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Title: Wireless Sensor Networks (WSNs): Towards an Energy -Efficient Routing Protocol Design

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Overview of Research

- Emerging as a class of network, wireless sensor network (WSN) remains highly resource constrained. Here, the primary concern revolving around WSN systems entails energy consumption.
- The current study employs a cross layer design approach towards the development of an energy efficient routing protocol. The proposed protocol entails the PRRP (Position Responsive Routing Protocol) system.
- Indeed, the design of the proposed PRRP protocol is informed by a quest to have the energy that is consumed in the respective distance nodes minimized relative to the given networks.

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- The study also involves a critical evaluation of how the proposed PRRP protocol behaves and performs in relation to the parameters of the network's energy consumption, throughput, and network lifetime, focusing on the individual basis for the respective data packets.
- From the results, the research has established that, upon being analyzed and also benchmarked relative to well-known models such as CELRP and LEACH protocols, PRRP comes with significant improvements in the WSN systems concerning energy efficiency. As such, PRRP is confirmed to steer marked improvements in WSNs' overall performance.

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Wireless Sensor Networks

- Wireless sensor technology continues to play a very crucial role in most commercialized industrial automation procedures, as well as certain real-life applications.
- Thus, in most cases, crucial systems such as security and surveillance applications have employed sensor-based applications. Also, previous studies indicate that most of the preferred sensors are those that are economical and small-sized .
- Imperative to note is that all sensor networks exhibit certain sensing mechanisms through which data is collected from targeted physical contexts, either by the event triggering method or a time-driven technique.

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- Through these techniques, sensors engage in the conveyance of the sensed data to destinations or sinks, as well as multiple sinks or destinations through routing frameworks or algorithms.
- Some of the previously proposed routing algorithms include the Directed Diffusion Routing Protocol (DDRP) and the Minimum Cost Forwarding Algorithm(MCFA), as well as cluster-based routing protocols.
- WSN nodes, therefore, they exhibit four crucial components in terms of power units, processing units, analogue-to-digital converters, and sensing elements.
- Of importance to note is that WSNs remain as resource constrained networks, whereby the main parameter that shapes operation ability involves energy efficiency, which determines the lifespan of the battery of the sensor nodes.

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- In WSNs, nodes tend to be memory, computation, and energy constrained. Hence, there tends to be a need for scholarly examinations of resource-aware and low-computation WSN algorithms, especially in relation to highly resource constrained and small embedded sensor nodes.
- This study focuses on WSN energy efficiency enhancement relative to communication routing protocols.
- Particularly, a new routing protocol in the form of PRRP (Position Responsive Routing Protocol) is proposed. The study also strives to offer a comparative analysis of the performance outcomes of the proposed PRRP protocol with CELRP and LEACH protocols, upon which the efficacy of the proposed model relative to system performance enhancement and energy efficiency realization or improvement might be confirmed or otherwise.

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Proposed Solution

The study strives to establish the PRRP protocol, a new and energy efficient routing protocol. The motivation lies in the need to have WSN energy issues addressed, as well as have the WSN energy efficiency enhanced. For the proposed PRRP protocol, it comes with a novel way through which WSN cluster heads are selected. For the existing CELRP and LEACH, cluster head selection occurs randomly relative to all nodes in relation to their associated residual energy. For the case of the proposed PRRP protocol, different variables are considered. They include the average distance between the candidate cluster head node and the neighbouring nodes, the energy level, and the distance from the sink.

The PRRP Protocol

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- In the proposed PRRP protocol, there is the division of the WSN into cells and grid and then into various tiers. For the sink, it is assumed to be placed on the topology's centre.
- Also, there is the random fashion distribution of the nodes, assuming further that they exhibit awareness of their location or position via local means such as the Global Positioning System (GPS).
- The gateways, thus, form nodes closer to sinks. Additionally, there is the selection of gateways alongside other tiers based on the factors of the number of nodes in the neighbour, position from the sink, and the node energy level.
- The operation of PRRP occurs in various phases, beginning with the selection of the gateways up to the point of data transfer.

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- There is also the formation of trees rooted at the sinks before allowing for data collection via TDMA scheduling. The assumption of the proposed routing protocol, at this point, is that it is only when a neighbour is available in the same tier that a node can join it.
- Thus, there is the ensuring of the minimum distance, allowing further for energy saving in the process of data transfer, as the respective nodes only select parents from closest neighbours, avoiding data transfer in long distances.
- The proposed PRRP routing protocols also focuses on short node transmission ranges, with the respective nodes listening to the transmission of nodes available in the same tier or close to them.
- Hence, the study strives to unearth a technique that might assure minimum distance among interacting nodes in the course of data transfer, translating further into a beneficial effect of energy saving in WSN applications.

Comparative Analysis

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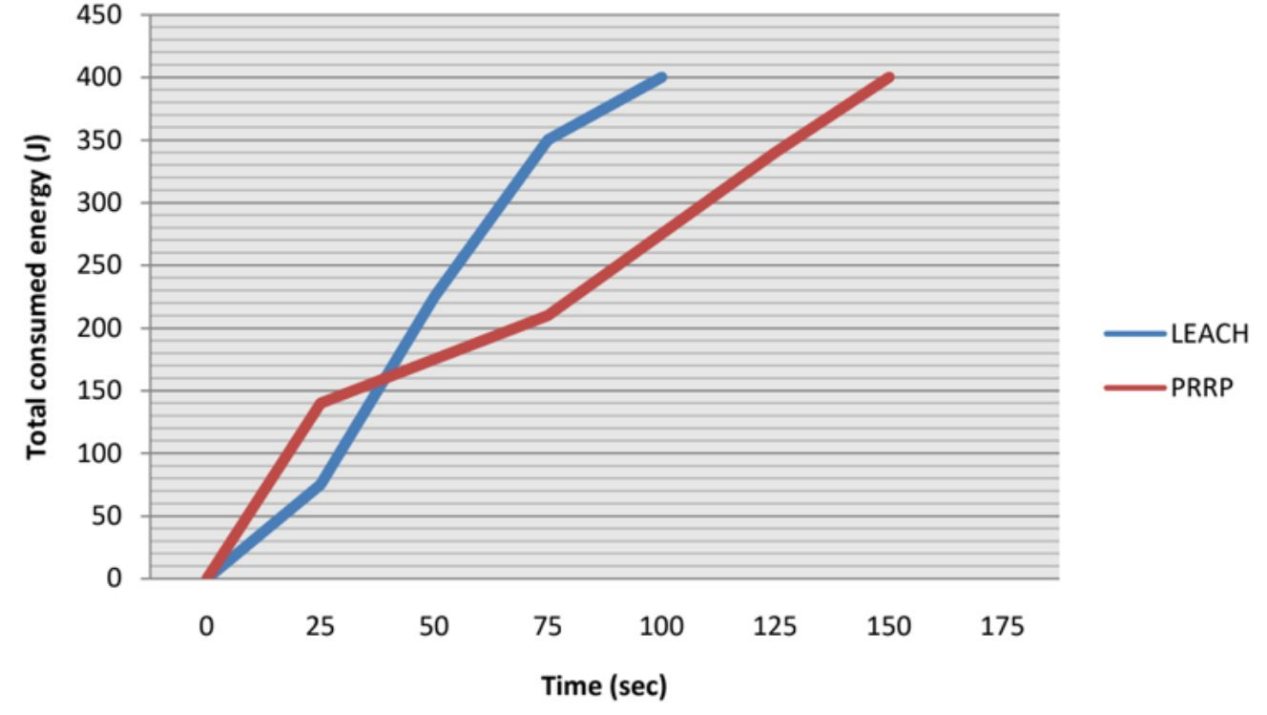
PRRP Vs LEACH



With all rounds considered, simulation outcomes revealed that PRRP nodes exhibit the capability to stay longer and also have the maximum possible energy utilized for a longer time period than the case of LEACH. A specific illustration confirming these observations was the case of a 10-round test run. From the figures, it can be seen that it is after 275 seconds that LEACH protocol's last node dies, but it is after 350 seconds that PRRP protocol's last node dies.

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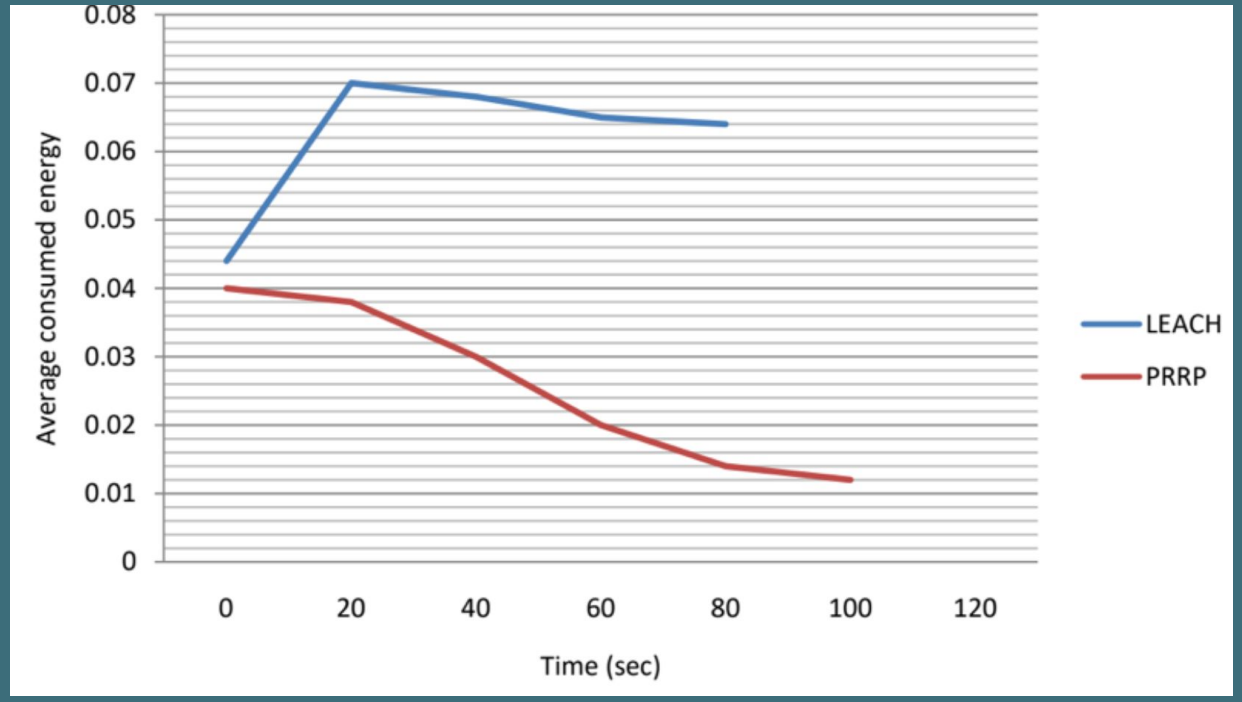
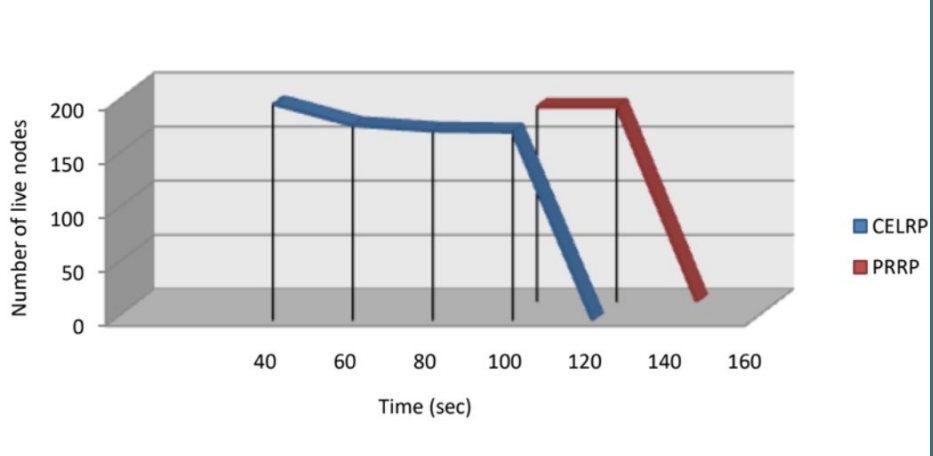
Here, PRRP exhibited superior performance because of its associated consumption of less energy as shown in Figure 2 above. Important to note is that as the initial transmission periods set in, PRRP exhibited higher average consumed energy. However, with more and more rounds of transferring data, a comparison of PRRP with LEACH revealed that PRRP exhibited higher efficiency.

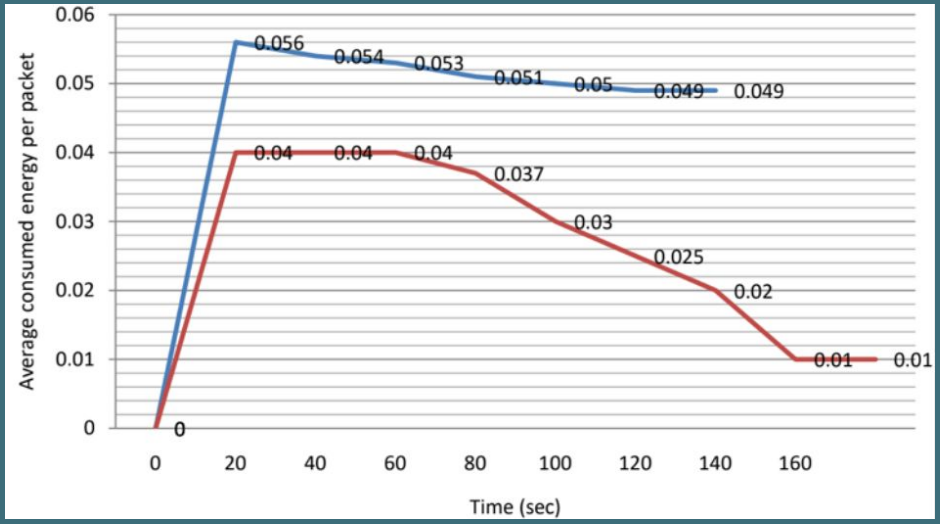
Regarding the throughput, for all rounds, PRRP yielded marked improvements in the network throughput, saving significant energy amount as the phase of transmitting data set in for various periods. There was also further increase in network throughput with increased number of rounds regarding PRRP implementation, with significant performance improvements noted concerning parameters of the utilization of maximum possible energy of sensor network nodes, the energy efficiency variable, and the factor of network lifetime.



Data transmission period	1	5	10
LEACH	3607.00	13045.00	25640.00
Proposed PRRP	15834.00	53950.00	64100.00

PRRP Vs CLERP





Data transmission period	1	5	10
CELRP	5950.00	19985.00	35710.00
Proposed PRRP	16733.00	54555.00	65305.00

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Concerning the factor of per packet average consumed energy, good performance was initially depicted by CELRP when compared to the case of PRRP. However, after some short time span, which involved increased data periods, PRRP exhibited significant improvement on this parameter. For PRRP, the higher average energy consumed initially was attributed to three initial phases required for setup, with there being no data transmission at these stages.

There was the comparison of PRRP with CELRP's performance based on the factor of throughput. Here, simulation outcomes depicted significant network throughput improvement for all rounds, but PRRP was found to exhibit the capacity to save more energy amount since the course of data transmission for multiple periods. Overall, the investigation established and confirmed PRRP's significant performance improvement relative to factors of network throughput, the utilization of maximum possible energy, energy efficiency, and the network lifetime.

Conclusions

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- This study focused on the performance evaluation of the proposed PRRP routing protocol relative to the variables of average energy consumption and the network's average lifetime, both on per packet basis and individually, as well as the behaviour of the proposed algorithm relative to the parameter of network throughput.
- The results were compared with the performance of previously proposed models of CELRP and LEACH. From the findings, PRRP was associated with superior results than LEACH, especially in terms of the capacity to steer improvements in the network lifetime through reductions in energy consumption, with a similar trend observed regarding the network throughput variable.
- Particularly, there was improvement by over 50% in the network lifetime and 2.5 times increase in the throughput.
- When compared to CELRP, the proposed PRRP model improved the network lifetime by over 35%, also increasing the network throughput by 1.82 times, yielding further energy consumption reductions by over 35%.
- Thus, the superiority of the proposed model over CELRP and LEACH was confirmed.

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