About the need to study the theoretical foundations of wireless data transmission in a school physics course

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Abstract. This article discusses the possibility of integrating issues related to the operation of wireless technologies into the school physics course. To analyze the study of the theoretical foundations of wireless data transmission in order to include this material in the school physics course.

Keywords: wireless technologies, 4G, Wi-Fi, NFC, school physics course.

In our time, the development of wireless technologies is especially intense. Technologies such as 4G and Wi-Fi are no longer exotic for anyone. Increasingly, people pay in stores with a smartphone with an installed NFC module, and we can replenish the transport card "troika" only by holding it to our mobile device. Therefore, we, as teachers, are faced with the task of making sure that these technologies are not something incomprehensible to the population of the country. We see that the transition to the 5G standard around the world provokes anxiety of people who do not understand what it is, and, sometimes, even material damage. Therefore, in this work, we set ourselves the

goal of reviewing information on this topic and assessing the possibility of integration into the school curriculum.

In our work, we used methods such as testing, a theoretical review of existing school course materials, analysis and synthesis of the information received. Testing included the following block of questions:

1. Are you a physics teacher?
2. What textbooks do you use in your lessons?
3. Specify what kind of wireless communication you are using.
4. Compare the technology and its range. There are three technologies to choose from: GPS, NFC, Wi-Fi, and three types of range: short, medium, long.
5. Which of the presented frequencies are Wi-Fi operating frequencies?
6. Where is NFC technology found?
7. Do you know the approximate maximum Bluetooth range?
8. What is the symbol for wavelength in physics?
9. How many satellites are used in civil aviation to track one GPS device?
10. Specify the approximate range of NFC.

According to the results of a survey by means of Google Forms, the following results were obtained: 76% of respondents find it difficult to answer more than half of the questions.

Analysis of textbooks for the content of information about modern wireless technologies showed their complete absence in the school physics course. Traditionally, over the course of decades, the school curriculum has paid attention to the following issues:

- The invention of radio by A. S. Popov.
- Principles of radio communication.
- Modulation and detection.
- Propagation of radio waves.
- Radar.
- The concept of television.
- Development of communication facilities.

Based on the foregoing, we can say that modern technologies for wireless transmission of information have not made it to textbooks. A This means that developing your own materials on this topic will be a good addition to any of

them. For example, you can turn on Wi-Fi or NFC for textbooks that only describe radio communication.

The principle of operation of NFC is based on the induction of a magnetic field: the devices have two compact antennas that are located within the short range of each other. Accordingly, as the devices approach each other, an air-core transformer is formed. There is no need for registration, configuration and any additional manipulations. It is enough to bring two smartphones to each other, for example, and a stable connection is instantly formed between them. The distance between compact antennas built into mobile devices or digital devices should not exceed twenty centimeters. Only in this case will you get a reliable, wireless connection. NFC uses a frequency of 13.56 MHz to transmit information, the data transfer rate reaches up to 424 Kbps.

NFC has a lot of advantages, including the following:

- Fast speed of connection establishment;
- Convenience;
- Security;
- Versatility;
- Support for other wireless technologies;
- Openness.

Today, NFC chips are installed in a wide variety of devices, but, first of all, we are talking, of course, about smartphones and communicators. NFC technology is attracting great interest from mobile companies and providers. However, the scope of NFC is not limited to this. In the next part we will dwell in more detail on the various applications of this short-range wireless technology.

The main area of application of NFC technology is, of course, its implementation in various mobile devices - from smartphones to tablet computers and compact cameras. The first phone equipped with an NFC chip was introduced in 2006. It was a simple for today "clamshell" Nokia 6131. At the moment, hundreds of mobile phones and communicators with an NFC chip have already been released, thanks to which it becomes possible to wirelessly transfer data from one device to another with just one touch. Some modern digital cameras are also equipped with Wi-Fi along with NFC to instantly transfer captured photos and videos to the tablet.

With the help of NFC, it became possible to play on the TV screen the video that is stored on the smartphone. To do this, you just need to bring the smartphone closer to the TV remote control. For example, on Sony TVs, this feature is called One Touch Mirroring. Of course, in order for it to work, you

need a built-in NFC chip both in the smartphone and in the remote control itself. As we can see, the field of application of NFC technology in mobile devices and household appliances is very diverse, but even greater prospects have opened up for this technological solution in other areas, for example, in banking.

NFC is very attractive for making electronic payments and, accordingly, banks, since it supports the so-called emulation mode. That is, with the help of this technology, you can emulate the work of a bank card that is well known to everyone. In particular, the user just needs to bring his smartphone with a built-in NFC chip to the terminal and he can easily make any payment. Thanks to NFC, you can create your own e-wallet. The advantage here is that the technology can be implemented in almost any device, be it a smartphone or a key fob.

An example is the work of the PayPass technology. Its essence is as follows. If the user has a phone with an NFC chip and his NFC bank card is activated in the SIM-menu, then he can go to any terminal that supports the MasterCard PayPass payment function, present the phone to him at the required distance (20 centimeters) and the payment will be made. Everything is very fast and convenient. You don't even need to interact with the payment terminal by examining its menu. Sound and light signals will confirm that the required funds have been debited from the bank card account. All a person needs to implement such a solution is that, in addition to the NFC chip, the data on bank accounts are also uploaded on his phone. It should be noted that mobile operators are the main drivers of NFC distribution. Mobile commerce, electronic ticketing, electronic payments are all relevant to NFC technology.

One of the most promising fields of application for NFC is in the payment of transportation systems. Thanks to the emulation mode, a smartphone with a built-in NFC chip makes it easy to purchase tickets for trains or public transport. You can create a ticket purchase request by touching your phone to the NFC tag on the smart poster. After that, a special application is instantly launched and a ticket purchase request is activated. In this case, the smartphone already works as a reader, reading the information that is stored in the tag. Then the user confirms the purchase, and the e-ticket is downloaded to his phone. Moreover, the ticket data is stored in the security elements of the device, making it impossible to change them.

The ticket price is automatically debited from the user's account with a mobile operator or from a bank card. Control of fare payment can be performed using a turnstile or a controller directly on the route. To do this, the smartphone is simply brought to the reader and the ticket data is instantly sent to the processing center, which provides the appropriate verification. After confirming

the authenticity, the turnstile opens. In such a simple and at the same time convenient way, the work of the transport fare payment system can be organized. Such systems are beginning to be actively implemented today.

The use of NFC-enabled smartphones enables next generation transport applications. In this case, the phone can act as a carrier of electronic tickets, which contains information about the user, his travel history and other data useful for the transport company.

Consider Wi-Fi technology. Like dial-up and cable modems, Wi-Fi devices modulate the transmitted signals. Using various modulation methods, they convert digital signals received from a computer into analog radio frequency signals. The data transfer rate using a modulated carrier depends on a number of factors, including the bandwidth of the communication channel and the type of modulation method used.

Any Wi-Fi device, be it a PC Card, a wireless network adapter for a desktop PC or an access point, functions as a transceiver, that is, it transmits and receives radio signals. It is worth noting that 5-GHz radio signals from 802.11a devices are attenuated more than 2.4-GHz signals, especially when walls or other objects are encountered in their path.

The power output of radio devices is usually measured in watts. Unlike stereos, which can have 500W of output power, Wi-Fi equipment emits significantly weaker signals - up to 200mW. Because radios operate on low-power signals, engineers prefer to express levels in logarithmic units called decibels (dB). The abbreviation "dBm" is used to determine the signal level in relation to one milliwatt. A signal level of 0 dBm corresponds to a power of 1 mW.

If the signal power is less than 1 mW, its level is negative. For example, the sensitivity of an 802.11b wireless LAN adapter with a 2 Mbps bandwidth can be -90 dBm.

Remember two rules that are useful in engineering practice. An increase or decrease in the signal level by 3 dB means an increase or decrease in its power by half. An increase in the signal level by 10 dB corresponds to a tenfold increase in its power. So if 0 dBm equals 1 mW, then 10 dBm is 10, 20 dBm is 100 and 30 dBm is 1000 mW, or 1 W. Using these rules, it is easy to determine that a signal level of 23 dBm corresponds to a power of 200 mW.

According to analytical agencies, the volume of Wi-Fi use is increasing by 60-100% annually. In the near future, the technology will move from commercial use to free use. In many cities, work is already underway in this direction, where the initiators of the free network are city authorities, youth

organizations, libraries, etc., which allow everyone to use their access points to the Internet. Therefore, in the near future, cities and areas will appear on the territory of many countries, where it will be possible to connect to the Internet using Wi-Fi for free, such as Jerusalem - the first city on the planet, whose residents and guests can connect to the network for free using Wi-Fi devices.

If we consider the statistics of Wi-Fi access points in the world, then according to iPass, there are now more than 47.7 million hotspots in the world. Largest hotspot growth in North America. Russia is in second place. African countries have the least number of hotspots so far, but they are at the very beginning of the journey.

Let's move on to mobile communications. At the moment, we are aware of the existence of five generations of mobile communications. Within each generation there is a set of technologies that are often mistakenly associated with the generation itself. The first generation was developed in Japan in the 80s of the last century based on AMPS. Disadvantages such as low capacity and analog technology forced the transition to the second generation of mobile communications (2G) in the 90s. The standard that formed the basis of this generation was GSM. Signals have become digital, which has increased the level of security. The improved version of 2G had GPRS technology, which was known to provide Internet access that was not possible in the first generation. Mobile communications functioned well in the second generation, but with the development of devices, there was a need for faster access to the Internet. The third generation, in addition to providing a good (relative to that time) speed of data exchange with the Internet, also provided backward compatibility with the second generation. In 2010, a 4G communication system was presented in Finland, which had an even higher speed of data exchange with the Internet, which allowed users to work with streaming video, online games, and interactive television most comfortably. Today, an even more advanced fifth generation has already been presented and at the moment it is being actively introduced.

As can be seen from the above, there is a large amount of information not presented in the school course, but at the same time, affecting almost all people in everyday life. It is especially important that the 5G technology that has not yet been implemented will be actively used in systems like "Smart Home", which will become an even more important part of every person's life. The most effective solution to this problem, in our opinion, is the inclusion in the educational process in the format of extracurricular activities. The course may be called "Modern technologies of wireless and mobile communications", includes four modules:

- NFC: development, features, security.

- Wi-Fi and Wi-Max - an affordable way to access the Internet and security features.

- Generations of mobile communications: past and future.

- System project development: "Smart House".

As can be noted, we propose to focus not only on physics and technology, but also on safety when working with equipment that has Wi-Fi modules and NFC antennas. In our opinion, it is very important that people in the community understand how to work in anonymous Wi-Fi networks, for example, in a cafe or park, and not become a victim of cybercriminals. And among other things, at the end of the course, you can work on applying the knowledge gained in organizing a single network environment based on your picture. How to combine simple gadgets into a system reminiscent of the “Smart House” from science fiction films and our near future? By answering this question, students will certainly be able to understand both the principles of work and safety, and the possibilities of applying the knowledge gained in practice.

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