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WG5: Definition of a Cross-Layer Cognitive Engine

Design a Cross-Layer Cognitive Engine using Cross-Layer Optimization with Case-Based Reasoning and Reinforcement Learning

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Cognitive Radio (CR) is one of the promising technologies which investigated to solve autonomously the spectrum congestion problem because of wide users' applications. In order to use CR for solving the aforementioned problem, we need to have a smart entity which can autonomously perform the desired behavior. Otherwise, it would cause interference, and lacking to required Quality of Service (QoS). The task of the smart entity is to use Artificial Intelligence (A.I)-based methodologies to control autonomously the behavior of CR in wireless spectrum, learn from previous states and decisions, optimizes its performance, and adapts the communication link according to previous knowledge and current environment. This smart entity is called Cognitive Engine (CE).

In literatures, a design for a Cognitive Engine (CLCE) to modify the parameters from different layers was missed. Also, there was no role for learning process to improve the decision making process in CE [1], [2].

Our contribution is a proposal of a Cross-Layer Cognitive Engine (CLCE) which applies three AI-based methodologies: Cross-Layer Optimization (CLO), Case-Based Reasoning (CBR), and Reinforcement-Learning (RL), as shown in Figure 1. CLCE uses Adaptive Discrete particle Swarm Optimization (ADPSO) [3] as a CLO algorithm to determine the configuration parameters from different layers according to the surrounding parameters. The role of CBR is to keep the previous surrounding environments (free channels ID, Noise, Loss) as cases, the configuration determined by ADPSO (Transmit power, Modulation Scheme, Packet Length, and Channel ID) as decisions related to them, and the fitness value of the decisions under related cases [Mahdi20132]. RL re-evaluates the fitness value of similar decision (in CBR) which could be used in current state.

RL will either increase or decrease the fitness value of similar decision according to how many times the selected decision will achieve the required QoS at both sides (transmitter and receiver).

Figure 2 shows the signaling overhead versus number of handover for three different approaches: CLCE, ADPSO, and ADPSO+CBR. CLCE achieves an improvement of 60% in signaling overhead comparing to ADPSO and 20% comparing to ADPSO+CBR.

Figure 3 shows the throughput for CLCE ADPSO, and ADPSO+CBR. CLCE achieves an Improvement of 50% in throughput comparing to ADPSO and 30% comparing to ADPSO+CBR.

Our Contribution shows a promising design of CLCE which can be used to control the operation of CE under different environments. Also, it is can be adapted to include controlling some tasks of MAC protocol and routing protocols in order to improve the performance of CRN.

References:

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[3] Mahdi, A.; Kalil, M.; Mitschele-Thiel, A.: *Cross Layer Optimization for Efficient Spectrum Utilization in Cognitive Radios*, International Conference on Computing, Networking and Communications (ICNC), San Diego, USA, January 2013, pp. 305-309.

[4] Mahdi, A.; Kalil, M.; Mitschele-Thiel, A.: *Dynamic Packet Length Control for Cognitive Radio Networks*, 78th IEEE VTC-2013fall, Las Vegas, USA, September 2013.

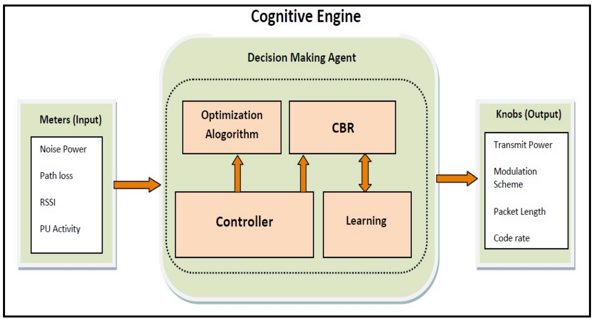

Figure 1: CLCE

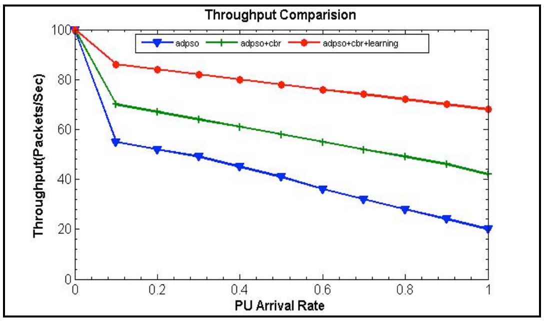

Figure 2: Throughput

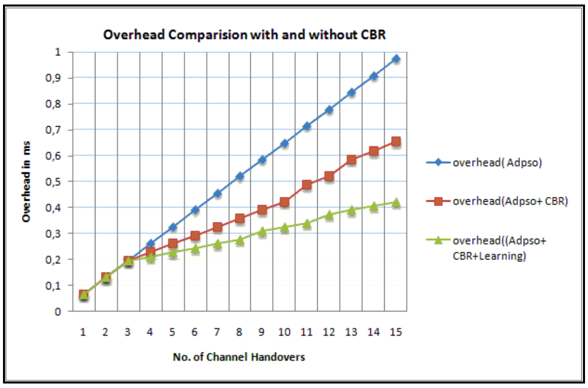

Figure 3: Signaling Overhead