Wireless Data Transfer Technologies Suitability Evaluation for Educational Laboratories Modernization

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Abstract – The results of research, evaluation and comparison of wireless data transmission technologies that can be used in the construction of the collection and data management system for the scientific and educational institutions. An expediency of the study in this direction made by analyzing the current trends of computer networks and systems. It is proposed to use Bluetooth Low Energy Protocol as a decision for modernization of the processes of setting scientific research and adaptation of the educational process of higher education in Ukraine with the requirements of society and the labor market.

Key words – wireless technology, data transmission, Bluetooth Low Energy, ZigBee, Z-Wave, Wireless USB, ANT, Programmable System on Chip.

I. Introduction

Over the last decade, wireless data transfer technologies have been spread drastically. It has happened due to numerous benefits given to system embedders and users. Aforementioned trend has also affected distributed data collection and control systems. High effectiveness and flexibility, low deployment cost are the utmost issues due to which aforementioned systems are extremely successful at various fields of science and industry. As an example worth to mention some of them: industrial process management, scientific experiments control, IoT infrastructure, educational process automation. The last one usually demand to manage such operations as data acquisition from numerous sensors and/or measurement equipment, experiment control and data transfer. In this paper results of the up-to-date special surveys are investigated in terms of its application to the educational and research process modernization. An optimal wireless technology is offered.

II. Literature Overview

Different data collection models and its optimization in wireless sensor networks were analyzed in [1]. [2] covers a problem of large wireless network for skyscrapers monitoring. At [3] were stated main keypoints for the wireless networks implementation. [4] contains Bluetooth Low Energy protocol description, while at [5] scatternet and piconet topologies formation and functioning are investigated. Full information about Z-Wave, ZigBee, ANT, Wi-Fi and Wireless USB is presented in [5 - 9] respectively. Table I contains most important parameters comparison for each technology. Fig.1 is an example of BLE network usage in order to maintain laboratory equipment and experiment control.

Despite the large amount of information provided, suitability issue of the wireless data transfer technologies and commercial solutions for educational and research process modernization is not clearly described in analyzed publications.

III. Problem Formulation

Taking aforementioned publications into consideration, authors summarized that effective implementation of any wireless solution for research and educational experiments automatization purpose have to fulfill: 1) hardware components should be low-cost and commercially available (COTS); 2) high downstream flexibility should be achieved to make the system compatible with different sensors/devices; 3) network has to contain up to 10 data collection/control devices; 4) open-source firmware and software; 5) low power consumption (suitability for battery-powered systems); 6) modules and network in general should be easy in configuration and operation.

IV. Results

To solve stated problem an optimal wireless protocol was chosen. Decision was made by elimination of unsuitable ones. ANT/ANT+ is proprietary and is not widely spread. Wireless USB Protocol is excessive, because of the high speed of the wireless transfer channel. Moreover module cost is relatively high in low quantities. Z-Wave (and its derivative) has low effectiveness and stability in case of small node number. ZigBee is a fault-tolerant technology suitable for high-stable networks at the large area. Deployment and configuration of such networks are complicated. Wi-Fi protocol, despite its popularity, consume lot of power and can not be used in battery-powered devices.

As a result of the analysis Bluetooth Low Energy (BLE) protocol seems to be the most suitable solution. This protocol meets all demands and can be used for implementation in downstream data collection and control devices for educational and research purposes. Certainly, BLE has some shortcomings, in particular interaction between two Piconet networks is not implemented.
### Wireless Network Protocols Comparison

<table>
<thead>
<tr>
<th></th>
<th>ZigBee</th>
<th>Z-Wave</th>
<th>BLE</th>
<th>ANT</th>
<th>Wi-Fi</th>
<th>W-USB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range, MHz</td>
<td>868/915/2400</td>
<td>896/908(all) 2400</td>
<td>2400-2483</td>
<td>2400-2483</td>
<td>2483-5500</td>
<td>3100-10600</td>
</tr>
<tr>
<td>Bitrate, Kbit/s</td>
<td>20/40/250</td>
<td>9.6/40(from 200s.)</td>
<td>1000</td>
<td>1000</td>
<td>100-54000</td>
<td>110000-48000</td>
</tr>
<tr>
<td>Node number</td>
<td>1 router is serving up to 32 nodes</td>
<td>1 router is serving up to 32 nodes</td>
<td>1 master is serving up to 7 slaves</td>
<td>1 master is serving up to 7 slaves</td>
<td>Not less than 2 nodes</td>
<td>1 host is serving up to 127 nodes</td>
</tr>
<tr>
<td>Range, m</td>
<td>10-100</td>
<td>30-100</td>
<td>50</td>
<td>30</td>
<td>150</td>
<td>3-100</td>
</tr>
<tr>
<td>Node types</td>
<td>coordinator, router, peripheral device</td>
<td>coordinator, router, end device</td>
<td>master slave</td>
<td>master slave</td>
<td>access point, client</td>
<td>host, peripheral device</td>
</tr>
<tr>
<td>Peak current per node, mA</td>
<td>&lt;150</td>
<td>21 (wake-up)</td>
<td>12.5</td>
<td>17</td>
<td>116 (1.8V mode)</td>
<td>&lt;500</td>
</tr>
</tbody>
</table>

### Conclusion

Analysis of modern wireless data transfer technologies has shown that BLE protocol is a most suitable for assigned task. There is enough data for further development of the wireless input-output module (as a slave device for data collection and control system). Such module should become a powerful instrument for research and educational experiments automation. Moreover, module is planned to be integrated into Bluetooth network, which can cover the whole experiment area or laboratory building.

### References

7. ANT Alliance, [https://www.thisisant.com/](https://www.thisisant.com/)