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Implementation of FPGA based Decision Making Engine and Genetic Algorithm (GA) for Control of Wireless Parameters

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Abstract

The users can use relatively generic hardware, and customize it to their needs by choosing the software that fits specific application. This dynamic adaption in Cognitive Radio is done by a novel hardware/software co-design architecture of Genetic-Algorithm (GA) driven by Field Programmable Gate Array (FPGA) based decision making engine. One obvious benefit is that instead of building extra circuitry to handle different types of radio signals, one can just change an appropriate vhdl code. **F**requency, Modulation, Power, Bit error rate are the radio parameters which are reconfigured according to environment change. Awareness is the starting point of a CR process and is the foundation of learning and reasoning, Genetic algorithm is an intelligent search strategy inspired by biological evolution supported by biological operations The execution of fitness functions that drive the GAs is carried out as embedded approach using NIOS processor and present simulations and analysis. It would be so difficult to build a new circuitry any time in order to do the hardware upgrade.

By reusing identical hardware platform for many terminals with different protocols, it is possible to reduce the time to market and development cost. SDR allows service providers to upgrade infrastructure without unreasonable cost.

INTRODUCTION:

Nowadays, the available wireless network spectrum are assigned to fixed policy in that most of the spectrum is unused. Because of limited resource and inefficiency in the use of assigned spectrum commence a new technology to exploit wireless spectrum opportunistically. Cognitive radio (CR) technique concept has been proposed by Mitola in 1999 to alleviate the apparent scarcity of available radio spectrum. CR techniques enable the user to share or reuse the spectrum in an opportunistic manner. Cognitive radio encloses all the features of conventional software defined radio (SDR) with its intelligence named as ”cognitive engine (CE). It has the ability to sense which portion of spectrum is unused, capability to learn from the observed spectrum and ability to reconfigure within any layer of radio communication system.

Cognitive radio: The concept of cognitive radio in wireless communications, is described as: wireless transceiver which is a fully reconfigurable and automatically adapts its parameters to network and user demands accordingly. But inefficient usage of radio frequency spectrum leads to overloaded bands due to usage of military, tv, other coverage bands. To prevents rarely used frequencies in fixed spectrum allocation and to to allow unlicensed users in licensed bands,without causing interference dynamic spectrum access is needed.

FPGA : The structure of this paper is a novel hardware/software co-design architecture of Genetic-Algorithm (GA) driven Field Programmable Gate Array (FPGA) based decision making engine for cognitive radio is presented. Cognitive radio, which can greatly utilize the natural spectrum resource, is able to reconfigure the radio parameters according to environment change his approach will attempt to increase data rate and minimize the transmission error, power consumption caused by external environment change.

FPGA remains for Field Programmable Gate Array which has the variety of rationale module, I/O module and steering tracks (programmable interconnect). FPGA can be designed by end client to execute particular hardware. Speed is up to 100 MHz yet at show speed is in GHz.

Fundamental applications are DSP, FPGA based PCs, rationale copying, ASIC and ASSP. FPGA can be customized principally on SRAM (Static Random Access Memory). It is Volatile and fundamental favorable position of utilizing SRAM programming innovation is re-configurability. Issues in FPGA innovation are intricacy of rationale component, clock bolster, IO support and interconnections (Routing).

Genetic algoritms (GA): Genetic algoritms has shown its impact in many applications, including power system control, signal processing circuit partitioning problems, fault detection, and control systems.

1. For re-configuration Xilinx FPGA is used.
2. Fitness calculation using genetic algorithm is done employing VHDL code

3. Chromosomes are transmitted to bit streams and uploaded into the FPGA.

Alternative algorithms:

A. Memetic algorithm

MAs are inspired by Dawkins' notion of a meme .MAs are similar to GAs but the elements that form a chromosome are called memes, not genes. The unique aspect of the MAs algorithm is that all chromosomes and offspring's are allowed gaining some experience, through a local search, before being involved in the evolutionary process. As such, the term MAs is used to describe Gas that heavily use local search. Similar to the GAs, an initial population is created at random. Afterwards, a local search is performed on each population member to improve its experience and thus obtain a population of local optimum solutions. Then, crossover and mutation operators are applied, similar to GAs, to produce offspring's. These offspring's are then subjected to the local search so that local optimality is always maintained. Mimetic algorithms have been successfully applied to a multitude of real-world problems. Although many people employ techniques closely related to mimetic algorithms, alternative names such as hybrid genetic algorithms are also employed.

B. Particle swarm optimization

Kennedy and Eberhart. was the PSO. It works by having a population (called a swarm) of candidate solutions (called particles). and are moved around in the search space according to a few simple formulae. They reach the destination by the behaviour of the flock of migrating birds trying to reach an unknown destination. In the search-space particles are guided by by their own best known position as well as the entire swarm's best known position.

A particle is analogous to a chromosome (population member) in GAs. As opposed to GAs, the evolutionary process in the PSO does not create new birds from parent ones. Birds evolve their social behaviour and moved according towards destination.. Physically, this mimics a flock of birds that communicate together as they fly. While moving in specific direction they communicate together and identify the best location in which the bird is.Towards the best bird , each bird speeds up and they follow using a velocity that depends on its current position.. Each bird, then, investigates the search space from its current position, and the process will be repeated until the flock reaches the destination. It is important to note that the process involves both social interaction and intelligence so that birds learn from their own experience (local search) and also from the experience of others around them (global search).

C .Significance of Genetic Algorithm

Proposed Hardware Software Co-Design Architecture :

Genetic Algorithm is an evolutionary algorithms which utilize the biological techniques like natural selection, crossover and mutation. Traditionally, solutions to GAs are represented in binary as strings of 0s and 1s, but different encoding schemes are also possible.

A. Overview

John Holland introduced GA to describe the natural selection processes in 1975. Charles Darwin introduced The theory of evolution to explain observations of plants and animals in the natural ecosystem. He noticed that every new generation was associated with some changes; hence the worst -fit individuals lost their survival in the competition. Thus, the basic principle survival of the fittest " is adapted in all GA systems.

B. Terminology of Genetic Algorithm

The terminology used in Genetic Algorithms is mix of both genetics and engineering. All GAs work on a population or a collection of solutions to the given problem . Each individual are referred as genes coded with binary strings Each individual in the population are named as a string or chromosome shown in fig 1. For every iteration a new generation is evolved from the existing population in an attempt to produce good solutions.

Population : A number of chromosomes that are available to the best.

Initial population : Obtained by Pseudo random number generation

. Solutions : Usually represented in binary as strings of 0s and 1s

Reproduction : Generate a second generation population of solutions(crossover and/or mutation.)

Chromosomes : Population of strings

Variation : A random process(creates a new solution)

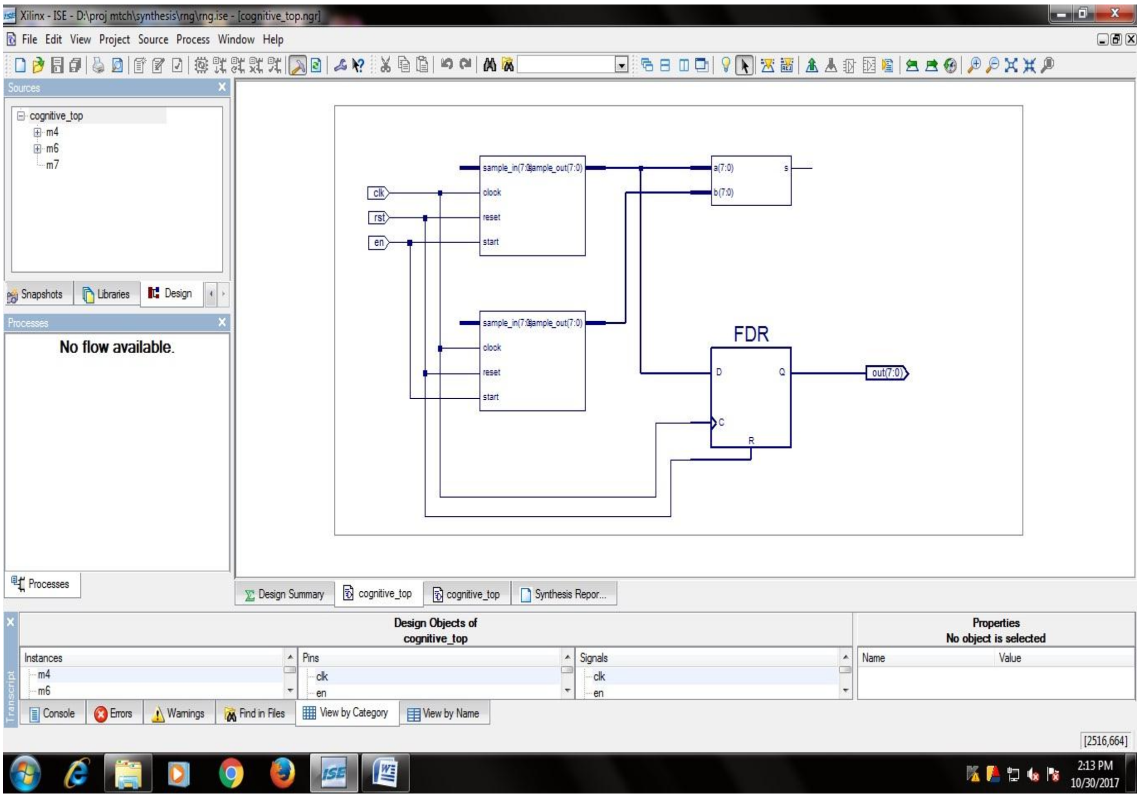
The fitness of chromosome : Percentage of the correct output bits for every input combination of the

complete specification.

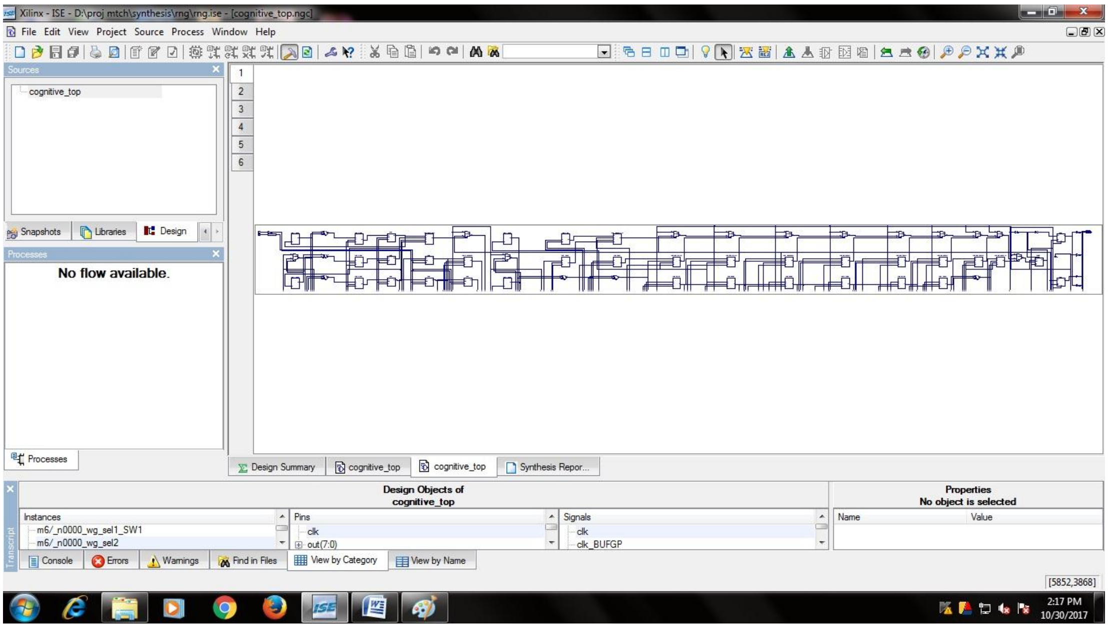
Note : The fitness function is always problem dependent.

SYNTHESIS RESULTS

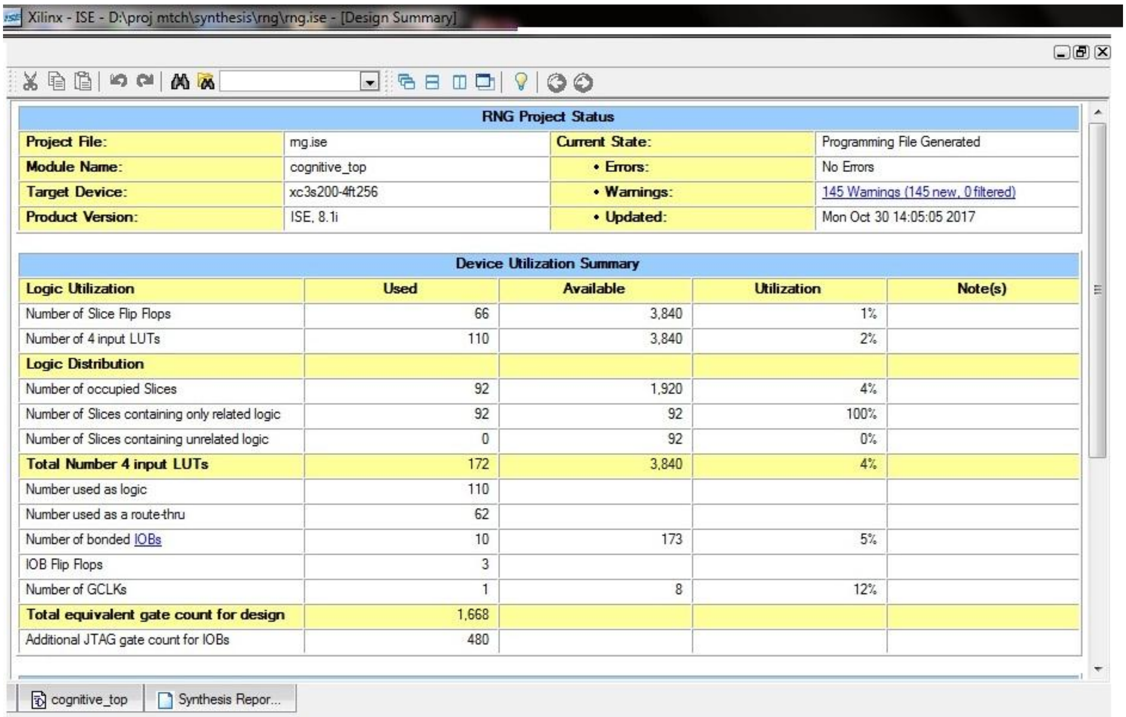
RTL Schematic



Technology Schematic:



Design Summary:


Xilinx - ISE - D:\proj mtch\synthesis\rng\rng.ise - [Design Summary]

RNG Project Status			
Project File:	rng.ise	**Current State:**	Programming File Generated
Module Name:	cognitive_top	**• Errors:**	No Errors
Target Device:	xc3s200-4ft256	**• Warnings:**	145 Warnings (145 new, 0 filtered)
Product Version:	ISE, 8.1i	**• Updated:**	Mon Oct 30 14:05:05 2017

Device Utilization Summary				
Logic Utilization	**Used**	**Available**	**Utilization**	**Note(s)**
Number of Slice Flip Flops	66	3,840	1%	
Number of 4 input LUTs	110	3,840	2%	
Logic Distribution				
Number of occupied Slices	92	1,920	4%	
Number of Slices containing only related logic	92	92	100%	
Number of Slices containing unrelated logic	0	92	0%	
Total Number 4 input LUTs	172	3,840	4%	
Number used as logic	110			
Number used as a route-thru	62			
Number of bonded IOBs	10	173	5%	
IOB Flip Flops	3			
Number of GCLKs	1	8	12%	
Total equivalent gate count for design	1,668			
Additional JTAG gate count for IOBs	480			

cognitive_top | Synthesis Repor...

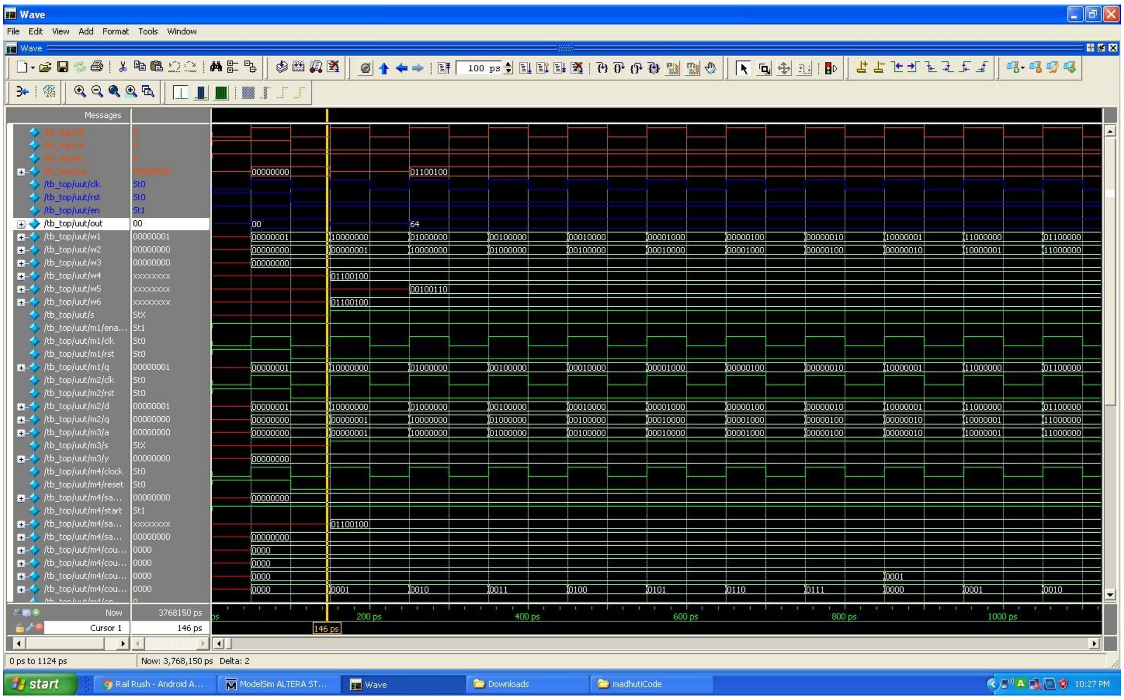


Fig 1: Image

CONCLUSION

As a whole, genetic algorithm based decision making setup is implemented on FPGA for the cognitive radio applications. Moreover keeping in mind the implementations issues regarding the fitness module for cognitive engine a mixed hardware and software approach is studied and implemented successfully. Initially the design is tested on ModelSim and implemented on ALTERA Cyclone II FPGA . The QoS is fixed to arrive the optimal solutions. The whole system runs at 90MHz and the optimum solution is obtained in 6 μs over software design.

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