A Wireless Cognitive Radio Network with a Synchronized Cooperative Relaying

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- System model

- Protocol procedure

- Simulation results

- Conclusion

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- Protocol procedure

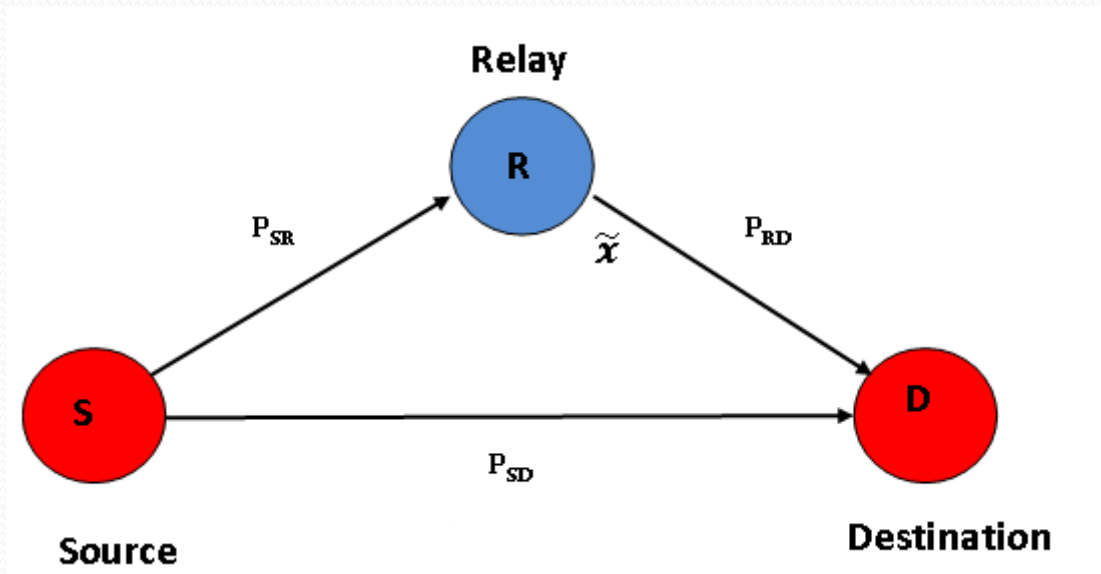- Simulation results

- Conclusion

Introduction

- This paper attempts to apply cooperative relay in an underlay wireless cognitive radio network

- Relay technology is one of these methods that are used to enhance the performance of wireless networks

- This technique is based on using relay nodes that are located in the path between the source and the destination

- These cooperative nodes receive the signal from the transmitter, then process it, and retransmit it to the destination

Introduction

- Cognitive radio is another technique that was suggested in order to improve the performance of the wireless networks

- This technique depend on the phenomenon of the spectrum utilization , where it is expected to overcome the shortage on the frequency spectrum and to enhance its utilization

- Underlay scheme, cognitive radio gives wireless communication users (the secondary users) the opportunity to use the frequency bands that are not occupied by their licensee users (the primary users)

Introduction

- We use the relay technology in the sense of cognitive radio

- We intend to employ the features of relay in cognitive radio to get the maximum benefits from both techniques

Outline

- Introduction

- System model

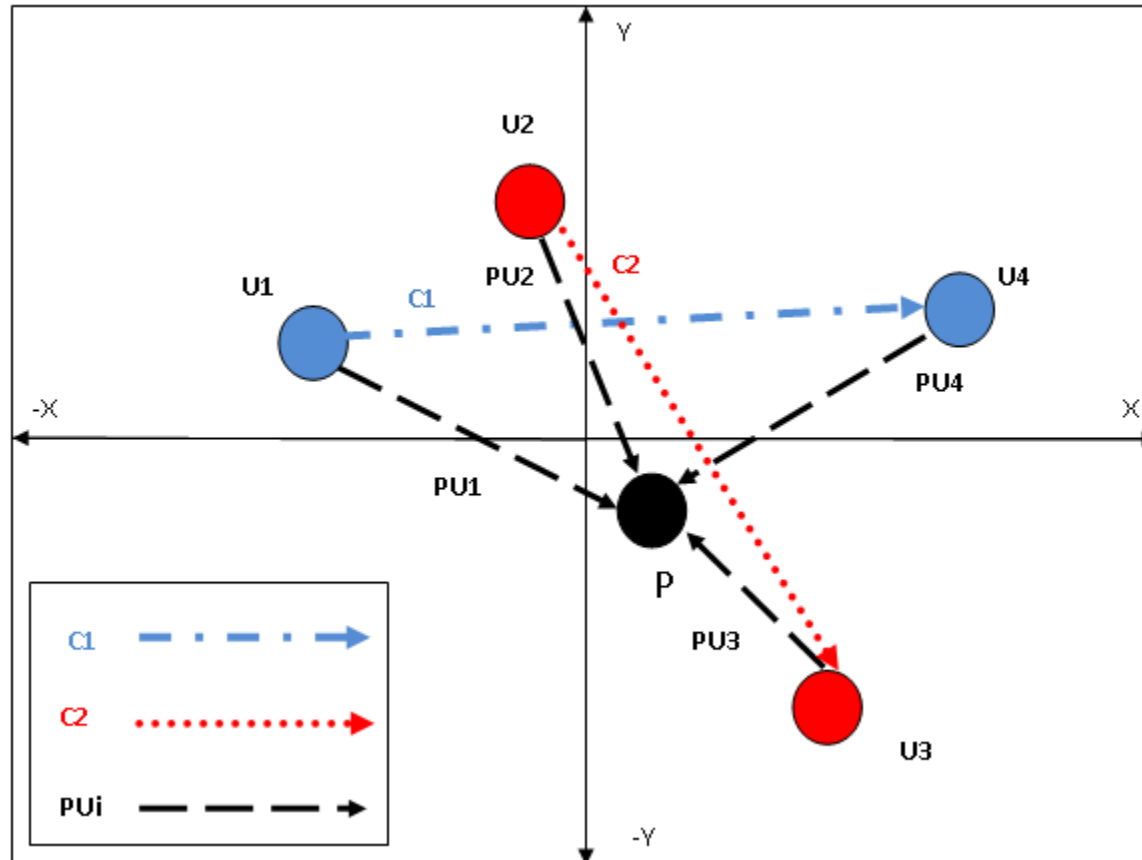- Protocol procedure

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System model

- We adopted a system that consists of four secondary users in addition to a single primary user

- The secondary users SUi are located around the primary user PU, as they adapt their power from the primary user

System model

- Each two nodes connect together and form a communication pair while the other two nodes work as relay nodes for this pair

- Inversely, those relay nodes form the second communication pair and the nodes in the first pair work as relay nodes for the second pair

System model

Outline

Protocol procedure

- Each secondary user connects randomly chooses another secondary user to form a pair

- Two pairs have been formed. The first pair exchanges data after choosing a best relay node from the other two secondary users

- The same process is performed by the second pair

Protocol procedure

- Calculating the signal to noise ratio (SNR) for each relay node path in addition to the direct link is necessary for the best path detection process between the source and the destination of a pair

- The best relay selection process (choosing the highest SNR) is executed

Protocol procedure

- SNR value depends on the channels conditions

- The next figure illustrates the connections for the first pair which consists of secondary user U1 and secondary user U4. Secondary users U2 and U3 are relay candidates for pair 1

Protocol procedure
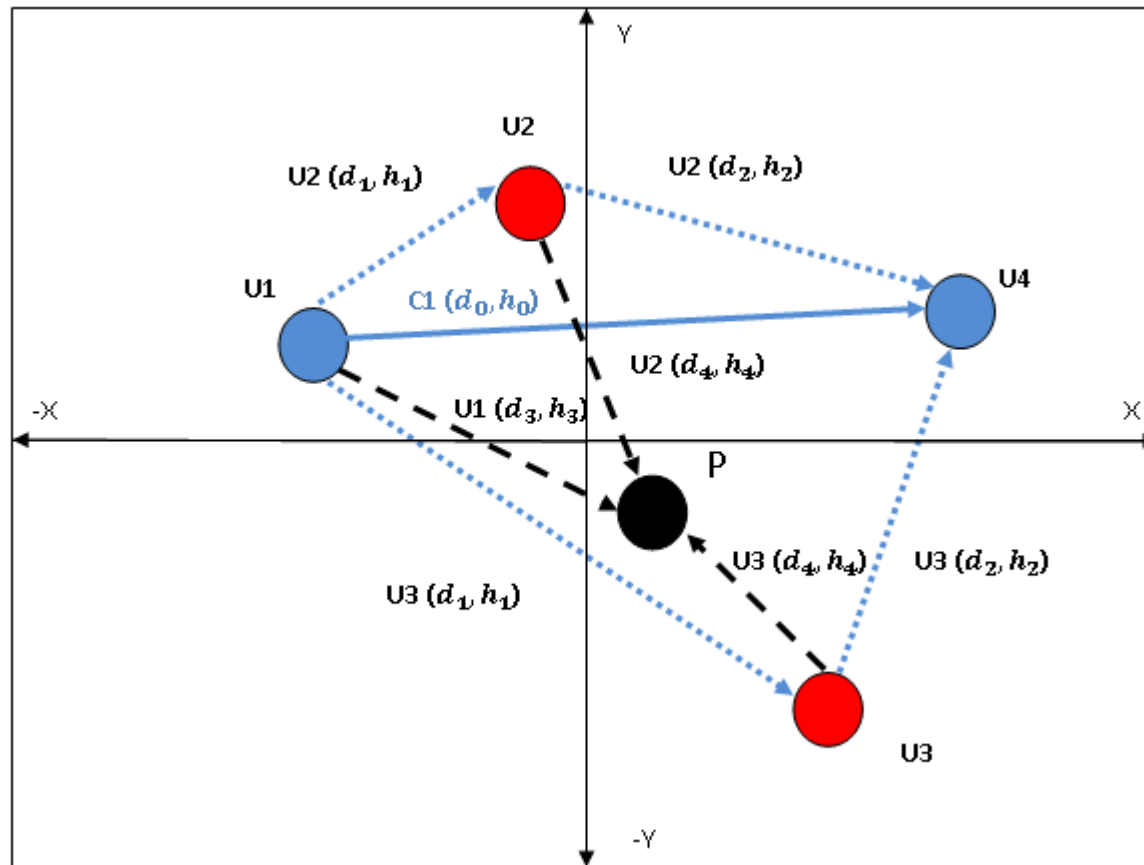
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Simulation results

- The outage probability calculation through applying Monte Carlo simulation presents the system's performance where each two nodes work as source and destination while the other two nodes work as relay ones

- The locations of the nodes are distributed randomly, and any two nodes can establish a connection to form a pair

Simulation results

- Thus giving the system better flexibility and providing a more realistic behavior

- Each node works as a transmitter / receiver and as a relay node simultaneously

Simulation results

For example:

- The system model assumed that the distribution of the nodes is $U1(1,O.5)U2(0.8,0.5)U3(0.3,0.9)$ and$U4(0.4,0.4)$

- The first pair is modeled to contain $U4,U2$and the second pair contains $U3,U1$

- The location of the primary user has been assumed to be $(0.5, 0.5)$

Simulation results

- Figure (1) shows the system procedure when the first pair works as a source and destination and the second pair nodes works as relay nodes

- Figure (2) presents the case when the nodes of the first pair work as relay nodes while the nodes of the second pair transmit data
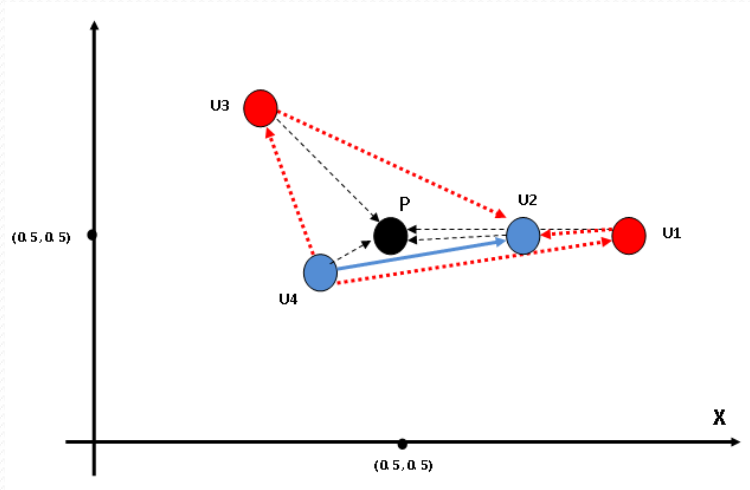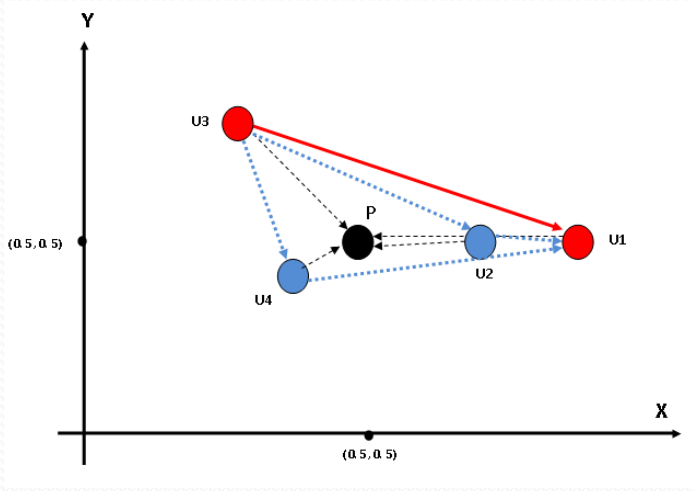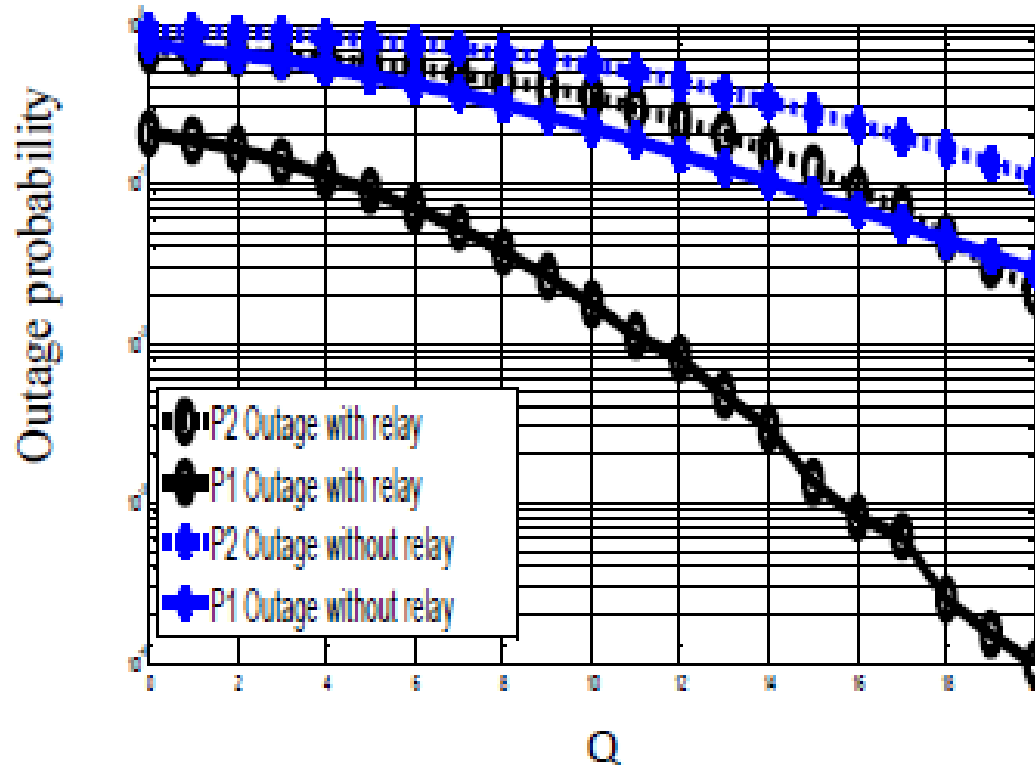
Figure 1

Figure 2

Simulation results

- For the outage probability calculations, the system applies (10^5) trials and adopts the average value of the simulation

- The next figure presents the outage probability in two cases; the first one is applying cooperative relay and the second one is deactivating it

- It can be seen that activating cooperative relay enhances the performance significantly for each pair within the system.
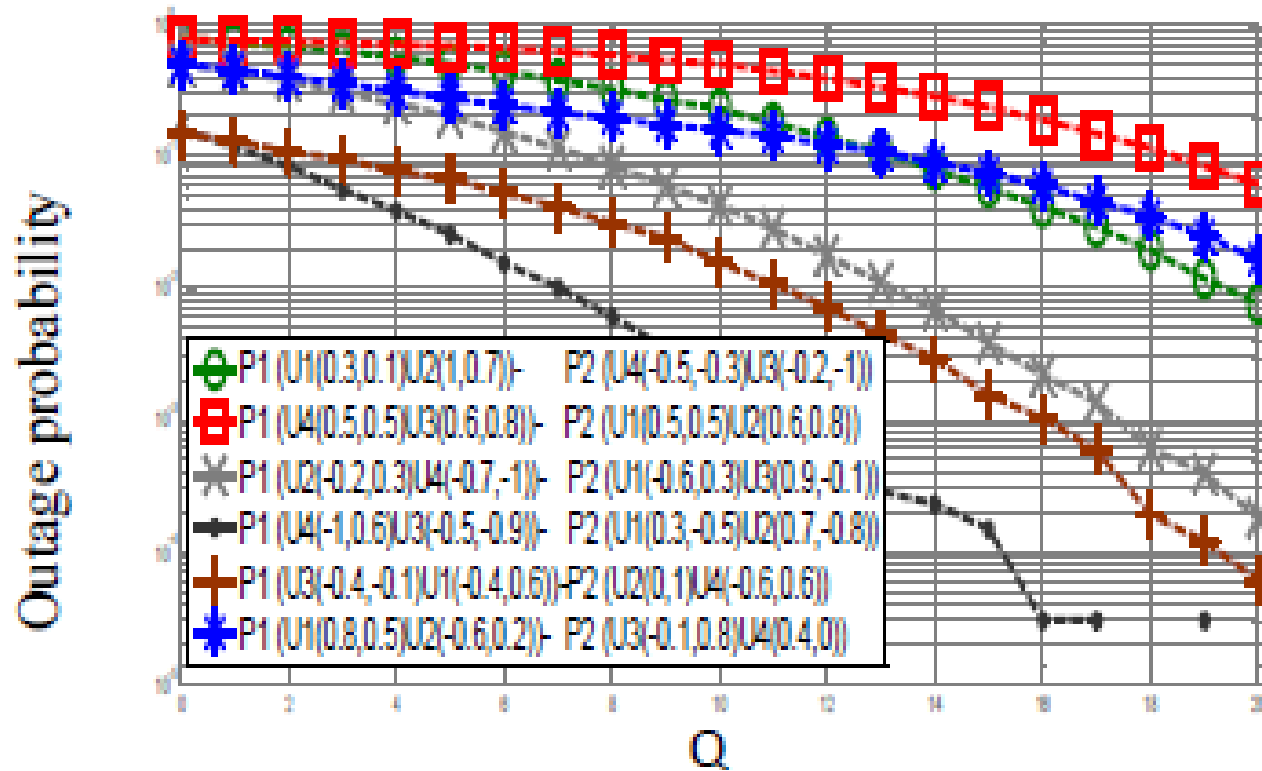
Simulation results

Simulation results

- The next figure shows the system performance with different distribution models to the four communication nodes

- The outage probability of each system model is considered as a total value of outage for the two communication pairs

- The best performance o the system model can be obtained when users and relay nodes are located far away from the primary user

Simulation results

Legend:
- P1 (U1(0.3,0.1)U2(1,0.7))-   P2 (U4(-0.5,-0.3)U3(-0.2,-1))
- P1 (U4(0.5,0.5)U3(0.6,0.8))- P2 (U1(0.5,0.5)U2(0.6,0.8))
- P1 (U2(-0.2,0.3)U4(-0.7,-1))- P2 (U1(-0.6,0.3)U3(0.9,-0.1))
- P1 (U4(-1,0.6)U3(-0.5,-0.9))- P2 (U1(0.3,-0.5)U2(0.7,-0.8))
- P1 (U3(-0.4,-0.1)U1(-0.4,0.6))-P2 (U2(0,1)U4(-0.6,0.6))
- P1 (U1(0.8,0.5)U2(-0.6,0.2))- P2 (U3(-0.1,0.8)U4(0.4,0))

Y-axis: Outage probability
X-axis: Q

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Conclusion

- This system is suggest a way to employ all the existing nodes to work as a send/receive node or as a relay node

- Which enhances the performance of the communication path

- Using relay technique between the secondary users make the improvement in the system's performance is noticeable