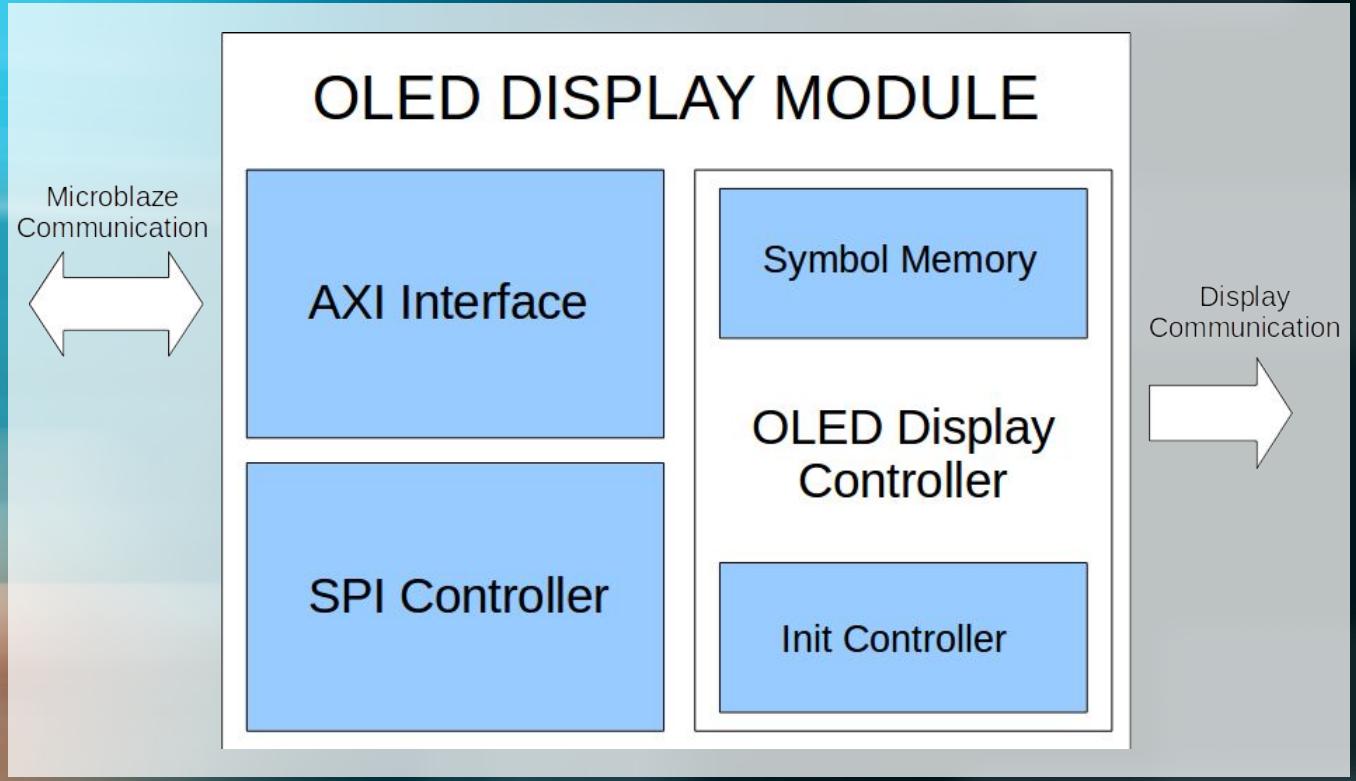

KEYPAD MODULE
Microblaze
AXI Interface
Clock Prescaler
Controller
Decoder
Col Out
Row In

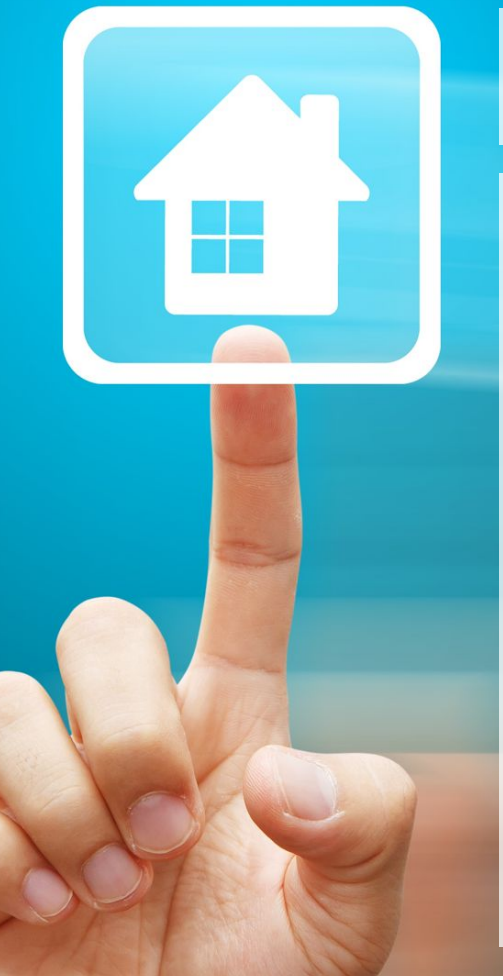


HW/OLED Display

- Usage: Key exchange (client registration)
- Technical facts:
  - 128x32 pixel graphic OLED display
  - Communication via SPI
- Implementation on Zynq:
  - Hardware module (PL)
    - Microblaze communication: AXI
    - Display communication: SPI send controller
    - Control logic (sending symbols, sending commands)

HW/OLED Display

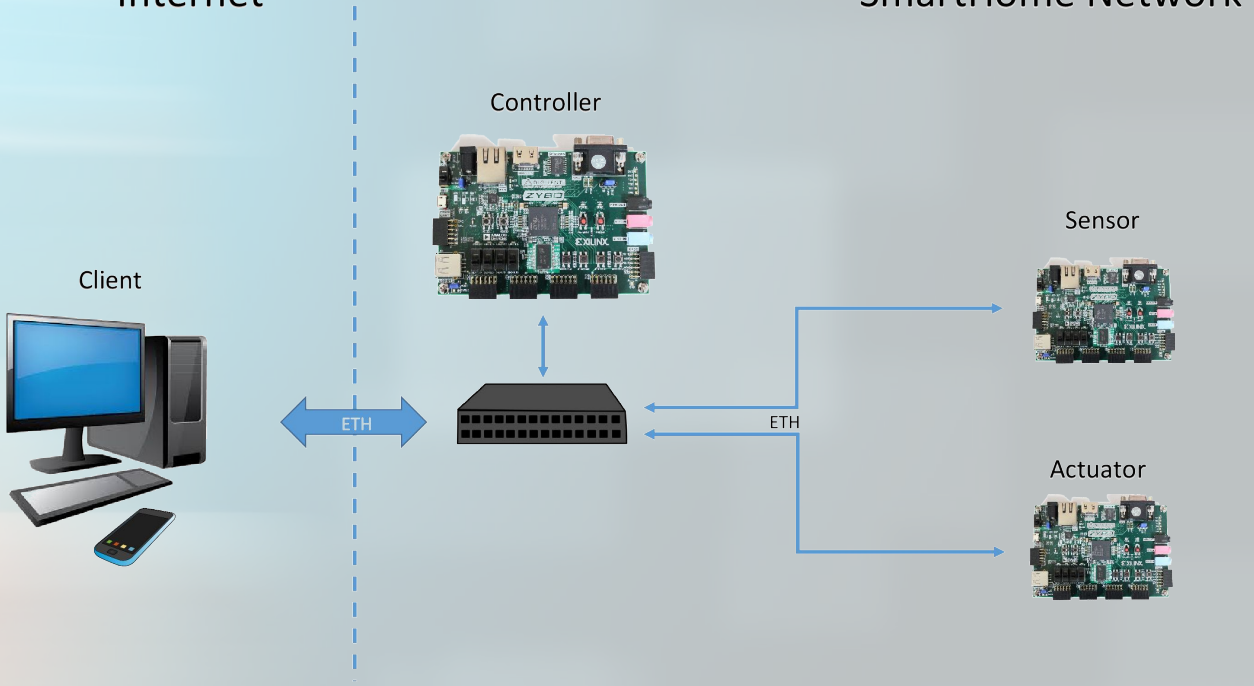




SW/Client

- Python 3.5
  - GUI - tkinter
  - Threading
  - Sockets
- Security
  - Ascon
  - ECDH

Live Demo


Internet
SmartHome Network
Controller
Client
Sensor
Actuator
ETH
ETH

End