

Design of the Cognition-based Across Applications Resources Scheduling Scheme for Wireless Sensor Networks

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Abstract. For coping with the problems such as network coverage shrinking or network energy holes, the wireless sensor networks import kinds of functions to perform the intended business thing. Therefore, one network node with limited resources has to support many functions. At present, researchers mostly design and evaluate a solution as a unit with only a particular problem. This paper provides a new solution which makes various functions to be optimally combined and worked together. It proposes a cognition-based across application resources scheduling scheme to resolve the previous problem.

Introduction

Wireless sensor network (WSN) is a dedicated network consisting of many small volumes, low cost and resource-constrained nodes [1]. The nodes in WSN are scattered randomly and formed a network in self-organizing style. Nodes measure environmental physical features with built-in sensors to describe the circumstances comprehensively. It makes the real-time monitoring, information collection and analysis possible. The prospect of WSN applications is very extensive. Therefore, there are many application projects based on WSN.

Due to limited energy, unattended employment and self-organization, there are a lot of problems such as network coverage shrinking, network energy holes, network attacking etc. For coping with these problems, WSN need to import kinds of functions or applications to avoid the network coverage shrinking or network holes and extend the network lifetime. That makes a resource-constrained platform support too excessive functions. The present reviews mostly aim at one problem to design the solution and evaluate the availability with single situation. The shortcoming of these solutions is that they cannot optimize working together when they are combined with one node. It brings WSN node a very heavy workload and impact the network lifetime.

Energy is the pivotal resource in WSN. The energy control and low-energy design has become an important research field. With the analysis of energy distribution, the communication process uses the highest unit consumption of energy. The higher energy consumption processes include channel detecting, communication conflict, data sending and data receiving [2]. So there are many solutions that use effectively process and reduce communication to make the energy consumption lower. Literature [3] proposes the duty cycling concept to manage the switching of two states between node active and node hibernation. It makes node hibernate as long as possible to save energy and prolong the network lifetime.

The redundant data will increase the energy consumption of calculation and communication, so we should control data receiving and reduce data size when data reading is beginning. Use the “in-networking processing” or data compression technology to reduce data size in the wireless communication and make energy consumption lower. Literature [4] studies the method of controlling energy consumption in data sampling process. Literature [5] analyses the present solutions of data aggregation and data fusion. After composite analysis of the literatures, we find the present researches mostly aim at a certain application to control the energy consumption to adapt the node

resource-limited situation. The study of overall energy consumption control when a node running kinds of functions is very defective.

This paper studies the key technology of cognition-based across application resource schedule. According to the theory system, the main research content is context awareness and intellectual learning application. How to control the energy consumption is also a primary research direction. The cognition-based network can perceive the external environment and adjust the internal configuration in real time.

W.Thomas gives the concept of cognitive network: A cognitive network has a cognitive process that can perceive current network conditions, and then plan, decide and act on those conditions [6]. Because of the advantage of cognitive network, it becomes the research focus at present. Existing literatures mainly concentrate on these aspects: Literatures [7-8] study the network architecture, literature [9] researches the network theory, and literatures [10-14] study the QoS applications. The researches of cognition-based method in WSN are still in the early stage.

Problem analyses

The solution of this paper is to abstract the basic functions of various applications. Then integrate these functions to a “data center” unit. The goals are:

- Save the storage;
- Provide the chance of integrating communications between various applications;
- Make it possible to share data with various applications.

Our basic idea is that the data center provides the services of calculation, storage and data request. Then applications don't need to run the calculation or communication tasks. The data center will maintain the time-efficient data according to its own logic. In this way, various functions or applications can work together optimally when they are combined in one node.

Base on the previous analyses, the solution directed at one application caused some problems. At first, the discrete development will lead to that various applications have their own data package structure and nodes hibernation/active schedule. Secondly the communications between WSN nodes are mostly from adjacent nodes, that brings repeated communications. For example, we assume that WSN nodes preset energy-aware algorithms include energy-aware routing and energy-aware data integration. For the node A, its energy-aware routing function wants to know the environment energy distribution, and then it will initiate a communication to its neighbour node B to request the energy state information of node B. As well its energy-aware data integration function also wants to know the environment energy distribution, so this function will initiate a communication to node B too. That brings the repeated communications. For increasing the information efficiency of various applications, we should resolve these three questions:

- The message reuse and decomposition;
- The data sharing of various applications;
- The services provision mode (design of application program interface).

Design of cognition-based across application resource schedule

According to the analyses of the second part, we propose the solution of cognition-based across application resource schedule.

Construct a scheduler of calculation, storage and communication service based on hardware and basic driver software. The scheduler provides the resource schedule service to the upper application. There is a framework which supports for increasing the resource usage efficiency.

Base on the framework of resource schedule scheme, the major research content is how to make the individual design functions to work together optimally after they are combined in a node. The research of this paper will focus on the resource planning when all kinds of applications are coexisting.

The framework of resource schedule scheme is shown as figure 1.

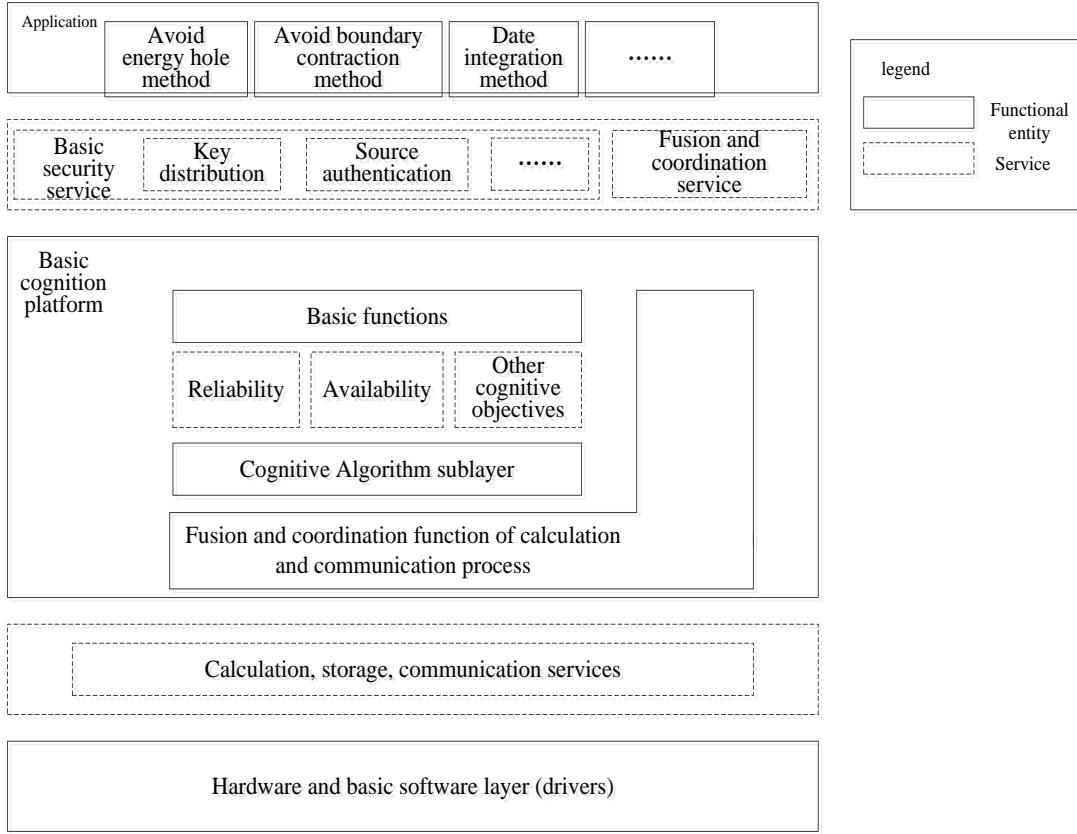


Fig.1. Cognition-base resource schedule scheme framework.

The core of calculation, storage and communication services scheduler is how to find the sharing data between various applications. According to applications analyses, we find the application function is composed of data (collection) and data processing (calculation method). These two factors determine the difference of various applications. The data in WSN is relatively stable and the data processing mode is changed from applications requirement. Then it is easy to find the sharing data but hard to find the sharing data processing mode in WSN. So the resource schedule will set about doing these two technical routes as follows.

1) Message reuse and decomposition.

For reducing the active time of wireless function unit, we can reuse the applications data according to the destination node address. For example, there are three applications A, B and C. The data destinations of them are both the same node. The message reuse and decomposition of these three applications is shown as figure 2.

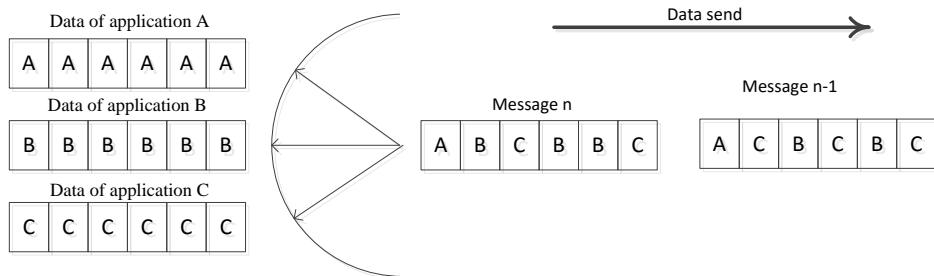


Fig.2. Three applications messages reuse and decomposition.

The key point of message reuse and decomposition is the design of reuse mode. The decomposition is just the opposite process of reuse, and then running the reverse operation according to the reuse rules. There are two key issues to be resolved: the method of scheduling wireless communications of various applications and the concrete method of reusing message.

The applications wireless communications schedule means that the application can't launch the wireless communication by itself. All of the data receiving and sending in wireless communications

should be launched by resource scheduler. The scheduler can control the interfaces of wireless communications and collect the data of various applications. It can reuse the message according to the marked data boundary or message structure.

The research procedure is as follows:

- Research the mechanism of scheduling various applications wireless communications. Mainly includes: time-critical communication schedule, time-uncritical communication schedule and the mechanism of returning data to applications;
 - Research the method of message reuse and decomposition;
 - Research the service delivery of message reuse and decomposition;
 - Evaluate the research result.
- 2) Data sharing of across applications resources.

The data center provides data sharing service of across applications. The applications obtained data through wireless communication before, but now the data center has stored the data as its local data. It maintained data time-efficient through its scheduler. In this way, we can share data with various applications and avoid repeated communications. The overall system resources can be used optimally.

The flow diagram of across applications data sharing is shown as figure 3.

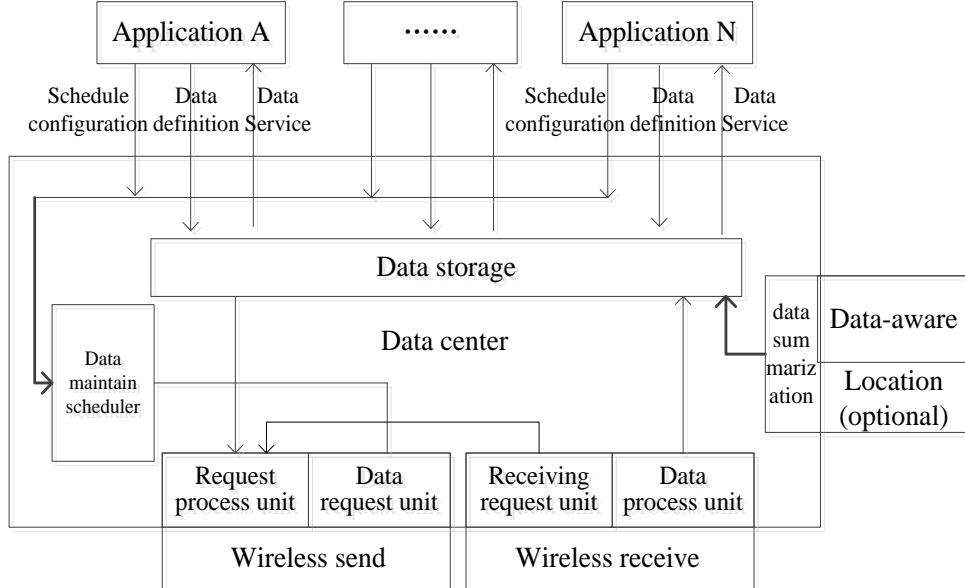


Fig.3. Flow diagram of across applications data sharing.

The each part of flow diagram is explained as follow:

The data scheduler will send the data request regularly to maintain the time efficiency of applications data. It can setup the schedule for all applications. The parameters for scheduler are shown as table 1.

Table.1. Table of data maintaining schedule.

Application serial number	Interval/min
1	160
2	200
3	120
4	60

The data storage is used for data cache and history data accumulation. There are two data sources: the network (mainly the data from neighbour nodes) and the nodes (the data from sensors, locators and power checked circuits).

The function unit of request process takes charge of processing the request from neighbour nodes in the WSN. It will return its local data to the request node.

The function unit of data request is controlled by the scheduler to send the data request to neighbour nodes. The request data is irrelevant to applications.

The function unit of receiving request takes charge of receiving request and invokes the request process unit to handle the request data.

The function unit of data process is used to process the return data of data request unit. It stored the data in a certain way. The mode of data storage has some semantics. It means that the data has some adjectives like neighbour nodes or upstream nodes etc.

The research procedure is as follows:

- Research the arithmetic of schedule generation;
- Research the arithmetic of semantic data generation;
- Research the data sharing mode of across applications resources;
- Evaluate the research result.

Conclusion and prospect analyses

The key problem of WSN at present is how to make the various applications work together optimally under the resource-constrained conditions. As to solve the critical problem during the implementation, a new solution is given by this paper.

The solution considers two aspects to share data of various applications: data storage and communications. It can increase the data efficiency and reduce the repeated communications.

The abstract of cognitive objectives and quantitative description is the foundation of the following work. The node needs to aware, study and cognize the features of overall nodes or neighbour nodes in WSN.

Base on the analyses of WSN researches at present, coordinate all kinds of applications resources and enhance the information sharing between applications is the new breakthrough to control the energy consumption. This paper is the research of basic solution and key point technique based on the above research hotspots. The research results can be applied to WSN or similar kind of structure of Internet of Things. It provides the effective solution of context-aware and intelligent learning. It also can effectively reduce the energy consumption when the node has been running various applications.

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