WIRELESS TESTBEDS AND TUTORIAL
A GENERIC TESTING ENVIRONMENT OVERCOMES THE DRAWBACKS OF INDIVIDUAL SET-UPS

- Individual set-ups: difficult to reproduce and to compare results
- The benefit of scale
  - testbed size
  - re-use and professionalization of tools

Some of the nodes in our test set-ups, before 2007
GENERIC WIRELESS TESTING ENVIRONMENTS

OVERVIEW

- w-iLab.t
  - w-iLab.1 (officelab)
  - w-iLab.2 (industrial lab)

- Portable testbed

- Industrial-IoT lab

- Homelab
W-ILAB TESTBED ARCHITECTURE (ALL TESTBEDS)

- Switch
- PDU
- embedded PC
- environment emulator
- sensor node

- webcam (40% of nodes)
- 2x Wi-Fi 802.11 a/b/g/n
- Bluetooth 3.0 EDR
- 50 x 802.11ac
W-ILAB.T TESTBED

2 testbed locations:

- w-iLab.1: datacenter with 44 embedded PCs (WiFi and sensor nodes)
- w-iLab.2: industrial room with 100 fixed +15 mobile nodes (WiFi, sensor, LTE, SDR)

Use cases: wireless, sensor, mobile, networking, SDR, 3rd party hardware

https://wilab1.ilabt.iminds.be/inventory

https://inventory.wilab2.ilabt.iminds.be
W-ILAB.T – SOFTWARE DEFINED RADIO

- **USRP x310 (x2)**
  10Gbps fiber to switch
  10 Gbps Ethernet to server

- **USRP B210 (x4)**
  USRP B200 (x4)
  USB3.0 to Intel NUC

- **SERVER (x7)**
  Intel Xeon Processor D-1541
  (2.1GHz, 8 cores, 16 threads)
  16GB DDR4 RAM

- **NUC (x8)**
  Intel Core i5-4250U
  (3M Cache, up to 2.60 GHz)
  8GB DDR3 RAM

- **ZC706 with Zync-7000 SoC (x3)**
  1Gbps Ethernet to APU
  2 x USB (UART + JTAG)

- **APU**
  AMD G-series (1GHz)
  Only for programming & debugging

- **Xilinx ZedBoard**
  Zync-7000 SoC (x1)
  2 x USB (UART + JTAG)

- **SERVER**
  Intel Xeon
  Only for programming & debugging

---

**First FREE open source full stack real-time Wi-Fi**

**open-source 4G from handset to core**

**GNURadio**

**RFNoC**

**SRS LTE**

**imec**

**idLab**

**Openwifi**
IOT-OFFICELAB
Office environment with 110 embedded PCs spread over 3 office floors
Use cases: wireless, sensor, networking, 3rd party hardware, indoor localization (UWB)

https://wilab1.ilabt.iminds.be/inventory
CONSTRAINED IOT DEVICES

- **Zolertia Re-Mote**
  - 2.4GHz / 868MHz
  - UWB-shield (in-house developed)
- **Currently deployed:**
  - Temperature sensors
  - Many other sensors possible
- **Zolertia Z1**
  - 2.4GHz
- **RM090**
  - 2.4GHz
- **Environment Emulator**
  - Battery emulation
  - 6KHz sample rate
  - Generate I/O events on DUT
  - RM090/Re-Mote
- **Nordic Semiconductor nRF52 DK**
  - BLE development kit
- **UWB shield**
  - UWB radio, sub-cm accuracy
- **Sparklan WPEA-251N(BT)**
  - 802.11a/b/g/n
  - Bluetooth 4.0 LE/ 3.0 HS/ 2.1 EDR standard
PORTABLE TESTBED
Portable wireless test infrastructure with 15 embedded PCs (WiFi/sensor) & SDR equipment. Easily extendable with 3rd party hardware.
Use cases: wireless, sensor, networking, on-site testing, rapid deployment
W-ILAB.T WIRELESS TESTING: FACTS AND FIGURES

- generic testbed for wireless networks
  - implementing and testing protocols, applications, complete products,…
  - using the installed equipment and technologies and/or by integrating 3rd party products or technologies

- 2 testbed locations
  - w-iLab.1
    - iGent datacenter: 40+ locations + 4 shielded boxes
    - iGent offices: 100+ locations
  - w-iLab.2 Plenum cleanroom
    - 70m x 22m
    - 150 fixed + 20 mobile node locations + SDR
W-ILAB.1 IGENT DATACENTER

- Limited wireless interference
- (almost) no human presence

44 Intel NUC
i5 / 8GB RAM / 320GB HDD
802.11a/b/g/n + BT 4.0
802.11ac (3x3)

2x Zolertia Remote

https://wilab1.ilabt.iminds.be/inventory
W-ILAB.1 IGENT OFFICES

100+ NUCS with 1x Zolertia Remote
W-ILAB.2 PLENUM CLEANROOM

- external interference limited compared to office environment
- (almost) no human presence

150 fixed nodes
20 mobile nodes

https://inventory.wilab2.ilabt.iminds.be
W-ILAB.2 PLENUM CLEANROOM SPECIAL NODES AND PROXY USE

- some embedded nodes are used as proxy to connect to specialized hardware
- more powerful servers available for special purposes (16x 10Gbit interfaces)

2 x femtocell (ip.access) + emulated core (SiRRAN)

USRP, WARP, IMEC SE SDR/cognitive

sensor nodes (RM090 with MSP430), environment emulator,...

+20 UE (Huawei)

? your custom hardware (e.g via USB, PoE, 220V, ethernet)
MOBILE NODES INTRODUCE REPRODUCIBLE MOBILITY IN EXPERIMENTS

- Remote controllable
- 5cm accuracy => Repeatability
- Automated charging
- PTZ-camera system
- Possible to add extra IoT devices (USB)
THIRDPARTY HARDWARE INTEGRATION & TESTS
PORTABLE TESTBED

IoT extensions possible over USB
PORTABLE TESTBED

- https://www.youtube.com/watch?v=dkiTrK7zlPu
INDUSTRIAL IOT LAB

- 30x10m
- 3 areas:
  - Flexible production area with industrial robotic arms
  - Open space 6mx10m (e.g. for drone flying)
  - Warehouse area (17m x 10m)
- UWB localisation (IDLab development)
- mocap for drone localisation verification (5x5m, 8x Qualisys Miqua)
CITYLAB TODAY: A CONNECTIVITY INFRASTRUCTURE
MULTI-TECHNOLOGY CONNECTIVITY

- Large deployment operational outdoor
  - 35 CityLab gateways in City Campus
  - 15 additional gateways pending
  - 15 in Smart Zone for connectivity services

- Focus on coexistence testing in unlicensed spectrum and edge computing
  - Outdoor edge computing
  - Supporting WiFi, 802.15.4, Bluetooth and sub-GHz
  - Backed up by commercial LPWAN backends (LoRa, SigFox, NB-IoT)
HOMELAB

- Flexible home environment
  - Integration of technologies
  - User experiences
  - E-health / home automation / localization …
WHAT DOES THE TESTBED DO?

The testbed does not do anything by its own, but all devices/interfaces/… in the testbed can be used “as if a set-up was on your desktop”…

Yet with tools that help you to

- Discover and reserve
- Provision, install and configure
- Experiment with / control / monitor / measure nodes easily, at scale

Obtain more reliable developments and results, in a faster and more easy way.
HOW TO OPERATE THE TESTBED?

- Can be operated fully remotely: jFed
- Typical way of working:
  - 1/ reserve a slot for testing [ + indicate what hardware will be used ]
  - 2/ “swap in” test/experiment after reservation slot starts
    - i.e. configure all nodes according to experiment description
  - 3/ during experiment, trigger certain manual or automated events (e.g. “imitate traffic”, “generate interference”, switch on/off node, change config. parameters…) and log relevant data
  - 4/ after experiment ends, “swap out” experiment
  - 5/ process data
BLE MESH EXPERIMENTS

- 22 nodes
- All nodes equipped with:
  - nRF52 development boards
  - Bluetooth 5.0 support
  - Long range support (nRF52840)
- All nodes are synchronized for logging purposes
- BLE Mesh topology experiments
  - Round-trip time validation
  - Scalability tests
  - Collision detection
SOUNDS INTERESTING?

IMEC iLab.t technical testing offers hardware and tools, and all necessary knowledge and support to answer your technical (testing) needs

https://doc.fed4fire.eu
https://doc.ilabt.imec.be

helpdesk@ilabt.imec.be
W-ILAB.2 DEMO & HANDS ON
- **Embedded PC (Zotac)**
  - 2x WiFi 802.11 a/b/g/n
  - 802.15.4 sensor node
  - Bluetooth 3.0 EDR
TUTORIAL

- http://inventory.wilab2.ilabt.iminds.be/: reservation
MORE ADVANCED: OPENWIFI

https://github.com/open-sdr/openwifi
DEMO MOBILE NODE

embracing a better life