Facilities, Equipment and Other Resources (WINLAB, Rutgers University)

Laboratories

WINLAB, the Electrical and Computer Engineering Department and Computer Science Department, at Rutgers University, have extensive laboratory and equipment facilities to support research activities in the general areas of:

- Software defined radio (SDR) hardware and software
- Emulation, simulation, and analysis of large scale complex wireless systems
- Cross-layer wireless networks protocol design
- Integration of wireless networks into next-generation Internet
- Securing wireless systems using physical-layer characteristics
- Security, privacy, and robustness of wireless sensor networks

Clinical

N/A

Animal

N/A

Computer

WINLAB has the capability of fabricating prototype devices and printed circuits with K&S wedge bonder, SMT rework equipment as well as various FPGA development platforms and programmable embedded platforms (APTIX, GNU radio USRP, etc.). The laboratories are also equipped with various network analyzers, RF spectrum analyzers, high-speed digitizing oscilloscopes, function generators, power meters and other general purpose laboratory equipment (shielded enclosures, antennas, etc.). WINLAB also maintains state-of-the-art computing facilities including 12 compute servers, 4 storage servers, a 20-processor HPC cluster and 12 high-performance workstations, and over 200 networked computers and laptops. The center maintains software licenses for a variety of simulation tools including Matlab, OPNET, all major hardware design tool chains including Cadence, Synopsys and Mentor Graphics, as well as specialized wireless communications tools like EEs of EDA, Wise, XFDTD and numerous other public domain simulation tools.

Office

WINLAB's research and administrative operations are now located at the Rutgers Technology Centre II, at 671 US Route One, just south of the Rutgers Cook Campus. The Technology Centre provides meeting rooms and facilities for hosting workshop-oriented events and is capable of supporting roughly 70 attendees. Faculty advising offices and a satellite administrative office are also located on the 5th Floor of the CORE building in Busch Campus near the Electrical and Computer Engineering and Computer Science

departments. Total floor space at these two locations is approximately 18,000 sq-ft including about 7000 sq-ft of laboratories.

Equipment

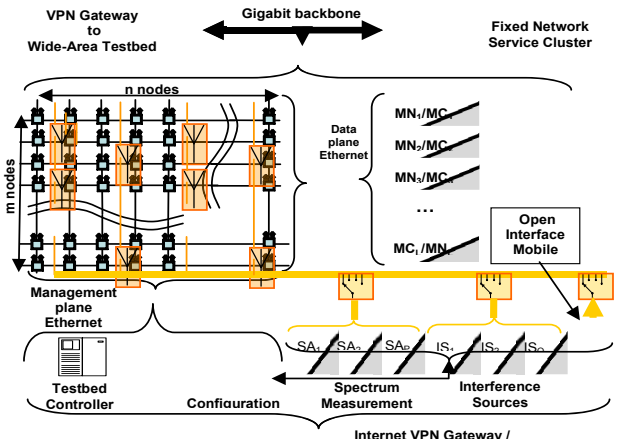

Fig. A: ORBIT radio grid architecture

Fig B: ORBIT Radio Grid at RU Tech Center Building

Major Development and Evaluation Testbeds:

- The ORBIT *open access testbed for next-generation wireless networking* at WINLAB provides a "real-world" experimentation means that is capable of capturing the complexity of the wireless channel and its impact on the protocol stack. ORBIT consists of a large-scale radio grid emulator (an array of 20x20 programmable nodes) as in Figure A and Figure B, with *multiple* 802.11a/b/g and other interfaces. Already, the ORBIT testbed has been extended to support additional wireless technologies beyond 802.11, and in particular the testbed consists of several GNU Universal Software Radio Peripheral (USRP) software radio boards attached to ORBIT nodes via a USB2.0 interface. ORBIT will also be augmented by incorporating both WINLAB's cognitive radio prototype and USRP2. In addition to the basic grid, ORBIT provides radio mapping algorithms and a mobility emulation server that allows users to emulate real-world wireless scenarios in a controlled, reproducible experimental setting. ORBIT software allows experimenters to manipulate wireless interfaces (such as the GnuRadio/USRP) to choreograph experiments, and to collect large volumes of performance data. Beyond the core testbed, ORBIT is augmented with additional experimental resources. **RF instrumentation**: The ORBIT grid includes equipment for measurement of radio signal levels and to create various types of artificial RF interference (white noise, colored noise, microwave oven like noise etc.) inside the grid. The interference generator is based on the RF Vector Signal Generator while the spectrum measurements are done using Vector Signal Analyzers. **Network Monitoring:** An independent WLAN monitoring system (using equipment donated by Aruba Networks) provides a MAC/network layer

view of the radio grid's components using a number of WLAN "observers" spread across the system. **Support Servers:** The testbed's backend equipment includes several front-end servers for web services, experiment support and data storage. The database servers support multi-terabyte storage capacity. There is also an Ethernet switching array with ~1400 ports necessary to switch traffic from 3 x 400 grid node interfaces and the servers.

- WINLAB is also host organization for several cognitive radio platform developmental efforts. WINLAB's cognitive radio prototype's architecture is based on four major elements: (1) MEMS-based tri-band agile RF front-end, (2) FPGA-based software defined radio (SDR); (3) FPGA-based packet processing engine; and (4) embedded CPU core for control and management. These components are integrated into a single high-end prototype system (WINC2R) which leverages an SDR implementation from Lucent Bell Labs as the starting point. A second platform, the SPIRAL-II GENI cognitive radio platform (depicted in Figure C), is being developed at WINLAB as part of the NSF GENI initiative. The SPIRAL-II GENI platform leverages off the shelf FPGA components and a wide-tuning-range custom-made RF front-end to support experiments in the 300MHz to 7GHz. The SPIRAL-II platform supports up to 4 full-duplex RF chains and multiple baseband transceiver implementations. The SPIRAL-II GENI platform will be integrated into the ORBIT wireless testbed so as to provide cognitive radio resources to the broader networking research community, and to support experimentation with new physical and MAC layer protocols. Lastly, WINLAB is part of the NSF-funded effort to expand the GNU-radio-based open-source software to enable MAC-layer networking experimentation. As part of this effort, the ORBIT testbed has been equipped with a large number of USRP2 software radio platforms.
- Further, WINLAB is the host organization for the SPIRAL-II GENI meso-scale WiMax deployment, which provides NEC WiMax basestations with open-APIs to seven campuses across the USA (with Rutgers-WINLAB serving as the lead). The WiMax basestations enable large-scale mobile networking experiments covering a wide geographic area. A depiction of the WiMax basestation deployment in central New Jersey is provided in Figure D.

Fig. C: GENI SPIRAL-II Cognitive Radio platform

Fig D: GENI SPIRAL-II WiMax deployment in North Brunswick, NJ

Other Resources

WINLAB @ Rutgers University maintains close contact with the wireless industry, government and other universities. The center disseminates research results to the aforementioned entities on a half-yearly basis. In support of this effort, WINLAB maintains a full-time administrative and engineering staff.