

Advances in Wireless Data Transmission in Chemical Systems

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Abstract. New type of wireless computer network in chemical systems is presented in this article. This wireless network uses chemical system as physical media for data transmission, instead of environment. Thus, represented wireless network differs substantially from molecular communication networks and wireless networks covered by IEEE standards, such as radio frequency based wireless networks. This new wireless technology can be used not only in chemical industry for continuous controlling chemical processes in chemical reactions zones but also for medical purposes, and as a new type of wireless body area computer network.

Аннотация. Новый тип беспроводной компьютерной сети в химической системе представлен в этой статье. Эта беспроводная сеть использует химическую систему в качестве физической среды для передачи данных, вместо окружающей среды. Таким образом, представленная беспроводная сеть существенно отличается от сетей передачи данных, в которых для передачи данных используют молекулярные коммуникации, и от беспроводных сетей, охваченных IEEE стандартами, такими как беспроводные компьютерные сети, в которых для передачи данных используют системы радиосвязи. Эта новая беспроводная технология может быть использована не только в химической промышленности для непрерывного контроля химических процессов в зонах химических реакций, но и для медицинских целей, и в качестве беспроводной натальной компьютерной сети нового типа.

system, chemical analysis.

Ключевые слова: беспроводная сеть, беспроводной канал связи, физическая химия, химическая система, химический анализ.

Chemical system is one of the most important terms in physical chemistry, medicine, chemical engineering, etc. Physical chemistry is the branch of chemistry concerned with the application of the techniques and theories of physics to the study of chemical systems [1, p. 1340]. Chemical system is thermodynamic system where chemical reactions are possible. Therefore, chemical system is particular case of thermodynamic system. Enrico Fermi considered the environment as all that is not included in the thermodynamic system [2, p. 11]. Thus, the term «chemical system» is opposed to the term «environment» according to the main principles of physical chemistry. Now many scientists consider a living organism as a complex chemical system, though some students of 1980s had difficulty thinking of the human body as a chemical system [3, p. 107-109]. There is well known NASA's definition of



life stating that «Life is a self-sustained chemical system capable of undergoing Darwinian evolution» [4, p. 388].

The term «computer network» means a collection of autonomous computers interconnected by a single technology, where two computers are said to be interconnected if they are able to exchange information [5, p. 11]. Due to the importance of electronic transactions, the definition of «electronic message» is fixed in laws in many countries that are party to the Patent Cooperation Treaty. Thus the term «electronic message» means electronic data sent or received through electronic means regardless of the extraction method upon receipt.

In [6, p. 10], wireless nanoscale communications are considered under different perspectives, including pure electromagnetic nano communications as well as molecular communications. It was noted that now the wireless communication paradigm is changing, and molecular communications can be considered as wireless communications. Thus, the New Jersey Cybersecurity and Communications Integration Cell (NJCCIC) defines the term «wireless communication» as the transfer of information between two or more points that are not connected by an electrical conductor. In molecular communication networks and wireless networks covered by IEEE standards, signals representing electronic message are transmitted through the environment. It is true not only for radio frequency based wireless networks but also for molecular communication networks. For example, as it explained in [7, p. 248], communication channel for molecular communications consists of information molecules that represent the information to be transmitted, sender nanomachines that emit the information molecules, receiver nanomachines that receive and react to information molecules, and the environment in which the information molecules propagate from the sender nanomachine to the receiver nanomachine.

New type of wireless computer network was established in April 2015 in [8]. This wireless network uses chemical system as physical media for data transmission, instead of environment, and can be used in medical applications, chemical engineering and chemical industry.

Main principles of the new wireless technology

The nodes of this wireless computer network are computers with connected chemical feed systems and in-line chemical analysers. These chemical feed systems are set up to feed substances into the chemical system, and these in-line chemical analysers are set up to conduct continuous inline chemical analysis of the substance located in the chemical system. The nitrogen-oxygen gas mixture in the gaseous phase located in the vessel with the volume fraction of nitrogen in this mixture 80%, and with the volume fraction of oxygen in this mixture 20%, can be used as an example of the chemical system. The chemical feed system capable of feeding nitrogen and oxygen in the gaseous phase, in predetermined masses, into the chemical system, can be used as an example of the chemical feed system. The in-line gas analyser capable of measuring the mass concentrations of nitrogen and oxygen, can be used as an example of the in-line chemical analyser.

Consider simplex wireless communication with a point-to-point data communication technique. Each wireless communication channel of this wireless computer network transmits data as follows. Initially, the in-line chemical analyser is connected to the receiving

computer, and set up to conduct continuous in-line chemical analysis of the substance located in the chemical system, and transfer the results of this in-line chemical analysis to the connected computer. At first, the coding of the electronic message (that is transmitted) as a finite sequence of symbols consisting of 0s and 1s is implemented, using an error-correcting code satisfying the unique decoding condition. Then this electronic message is encoded in the form of a finite sequence of chemical feed system's operating modes. As an example of such a coding may be used the following coding. Each 0 is assigned to the ordered pair of numbers (3, 15), whereby the chemical feed system's operating mode is set up. Where the first number 3 is the mass, in grams, of nitrogen that is fed, in the gaseous phase, into the chemical system by this chemical feed system. And the second number 15 is set equal to 15 seconds of this chemical feed system idle duration that takes place after the completion of feeding nitrogen into the chemical system, in mass, in grams, equal to the first parameter of this chemical feed system's operating mode. Each 1 is assigned to the ordered pair of numbers (1, 15), whereby the chemical feed system's operating mode is set up. Where the first number 1 is the mass, in grams, of oxygen that is fed, in the gaseous phase, into the chemical system by this chemical feed system. And the second number 15 is set equal to 15 seconds of the chemical feed system idle duration that takes place after the completion of feeding oxygen into the chemical system, in mass, in grams, equal to the first parameter of this chemical feed system's operating mode.

Then, the substances are fed into the chemical system through the implementation of work of chemical feed system in accordance with the finite sequence of the chemical feed system's operating modes, representing transmitted electronic message. Then, the receiving computer gets the results of in-line chemical analysis of the substance located in the chemical system, conducting by the in-line chemical analyser. Then, from these results of in-line chemical analysis, the receiving computer obtains the finite sequence of chemical feed system's operating modes. Then this finite sequence is decoded, and the transmitted electronic message is obtained.

Thus, the signals representing electronic message transmitted through the wireless communication channel of this wireless computer network in chemical system are changings of the chemical system's chemical composition. These signals are created by feeding the substances into the chemical system through the implementation of work of chemical feed system. According to the main principles of physical chemistry, all intensive properties of the chemical system are determined by the chemical system's chemical composition. Therefore, the receiving of the electronic message is provided by the fact that after feeding the substances into the chemical system, the intensive properties of this system are changing due to the new chemical composition of this chemical system, and become aligned for each amount of material in this system.

Duplex wireless communication with point-to-point data communication technique, and bidirectional multiuser communication, such as point-to-multipoint communication, can be implemented, for example, using the additional condition that each node of this network can feed a unique set of substances into the chemical system. Duplex wireless communication works by using two simplex wireless communications. For example, if each node of this network can feed a unique set of substances into the chemical system, then each receiving computer not only can receive the transmitted electronic message through the in-

line chemical analyser, but also determine the node from which the substances, representing this electronic message, are fed into the chemical system.

Conclusion

The proposed wireless technology can be used for wireless data transmission between computerized medical devices implanted in the human body, such as implantable cardioverter defibrillators, implantable drug delivery devices, etc. Therefore proposed wireless technology can be used to deploy hybrid wireless body area networks. The proposed wireless technology can be used in chemical industry by deploying these wireless networks in chemical reactions zones, aiming continuous monitoring and controlling the chemical processes.

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