Relaying Protocols for Wireless Energy Harvesting and Information Processing

Nada Taher Malik, Ahmad T. Abdulsadda, AbdulKadum Jafar Al Yasiri

***Abstract:** Most of the ongoing exploration in wireless relay node networks and data preparing has considered point-to-point correspondence system. In remote helpful or then again sensor organizes, the hand-off or sensor relay node may have restricted battery holds and may need to depend on some outside charging component so as to stay dynamic in the system. Along these lines, vitality reaping in such systems is especially significant as it can empower data handing-off. In this thesis, we are worried about the issue of remote vitality collecting and data preparing in an intensify and-forward (AF) remote agreeable or sensor arrange. We consider the situation that a vitality obliged hand-off relay node harvests vitality from the RF sign communicated by a source node and utilizations that reaped vitality to advance the source signal to a destination node. We consider time switching (TS) and power switch (PS) scheme structures. we propose two transferring conventions:*

i) TS-based handing-off (TSR) convention and;

ii) PS-based handing-off (PSR) convention for discrete data handling and vitality reaping at the vitality compelled wireless relay node. The primary commitments of this thesis are abridged as pursues:

- ***We propose the TSR and the PSR conventions to empower remote vitality reaping and data handling at the vitality obliged transfer in remote AF transferring systems, in light of the TS and PS collector structures.***
- ***For the TSR and the PSR conventions, we determine logical articulations for the reachable throughput at the goal.***
- ***Comparing the TSR and the PSR conventions, our numerical investigation demonstrates that in postponement restricted transmission mode, the throughput execution of the TSR convention is better than the PSR convention at higher transmission rates, at generally lower signal-to-commotion proportion (SNR), and for lower vitality gathering productivity.***
- ***We propose the combination ATPSR system and demonstrate the optimal throughput for that system.***
- ***Finally, design and built the hardware circuit and using particle swarm optimization techniques to find the optimal value for the parameters.***

***Keywords:** wireless relay nodes, PSR, TSR, optimization techniques, energy harvesting.*

I. INTRODUCTION

We present the Literature Survey for the subjects:

• Shixin Luo, Rui Zhang, (2013),[1], has been studied wireless system under practical conditions for energy harvesting. They did a new assumption model with non-ideal save effectiveness, therefore (Save- then- transmission) protocol was proposed in order to improve performance of ideal save ratio, and performance comparison for outage probability between fixed energy and random Rayleigh power has been investigated. Moreover, wireless network protocol in multi transmission devices (TDMA-ST) was proposed. Two types of data were tested: independent data and shared data. As a result, this research work shows that each sender should be worked at minimum (lowest) of outage ratio, the sender should be italicized ideal operation point when the number of Transmitters exceeds the threshold as shown in Fig.1.

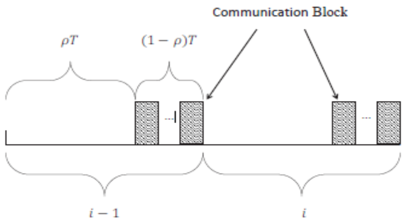

Figure 1: The [Save- then- transmit] protocol schematic diagram.

Where T is the period of the transmitted RF signal (length of communication block of the data) , i is the indexing factor to divide the RF signal to small block. ρ is the optimal time factoring that should be obtained by using optimization techniques. Their simulation results demonstrated the model that was proposed is unique and does not consider how we could deal particularly with the energy harvesting.

• Dinh-Thuan.Do (2015),[2],they submitted a new protocol for the mobile node in order to wireless energy obtain and information transfer in the energy harvesting cooperative networks, where harvesting energy used for source information amplification and transmission to the destination. Their conclusion were done on the optimal value for protocol [TPSR] based upon time switching and power splitting in order to energy harvesting.

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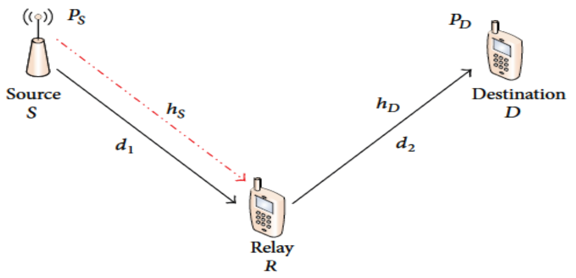

Figure 2: The (TPSR) protocol at the relay mobile node.

Where h_s and h_d are the source relay transmission channel propagation gain factor and relay destination channel propagation gain, respectively.

• S.T. Shah, K.W. Choi, S.F. (2016),[3], proposed to establish a two-way relay node to collect EH and information processing, where the nodes would communicate with each other through multiplicative relay node and energy restricted, in terms of throughput, the performance of the proposed relay is superior to traditional (AF) relay, and second with a different transmission rates, the relay achieves much higher throughput than the AF relay.

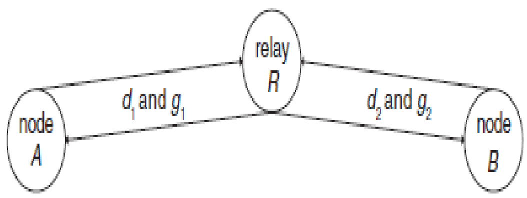

Figure 3: The protocol model two-way for information processing and EH.

Where d1is the distance from source node A to relay node R whereas g1 is the gain of the channel from node A to relay node R. d_2 is the distance from relay node R to the node B whereas g2 is the gain of the channel from node R to the node B. Their results were demonstrated the above model by using trial and error method to figure out the optimal energy harvesting time factor.

• Sy Nguyenl, Roa Bui (2016),[4], they are considered the effect of the performance analytical to three and four transmitter systems at time interval (3TS,4TS) (shown in Fig.4), trans the information and the wireless energy to channels relay in two direction through compare of the throughput performance to (3TS,4TS), in which derived proximate expressions of outage and throughput. Through the numerical results we can be seen obviously the throughput performances are lower when the distance between both the sources is far.

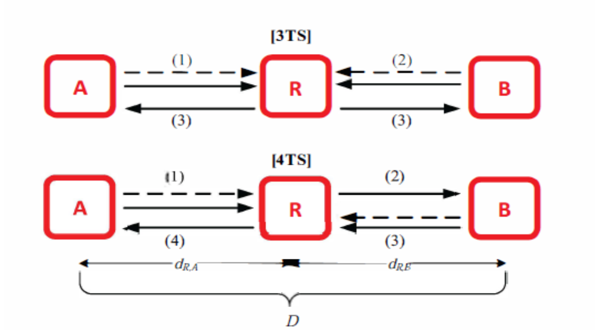

Figure 4: The system model for (3TS, 4TS) transmission scheme.

Where A, B are the source destination nodes, respectively. D is the total distance from node A to node B which is equal to $dR_{,A}+dR_{,B}$.

II. PROBLEM FORMULATION

Delaying the lifetime of a remote system through vitality reaping has gotten huge consideration in all respects as of late [5],[6],[7],[8],[9]. However, supplanting or reviving batteries can stay away from vitality collecting, it brings about a surprising expense and can be badly arranged or dangerous (e.g., in an environments conditions), or profoundly unfortunate (e.g., for sensors implanted in a structures or inside the human body, or in battlefield) [6]. In such situations, a safe and helpful choice might be to gather the vitality from nature. Aside from the ordinary vitality gathering techniques, for example, sunlight based, wind, vibration, thermoelectric impacts or other physical marvels [5],[6],[4], another developing arrangement is to benefit encompassing radio frequency signal (RF) signals [8].

The favorable position of this arrangement lies in the way that RF sign can convey vitality and data at the equivalent time. Subsequently, vitality relay node can search vitality and procedure the data at the same time [8],[9],[10].The first stage of model of the problem of wireless energy harvesting and information processing in amplifying and forward (AF) the information signal into wireless sensor network which is proposed by in this paper is shown in Fig.5 which has the simplest wireless sensor network which will consider in this paper.

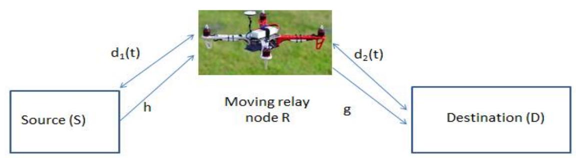

Figure 5 : Schematic diagram of the moving relay node system.

Then we have proposed the solution of some problem of the dynamics moving of the relay by proposed the modified time switching and power splitting merging one system with two protocols.

III. ADAPTIVE TIME - POWER SWITCHING BASED RELAY(ATPSR)

The proposed protocol's working principle depends on the switching of energy, where (P) represents the total energy of the transmitted signal. The(ATPSR) protocol divides the signal energy received in the sequence to ω, (1-ω), where (ωp) is part of the signal energy received in the relay node for harvesting the power is used to charge the relay while the remaining part((1-ω) p) is used for sending the source information to the relay node as shown in fig.6.

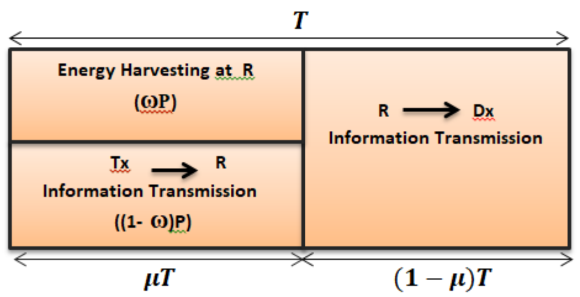

Figure 6: Illustration diagram for (ATPSR)protocol at relay mobile node.

Where µT,is represented the switching time for harvesting energy and transfer information from the source in the same time at relay mobile node , while the other part ((1-µ)T), which is using to transfers the information from the relay to the destination. We have studied the effect of the energy harvested for this protocol (ATPSR) in the relay node on the performance of throughput and the outage probability as in fig.7.

Through of derive the outage probability we concluded that the optimum value of the throughput depends on the time switching and power splitting factor.

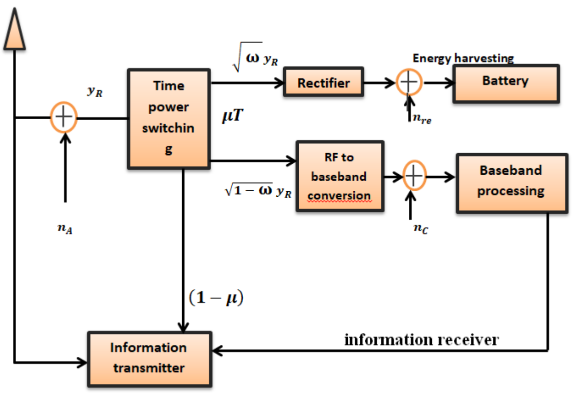

Figure 7: Receiver architecture of the (ATPSR) protocol in the relay mobile node

where the signal received as defined by:

$$y_r(k) = \frac{1}{\sqrt{d_1^{m1}}} \sqrt{(1-\omega)P_s}\, g_1 x_s(k) + \sqrt{(1-\omega)} n_r \quad ....(1)$$

And by doing the same manipulation equation we can be found the expression for the outage probability as:

$$P_{out}^{TPSR} = 1 - exp\left(-\frac{e}{j\lambda_{g_1}}\right) \sqrt{\frac{4*f}{j\lambda_{g_1}\lambda_{g_2}}} K_1 \left(\sqrt{\frac{4*f}{j\lambda_{g_1}\lambda_{g_2}}}\right) \quad ....(2)$$

The optimal value for the throughput based upon the outage probability is given as:

$$\tau_{TPSR} = (1 - P_{out}^{TPSR}) R \frac{(1-\mu)T}{T} = (1 - P_{out}^{TPSR}) R (1-\mu) \quad ....(3)$$

IV. EXPERIMENTAL HARDWARE SETUP AND RESULTS

We tried to be illustrated the setup configuration for the hard ware implementation circuit. Fig.8 shows the main diagram for the receiving circuit diagram in the wireless relay node.

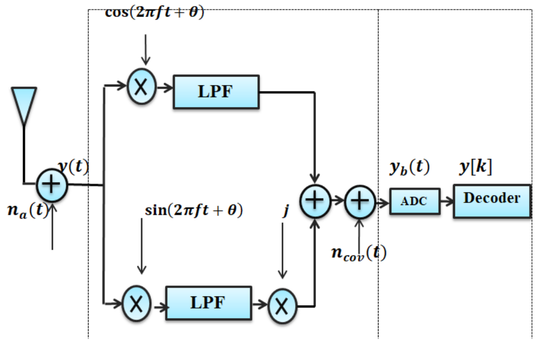

Figure 8: Practical Circle setup in relay node.

Generally, we would like to build up the circuit, so that first we have built the simulation Protos circuit diagram with the micro controller PIC cheap.

This circuit has three main parts:

- The joystick that is represented RF signal which is sending to the relay node. This signal has two main parts: information and signal for charging the battery of the relay.
- The relay node with microcontroller has a PIC that programmed using micro c language code to find the optimal value for the throughput.
- Two LEDs and shows screen, when the first one is turned on that means the information with amplifying through the AF, otherwise when the second one turn on that means the battery starts charging. The screen shows the value of the period of time for the amplifying and charging.

  The main circuit is shown in Fig.9, where the microcontroller pic would be calculating the parameters: µ,ω, throughput τ.

Figure 9: The hardware circuit.

V. PARTICLE SWARM OPTIMIZATION TECHNIQUES

PSO recreates the practices of fledgling rushing. Assume the accompanying situation: a gathering of fowls is arbitrarily looking through nourishment in a zone. There is just one bit of nourishment in the territory being looked. Every one of the feathered creature's doesn't have the foggiest idea where the nourishment is. Yet, they know how far the nourishment is in every emphasis. So what's the best system to discover the sustenance? The viable one is to pursue the fledgling which is closest to the antenna. PSO gained from the situation and utilized it to take care of the enhancement issues. In PSO, every single arrangement is a "winged animal" in the pursuit space. We call it "molecule". All of particles have wellness esteems which are assessed by the wellness capacity to be enhanced, and have speeds which direct the flying of the particles. The particles fly through the issue space by following the present ideal particles. PSO is instated with a gathering of arbitrary particles (arrangements) and afterward scans for optima by refreshing ages. In each emphasis, every molecule is refreshed by following two "best" values. The first is the best arrangement (wellness) it has accomplished up until now. (The wellness worth is additionally put away.) This worth is called p best. Another "best" esteem that is followed by the molecule swarm streamlining agent is the best worth, got so far by any molecule in the populace. This best worth is a worldwide best and called g best. At the point when a molecule removes a portion of the populace as its topological neighbors, the best worth is a nearby best and is called l best. We used the PSO to find the optimal value of the parameters: τ, μ, ω, and distance. The main steps are as following:

Input: V_{max}, ω, ζ, η, c_1, c_2, S and D.

1: t=0.

2: Randomly generate a feasible $X_i(t)$, where

$V_{id}(t) \in [-V_{max}, V_{max}]$ $(1 \leq d \leq M)$.

3: Comput the fitness value of partical i, $EE(xi(t)$ and set the best solution by particle i until the t-th iteration as $\hat{X}i(t)$.

4: Select the particle b with the largest fitness value and set the best solution by the swarm until the t-th iteration as $\hat{X}b(t)$.

5: **repeat**

6: $t = t + i$.

7: Calculate each vid(t) as

vid(t)=ω vid(t-1)+c1ζ (xid(t-1) - xid(t-1))+c2η(xbd(t-1) - xid(t-1)).

8: $V_{id}(t)$=min{V_{max}, max {$V_{id}(t)$, $-V_{max}$}}

9: xid(t)=min {$\widehat{P_d}$, max{0,Xid(t-1)+vid(t)}}

10: Xi,M+1(t)=min{1, $\min_{1 \leq d \leq M} \frac{\zeta_d h_d P_{max} + e_d}{\zeta_d h_d P_{max} + \eta_d P_{d+} P_d^c}$}

11: **for all** particle i **do**

12: **if** Xi(t) is a feasible solution **then**

13: **if** $EE(x_i(t)) > EE(\hat{x}_i(t))$ **then**

14: Update $\hat{x}_i(t) = x_i(t)$.

15: **end if**

16: **if** $EE(x_i(t)) > EE(\hat{x}_b(t))$

17: Update $\hat{x}_b(t) = x_i$(t).

18: **end if**

VI. RESULT AND DISCUSSION

The main results for PSO listed in table I. where the analytical results listed in Tabl1 II and table III.

Table I: PSO Results

No.	Parameters	protocol	scheme	Swarm size	Optimal value	throughput
1	M	TSR	Delay limited	20	0.3	1.2
2	M	TSR	Delay tolerant	20	0.288	0.65
3	Ω	PSR	Delay limited	20	0.53	0.7
4	Ω	PSR	Delay tolerant	20	0.58	1.4
5	Ω	ATPSR	Delay tolerant	20	0.68	1.23

Table II: ATPSR protocol analytical solutions. Where μ =0.

ω	e	f	j	v	$k_1(v)$	P_{out}	τ
0.01	0.0002	0.088	0.004	9.3	0.00003	0.999	0.002
0.1	0.0026	0.08	0.037	2.9	0.04	0.89	0.3
0.2	0.005	0.07	0.06	2	0.13	0.76	0.67
0.3	0.008	0.06	0.08	1.7	0.2	0.69	0.86
0.4	0.01	0.05	0.1008	1.4	0.3	0.6	1.12
0.5	0.013	0.04	0.105	1.2	0.4	0.57	1.2
0.6	0.016	0.03	0.1008	1.09	0.5	0.5	1.4
0.7	0.018	0.026	0.08	1.14	0.47	0.57	1.2
0.8	0.02	0.017	0.06	1.06	0.5	0.6	1.12
0.9	0.024	0.008	0.037	0.9	0.7	0.67	0.9
0.95	0.025	0.004	0.01	1.2	0.4	0.96	0.1

Table III: ATPSR protocol analytical solutions. Where μ =0.7

ω	e	f	j	v	$k_1(v)$	P_{out}	τ
0.01	0.0006	0.037	0.009	4	0.01	0.96	0.04
0.1	0.006	0.034	0.088	1.2	0.4	0.55	0.54
0.2	0.013	0.03	0.15	0.89	0.7	0.42	0.69
0.3	0.018	0.026	0.2	0.7	1	0.36	0.76
0.4	0.02	0.022	0.2	0.66	1.14	0.31	0.8
0.5	0.03	0.019	0.24	0.56	1.4	0.3	0.84
0.6	0.037	0.015	0.23	0.5	1.65	0.29	0.85
0.7	0.04	0.011	0.2	0.46	1.84	0.3	0.84
0.8	0.049	0.007	0.15	0.4	2.1	0.39	0.7
0.9	0.056	0.003	0.08	0.38	2.3	0.56	0.5
0.95	0.059	0.0019	0.04	0.4	2.1	0.8	0.2

As apperception, Fig. 10 and Fig. 11 demonstrate that reenactment aftereffects of feasible throughput impeccably coordinate the diagnostic results for the ideal qualities scope of 0 < μ < 1 what's more, 0 < ω < 1 for the TPSR convention. In this delineation, comparable commotion changes at the transfer and goal versatile hubs are accepted; that is, $\sigma 2D=\sigma 2R= \sigma 2$ = 0.01. As can be seen from Fig..10, the throughput increments from 0 to 1.25 when μ increments from 0.01 to 0.35 yet later it begins diminishing as μ increments from its ideal worth (for ω = 0.7) also,

the throughput increments from 0 to 0.95 as μ increments from 0.01 to 0.45 yet then declines as μ increments from its ideal worth (for ω = 0.3). In Figure 5, the throughput increments from 0 to 1.25 as ω increments from 0.01 to 0.7 however later it begins diminishing as ω increments (for μ = 0.3), and the throughput increments from 0 to 0.84 as ω increments from 0.01 to 0.6 however then declines as ω increments from its ideal esteem (for μ = 0.7). Curiously, for the situation when estimation of μ expands, we get ideal throughput just if ω diminishes furthermore, the other way around. We can clarify significant outcomes that the estimation of μ is littler than the ideal estimation of μ which implies that there is less time for vitality collecting and that's only the tip of the iceberg time for data transmission. Therefore, less vitality is reaped and throughput accomplished at the goal versatile hub is more prominent. In contrast, when the estimation of μ is more prominent than the ideal μ, there is more opportunity for vitality reaping however less time for data transmission.

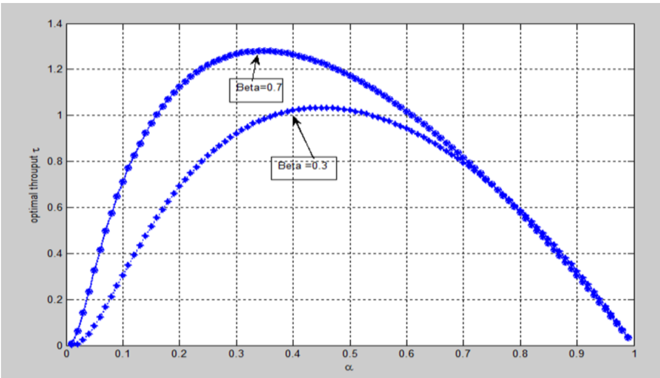

Figure 10: Simulation based and analytical throughput τ at the destination with respect to the fraction of the block time switching.

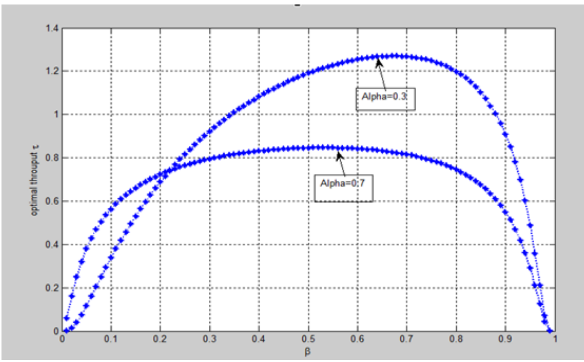

Figure 11: Simulation based and analytical throughput τ at the destination with respect to the fraction of power splitting.

Moreover, when the estimation of ω is littler than the ideal ω, there is less power accessible for vitality reaping and more power for preparing the got sign. Accordingly, high sign quality is seen at the hand-off portable hub and results in higher throughput at the goal portable hub. What's more, in case the estimation of ω is more noteworthy than the ideal ω, more power is squandered on vitality reaping and less power for data transmission from the source to transfer versatile hub.

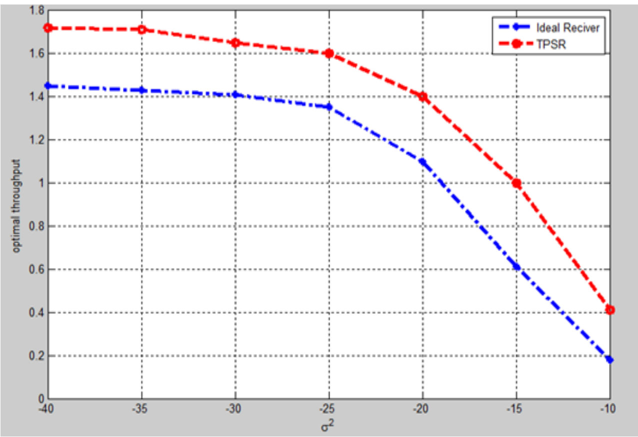

Figure 12: The optimal throughput achieved for the TPSR protocol and the ideal receiver by the different value of noise.

VII. CONCLUSION

In this paper, an enhance and-forward remote agreeable or sensor system has been considered, where a vitality compelled transfer hub harvests vitality from the got RF sign and uses that reaped vitality to advance the source sign to the goal hub. Two transferring conventions, to be specific,

- TSR convention what's more,
- PSR convention, are proposed to empower remote vitality reaping and data handling at the hand-off, in light of the as of late created and broadly embraced TS and PS, recipient models.

Both the delay limited and the delay tolerant transmission modes are considered for correspondence. All together to decide the attainable throughput at the goal, expository articulations for the blackout likelihood also, the ergodic limit are determined for the delay limited and the delay tolerant transmission modes, individually. The ideal estimation of vitality gathering time in the TSR convention and the ideal estimation of power part proportion in the PSR convention are numerically examined. The numerical investigation in this thesis has given useful bits of knowledge into the impact of different framework parameters on the exhibition of remote vitality reaping and data preparing to utilize AF transfer relay node. The key bits of knowledge is summarized in the following table:

Table IV: Comparison between the TSR and PSR delay limited and delay tolerant transmission mode.

System parameters	Throughput(τ) of TSR vs PSR
Noise variance(σ_{na}^2 or σ_{nc}^2)	At low noise variance,PSR outperforms TSR and vice versa at high noise variance.
Source to relay distance(d_1)	For small values of d_1 ,PSR outperforms TSR and performance is similar for large d_1.
Transmissiom rate(R)	For small values of R,PSR outperforms TSR and and vice versa at large value of R.
Energy harvesting efficiency (η)	For small values of η ,TSR outperforms PSR and and vice versa at large value of η.

The numerical examination in this paper is supported by the determined expository articulations for the throughput for both TSR and PSR conventions, which are condensed in Table.4,

The throughput results inferred in thesis speak to the upper bound on the for all intents and purposes feasible throughput. In this work, we accept that the CSI is accessible at the goal relay node as it were. On the off chance that the CSI is accessible at the hand-off, the proposed conventions can be made versatile by adjusting the vitality gathering time or power part proportion as indicated by the channel conditions. Also, in this thesis proposes TPSR convention and the structure of the beneficiary engineering for remote vitality reaping and data transmission in the EHCN. Furthermore, the blackout execution of the AF transferring plan where the relay mobile hub harvests vitality from source hub through the got RF sign and after that utilizations reaped vitality to enhance the data and forward the source sign to the goal versatile relay node has been inferred. For effortlessness in calculation, we likewise build up the shut structure articulation of the reachable throughput at the goal. All the more critically, the ideal estimations of time exchanging and power part proportion for vitality gathering in the proposed TPSR convention which is picked so as to boost the throughput of the framework were likewise numerically examined.

SUGGESTION FOR FUTURE WORKS

In this paper we suggest the following direction to be as future works: Build in new hardware drone system that depends on energy RF harvesting system to recharge the battery. Using optimal global algorithms to find the optimal throughput value such as PSO algorithm. Change the assumption by making the destination and the node relay are moving in different direction, that we need to calculate the distance as dynamic parameter.

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