One of the goals of the fifth generation (5G) cellular network is to support a much higher data capacity (e.g., 1,000 times higher than today's current capacity). Despite its common usage, device to device (D2D) communications were used in different disciplines to mean other things. The device to device (D2D) communication acts as the relying functionality and includes multi-hops to improve cellular downlink throughput performances. Therefore, most studies in the field of D2D communications have focused on multi-hop relay-assisted out-band D2D communications to fulfill increase overall those performances. In this context, the this study scope here is aims to extending the numbers of the hops in the communication link to efficiently reduce the receiving bit error ratio, efficiently and thus in turn improve the wireless coverage services efficiency [1, 2].

D2D communications are used under a centralized control by the cellular network to increase system capacity, energy/spectrum efficiency, and improve the wireless coverage in the public safety network. In the natural disaster events, the coverage services help secure the people is an essential requirement when the wireless network is damaged and unable to provide the wireless coverage service to user devices [4, 5,6]. The relay assisted D2D network uses the achievable transmission capacity of multi-hop D2D system over Rayleigh fading channels. Then the conceivable the optimal design of D2D parameters and evaluate the influence of the number of relays hops on the system capacity and power efficiency are evaluated [7]. The role of UAVs and multi-hop D2D communications is to provide reliable connectivity in disaster situations, and established the communication link with user devices in out of coverage scenarios [3].

Therefore, extending the UAV coverage through the relay hop and D2D communication act to improve the wireless coverage services, spectrum, and energy efficiency in public safety communications [8].

The optimal relay nodes act as an essential role in public safety networks by helping the UAV to communicate within long distance, and overcome the transmission power limitations [9].

The This study aims to extend the UAV coverage through relay hops and D2D pair for a downlink unmanned aerial vehicle (UAV)-aided wireless communication system, where D2D users coexist in an underlay manner. The UAV will be able to fly and transmit wireless coverage to the relays in the disaster zone. The relays will forward the wireless coverage services to the user device in out of the UAV coverage, through multi-hop D2D communications [10,11,12]  

1.1 Contribution

The UAV is used in public safety networks to increase the system capacity and spectrum efficiency under control by the cellular system. In any natural disaster event, communication recovery public safety plays an essential role in public safety communication recovery and saving lives. Therefore, UAV has limitations for the transmission distance and Power to recover disaster communication. An optimal relay is a promising approach to extending the coverage based on multi-hop D2D communication to improve wireless coverage services in an injured area during disaster.
events. The UAV will provide configuration to centralize beamforming to an optimal relay for reliable connectivity and increases the signal strength at relay nodes to be able to link with the nodes outside the coverage area. Furthermore, an optimal relay node is selected based on the residual energy and link quality in the edge of UAV coverage. The performance of an optimal relay will increases the coverage area through increased the number of hops and reliably provides wireless coverage services to remote user devices.

2. System model

The system model is presented in Figure 1. We consider a scenario to help public safety networks in disasters situations. The ground user devices will be distributed according to the passion point process (PPP) in the disaster area. The user devices in the edge of UAV coverage will be selected as relay nodes. The relay nodes $R_i$ are able to be received wireless coverage services for the UAV, and forwarded it to the user devices in the out of the coverage area.

The multi-hop D2D communications architecture extends the UAV coverage, and improves the energy and spectrum efficiency. The UAV is deployed to provide the wireless coverage services to the ground user devices (GUDs) in the range of the UAV coverage area. The UAV provides the line-of-sight coverage of the GUDs in full-duplex mode, and transfers the wireless coverage signals to the cellular system in out of the disaster zone area. Then, the relays $R_i$, where $i=1, 2, \ldots, N$ to users that will receive the wireless coverage services from the UAV, and forward the wireless coverage to GUDs in out of the UAV coverage, through multi-hop D2D communication.

The main goal of this proposed model is to verify the reliability and availability of QoS signals. The ground user devices receivers during a natural disaster scenarios. The user devices can obtain the wireless coverage services directly from UAV, and the GUDs out of the UAV coverage get indirect wireless coverage services for the optimal relays that link directly with the UAV. The multi-hop D2D communication was able to extend the coverage services for user devices that are far away from the UAV coverage. Therefore, the optimal relay hop is a promising technology to support the fifth generation (5G) of wireless communications for extending the coverage area in the case of coverage services unavailability. The optimal relays can change its location dynamically to respond to an emergency, and have fast reconfiguration to provide effective communication and quicker disaster recovery.