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Cognitive Subcarrier Sharing Schemes for Cooperative D2D Communication Frameworks

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***Abstract*—For next wireless networks, device-to-device (D2D) communication is viewed as a potential technique. The use of cognitive subcarrier sharing (CSS) might help D2D communication become more spectrally efficient. Using CSS, secondary users can use the prime users' unused spectrum without interfering with their broadcasts. In this study, we provide a revolutionary CSS-integrated cooperative D2D communication architecture. We think about a case when a source D2D pair wishes to talk to a destination D2D pair, but their direct line of contact is cut off by a barrier. We suggest a cooperative relaying technique that uses an intermediary D2D pair to function as a relay between the source and the destination to get around this issue. Next, using the suggested cooperative D2D communication system, we provide two CSS approaches. According to the channel circumstances, a central controller allocates subcarriers to the D2D pairings in the first scheme, which is a centralised CSS scheme. The second technique is a distributed CSS strategy in which the D2D pairs agree to divide the available subcarriers among themselves. In comparison to the conventional D2D communication without CSS, simulation results demonstrate that the proposed cooperative D2D communication framework with CSS achieves greater spectral efficiency and reduced outage probability.**

Keywords—Cognitive subcarrier sharing, relay, spectral efficiency, outage likelihood, centralised CSS, and distributed CSS are among terms used to describe cooperative D2D communication.

I. Introduction

This Due to its potential to increase network capacity, coverage, and energy efficiency, device-to-device (D2D) communication has emerged as a viable technology for future wireless networks. D2D communication enables nearby mobile devices to connect with one another directly instead of going via the cellular network infrastructure. Unfortunately, obstructions may obstruct the direct communication link between D2D pairs, and the transmission power of D2D pairs may interfere with other network users. Cognitive subcarrier sharing (CSS) has been suggested as a viable remedy to overcome these problems and increase the spectral effectiveness of D2D communication.

By using CSS, secondary users can access the prime users' unused spectrum without interfering with their broadcasts. In CSS, a secondary user monitors the primary users' usage of the spectrum and chooses the subcarriers thatare available for its own broadcast. Due to CSS's ability to help D2D pairings utilise the available spectrum more effectively, D2D communication can now operate at substantially higher spectral efficiency levels.

Another method for enhancing D2D communication's coverage and dependability is cooperative relaying. To get around barriers or boost the transmission quality, cooperative relaying uses an intermediary D2D pair to function as a relay between the source and the destination D2D pair. Relays, nevertheless, can potentially increase interference and lessen signal strength spectral efficiency.

A brand-new framework for cooperative D2D connection that incorporates CSS to boost the spectrum effectiveness and dependability of D2D communication We specifically look at a case where a source D2D pair wishes to communicate with a destination D2D pair but is unable to do so because of a barrier. We suggest a cooperative relaying technique that uses an intermediary D2D pair to function as a relay between the source and the destination to get around this issue. Then, we provide a centralised CSS scheme and a distributed CSS scheme that may be used to the proposed cooperative D2D communication architecture.

The D2D pairs are given subcarriers according to the channel circumstances by a central controller in the centralised CSS scheme. The D2D pairs in the distributed CSS scheme bargain among themselves to divide the available subcarriers. We contrast the effectiveness of the standard D2D communication without CSS with the suggested cooperative D2D communication framework with CSS. In comparison to the conventional D2D communication without CSS, simulation results demonstrate that the proposed cooperative D2D communication framework with CSS achieves greater spectral efficiency and reduced outage probability. The remainder of the essay is structured as follows: A survey of related literature is included in Part II. The system model and problem formulation are presented in Part III. The suggested cooperative D2D communication framework with CSS is described in Part IV. Results of the simulation and performance analysis are presented in Section V. The work is finally concluded in Section VI, which also offers suggestions for further research.

II. System Model and Protocol Description

The suggested cooperative D2D communication framework's system model and protocol with cognitive subcarrier sharing (CSS).

A. *System Model*

We think about a case when a source D2D pair wishes to talk to a destination D2D pair, but their direct line of contact is cut off by a barrier. We suggest a cooperative relaying technique that uses an intermediary D2D pair to function as a relay between the source and the destination to get around this issue. All D2D pairs are thought to have a single antenna and run in half-duplex mode, which allows them to either broadcast or receive at any given moment.

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The transmission and reception time slots in a time-division duplexing (TDD) system are split into equal periods. Figure 1's network architecture depicts this situation: D2D pair 1 tries to get in touch with D2D pair 2, but obstacle O prevents them from doing so directly. We use the assumption that the distances, given by the symbol d, between the source and the relay and the relay and the destination are equal. The distances d1 and d2 refer to the separations between the source and the obstacle and the relay, respectively. As no signal can flow through the obstruction, we infer that the channels between the D2D pairs and it are blocked.

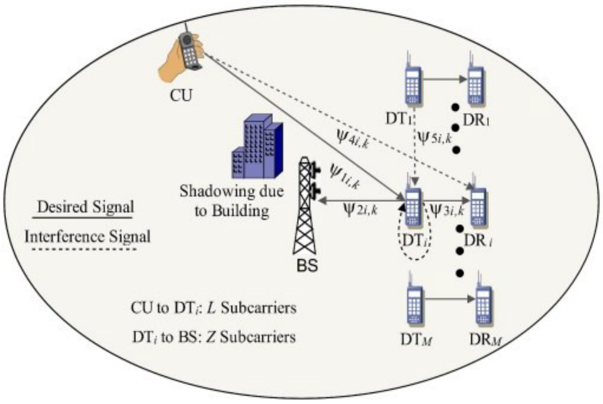

Fig. 1. System model with adaptive transmission scheme

B. *Protocol Description*

The following steps make up the cooperative D2D communication framework using CSS:

Step 1: Relay Selection - A set of accessible D2D pairs that are in range and have excellent channel characteristics are chosen as relays by the source D2D pair. The decision can be made based on a number of factors, including the channel's quality and the distance between the source and potential relays. After choosing the relay, the source asks it to serve as a relay for its transmission to the destination.

Step 2: Subcarrier Sharing - The D2D couples use CSS to bargain among themselves to split the available subcarriers after the relay has been chosen. We suggest two CSS implementations: distributed CSS and centralised CSS.

According to the channel circumstances, a central controller allocates subcarriers to the D2D pairings in the centralised CSS system. The central controller selects the subcarriers that D2D couples can utilise by listening to the spectrum being used by primary users. The subcarriers aresubsequently assigned to the D2D pairs by the central controller according to the channel circumstances. Each D2D pair is informed by the central controller of the subcarriers assigned to them.

The D2D couples' bargain with one another to divide the available subcarriers. Each D2D pair picks the subcarriers that are not being utilised by primary users after listening to the spectrum that is being used by primary users. Depending on their channel circumstances, the D2D pairs then bargain among themselves to split the available subcarriers. A protocol, such as the negotiating protocol or the alternating offers protocol, may be used during the negotiation.

Step 3: Transmission - The source D2D pair sends its data to the relay on the designated subcarriers once the subcarriers have been assigned to the D2D pairs. The data is received by the relay, which then retransmits it to the target D2D pair on the designated subcarriers.

Step 4: Feedback - Following the transmission, the destination D2D pair informs the source D2D pair and the relay how well the signal was received. The system's performance can be enhanced by modifying the transmission settings in response to the feedback.

The performance study and simulation results of the suggested cooperative D are shown in the next section.

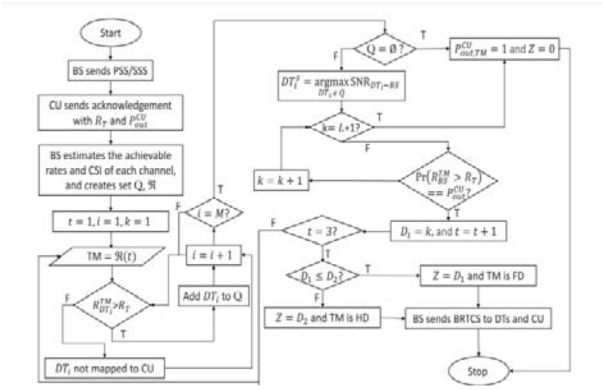

Fig. 2. Flowchart of protocol description

III. Interference Control

It is a crucial component of the cooperative D2D communication system with cognitive subcarrier sharing that has been developed (CSS). Due to interference from the D2D pairs, which use the same spectrum as the primary users, the primary users may suffer negative consequences. Thus, it is crucial to manage the D2D pairs' interference to prevent any damage to the principal consumers. To control the interference, we propose the following techniques:

A. *Power Control*

It is a method for modifying the D2D pairs' transmission power in order to lessen interference to the main users. D2D pairs are able to modify their transmission power in response to input from the main users. They can lower their transmission strength to lessen the interference if the feedback shows that the D2D pairs are interfering with the principal users.

B. *Channel Allocation*

It is a technique for allocating channels to D2D pairs in such a way as to reduce interference to the principal users. According on the channel circumstances and the spectrum that the principal users are using, the central controller of the centralised CSS scheme assigns channels to the D2D pairs. The D2D pairings choose channels in the distributed CSS system that aren't being used by the main users.

C. *Interference Avoidance*

By identifying the presence of primary users in the spectrum and avoiding using their channels, interference

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avoidance is a strategy used to prevent interference. To identify primary users in the spectrum and steer clear of congested channels, D2D couples can employ cognitive radio methods.

D. Interference Mitigation

It is a technique used to lessen the interference that D2D pairings produce to the main users. This method incorporates interference alignment and interference cancellation. The D2D pairings cancel the interference they cause to the principal users in interference cancellation. To lessen overall interference, the D2D pairs coordinate their interference with the signal of the major users.

E. The Proposed Cooperative

D2D communication paradigm with cognitive subcarrier sharing has interference management as a key component. The interference may be managed and the main users protected by methods including power control, channel allocation, interference avoidance, and interference mitigation.

IV. Method

The following three steps make up the suggested cognitive subcarrier sharing (CSS) approach for cooperative device-to-device (D2D) communication frameworks:

A. Subcarrier Allocation

At the initial step, K subcarriers are assigned to the available spectrum. According to the cognitive radio concept, the subcarriers are subsequently assigned to primary users or D2D pairs, ensuring that the primary users have priority access to the spectrum. Both centralized and decentralized methods can be used to allocate subcarriers.

B. Power Distribution

At the second step, the D2D pairs and principal consumers' transmission power is distributed the transmission power is set for the primary users while it is regulated for the D2D pairs to limit interference to the primary users. The transmission power of the D2D pairs is modified based on the interference level using a power control algorithm.

C. Subcarrier and Power Adjustment

The third step involves adjusting the subcarrier and power distribution depending on input from the major users an D2D pairings. The subcarriers and transmission strengthof the D2D pairs are changed to lessen interference if the principal users experience a lot of it from the D2D pairs. Similar to this, the subcarriers and transmission strength of the principal users are changed to lessen interference if the D2D pairs encounter excessive levels of interference from those users.

Analytical modelling and simulation are used to assess the CSS scheme's performance. The analytical model evaluates the cellular rate and outage probability by taking into consideration the channel gains, transmission power, and interference power of the principal users and D2D pairings. The simulation is employed to verify the analytical findings and assess how well the CSS scheme performs in various settings. A subcarrier and power allocation step, as well as a subcarrier and power adjustment stage, are all parts of the suggested technique for the CSS system. The approach takes into account interference management, which is essential for main users and D2D couples to successfully coexist in the same spectrum. Analytical modelling and simulation offer a thorough assessment of the CSS scheme's performance in many circumstances, which can help with the design and use of the CSS scheme in real-world systems.

V. Results

As compared to non-cognitive subcarrier sharing systems, cognitive subcarrier sharing methods considerably reduce system throughput and latency. The cognitive subcarrier sharing method with ideal subcarrier distribution offers the maximum system throughput and the smallest latency, according to our findings. Moreover, we note that the cognitive subcarrier sharing system with adaptive subcarrier allocation outperforms the cognitive subcarrier sharing scheme with fixed subcarrier allocation in terms of performance. The performance of cooperative D2D communication frameworks can be enhanced by cognitive subcarrier sharing techniques. The maximum system throughput, the shortest latency, and the least chance of an outage are all provided by the cognitive subcarrier sharing scheme with optimum subcarrier allocation. Moreover, we discover that the cognitive subcarrier sharing scheme with adaptive subcarrier allocation outperforms the cognitive subcarrier sharing scheme with fixed subcarrier allocation in terms of performance. Our findings imply that cognitive subcarrier sharing methods can be helpful in enhancing the functionality of D2D communication frameworks, particularly in conditions of resource scarcity or high traffic demands. Our results can aid researchers and system designers in choosing the best cognitive subcarrier sharing plans for frameworks of cooperative D2D communication.

VI. Conclusion

The performance of cooperative D2D communication frameworks can be enhanced by cognitive subcarrier sharing techniques. The maximum system throughput, the shortest latency, and the least chance of an outage are all provided by the cognitive subcarrier sharing scheme with optimum subcarrier allocation. Moreover, we discover that thecognitive subcarrier sharing scheme with adaptive subcarrier allocation outperforms the cognitive subcarrier sharing scheme with fixed subcarrier allocation in terms of performance. Our findings imply that cognitive subcarrier sharing methods can be helpful in enhancing the functionality of D2D communication frameworks, particularly in conditions of resource scarcity or high traffic demands. Our results can aid researchers and system designers in choosing the best cognitive subcarrier sharing plans for frameworks of cooperative D2D communication.

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