Automatika

Journal for Control, Measurement, Electronics, Computing and Communications

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/taut20

QoS optimization for full-duplex enabled relaying system with consecutive interference annulment

G. Linta Salvin & J. Arul Linsely

To cite this article: G. Linta Salvin & J. Arul Linsely (2024) QoS optimization for full-duplex enabled relaying system with consecutive interference annulment, Automatika, 65:2, 463-472, DOI: 10.1080/00051144.2023.2297482

To link to this article: https://doi.org/10.1080/00051144.2023.2297482

AUTOMATIKA
2024, VOL. 65, NO. 2, 463–472
https://doi.org/10.1080/00051144.2023.2297482

Taylor & Francis
Taylor & Francis Group

QoS optimization for full-duplex enabled relaying system with consecutive interference annulment

G. Linta Salvin[a] and J. Arul Linsely[b]

[a]Department of Electronics and Communication Engineering, Noorul Islam Centre for Higher Education, Kumaracoil, Tamilnadu, India;
[b]Department of Electrical and Electronics Engineering, Noorul Islam Centre for Higher Education, Kumaracoil, Tamilnadu, India

ABSTRACT

In this research work QoS optimization issue while power division in with full-duplex enable transfer capability in the presence of a direct connection. A novel system model for power division based relaying system with full-duplex capability and a strategy that employs techniques such as consecutive interference cancellation. They also use the existing system to define the channel capacity alleviation issue. Then, using the suggested repeated power division ratio method and the planned information architecture, the defined issue is solved. FDBPT created a Power dividing based relaying technology with FD Decode and forwarding capability in this research paper, taking into account the existence of a direct connection. Then, to solve the spectrum efficiency optimization model, information decoding strategy based on SIC and MRC algorithms was presented to decipher signals from the destination node. An IPDP methodology was presented in the proposed way to solve the stated enormous performance maximizing issue. The proposed information decoding technique takes into account the benefits of direct connection, FD, and SIC. Furthermore, a number of simulations demonstrate the higher performance of the proposed approach. NS2 simulations are used to attain higher performance than previous techniques.

ARTICLE HISTORY
Received 4 November 2023
Accepted 13 December 2023

KEYWORDS
Full duplex; interference annulment; remote radio head; resource distribution; full duplex (FD) broadcast and power transport (FDBPT)

1. Introduction

Relay nodes have been proposed as a promising option for improving connection speeds and assisting resource sharing in future wireless networks [1–26]. Relay nodes, on the other hand, frequently have limited battery capacity and must gather energy to continue working in the atmosphere. In woods, farms, and other locations, tracking equipment and metres are installed. Battery replacement and refilling are inconvenient in some areas. To improve network efficiency and enhance interaction, it is required to provide energy for broadcasting nodes using an enhanced full duplex (FD) broadcast and power transport (FDBPT) technology. FDBPT is a potential technique for upcoming resource broadcasting networks because it can concurrently conduct information decoding (ID) and energy yield (EY) [9–11,27–29]. Many studies have recently focused on the SWIPT system. The EH issue of the FDBPT system has been explored in several literatures. Jang et al. [1] set out to improve the EH efficiency of multi-cell multi-user systems. A downlink system with many inputs and a single output, in which the Beam-forming algorithms with a centralized approach and distributed methods were put forth. Wei et al. [2] presented how to transfer mobile edge computing (MEC) via connected devices, using the continuous learning method to find the best successful strategy. Li et al. [3] addressed how mobile devices may employ energy collected from massive base stations and access points (APs) for machine to machine, cellular communications etc.

An energy-efficient wealth distribution method for wireless enabled communication systems that took into account each subscriber's quality of service (QoS) requirements [4]. Wang and Zhang [5] used the Energy recap method into mobile phones in order to ensure that they gather reusable energy from their surroundings. Furthermore, to reduce the overall duration of job execution, a combined computation offloading and resource allocation strategy for supporting MEC systems with numerous Energy recap mobiles was developed. Mao et al. [6] presented a dynamic computation offloading technique based on Sliding mode optimizing to lessen and lower the implementation cost of future MEC systems with sustainable power equipment. To tackle the perspective preventative caching issue, [7] presented a post decision specific state approximation retraining learning method. Furthermore, simulation results shown that when the number of distributed users grows, the developed algorithm can meet the needs of additional users. Zhang et al. [8] improved mobile appliances clock frequency, transmit power and the ratio of offloading using partial resource

CONTACT G. Linta Salvin lintasalving.ece@gmail.com Department of Electronics and Communication Engineering, Noorul Islam Centre for Higher Education, Kumaracoil, Tamilnadu, India-629180

provisioning to minimize energy cost of mobile appliances. However, full-duplex communication and innovative information method were not common objectives [1–8]. Xu et al. [9] suggested a durable power allocation issue for SBSs fuelled by sustainable and grid energy, including cross-tier and Energy recap restrictions, to best antenna energy consumption. A downstream FDBPT enabled heterogeneity non-orthogonal multiplexing network aims to maximize users' overall energy efficiency while taking into account user and intrusion outage restrictions. An optimal energy distribution and defined as a structured approach was presented by Zhang et al. [10]. In [11], a vigorous resource distribution technique for received signal FDBPT based routing protocols is portrayed, in which the bayesian possibility machine method, Dinkelbach strategy, and algebraic transform methodology were used to reconstruct the raw non-convex impact on energy productivity maximization into a probabilistic and linear convex approach. After then, Lagrangian dual technique and sub-gradient boosting approaches were used to address the problem. The signal strategy, on the other hand, was not studied in [9–11].

In furthermore, some papers [12–26] have addressed relaying transmission in the SWIPT scheme. For the combined timeline and power division dilemma in the half-duplex demodulate system, the authors presented a separated adaptive process and an alternative convex optimization methodology in [12]. Energy recap relays infrastructure to reduce the chance of outages and increase immediate signal quality. [13] proposed a low-complexity clustering technique to tackle the end-to-end attainable rate redistribution problem involving joint power division proportions and available bandwidth in a half duplex micro transmitter. The best power division ratio for an energy recap three-step two-way exponential enhance coverage area was obtained using a dinkelbach-based adaptive approach presented in [14]. In [15], the authors suggested a dynamic than more combine strategy to better communicates by selecting time switching manner and power division manner. Under the routing approach time power-based coordinated dynamic spectrum strategy for the augment and broadcast and decode and broadcast communicating FDBPT technology, Zhang et al. [16] obtained accurate locked values of data rate and attainable bandwidth of low and high systems. In the case of a direct connection, the research evaluated transient and steady state PS schemes to maximize providing employee and utilize the diversification advantage of a double decode and broadcast relaying network [17]. Nonetheless, the relayed node's full duplex capability is not taken into account in [12–17]. [18–20] considers the characteristic of full duplex for cluster heads.

Hu et al. [18] collaboratively developed the best signal strength and PS ratio to enhance the energy harvested of the FDBPT technology, and simulation studies were used to generate and confirm restricted objective function for the initial problem. By maximizing the power division percentage, Fang and Gao [19] investigated the maximum resource utilization of FD and HD. The availability of a direct relationship, on the other hand, is not taken into account in [18,19]. In [20], time shifting was developed to maximize channel capacity while ensuring that the FD FDBPT system's goal time complexity was minimized and maintained under QoS restrictions. The new decoding strategy, on the other hand, is not taken into account. In [21], a combination phase partitioning and available bandwidth optimization method is presented to optimize the end-to-end attainable rate for a multi-carrier decode relaying routing scheme. In [22], the topic of signal strength minimization for multi-hop DF SWIPT systems is defined, and a controlled and dispersed approach for determining the power dividing proportion for routing protocols is given. To reduce the battery's power consumption, Aruna et al. [23] suggested a Power dividing based SWIPT approach for the cluster heads of a power in collaborative telecommunication system. In [24], an identified utility leader needs was handled by concurrently maximizing the power level, the resources power dividing ratio, and the intermediary reflector matrix to increase total collected energy, condense, and use the self interference of FD channel. In [25] presented two transmission evaluation metrics to meet the goals of interruption likelihood minimization and sum throughput optimization, accordingly. Moon et al. [26] used FD method for all terminals in a two-way cellular modem and customized the ability to maximize performance. The MRC system, on the other hand, is not taken into account in [21–26].

The study attempts to maximize the channel capacity of power dividing based transmitting FDBPT systems with FD decoding capability in the existence of a direct connection, based on research concerning FDBPT systems in [1–26]. To decrypt signals from the intermediate nodes, an information decoding strategy based on successive interference cancellation (SIC) and maximum ratio combining (MRC) approaches is presented. Furthermore, using the suggested information decoding system, an iterative power division proportion (IPDP) method is presented to address the specified data rate maximizing issue.

The following are the key achievements of this work.

(1) In the existence of a direct connection, a PS-based mediating FDBPT mechanism with FD decoding capability is built, providing all FD and straight link transmission advantages.
(2) For decode signals from the intermediate nodes, an information decoding strategy employing combining SIC and MRC methods is used, resulting in

the efficiency of obtaining greater data in a limited number of intervals.

(3) A challenge of maximizing transmit power is presented.

(4) By improving the power dividing proportion of the source nodes, the IPDP method is presented to address the specified transmission power maximization issue.

The remaining part of this work is structured as follows. Chapter ii contains a general framework model. Chapter iii presents an ID method based on SIC and MRC approaches. To tackle the specified transmission power maximization challenge, we present an iterative PS ratio method in Chapter iv. The simulation results shown in Figure 5. Finally, Chapter V brings the article to a conclusion.

2. Illustration of the network

Examine a FDBPT capability, as illustrated in Figure 1, with a direct connection among source node S and target node D. Furthermore, suppose that both S and D have one transmitter each, whereas relaying node R has multiple antennas in order to accomplish FD connectivity, i.e. R may broadcast and send input from S at the same time. Furthermore, R uses a power divider to divide the output receives from source S into two portions, information decoding and Energy recapping. Suppose that energy for S is provided by a reliable power supply. Rechargeable batteries gather energy through S to activate the resource relaying R. Furthermore, in R, the decode and forward method is used to decipher signal produced from S and then transfer the deciphered signals to D. The network values across S and D, S and R, R and D, R and R, and R and R, correspondingly, are denoted by C_{S-D}, C_{S-R}, C_{R-D}, and C_{R-R}. Suppose that network status information is accessible only at recipients, i.e. relaying and destination nodes, and that it persists throughout each broadcast time block, as described in [12,15]. The standardized information between S and R are denoted by $S_{sig(S)}$ and $S_{sig(R)}$, correspondingly, where $E_{eng}(|S_{sig(S)}|^2) = 1$ and $E_{eng}(|S_{sig(R)}|^2) = 1$ indicate the intensity of signal power $S_{sig(S)}$ and $S_{sig(R)}$, in both.

3. Information decoding method

In our suggested system architecture to accomplish data transfer specified in Information decoding procedures at D that conducts SIC and MRC. Three works are examined in this article.

Relay node R has three methods, and is as follows:

(i) True ER method involves the usage of the R's input signal entirely as ER.

(ii) HD decode and forward power division method, wherein the R's input signal is utilized as information decoding and ER, and the R operates in HD broadcasting manner.

(iii) FD decode and forward power division method, wherein the R's input signal is utilized as information decoding and ER, and the R operates in FD broadcasting manner.

(iv) True ER method

S delivers signal S_{sig1} to D, D decodes S_{sig1}, and R_{eng} recapping energy. The data rate at D can be described as follows and for connection oriented S to D,

$$Y_{D(1)} = \sqrt{B_{S-D}C_{S-D(1)}}S_{sig1} + In_{S-D(1)} \qquad (1)$$

where $C_{S-D(1)}$ signifies the channel gain from S to D and B_{S-D} denotes the broadcasting power from S to D. The impulsive noise signal is $In_{S-D(1)} \sim CN(0,(\sigma_{S-D(1)})^2)$

D's signal-to-noise ratio (SNR) for the linkage may also be calculated as follows,

$$e_{S-D(1)} = B_{S-D}(C_{S-D(1)})^2/(\sigma_{S-D(1)})^2 \qquad (2)$$

As a result, True ER method the amount of signal at D can be expressed as follows,

$$R_{(1)} = T * \log_2(1 + e_{S-D(1)}) \qquad (3)$$

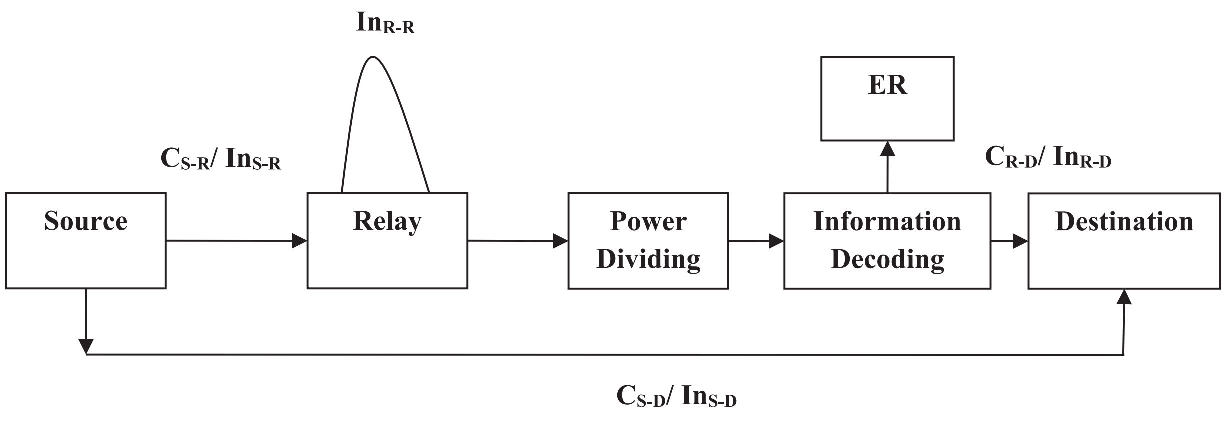

Figure 1. FDBPT capability.

The obtained information of R for the relaying connection S to R may be represented as shown,

$$\mathbf{Y}_{\mathbf{R(1)}} = \surd \mathbf{B}_{\mathbf{S-R}}\mathbf{C}_{\mathbf{S-R(1)}}\mathbf{S}_{\mathbf{sig1}} + \mathbf{In}_{\mathbf{S-D(1)}} \tag{4}$$

where $C_{S-R(1)}$ signifies the channel gain from S to R and B_{S-R} denotes the broadcasting power from S to R. The impulsive noise signal is $In_{S-R(1)} \sim CN(0,(\sigma_{S-R(1)})^2)$.

As a result, the energy recapped at R in time period T may be expressed as,

$$\mathbf{E}_{\mathbf{Reca(1)}} = \mathbf{T} * [(\mathbf{B}_{\mathbf{S-R}}(\mathbf{C}_{\mathbf{S-R(1)}})^2) + (\boldsymbol{\sigma}_{\mathbf{S-R(1)}})^2] \tag{5}$$

(ii) HD decode and forward power division method

The Signal-to-Interference-plus-Noise Ratio (SINR) is a metric used in telecommunications and wireless communication to quantify the quality of a received signal. It represents the ratio of the desired signal power to the sum of interference and noise power. A higher SINR indicates a better-quality signal and, consequently, a more reliable and efficient communication link. SINR is a crucial parameter in assessing and optimizing the performance of wireless communication systems, including cellular networks and wireless LANs.

$$\text{SINR} = \frac{P_{signal}}{P_{interference} + P_{noise}}$$

S delivers signal S_{sig2} to D and R, D decodes S_{sig2}, and R executes HD decode and forward power division. The data rate at D can be described as follows and for connection-oriented S to D,

$$\mathbf{Y}_{\mathbf{D(2)}} = \surd \mathbf{B}_{\mathbf{S-D}}\mathbf{C}_{\mathbf{S-D(2)}}\mathbf{S}_{\mathbf{sig2}} + \mathbf{In}_{\mathbf{S-D(2)}} \tag{6}$$

where $C_{S-D(2)}$ signifies the channel gain from S to D and B_{S-D} denotes the broadcasting power from S to D. The impulsive noise signal is $In_{S-D(2)} \sim CN(0, (\sigma_{S-D(2)})^2)$

The obtained information of R for the relaying connection S to R may be represented as shown,

$$\mathbf{Y}_{\mathbf{R(2)}} = \surd \mathbf{B}_{\mathbf{S-R}}\mathbf{C}_{\mathbf{S-R(2)}}\mathbf{S}_{\mathbf{sig2}} + \mathbf{In}_{\mathbf{S-D(2)}} \tag{7}$$

where $C_{S-R(2)}$ signifies the channel gain from S to R and B_{S-R} denotes the broadcasting power from S to R. The impulsive noise signal is $In_{S-R(2)} \sim CN(0,(\sigma_{S-R(2)})^2)$. As a result, the obtained information of R utilized as Information decoding and ER when power dividing method is applied can be represented as,

$$\begin{aligned}\mathbf{Y}_{\mathbf{R-Info(2)}} &= \surd(\mathbf{1} - \boldsymbol{\lambda})((\surd \mathbf{B}_{\mathbf{S-R}}\mathbf{C}_{\mathbf{S-R(2)}}\mathbf{S}_{\mathbf{sig2}} \\ &\quad + \mathbf{In}_{\mathbf{S-R(2)}}) + \mathbf{In}_{\mathbf{I-D(2)}}) \qquad (8)\\ \mathbf{Y}_{\mathbf{R-Eng(2)}} &= \surd\boldsymbol{\lambda}(\surd \mathbf{B}_{\mathbf{S-R}}\mathbf{C}_{\mathbf{S-R(2)}}\mathbf{S}_{\mathbf{sig2}} + \mathbf{In}_{\mathbf{S-R(2)}}) \qquad (9)\end{aligned}$$

where $In_{I-D(2)} \sim CN(0,(\sigma_{I-D(2)})^2)$ is impulsive noise signal, λ is power dividing percentage.

R's signal-to-interference and noise percentage (SINR) for the linkage may also be calculated as follows,

$$\begin{aligned}e_{\mathbf{S-R(2)}} &= \left[(\mathbf{1} - \boldsymbol{\lambda})\mathbf{B}_{\mathbf{S-D}}(\mathbf{C}_{\mathbf{S-D(2)}})^2\right]/\big] \\ &\quad \times (\mathbf{1} - \boldsymbol{\lambda})(\boldsymbol{\sigma}_{\mathbf{S-R(2)}})^2 + (\boldsymbol{\sigma}_{\mathbf{I-R(2)}})^2]\end{aligned} \tag{10}$$

As a result, the energy recapped at R in time period T may be expressed as,

$$\begin{aligned}\mathbf{E}_{\mathbf{Reca(2)}} &= \mathbf{T} * [\boldsymbol{\lambda}\{(\mathbf{B}_{\mathbf{S-R}}(\mathbf{C}_{\mathbf{S-R(2)}})^2) + (\boldsymbol{\sigma}_{\mathbf{S-R(2)}})^2\} \\ &\quad + (\boldsymbol{\sigma}_{\mathbf{I-R(2)}})^2]\end{aligned} \tag{11}$$

where entire energy renovation is assumed, i.e. energy renovation effectiveness is 1.

As a result, the relay node's broadcasting energy B_{Eng} can be written as,

$$\begin{aligned}B_{Eng} &= \mathbf{E}_{\mathbf{Reca(2)}}/\mathbf{T} \\ &= \boldsymbol{\lambda}\{(\mathbf{B}_{\mathbf{S-R}}(\mathbf{C}_{\mathbf{S-R(2)}})^2) + (\boldsymbol{\sigma}_{\mathbf{S-R(2)}})^2\} \\ &\quad + (\boldsymbol{\sigma}_{\mathbf{I-R(2)}})^2\end{aligned} \tag{12}$$

(iii) FD decode and forward power division method

S delivers signal S_{sig3} to D is related to the procedure of S delivers signal S_{sig2} to D and R in HD decode and forward power division method. Furthermore, when R obtains signal S_{sig3} through S, it broadcast S_{sig2} to D in the FD decode and forward power division method. D's received signal as,

$$\begin{aligned}\mathbf{Y}_{\mathbf{D(3)}} &= \surd \mathbf{B}_{\mathbf{S-D}}\mathbf{C}_{\mathbf{S-D(3)}}\mathbf{S}_{\mathbf{sig3}} + \surd \mathbf{B}_{\mathbf{Eng(2)}}\mathbf{C}_{\mathbf{R-D(3)}}\mathbf{S}_{\mathbf{sig2}} \\ &\quad + \mathbf{In}_{\mathbf{D(3)}}\end{aligned} \tag{13}$$

Utilize SIC to decode S_{sig3} first in the scenario where $B_{S-D(3)} > B_{R-D(3)}$. SIC is associated with the physical layer interface that provides a recipient to accept signals may come consecutively and decipher these as per the intensity of the data. The SINR of signal S_{sig3} can then be calculated as,

$$\begin{aligned}e_{\mathbf{S-D(3)}} &= [\mathbf{B}_{\mathbf{S-D}}(\mathbf{C}_{\mathbf{S-D(3)}})^2]/\ \{\mathbf{B}_{\mathbf{Eng(2)}}(\mathbf{C}_{\mathbf{R-D(3)}})^2 \\ &\quad + (\boldsymbol{\sigma}_{\mathbf{D(3)}})^2\}]\end{aligned} \tag{14}$$

Decode S_{sig2} and get the SNR of S_{sig2} as,

$$e_{\mathbf{R-D(3)}} = \mathbf{B}_{\mathbf{Eng(2)}}(\mathbf{C}_{\mathbf{R-D(3)}})^2/(\boldsymbol{\sigma}_{\mathbf{D(3)}})^2 \tag{15}$$

In the instance when $B_{S-D(3)} < B_{R-D(3)}$, Initially decipher signal S_{sig2} using SIC. The SINR of signal S_{sig2} can then be calculated as,

$$\begin{aligned}e_{\mathbf{R-D(3)}} &= \mathbf{B}_{\mathbf{Eng(2)}}(\mathbf{C}_{\mathbf{R-D(3)}})^2/\ [\mathbf{B}_{\mathbf{S-D}}(\mathbf{C}_{\mathbf{S-D(3)}})^2 \\ &\quad + (\boldsymbol{\sigma}_{\mathbf{D(3)}})^2]\end{aligned} \tag{16}$$

Decode S_{sig3}, and achieve SNR of S_{sig3} as,

$$e_{\mathbf{S-D(3)}} = \mathbf{B}_{\mathbf{S-D}}(\mathbf{C}_{\mathbf{S-D(3)}})^2/(\boldsymbol{\sigma}_{\mathbf{D(3)}})^2 \tag{17}$$

At this point, for $B_{S-D(3)} > B_{R-D(3)}$ and $B_{S-D(3)} < B_{R-D(3)}$, assume MRC to evaluate signal S_{sig2} in ii and iii methods, therefore the entire amount of obtained bits at D in 3rd method as,

$$\mathbf{R}_{(3)} = \mathbf{T} * (\mathbf{log_2}(\mathbf{1} + e_{\mathbf{S-D(2)}} + \mathbf{min}(e_{\mathbf{S-R(2)}}, e_{\mathbf{R-D(3)}}))) \tag{18}$$

Relaying connection S to R, the obtained information of R articulated as,

$$\mathbf{Y_{R(3)}} = \sqrt{}\mathbf{B_{S-R}C_{S-R(3)}S_{sig3}} + \sqrt{}\mathbf{B_{Eng(2)}C_{R-R(3)}S_{sig2}} + \mathbf{In_{S-R(3)}} \tag{19}$$

where $C_{S-R(3)}$ signifies the channel gain from S to R and B_{S-R} denotes the broadcasting power from S to R. The impulsive noise signal is $In_{S-R(3)} \sim CN(0,(\sigma_{S-R(3)})^2)$. As a result, the obtained information of R utilized as Information decoding and ER when power dividing method is applied can be represented as,

$$\mathbf{Y_{R-Info(2)}} = \sqrt{}(\mathbf{1} - \boldsymbol{\lambda})((\sqrt{}\mathbf{B_{S-R}C_{S-R(3)}S_{sig3}} + \sqrt{}\mathbf{B_{Eng(3)}C_{S-R(3)}S_{sig2}} + \mathbf{In_{S-R(3)}}) + \mathbf{In_{I-D(3)}}) \tag{20}$$

$$\mathbf{Y_{R-Eng(2)}} = \sqrt{}\boldsymbol{\lambda}(\sqrt{}\mathbf{B_{S-R}C_{S-R(3)}S_{sig3}} + \sqrt{}\mathbf{B_{Eng(2)}C_{R-R(3)}S_{sig2}} + \mathbf{In_{S-R(3)}}) \tag{21}$$

where $In_{I-D(3)} \sim CN(0,(\sigma_{I-D(3)})^2)$ is impulsive noise signal, λ is power dividing percentage and self interference gain of R is $C_{R-R(3)}$.

R's signal-to-interference and noise percentage (SINR) is evaluated as,

$$e_{\mathbf{S-R(2)}} = \left[(\mathbf{1} - \boldsymbol{\lambda})\mathbf{B_{S-R}}(\mathbf{C_{S-R(3)}})^2\right]/\left](\mathbf{1} - \boldsymbol{\lambda}) \times \{\mathbf{B_{Eng(3)}}(\mathbf{C_{R-R(3)}})^2(\boldsymbol{\sigma}_{\mathbf{S-R(3)}})^2\} + (\boldsymbol{\sigma}_{\mathbf{I-R(3)}})^2\right] \tag{22}$$

$$\mathbf{E_{Reca(2)}} = \mathbf{T} * [\boldsymbol{\lambda}\{(\mathbf{B_{S-R}}(\mathbf{C_{S-R(3)}})^2) + \mathbf{B_{Eng(3)}}(\mathbf{C_{R-R(3)}})^2 + (\boldsymbol{\sigma}_{\mathbf{S-R(3)}})^2\} + (\boldsymbol{\sigma}_{\mathbf{I-R(3)}})^2] \tag{23}$$

where entire energy renovation is assumed, i.e. energy renovation effectiveness is 1.

As a result, the relay node's broadcasting energy B_{Eng} can be written as,

$$B_{Eng} = \mathbf{E_{Reca(3)}}/\mathbf{T} = \boldsymbol{\lambda}\{(\mathbf{B_{S-R}}(\mathbf{C_{S-R(3)}})^2) + \mathbf{B_{Eng(3)}}(\mathbf{C_{R-R(3)}})^2 + (\boldsymbol{\sigma}_{\mathbf{S-R(3)}})^2\} + (\boldsymbol{\sigma}_{\mathbf{I-R(3)}})^2 \tag{24}$$

Derive the broadcasting energy $\mathbf{B_{Eng(3)}}$ of R as,

$$B_{Eng} = \left[\boldsymbol{\lambda}\{(\mathbf{B_{S-R}}(\mathbf{C_{S-R(3)}})^2) + (\boldsymbol{\sigma}_{\mathbf{S-R(3)}})^2\} + (\boldsymbol{\sigma}_{\mathbf{I-R(3)}})^2\right]/\left]\mathbf{1} - \boldsymbol{\lambda}(\mathbf{C_{R-R(3)}})^2\right] \tag{25}$$

where R is True ER method whilst λ = 1.

S broadcast signal S_{sig4} to R and D, is identical to the procedure in which S transmits signal S_{sig3} to R and D. Furthermore, while D is functioning in the FD power dividing manner, R transmits S_{sig3} to D. S sent a signal S_{sig4} times. D's obtained signal is indicated as,

$$\mathbf{Y_{D(4)}} = \sqrt{}\mathbf{B_{S-D}C_{S-D(4)}S_{sig4}} + \sqrt{}\mathbf{B_{Eng(3)}C_{R-D(4)}S_{sig3}} + \mathbf{In_{D(4)}} \tag{26}$$

In the instance when $B_{S-D(4)} > B_{R-D(4)}$, Initially decipher signal S_{sig4} using SIC. The SINR of signal S_{sig4} can then be calculated as,

$$e_{\mathbf{S-D(4)}} = \mathbf{B_{S-D}}(\mathbf{C_{S-D(4)}})^2/\ [\mathbf{B_{Eng(3)}C_{R-D(4)}})^2 + (\boldsymbol{\sigma}_{\mathbf{D(4)}})^2] \tag{27}$$

Decode S_{sig3}, and achieve SNR of S_{sig3} as,

$$e_{\mathbf{R-D(4)}} = \mathbf{B_{Eng(3)}}(\mathbf{C_{R-D(4)}})^2/(\boldsymbol{\sigma}_{\mathbf{D(4)}})^2 \tag{28}$$

In the instance when $B_{S-D(4)} < B_{R-D(4)}$, Initially decipher signal S_{sig4} using SIC. The SINR of signal S_{sig4} can then be calculated as,

$$e_{\mathbf{R-D(4)}} = \mathbf{B_{Eng(3)}}(\mathbf{C_{R-D(4)}})^2/\ [\mathbf{B_{S-D}C_{S-D(4)}})^2 + (\boldsymbol{\sigma}_{\mathbf{D(4)}})^2] \tag{29}$$

Decode S_{sig3}, and achieve SNR of S_{sig3} as,

$$e_{\mathbf{S-D(4)}} = \mathbf{B_{S-D}}(\mathbf{C_{S-D(4)}})^2/(\boldsymbol{\sigma}_{\mathbf{D(4)}})^2 \tag{30}$$

At this point, for $B_{S-D(4)} > B_{R-D(4)}$ and $B_{S-D(4)} < B_{R-D(4)}$, assume MRC to evaluate signal S_{sig2} in ii and iii methods, therefore the entire amount of obtained bits at D in 3rd method as,

$$\mathbf{R}_{(4)} = \mathbf{T} * (\mathbf{log_2}(\mathbf{1} + e_{\mathbf{S-D(3)}} + \mathbf{min}(e_{\mathbf{S-R(3)}}, e_{\mathbf{R-D(4)}}))) \tag{31}$$

S broadcast signal $S_{sig(n)}$ to R and D in n cycle (nC), but is identical to the procedure wherein the S broadcast signal S_{sig4} to R and D in the executing stage. Furthermore, R broadcasts $S_{sig(n-1)}$ to D's functioning. Whenever it receives signal $S_{sig(n)}$ from S, it enters FD power dividing method. D's received signal is,

$$\mathbf{Y_{D(n)}} = \sqrt{}\mathbf{B_{S-D}C_{S-D(n)}S_{sig(n)}} + \sqrt{}\mathbf{B_{Eng(n-1)}C_{R-D(n)}S_{sig(n-1)}} + \mathbf{In_{D(n)}} \tag{32}$$

In the instance when $B_{S-D(n)} > B_{R-D(n)}$, Initially decipher signal $S_{sig(n)}$ using SIC. The SINR of signal $S_{sig(n)}$ can then be calculated as,

$$e_{\mathbf{S-D(n)}} = \mathbf{B_{S-D}}(\mathbf{C_{S-D(n)}})^2/\ [\mathbf{B_{Eng(n-1)}C_{R-D(n)}})^2$$

$$+ (\sigma_{\mathbf{D(n)}})^2] \tag{33}$$

Decode $S_{sig(n-1)}$, and achieve SNR of $S_{sig(n-1)}$ as,

$$e_{\mathbf{R-D(n)}} = \mathbf{B}_{\mathbf{Eng(n-1)}}(\mathbf{C}_{\mathbf{R-D(n)}})^2/(\sigma_{\mathbf{D(n)}})^2 \tag{34}$$

In the instance when $B_{S-D(n)} < B_{R-D(n)}$, Initially decipher signal $S_{sig(n)}$ using SIC. The SINR of signal $S_{sig(n)}$ can then be calculated as,

$$e_{\mathbf{R-D(n)}} = \mathbf{B}_{\mathbf{Eng(n-1)}}(\mathbf{C}_{\mathbf{R-D(n)}})^2/\ [\mathbf{B}_{\mathbf{S-D}}\mathbf{C}_{\mathbf{S-D(n)}})^2 + (\sigma_{\mathbf{D(n)}})^2] \tag{35}$$

Decode $S_{sig(n)}$, and achieve SNR of $S_{sig(n-1)}$ as,

$$e_{\mathbf{S-D(n)}} = \mathbf{B}_{\mathbf{S-D}}(\mathbf{C}_{\mathbf{S-D(n)}})^2/(\sigma_{\mathbf{D(n)}})^2 \tag{36}$$

At this point, for $B_{S-D(n)} > B_{R-D(n)}$ and $B_{S-D(n)} < B_{R-D(n)}$, assume MRC to evaluate signal $S_{sig(n-1)}$ in (n-1) and 'n'th methods, therefore the entire amount of obtained bits at D in 'n'th method as,

$$\mathbf{R}_{(\mathbf{n})} = \mathbf{T} * (\mathbf{log_2}(\mathbf{1} + e_{\mathbf{S-D(n-1)}} + \mathbf{min}(e_{\mathbf{S-R(n-1)}},\ e_{\mathbf{R-D(n)}}))) \tag{37}$$

Imagine $T = 1,\ 2,\ 3, \dots n \dots,\ N$ symbolize the deposit of time intervals. Finally, prepare spectral effectiveness maximization dilemma of proposed methodology as,

$$\mathbf{max(\lambda)}\{(\mathbf{R}_{(\mathbf{1})} + \sum_{\mathbf{n}\ \in\mathbf{T[1,2]}} \mathbf{R}_{(\mathbf{n})})/\phi * \mathbf{NT}\}, \mathbf{0} \le \lambda \le \mathbf{1} \tag{38}$$

where $R_{(1)}+\sum_{n\in T}[1,2]R_{(n)}$ is amount of information obtained by D throughout N^{th} time intervals, and $R_{(n)}$ designates the amount of information obtained by D in *n*th time interval. Furthermore, $\boldsymbol{\phi}$ signifies the frequency of the environment.

4. Iterative power division proportion (IPDP)

When the entire amount of consecutive intervals is supplied, the issue created may be addressed and translated into the subsequent two sub-problems and X2 using the bandwidth efficiency acquired from the preceding innovative Information decoding technique. The explanation for this is that the defined issue's computation of the amount of packets received bits is split into 2 parts $R_{(1)}$ and $\sum_{n\in T}[1,2]R_{(n)}$, correspondingly.

(i)

$$X1 : \mathbf{R}_{(\mathbf{1})} = \mathbf{T} * \mathbf{log_2}(\mathbf{1} + e_{\mathbf{S-D(1)}}) \tag{39}$$

(ii)

$$X2 : \mathbf{max} = \sum_{\mathbf{n}\in\mathbf{T[1,2]}} \mathbf{T} * (\mathbf{log_2}(\mathbf{1} + e_{\mathbf{S-D(n-1)}} + \mathbf{min}(e_{\mathbf{S-R(n-1)}},\ e_{\mathbf{R-D(n)}}))), \quad \mathbf{0} \le \lambda \le \mathbf{1} \tag{40}$$

Because the characteristics of X1 are available. As a result, concentrate on solving X2 and present an IPDP method to do so; the IPDP Methodology is extensively described in Protocol 1.

Using proposed Method calculate the total amount of data sequence for issues X1 and X2 based on the maximum number of received bits in time periods n ∈T[1,2] and also achieve maximum bandwidth efficiency.

Algorithm IPDP

```
Begin.
Initialize $B_S$, $C_{S-D(n)}$, $C_{S-R(n)}$, $C_{R-D(n)}$ and $C_{R-R(n)}$,
Begin for $\lambda = 10^{-7}$-$10^{-4}$,
If $\lambda = 1$ do,
Evaluate €$_{S-R(n-1)}$, €$_{R-D(n)}$ and min(€$_{S-R(n-1)}$, €$_{R-D(n)}$),
End for.
Yield maxmin(€$_{S-R(n-1)}$, €$_{R-D(n)}$) and amount of information
    obtained $R_{(n)}$ at D.
End.
```

5. Simulation outcomes

$C_{R-R} = 10^{-3}$, with node R at 60 dB. Investigate the routing protocol with propagation loss and Rayleigh fading, i.e. $C_{S-R} = RF_{S-R}d^{-3}{}_{S-R}$, $C_{R-D} = RF_{R-D}\ d^{-3}{}_{R-D}$, and $C_{S-D} = RF_{S-D}d^{-\alpha}{}_{S-D}$, with route disappearing exponents of 3, -α and 3, correspondingly. The Rayleigh fading RF_{S-R}, RF_{R-D}, and RF_{S-D} exponential distribution parameters are all set to 1. Furthermore, the amount of input time intervals N is set to 10,000, with each time slot lasting 1 s. In addition, at each time interval, set $B_{S-D(n)} = B_{S-R(n)} = B_S$. The suggested system is then compared to the system is in operation.

- Comparable approach1: HD Decoding and Forwarding provision with a direct connection presume the consistently timeline.
- Comparable approach2: FD Decoding and Forwarding relaying system without a link presume the consistent timeline.
- Comparative approach3: HD Decoding and Forwarding relaying technique presume two-hop connectivity.

Figure 2, depicts spectral efficiency when compared to B_S at various distances. Set $\sigma^2{}_{S-R} = \sigma^2{}_{R-D} = \sigma^2{}_{S-D} = \sigma^2{}_{I-R} = -40$ dbm; $d_{S-R} = 4$ m, $d_{R-D} = 4$ m, and $d_{S-D} = 8.7$ m correspondingly. The proposed scheme outperforms the techniques presented in [28–30] when the range is kept constant. The reason for this is that, in comparison to [28,30] proposed methodology enhances time capacity utilization by using an FD

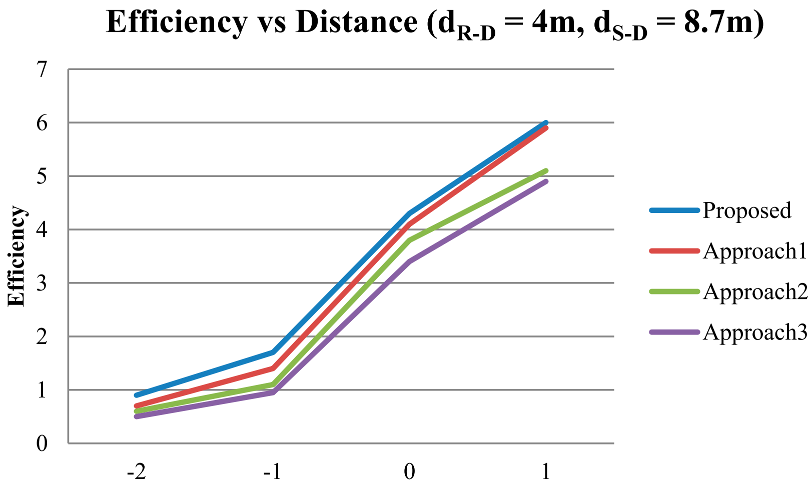

Figure 2. Spectral effectiveness diverges with B_S under remoteness.

Decoding and Forwarding relaying approach and a SIC technique to decode incomplete signals.

In comparison to [29], our suggested approach takes use of variation gains, as well as SIC and MRC deciphering algorithms. Furthermore, B_S gives improved since increasing power allocation leads to higher SINR and much more obtained bits of target D, which improves the system's signal quality. Furthermore, as the ranges d_{S-D} become shorter, wavelength efficiency improves. The rationale for this is that a reduced d_{S-D} can result in higher bandwidth efficiencies via direct link.

Signal power with regard to B_S is shown in Figures 3 and 4 for varied route losses of direct links, where $\sigma^2{}_{S-R} = \sigma^2{}_{R-D} = \sigma^2{}_{S-D} = \sigma^2{}_{I-R} = -40$ dbm.

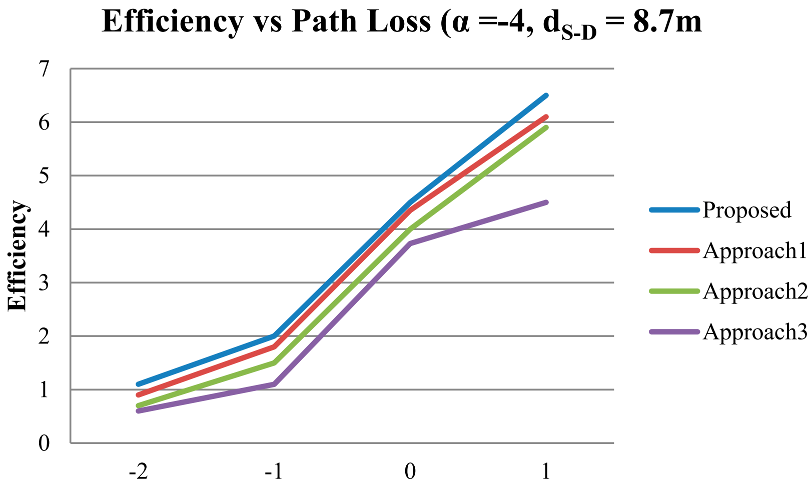

Figure 3. Spectral effectiveness diverges with B_S under path loss $\alpha = -4$ of straight connection ($d_{S-D} = 8.7$ m).

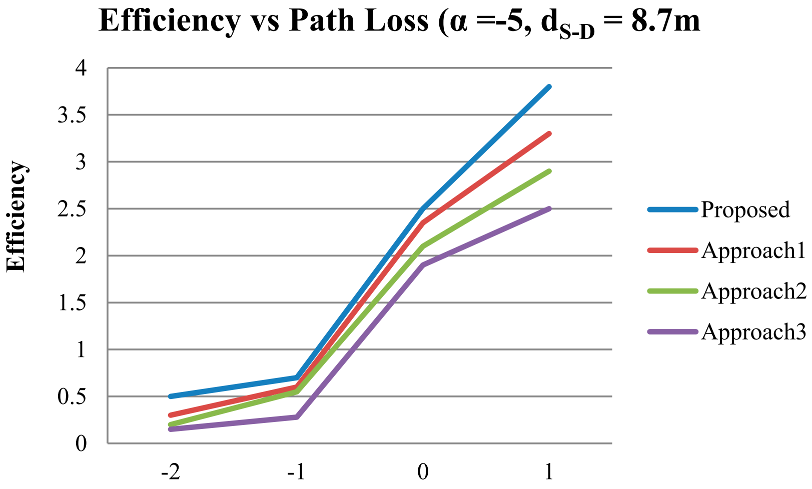

Figure 4. Spectral effectiveness diverges with B_S under path loss $\alpha = -5$ of straight connection ($d_{S-D} = 8.7$ m).

Furthermore, for Figures 3 and 4, use $d_{S-R} = 4\,m$, $d_{R-D} = 4\,m$, and $d_{S-D} = 8.7\,m$ correspondingly. The effectiveness of our suggested approach and [28–30] improves when the channel capacity of the direct connection decreases. The rationale for this is because a smaller point to point route loss might produce in a greater acquired SINR. Furthermore, we can show that our suggested technique outperforms [28–30] in the instances when the latency factor of the point to point link α is equal to -5 and -4. Furthermore, the effectiveness of our proposed approach and [28–30] improves when B_S increases since greater signal strength might result in a greater obtained information at D. System performance with regard to PS is shown in Figures 5 and 6, where $\sigma^{2}_{S-R} = \sigma^{2}_{R-D} = \sigma^{2}_{S-D} = \sigma^{2}_{I-R} = -40$ dbm, correspondingly, for varying levels of noise. In addition, we set $\sigma^{2}_{S-R} = \sigma^{2}_{R-D} = \sigma^{2}_{S-D} = \sigma^{2}_{I-R} = -40$ and -20 dbm. Furthermore, for Figures 5 and 6, set $d_{S-R} = 4\,m$, $d_{R-D} = 4\,m$, and $d_{S-D} = 8.7\,m$ correspondingly. The noise level decreases, the effectiveness of our suggested method and [28–30] improves. The cause for this is because decreased noise level might lead to greater SINR perceived. Furthermore, we can show that our suggested technique outperforms [28–30] in the instances when the noise level is equivalent to -40 and -20. The cause for this is that, in comparison to [28,30] suggested technique incorporates the significant improvement of FD transmission and SIC, as well as the diversity benefit provided by a direct connection, as opposed to [29]. Furthermore, as BS increases, the effectiveness of our proposed methodology and [28–30] improves since more signal strength allows the target node to acquire more bits.

6. Conclusion

FDBPT created a Power dividing based relaying technology with FD Decode and forwarding capability in this research paper, taking into account the existence of a direct connection. Then, to solve the spectrum efficiency optimization model, information decoding strategy based on SIC and MRC algorithms was presented to decipher signals from the destination node.

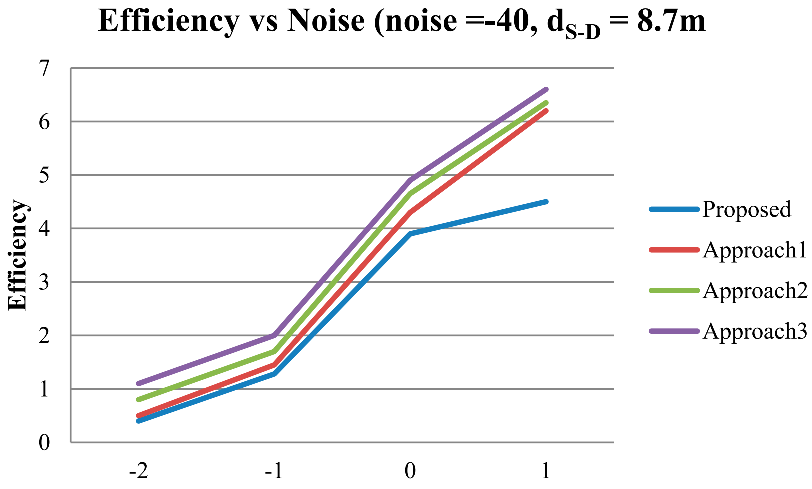

Figure 5. Spectral effectiveness diverges with B_S under power of noise (noise $= -40$, $d_{S-D} = 8.7$ m).

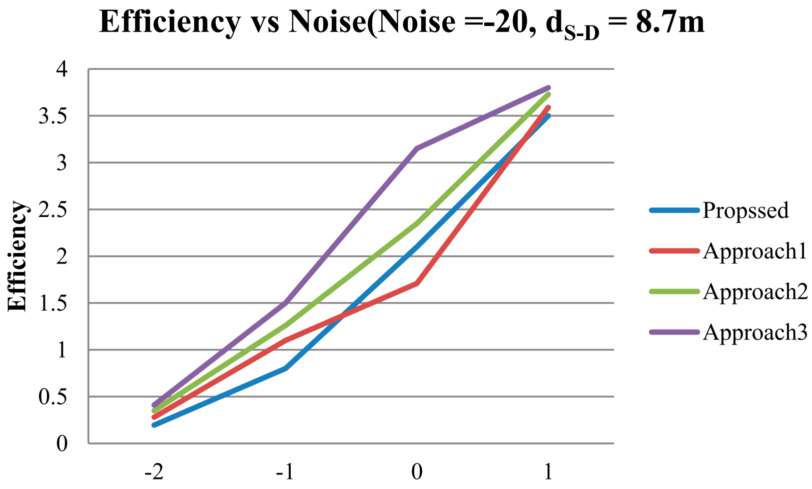

Figure 6. Spectral effectiveness diverges with B_S under power of noise (noise $= -20$, $d_{S-D} = 8.7$ m).

Furthermore, an IPDP technique to solve the given huge performance maximizing issue was provided. The suggested Information decoding scheme considers the advantages of direct connection, FD, and SIC. Finally, a number of computations confirmed the superior effectiveness of the suggested system.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

[1] Jang S, Lee H, Kang S, et al. Energy efficient SWIPT systems in multicell MISO networks. IEEE Trans Wirel Commun 2018;17(12):8180–8194. doi:10.1109/TWC.2018.2874646

[2] Wei Z, Zhao B, Su J, et al. Dynamic edge computation offloading for internet of things with energy harvesting: a learning method. IEEE Internet Things J. 2019;6:4436–4447. doi:10.1109/JIOT.2018.2882783

[3] Li B, Fei Z, Shen J, et al. Dynamic offloading for energy harvesting mobile edge computing: architecture, case studies, and future directions. IEEE Access. 2019;7:79877–79886. doi:10.1109/ACCESS.2019.2922362

[4] Rajesh D, Jaya T. ECIGC-MWSN: Energy capable information gathering in clustered secured CH based routing in MWSN. Mater Today Proc. 2021;43:3457–3462. doi:10.1016/j.matpr.2020.09.100.

[5] Wang F, Zhang X. 'Dynamic computation offloading and resource allocation over mobile edge computing networks with energy harvesting capability'. Proc. IEEE Int. Conf. on Communications, Kansas City, MO, USA, 2018, pp. 1–6.

[6] Rajesh D, Jaya T. A mathematical model for energy efficient secured CH clustering protocol for mobile wireless sensor network. Wireless Pers. Commun. 2020;112:421–438.

[7] Giji Kiruba D, Benita J. A survey of secured cluster head: SCH based routing scheme for IOT based mobile wireless sensor network. ECS Trans. 2022;107(1):16725–6745. doi:10.1149/10701.16725ecst.

[8] Natesan G, Konda S, de Prado RP, et al. A hybrid Mayfly-Aquila optimization algorithm based energy-efficient clustering routing protocol for wireless sensor networks. Sensors. 2022;22(17):6405. doi:10.3390/s22176405

[9] Rajesh D. Energy-resourceful routing by fuzzy based secured CH clustering for smart dust. International Journal of Electrical and Electronics Research (IJEER). 2022;10(3):659–663. doi:10.37391/ijeer.100340

[10] Zhang G, Wu C, Xu Y, et al. 'Robust energy efficiency optimization for SWIPT-enabled heterogeneous NOMA networks'. Proc. IEEE Int. Conf. on Wireless Communications and Signal Processing, Xi'an, People's Republic of China, 2019, pp. 1–5.

[11] Xu Y, Li G, Yang Y, et al. Robust resource allocation and power splitting in SWIPT enabled heterogeneous networks: a robust minimax approach. IEEE Internet Things J. 2019;6(6):10799–10811. doi:10.1109/JIOT.2019.2941897

[12] Rajesh D, Jaya T. A mathematical model for energy efficient secured CH clustering protocol for mobile wireless sensor network. Wirel Pers Commun. 2020;112(1):421–438. doi:10.1007/s11277-020-07036-4

[13] Rajesh D, Jaya T. Energy competent cluster-based secured CH routing EC2SR protocol for mobile wireless sensor network. Concurr Comput: Prac Exper. 2022;34(1):6525. doi:10.1002/cpe.6525

[14] Wang Z, Li Y, Ye Y, et al. Dynamic power splitting for three-step two way multiplicative AF relay networks. Proc. IEEE Vehicular Technology Conf., Toronto, ON, Canada, 2017, pp. 1–5.

[15] Zhao N, Hu F, Li Z, et al. Simultaneous wireless information and power transfer strategies in relaying network with direct link to maximize throughput. IEEE Trans Veh Technol 2018;67, (9):8514–8524. doi:10.1109/TVT.2018.2850747

[16] Zhang Z, Lu Y, Huang Y. Simultaneous wireless information and power transfer for dynamic cooperative spectrum sharing networks. IEEE Access. 2018;7:823–834. doi:10.1109/ACCESS.2018.2885849

[17] Rajesh D, Jaya T. Exploration on cluster related energy proficient routing in mobile wireless sensor network. Int J Innov Technol Expl Eng (IJITEE). 2019;8(4):93–97. doi:10.35940/ijitee.I8475.078919.

[18] Hu Z, Yuan C, Gao F. Maximizing harvested energy for full-duplex SWIPT system with power splitting. IEEE Access. 2017;5:24975–24987. doi:10.1109/ACCESS.2017.2767178

[19] Rajesh D, Kiruba DG. A comparative study on energy efficient secured clustered approaches for IOT Based MWSN. Suran J Sci Technol. 2022;29(4):1–18.

[20] Liu H, Kim KJ, Kwak KS, et al. QoS-constrained relay control for fullduplex relaying with SWIPT. IEEE Trans Wirel Commun 2017;16(5):2936–2949. doi:10.1109/TWC.2017.2672551

[21] Giji Kiruba D, Rajesh D. Analysis on clustered energy organized in mobile wireless sensor networks. Int J Eng Robo Techn. 2018;5:37–42.

[22] Rajesh D, Kiruba GD. Energy efficient secured CH clustered routing (E2SCR) in smart dust network. J Intell Fuzzy Syst. 2022;43(6):8349–8357. doi:10.3233/JIFS-212012

[23] Li S, Haipeng Y, Miao M. Cat swarm optimization algorithm based on the information interaction of subgroup and the top-N learning strategy. J Intell Syst. 2022;31(1):489–500. doi:10.1515/jisys-2022-0018

[24] Sharma N, Gupta V. A framework for wireless sensor network optimization using fuzzy-based fractal clustering to enhance energy efficiency. J Circuits Syst Comput . 2022;31(13):2250223. doi:10.1142/S0218126622502231

[25] Al-Zahrani AY. A game theoretic interference management scheme in full duplex cellular systems under infeasible QoS requirements. Fut Int. 2019;11(7):156. doi:10.3390/fi11070156

[26] Rajesh, D, Kiruba, DG. A probability based energy competent cluster based secured ch selection routing EC2SR protocol for smart dust. Peer-to-Peer Netw. Appl. 2021;14(4):1976–1987. doi:10.1007/s12083-021-01144-z.

[27] Rajesh D, Rajanna GS. Energy aware data harvesting strategy based on optimal node selection for extended network lifecycle in smart dust. J Intell Fuzzy Syst. 2023;44(1):939–949. doi:10.3233/JIFS-221719

[28] Ye Y, Li Y, Zhou F, et al. Power splitting-based SWIPT with dual-hop DF relaying in the presence of a direct link. IEEE Syst J 2018;13(2):1316–1319.

[29] He J, Tang Z, Ding Z, et al. Successive interference cancellation and fractional frequency reuse for LTE uplink communications. IEEE Trans Veh Technol 2018;67(11):10528–10542. doi:10.1109/TVT.2018.2865814

[30] Rajesh D, Rajanna GS. CSCRT protocol with energy efficient secured CH clustering for smart dust network using quantum key distribution. Int J Saf Sec Eng. 2022;12(4):441–448. doi:10.18280/ijsse.120404