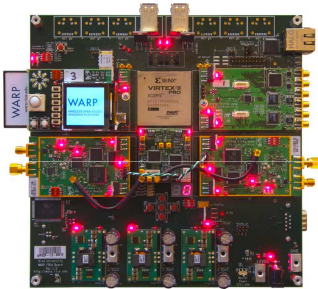


INSIDE CRAMNET

WIRELESS OPEN ACCESS RESEARCH PLATFORM (WARP)



The platform developed by CMC at Rice University

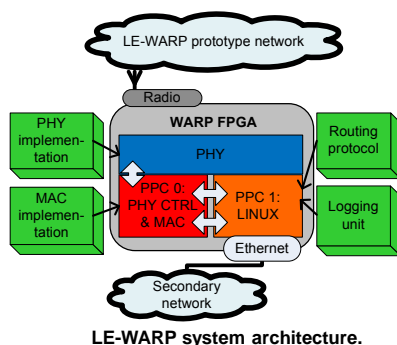
- Designed for prototyping wireless protocols and algorithms in PHY and MAC layers
- Xilinx Virtex II Pro FPGA, with two embedded PowerPC cores
- Radio functionality at 2.4 & 5 GHz ISM bands

The OFDM reference design by CMC (under RUSD license)

- OFDM physical layer
 - BPSK, QPSK, and 16-QAM modulation schemes available for OFDM sub-carriers
- WARPMAC and WARP PHY frameworks enables to build own MAC protocols
- No TCP/IP networking stack

LINUX ENRICHED WARP (LE-WARP)

CRaMNET demonstration is implemented on LE-WARP (Linux Enriched Wireless open Access Research Platform by CWC. LE-WARP is an extension of WARP.



LE-WARP system architecture.

Dual core design on the FPGA:

PPC0 for physical and MAC layer designs

- Customized OFDM reference design framework (PHY/MAC)

PPC1 for network and higher layer designs

- Linux OS
- TCP/IP networking stack
- Multitasking environment
- Open source programmability
- Statistics logging unit (input data for GUI)

Intercommunication between the cores

- Enables control/payload data flow
- Enables statistics gathering from PPC 0 to Linux OS and beyond via secondary network

MODULES

CRaMNET comprises of 6 basic modules:

• Spectrum Sensing at PHY layer (SS)

The main idea is to inform the secondary user about the spectrum layout and its occupancy by the Primary users.

LE-WARP uses LAD algorithm to perform the spectrum sensing. This is a localization algorithm based on double-thresholding i.e. it uses a lower threshold and an upper threshold to decide whether there is a valid signal or not. LAD thresholds are calculated using forward consecutive mean excision algorithm (FCME), LAD does not need a priori knowledge about the signal to be detected or the noise level. The lower threshold is used to compose adjacent signal samples into clusters whereas the upper threshold is used to detect signals. The LAD output is given as an input to the CE module.

• Cognitive Engine module (CE)

CE module is the brain of CRaMNET. It has the cognitive intelligence, it controls the LAD module by invoking it at different intervals and processing the LAD output by performing suitable averaging and false signal elimination and precisely realizing the free spectrum holes and it collects and utilizes the statistics of spectrum usage.

This information is used to determine the centre frequency and the bandwidth that can be used by the SU so that opportunistic channel usage can be achieved, these parameters are then passed on to the APHY module so that it adapts the physical layer accordingly.

• Adaptive PHY layer module (APHY)

APHY is controlled by the CE module and is a separate hardware module in CRaMNET. It has 10 MHz instantaneous bandwidth with ability to change it to 5 and 2.5 MHz if needed. After receiving the centre frequency and the bandwidth from CE module, the APHY module will accordingly change the centre frequency and suppress the subcarriers to match the bandwidth requirement.

• Time synchronization module

When a SU is powered up it starts to listen to a time synchronization signal (TSync), if a valid TSync is received it will perform a network entry with the timing information given by the TSync after performing the required offset, if it does not receive the TSync then an assumption is made that it is the first SU in the vicinity and starts sending TSync messages at regular intervals, the subsequent SUs performing network entry will use these TSync messages to synchronize with the network.

• Opportunistic MAC with Network layer information (OMAN)

OMAN is a MAC protocol specially designed for cognitive MANETS. It defines a set of protocols to use the shared media among secondary users effectively with efficient bandwidth usage, it does not support any particular service classes as well as quality of services and hence treats all types of traffic uniquely. OMAN uses TDMA and random access techniques to achieve the desired result. It consists of a CCH and several OTCHs.

• Linux OS as the Network layer handler with OLSR and full IPv4 TCP/IP protocol stack running on it

LE-WARP has Linux running on one of its dual processors i.e. PPC-0 and PPC-1 of the Xilinx Virtex II FPGA chip. PPC-1 with Linux OS acts as the network layer, it has a fully functional TCP/IP stack and OLSR routing daemon running. The core functionalities carried out by Linux OS are:

- Provide network layer interface
- Route IP packets using configurable routing stack (currently OLSR algorithm)
- Additional control of MAC and PHY layer operations through APIs
- Receives radio environment information from MAC and PHY
- Logging of statistics related to all the layers PHY, MAC and NET
- Command line interface

• Graphical user interface (GUI)

All the nodes are connected to the GUI and the nodes send statistics to it. The GUI is implemented using Java language.