Energy-Efficient Wireless Transceiver Operation using Optimized Heterogeneous Processor-FPGA Computations

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Abstract

• Recent explosion in the number & diversity of devices, protocols, and applications
• Trend points towards systems with high data rates and low energy consumption
• Emerging vision of creating a transceiver architecture that can adapt to the functional and processing needs of existing and future protocols
• Maps computation to underlying heterogeneous platform, with CPU and FPGA
• We introduce a method for modeling 802.11a-based OFDM wireless transceiver
• Prototype on Xilinx Zynq system-on-chip by dividing PHY layer into functional units
• Our approach creates MathWorks Simulink model variants for both transmitter and receiver, each with a different boundary between HW and SW components
• Use models to generate HDL code-FPGA bitstream & C code-ARM CPU executable
• Results demonstrate how to select a HW-SW codesign for ideal 802.11a operation

Hardware Components

• Platform uses Xilinx ZC706 Evaluation Kit, ADI FMComms3 RF front end, Host PC

Method: Hardware-Software Codesign Model Variants

• Create seven models to represent HW-SW divides between 802.11 function units

Results: Execution Time

• Faster speed moving more components on PL. IFFT & Preamble Detection longest.

SCRAMBLING/INTERLEAVING

• Design follows IEEE 802.11a Physical (PHY) layer specifications [1]
• Scrambling: XOR to make data pseudorandom, unbiased, independent
• Interleaving: rearranges bit indices to make random errors seem more random
• Convolutional Encoding: adds redundancy by producing parity bits
• Binary/Quadrature Phase Shift Keying (B/QuPSK): modulation from bits to symbols
• Orthogonal Frequency Division Multiplexing (OFDM): map symbols to subcarriers and use Inverse Fast Fourier Transform (IFFT) to carry data on multiple channels
• Preamble: the fixed initial sequence at the start of a transmission, used to detect the beginning of frame at Rx

Software Tools

• Workflow uses MathWorks Simulink, HDL Coder, Embedded Coder, Xilinx Vivado

Discussion

• A benefit of flexible SDR testbed is reuse for other 802.11 & mobile standards
• Some units (scrambling, interleaving) can be reused directly in their present form
• Modifications needed for different encoding rates (2/3) and modulation schemes
• This reusability allows us to explore LTE and Wi-Fi coexistence on the same channel, TV whitespace reuse, and co-operation with RADAR

Acknowledgements

MathWorks

References