Wireless @ Virginia Tech

CWT

Leveraging Embedded Heterogeneous Processors for SDR Applications

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Outline

- Introduction
- Hardware Platform
- Software Tools
- GNU Radio DSP Extension
- Performance Testing
- Future Work
- Questions

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Introduction

- SDR applications vary in computational and power needs.
- Different computing devices needed for different scenarios.
  - General Purpose Processors (GPPs), Digital Signal Processors (DSP), and Field Programmable Gate Arrays (FPGAs)
- Targeting open source tools for SDR.

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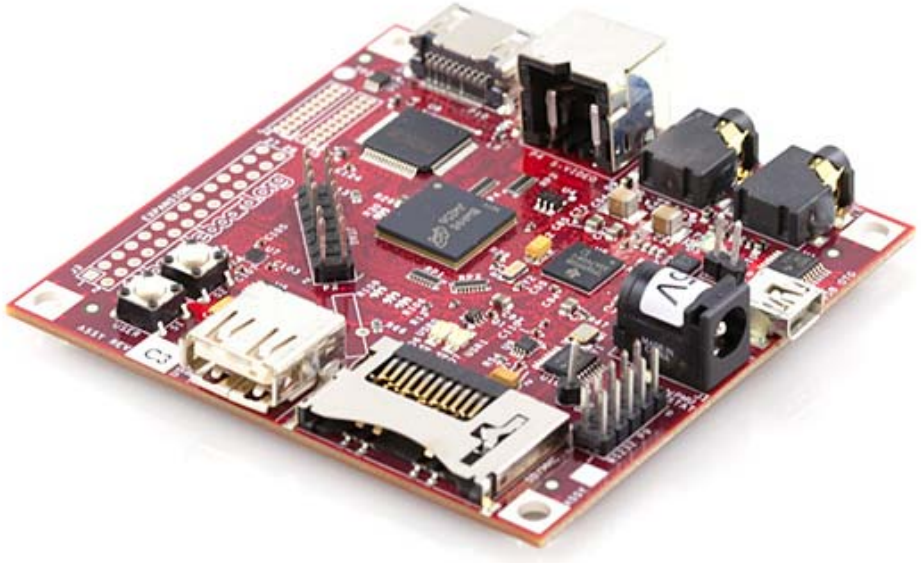
Hardware Platform

- **Beagleboard**
  - **OMAP 3530 Processor**
    - **Arm Cortex A-8 (500 MHz)**
    - **C64x+ Fixed Point DSP (360 MHz)**
    - **NEON SIMD – media acceleration coprocessor**



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Software Tools

- OpenEmbedded
  - Build framework for embedded Linux.
- DSP/BIOS Link (DSPLink)
  - Library for inter-processor communication.
- C64x+ Compiler
  - DSP compiler.

Software Tools

- DSP BIOS
  - DSP Real-Time Operating System.
- Code Composer
  - Texas Instrument IDE.
- GNU Radio
  - SDR software development kit.

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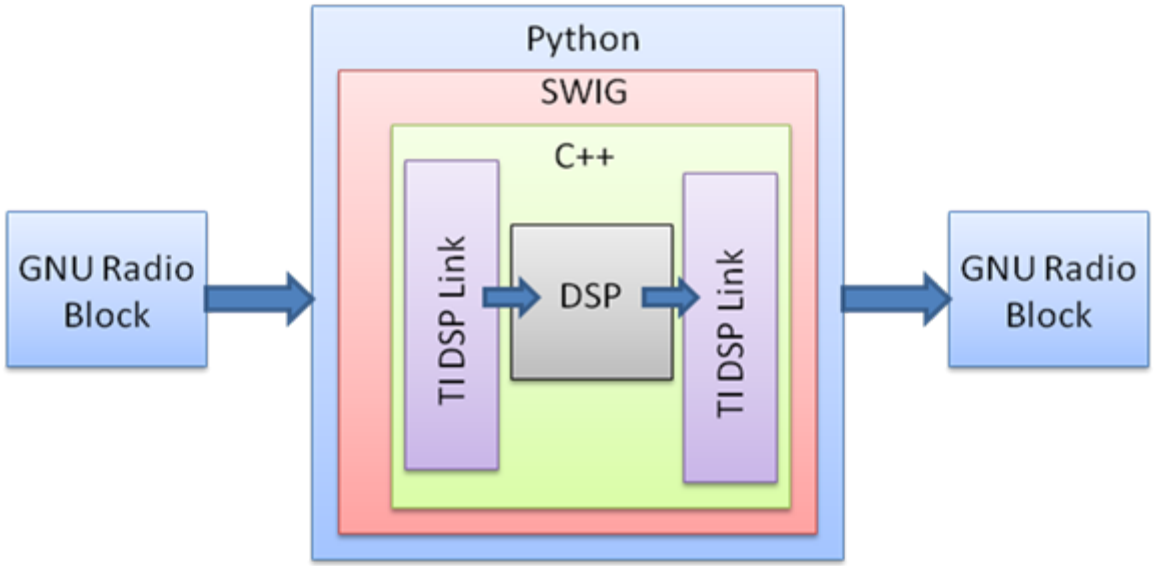
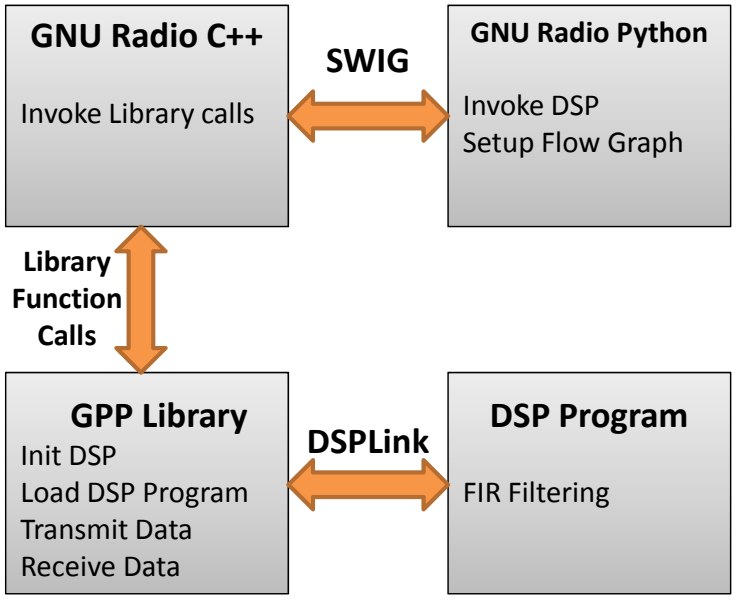
GNU Radio DSP Extension

- GNU Radio blocks which utilize the DSP.
- DSP blocks invoked using Python.
- DSP backend written in C/C++.
- SWIG allows C++ functions to be invoked from C++.



GNU Radio DSP Extension

- **GPP Library**
  - **Abstracts inter processor communication.**
- **DSP Program**
  - **Contains various DSP functions that can be invoked.**



GNU Radio DSP Extension

- Each GPP/DSP stream contains header tokens.
  - Identifies function to be implemented.
  - Unique ID.
  - Interpolation/decimation factors.
- Fixed/Floating point conversions.
  - GPP floating-point .
  - DSP fixed-point.

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Performance Testing

- **Test FIR filter implementation with IQ Input/Output and real coefficients.**
  - **300 Taps**
  - **Input data varying from 1.6k floating-point IQ pairs to 16M floating-point IQ pairs.**
- **Test program inputs IQ data from a file, filters, and saves them to another file.**

Performance Testing

- **DSP FIR implementation requires**
  - **Converting data between floating/fixed point format.**
  - **Physically copying data between GPP buffer to a shared GPP/DSP buffer.**

Performance Testing

- **GPP / DSP performance using Linux's *time* command.**
- **Time is measured as *real time* versus *CPU time*.**

Input (IQ pairs)	GPP Execution (seconds)	DSP Execution (seconds)	Speedup factor
$1.6*10^3$	1.916	2.109	0.91
$16*10^3$	3.63	2.19	1.66
$160*10^3$	20.519	2.494	8.23
$1.6*10^6$	189.308	6.237	30.35
$16*10^6$	1876.937	46.837	40.07

Performance Testing

- **Measuring DSP overheard.**

Input (IQ pairs)	Flowgraph setup IQ data I/O (seconds)	Loopback without conversion (seconds)	Loopback with Conversion (seconds)
$1.6*10^3$	1.718	2.11	2.128
$16*10^3$	1.713	2.153	2.151
$160*10^3$	1.782	2.361	2.487
$1.6*10^6$	3.159	5.085	5.735
$16*10^6$	22.987	37.919	42.11

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Future Work

- Pass pointers to DSP instead of explicitly copying buffers.
- Allocate GPP/DSP link interfaces on per block basis versus per DSP program basis.
- Provide feedback from DSP to GNU Radio scheduler.
- Create more blocks to run digital radios.

Questions

- **Thanks for listening … Questions ???**

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