# ABSTRACT

The fourth-generation wireless communication systems do not meet the requirements of ultra-low latency and high data rates in the order of Gbps for applications such as autonomous driving. The fifth-generation (5G) new radio (NR) includes various vital enabling technologies to address the data rates and latency requirements. These technologies are device-to-device (D2D) communication, full-duplex, massive multi-input multi-output, cooperative communications, visible light communications, to name a few.

Device-to-device (D2D) communication is another interesting technology 3GPP included in the earlier and evolving 5G standards. D2D communication helps the user equipment communicate without a base station within its proximity. D2D communications provide benefits like traffic offloading, spectrum re-use, reduced delay, and energy consumption. However, if the user equipment is not in proximity, the signal transmission get disrupted. Therefore, incorporating cooperative communication techniques in D2D communication can overcome this problem. Furthermore, to reveal the true potential of the cooperative D2D communication techniques for next- generation wireless systems, we aim to model, design, and analyze novel regenerative, and hybrid cooperative D2D wireless systems. Specifically, we design and develop various novel relay selection and relaying policies for reliable and efficient next-generation wireless systems.

We propose a simple and intuitive probabilistic relay selection policy (PRSP) for two-hop, two regenerative relay-assisted cooperative D2D communication systems and evaluate its symbol error probability (SEP) performance and diversity order. The proposed relay selection policy is lightweight in terms of the channel state information (CSI) burden on the system since it is a partial relay selection policy that depends on first hop signal power to noise power ratios (SNRs). For the same four-node, cooperative D2D system model, we propose a power-adaptive decode-and-forward (PA-DAF) relaying policy. The proposed PA-DAF relaying policy is novel since the PA-DAF relay decodes and re-encodes the received signal and optimally amplifies it as a function of second hop CSI before transmitting it to the destination. To evaluate PA-DAF policy's performance, we derive fading averaged symbol error rate (FASER), fading averaged spectral efficiency (FASE), and fading averaged energy efficiency (FAEE) and compare its performance with the benchmark policies. We show that the proposed PA-DAF relaying policy outperforms the benchmark policies in terms of various performance measures. Specifically, we show that the proposed

policy achieves FAEE 2.2 times higher compared to the benchmark fixed gain DAF relaying policy at 5 dB.

With the advent of the internet of things (IoT) and 5G cellular IoT, energy efficiency became a more critical network performance measure. Since the 5G architecture envisions deploying an ultra-dense, heterogeneous network, it poses a significant threat to high carbon dioxide emissions. Noting that climate action is one of the sustainable development goals proposed by the united nations, our focus also lies on energy-efficient designs. To make contributions in achieving this goal, we also present outage-constrained radio frequency (RF) energy harvesting-based relay selection (OC-EHRS) policy for a two-hop, green cooperative D2D communication system model. The model that we propose uses time-switching based simultaneous wireless information and power transfer (SWIPT). The proposed relay selection policy selects the relay that harvests maximum RF energy. Since the relay transmissions are outage constrained, the relay does not participate in forwarding data in the presence of poor channel conditions. The inclusion of energy conservation rule makes the system model that we propose more energy efficient. We evaluate the outage probability, FASE, and FAEE to analyze the performance of the OC-EHRS policy. We also compare the numerical results of the proposed relaying policy with the benchmark policies to determine achievable performance gains. We observe that the proposed policy achieves a performance gain of 9.9 % in FAEE than the benchmark partial relay selection policy.

We develop the generalization of the PA-DAF relaying policy for cooperative spectrum sharing systems (C-SSS). Specifically, we design and develop an interference-constrained PA-DAF (IC-PA-DAF) relaying policy for relays that acts as a secondary or unlicensed user in the system model. The proposed relaying policy is interference-constrained to avoid interference at the licensed or primary receiver. We design, develop and analyze the IC-PA-DAF policy for two different C-SSS, that is, non-EH relay-assisted C-SSS and RF-EH relay-assisted C-SSS. The relay selection policy adopted for both the system models is different. For the non-EH model, we employ PRSP and for EH model we employ energy harvesting based relay selection policy. Further, we specifically analyze FASE and FAEE for both the system models and investigate the trade-offs. Furthermore, we compare our novel relaying policies with the benchmark policy to show the achievable performance gains for different sets of simulation parameters. Specifically, we see that the proposed policy achieves FAEE 1.7 times higher compared to fixed gain DAF policy for non-EH system model and a performance gain of 1.2 times higher compared to simple decode-and-forward (DAF) policy for EH system model. The performance gains we achieve in terms of energy efficiency motivate the use of proposed policies in next-generation green C-SSS.