CALL ADMISSION CONTROL WITH INTER-NETWORK COOPERATION FOR COGNITIVE HETEROGENEOUS NETWORKS

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ABSTRACT

In communication system each wireless network, mobile terminals (MTs) do not always occupy all spectrum resources, and there exist vacant spectrum holes. Due to the spectrum resource scarcity, cognitive radio can be applied in each wireless network to utilize the vacant spectrum holes. This leads to cognitive heterogeneous wireless networks, where the coverage areas of multiple cognitive wireless networks overlap and secondary MTs can opportunistically utilize the temporary spectrum holes. In cognitive heterogeneous wireless network in order to guarantee QoS for MTs, multihoming technology can be applied, where the data stream from an MT is split into multiple sub-streams, and transmitted over multiple networks by different radio interfaces simultaneously.

1. INTRODUCTION

Call admission control, based on inter-network cooperation, for cognitive heterogeneous networks is formulated as a Stackelberg game framework, and call blocking probability is analyzed with $M=M=\infty$ queuing theory; Stackelberg game analysis is proposed, joint subchannel allocation prices and network selections are analyzed via the dual decomposition method, and vacant spectrum prices are determined based on Bertrand game theory; A call admission control algorithm is presented for cognitive heterogeneous networks, and simulation results demonstrate that the proposed algorithm can reduce the call blocking probability at secondary MTs efficiently.

2. METHODOLOGY

In cognitive heterogeneous wireless networks (CHWNs) that utilize multihoming, mobile terminals (MTs) can leverage multiple radio interfaces to combine the resources of different networks. This setup introduces complex, multi-layered resource allocation challenges to guarantee Quality of Service (QoS) for secondary users, who opportunistically use the spectrum.

A call admission control algorithm based on inter-network cooperation is proposed via queuing theory for cognitive heterogeneous networks. The call admission control problem is subject to the variable bandwidth rate traffic, network service selection, subchannel allocation, and call blocking probability. The call admission control algorithm is based on spectrum price at primary heterogeneous networks and subchannel allocation price and network selection at cognitive heterogeneous networks. In order to determine the call blocking probability, a probability upper bound of exceeding the maximum admission number for secondary mobile terminals (MTs) is analyzed based on M=M=∞ model. Finally, a call admission control algorithm is proposed. Simulation results demonstrate that the proposed algorithm not only improves quality of service (QoS) at each secondary MT, but also reduces the call blocking probability for cognitive heterogeneous networks.

3. MODELING AND ANALYSIS

Ageographical region with primary wireless access networks, grounded on different wireless access technologies and operated by different service operators.In network n, there's a set of base stations(BSs). Corresponding to network n BS s, there's a cognitive wireless network n BS s. The cognitive miscellaneous wireless networks are shown in Fig. 1. There's a set of secondary MTs in the geographical region, and a subset of the MTs, which live in the content area of network n BS s. In primary network n BS s, the total diapason is divided into Kns subchannels, and each subchannel has the same bandwidth. also, the transmission power at secondary BSs for downlink or at secondary MTs for uplink should be controlled to cover the transmission in primary networks according to the hindrance temperature model. In the same cognitive network, hindrance mitigation is achieved by hindrance operation schemes. Using themulti-homing medium and multiple radio interfaces, each secondary MT can communicate with multiple secondary BSs contemporaneously.
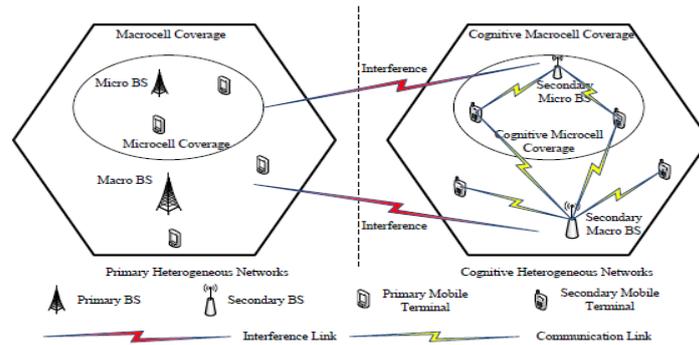
Figure1: Cognitive heterogeneous network.

4. RESULTS AND DISCUSSION

The core simulation mechanism

The simulation uses a queuing system to model how call requests are handled.

- **Arrival of calls:** Calls are generated randomly, likely following a probability distribution like the Poisson process, which is common for modeling random arrival events.

- **The processing system:** The system has a fixed capacity, which in this case is the ability to process up to three calls simultaneously. This is represented by three "servers" in queuing theory terminology.

The FIFO queue:

o   If a call arrives and fewer than three other calls are currently being processed, it is immediately admitted and handled by an available server

o   If a fourth call arrives while all three servers are busy, it is placed in a waiting queue.

o   The queue operates on a FIFO principle, meaning the fourth call will not be processed until one of the first three calls has been completed.

o   **Call completion:** When a call's processing is finished, one of the three servers becomes free. This allows the next call in the FIFO queue (if any) to move from the queue into the processing stage.
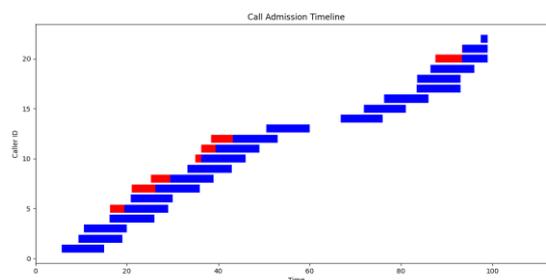

Figure 2: Simulation results.

Graph 1: Call arrival rate vs. total utility (total call duration)

This graph illustrates the system's capacity and overall performance under increasing demand.

- **Initial phase (Low call arrival rate):** As more calls arrive at the cognitive microcell, more Secondary Mobile Terminals (MTs) are generated. The CAC system, with its available resource pool, can successfully admit these calls. As a result, the total utility (or total call duration across the network) increases.

- **Saturation phase (High call arrival rate):** The rate of increase in total utility slows and eventually flattens out, indicating the network is reaching its capacity limit.
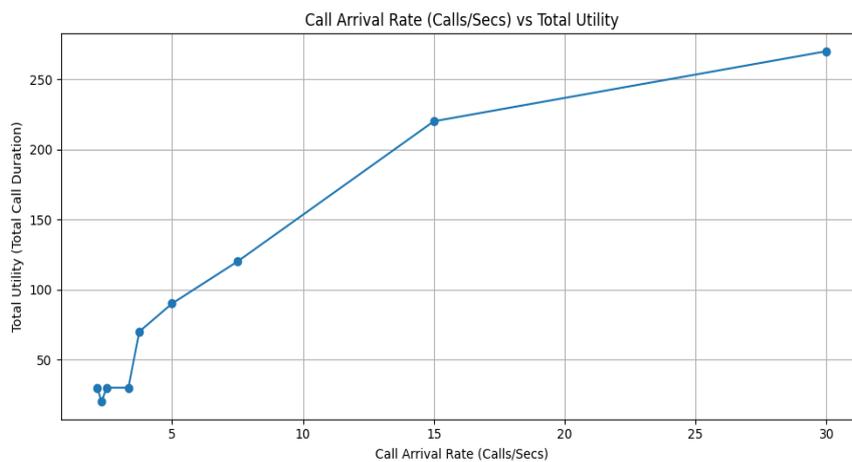
Graph 1: Call arrival rate vs. total utility. (total call duration)

Table1: Call arrival rate/Total utility.

| Call Arrival Rate (Calls/Secs)	Total Utility (Total Call Duration)
2	30
2	35
2.5	32
3	38
4	75
5	90
7.5	120
15	220
30	270

Graph 2: Average residence time vs. total utility

This graph highlights the trade-off between network efficiency and user experience.

- **Inverse relationship:** The average residence time (how long a call stays in the system, including wait time) increases as total utility increases. This is a classic queuing theory

outcome. As more calls are successfully completed (higher utility), the network becomes more congested, causing new calls to wait longer in the FIFO queue.

- **Post-saturation:** In a heavily congested network, even as total utility flattens (due to the maximum processing capacity of three calls), the average residence time may continue to increase significantly. This is because the waiting queue grows longer, even though the number of calls being served at any moment remains constant.
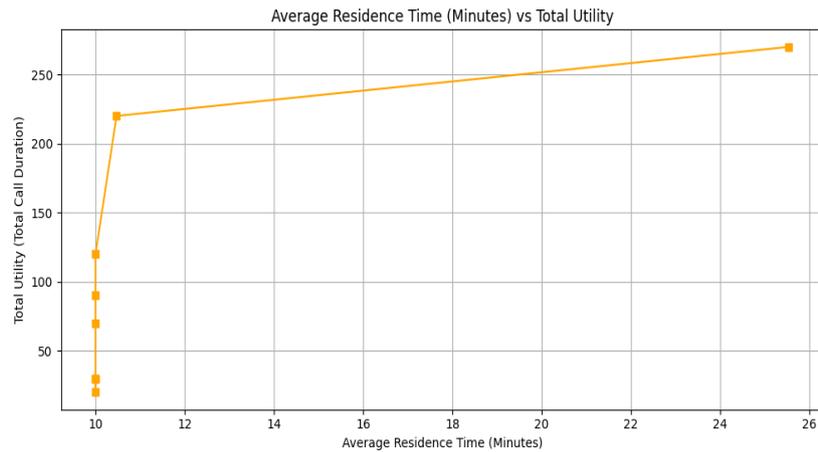
Graph 2: Average residence time vs. total utility.

Table 2: Average residence time/total utility.

Average Residence Time (Secs)	Total Utility (Total Call Duration)
10	24
10	30
10	75
10	88
10	121
10	214
11	220
25.5	265

5. CONCLUSION

The simulation demonstrates the crucial role of CAC in managing network resources. Without proper CAC, a FIFO queuing system with limited parallel processing would suffer from severe performance degradation under high traffic load. By showing the trade-off between maximizing network utilization and keeping residence times acceptable, the simulation highlights the need for a CAC strategy that can dynamically balance these factors. The graphs provide a clear visual representation of this trade-off, underscoring that there is an

optimal call arrival rate that maximizes network efficiency while still providing a quality user experience.

6. REFERENCES

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