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Мобільні пристрої, такі як мобільні телефони, стають щороку більш популярними. Використання їх, однак, тягне за собою певний недолік, а саме укладення договору із оператором стільникового зв'язку, де користувач зобов'язується працювати з пристроєм відповідно до заданих правил. Ідеєю є одночасне зниження витрат на використання мобільних телефонів та досягнення повної незалежності від оператора мобільного зв'язку

Ключові слова: мобільні пристрої, мобільні мережі, мережа датчиків, само організаційні протоколи, передача даних

Мобильные устройства, такие как мобильные телефоны, становятся ежегодно более популярными. Использование их, однако, влечет за собой определенный недостаток, а именно заключение договора с оператором сотовой связи, где пользователь обязуется работать с устройством в соответствии с заданными правилами. Идеей является одновременное снижение затрат на использование мобильных телефонов и достижения полной независимости от оператора мобильной связи

Ключевые слова: мобильные устройства, мобильные сети, сеть датчиков, самоорганизационные протоколы, передача данных

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THE APPLICATION OF SENSOR NETWORKS WITHIN MOBILE CELL NETWORKS

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1. Introduction

Rapid development of the mobile network infrastructure, easy access to mobile phones, and operators vying for customers by offering them more and more favourable terms and conditions have caused stationary telephones to cease playing any greater role in distance communications. Users have lost interest in the use of devices that restrict their mobility. This process has become so conspicuous that these days many developers no longer install telephone cables in new builds, and many operators abandon stationary telephony services.

Today's society puts great emphasis on mobility. Having a mobile phone is natural and many employers recognise mobile phone as one of the primary equipment when hiring a new employee. Mobile phones not only give us mobility, but also allow us to call any other person on planet Earth. Of course, there still exist dead zones not covered by the network infrastructure, however, their surface is shrinking by the year [1].

The very idea of mobile telephony was postulated in the early nineteen-thirties. However, the first physical network was only established in the late sixties in Stockholm, Sweden. Its range did not exceed 30 km, and the number of users approximated one hundred. The principle of operation of mobile network's basic scheme is very simple. Mobile phone users can make calls provided that they are in the so-called "cell", that is in an area supplied with a signal from one of the base stations located nearby. The strength of the signal and the size of the cell's area relies on the technology applied by the operator, the transmitter's development status, and topology of the area.

Mobile phones at all times inform the base stations whether they are available. The base station receives these signals and transmits them to the next central control network which controls a group of base stations. In turn, control stations are connected to the telephone exchange whose function is to switch calls to the normal telephone network. Mobile network checks the quality of each call and selects the testing station

to connect two mobile phones users [2]. During the conversation the quality of the call is analysed on regular basis. Whenever a lower range or decrease in signal quality is detected, the currently used base station transmits the call to another base station offering a better quality signal. The change that occurs in the digital networks does not affect the quality of communication between the callers. Only the message shown on the screen informs the user of the change of the base station's name. The key assumption of the original concept proposal of a free mobile network is to reduce the costs and ensure complete independence of the mobile phone user from the operator offering paid communications services. This paper presents the concept proposal of a free mobile network.

2. Analysis of published data and problem statement

Currently, the development of wireless sensor networks occurs very rapidly [3]. These networks form a special group of distributed measurement systems are increasingly used to observe environmental factors for civilian or military. These observations do not occur on a single node, and they are observed when the cooperation of network nodes, where each node create ad-hoc network. Functionality of such a network, we can observe when the nodes exchange information, caused by periodic query or by random event, with the observer. This type of network can be used to monitor weather changes, patient condition or even follow deformations or vibrations in the industry construction, where it may become an early warning system [4]. It would lead to the prevention of disasters, accidents and contribute to the improvement the design and technology. So as we can see most research is focused on collecting data from the test environment [5], than on the analysis and communication method between nodes. The concept of using sensor networks in mobile networks, (in order to send simple messages eg. SOS messages from places not covered by the reach of the operator), is a new concept and only proposed by the authors of this article.

Thanks to the advances in technology it is now possible to produce nodes that are very small in size and could be easy installed in mobile phones [6]. This allows us to use sensor nodes on an unprecedented scale and it opens new opportunities for so-called. ubiquitous computing.

3. Purpose and objectives of the study

The key purpose of this paper is to represent a new idea of a communications system that omits the mobile network operator's infrastructure using methods taken from sensor networks.

In accordance with the set goal the following research objectives are identified:

1. Increase the public interest in wireless sensor networks.
2. Commercialize the concept of free mobile networks.
3. Analyze the routing protocols that could be used in such networks.

4. Concept of free, independent mobile network

Currently, communication between mobile phone end users proceeds to a schedule. The caller selects the ID of the target user. The signal is transmitted to the nearest base station which then redirects the signal to the target user. This type of communication is called «dialup» and is shown in Fig. 1.

The overarching objective of the authors of this paper is to present the concept proposal of a free mobile network completely independent from the operator and his intermediary devices, such as, e.g. the base station. This idea is shown in the Fig. 2.

Fig. 1. Standard communication between mobile phones

Fig. 2. Free, independent mobile network

The caller, as opposed to the standard call, does not connect to the base station, but directly to the target user. This is how to achieve independence from the operator, his infrastructure and fees for the service. In order to achieve such independence from the services offered by the operator it takes to apply the right technology, i.e. wireless sensor network [7]. Such a network is comprised of numerous small devices distributed across a certain area in order to fulfil a certain task that is common to all. The basic element of this network is a node equipped with a sensor that monitors the variability of certain phenomena, such as temperature, humidity, presence (absence) of an object, sound, pressure, motion, degree of air pollution, etc. Initially the technologies based on wireless sensor networks were developed only for military purposes, but over time these networks have found more and more applications in the fields of everyday life, such as environmental monitoring, traffic management, home automation. In this paper the authors propose that a single mobile phone be called a node. A standard sensor node within a wireless network is comprised [8]of (Fig. 3):

– a module responsible for communication with other nodes within the network (transmitter/receiver);

– calculation module that incorporates a processor and memory and whose main task is to convert the data obtained from the measurement;

– gauging module, whose aim is to acquire information using specialised sensors;

– a power supply module being either a fixed power supply system or battery.

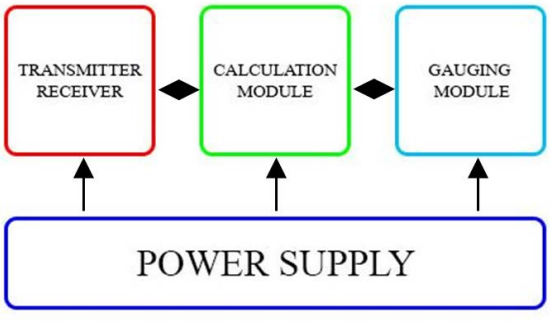

Fig. 3. A standard sensor node within a wireless network

The algorithms applied to enable sensor networks to self-organise must be able to operate locally, because most often the size of the network exceeds the range of single nodes and their distribution is random and irregular. Each node in the sensor network is, therefore, a standalone device and may have one or more sensors. They can be, e. g. temperature, humidity, pressure, radiation, acceleration sensors, etc. The electrical signal from the sensor is digitised and propagated within the network in accordance with the transmission protocol adopted. Responsible for handling the measurement and data transmission is the calculation module which serves as a bridge between the gauging module and the module responsible for communication.

Wireless sensor network nodes require an autonomous source of power supply. Most often this is a battery. Its capacity determines the life of the nodes. Depending on their power consumption and battery type, networked nodes can work from a few hours to several years. The latest solutions envisage the functionality of replenishing the resources by recovering energy from the environment utilising transducers that convert kinetic energy or solar heat into electricity. A key role in minimising energy consumption is played by a suitable hardware design, complexity of measurement algorithms, and data transmission algorithms [9].

In this paper a node is a phone that in order to establish communication between the caller and the receiver, mobile phone must operate as a standalone base station. The idea of the sensor network's functionality is shown in Fig. 4.

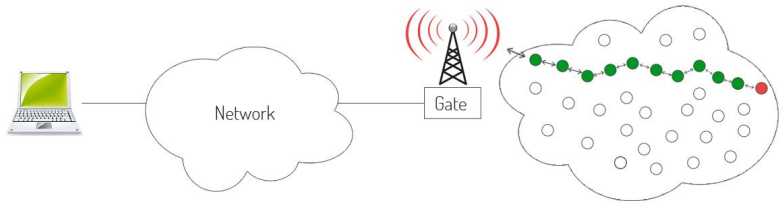

Fig. 4. The functionality of the sensor network

The gateway operates as the transmitter/receiver. This is conducive to building a sensor network comprised of nodes/mobile phones. Special attention needs to be paid to the lines showing the ability to exchange information without having to connect to the gateway at each attempted call. This application helps to reduce the costs and avoid excessive network traffic.

5. Routing in sensor networks

In sensor networks routing is a more complex problem than is the case with normal routing used in TCP/IP networks or in standard phone communications. The very large number of sensor nodes makes it impossible to assign each node a global identification address. Additionally, such a solution would introduce a very large information overload into the network. The nodes must also self-organise, because they are very often randomly set and operate in an uncontrolled manner [10]. The entire configuration and organisation must proceed automatically. Another significant problem is the shortage of energy resources, data processing and working memory storage capacity, hence requisite is efficient management of the nodes' resources, which is not granted by the protocols used in TCP/IP networks [11]

The criteria that characterise routing protocols in sensor networks are:

– *position, density, and distribution* of nodes in the environment – frequently, sensor nodes are completely randomly distributed and the number of nodes operating in the designated area can vary from a few to several thousand. Consequently, a routing protocol has to cope with this nodal distribution system in order to ensure communication between the nodes, whatever their configuration and density of coverage in the given area.

– *energy* – nodes often have no fixed energy resources and are dependent on mobile and limited energy sources. Appropriate use of energy is extremely important and has a major impact on the life of the node. In sensor networks a single node plays the roles of both data transmitter and router [12].

– *adaptability* – when a sensor network node is damaged or the energy resources in a single unit is exhausted, the routing protocols used must respond to this change, often by reorganising the network anew. Such "disabled" status of certain nodes must not affect the network functionality or prevent execution of the task in this situation – communication.

– *distance* – communication between the nodes is limited and, therefore, the pathway configured for data transmission is mostly multi-nodal.

– *communication* – measurements and data transmission in sensor networks depend on the application. Routing protocols are selected from the angle of the test environment, data collection frequency, and the energy source used.

– *Quality of Service* – as for TCP/IP networks, it is important to determine what feature of the given protocol will be most useful. Some applications require that the data be delivered at a specified time following the communication, otherwise they become useless. In other applications the operating time of the given node is more essential. In this situation the emphasis is on energy saving, which reduces to the minimum the quality of the data transmitted and the activity of the given node.

6. Exploitation of proposed concept

In the opinion of experts of the International Telecommunication Union (ITU), a specialised UN organisation headquartered in Geneva, by the end of 2014 the number of phones in the world had been exceeded the limit of 7 billion, and the number of users had been increased to 4.3 billion (Fig. 5). Today the number of mobile phone users is approximately 4.9 billion. In subsequent years, these numbers will grow rapidly to reach, according to forecasts, 5.3 billion mobile phone users in 2017. At the moment, the fastest growth is observed in Asia. This continent accounts for more than a half of all mobile phones in the world.

One of the factors affecting the proper operation of the network described in this paper is high density of mobile phone users. This solution will perform best in highly populated places like cities and industrial areas with the highest number of users. In less populated areas it is also possible to maintain such a network, provided that the distance between mobile phones is small enough for the sensor network to handle such calls with no errors preventing proper communication. For example, consider travelling between Brussels and Warsaw. If throughout the entire time of the travel other mobile phones operating as base stations are present within our node (our mobile phone), we will be able to continuously communicate with another network user. However, if the number of mobile phones that mediate communication is insufficient, such calls will be limited or impossible. In areas where user density is large enough for the proposed network to function smoothly, it is possible to use an application utilising flat routing. Flat routing protocol is a network communication protocol implemented by routers in which all routers are each other 's peers.

Flat routing protocol distributes routing information to routers that are connected to each other without any organisation or segmentation structure between them. In practice, this application would organise cooperation of all the nodes in order to achieve a continuous flow of information between two end users. Another essential aspect is the issue of keeping up quality [13] and selecting the most suitable path in the sensor network consisting of a large number of nodes. The absence of adequate solutions may cause excessive network traffic, looping, and, ultimately, complete network block. One option is to transmit data from the sensors at certain intervals or when an incident occurs, such as a change of the data flow beyond the prescribed standard (triggering event). In such a case it is possible to observe which nodes are involved in exchanging information and which are not. The key objective of such observation is to find the shortest reliable path [14]. Assuming that each node is a mobile phone it is possible to observe how the signal is transmitted from one node to another in order to ensure communication between the caller and the receiver. Communication between the caller and the receiver is shown in Fig. 6.

Not every mobile phone within the range is engaged in communication. Only those that offer the shortest path are used.

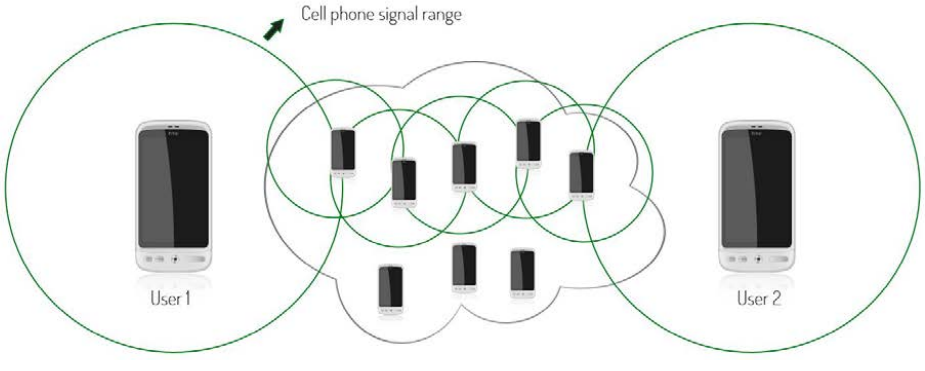

Fig. 6. Communication between the caller and the receiver

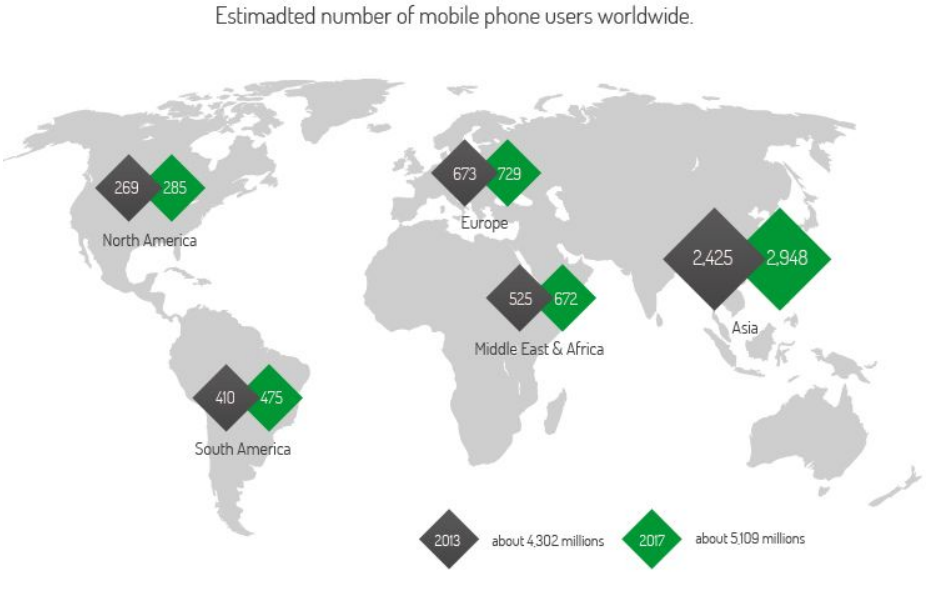

Fig. 5. Estimated number of mobile phone users worldwide

6. Conclusion

To sum up, our concept met with quite a lot of interest among the members of our institute and other collaborating institutions. We have developed an appropriate topology and selected for the experiment, after several debates, routing protocol – Low Energy Adaptive Clustering Hierarchy Protocol (LEACH), which will be adapted for research especially for testing.

Our proposal may have a big impact on technological development and economic growth. The major advantage of the proposed solution is its gratuitousness. Given the high licence fees paid by corporations for the provision of services by mobile

operators, it is expected that companies will invest in the infrastructure required to operate such a network. For companies, to implement such a solution would be more cost effective than remaining dependent of a GSM network operator.

A major drawback of the proposed model is that it would take to upgrade mobile phones not only by uploading new software, but also by changing the technical specifications of the devices. Another problem would be the presence on the market. Free mobile phone network would be a tremendous competition for all operators causing a dramatic reduction in their profits. Creating such a network on a global scale would be a challenge, but its basic advantage, i. e. free calls, would win enormous support from a majority of the public.

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