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Quality of Services Support and Provisioning Issues Followed By RCSDN Algorithm in Wireless Sensor Networks

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Abstract

Wireless Sensor Network (WSN) is used by many applications such as security, command and control and surveillance monitoring. In all such applications, the main application of WSN is sensing data and retrieval of data. There are many WSN systems that are query based. They give responses in a stipulated time based on the user's query word. However, the WSN has possible sensor faults for it is not reliable and thus the network energy level goes down. It results in reduction of lifetime of network. To overcome the fault tolerance mechanisms can be used to improve reliability of the finding failure nodes and recovered by cluster heads.

In this paper, we assess the state of the art of Quality of Services (QoS) support in wireless sensor networks (WSNs). We also review the work being carried out in provisioning QoS in WMSN followed by some open research issues.

1. Introduction

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to *monitor* physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling *control* of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

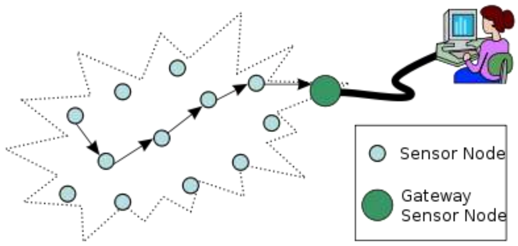

Figure 1: Typical Multi hop WSN Architecture

Of late Wireless Sensor Networks (WSNs) became popular for many applications such as industrial space, military and security. Mostly they are used in surveillance monitoring and security applications. The WSN is of two types basically. They are known as query based WSN and source-driven WSN. Data flow in WSN is the basis for the classification. In the former data transmission is initialized by sensor while in the latter, the data transmission is the result of user query. Strict QoS requirements are associated with user-based WSN and also expect best conservation of energy. User query is targeted to select sensor only. Query processing with completely satisfying QoS requirements is a challenging problem. Recently it has been addressed mostly. The solution is generally applying redundancy. In this paper we are interested in applying redundancy not only for satisfying QoS requirements but also timeliness and reliability requirements in case of query based WSN. The proposed system also aims at increasing lifetime of network besides satisfying QoS requirements by using optimal redundancy level. In order to achieve this, we use both path and source level redundancy. The algorithm proposed by is known as AFTQC (Adaptive fault Tolerant QoS Control). It is meant for achieving QoS requirements and also ensuring conservation of energy in WSN.

It is well known that QoS is an overused term with various meanings and perspectives. Different technical communities may perceive and interpret QoS in different ways. In the application communities, QoS generally refers to the quality as perceived by the user/application while in the networking community; QoS is accepted as a measure of the service quality that the network offers to the applications/users. For instance, RFC 2386 characterizes QoS as a set of service requirements to be met when transporting a packet stream from the source to its destination. In this scenario, QoS refers to an assurance by the Internet to provide a set of measurable service attributes to the end-to-end users/applications in terms of delay, jitter, available bandwidth, and packet loss. These two QoS perspectives can be demonstrated via a simple model shown in Fig. 2.

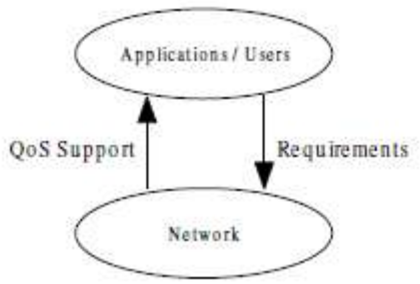

Figure 2: A Simple QoS Model.

In this model, the application/users are not concerned with how the network manages its resources to provide the QoS support. They are only concerned with the services that networks provide which directly impact the quality of the application. From the network perspective, the network's goal is to provide the QoS services while maximizing network resource utilization. To achieve this goal, the network is required to analyze the application requirements and deploy various network QoS mechanisms.

QoS requirements in traditional data networks mainly result from the rising popularity of end-to-end bandwidth-hungry multimedia applications. Different multimedia applications have different QoS requirements expressed in terms of end to-end QoS parameters. The network is thereby required to provide better services than original best effort service, such as guaranteed services (hard QoS) and differentiated services (soft QoS), for end-to-end users/applications. The researchers in the literature have pursued end-to-end QoS support using a large number of mechanisms and algorithms in different protocol layers while maximizing bandwidth utilization. At the same time, different types of networks may impose specific constraints on the QoS support due to their particular characteristics.

For example, the bandwidth constraint and dynamic topology of mobile ad hoc networks make the QoS support in such networks much more challenging than in others. However, QoS requirements generated by the applications of WSNs may be very different and traditional end-to-end QoS parameters may not be sufficient to describe them. As a result, some new QoS parameters are desired for the measurement of the delivery of the sensor data in an efficient and effective way. Further, by measuring these parameters, network designers are also able to investigate which QoS architecture or mechanism can be exploited to provide QoS support for the applications.

2. Traditional Data Networks QoS

Supporting QoS in wired networks can generally be obtained via the over-provisioning of resources and/or traffic engineering. With the method of over-provisioning, we add abundant resources in the network so that it can provide satisfactory services to bandwidth-hungry multimedia applications. This method is easy to realize but all the users are served at the same service class. Therefore, the service may become unpredictable during peak traffic. In the method based on traffic engineering, we classify our users/applications in service classes and assign each class a different priority. In the literature, two approaches based on traffic engineering are exploited to achieve QoS, i.e., reservation-based and reservation-less approaches. In the reservation-based approach, network resources are assigned according to an application's QoS request and subject to bandwidth management policy.

This is employed in Asynchronous Transfer Mode (ATM) and is also the approach of the Inter server model in the Internet. In the reservation-less approach, no reservation is required. QoS is achieved via some strategies such as admission control, policy managers, traffic classes, and queuing mechanisms. Admission control strategy decides if a node can access the network and guarantees that once the node obtains the permission, it will be served with the QoS it is requesting. Policy managers ensure that no node will violate the type of services it is pre-assigned. Traffic classes differentiate the priority of data packets and they thereby achieve a particular per-hop behavior at each intermediate node. Queuing mechanisms are responsible for dropping the packets with lower priority in the case of congestion. This approach is well known as the approach of the DiffServ model in the Internet. Infrastructure-based wireless networks, such as Wireless Local Area Networks (WLANs) and Broadband Wireless Access Networks (BWANs), are the extension of wired networks, so that the connections can be extended to mobile users. All mobile hosts in a communication cell can reach a base station in one hop. QoS challenges in this context mainly arise from the scarce bandwidth and the complexity of user mobility during the last wireless hop. Thus, it is intuitive for us to integrate the QoS architecture deployed in wired networks with wireless MAC protocols. Wireless MAC protocols may provide data traffic of differentiated classes with corresponding access priorities over the shared wireless medium so that the overall QoS can be supported.

Wireless ad hoc networks can be regarded as an autonomous system or a multi-hop wireless extension to the Internet. As an autonomous system, it has individual routing protocols, while as a multi-hop wireless extension to the Internet, it is required to provide a seamless access to the Internet. Unfortunately, QoS mechanisms used to support QoS in wired data networks cannot be directly applied to ad hoc networks because of the bandwidth constraint and dynamic network topology. In this context, we are required to implement complex QoS functionality with limited available resources in a highly dynamic environment. In the literature, QoS Support in ad hoc networks includes QoS model, QoS resource reservation signaling, QoS routing, and QoS Medium Access Control (MAC). A QoS model specifies an architecture and impacts the functionality of other QoS components. For instance, if the network is only required to provide differentiated services, signaling for every flow state is unnecessary. QoS signaling, the functionality of which is determined by the QoS model, acts as a control center in the QoS support system. It coordinates the behavior of QoS routing, QoS MAC, and other components. The QoS routing process searches for a path with enough resources but does not reserve resources, which enhances the chance that resources can be assured when QoS signaling needs to reserve resources. Without QoS routing, QoS signaling can still work but the process of resource reservation may fail. All upper-layer QoS components are dependent on and coordinate with the underlying QoS MAC protocol.

Based on the above discussion, we can draw the following conclusion about QoS support in traditional data networks. They have common QoS requirements, which come from bandwidth-hungry multimedia applications. The same end to- end QoS parameters are exploited to evaluate the QoS mechanisms in these networks. The research models, such as Interserv, Diffserv or mixed models, do not experience much change. However, the specific techniques to realize QoS support are diverse because of the unique properties of underlying networks. Generally, QoS support is becoming more and more challenging due to our increasing desire for the connectivity to exchange information of the best quality at any time, at any location, and by any manner.

3. QoS Provisioning issues in WMSN

In this section we will discuss various QoS issues in network layer in WMSN and explain the reasons for the failure of traditional QoS models in WMSN.

3.1 QoS Challenges and issues in WSN

Wireless Sensor Networks differ from traditional wired Internet Infrastructures and Mobile Ad-Hoc Networks. The differences introduce unique issues or challenges for supporting QoS in wireless sensor networks. Approach for provisioning QoS in sensor networks is not fixed. It changes according to the application. Some of the major challenges/ issues that make provisioning QoS in sensor networks different from Traditional Networks are discussed below:

- **a.** Severe Resource Constrained
- **b.** Data- Centric
- **c.** Node Mobility
- **d.** Heterogeneous Traffic
- **e.** Packet Criticality
- **f.** Scalability

Wireless sensor network is a new member of wireless data networks family with some specific characteristics and requirements. A generic wireless sensor network is composed of a large number of sensor nodes scattered in a terrain of interest. Each of them has the capability of collecting data about an ambient condition, i.e., temperature, pressure, humidity, noise, lighting condition etc., and sending data reports to a sink node. Since there exist many envisioned applications in WSNs and their QoS requirements may be very different, it is impossible for us to analyze them individually. Also, it is unlikely that there will be a "one-size-fits-all" QoS support solution for each application. However, since our focus here lies in QoS requirements imposed by the applications on the network, we can initially separate QoS requirements using other perspectives from the networking perspective. As we demonstrated in Section, different communities may interpret QoS of WSNs in different ways. For example, in applications involving event detection and target tracking, the failure to detect or extracting wrong or incorrect information regarding a physical event may arise from many reasons. It may be due to the deployment and network management, i.e., the location where the event occurs may not be covered by any active sensors. Intuitively, we can define coverage or the number of active sensors as parameters to measure the QoS in WSNs. In addition, the above failure may be caused by the limited functionality of sensors, e. g. , inadequate observation accuracy or the low reporting rate of sensors. We can thereby define observation accuracy or measurement errors as parameters to measure QoS. Further, it may be induced by information loss during the delivery. We can also define some information transportation related parameters to measure QoS. However, our separation of QoS perspectives is not absolute since a common application requirement such as the performance measure associated with event detection may involve all of them. Our purpose here is to focus on how the underlying network can provide the QoS to applications, in terms of which parameters we can map application requirements into the network infrastructure and measure the QoS support accordingly. For this purpose we describe two perspectives of QoS in WSNs:

A. Application-specific QoS
B. Network QoS
C. Event-driven
D. Query-driven

3.2 QoS Requirements in WMSN

Every application has certain service requirements from the network. These requirements are called its expected Quality of Service (QoS). QoS in wireless sensor multimedia networks can be defined from three perspectives: timeliness, reliability & energy. By timeliness we mean delivery of data within some specified time interval i.e., QoS parameters measured are delay, jitter, throughput etc. Reliability means delivery of accurate data with minimum loss. QoS parameters are packet loss, accuracy & coverage. By coverage we mean number of sensor nodes required to get the full information about the area of interest and accuracy is the measure of discrepancy between actual sensed data and data as received by the user. Energy as QoS metric means node that maintains desired energy level could be used to forward data.

The algorithms designed for provisioning QoS in wireless sensor networks can be single objective that is based on one parameter or it can be multi objective that is based one more than one parameter. Optimizing multiple QoS parameters while preserving network resources is a complex problem.

3.3 QoS Routing Protocols

Routing Protocols developed so far aims at efficient usage of energy in order to increase the network lifetime. Very few protocols are being developed which satisfies QoS parameters while routing data from node to sink. Some of them are described below:

- Sequential Assignment Routing Protocol
- (SAR)
- SPEED
- Energy-aware QoS routing protocol
- MMSPEED
-

4. Newly Presented Algorithm RCSDN

RCSDN is created based on rounds in which each round contains two phases:

(1) set-up and
(2) steady-state.

In the Set-up Phase, the CHs are determined and the cluster structures are formed. In Steady–state Phase the nodes send the data they've received from the environment to the corresponding CH and after gathering data in the cluster head, data will be sent to the BS. In the beginning of each round all of nodes have a normal state. The Set-up Phase in RCSDN starts by sending a start message via BS with a specified range to the environment. After a node receives the start message from the BS, it provides a relative estimate of its distance from the BS through the intensity of the received signal. Then it broadcasts a message for its neighboring nodes including ID, the distance to BS, and the level of remaining energy. Nodes bound in the radio range of this message, receive it and set this node as a neighbor node, and register its ID and energy level in their memory; again they proceed to estimate their distance with the neighboring node by calculating the intensity of the received signal and finally calculate their distance from the BS. This is the done by all nodes in the network and all nodes will acquire the ID, level of energy and distance of all neighboring nodes.

In RCSDN we use a local threshold detector (T_D) so that only nodes having selection conditions participate in competition for selecting CH. This threshold detector is locally calculated in each node to prevent the lack-of-candidates problem in some areas because of the central selection. The following qualification function is used to prevent this problem:

Algorithm 1 CH selection and cluster formation

$state(S_i)$ = normal
calculate $T_D(S_i)$
if $E_{re}(S_i) \geq T_D(S_i)$
  $state(S_i)$ = candidate-CH
end if
Initialize T
While (($state(S_i)$ = candidate-CH) **OR** ($state(S_i)$ = normal)) **AND** (timer < T))
  if (($state(S_i)$ = candidate-CH) **AND** ($\forall S_j \in S_n(S_i) \mid E_{re}(S_i) > E_{re}(S_j)$))
    $state(S_i)$ = CH
    broadcast a CH($Id(S_i)$) message
    break
  end if
  if ((received a CH($Id(S_j)$) message) **AND** ($S_j \in S_n(S_i)$))
    if ($state(S_i)$ = normal)
      $state(S_i)$ = cluster-member
      $CH(S_i) = S_j$
      break
    else if ($state(S_i)$ = candidate-CH)
      $state(S_i)$ = cluster-member
      $CH(S_i) = S_j$
      broadcast a Abort ($Id(S_i)$) message
      break
    end if
  end if
  if ((received a Abort ($Id(S_j)$) message) **AND** ($S_j \in S_n(S_i)$)
    $S_n(S_i) = S_n(S_i) - S_j$
    recalculate $T_D(S_i)$
    if $E_{re}(S_i) \geq T_D(S_i)$
      $state(S_i)$ = candidate-CH
    end if
  end if
end while
if (($state(S_i)$ = candidate-CH) **OR** ($state(S_i)$ = normal))
  $state(S_i)$ = CH
  broadcast a CH($S_i.Id$) message
end if

5. Conclusion

Few efforts have been made in the research field of QoS support in WSNs so far. In this survey paper, we analyzed the QoS requirements imposed by the main applications of WSNs, and we claim that the end-to-end QoS concept used in traditional networks may not be sufficient in WSNs. Some Non end-to-end collective QoS parameters are envisioned due to this significant change. Further, we list many challenges posed by the unique characteristics of WSNs and report on the state of the art in terms of a few current research efforts in this field. Finally, we are convinced that the QoS support in WSNs should also include QoS control besides QoS assurance mechanisms, and some exciting open issues are identified in order to stimulate more creative research in the future.

In this paper we have presented a new algorithm to form clusters in sensor networks. The formation of optimal clusters plays an important role in increasing the lifetime and reliability of the network. With multiple simulations we have shown that the RCSDN can distribute clusters in an almost balanced manner in the network.

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