Key technology analysis of wireless sensor networks networking

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Abstract

This paper studies the networking mode of heterogeneous network in wireless sensor network and put forwards the hierarchical and distributed networking architecture suitable for large-scale heterogeneous wireless sensor networking. This structure achieves the unification of heterogeneous sensor network networking without changing the existing sensor network internal networking mode. By LBA addressing algorithm, we can convert the address-based addressing mode to content-based addressing mode by the map between label and address. The result shows that LBA is more suitable for large-scale WSN addressing requirements in hierarchical structure.

Keywords: wireless sensor, network networking, resource addressing, network deployment

1 Introduction

Wireless sensor network is a data collection network system is combined by a large amount of sensor nodes with computing power and communication capability deployed in examination areas and connected by wireless self-organizing manner. The nodes percept, collect and manage the information of monitoring objects in examination areas and sent it to the observers. Wireless Sensor network (WSN) is an integrated system collected by information collection, transmission and management, which now is wildly used in environment monitoring, urban traffic, medical treatment, smart home, military defence, space exploration etc. With the ever-growing of Internet of Things application, the need to integrate WSN networking size with heterogeneous network is more and more urgent. WSN needs new technical supports in networking mode, resource addressing, networking deployment and energy conservation. Generally, WSN doesn't need basic network devices. It can be regarded as a special multihop self-organizing network, and a large number of network nodes and the complex application environment make the self-organizing network more complex. From the perspective of WSN, this article discusses and researches the key technology of large-scale heterogeneous network and resources addressing.

2 Networking architecture study of wireless sensor networks

2.1 ARCHITECTURE DESIGN OF HIERARCHICAL DISTRIBUTED NETWORK

In the existing WSN techniques, different sensor networks is with different networking architectures and communication modes, like ZigBee, Wi-Fi, Bluetooth etc. however, with the development of WSN techniques, especially the wild use of Internet of Things, the requirements for networking of WSN is more and more high. Therefore, the gradualism of network deployment and isomerism of network is needed. Multi-aspects factors need to be considered, like communication technology, network structure, protocol hierarchies etc. to design WSN architecture supporting heterogeneous incremental deployment. As for large-sale sensor network, planar construction can restrict the network extension and flexible access, which is unfit for networking architecture. Hierarchical structure becomes the first choice of large-scale architecture because of the favorable extendibility. Figure 1 shows the network architecture of hierarchical distributed large-scale heterogeneous WSN.

To achieve the smooth access of heterogeneous WSN, this level require nothing for the communication system and networking mode of the existing sensor. In the traditional network, sensor nodes pass on the information to sink node by hop or multi-hop. In this construct, sensor subnets transfer the sensing information to sink node still by their own network mechanism. This sink node is a node up one level and the transmittal mode doesn't change for the sensor subnets, which will not influence the original networking mechanism of the sensor subnets.

Considering that the sensor network can interconnect by Internet or other private network, we adopt the method of gateway to achieve external interconnection to make the interconnection with universality. As shown in Figure 2, application gateway provide outside with the abstract and image of sensor network application model and the specific networking technical details of the interior shield to achieve the versatile interconnection effect. When the sensor network scale is relatively large, the application is relatively complex and operational capacity is relatively high, application gateway can adopt autonomous devices, on the contrary, the application can integrate with sink or the logical application gateway constituted by several sinks.

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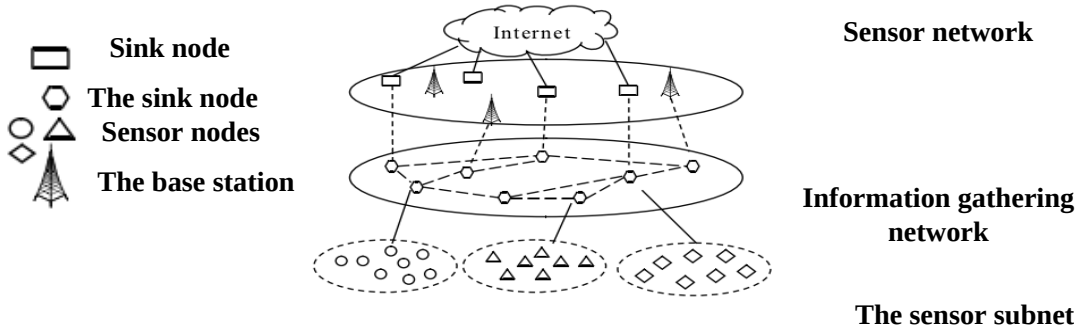

FIGURE 1 Framework of hierarchical network

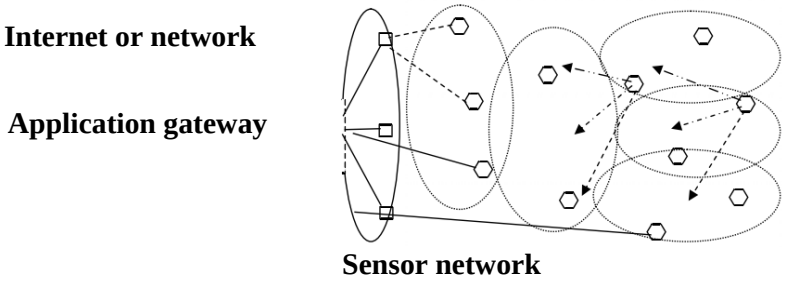

FIGURE 2 Structure of sense access network

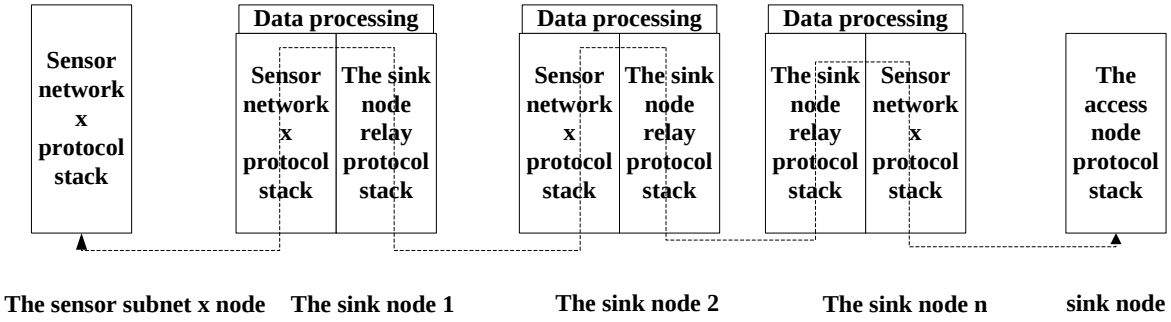

FIGURE 3 Data transmission process

2.2 PROTOCOL ARCHITECTURE DESIGN

In order not to affect operating mechanism of the existing sensor subnet, the nodes inner the sensor subnet have the protocol stack according with each communication standards. The aggregation nodes need support the communication of the following subnet as well as the network communication between aggregation nodes, thus the multi-protocol stacks are needed. From the perspective of compatibility, the protocol stack of aggregation nodes should include full protocol stack of each sensor subnet. The aggregation node gets the sensor subnet data from the application level and package into the TCP/IP protocol stack required pack to transmit to other aggregation node after fusion deposal. All the transmissions between the aggregation nodes follow TCP/IP protocol. When arriving at the target aggregation node, the target aggregation node will encapsulate the data into the corresponding sensor subnet protocol stack required data format in application level and send it to the access point. Figure 3 shows the process of the data collection in the nodes of sensor subnet x delivering to sink node after passing several aggregation nodes. Sensor message is sent out from the nodes in sensor subnet x, and submitted to the nearest aggregation node 1, which receives data from the corresponding physical interface. After the analysis of the protocol stack of complete corresponding sensor subnet x, the data are processed in application level and package into the aggregation node protocol stack required packet format and transmit between the aggregation nodes. The aggregation nodes adopt independent protocol stacks. After arriving at the target aggregation node n, the data are

converted into the protocol stack packet format of the corresponding sensing subnet x in application level to send to sink node. Sink node shares the same protocol stack with sensing subnet x.

3 Hierarchical-structure-based wireless sensor network addressing algorithm

3.1 LBA LABEL ADDRESSING ALGORITHM

For the large-scale Internet, address-based addressing mode completes the transformation between resource objective and address at the user side. Data addressing process is a resolving process from resource name to resource address. Define the WSN resource name as R, the resource address as D, then the name space of resource name and resource address in N level is:

$$NameSpaceRN=\{R1,R2,\ldots,Rj,\ldots,RK\} \quad (1)$$

$$NameSpaceDN=\{D1,D2,\ldots,Dj,\ldots,DK\} \quad (2)$$

Define the addressing function of WSN as unary function AS, then the addressing function in N level is:

$$NameSpaceDN=ASN(NameSpaceRN) \quad (3)$$

$$Ri=Rj\rightarrow ASN(Ri)=ASN(Rj) \quad (4)$$

The hierarchical iteration model of WSN resource addressing can be expressed as:

$$NameSpaceD=AS(NameSpaceR) \quad (5)$$

The name space of resource name can be transferred into the name space of resource address by some addressing function, which can be regarded as mapping function. This mapping function can be one-to-many as well as some resource name to a group of resource addresses.

Sink node is on the Internet and can be accessed directly to by the main engine of internet. Thus Global IP Address should be configured. Although the number of Sink node is relatively small, we need adopt DHCP to allocate IP address automatically considering the large-scale support. Because the aggregation node is function node, it doesn't need to be visible for the main energy of the Internet. This is different from Sink node. Aggregation nodes only need to configure intranet IP address.

We need to encode the known business information type to achieve content-based addressing. This encoding is called label. The data passing aggregation node and sink node will be marked by this label. Aggregation node and sink node will add a label region before the data and the length of the label region depends on specific coding rule. Label coding comes from the label sever in the Internet, on which there are label coding address mapping table, as shown in Table 1. This table contains the corresponding label coding of different businesses and mapping relation between label and sink IP address, among which the mapping between label and sink IP address is achieved by constant registrations from the collected data label type to label sever.

TABLE 1 Label encode address mapping table

The type of business	Label	Sink
Business 1	Label1	1
Business 2	Label2	2
…	…	…
Business n	Labeln	n

3.2 LBA ALGORITHM

In the whole system, both the node and data have address, but the two address type is different. LBA addressing mechanism achieves the business-based addressing mode by achieving the map between the two addresses. Two periods are included in LBA addressing mechanism: the initialization phase and data addressing period. Figure 4 shows the general flow of the two phases.

LBA addressing is accomplished on the Sink level. As long as there are the aggregation node data on the sink node, we don't need to address to the level of aggregation node. Only before the aggregation node reports the data to sink node, there will be a request, at which time the Sink node will address to the next level, namely the aggregation level. Thus, LBA addressing mechanism generally has a swift response and the request cost is relatively small.

4 Analysis of simulation results

We compare the LBA addressing, the Address-Based Addressing, ABA mechanism and the content-based DD, CBP mechanism in simulation. We mainly compare the response time and delay variation of different search request, response time and massage submitted rate in different scales etc. ABA mechanism adopts the broadcast addressing mode. We use grid topology to layout 100 sensing nodes, 9 aggregation nodes, 4 sink nodes in the 1200m×1200m simulation area. Three kinds of business is contained in this area: temperature, humidity and illumination. Sensing subnet adopts ZigBee networking and aggregation network adopts AODV routing protocol. The user generate 30 times request task, requesting the value of temperature, humidity and illumination in different areas and record the response time and delay variation of the 30 times search request.

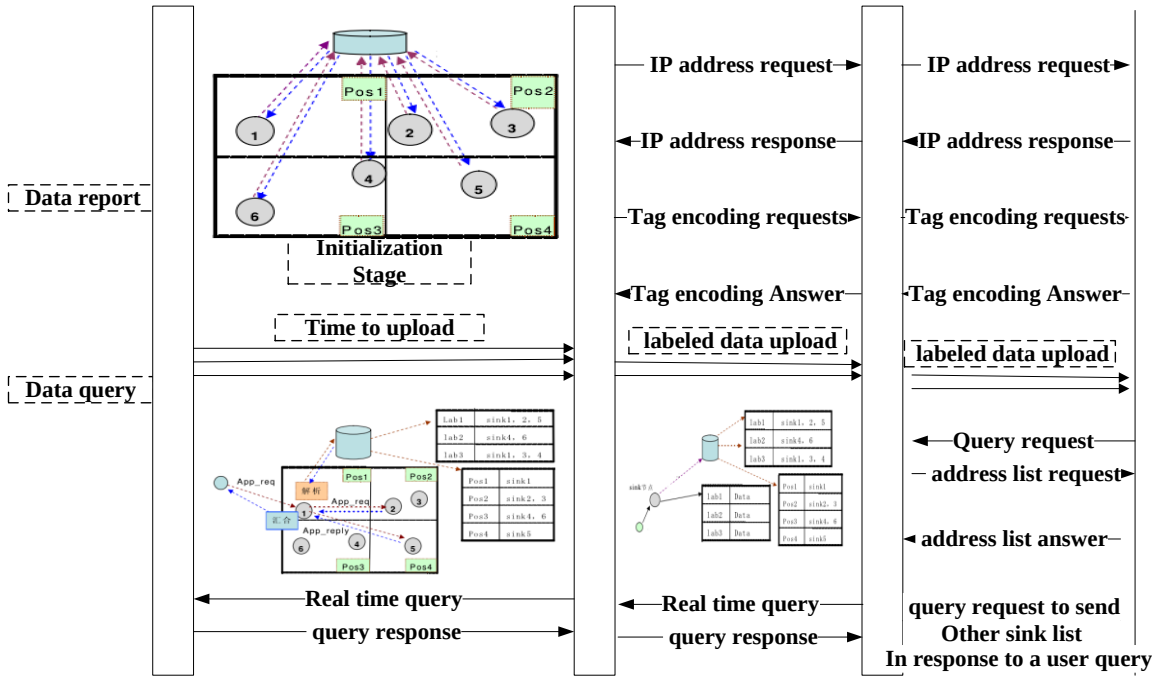

FIGURE 4 LBA addressing process

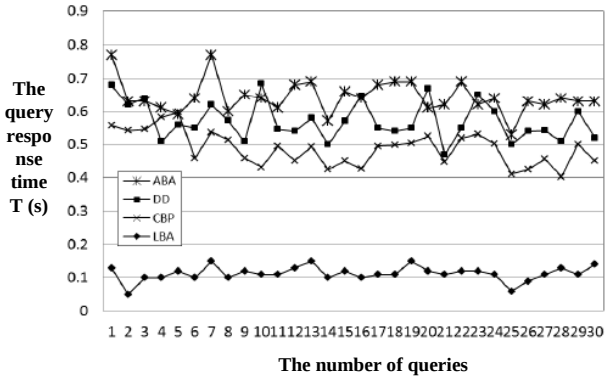

FIGURE 5 Inquire response time and delay variation

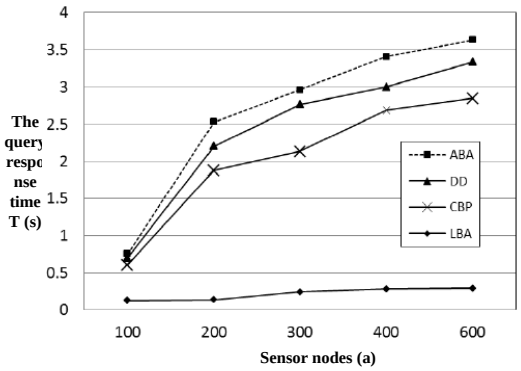

FIGURE 6 Response time in various scale

Figure 5 shows the response time comparison of appointed business types of several different addressing schemes. The simulation result is the response time in the 30 times different request conditions. The general response time of DD and CBP is relatively short comparing to ABA because DD and CBP build reverse route. Because that LBA isn't broadcast query and will not generate a large amount of broadcast message and it will only inquire to the sink level, the response time is relatively short. For the network with 100 sensing node, the response time of LBA is the 1/3-1/5 of several other algorithms. In addition, from the perspective of delay variation, the delay variation of LBA is relatively small because it is not affected by broadcast message, which means the response time is relatively stable (see Figure 6). The curve fluctuation of the other three addressing algorithmic is relatively large.

We can see from the chart that with the enlargement of network size, the response time of ABA, DD, CBP show significant growth, and the response time of LBA shows a little change. The influence of response time delay is large too. When the network scale is 100 sensing nodes, the response times of three other algorithms are 3-5 times of LBA; when the network scale is 600 sensing nodes, the response times are 7-8 times of LBA. All these mean that LBA is more suitable for large-scale network application.

Figure 7 is the message submitted rate comparison of several addressing mechanism. From the figure we can see that with the enlargement of network scale, LBA always keep relatively high message submitted rate. When the network scale is with 600 nodes, LBA still can keep message submitted rate more than 80% and message submitted rates of the others drops significantly with the enlargement of network scale.

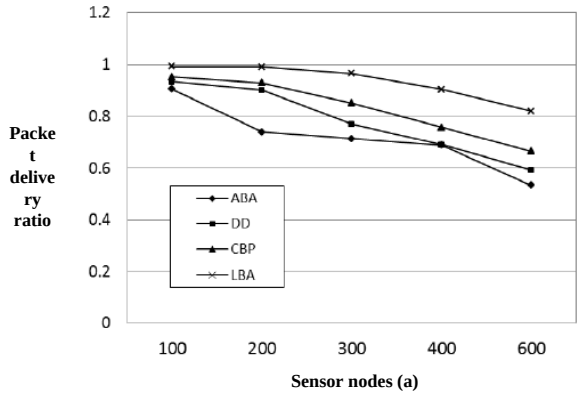

FIGURE 7 Message submitted rate

5 Conclusions

Based on WSN hierarchical structure, we design a business-content-based LBA addressing scheme, which distinguish data with business label to form the map between node addresses and label addresses, not destroying the addressing strategy of existing node but addressing according to business content. We simulate three kinds of addressing mechanism: DD, CBP, LBA, to compare the inquiry operating lag and massage submitted rate etc. The result shows that LBA is more suitable for the hierarchical structural large-scale WSN addressing requirement. However, further study is needed as to how to achieve efficient business encoding and the distributed storage of data.

Acknowledgments

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