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THE SCOPE OF WIRELESS BODY AREA NETWORKS WITH THE PERSPECTIVE OF ENERGY HARVESTING

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Abstract: **Wireless Body Area Networks (WBANs) are a small network of sensing element nodes that are deployed either within or outside the physical body. Due to the restricted transmission range and battery constraint in WBAN, the routing protocols can play a very important role in creating the communication between the nodes more practical and additionally prolonging the life of a WBAN. In a previous couple of years, development and analysis of the routing protocols in WBAN are very important and engaging research topic, particularly for applications in medical analysis.The energy scavenging studies have also become an important research area not only for the utilization of ambient energy sources but also for their high potential to replace the batteries especially for wireless body area networks (WBANs). Conventionally, batteries are used to provide energy to WBANs. The battery recharging or replacement is significantly impractical. Therefore, different energy scavenging interface circuits with different efficiencies have been proposed to overcome these limitations. This study focuses on energy harvesting and their potential utilization for low-power systems.**

Index Terms **- WBAN, Routing, Energy harvesting**

I. INTRODUCTION

Growth within the field of physics has reshaped the technology of Micro-Electro-Mechanical Systems (MEMS) that created the sensors additional powerful and smart. MEMS sensors can measure devices with the power of sensing the atmosphere, information gathering, processing and, transmission. To require advantage of development in wireless communication, sensors became ready to communicate by utilizing this technology in an untied manner[1]. These developments additionally provided a platform for device networks to speak with a base station (BS) by creating ad-hoc connections for information transmissions. BS or additionally called sink may be a device with significantly large storage and processing power as compared to traditional sensor nodes (SNs). BS gathers information from SNs deployed in the field. Among numerous styles of device networks, wireless body area network (WBAN) is a special style of network.This is used for monitoring the various parameters of human body without disturbing their daily life routine.The composition of WBAN includes little sized SNs deployed on completely different components of the body that observe different kinds physiological parameters like blood pressure, rate of heart beats, aldohexose level, etc.Sensors nodes are planted within the body tissue of the body. The major role of sensor nodes is to send the collected information to the nearby servers for the analysis of the health of the patient and send collected knowledge to the hindmost servers that are connected with Wireless Local Area Networks (WLAN). Different kinds of signals are transmitted from the nodes like electrooculography (EOG), electromyography (EMG), electrocardiography (ECG), electroencephalography (EEG) can also sense the temperature and the electrical phenomenon of the skin. These deployed SNs record and process the detected knowledge of a person's body to transmit it to BS/Sink [2]. This recorded knowledge may be directed to an associate degree external network by providing associate degree interface between native network and web or cloud storage from where different medical professionals that are located remotely can access the patient body data.

The continuous increase in the range of patients suffering from totally different diseases worldwide like diabetes, asthma, cardiovascular, etc. is one of the explanations that greatly influenced the researchers to require an interest in providing efficient health-care solutions. WBANs provides one of the cost-effective health-care solutions for this issue. it is made up of small and light-weighted biological SNs so that they will be deployed on a person's body with ease and luxury. The main downside of those small-sized SNs is their restricted resources like battery capability, that drain quickly due to different operations. The fast depletion of battery energy mostly happens due to the repetitive transmission of redundant sensed knowledge in sequent rounds and re-transmission of knowledge packets. The retransmission of knowledge packets is allotted due to unsuccessful knowledge reception at the destination that principally occurs path-loss, and choice of inefficient routes among the SNs [3], [4]. The energy voidance ends up in the early death of SNs that severely affect the network lifetime [9]. This article discusses the types of WBAN, routing protocols involved and the scope of energy harvesting for the future developments.

II. WIRELESS BODY AREA NETWORKS

WBAN could be a promising field of Wireless Sensor Network (WSN). Since it's the a part of WSN however it's its own features that create it completely different from the WSN[36]. In WBAN, the restricted range of nodes is deep rooted and nodes should be little in size. Every node deployed has its own options that create one node completely different from another. There are various types of WBAN depending on their application.

TYPES OF WBAN

1) Managed WBAN: Using the managed WBAN design, just in case of medical applications, the information is gathered and sent to any authorized person or doctor to require choices on the detected knowledge. The advantage of this kind of network is that teach one physiological signs are analyzed and diagnosed at a similar time, and also the disadvantage is that matter goes worse if the authorized person is busy to answer or will different work.
2) Autonomous WBAN: In the autonomous WBAN, the biosensor nodes are connected with the actuators to make an action on the build as per detected information, with no decision of the medical examiner or authorized person [22]. It works best in emergency things. The actuators are the action systems that interact with the users for acquiring information from the biosensors.
3) Intelligent WBAN: Considering an intelligent WBAN,it's a bunch of autonomous and managed WBAN. It has a straightforward and complex scenario during this kind. For the easy situation, selections are assumed by actuator nodes however for the advanced scenario the detected information is sent to the medical examiner or authorized person. However, the intelligent WBAN makes selections when a selected time interval if the medical examiner is busy.

III. ROUTING PROTOCOLS USED IN WBAN

A proper and well-designed routing theme offers to prolong network life-time with the prime quality of services by economical resource management ways. As WBANs operational conditions and their design area are different than other ancient sensor networks, there are various routing schemes designed for those networks [11]–[15], Those routing schemes aren't appropriate to be enforced in WBANs applications. A typical WBAN contains a restricted number of SNs with no provision of redundancy [23].These nodes have restricted process, storage, and power capacity [24]. Therefore, routing protocols for WBANs must be designed in like means that consider these limitations of sensor nodes.

A. Based on CH selection

1) IRMB protocol: This is projected to boost the performance of the CICADA protocol [10]. CICADA could be a cross-layered protocol that works on mac and routing layer, which supports multi-hop communication situation. It supports high-energy potency and offers low end-to-end delay by setting up the data gathering tree. it's supported the model of multi-hop probabilistic network property. The major aim of this work is to boost the reliableness of knowledge transmission in WBANs. It uses a path-loss model to hide the full human body rather than covering solely the circular space, as unremarkably done in most schemes. In this projected protocol, a time slot-based mechanism is employed that assigns short however equal interval time slots to each SN within the network. Furthermore, this projected work analyses the CICADA protocol and a few modifications are done to gain high reliability.
2) A low overhead tree-based energy-effificient routing scheme: This is an energy-effificient routing theme (EERS) for multi-hop WBANs. The proposed theme chiefly focuses on the economic utilization of energy and transmission power. The authors have done some experimentation to support their proposition, that describe the issue i.e. energy-loss because of low-reliability in transmission. The low-reliability in transmission happens due to body shadowing and stable transmission power in WBANs by not considering the wireless link quality. To solve these issues, the planned routing theme establishes a tree-based and energy economical end-to-end wireless communication path by selecting the acceptable transmission power for each sensor node. The planned protocol was enforced mistreatment real-time work of MicaZ WBAN test-bed and intensive experimentation was done. The performance of the planned scheme was compared with the collection tree protocol (CTP) in terms of end-to-end delay, packet delivery quantitative relation (PDR), and energy consumption/balancing [8].
3) Dual Sink approach: The planned Dual Sink approach clustering in Body area network (DSCB) protocol [17] is used to hide the path-loss issue using a clustering approach with the employment of dual sinks. Dual sink nodes are deployed on anatomy at the front and back aspects. To select the most effective forwarder node, the cost function is based on the residual energy of the sensor node, the distance between the SN and needed transmission power. Sensor node with minimum value function is chosen as forwarder node. DSCB is compared with DARE and SIMPLE[18] routing protocols to examine its performance.

B. Based on residual energy

1) Minimum Energy Packet Forwarding Protocol(MEPF): It considers minimum energy packet forwarding as an entire, by a characteristic trade-off of the transmission power management and the re-transmission energy consumption. Secondly, it proposes lightweight solutions for transmission power management and ACK power management as sensible ARQ (Automatic Repeat Request). MEPF transmits packet exploitation of the minimum transmission power which will guarantee a high packet reception rate. At a similar time, re-transmissions are postponed till the link is adequate. Using a machine learning algorithm, the standard of the link is judged that are designed for the restricted capabilities of typical body area network devices. Through MEPF, the energy consumption to forward a packet is reduced without sacrificing the packet reception magnitude relation[7].

2) *Distance Aware Relaying Energy Effificient(DARE):* This is to analyze patients in multi-hop body area sensor networks (BASNs), which is provided in [6]. To decrease the energy consumption, the sensors create a link with the sink by means that of an associate on-body relay, hooked up on the chest of every patient. The hooked-up body relay retains greater energy resources as compared to the body sensors since they perform gathering and relaying of knowledge to the sink node. Hence, for heterogeneous networks (for instance for observance patients), a relaying energy-efficient protocol is recommended. Within the given situations, few sensor nodes perpetually monitor patient's knowledge whereas other nodes monitor knowledge only they notice an exact threshold stage. The protocol defines minimum energy parameters for the sensors to avoid heat harm to the sensitive physical body tissues. Results of the analysis depict greater packet delivery quantitative relation, longer network lifetime, and better stability amount.

3) *Cooperative Routing Protocol:* A cooperative routing protocol that considers energy consumption and QoS as performance parameters is proposed in [5]. QoS is measured by the received signal strength indicator (RSSI). To integrate consumption and QoS parameters within the routing protocol, a competitive/opponent mechanism is enforced at every node by utilizing multi-agent reinforcement-learning algorithm. The program (RSSI/energy-CC) is an associate in nursing energy and QoS aware routing protocol. Taking into consideration the consumed energy through the network, better performance in terms of end-to-end delay and packet loss rate can be achieved by this method. Cooperative communication permits sharing of resources, thereby, enhancing the network performance.

IV. ENERGY HARVESTING IN WBAN

Numerous analysis efforts at varied layers have focused on minimizing energy constraints via energy-efficient protocols, conservation schemes, and effective topology style. However, energy limitations stay a vital constraint creating WBAN usage less fascinating. thanks to recent technological advancements, varied battery recharging techniques are projected to eliminate energy restrictions.These mechanisms are often loosely classified into two categories: wireless power transfer [19] and energy harvesting. Wireless power transfer involves the wireless transfer of voltage victimization techniques such as inductive coupling ,magnetic resonant coupling, and radiation. These methods work well most of the time, however need the wearer to be within the proximity of an associate in nursing energy transmitter, that is restricted to many meters solely. Moreover, a line of sight and a relentless electrical source also are necessary. Static devices would possibly meet these conditions, except for mobile devices, fulfilling such needs isn't continually potential. In distinction, energy harvest involves scavenging power from a range of limitless close sources and changing it to usable electrical energy. Energy harvesting is often thought-about a viable solution for enhancing operational lifetimes because it's not restricted by restricted vary or line of sight. Moreover,energy is offered in associate nursing with infinite capacity and a range of forms. what is more, energy harvest will modify time observance-of various biological parameters victimization in-body sources, therefore providing self-sustainable systems. Several sources of non-electric renewable energy exist all around us. Power from these sources can be controlled using applicable hardware and regenerate to electrical type to meet energy requirements cited as energy harvesting. Although it's not a brand new thought, only if it's been enforced on an
out-sized scale worldwide, its exploitation in compact devices like sensor nodes may be a trending topic in each world and trade. This autonomous resolution will provide energy by reducing system prices and electrical waste within the variety of depleted (dead) batteries. Energy harvesting will also build WBAN usage a lot, by reducing its energy constraints. Recent advances have made it attainable to scavenge energy from a range of sources within the form, which was antecedently not possible or not thought of. In this paper, it offers a cryptic review of current analysis on energy harvest in WBAN. Specifically, it discusses potentially harvestable sources, and their characteristics and usefulness in minimizing energy constraints.

A. Process of Energy Harvesting

First, energy from nonelectrical sources is scavenged and transformed to electric potential with appropriate energy harvesters for specific sources. the electrical energy made will then be utilized in two ways in which, looking on the detector node's architecture: harvest-use and harvest-store-use [26]. With harvest-use, the voltage made is directly used by the detector load with no form of storage concerned. Consequently, the energy harvester should offer a nonstop power output that must be bigger than the minimum power required by the node for optimum functioning. With the harvest-store-use design, the generated energy is kept for a gift or later use. Energy storage can be typically reversible batteries, super-capacitors, or a mixture of each. Energy harvesting/gathering techniques in WBANs encompass remodeling the ambient energy sources into electrical signal with the help of energy harvesters [20] such as piezoelectric transducers (rework mechanical activity into electrical signal), thermoelectrical components (alter body heat into associate degree electrical signal), photovoltaic cells (transform light into associate degree electrical signal), or antennas (convert frequency radiation into an electrical signal).

B. Energy sources from the human body

The human body itself contains ample sources of energy sensor. Betting on the nature of the energy it can be classified into biochemical sources and biomechanical energy sources.

1) ***Biochemical energy sources:*** The bio fluids present within the body involves a range of substances and active enzymes that offer energy to the body. These chemical compounds are often harvested via electrochemical reactions. The 3energy scavenged are often used for powering ultra-low power implantable sensors, drug delivery systems, and other applications. The supply of harvestable substances within the body varies with age and depends for the most part on people's health and daily intake of foods and nutrients. Generally, these sources can be harvested whenever needed, given that the body maintains an ample provide of potential substances. The main sanctionative technology for harvesting chemical compounds is biofuel cells [26]- [28] that generate power via complementary chemical reactions that occur between the anode and cathode and are separated by a catalyst to accelerate the chemical reactions. The anode is accountable for oxidizing the fuel (chemical compound), while reduction takes place at the cathode. As long as the body maintains an energetic provide of harvestable substances, biofuel cells will unceasingly produce power, therefore in theory providing an endless supply of energy.

2) Biomechanical energy sources: The energy controlled is utilized to autonomously power active implants, such as progressive low-power pacemakers. One example, an electromagnetic generator that supported a poster automatic watch mechanism, which will scavenge vibration from internal organ motions [33]. Another uninterrupted, harvestable source is that the small-scale flow of wind caused by the respiratory. The inhalation and exhalation of air generate a pressure distinction that can be controlled to provide current. A straightforward thanks to harvesting this pressure difference would be to use wind turbines that mimic large-scale wind harvest home systems. This method used in wearable electronic masks is known as AIRE.[34] The mask exploits the mechanical energy from the wearer's breath using small wind turbines and uses harvested energy to power external electronic devices. A major portion of biomechanical sources is associated with human locomotion, including sources like footfalls, knee motion, and arm motion. These sources are harvested by various electricity and mechanical generators. A considerable quantity of energy is generated from foot strikes throughout walking, which may be scavenged with the help of electricity polymers placed in the sole of the shoe. The energy generated is used to power biometric sensors. Throughout the movement, vital levels of vibration or displacement occur at the knee, manufacture mechanical energy. Such energy may also be scavenged by exploiting a generative braking harvester at the knee, which can generate a lot of power than shoe inserts. The stretching of muscles or sound of a finger is also a source of energy which will be harvested using a nanowire nanogenerator [35] to provide low amounts of power.

V. ENERGY SCAVENGING FOR WBANs

In this section, various energy gathering interface circuits that want to power WBANs have been investigated. Classification of energy scavenging strategies as per the source types is analyzed. To compare different scavenging strategies, this paper focuses on energy gather circuits specifically for WBANs.

A. Thermoelectric Energy Scavenging for WBANs

Thermoelectric energy scavenging is one of the foremost promising gathering technologies to be utilized in WBANs since the material body will facilitate to form of a relentless temperature distinction between the hot and cold surfaces of TEGs. This kind of contact will offer a relentless temperature distinction between the material body and also the surrounding air [25]. It clearly states that having higher temperature differences between the surfaces will increase the potency of the TEG. Once the temperature distinction is low between the surfaces, the output voltage is low to be used in WBANs. In such cases, the output voltage is critical to be boosted to the required level. Also, increasing the quantity of TEGs will offer a higher output power. A thermal energy harvesting system has been planned by [32] to power a WBAN by using the build-in temperature of the human. The system has been designed to discover any falling event. An accelerometer device is employed to sense fall detection. The harvested energy is held on a capacitor to have the next energy that is critical to power the loads. Energy storage and unleash events are controlled by two MOSFETs. For charging the capacitance, each MOSFETs, Q1 and Q2, have been turned off to isolate the circuit from the RF load. Once the voltage level across the capacitance becomes 4.9V, the predetermined voltage level, Q1, and Q2 are turned on and thus the capacitance-voltage is discharged through the voltage regulator. The voltage of 4.9V is stepped all the way down to 3.3V by the transformer and transferred to loads for sensing and communication operations.

B. Piezoelectric Energy Scavenging for WBAN

Vibration or mechanical movement will be converted into electric power. A Piezoelectric transducer-based system is in [31] for the low-power respiratory watching system. It is reported that the system will be used as a wearable device around the chest employing a belt. The electricity transducer generates charge in response to the vibration caused by the respiratory. Then, the charge electronic equipment is employed to convert the generated charge into a voltage. For the convenience of transmission, the voltage is digitized and transmitted to a central server wherever respiratory information is monitored and keep. An impulse radio ultra-wide-band transmitter is employed for this transmission. Therefore, the respiratory information is collected effectively. Moreover, processing and wireless transmission of the respiratory information use the lowest resource due to the bespoken integrated circuit style. This different approach will be used in hybrid systems to form the sensing simpler wherever the rest of the circuit is highpowered by the opposite scavenging method.

VI. APPLICATIONS OF WBAN

WBAN is employed for several treatments and diagnoses the disease within the soma. Many researchers doing work on WBAN applications.The WBAN could be communication in, on, or around the human body taking into thought a low power device and operation, however, it's not restricted to the humans, it will serve a spread of application as well as medical like attention systems and non-medical like sports application, military application.

VII. FUTURE RESEARCH DIRECTIONS

Energy harvesting for powering WBAN nodes is still in its infancy. To completely exploit its potential, effective solutions should be projected to eliminate current challenges. Moreover, right smart research should even be centered on future applications. This article tends to currently highlight some future analysis directions.

A. Decreased Size and rising energy conversion potency

An uppermost issue in incorporating energy harvesting modules in WBAN applications is related to the scale and weight of detector nodes, which must retain compact to avoid any sort of discomfort or burden to the user. Most biomechanical and close energy harvesters lose their energy-generation capability once reduced in size. Thus, there's important got to develop solutions for increasing conversion potency without increasing a node's size and weight.

B. Actual Use of In Vivo Sources

The actual use of in vivo energy sources to power sensor nodes is kind of low, which limits its realization. The soma is advanced and fragile; implanting a physical node within the body will generate numerous issues, together with inflammation and clotting problems arising from blood vessel blockage. In-depth utilization and analysis can highlight the most limiting factors and alter more exploitation of in vivo sources.

C. Hybrid Solutions

Being passionate about one energy supply restricts the functioning and responsibility of a device node. To exploit the potential of energy harvesting, a fair analysis should be targeted at harvesting multiple sources at the same time. Doing this won't solely offer further power however will also improve responsibility.

VIII. CONCLUSION

Energy potency is one of the most important needs that has got to be thought of in WBANs. Therefore, there's abundant research that has targeted providing mechanisms to enhance the energy potency of WBANs, together with energy harvesting from completely different sources around the human body. In this paper energy gathering strategies in Wireless Body Area Networks are reviewed, as various sources for powering WBAN nodes. However, these strategies ought to be exploited as they're variable and time-dependent.

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