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Innovations for future networks and services

OPTIMAL SPECTRUM HOLE SELECTION & EXPLOITATION IN COGNITIVE RADIO NETWORKS

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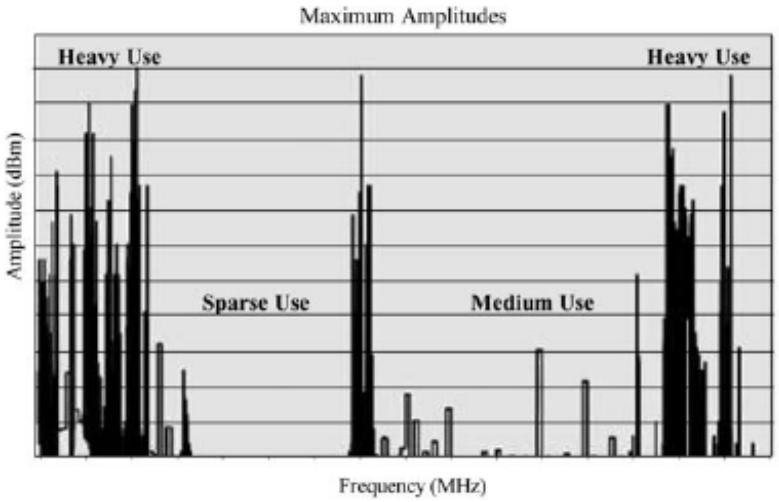
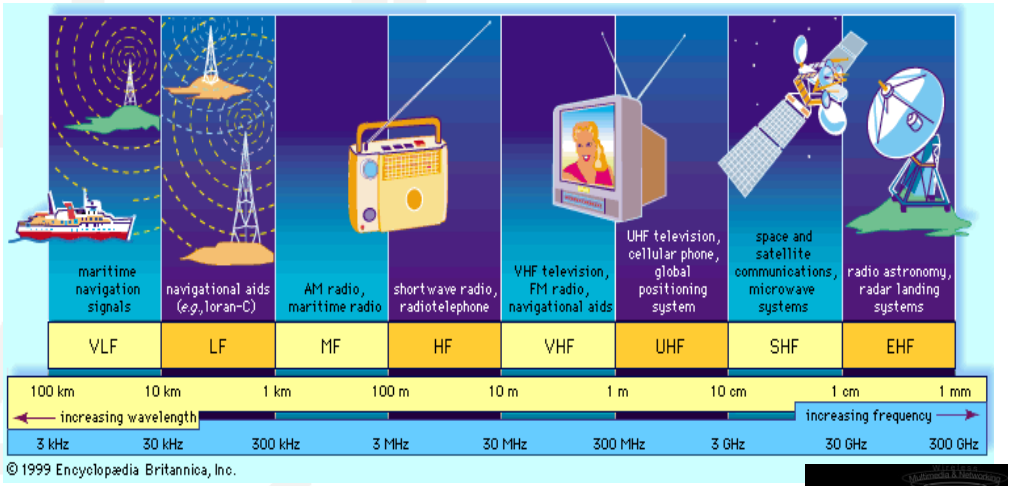
Outline

- Introduction
- Cognitive Radio
- System Model
- Performance Evaluations
- Conclusion and Future Works

Introduction

- The mobile data traffic grew by 280% (during last two years)
- A huge increase in the machine-to-machine (M2M) wireless communications
- Radio spectrum needs to fulfill the above demands





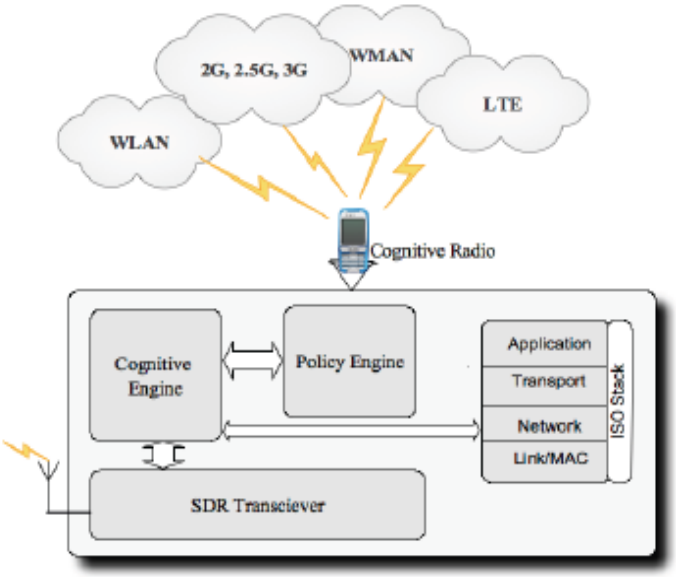
Cognitive Radio

- A radio or system that senses, and is aware of, its operational environment and can dynamically and autonomously adjust its radio operating parameters accordingly [ITU].

- Cognitive Radio (CR) is defined as a radio that can change its transmitter parameters based on interaction with the environment in which it operates [Ofcom].

Cognitive Radio Capability

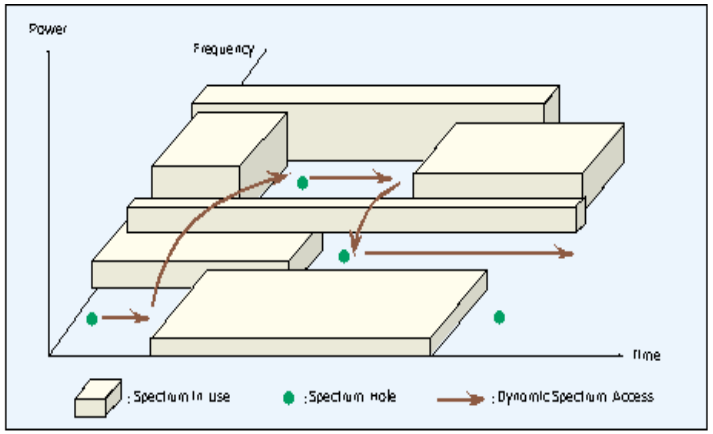
- Intelligent wireless system that possess rapidly reconfigurable radio functions.
  - Uses SDR technology (Technology that enables reconfigurable system for wireless networks.)
- Is Aware of its environment
  - Network Traffic.
  - RF spectrum occupancy
  - Transmission Quality.
- Can learn from its environment and adapts to new situations based on its previous experiences.

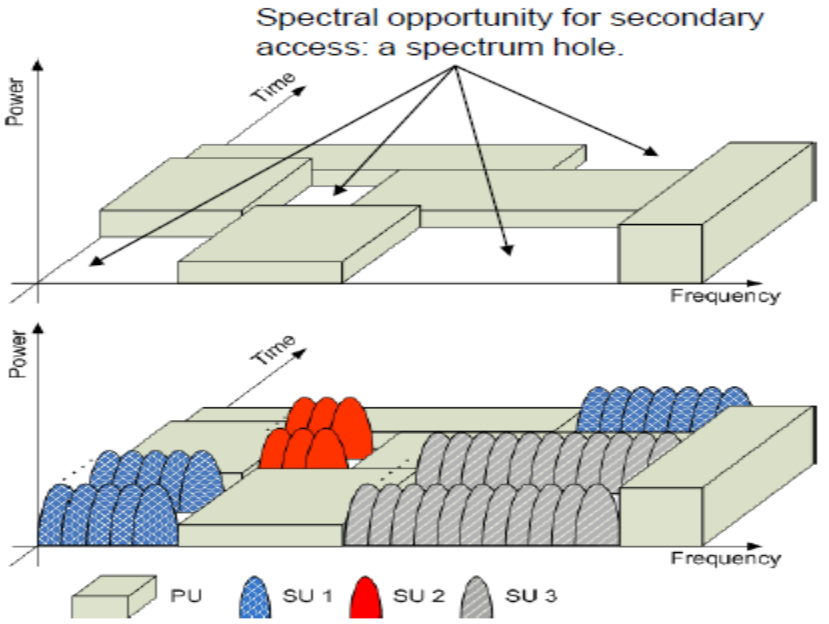


Dynamic Spectrum Access

Dynamic spectrum access and cognitive radio techniques

- Concepts of a spectrum hole and opportunistic spectrum sharing:





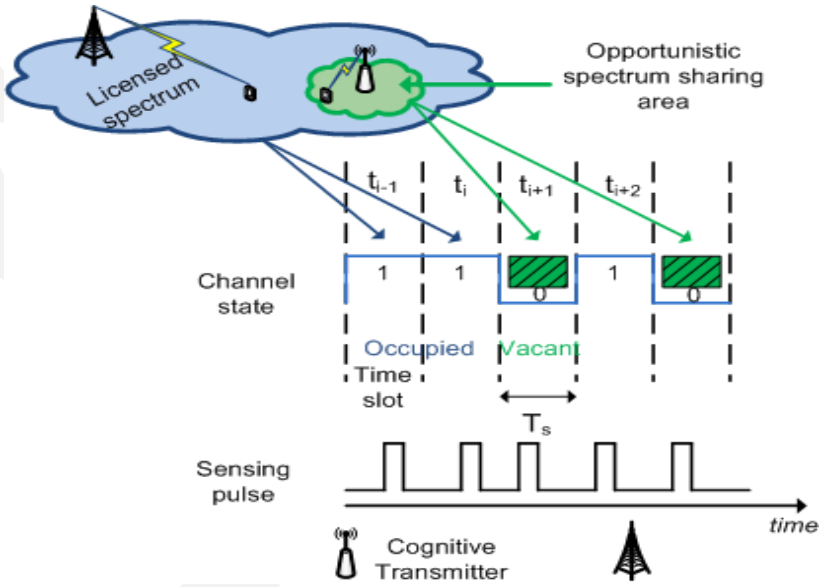
Concept of opportunistic spectrum sharing: secondary utilization of the identified spectrum holes.

DSA Benefits and Challenges

- Dynamic spectrum access can drastically improves the performance of wireless networks struggling under increasing user demand.
- Ofcom believe DSA technology could generate up to 6.5 bn for UK economy in next 20 years.
- More efficient use of spectrum
  - Minimize cost of changing channels
  - Coordination
  - who uses which channels when
  - Synchronization
  - overhead for coordination

System Model

- Multi-Licensed channels
- Secondary Users locate inside network
- Profoundly & frequently sensing
- Perfect adaptation phase (no delay)



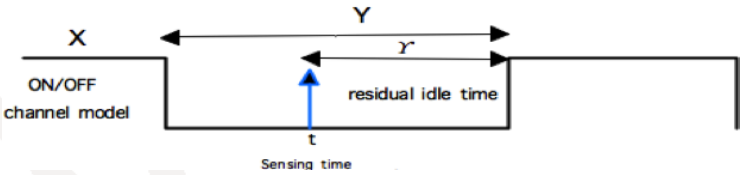
Analysis Specifications

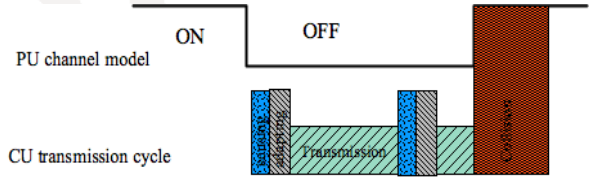
- Primary user channel utilization is Poisson process.
- OFF/ON channel model (identical independent random variable)
- μoff and μon: OFF and ON arrival rates
- OFF/ON period of times are exponential random variable

$$f(t,\mu_{off}) = \begin{cases} \mu_{off} e^{-\mu_{off} t}, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

$$f(t,\mu_{on}) = \begin{cases} \mu_{on} e^{-\mu_{on} t}, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

X,Y random variables





Secondary transmission cycle

Spectrum Hole Selection Schemes

- Minimum Collision Technique (MCT)
- Based on the minimum evaluated probability of collision.

$$H_j(t) = argmin(i \Big| P^i(\Upsilon^i \leq T_{th}^I) < \varepsilon)\ i \epsilon \mathbb{N}(t)$$

- Maximum Remain Lifetime Technique (MRLT)
- Maximum remain lifetime of the idle channel at time instance t.

$$H_j(t) = argmax\left(i \Big| T_R^{Idle\ i}\right)\ i \epsilon \mathbb{N}(t)$$

Proposed Algorithm

- Channels mean OFF time values; 1, 5, 3, 6, 2, 1, 7, 1, 4, 3 seconds
- Channels mean ON times: 2second
- Minimum period of secondary transmission: 3.2ms

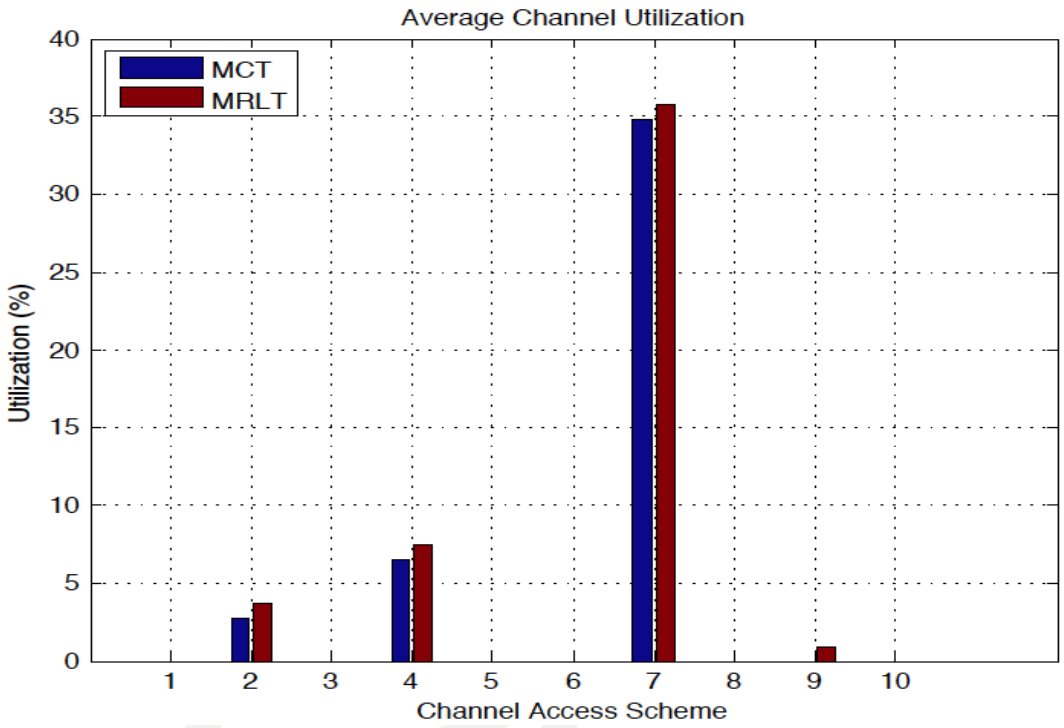
Algorithm. Channel selection algorithm using (13) and (14)

1. **Begin**
2. **Inputs** N , μoff, μon, ε, δ, *TthI*
3. ***For*** *i=1:N*
4. **Sense channels**
5. *Nt←unoccupied channels*
6. Evaluate (12)
7. ***end***
8. **If** *Nt* is empty
9. **Stop** Transmission
10. **Else**
11. $Hjt=argminiPi\Upsilon\ i\leq TthI<\varepsilon\ i\epsilon N(t)$
12. **If** $(j\neq 0)$
13. Transmission on channel j
14. **Else**
15. **Stop** Transmission
16. **End** (If)
17. $Hj1t=argmaxiTRIdle\ i\geq TthI\ i\epsilon Nt$
18. **If** $(j1\neq 0)$
19. Transmission on channel j1
20. **Else**
21. **Stop** Transmission
22. **End** (If)
23. **End**

Average Channel Utilization

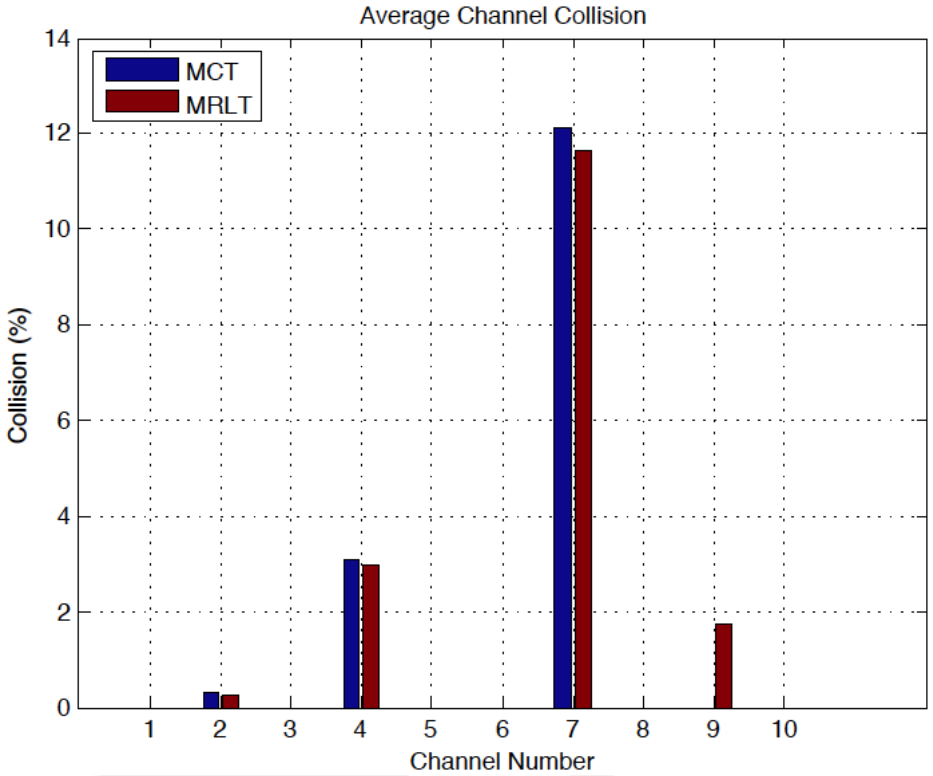
- Average channel utilization through MRLT and MCT schemes

$$ACU^i = \frac{1}{T}\sum_{k=1}^{M}\frac{(1-\exp(-\mu_{off}^i T_{th}^i)}{\mu_{off}^i} \times 100\%$$



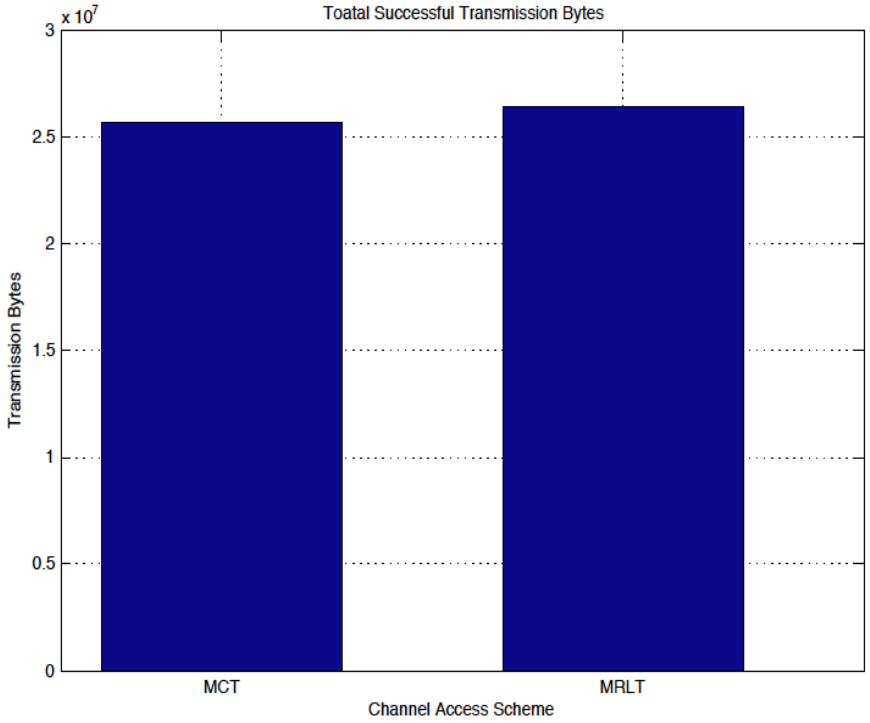
Average Channel Collision

$$ACC = \lim_{T \to \infty} \frac{Total\ period\ of\ Collision\ in\ [0,T]}{Total\ secondary\ transmission\ in\ [0,T]} \times 100\%$$



- Channels 4, 7 and 9 will be targeted because of channel OFF time.

Secondary Data Delivery



- Data delivery will be more through MRLT scheme during 100s.

Conclusion & Future works

- It can be seen that MRLT scheme improves spectrum utilization in comparison with MCT.
- Adaption delay and real sensing delay and sensing time need to be considered.
- Cooperative spectrum selection scenario in coexistence networks.

Thank you for your attention

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