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Mobile user tracking system with ZigBee

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ABSTRACT

In the paper an implementation of mobile nodes tracking system based on ZigBee and Wi-Fi wireless networks is presented. On the base of known algorithmic as well as circuit solutions a simple yet universal system, applied in prototype application dedicated for person's localization in museum premises has been developed. Since system utilizes entirely wireless communication, it can be applied in any closed objects. The system has been preliminarily verified in real in-situ environment.

1. Introduction

Museums as well as art galleries are often very specific venues. They may be historical buildings, where no installation work is allowed (museums) or space re-arrangements such as significant lighting or sound system modification (art galleries). On the other hand modern objects of that kind require – for different reasons – to be equipped with smart monitoring and control allowing for instance an automatic detection of visitors in specific room and/or supervising the group size. When systems with portable audio guides are used, two basic requirements should be fulfilled:

- Wireless communication between stationary and mobile system's elements, which should assure that the specific information reaches the group of visitors (respectively its guide) independently on their position. For obvious reason this communication system must cover entire building,
- Possibility of tracking for chosen mobile elements (e.g. groups' guides). On one hand it may guarantee an optimal visitors groups traffic to avoid eventual jams, supplying the group with appropriate information related with its position (e.g. information about the object, the group just is nearby). On the other, it may be used to activate additional building automation elements such as extra lighting or muting the music in appropriate region – i.e. where the group stays at.

Widespread use of different wireless communication protocols simplifies an adjustment of new solutions to specific requirements of an application under the design. In the presented system one of fundamental assumptions was to assure entirely wireless communication between all elements: stationary, firmly located in predefined points as well as mobile ones all persons moving within the venue are equipped with. Simultaneously stationary nodes must exhibit some flexibility – allowing simple spatial reconfiguration of the system, when necessary. Moreover due to battery operation of mobile nodes energy consumption must be optimized, otherwise frequent recharge is necessary. Finally, functional requirements are different for different node types. In the system four types of nodes have to cooperate with each other:

- Main (coordinating) nodes – located in each room. It collects the information form all the other nodes in particular room and communicates with the central system;
- Stationary nodes – each room is equipped with at least two such nodes (bigger or unusual rooms – e.g. that with untypical shape may need even more nodes of that type). They are used for tracking mobile nodes, sending to mobile nodes data related to their actual positions and driving room amenities.
- Mobile nodes – facilities born by group guides. They communicate with stationary – and main nodes in order to properly locate the group within the venue.
- Secondary mobile nodes – all visitors belonging to specific group have them. That nodes can only receive data and play voice messages. Actually that kind of nodes are not a part of the system – their operation is local and limited to the area where the information of visible object is broadcasted.

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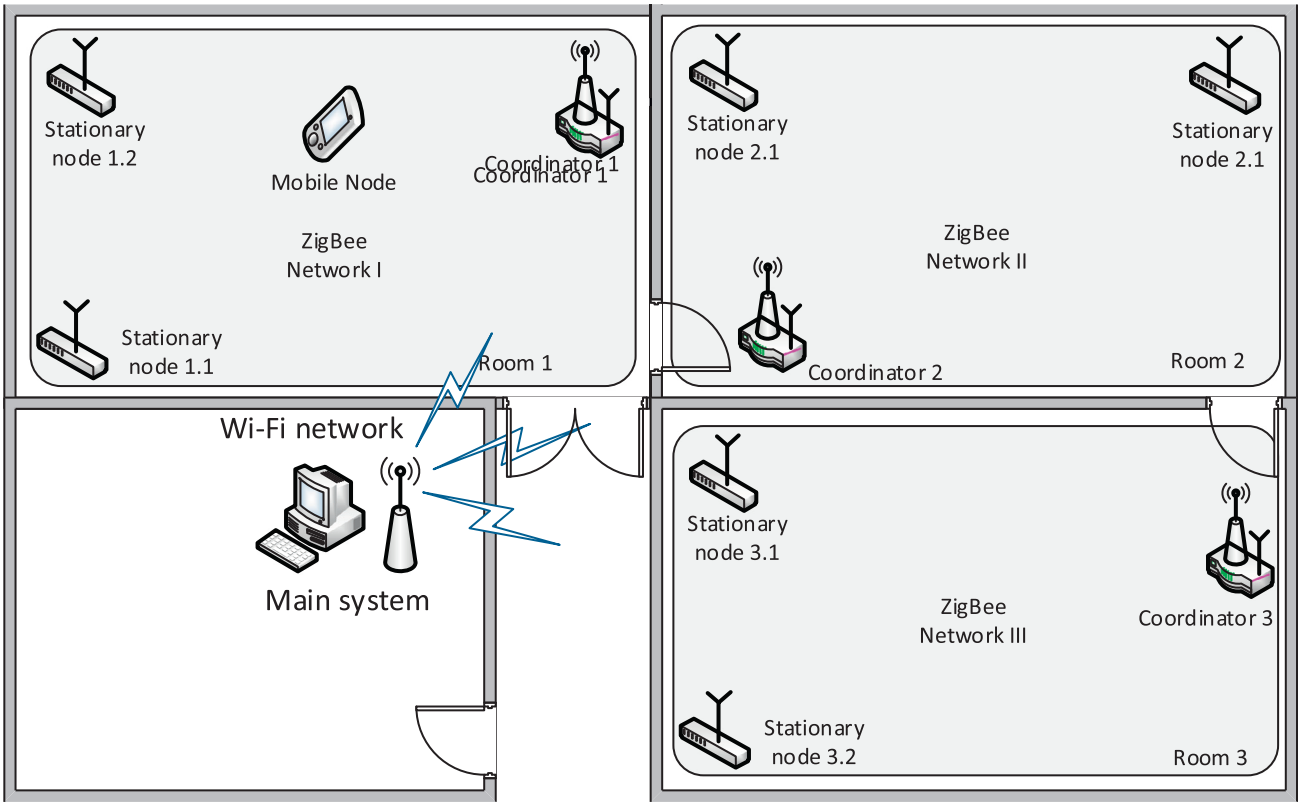

Fig. 1. System structure.

Due to system specification and significant functionality differentiation for particular nodes we decided to use different processors and controllers fitting different requirements for each node type, two independent wireless communication protocols were also used. First protocol, used by main nodes to communicate with central computer is the IEEE802.11 (Wi-Fi) protocol, the second used by stationary and mobile nodes is ZigBee.

The structure of the system is shown in Fig. 1.

Assumptions about system operation are as follows:

- The group enters the room – coordinator node detects a mobile node, an information about room occupation is sent to the central system, which blocks the possibility of coming another group (just single group may be in one room at the moment);
- Stationary nodes perform cyclic measurements of object position
- Gathered information are sent to the central system it eventually activates additional elements (light, background music, relevant information for secondary mobile nodes) accordingly to object position;
- Group leave the room – information is sent to the central system, which releases the blocking process, next group may enter the room.

In the paper we present first development stage related with implementation of mobile user localization and sending its position coordinates to the central system. The second implemented functionality is broadcasting the general information addressed to entire group.

2. ZigBee protocol

Over the last dozen years both researchers and practitioners are more and more interested in short distance wireless transmission. Actually we all have been observing significant paradigm change – what previously was wireless (e.g. long distance range radio transmission) is being substituted by “wire” (fiber optics – like backbone networks) and vice-versa (keyboards, mousse, headphones, printers etc.). For computer networks that type of transmission at the very beginning was considered as an alternative to wired transmission, treated as better and more robust. Therefore wireless transmission was considered as an ultimate choice. Both devices as well as protocols were immature, consequently most wireless solutions had significantly worse transmission parameters than cable ones. However later on, protocols have been refined, advances in electron devices technology resulted with significant reliability improvement, and nowadays wireless dominates in short range data transmission. More and more application areas are discovered. In local areas networks (LANs) for personal computers new variants of IEEE 802.11 protocol appeared, some personal area network (PAN) have been elaborated with the most popular Bluetooth (IEEE 802.15.1) standard, the same for long distance wireless (GSM, IEEE 802.16). However that protocols share one specific feature – they are relatively sophisticated, with expanded data validation and protection procedures, excluding or at least making very difficult energy optimization for the transmission process. Though wireless sensor networks require as long as possible mobile sensor nodes operation (otherwise frequent recharging their batteries is necessary). For needs of sensor networks, as well as home automation networks many wireless communication protocols have been developed. They are suitable for low-power, short range (100 m max) and relatively low data throughput (up to 100kbps). One of such a standard is ZigBee. It belongs to LR-WPAN (Low-Rate Wireless Personal Area Network) class. ZigBee standard defines recommendations for network as well as application layer, utilizing for direct data transmission specified by IEEE 802.15.4 standard. Both recommendations are to be treated as single entity, defining rules for transmission. IEEE 802.15.4 standard was developed to fit