Resourceful Data Collection and Transmission Strategies for Wireless Body Sensor and IOMT Network under Delay Sensitive and Energy Conservations as Quality Factors

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1. Abstract

Rapid development in the area of communications through wireless sensor networks attracted more attention of scientists and researchers over the last few years. Wireless sensor networks have proved to be an equally valuable and novel platform for wireless communication and other areas of applications. The potential of wireless sensor networks proportionately deployed in the broader field of applications such as defense equipment, ecological and habitat monitoring, industrial process control, home automation, weather forecasting, health care system, traffic control, civilian applications, etc. Wireless sensors are small size devices equipped with radio transceivers and low power batteries. Typical features of sensor node include power, storage, and low-cost computational capability hardware. A wireless sensor network is intended to sense, collect, processes, and transmit event-specific information to accomplish a distributed domain task.

Moreover, wireless sensor networks are the type of systems where the resultant have based on sensor nodes cooperation. A wireless sensor network consists of a group of sensors or nodes

connected through a linked mechanism to accomplish a distributed sensing task. Wireless sensor networks deployed in the conditions are severe from the physical deployment point of view. The significance of scalability on the behavior of the application, MAC, transport, and physical layer performance are vital criteria of the contemporary research in recent past.

The critical constraint of the wireless sensor networks is a significant redundancy of data traffic in most cases because many sensing nodes can generate the same data while sensing.

The wireless sensor networks such as "wireless body area sensor networks" are a domain-specific and effective solution that has varied benefits in the healthcare domain. However, the challenge is about the efficient performance of such solutions with optimal efficiency. Due to certain intrinsic factors like many standards that are available, and also because of the need to detect the best solutions are based on application requirements.

However, the wireless sensor networks influenced by constraints such as impacts that are taking place from the wireless medium, lifetime of batteries. The other significant condition like the coexistence of systems among various other wireless networks that constituted in the proximity, delay in data collection, and repetitive attempts of data transmission in specific priority.

Hence, it is obvious to exploit such domain-specific constraints of the wireless body area sensor networks by enabling the data collection and transmission with the ability of fault-tolerant, delay tolerance, and utilize the available bandwidth and energy as efficiently as possible.

2. Introduction

Unlike traditional ‘wireless communication networks' like a cellular network, MANET, the ‘wireless sensor network' has intrinsic characteristics. It is an extremely active network and particular to the application; moreover, it has confined storage and has the capability of processing and energy. The work [1], [2], [3] presents that these characteristics create a highly challenging task for improving the routing-protocol. In many instances, different sources are pre-requisite for forwarding their data towards specified "base-station." And nodes which are close to sinking spend more amount of energy & therefore they die ultimately. Here, this will cause segmenting of the network; accordingly, the network lifespan gets lessened. This occurrence is called "energy hole problem [4]" or hotspots [5].

In network, for overcoming this issue, they utilized a mobile-sink (MS) [6], [7]. The work [5] presents that system through MS indirectly manages the load amid sensor-nodes and lessens the opportunity of the hotspots. It might assist in attaining the regular consumption of energy and extending lifespan. However, some issues are related to MS. The MS needed for sending its current location information along with its network. This procedure causes an essential consumption of energy overhead.

Additionally, the MS creates "sensor network" vigorous in the environment. Therefore, it will not be adaptable to identify the path routing former to its pre-requisite. Usually, in reactive-routing, the "end-end latency is maximum" that can contain the prerequisite of new data. And in "event-based application," the sensor data validity relies on its novelty. For optimizing end-to-end latency in delay-sensitive transmission, it is recommended to perform priority-based data transmission. The lag might impact several aspects such as routing-path accessibility, identified location of MS, "the presence of non-interference paths."

It noticed that "rendezvous-based methods" are appropriate for the applications of time-sensitive. They were able to lessen latency. Some of the instances of the applications of time-sensitive might be "intruder detection systems" for tracking the target, the security of the building, monitoring the health status of human and detection system of CO/ Smoke. In an environment of MS, the source node should wait till it receives the path routing for data transmitting. In "rendezvous-based routing," some of the predefined regions are given, where the source-node might interact. And in some methods like "line-based data dissemination (LBDD) [8]" and "grid-based energy-efficient routing [9]" the source-node will transmit the data aimed at rendezvous area, and nodes of the rendezvous might further send data towards sink, while in methods such as ring routing [10] and railroad [11], the source node will regain the current location of sink from area of rendezvous and transfer the information straightly to sink through an intermediate nodes utilizing "geographical based methods" [12], [13]. Initially, the "end-end latency" is minimum. However, it contains sufficient energy. The second kind of techniques are productive energies, yet cooperates with latency, which therefore motivates suggested "rendezvous-based routing protocol."

In this article, "Delay Sensitive Data Routing Optimization using Rendezvous Agents (DSDRO)" is suggested that addresses pre-requisite of fault tolerance, productive energy, low end-end latency, and priority scheduling. In DSDRO, the network area is virtually segmented into numerous regions and provides node as "rendezvous agent" of MS for the respective field. Every node of the region will interact with "rendezvous agent" of that area. The path is determined to MS, which allows for visiting these areas under different QoS factors. The model involved in "Delay Sensitive Data Routing Optimization using Rendezvous Agents" chooses specific regions and determines the sequence of areas which selected for visiting through MS. The chosen fields "rendezvous agents" from entire areas have to get a chance for reaching MS, whereas the MS is traversing via selected areas.

The works [1], [2], [3] contribute that the Wireless Sensor Networks with inbuilt features like extreme dynamic networkability, application specificity, restricted processing, energy, and storage capabilities tends to be a highly tall order task for developing a routing protocol which is in contrast to the traditional wireless communication networks such as MANET, cellular network. Mostly, for sending data to a particular database set, it uses various sources. And the nodes which are about to sink ultimately die because of extreme energy depletion and leads to network partition and subsequently diminish the lifespan of the network. i.e., hotspots [5] or energy hole problem [4]. For overcoming this issue [6], [7], the system uses a mobile sink, where such mobile sinking networks subtly stable the sensor nodes load a well as dwindles the hotspot chance [5] also supports for achieving even energy consumption as well as extends the lifespan of the network. Contrarily, the mobile sink has a few issues like the requirement of sending existing position information throughout the system, which leads to the significant overhead of energy consumption. Besides, adding a dynamic feature to the sensor network. Therefore, to identify the route path as per the demand is complex. There is an extreme end-to-end latency in reactive path routing that leads to compromise a need for new data. The sensor data validity in the application that base on the event depend on the data freshness; there is a utilization of delayed data. Hence, the end-to-end latency has reduced in the application that is on an event which will be the primary requirement. However, factors such as routing path accessibility, mobile sink location familiarity, non-interference paths existence affect the latency.

2.1 Problem Era in IOMT

According to the observations made, for the time-sensitive applications, the approaches based on the rendezvous most opt because these approaches can diminish latency. The communication through source node happens in the rendezvous-based routing after quantifying of the predefined area.

Wireless Area Networks became a demand for wearable devices and also wireless devices and solutions adapted in terms of medical, healthcare diagnostics. Also, in the process of communication, the related routing protocols have gained significant importance. Alongside positive developments, even challenges and complexities in handling such solutions are also rising to a great extent.

Many sources are contributing to improving the quality of data collection and transmission services. However, it is imperative that despite numerous models have evolved in terms of enhancing the operational efficacy; there are potential solutions that achieved from the process.

2.2 Research Scope

The objectives comprised by the contributions of this doctoral thesis handles a diverse range of traffic classes more efficiently through the transmission of the missing packets with high priority; multicast transmission that usually a sequence transmission in other contemporary models; and avoidance of the transmission complexity with minimal control packets. The avoidance of delay at controller due to transmission resource blockage is another crucial objective, which often occurs in condition. The active sensor of a node suddenly lost scope that fails to raise any acknowledgment to the controller that leads to pushing the node into a hanging state.

Congestion Control: Several mechanisms have been designed that use different aspects of the network to control congestion, and either actively or passively deal with it [14]. Packet loss is one of the most commonly used signs of congestion. Once a source sends a packet, it waits for a fixed amount of time for an acknowledgement from the destination by maintaining a timer at its end. If no acknowledgement is received within this duration, the packet is considered lost due to network congestion. Once a packet loss is detected, the congestion control algorithm in place takes charge to reduce the network congestion. Mechanisms that depend on packet loss to detect network congestion prove to be of no use in IoT networks because: (i) these mechanisms assume that a packet loss happens only due to congestion, which is not true for low power and lossy networks e.g., packet loss can happen due to link errors or poor signal strength [15], and (ii) delaying congestion response until a packet is lost deteriorates the performance since IoT packets usually carry small payloads and their retransmission is costly, causing additional delays [15]. Typically, the congestion control mechanisms are tightly coupled with TCP. The major concern is that TCP is not a defacto transport protocol for IoT applications [16], and hence, designing congestion control mechanisms for IoT applications is a non-trivial task, which has considered as one among the critical objectives of the proposed research.

Handling Trade-off between Energy Efficiency and Delay Sensitivity: Numerous studies have shown that event report delays and energy efficiency have a trade-off [17]. When a node needs to forward packets, all the nodes in its transmission range closer to the sink than itself are in the candidate forwarding set. In asynchronous sleep-wake cycling networks, nodes are randomly asleep or awake; therefore, the corresponding nodes are able to relay packets only when they are in the active state.

It can clearly be observed that the nodes available vary at different times. When a node must forward data and an available node is the closest to the sink, the one-hop transmission distance is the longest, but the information can be sent to the sink with fewer hops. In that case, the energy efficiency is optimal [18], [19], [20]. However, in most cases, the first available node is not the closest to the sink when the node needs to forward data. In this situation, the node transmits immediately as soon as any nodes are available. Although transmission delay is reduced using this scheme, it is difficult to guarantee that each hop will progress quickly toward the sink. Consequently, many more hops may be required to transfer the data to the sink. Moreover, the total delay is not always reduced, and the energy efficiency is not necessarily high. In contrast, when a node decides to wait for the optimal node to be active, which may make it to ensure greater forward progress and improve the energy efficiency. However, the per-hop delay is increased because of the extra waiting time; thus, the total delay can also be longer. Henceforth, the delay sensitivity and energy efficiency in IOT that are highly correlate and having high priority as research objectives in medical domain.

Edge Level Scheduling: To connect massively deployed IoT devices associated with a variety of smart-world applications and process the large volumes of data that IoT devices collect, the integration of edge/fog computing with target IOT network is vital. These IoT devices, which are wireless devices connected to a network of IoT gateways, transmit data in large volumes to edge computing nodes. The edge nodes then process data and send results to cloud datacenters. Particularly, medical domain real time streaming and sensitive data transmissions require the high rate of data transfer between the IoT devices and the edge/fog connectivity, must be reliable and efficient to fulfill performance requirements of the target applications. Concerning this, optimizing the scheduling process that prioritizes delay sensitivity and order of the data frames sourced from the Internet of Medical Things is another research objective along the aforesaid crucial objectives of the IOT networks of medical domain

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