Молодой специалист
Young specialist
Жас маман
Yosh mutaxassis

Volume 2 | Issue 1 |
January 2023
ISSN: 2791-3651

БАЛАНСИРОВКА ЭНЕРГЕТИЧЕСКИХ ХАРАКТЕРИСТИК ДАТЧИКОВ В БЕСПРОВОДНЫХ СЕНСОРНЫХ СЕТЯХ

Элов Джамшид Бекмуродович
Руководитель Центра дистанционного образования
Ташкентского университета информационных технологий имени Мухаммеда аль-Хорезми

Каршиева Джамиля Яшнар кизи
Магистрант филиала “Нурафшан” Ташкентского университета информационных технологий имени Мухаммеда аль-Хорезми

Аннотация: В статье предложен метод балансировки энергетических характеристик датчиков в беспроводных сетях. Способ основан на использовании энергии в радиодиапазоне датчиков, передающих данные. Неактивные в данный момент датчики могут принимать и обнаруживать пакеты данных и использовать их для подзарядки источника питания. Энергоэффективность определяется точностью согласования приемной антенны с входной цепью и падением напряжения на модуле выпрямителя. Проведен анализ относительных потерь в зависимости от частоты для типичной антенны беспроводного диапазона.

Ключевые слова: беспроводные сенсорные сети, кластеризация, выбор вершины кластера, динамическая балансировка нагрузки, энергия радиодиапазона, сопротивление приемной антенны, зарядка от беспроводного интерфейса.

BALANCING THE ENERGY CHARACTERISTICS OF SENSORS IN WIRELESS SENSOR NETWORKS

Elov Jamshid Bekmurodovich
Head of Distance Education Center Nurafshan branch of Tashkent University of Information Technologies named after Muhammad al-Khwarizmi

Karshiyeva Jamila Yashnar kizi
master degree, Nurafshan branch of Tashkent University of Information Technologies named after Muhammad al-Khwarizmi

Annotation. The paper proposed a method of balancing the energy characteristics of sensors in wireless networks. The method is based on the use of energy in the radio range of sensors transmitting data. The currently inactive sensors can receive and detect data packets and use them to recharge the power supply. Energy efficiency is deter- mined by the accuracy of matching the receiving antenna with the input circuit and the voltage drop across the rectifier module. The analysis of relative losses depending on the frequency for a typical antenna of the wireless range.

Key words: wireless sensor networks, clustering, cluster vertex selection, dynamic load balancing, radio band energy, receiving antenna impedance, charging from a wire- less interface.

The relevance of the work is due to the increasing spread of wireless sensor networks and the need to extend their life, which is determined mainly by the discharge of the power source built into the sensor. The aim of the work is to develop a method for balancing the energy characteristics of sensors in a wireless network.

Молодой специалист
Young specialist
Жас маман
Yosh mutaxassis

Volume 2 | Issue 1 |
January 2023
ISSN: 2791-3651

The basic clustering algorithm in such networks does not take into account the energy reserve of each sensor when choosing a cluster vertex. As a result, a sensor with insufficient energy characteristics can be selected as the top of the cluster, which will lead to data loss.

At the same time, in networks that register a certain event, the sensors are in an inactive state until the event occurs. This allows the use of data packets between the base station and active sensors to recharge the power supplies of the most discharged sensors.

Since in wireless sensor networks, data packets can be received not only by the source and receiver of the signal, sensors that are not currently active can receive and detect these packets.

The wireless interface, due to the use of the 2.4 GHz microwave band, in the case of network traffic and the proximity of the receiving sensor to the signal source, after detection, provides sufficient power to effectively recharge the power sources of the sensors. The detection efficiency in this case is determined by the consistency of the receiving antenna impedance with the input circuit and the losses on the detecting diodes.

The method proposed in the paper allows balancing the energy parameters of sensors in the network due to the energy of the wireless range. This approach differs from known analogues by the non-use of more complex exchange protocols that take into account the energy characteristics of each sensor, and the dynamic balancing of the sensor power supply charge, which significantly extends the life of the network.

Wireless sensor networks (WSNs) are increasingly penetrating into all spheres of modern life.

They are used to monitor technical systems and observe natural phenomena.

The development of methods and tools for managing such networks is the most promising direction in the development of modern wireless technologies.

In the general case, the WSN includes a set of sensor elements (nodes) and one (or more) base station that receives information. The tasks of the sensor include not only the registration of one or more environmental parameters, but also the primary processing of the collected data, as well as the transmission of this data to a neighboring node or base station.

Sensors generally include a sensitive element, a primary data processing unit and a transceiver. Depending on the tasks to be solved, the set of functional elements can be supplemented, but the basic set of blocks is present in almost all modern WSNs.

BSS sensors focused on long-term monitoring or designed to work in an aggressive environment, as a rule, do not require the replacement of built-in power supplies. Thus, the operating time from such a power source determines the lifetime of the WSS as a whole.

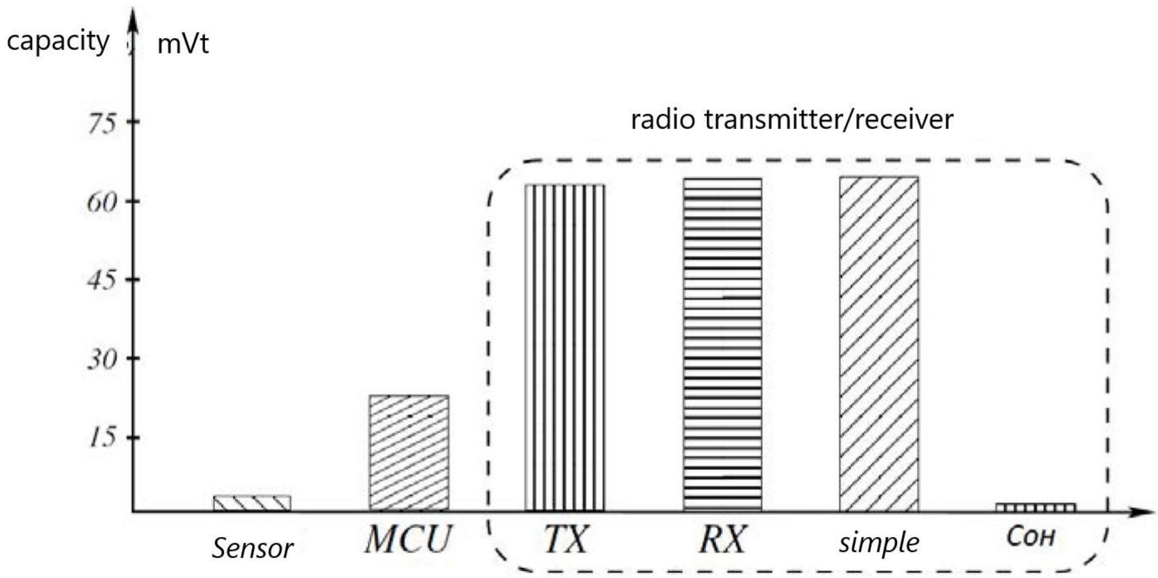

Fig. 1. Radio transmitter

Volume 2 | Issue 1 |
January 2023
ISSN: 2791-3651

In WSNs that register an event, to save energy, specialized exchange protocols are used that implement dynamic clustering, in which the sensors become active only after the event is registered. Next, a cluster of active sensors is formed and a transaction tree is synthesized, which makes it possible to transmit data to the base station with minimal energy losses and with a given reliability.

At present, a large number of such specialized protocols have been developed, which make it possible to optimize one or another set of FSN parameters. At the same time, only a few of these protocols use information about the energy state of each sensor, which can lead to data loss if the energy supply of the sensor's power supply is not enough to establish communication with the base station.

In this work, an attempt was made to solve this problem by using the mechanism of dynamic balancing of energy parameters by detecting the energy of currently active sensors that transmit data packets of the wireless interface of the WSN of the base station and neighboring sensors.

ENERGY CONSUMPTION ANALYSIS OF SENSOR NETWORK ELEMENTS

About 4% of the total energy consumption is spent on the sensitive element. At the same time, 90% of the energy is spent on organizing radio communication with neighboring nodes or a base station, depending on the exchange protocol used.

At the same time, WSNs are mainly used to register certain events, the time intervals between which are very significant. In this mode, the sensor is up to 99% of the time in an inactive state, in which only the sensitive element functions. The sensor switches to the active state only when an event occurs, when the signal from the sensitive element exceeds a certain threshold value, or by a command from the base station or from a neighboring node. For such WSNs focused on event registration, a whole class of information exchange protocols has been developed that allows minimizing energy costs, reducing information delivery time, increasing the reliability of transmitted data, and controlling network congestion.

From the point of view of energy efficiency in the WSN, modifications of the basic data transfer protocol, Low Energy Adaptive Clustering Hierarchy (LEACH), which is a TDMA protocol with adaptive clustering [9], are of the greatest practical interest. The goal of the protocol is to minimize the energy required to create and maintain dynamically organized sensor clusters. LEACH is a hierarchical protocol in which sensors transmit data to the top of the cluster, where data is accumulated and compressed, and then transmitted to the base station. The LEACH protocol assumes that each sensor has enough energy to transmit data directly to the base station or the nearest cluster top.

Sensors that have already been the top of the cluster cannot become it during P communication sessions, where P is the user-specified percentage of cluster tops. After that, each sensor has a probability 1/P to become the top of the cluster during this communication session. At the end of each communication session, sensors that were not cluster vertices choose a new cluster vertex closest to them and connect to it. The top of the cluster then prepares a list of transactions for each sensor in the cluster.

LEACH is an efficient algorithm in terms of network energy consumption as a whole, but at the same time, LEACH does not ensure the selection of a sensor node with sufficient energy as the top of the cluster. Since the LEACH algorithm does not use information about the current energy state of the sensor node, a long-unelected member of the cluster with insufficient energy can be selected as the head node, which will lead to data loss. Thus, balancing the energy reserves between the elements of the cluster is the most important task that ensures the reliability of the transmitted data.

ENERGY BALANCING IN A SENSOR NETWORK

Balancing can be carried out both by using more complex algorithms that take into account the energy reserve of each node, and by recharging the power sources of the most discharged nodes directly from the wireless interface.

In the idle state, the receiving part of each node that is not participating in the cluster can receive and accumulate the energy of the wireless interface packets. When using the 2.4 GHz band and a sufficiently large number of nodes participating in the exchange of data with the base station and neighboring nodes, the energy received by inactive sensors is sufficient to effectively recharge the sensor. Energy can be accumulated on a capacitor of a sufficiently large capacity (ionistor), after the discharge of which, when the sensor switches to the active mode, it switches to the main non-rechargeable power source.

Let us consider a variant of the structural construction of a sensor energy storage system operating in wireless communication bands.

When working in different frequency ranges of wireless interfaces, only the parameters of the input circuit change. The rectifier has a maximum output voltage requirement. Therefore, the rectifier can be implemented as a voltage doubler circuit based on microwave Schottky diodes with a minimum forward voltage drop.

The main energy losses in this case are due to the large distance between the source and receiver of the network signal (usually more than 10 m), low traffic in the network, and mismatch between the impedance of the receiving antenna and the input circuit.

When the impedance of the receiving antenna mismatches with the input circuit of the rectifier unit, part of the energy will be lost. Therefore, the most important task is to accurately match the impedance over the entire range of the WSS.

On fig. Figure 1 shows loss versus frequency for a typical sensor antenna operating in the 2.4 GHz Wi-Fi band. As you can see, over the entire range, the relative losses do not exceed 10 dB. The minimum loss is observed in the range of 2.401–2.473 GHz.

CONCLUSION

The use of the energy of the wireless interface when organizing the power supply subsystem of the WSN sensors makes it possible to significantly increase the lifetime of the network and increase its reliability due to the redistribution of energy between the sensors. This approach is especially effective for WSNs that register an event when the sensors are in standby mode 99% of the time. During the waiting time, the storage element of the sensor can be fully charged if there is an intensive information exchange between nearby elements of the WSN.

REFERENCES

1. Akyildiz F., Su W., Sankarasubramaniam Y., Cayirci E. Computer Networks. 2002, 38 (4), pp. 393–422.
2. Reshma I. Leach Protocol in Wireless Sensor Network: A Survey. Tandel, Shri S’adVidya. Mandal Institute of Technology. 2016, pp. 1894–1896.
3. Taruna S., Tiwari Megha R., Shringi S. International Journal on Computational Sciences & Applications (IJCSA). 2013, vol. 3, no. 2.
4. Fodor V., Glaropoulos I., Pescosolido L. Proceedings of IEEE ICC’09 (Dresden, Germany, June 2009). 2009.
5. He T., Krishnamurthy S., Stankovic J. A., Abdelzaher T., Luo L., Stoleru R., Yan T., Gu L., Zhou G., Hui J., Krogh B. ACM Transactions on Sensor Networks. 2006, no. 2 (1), p. 38.
6. Jaikaeo C., Srisathapornphat C., Shen C. In Proceedings of IEEE ICC’01 (Helsinki, Finland, June 2001). 2001, vol. 5, pp. 1627–1632.
7. Krishnamurthy L., Adler R., Buonadonna P., Chhabra J., Flanigan M., Kushalnagar N., Nachman L., Yarvis M. Proceedings of SenSys’05 (San Diego, CA, USA, 2005). 2005, pp. 64–75.
8. Adamov A. P., Sementsov S. G. Nadezhnost' i kachestvo slozhnykh system [Reliability and quality of complex systems]. 2018, no. 1 (21), pp. 79–83.
9. Adamov A. P., Adamova A. A., Yuldashev M. N. Problemy razrabotki perspektivnykh mikro- i nano- elektronnykh sistem (MES) [Problems of development of perspective micro-and nanoelectronic systems (MES)]. 2016, no. 2, pp. 248–251.
10. Vlasov A. I., Yuldashev M. N. Tekhnologii elektromagnitnoy sovmestimosti [Electromagnetic compatibility technologies]. 2017, no. 3 (62), pp. 35–43.

11. Vlasov A. I., Yuldashev M. N. Datchiki i sistemy [Sensors & systems]. 2018, no. 1 (221), pp. 24–30.

12. Adamov A. P., Adamova A. A., Yuldashev M. N. Trudy Mezhdunarodnogo simpoziuma Nadezhnost' i kachestvo [Proceedings of the International Symposium Reliability and Quality]. 2016, vol. 1, pp. 197–199.

13. Vlasov A. I. Energosberezhenie i effektivnost' v tekhnicheskikh sistemakh: materialy V Mezhdunar. nauch.-tekhn. konf. studentov, molodykh uchenykh i spetsialistov [Energy saving and efficiency in technical systems: materials V international. scientific.- techn. Conf. students, young scientists and specialists]. 2018, pp. 90–92.

14. Adamova A. A., Alfimtsev A. N., Vlasov A. I., Sementsov S. G., Tsivinskaya T. A., Yuldashev M. N. Otchet po NIR № 17-07-00689. Issledovanie metodov sinteza raspredelennykh sensornykh sistem po kriteriyu minimizatsii setevoy nagruzki [Report on research № 17-07-00689. Study of methods of synthesis of distributed sensor sys- tems by the criterion of minimizing the network load]. Moscow: MGTU im. N. E. Baumana, 2017. – 75 p.