Temasek Defence Systems Institute

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Localization and tracking of 4G cognitive radio

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Introduction

4G-CR definition

 Cognitive radio system in a 4G network which utilizes orthogonal frequency-division multiplexing (OFDM)

Issues and challenges

• Spectrum efficiency still an issue in 4G network

Localization error analysis

Summary of results

- Differential distance error of <20m results in a mean localization error of 19.734m (worst case) and a mean localization error of 8.062m (uniform RV case).
- Localization error varies linearly with differential distance error, or TDOA error, as shown in figure below.
- Cognitive radio system (CRS) able to employ opportunistic spectrum access as a solution
- Need to localize 4G-CR targets for various purpose eg. Urban environment warfare, surveillance, cyber warfare
- In an era of cyber warfare, an adversary can exploit a group of 4G-CRs after they have been registered as SUs in the network
- 4G-CR signal has simultaneous changes in temporal, spatial and frequency components.

Objectives

- 1) Localization error analysis on three proposed TDOA algorithms for 4G-CR
- 2) Proposed adaptive localization methodology for 4G-CR

Localization error analysis

Three TDOA algorithms for 4G-CR

1) Early-late FFT sampling algorithm Direct timing measurement based on synchronized clock time.

2) Double differential phase algorithm (DDPA)
Difference in phases between two pilot symbols
obtained from two sensors.
3) Data aided double differential phase algorithm
Difference in phases between one pilot symbol and
one data symbol obtained from two sensors.

- Lower sensor altitude results in a larger localization error than sensors at larger height or random height.
- For short range (1-5km) between sensor and emitter, the localization error increases with range while for long range (10-20km), the localization error converges.
- The use of 4 sensors results in > 13% decrease in mean localization error, as compared to the use of 3 sensors.
- Differential distance error and altitude of sensor has the most and least effect, respectively, on localization error.

Adaptive localization methodology

Objective

Employ an external wireless sensor network to locate the target 4G-CR using adaptive localization methodology.

Proposed adaptive localization of cognitive radio in cognitive radio network (CRN)

Objectives

To provide insight on the accuracy of the above three TDOA methods, or emitter-position error.

 Enhanced cooperative spectrum sensing (ECSS) with active monitoring of channels of interest
 Localization through iterative non-linear leastsquares method with Kalman filter

Follow-up research activities

- Localization error analysis with geographical simulation of the environment
- Simulation of adaptive localization methodology

