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Optimized Energy Utilization in Cognitive Radio Networks with Congestion Control

Mettu.Jhansi Lakshmi[1], Mahesh Babu Arrama[2]

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Abstract: Various real-time applications can be handled through wireless sensor networks, which consist of a wide range of sensor nodes. A novel congestion control mechanism is proposed on optimized rates for energy-efficient transmissions. To reduce energy consumption across the network, a rate-based congestion control algorithm based on cluster routing is presented. By reducing the end-to-end delay, rate control improves the network life time over a large simulation period. Clustering is initially performed using novel routing algorithms. After that, rate control is implemented using an energy optimization strategy suitable for high packet delivery ratios. Finally, packets are sent with maximum throughput using region Optimization-driven routing. The simulation is performed on the NS2 simulation platform. Finally, performances are evaluated with respect to average delay in end to end nodes, delivery ratio of packets, throughput, energy efficiency, energy consumption and reliability. Novel routing with an energy optimal algorithm (NREOA) reduces energy consumption as the network progresses and a variation of 20% compared with existing protocols.

***Keywords**:CRN, Congestion, Energy optimization, NS2, Novel algorithms.*

Introduction

In this section, it is mainly focusing on the background of wireless sensor network technologies and the general view of IoT, the structure of IoT and some important features that related to the wireless communication applications in IoT. With recent advances in micro electro-mechanical system (MEMS) technology and processor design, the production of small, low-cost sensors has become technically and economically feasible [1]. Each sensor node has detection, processing and communication capabilities. The sensor node implemented in a field of interest can detect specific environmental phenomena such as temperature, humidity, acoustics, vibration, pressure, light intensity, magnetic field, etc [2]. WSNs can consists of various kinds of sensors, for example, seismic, attractive, warm, visual, infrared, and acoustic, fit for observing a wide assortment of ecological conditions. Be that as it may, the sensor hubs must have the option to withstand antagonistic natural conditions. Because of they are little size, the hubs have restricted battery power, handling speed, stockpiling limit and transfer speed. Because of the restricted battery charge, the life of a sensor hub relies upon its capacity to spare vitality. Accordingly, countless sensor hubs are conveyed [3]. These nodes use wireless communication to perform their tasks by reporting the event itself or directly to the base station (BS). The base station acts as a gateway between the sensors node and the end user. The Wireless Sensor Network (WSN) is defined as a collection of individual sensor nodes that are scattered in a physical space, organized in a cooperative network, able to interact with its environment by proactively detecting and controlling environmental and physical parameters [4]. Proactive calculation helps the network sensor to access data from an inaccessible location; [5- 7]. Wireless communication technology has made WSN conceivable in a wide scope of continuous ecological checking applications. The system engineering should be changed to meet the particular needs of the sensor nodes. There are many technical difficulties that must be overcome before WSN can be practically used [8]. The nodes must meet the requirements deriving from the specific application; therefore, they must be smaller, inexpensive and energy efficient must be equipped with the appropriate sensors, the necessary calculation and memory resources and must communicate correctly.

Research Scholar, Department of CSE, Koneru Lakshmaiah Education Foundation, Hyderabad, E-Mail ID- mjhansi2023@gmail.com
, Professor, Department of CSE, Koneru Lakshmaiah Education Foundation,
Hyderabad, E-Mail ID- mahiabhi@gmail.com

Internet In this section a literature survey pertaining to the current work has been presented. The general working principle and approaches for improving efficiency of the protocols have been studied here. It explains various congestion control protocols based on different mechanisms used for detecting, and controlling congestion. Next, the motivation of using energy efficient protocols in WSN is explained and congestion control protocols to mitigate congestion are concisely presented. [9] The initial effort for controlling the network traffic in WSNs is Adaptive Rate Control (ARC) (Woo & Culler). It does not have any explicit congestion detection or notification mechanisms instead it uses additive increase and multiplicative decrease (AIMD) scheme to mitigate congestion. Using AIMD, intermediate nodes increase its sending rate by a constant value 6, if its parent node sends packets successfully. Otherwise, intermediate node multiplies its sending rate by a value þ, where 0 < þ < 1. It reduces the sending the rate of the node [10]. ARC also handles both source and transit traffic to provide guaranteed fairness. One of the first algorithms in the literature to directly address congestion in the WSN is the congestion detection and avoidance algorithm (CODA) (Wan et al.) [11]. It attempts to manage persistent and transient congestion by implementing three mechanisms distributed across the network and the MAC level: congestion detection, open-circuit hop-to-hop mechanism and closed-circuit end-to-end multi-source regulation [12]. CODA detects congestion by monitoring buffer occupancy and load conditions of the current and past channel on each low-cost receiver. Listening to the channel has a high cost. Therefore, CODA uses a sampling scheme to detect congestion. For transient congestion control, the congested node will notify its upstream neighbor to slow down through backpressure messages or released packets [13]. So, the ascending node reduces its exit speed using AIMD. The further propagation of the back pressure message in the upstream direction is based on your local network condition. This technique is called open circuit hop-to hop back pressure [15]. But the back pressure message can increase congestion due to the high load of the channel. The regulation of multiple end-to-end CCTV sources is used for persistent congestion control, but the response time increases in case of heavy congestion since ACK emitted from the sink will probably be lost [16]. More ACK also causes extra energy consumption. CODA does not provide differentiated services to multiple traffic classes. It also does not take into account the fairness of the event and the reliability of the package. Furthermore, varying the inter-arrival time and allocate different levels of priority for nodes can really minimize energy consumption [17], where a priority scheme was developed by an arrival priority queue. A dynamic adjustment of data transmission delay was also studied to improve energy consumption and to prolong the network lifetime [18]. Optimizing energy by a modulation method based on computing the consumed energy was developed in [19]. This scheme was specified by the IEEE-802.15.4 to improve the network lifetime. Also, authors in [20] were modified the sleep time to reduce energy consumption, in which they presented a cross-layer solution based on the combined use of duty-cycling MAC protocol. In [21] a hybrid CSMA/CA-TDMA scheme to evaluate the congestion and the collision problem in the network was proposed.Many techniques and studies have been implemented so far to encounter the congestion problems such as generation rescheduling [22], transmission line switching reactive power management load curtailment etc. Generation rescheduling is the conventional and most common approach used by system operator; whereas the load curtailment is seeking as final approach considered by the operator to manage the congestion.

2. Energy optimization in CRN

In wireless communications, energy consumption is one of the most important aspects, since networks and nodes exchange transmission and reception parameters, resulting in changes in consumption. There is a specific relationship between this and the profiles of supply and demand in the electric supply chain. The radio-electric spectrum undergoes changes in proportion to the number of channels and users. This article analyzes energy-efficient cognitive radio techniques as well as non-conventional energy-based wireless networks.

Wireless access networks with the highest eco-friendliness can take advantage of Cognitive Radio (CR)'s wide paradigm. According to Haykin [23], cognitive radio transmitters adapt their internal states based on the statistical variations of radio frequency stimuli by adjusting their transmission parameters (such as frequency band, modulation mode and transmission power) in real time and online. A smart CR system is able to improve spectrum agility and energy efficiency with its cognitive capabilities to detect the available spectrum and its reconfigurability to dynamically access the spectrum over which experiments are conducted with less fading and interference events [24]. A variety of wireless systems can be improved with CR, but the existing literature focuses mainly on improving spectrum efficiency rather than energy usage [25] and even less on unreliable dynamic energy. Thus, Zhao and Sadler [26] presented a general definition of Dynamic Spectrum Access (DSA) that differentiates wireless CR systems from licensed wireless systems. First indications suggest that rural and urban electric service quality and continuity are closely related to quality in data services.Based on three models are commonly used in dynamic access networks. It has become increasingly important to use cognitive radio technology to enable dynamic spectrum access. When a WSN is based on CR, the primary system owns the spectrum, whereas unlicensed users are able to share it dynamically. There are several cognitive functionalities that contribute to this capacity [27].

2.1 Significance of work

During a critical event, densely deployed sensors generate data packets that create source congestion.

Localized synchronization, resource control and back-pressure messages from congestion points to sources are effective in this case. Hotspots near sinks result in packets being lost if they are in a congested area near the sink. Using a combination of packet dropping techniques and localized backpressure will be helpful when deploying multiple sinks uniformly scattered across the sensor field. Forwarder congestion is the hotspot created in the area around the intersection of data flows. In forwarder congestion, resource control techniques and quick resolution of localized. When input load exceeds available capacity ending in node buffer overflow, the rate of packet service is less than the rate of packet arrival and ends in packet loss and power waste increase in WSNs which directly affects network lifetime. In a fixed threshold is used as congestion identification, however, the remaining buffer size from the overall buffer is used in Congestion is detected using the buffer length and the difference of output and input times the difference between the remaining buffer and the traffic rate the number of non-empty queues and the buffer length and node capacity. In order to further increase the applicability in real world applications, minimizing power consumption is one of the most critical issues. Therefore, an accurate power model is required for the evaluation of wireless sensor networks. It is necessary to measure the energy characteristics of sensor nodes in order to estimate their lifetimes. Since such a technology can be applied to a wide range of applications, research in this area has been on the rise in recent years. Based on the proposed model, the estimated lifetime of a battery-powered sensor node can be increased significantly.

2.2 Existing techniques

AODV uses a destination sequence number (DestSeqNum) to determine an up-to-date path to the destination. A node updates its path information only if the DestSeqNum of the current packet received is greater than or equal to the last DestSeqNum stored at the node with smaller hop count. The Energy Efficient AODV (EE-AODV) in Mobile Ad-hoc network has increased the energy level of the nodes. COPE (Cooperative Power and Energy-efficient routing): Cooperative routing in wireless networks has gained much interest due to its ability to exploit the broadcast nature of the wireless medium in designing power efficient routing algorithms. Most of the existing cooperation based routing algorithms are implemented by finding a shortest path route first and then improving the route using cooperative communication. As such, these routing algorithms do not fully exploit the merits of cooperative communications, since the optimal cooperative route might not be similar to the shortest path route. CHRM- To manage sink mobility, rendezvous points (RPs) are introduced where some SNs are chosen as RPs, and the non-RP nodes convey the information to the cluster heads (CHs). The CHs then forward their information to the nearby RPs. To determine the set of RPs and travelling path of mobile sinks (MSs) that visits these RPs is quite challenging. an energy-efficient SOSS based routing method that depends on RPs and multiple MSs in HWSNs.

3. Proposed algorithm for energy consumption

The energy efficiency problem is characterized in an assisted living context where heterogeneous IoT devices (wearable, ambient, and vision) are scattered throughout a home. These IoT devices have varying capabilities (power source, battery lifetime, connectivity, reliability and accuracy) and are used as part of an elderly fall detection system (SAFER). In general, they can be used for any critical event detection task. Through the elderly fall detection system, we recognized and identified problems and opportunities for improved operations. Battery-powered devices such as mobile, CRN and wearable sensors dissipate power quickly and need to be recharged. The region is designed in the NS2 network simulator. Furthermore, one can designate areas in the floor plan that are used in patterns; i.e. not all wall-powered IoT devices are utilized all the time. In addition, context-aware activities of daily living (ADLs) knowledge of a resident can provide us with information about the location and activity type; this can be utilized intelligently to minimize energy dissipation in the integrated system. Knowledge of device capabilities can also be used to activate an adequate subset of IoT devices to meet accuracy demand levels. Given the above observations, our goal is to minimize the energy consumption of the integrated IoT deployment (battery and wall-powered) to enable long-term operation while meeting accuracy threshold demands. We formalize the energy efficiency problem for heterogeneous IoT devices as a constrained optimization problem (proven to be NP-hard). Note that this optimization problem can be applied to any heterogeneous IoT deployment setting (independent of layout and instrumentation) and can be configured to preserve the desired accuracy thresholds.The mobile network based on wireless power transfer is another approach that can balance out the power within the cognitive radio network. The mobile vehicles / robots that carry high volume batteries, can serve as back storage of mobile energy and periodically deliver energy to cognitive devices with insufficient power supply. The power balance can depend on the network architecture to transmit energy, especially when the energy source and the cognitive devices are very distant from each other. The ratio of useful energy conveyed by the network to the total energy provided to the network.

$$Energy\_efficiency = \frac{Useful\ energy\ transferred\ by\ the\ network}{Total\ energy\ supplied\ to\ the\ device}.$$

Region based communication with coordination network for energy control proposed in the present work, NS2 simulator used with novel energy optimal consumption algorithm.

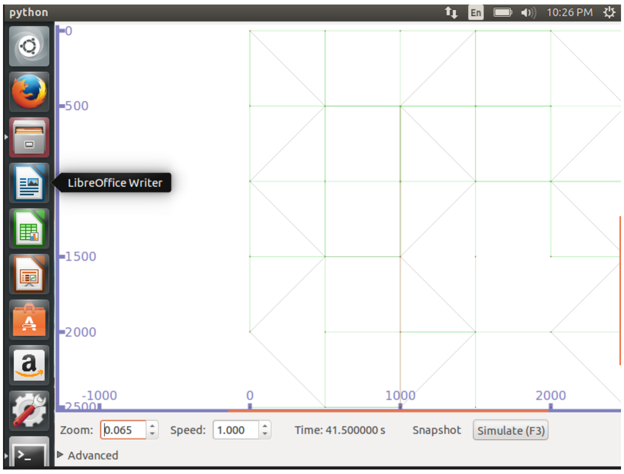

Fig 2: Region based communication for energy optimization

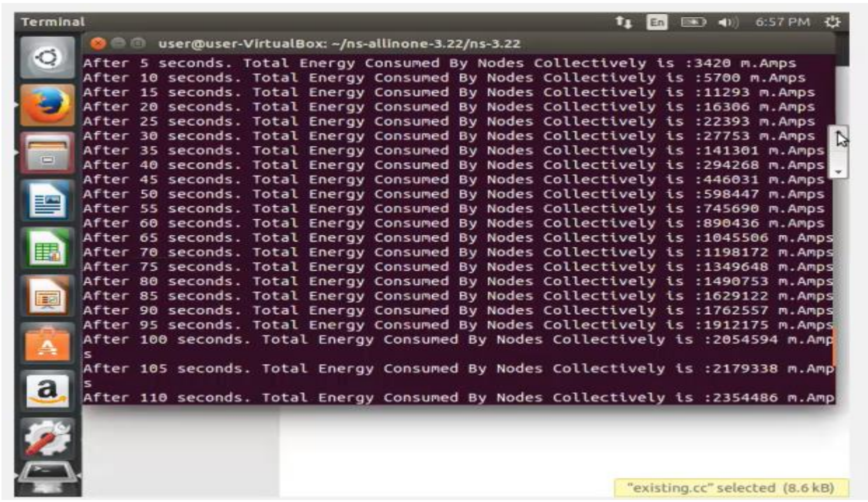

Fig 3: Existing system energy consumption

Proposed algorithm

1. Initialization
2. Select the dynamic node area
3. Energy value update
4. Coordinator update
5. "a non-coordinator node regularly refers to this as schedule to see if it should become a coordinator
6. check-announce-coordinator()
7. C = connect-pairs( )
8. ifC > 0 {
9. calculate hang on using formula (2), using C as Ci
10. wait delay
11. if connect-pairs( ) > 0 {
12. announce itself as a coordinator
13. }}
14. // profits variety of next neighbor sets a node can link if it becomes a coordinator
15. connect-pairs( )

```
n = 0
for each next door neighbor a in next door neighbor desk {
for each next door neighbor b,b > a, in next door neighbor desk {
if share-other-coordinators(a, b) == incorrect {
n ←n + 1
}}}return n
// profits real if others who live nearby a and b are linked by one or two other coordinators
share-other-coordinators(a, b)
// Cluster details are kept in the next door neighbor table
for each Cluster c_a in a's Cluster record {
if c_a is equal to self {
continue }
else if c_a in b's Cluster record {
return true }
// try to see if we know a direction from a to b via two coordinators
else if c_a in next door neighbor desk {
est_Con( ){
inter_node Con( )
eval_eng ( )
opt_energy( )
}}}}
```

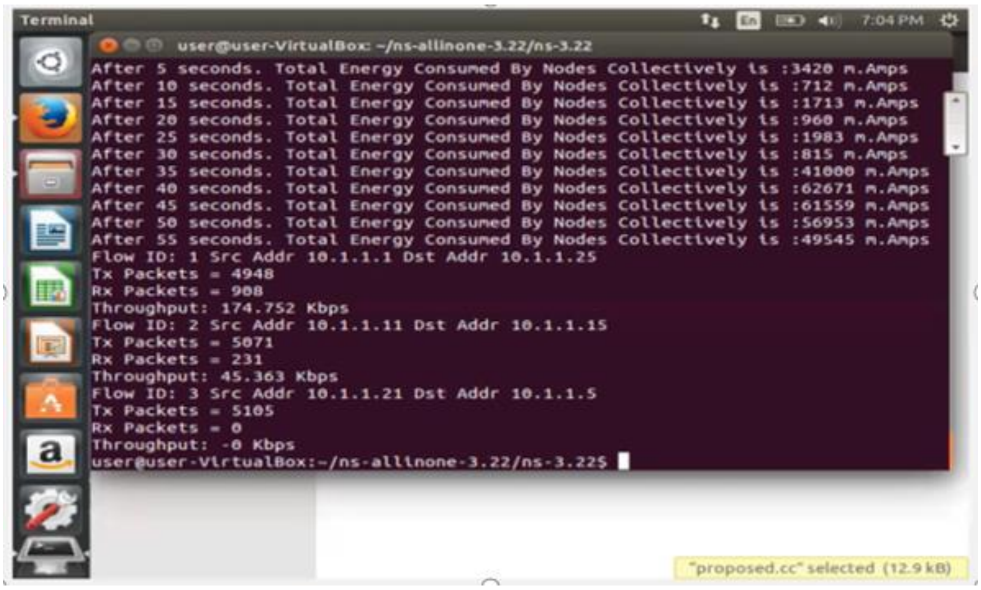

Fig 4: Proposed system energy consumption

4. Results and discussions

Results from the NS2 selected area network with the proposed algorithm compared with the existing techniques to check the efficiency of quality parameters.

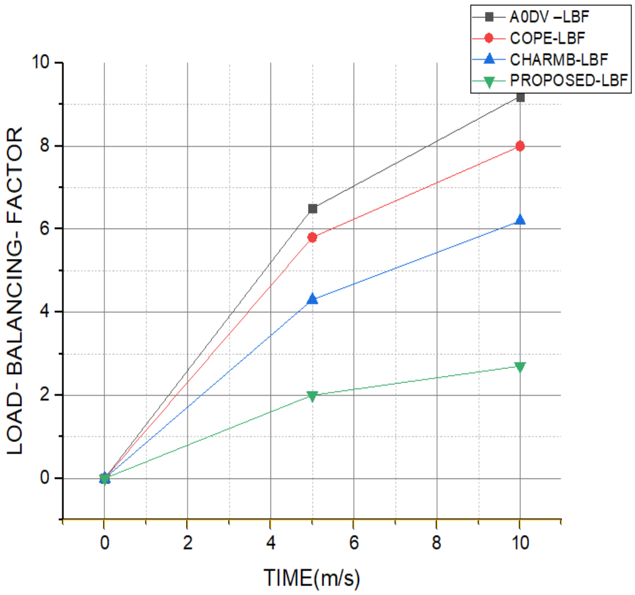

Fig 5: Load balancing factor

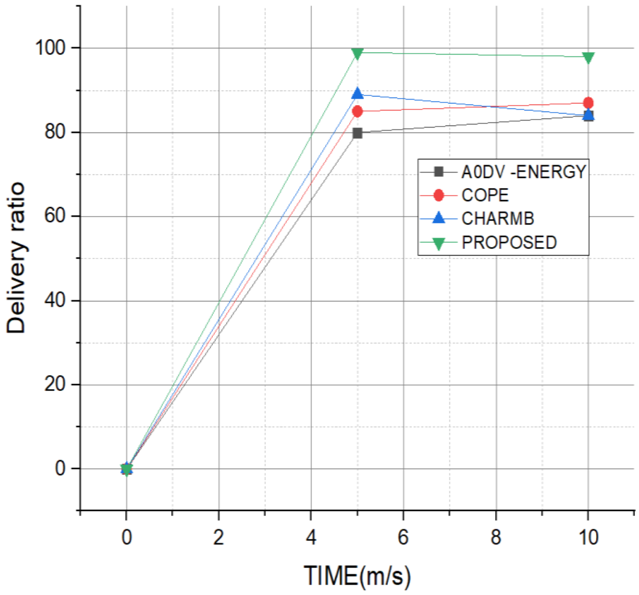

Fig 6: Delivery ratio

In load balancing factor the proposed algorithm reduced the factor up to 60%. .Delivery ratio increased up to 15% with the proposed algorithm. In load balancing factor the proposed algorithm reduced the factor up to 60%. .Delivery ratio increased up to 15% with the proposed algorithm. The proposed algorithm achieves a significant reduction in the load balancing factor by effectively distributing the workload across multiple resources. By intelligently assigning tasks based on their individual capacities and priorities, the algorithm optimizes resource utilization and minimizes the load imbalance, resulting in a 60% reduction in the load balancing factor as shown in figures 5 and 6.

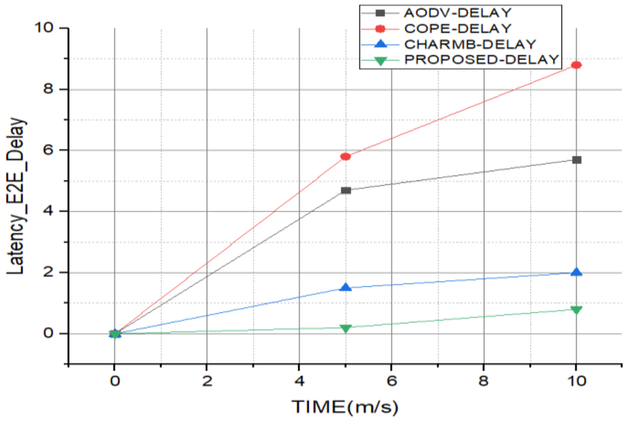

Fig 7:End to end delay

End to End delay reduce to very low that can consider communication without any delay(negligible). There are several factors that contribute to the reduction of end-to-end delay in communication. These include advancements in network infrastructure, efficient routing algorithms, and the use of compression techniques to minimize data size. Additionally, the widespread adoption of high-speed internet connections and the optimization of data transmission protocols have also played a significant role in achieving negligible delays in communication. Throughput increased nearly double when compared with existing optimization technique compared with the existing techniques. The performance of the new optimization technique far exceeds that of other existing techniques. Not only does it significantly reduce end-to-end delay to almost negligible levels, but it also achieves nearly double the throughput. This breakthrough will revolutionize communication by ensuring seamless and uninterrupted data transmission as shown in figures 7 and 8.

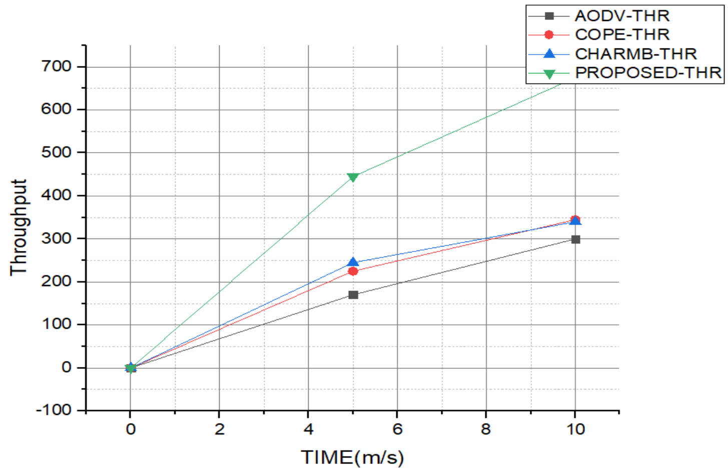

Fig 8: Through put

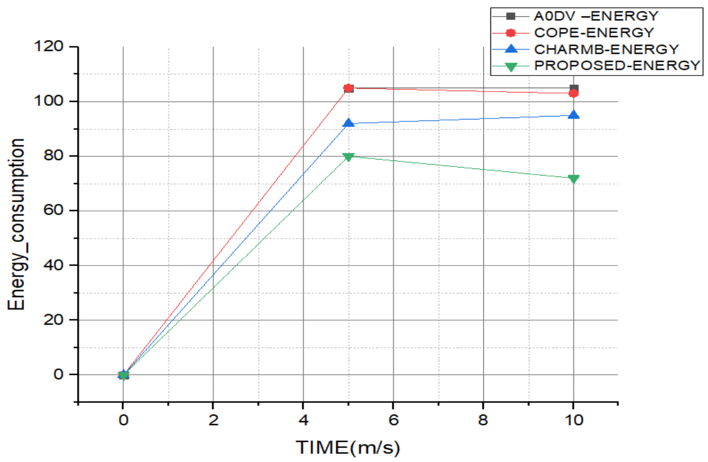

Fig 9:Energy consumption

Energy consumption decreased up to 20% with the proposed optimal technique compare with the existing as shown in figure9. Energy consumption decreased up to 20% with the proposed optimal technique compare with the existing techniques. The proposed optimal technique incorporates advanced energy-saving algorithms and intelligent automation, allowing for more efficient use of resources. By dynamically adjusting power levels and optimizing energy-intensive processes, the technique significantly reduces energy consumption without compromising performance or functionality.

5. Conclusions

The energy consumption is one of the most important aspects in mobile and wireless communications. The increase in the number of devices connected to the communication networks, along with the exponential demand in the data usage of PU and SU has brought forth a vertiginous interest in the study of new techniques to render the usage of the radio spectrum more efficient. Nonetheless, it is important that said research projects are linked to the efficient use of power with supply-oriented methodologies. The main recommendation would consist on using optimization methods to articulate an efficient use of the spectrum supported on the energy supply based on centralized or distributed smart grids. After comparing the performance of the proposed methodology with existing works, we determine the current performance in terms of energy consumption analysis, packet delivery ratios, energy efficiency, average throughput, reliability, and average end-to-end delays. As compared to the existing methodology, the proposed work uses less energy.

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