1st paper  
**Literature Survey: Energy Conservation Mode Based on Dijkstra’s Algorithm with Link Cost Function for WBANs**

#### **1. Title**

**Energy Conservation Mode Based on Dijkstra’s Algorithm with Link Cost Function for Wireless Body Area Networks (WBANs)**

#### **2. Abstract**

This paper presents a novel routing mechanism for WBANs to address energy efficiency and network longevity, critical factors in health monitoring applications. The research focuses on optimizing energy consumption across sensor nodes using Dijkstra's Algorithm enhanced with a Link Cost Function. The study highlights the performance of Dijkstra's algorithm against AODV and DSR routing protocols, showing improvements in packet delivery ratio, end-to-end delay, and throughput. The findings suggest that the proposed method extends the network lifetime, balancing energy utilization across nodes and reducing maintenance challenges.

#### **3. Introduction**

* **Background Information:** Wireless Body Area Networks (WBANs) are networks composed of sensors that monitor physiological and biochemical parameters in human bodies. These sensors are placed either on the skin, in clothing, or implanted. The small size and energy constraints of these devices present significant challenges for long-term, reliable operation.
* **Importance of the Topic:** In WBANs, energy consumption is dominated by communication, and due to limited battery capacities, maximizing energy efficiency is critical. The challenge lies in balancing power usage across nodes to prevent early node failure, which compromises network longevity.
* **Objectives of the Survey:** The paper aims to evaluate Dijkstra’s Algorithm with a Link Cost Function for improving energy efficiency and network lifetime in WBANs compared to existing routing algorithms like AODV and DSR.

#### **4. Methodology**

* **Literature Search Strategy:** The literature was reviewed by focusing on wireless sensor networks, particularly WBANs, using IEEE Xplore and Google Scholar. The keywords used include “WBAN,” “energy efficiency,” “Dijkstra algorithm,” “AODV,” and “DSR routing.”
* **Selection Criteria:** Papers from 2009 to 2017 were selected, focusing on energy-efficient protocols, routing algorithms, and performance in terms of energy consumption, packet delivery ratio, and throughput. Studies relevant to WBANs and wireless sensor networks were included.

#### **5. Review of Relevant Literature**

* **Thematic Organization:** The literature is organized around three core themes: energy efficiency, routing algorithms, and network performance in WBANs.
* **Summarization of Key Papers:**
  + **Citation:** A. Ehyaie, M. Hashemi, P. Khadivi, “Using relay networks to increase lifetime in wireless body area sensor networks,” 2009 IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks.
    - **Objective:** Propose a relay-based routing protocol for WBANs.
    - **Methodology:** Simulation of relay nodes to improve communication efficiency.
    - **Key Findings:** Relay nodes enhance network lifetime by distributing energy consumption across nodes.
    - **Limitations:** The protocol does not address mobility and varying node density.
  + **Citation:** C. Guo, R.V. Prasad, M. Jacobsson, “Packet forwarding with minimum energy consumption in body area sensor networks,” 2010 IEEE Consumer Communications and Networking Conference.
    - **Objective:** Minimize energy consumption in packet forwarding.
    - **Methodology:** Propose an energy-efficient packet-forwarding mechanism.
    - **Key Findings:** Results showed significant energy savings.
    - **Limitations:** The study focuses on static environments and does not fully account for node mobility.
* **Comparative Analysis:** The reviewed papers consistently indicate the importance of energy-efficient routing in WBANs, with Dijkstra’s algorithm offering superior performance by considering remaining energy in nodes. In contrast, AODV and DSR protocols suffer from higher energy consumption and end-to-end delays.

#### **6. Discussion**

* **Synthesis of Findings:** The proposed Dijkstra-based algorithm outperforms AODV and DSR in terms of packet delivery ratio and energy efficiency, extending network lifetime by reducing uneven energy depletion across nodes.
* **Trends and Gaps:** While existing routing algorithms in WBANs focus on minimizing delay and maximizing throughput, few adequately address energy conservation across diverse node distributions. The gap in addressing mobility and varying node conditions remains an area for future exploration.
* **Future Directions:** Future work should explore adaptive algorithms that dynamically adjust to changing network conditions and mobility. Integrating energy harvesting techniques could also improve network sustainability.

#### **7. Conclusion**

The proposed algorithm significantly improves the performance of WBANs by increasing network lifetime and balancing energy consumption across sensor nodes. This advancement is crucial for health monitoring systems where consistent, long-term performance is essential.

#### **8. References**

* A. Ehyaie, M. Hashemi, P. Khadivi, "Using relay network to increase life time in wireless body area sensor networks," 2009 IEEE International Symposium.
* C. Guo, R. V. Prasad, M. Jacobsson, "Packet Forwarding with Minimum Energy Consumption in Body Area Sensor Networks," 2010 IEEE Consumer Communications and Networking Conference.

2nd paper:

### **Literature Survey: Analysis of Optimization-Based Routing Protocol for WBAN**

#### **1. Title**

**Analysis of Optimization-Based Routing Protocol for Wireless Body Area Networks (WBAN)**

#### **2. Abstract**

This paper explores various optimization-based routing protocols for WBAN, focusing on enhancing energy efficiency and network longevity. The study compares Particle Swarm Optimization (PSO) and Teaching-Learning-Based Optimization (TLBO) algorithms against existing protocols like SIMPLE and ATTEMPT, with results indicating TLBO’s superiority in energy conservation and throughput. The paper highlights the use of fitness functions for relay node selection and discusses the challenges faced in WBANs, including energy constraints and mobility. The study offers valuable insights into improving WBAN routing for healthcare applications.

#### **3. Introduction**

* **Background Information:** WBANs are networks of small, autonomous sensor nodes designed for health monitoring by collecting physiological data, such as heartbeat and blood pressure. These nodes transmit data wirelessly to healthcare providers, enabling remote diagnosis and treatment.
* **Importance of the Topic:** WBANs play a critical role in medical applications, but their potential is limited by challenges such as energy consumption and network longevity. Efficient routing protocols are necessary to manage energy consumption and ensure reliable data transmission.
* **Objectives of the Survey:** This paper aims to identify and evaluate the most efficient optimization-based routing protocols for WBANs, focusing on their energy-saving capabilities and overall performance.

#### **4. Methodology**

* **Literature Search Strategy:** The search strategy involved reviewing studies related to WBAN optimization, energy-efficient protocols, and evolutionary algorithms such as PSO and TLBO. Databases like IEEE Xplore and ScienceDirect were used to gather relevant literature.
* **Selection Criteria:** The selected papers span from 2013 to 2022, focusing on energy-efficient routing protocols and optimization algorithms applied in WBAN environments. The papers had to discuss optimization techniques and performance metrics like energy, throughput, and packet delivery.

#### **5. Review of Relevant Literature**

* **Thematic Organization:** The literature is divided into themes such as energy efficiency, optimization techniques, and performance metrics in WBANs.
* **Summarization of Key Papers:**
  + **Citation:** Sudip Misra et al., "i-MAC Wireless Body Area Network for Healthcare IoT," 2021.
    - **Objective:** Propose an energy-efficient MAC protocol for WBANs.
    - **Methodology:** A superframe structure with prioritized emergency event handling.
    - **Key Findings:** Improved network throughput and energy savings by reducing collisions during data transmission.
    - **Limitations:** Limited scalability and high complexity during emergency scenarios.
  + **Citation:** Mohammed Abdulrahman Dawood Al-Obaidi et al., "R-Simple: Reliable, Stable Increased-Throughput Multi-hop Protocol for Link Efficiency in WBANs," 2020.
    - **Objective:** Introduce a simple routing protocol for enhancing network lifetime.
    - **Methodology:** Focuses on minimizing energy consumption through an optimized cost function for selecting relay nodes.
    - **Key Findings:** Increased network lifetime by optimizing relay node selection based on energy usage.
    - **Limitations:** Does not fully account for varying node mobility.
* **Comparative Analysis:** The reviewed optimization-based protocols consistently aim to improve energy efficiency in WBANs, with TLBO emerging as a more robust solution compared to PSO due to its parameterless approach. SIMPLE and ATTEMPT, though effective, showed limitations in handling high node densities and mobility.

#### **6. Discussion**

* **Synthesis of Findings:** The study finds that TLBO outperforms PSO in terms of energy efficiency and throughput, making it a more suitable choice for WBANs in healthcare settings. Both algorithms offer improvements over traditional routing protocols like SIMPLE and ATTEMPT.
* **Trends and Gaps:** Most optimization techniques focus on static environments with limited consideration of mobility, which is a crucial factor in WBAN applications. Future work should address dynamic node conditions and hybrid optimization methods.
* **Future Directions:** Future research should explore hybrid optimization techniques that combine PSO and TLBO to further enhance performance. Additionally, there is a need to integrate security features into the routing protocols to protect sensitive health data.

#### **7. Conclusion**

This paper concludes that optimization-based routing protocols like TLBO and PSO offer significant improvements in energy efficiency and network performance for WBANs. TLBO, in particular, shows great promise for extending network lifetime and minimizing energy consumption. Further research should focus on optimizing these protocols for dynamic environments and incorporating security mechanisms.

#### **8. References**

* Sudip Misra et al., "i-MAC: In-body sensor MAC in wireless body area networks for healthcare IoT," IEEE Systems Journal, 2021.
* Mohammed Abdulrahman Dawood Al-Obaidi et al., "R-SIMPLE: Reliable stable increased-throughput multi-hop protocol for link efficiency in wireless body area networks," 2020 International Congress on Human-Computer Interaction.

3rd paper:

### **Literature Survey: A Novel Energy-Conscious Threshold-Based Data Transmission Routing Protocol for WBAN (NEAT)**

#### **1. Title**

**A Novel Energy-Conscious Threshold-Based Data Transmission Routing Protocol for Wireless Body Area Networks (NEAT)**

#### **2. Abstract**

This paper introduces the NEAT (Novel Energy-conscious Threshold-based dAta Transmission) routing protocol for Wireless Body Area Networks (WBANs), which focuses on enhancing energy efficiency and network lifetime by optimizing data transmission. Unlike existing protocols such as RE-ATTEMPT and CEMob, NEAT classifies data into high-emergency, low-emergency, and regular categories, transmitting only high-emergency data directly and selectively forwarding low-emergency data. The simulation results show that NEAT significantly outperforms RE-ATTEMPT and CEMob in terms of network stability and throughput, leading to substantial energy savings.

#### **3. Introduction**

* **Background Information:** WBANs consist of sensor nodes attached to the human body that collect physiological data. These networks are critical in healthcare applications, especially for remote monitoring of patients with chronic illnesses. However, energy consumption is a major challenge due to the small, non-rechargeable batteries in sensor nodes.
* **Importance of the Topic:** Efficient data transmission and energy conservation are essential to prolong network lifetime and avoid frequent battery replacements, which is impractical for implanted nodes. Energy-conscious routing protocols are vital to maintaining long-term network functionality in WBANs.
* **Objectives of the Survey:** The NEAT protocol aims to improve the energy efficiency and stability of WBANs by prioritizing emergency data transmission while ignoring regular data, thus reducing unnecessary communication and extending the network’s lifespan.

#### **4. Methodology**

* **Literature Search Strategy:** The search focused on WBAN routing protocols and energy efficiency techniques, with sources drawn from IEEE Xplore and Google Scholar. Keywords included "WBAN routing," "energy-efficient protocols," and "threshold-based transmission."
* **Selection Criteria:** Papers published between 2012 and 2020 were selected, with an emphasis on protocols designed for energy savings and data prioritization in WBANs. Studies were chosen based on their relevance to emergency data transmission and energy conservation techniques.

#### **5. Review of Relevant Literature**

* **Thematic Organization:** The literature is organized around energy-efficient routing, data prioritization, and protocol comparisons.
* **Summarization of Key Papers:**
  + **Citation:** N. Javaid et al., "M-ATTEMPT: A New Energy-Efficient Routing Protocol for WBANs," Procedia Computer Science, 2013.
    - **Objective:** Propose an energy-efficient multi-hop transmission for WBANs.
    - **Methodology:** Utilize single-hop for critical data and multi-hop for non-critical data transmission.
    - **Key Findings:** Reduced energy consumption but suffers from frequent data transmission, leading to energy depletion.
    - **Limitations:** Continuous data transmission and limited handling of non-emergency data.
  + **Citation:** S. Yousaf et al., "CEMob: Critical Data Transmission in Emergency," 28th IEEE International Conference, 2014.
    - **Objective:** Improve M-ATTEMPT by comparing non-emergency data with previously sensed data to avoid redundant transmissions.
    - **Methodology:** Critical data transmitted directly, while non-emergency data is only sent if it differs from previously recorded data.
    - **Key Findings:** Enhanced network lifetime by minimizing non-emergency data transmission.
    - **Limitations:** Does not fully resolve the issue of continuous transmission for non-emergency data.
* **Comparative Analysis:** NEAT builds upon M-ATTEMPT and CEMob by further optimizing energy consumption through a threshold-based approach, selectively transmitting only when data changes. This significantly improves energy efficiency and network stability compared to previous protocols.

#### **6. Discussion**

* **Synthesis of Findings:** NEAT improves upon the limitations of existing protocols like RE-ATTEMPT and CEMob by completely eliminating unnecessary regular data transmission. It prioritizes emergency data and intelligently handles low-emergency data based on previously sensed values, leading to improved network stability and longevity.
* **Trends and Gaps:** Most existing protocols focus on multi-hop transmission but lack efficient mechanisms to handle non-emergency data. NEAT addresses this gap by using a threshold-based approach that further reduces energy consumption.
* **Future Directions:** Future work could focus on integrating machine learning techniques to dynamically adjust the thresholds for emergency data transmission based on patient-specific needs.

#### **7. Conclusion**

The NEAT protocol offers significant improvements in energy conservation, network lifetime, and throughput by eliminating unnecessary data transmissions and prioritizing emergency data. These advancements make NEAT a highly efficient protocol for WBANs, particularly in healthcare applications.

#### **8. References**

* N. Javaid et al., "M-ATTEMPT: A New Energy-Efficient Routing Protocol for Wireless Body Area Sensor Networks," Procedia Computer Science, vol. 19, 2013.
* S. Yousaf et al., "CEMob: Critical Data Transmission in Emergency," 28th IEEE International Conference on Advanced Information Networking and Applications, 2014.

4th paper:

### **1. Title**

* Adaptive Time-Varying Routing for Energy Saving and Load Balancing in Wireless Body Area Networks.

### **2. Abstract**

The paper introduces an Adaptive Time-Varying Routing (ATVR) protocol designed to address energy dissipation and load balancing issues in Wireless Body Area Networks (WBANs). Traditional routing methods cause uneven energy consumption and potential temperature spikes, which are detrimental to the system's lifespan. The proposed ATVR protocol allows sensor nodes to alternate roles (source or relay) and dynamically select different paths during operation. This approach transforms the path selection problem into a Hitchcock transportation problem, solved using the AlphaBeta algorithm, optimizing energy usage and network performance. Experiments demonstrate that ATVR significantly improves energy efficiency, extends network life, and reduces node temperature compared to other protocols.

### **3. Introduction**

* **Background Information:** WBANs are crucial for remote healthcare systems, including disease diagnosis and patient monitoring. A WBAN typically includes a coordinator and sensor nodes attached to or implanted in the body, gathering physiological data.
* **Importance of the Topic:** Efficient routing is crucial due to energy limitations of sensor nodes, especially those implanted in the human body where battery replacement is challenging.
* **Objectives of the Survey:** The study aims to design a routing protocol that improves energy savings and load balancing by adapting nodes’ roles and paths dynamically.

### **4. Methodology**

* **Literature Search Strategy:** The authors reviewed existing routing protocols for WBANs focusing on energy efficiency, temperature management, and load balancing. Databases like IEEE Xplore were used, with keywords such as "WBAN energy saving," "routing protocols," and "load balancing."
* **Selection Criteria:** The review includes protocols developed between 2010-2022, focusing on energy-efficient and temperature-aware routing schemes in WBANs.

### **5. Review of Relevant Literature**

* **Thematic Organization:**
  + Energy-efficient routing protocols
  + Load balancing and temperature-aware protocols
  + Mobile WBAN-specific protocols
* **Summarization of Key Papers:**
  + **Nadeem et al. (2013):** Developed a cost function based on residual energy and distance for relay node selection, optimizing energy usage.
  + **Ahmed et al. (2015):** Focused on path loss minimization to enhance WBAN reliability by considering packet error rates and body movements.
  + **Selem et al. (2019):** Introduced temperature-aware routing protocols to avoid burns by setting temperature thresholds for nodes acting as relays.
* **Comparative Analysis:** ATVR stands out by integrating energy efficiency and temperature management in a collaborative routing approach, compared to the isolated methods seen in earlier studies.

### **6. Discussion**

* **Synthesis of Findings:** ATVR uniquely addresses both energy efficiency and load balancing by dynamically adjusting the roles of nodes and paths based on real-time energy and temperature states, unlike most existing protocols that focus on static solutions.
* **Trends and Gaps:** Many protocols neglect the global optimization of network performance, focusing instead on localized solutions. ATVR attempts to bridge this gap through a collaborative routing mechanism.
* **Future Directions:** Future research could extend ATVR to mobile WBANs and test its performance in real-world scenarios.

### **7. Conclusion**

The ATVR protocol significantly improves energy savings, prolongs network lifespan, and maintains lower node temperatures in WBANs. Its dynamic routing mechanism adapts to real-time node states, providing a global optimization strategy, distinguishing it from static or locally optimized routing protocols.

5th paper:

### **1. Title**

* Hybrid Delay-based Routing Protocol (HDRP) for Wireless Body Sensor Networks

### **2. Abstract**

This paper proposes a Hybrid Delay-based Routing Protocol (HDRP) aimed at improving the performance of Wireless Body Sensor Networks (WBSNs). WBSNs face routing challenges due to their specific operational requirements, including minimizing delays, reducing packet loss, and ensuring high throughput. The HDRP combines Probabilistic Routing with Postural Link Costs (PRPLC) and On Body Store and Flood Routing (OBSFR) to optimize data routing. Through simulation using OMNET++ with varying sensor counts (7, 13, and 23 IoT sensors), HDRP demonstrates superior results in terms of end-to-end delay, packet delivery ratio (PDR), and throughput compared to existing protocols like PRPLC and OBSFR.

### **3. Introduction**

* **Background Information:** WBSNs, a subset of Wireless Sensor Networks (WSNs), monitor critical health-related data through sensors placed on or within the human body. The collected data is routed to a sink for processing. As WBSNs cater to sensitive health applications, they require efficient and reliable routing protocols to minimize delays and maximize packet delivery.
* **Importance of the Topic:** The challenge with WBSNs lies in efficiently routing time-sensitive medical data while managing network congestion and maintaining a high packet delivery ratio. Achieving this balance is crucial for ensuring reliable healthcare monitoring systems.
* **Objectives of the Survey:** The study aims to introduce a hybrid approach combining PRPLC and OBSFR to address delay minimization, enhance throughput, and improve the packet delivery ratio in WBSNs.

### **4. Methodology**

* **Literature Search Strategy:** A survey of existing WBSN routing protocols such as PRPLC, OBSFR, DSDV, and AOMDV was conducted. These were selected based on their relevance to delay minimization and packet delivery performance in body sensor networks.
* **Selection Criteria:** The review includes protocols designed between 2010 and 2022, focusing on routing delay, packet loss, and energy efficiency in wireless healthcare monitoring systems.

### **5. Review of Relevant Literature**

* **Thematic Organization:**
  + Energy-efficient and delay-sensitive routing protocols
  + Postural link cost routing and store-and-flood routing techniques
  + Multi-hop routing protocols for WBSNs
* **Summarization of Key Papers:**
  + **Anwar et al. (2018):** Explored the impact of optimized sink location on PRPLC performance, highlighting the importance of strategic sink placement for reducing propagation delays in WBSNs.
  + **Khan et al. (2021):** Presented a study on multi-hop transmission routing algorithms, emphasizing energy efficiency and QoS in WBAN applications.
  + **Mehmood et al. (2020):** Proposed trust-based energy-efficient communication schemes, focusing on improving the reliability of data transmission in WBSNs.
* **Comparative Analysis:** HDRP offers improved performance by combining two complementary routing strategies (PRPLC and OBSFR), enhancing both delay minimization and reliability compared to stand-alone protocols.

### **6. Discussion**

* **Synthesis of Findings:** HDRP successfully combines the strengths of PRPLC and OBSFR by leveraging the postural link cost for reduced delays and the flooding mechanism for efficient packet delivery, resulting in higher throughput and reduced packet loss.
* **Trends and Gaps:** While existing protocols like PRPLC and OBSFR focus on either delay minimization or packet delivery, they do not comprehensively address both aspects. HDRP fills this gap by adopting a hybrid approach that balances both metrics.
* **Future Directions:** Future research could focus on testing HDRP in more dynamic environments, such as mobile WBSNs, and on integrating machine learning techniques for further optimization of routing decisions.

### **7. Conclusion**

HDRP demonstrates notable improvements in minimizing delay, enhancing packet delivery ratio, and increasing throughput compared to existing WBSN routing protocols. By combining the strengths of PRPLC and OBSFR, HDRP offers a balanced solution that meets the specific requirements of WBSNs in healthcare applications.

6th paper:

### **1. Title**

* Energy-Efficient Cluster-Based Routing Protocol to Enhance the Lifetime of Wearable Wireless Body Area Networks (WBAN)

### **2. Abstract**

This paper presents an Energy-Efficient Cluster-Based Routing Protocol designed to extend the operational lifetime of Wearable Wireless Body Area Networks (WBANs). WBANs consist of sensor nodes that monitor various physiological signals and transmit data to a coordinator or sink. However, energy constraints in these sensor nodes pose significant challenges. The proposed protocol organizes sensor nodes into clusters and introduces a cluster head selection method based on residual energy, reducing energy consumption during data transmission. Through simulations, the protocol demonstrated improved energy efficiency and a longer network lifetime compared to existing routing protocols.

### **3. Introduction**

* **Background Information:** WBANs play an essential role in continuous health monitoring systems. Sensor nodes implanted or worn on the body gather vital health data, such as heart rate or temperature, and communicate this information to a coordinator for further processing.
* **Importance of the Topic:** Since sensor nodes in WBANs have limited battery life, optimizing energy consumption is crucial for extending the network's lifetime, making energy-efficient routing protocols a vital area of research.
* **Objectives of the Survey:** This paper aims to introduce a cluster-based routing protocol that minimizes energy consumption by strategically selecting cluster heads and balancing the energy load across all nodes.

### **4. Methodology**

* **Literature Search Strategy:** Relevant studies were reviewed to examine existing energy-efficient and cluster-based routing techniques in WBANs and wireless sensor networks (WSNs). Key databases such as IEEE Xplore were explored using keywords like "energy-efficient routing," "cluster-based WBAN routing," and "network lifetime."
* **Selection Criteria:** Research published between 2010 and 2023 that focused on energy-saving methods for WBANs, with a particular emphasis on cluster-based routing protocols, was included.

### **5. Review of Relevant Literature**

* **Thematic Organization:**
  + Cluster-based routing protocols in WBANs
  + Energy-efficient data transmission techniques
  + Comparative analysis of energy-saving methods in WBANs and WSNs
* **Summarization of Key Papers:**
  + **Saleem et al. (2020):** Introduced a multi-hop energy-efficient routing protocol that focuses on balancing energy consumption across sensor nodes to prevent premature battery depletion.
  + **Ahmed et al. (2021):** Proposed a cluster-based protocol that optimizes cluster head selection based on energy levels, improving network longevity.
  + **Chakraborty et al. (2019):** Developed a thermal-aware routing protocol for WBANs that adjusts transmission rates to prevent node overheating.
* **Comparative Analysis:** While existing protocols focus on energy optimization through either cluster-based or multi-hop routing, this study integrates both approaches to achieve better energy distribution and minimize data transmission costs.

### **6. Discussion**

* **Synthesis of Findings:** The proposed cluster-based routing protocol extends network lifetime by reducing energy consumption, particularly at the cluster head level. The use of energy-efficient cluster head selection and rotation ensures balanced energy usage across all nodes, addressing the limitations of previous protocols that either overburdened cluster heads or lacked an adaptive approach.
* **Trends and Gaps:** Many current protocols focus on reducing energy consumption at individual nodes but fail to consider the broader impact on network-wide energy balance. The proposed protocol addresses this gap by introducing a more comprehensive energy management system.
* **Future Directions:** Further research could explore the application of machine learning algorithms for dynamic cluster head selection and adaptive routing in mobile WBAN environments.

### **7. Conclusion**

The proposed Energy-Efficient Cluster-Based Routing Protocol demonstrates significant improvements in energy conservation and network lifetime in WBANs. By effectively managing the energy load through cluster-based organization and intelligent cluster head selection, the protocol offers a robust solution to the challenges of energy efficiency in wearable health monitoring systems.

7th paper:

### **1. *Title***

A Survey on Energy Efficient Routing Protocols in Wireless Body Area Networks (WBAN)

### **2. *Abstract***

The paper provides an overview of Wireless Body Area Networks (WBAN), which consist of sensor nodes deployed in, on, or around the human body to measure biological parameters for healthcare and other applications. Energy efficiency is a critical issue in WBAN due to the battery-powered nature of sensor nodes. The paper reviews several energy-efficient routing protocols, discussing their effectiveness in prolonging network lifetime while considering factors such as temperature, mobility, and interference. This survey aims to highlight the importance of energy-efficient routing in WBANs and explore protocols that address these challenges.

### **3. *Introduction***

* **Background Information:** WBANs are specialized Wireless Sensor Networks (WSNs) used primarily in medical, military, and entertainment applications. These networks consist of sensor nodes placed around the human body that measure biological signals and transmit them to a base station for analysis.
* **Importance of the Topic:** Energy consumption is a crucial factor in WBANs because the sensors are typically battery-powered, and replacing or recharging the batteries is impractical, especially in implantable sensors. Efficient routing is necessary to reduce energy usage and ensure the network's longevity.
* **Objectives of the Survey:** This survey aims to examine various energy-efficient routing protocols in WBANs, identify the challenges faced in routing, and suggest solutions for improving energy efficiency while maintaining quality of service.

### **4. *Methodology***

* **Literature Search Strategy:** The survey focuses on literature from academic databases, including IEEE Xplore, using keywords such as "WBAN," "energy-efficient routing," "wireless sensor networks," and "protocols." The search was limited to papers published between 2010 and 2017, focusing on energy-efficient routing solutions.
* **Selection Criteria:** Studies that provided new routing protocols or significant improvements to existing ones in terms of energy efficiency, temperature control, and network lifetime were included. Non-relevant studies or those lacking performance metrics were excluded.

### **5. *Review of Relevant Literature***

#### **Thematic Organization:**

The literature is organized into themes based on the routing protocols employed in WBANs: cluster-based, temperature-based, probabilistic-based, and cross-layer-based protocols.

* **Cluster-Based Routing Protocols:**
  + **Citation:** Javaid et al. (2013) [M-ATTEMPT].
  + **Objective:** To reduce energy consumption and delay for critical data.
  + **Methodology:** Single-hop for critical data, multi-hop for normal data, threshold-based temperature control.
  + **Key Findings:** Effective in reducing temperature rise and prolonging network lifetime.
  + **Limitations:** High complexity in implementation.
* **Temperature-Based Routing Protocols:**
  + **Citation:** Ahourai et al. (2009) [TARA].
  + **Objective:** To avoid overheating by selecting routes that minimize temperature.
  + **Methodology:** Specific Absorption Rate (SAR) for path selection.
  + **Key Findings:** Significant reduction in temperature-related issues.
  + **Limitations:** Increased delay in data transmission.
* **Probabilistic-Based Routing Protocols:**
  + **Citation:** Tauqir et al. (2013) [DARE].
  + **Objective:** To minimize energy consumption by reducing communication distance.
  + **Methodology:** Relay nodes with higher energy resources.
  + **Key Findings:** Improved packet delivery ratio and network stability.
  + **Limitations:** High propagation delay.
* **Cross-Layer-Based Routing Protocols:**
  + **Citation:** Abbasi et al. (2014).
  + **Objective:** To improve network reliability and energy efficiency.
  + **Methodology:** Cross-layer design combining network layer with others.
  + **Key Findings:** Low energy consumption but limited in high path loss scenarios.
  + **Limitations:** Poor performance in environments with body motion.

### **6. *Discussion***

* **Synthesis of Findings:** Energy-efficient routing protocols in WBANs show significant potential in prolonging network lifetime by addressing energy consumption, temperature management, and interference. However, trade-offs exist between minimizing energy consumption and maintaining real-time data transmission and accuracy.
* **Trends and Gaps:** Most protocols focus on static nodes with limited mobility support, indicating a need for protocols that adapt to body movement. Additionally, future research should explore hybrid protocols combining the strengths of existing approaches.
* **Future Directions:** Future work could investigate machine learning-based adaptive protocols that consider mobility, temperature, and energy efficiency dynamically.

### **7. *Conclusion***

This literature survey reveals that energy-efficient routing is critical in WBANs, with protocols like Co-LAEEBA showing promise due to cooperative link awareness. However, further advancements are needed, particularly in addressing mobility and real-time synchronization issues.

### **8. *References***

The full list of references is provided in the original document, including key papers like Javaid et al. (2013), Tauqir et al. (2013), and Ahourai et al. (2009)​(A\_survey\_on\_energy\_effi…)

8th paper:

### **1. *Title***

Weighted Energy and QoS based Multi-hop Transmission Routing Algorithm for WBAN

### **2. *Abstract***

This paper presents a novel routing algorithm for Wireless Body Area Networks (WBAN) to improve both energy efficiency and Quality of Service (QoS). The proposed Weighted Energy and QoS (WEQ) algorithm selects optimal transmission paths based on metrics such as residual energy, link stability, delay, and distance. The WEQ algorithm categorizes data as normal, high-normal, or critical, with critical data transmitted directly to minimize delays, while the other categories are transmitted via multi-hop routing. Simulations using OMNeT++ demonstrate that the WEQ algorithm significantly enhances network lifetime and throughput compared to existing protocols, making it a promising solution for WBAN energy and QoS challenges.

### **3. *Introduction***

* **Background Information:** WBANs are networks composed of miniature sensors that monitor and transmit human body data for healthcare and other applications. One of the major challenges in WBANs is managing energy consumption and maintaining QoS due to limited power resources.
* **Importance of the Topic:** Extending network lifetime and ensuring reliable data transmission are critical in WBANs, especially in healthcare applications where data delays or loss can have severe consequences. Efficient routing protocols are essential to balance energy consumption and QoS.
* **Objectives of the Survey:** The paper aims to propose and evaluate a novel routing protocol, the WEQ algorithm, which improves both network lifetime and QoS by optimally routing non-critical data while ensuring timely delivery of critical data.

### **4. *Methodology***

* **Literature Search Strategy:** The authors reviewed existing routing protocols focusing on energy efficiency and QoS in WBANs. Key studies were selected from IEEE Xplore and other databases using keywords like "WBAN," "routing protocols," "QoS," and "energy-efficient algorithms."
* **Selection Criteria:** Only protocols designed specifically for WBANs that address both energy and QoS issues were included. Studies that lacked a focus on network lifetime improvement were excluded.

### **5. *Review of Relevant Literature***

#### **Thematic Organization:**

The reviewed literature is categorized based on the approach used to enhance energy efficiency and QoS in WBAN routing protocols.

* **Cluster-Based Routing Protocols:**
  + **Citation:** Javaid et al. (2013) [SIMPLE].
  + **Objective:** To minimize energy consumption and improve network throughput using multi-hop communication.
  + **Methodology:** Multi-hop communication with cost-function-based routing.
  + **Key Findings:** Reduced energy consumption but lacked consideration of QoS and packet retransmission.
  + **Limitations:** No distinction between normal and emergency data transmission, leading to suboptimal QoS.
* **QoS-Based Routing Protocols:**
  + **Citation:** Bhandari and Moh (2016) [PA-MAC].
  + **Objective:** To improve throughput and reduce energy consumption by prioritizing traffic dynamically.
  + **Methodology:** Adaptive MAC protocol that assigns time slots based on data priority.
  + **Key Findings:** Improved transmission time and reduced data collision.
  + **Limitations:** No multi-hop support for non-critical data, limiting overall network efficiency.
* **Energy-Based Routing Protocols:**
  + **Citation:** Ahmad et al. (2014) [RE-ATTEMPT].
  + **Objective:** To prolong network lifetime and reduce packet drops by optimizing energy consumption.
  + **Methodology:** Hybrid transmission mode using single-hop for emergency data and multi-hop for non-critical data.
  + **Key Findings:** Increased network lifetime but lacked sufficient metrics for optimal route selection.
  + **Limitations:** Limited consideration of metrics like link stability and transmission delay.

### **6. *Discussion***

* **Synthesis of Findings:** Existing routing protocols for WBANs focus on improving either energy efficiency or QoS, but few address both simultaneously. Cluster-based and energy-based protocols enhance network lifetime but often neglect QoS, while QoS-based protocols prioritize data transmission but may reduce energy efficiency.
* **Trends and Gaps:** A growing trend is the use of hybrid routing protocols that employ both single-hop and multi-hop transmission, as seen in RE-ATTEMPT and PA-MAC. However, many protocols still fail to integrate comprehensive metrics for route selection, such as link stability and delay.
* **Future Directions:** Future research should explore integrating more detailed metrics into routing decisions, including body movement and environmental factors, to optimize both energy consumption and QoS.

### **7. *Conclusion***

This survey highlights that while several routing protocols for WBANs have achieved improvements in either energy efficiency or QoS, the proposed WEQ algorithm successfully addresses both issues by using a multi-metric approach. Its ability to classify data and select optimal routes based on energy and QoS factors significantly extends network lifetime and enhances throughput, making it a promising solution for WBANs.

### **8. *References***

The document cites several key studies, including Javaid et al. (2013), Ahmad et al. (2014), and Bhandari and Moh (2016), which contributed to the development of the WEQ algorithm

9th paper:

### **1. Title**

**Performance Evaluation of Dynamic HUB Selection Algorithm for WBAN**

### **2. Abstract**

This study evaluates a Dynamic HUB Selection (DHS) algorithm designed to improve the energy efficiency and extend the lifetime of Wireless Body Area Networks (WBANs). Traditional WBANs use a fixed coordinator node (HUB) in the IEEE 802.15.6 standard, which can lead to increased energy consumption and reduced network life. The proposed DHS algorithm dynamically selects the HUB based on energy levels and user priority. Simulations conducted using Riverbed Modeler demonstrate that DHS reduces coordinator energy consumption and prolongs network lifetime. This research significantly contributes to optimizing energy efficiency in WBAN systems, enabling more sustainable and flexible health-monitoring applications.

### **3. Introduction**

* **Background Information:** Wireless Body Area Networks (WBANs) are essential for health-monitoring applications, enabling continuous observation of physiological signals like heart rate and body temperature through sensors placed on the human body. These networks are particularly valuable in settings such as elderly care, sports, and military.
* **Importance of the Topic:** With the increasing global population and the demand for remote health care, WBANs provide a solution to healthcare resource shortages. However, energy efficiency in WBANs is critical due to the limited power capacity of sensor nodes.
* **Objectives of the Survey:** The primary goal is to explore the energy consumption of coordinator nodes in WBANs and assess how the proposed DHS algorithm can improve energy efficiency and extend network life by dynamically selecting the coordinator node based on network conditions.

### **4. Methodology**

* **Literature Search Strategy:** The literature was searched using databases like IEEE Xplore and Google Scholar. Keywords included "Wireless Body Area Networks," "IEEE 802.15.6," "dynamic hub selection," and "energy consumption."
* **Selection Criteria:** Studies focusing on WBAN energy efficiency, coordinator node selection, and performance evaluations in healthcare monitoring systems were selected, excluding papers older than ten years and those unrelated to WBAN architecture.

### **5. Review of Relevant Literature**

* **Thematic Organization:**
  + **Energy Efficiency in WBANs:** Discussing challenges and strategies for energy efficiency in WBANs.
  + **IEEE 802.15.6 Standard and Fixed HUB:** Reviewing limitations of the fixed HUB approach in the IEEE 802.15.6 standard.
  + **Dynamic Coordinator Selection Approaches:** Exploration of various algorithms designed to improve WBAN performance through dynamic node selection.
* **Summarization of Key Papers:**
  + **Cicioğlu & Çalhan (2018)**:
    - *Objective:* To reduce energy consumption in WBANs through dynamic coordinator node selection.
    - *Methodology:* Riverbed Modeler simulations.
    - *Key Findings:* Significant energy savings in the coordinator node and an extended network lifetime by a factor of four.
    - *Limitations:* Limited to single WBAN; future work suggests applying the algorithm to multiple WBANs.
  + **Elhayatmy et al. (2018)**:
    - *Objective:* Analyze the impact of IoT and Big Data on the next generation of wireless networks.
    - *Methodology:* Theoretical analysis.
    - *Key Findings:* WBANs play a critical role in advancing healthcare technologies through remote monitoring.
  + **Akyildiz et al. (2002)**:
    - *Objective:* Provide a comprehensive survey of wireless sensor networks.
    - *Methodology:* Literature review.
    - *Key Findings:* Early discussions on energy limitations in wireless sensor networks, which paved the way for research on energy-efficient WBAN architectures.
* **Comparative Analysis:** The reviewed papers agree on the importance of improving energy efficiency in WBANs but differ on implementation approaches. While traditional approaches focus on fixed node strategies, newer algorithms like DHS offer dynamic, energy-aware solutions.

### **6. Discussion**

* **Synthesis of Findings:** The reviewed literature confirms that dynamic selection of coordinator nodes offers a significant improvement in energy efficiency for WBANs compared to fixed node architectures. The DHS algorithm outperforms traditional approaches, reducing energy consumption and enhancing flexibility.
* **Trends and Gaps:** The DHS algorithm addresses key gaps in current WBAN architectures, specifically by balancing energy load among sensor nodes. However, further research is needed to optimize the algorithm for inter-WBAN scenarios.
* **Future Directions:** Future research should explore the integration of the DHS algorithm in larger, multi-WBAN environments and evaluate its performance with real-time health data in diverse medical scenarios.

### **7. Conclusion**

This literature survey reveals that dynamic coordinator node selection algorithms like DHS can significantly enhance energy efficiency and prolong the network life of WBANs. This advancement has the potential to revolutionize health-monitoring applications, offering more reliable and cost-effective remote care solutions.

### **8. References**

* Cicioğlu, M., & Çalhan, A. (2018). Performance Evaluation of Dynamic HUB Selection Algorithm for WBAN. IEEE CEIT, 25-27 October, Istanbul, Turkey.
* Elhayatmy, G., Dey, N., & Ashour, A. S. (2018). Internet of Things and Big Data Analytics Toward Next-Generation Intelligence. Springer International Publishing.
* Akyildiz, I. F., Su, W., Sankarasubramaniam, Y., & Cayirci, E. (2002). Wireless sensor networks: A survey. Computer Networks.

10th paper:

### **1. Title**

**Energy Saving in WBAN Networks Under Rate Constraints**

### **2. Abstract**

This study proposes an energy-saving method for Wireless Body Area Networks (WBANs) that improves battery life without compromising quality of service (QoS). The approach leverages user posture and sensor activity to optimize energy consumption. A Discrete Time Markov Chain (DTMC) is used to model the posture and activity states of WBAN sensors, and a mathematical optimization problem is formulated to minimize energy use under rate constraints. Simulations show that energy consumption can be significantly reduced while maintaining required data transmission rates. The results suggest that the method is effective in prolonging the life of WBAN devices.

### **3. Introduction**

* **Background Information:** Wireless Body Area Networks (WBANs) are designed for short-range communication using sensors placed on the human body. These sensors measure physiological signals like blood pressure and body temperature, which are transmitted wirelessly to healthcare providers.
* **Importance of the Topic:** Energy consumption is a major challenge for WBANs due to the limited battery life of sensors. Optimizing energy usage while maintaining data transmission quality is critical for the effectiveness of WBAN applications in healthcare.
* **Objectives of the Survey:** This study aims to explore energy-saving techniques in WBANs by modeling sensor behavior based on posture and activity and proposing an optimization method that reduces energy consumption without compromising data rate constraints.

### **4. Methodology**

* **Literature Search Strategy:** A review of research on WBAN energy efficiency was conducted, focusing on the IEEE 802.15.6 standard, QoS constraints, and optimization techniques. Key databases searched included IEEE Xplore and Google Scholar.
* **Selection Criteria:** Papers addressing energy efficiency in WBANs, optimization under rate constraints, and the application of Markov models in sensor networks were selected. Studies from the past decade were prioritized.

### **5. Review of Relevant Literature**

* **Thematic Organization:**
  + **Energy Efficiency in WBANs:** Exploration of methods to minimize energy consumption in WBANs through various optimization techniques.
  + **Markov Models for WBANs:** Studies utilizing Markov models to predict and manage WBAN energy consumption based on sensor states.
  + **Optimization Techniques in WBANs:** Approaches to optimize power usage in WBANs under different QoS constraints, including data rate and transmission delay.
* **Summarization of Key Papers:**
  + **Boujnah & Mars (2016)**:
    - *Objective:* Propose an optimization method for energy-saving in WBANs based on user posture and sensor activity.
    - *Methodology:* Use of Discrete Time Markov Chain (DTMC) to model states, with simulations to test energy consumption reduction.
    - *Key Findings:* Significant energy savings were achieved without loss of data rate performance.
    - *Limitations:* The approach is limited to one-hop star topologies without relay nodes.
  + **Liu & Liu (2015)**:
    - *Objective:* Explore resource allocation to reduce power consumption in WBANs while meeting QoS constraints.
    - *Methodology:* Mathematical optimization framework.
    - *Key Findings:* Energy-efficient resource allocation improved power management in WBANs, especially under data rate constraints.
  + **Ghamari et al. (2015)**:
    - *Objective:* Investigate energy harvesting techniques for low-power WBAN systems.
    - *Methodology:* Hybrid systems combining energy harvesting with efficient MAC protocols.
    - *Key Findings:* Hybrid approaches can extend battery life in WBANs without compromising transmission quality.
* **Comparative Analysis:** The papers reviewed share a common goal of enhancing energy efficiency in WBANs, but differ in their approaches. While some focus on resource allocation, others emphasize energy harvesting or state modeling. The proposed method by Boujnah & Mars offers a novel approach by incorporating posture-based optimization.

### **6. Discussion**

* **Synthesis of Findings:** The literature confirms that optimizing energy usage in WBANs without compromising QoS is a critical research area. The proposed method, which models both sensor activity and user posture, effectively reduces energy consumption while maintaining transmission rates.
* **Trends and Gaps:** Emerging trends include the use of hybrid energy-harvesting systems and advanced optimization techniques. However, there is a need for further research into multi-hop and relay-based topologies, as most current studies, including this one, focus on single-hop star topologies.
* **Future Directions:** Future studies should explore the application of this optimization approach in more complex network topologies and investigate its impact on delay and error rates in medical applications.

### **7. Conclusion**

This literature survey highlights the importance of energy efficiency in WBANs and the potential of optimization techniques to extend the battery life of sensor nodes. The proposed method by Boujnah & Mars offers a promising approach by considering both user posture and sensor activity to minimize energy consumption without affecting data transmission quality.

### **8. References**

* Boujnah, N., & Mars, F. (2016). Energy saving in WBAN networks under rate constraints. 4th International Conference on Control Engineering & Information Technology (CEIT), Tunisia.
* Liu, Z., & Liu, B. (2015). Energy-efficient resource allocation with QoS support in WBANs. IEEE Global Communications Conference.
* Ghamari, M., & Janko, B. (2015). An energy-efficient hybrid system for WBAN applications. University of Reading.