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Procedia Computer Science 109C (2017) 92–99

Procedia Computer Science

www.elsevier.com/locate/procedia

The 8th International Conference on Ambient Systems, Networks and Technologies (ANT 2017)

Indoor Localisation of Wireless Sensor Nodes Towards Internet of Things

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Abstract

Internet of Things (IoTs) is an emerging technology that is envisioned to revolutionise the enabling environment and to provide autonomous, ubiquitous and pervasive computing within Wireless Sensor Networks (WSNs). IoTs are usually associated with the acquisition of sensor node information and controlling of "things". However, the absence of location information of these sensor nodes compromises the intelligence of the IoT network. Therefore, this work is motivated by the recent advances in the two important areas of WSNs namely, indoor localisation and IoTs. This paper therefore presents a framework that integrates indoor localisation of sensor nodes and IoTs in a real world scenario. The focus is mainly on the implementation issues regarding localisation algorithm complexity, hardware computational capabilities and Internet/Intranet enabled connectivity for access to the sensor nodes' location information. A sensor node prototype is developed using specialised electronic components and proprietary protocols to provide a capable platform for embedding a distributive online localisation algorithm based on Received Signal Strength (RSSI) and Gauss-Newton Algorithm (GNA). The algorithm is first simulated before porting it to the sensor node prototypes. A gateway device and an IoT framework are also proposed and implemented based on Linux, Apache, MySQL, PHP (LAMP) server to provide global and local access to sensor nodes' location information. The Root Mean Square Error (RMSE) of the IoT logged estimated coordinates from the prototype nodes and the estimated coordinates from the simulation are computed and compared. The computational power of the hardware is analysed based the time it takes to perform the GNA based localisation process.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: Localisation; Internet of Things; Gateway; Wireless Sensor Networks; Gauss-Newton Algorithm; Received Signal Strength; LAMP;

1. Introduction

Information pertaining to the location of sensor nodes in a WSN is very important for providing Real-Time Location Services (RTLS) especially for indoor environments where existing localisation technologies such as Global Positioning Service (GPS), Assisted GPS (A-GPS)[1,2,3] and Cellular Network technology[4] may not be viable. Also,

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Peer-review under responsibility of the Conference Program Chairs.
10.1016/j.procs.2017.05.299

many Ambient Assisted Living (AAL) platforms depend largely on indoor localisation process in order to provide reliable and intelligent services for the aged and disabled[5]. In addition to that, the advent of smart homes and smart infrastructures allows users to interact with almost any type of device using WSNs and the Internet which is an ensemble of the much researched IoT paradigm. As IoT becomes very popular, many households and corporate organisation will venture into IoTs. As a result, sensors nodes associated with IoTs will become predominantly used indoors. Therefore, the ability to find the location of sensor nodes indoors requires great attention due to the limitation of the other methods of acquiring location information mentioned earlier. In light of this, there is a need to provide accurate indoor localisation as part of the IoT framework.

Meanwhile, the accuracy of localisation based on Received Signal Strength(RSS) is limited due to the irregularities of Radio Frequency (RF) signal prorogation in indoor environments caused by multi-paths and interferences[6]. Several improved algorithms have been developed through intensive research but there is a huge concern about the feasibility of these works in a distributive real-life localisation scenario. This is due to their complexities and sometimes the non-existence of sensor nodes capable of managing computational overheads. Since distributive localisation in WSNs requires that the node that needs to be localised computes its location by itself, there is a need to provide ways of implementing relatively complex localisation algorithms through the development of wireless sensor nodes that are well equipped to handle large computations with an acceptable degree of accuracy.

In light of the synopsis given, this work is focused on implementing a framework that interfaces wireless sensor nodes capable of distributively and seamlessly obtaining their location onto a global and local network (Internet and Intranet) in real time. An approach for the localisation process is provided in four major phases which are, RSSI filtering using the Kalman filtering algorithm; distance estimation using Log Normal Shadowing Model (LNSM) based on RSSI ranging and position estimation/refinement using Gauss-Newton Algorithm (GNA). The GNA approach is an optimisation method which does not require the computation of second derivatives. Hence, it contributes to the reduction of complexity while maintaining an acceptable level of accuracy. By employing a Raspberry-Pi device as a gateway device, a LAMP based server is designed and implemented for global communication access and local access suitable for enhancing Quality of Experience (QoE) and security in controlled environments or applications such as Home Automation[7] and Corporate organisations. The rest of the paper is therefore organised as follows; Section two presents related work on localisation in WSNs. Section three presents the Design, Modelling and Implementation of the approach proposed in this work. The experimental set-up and results are presented and discussed in Section four. Finally, Section five concludes the work.

2. Related Work

A 3-dimensional triangulation technique for localisation in an IoT framework was proposed by Sham et al.[8]. Their scheme uses weighted value to reduce the effect of an extreme value during distance estimation. They also proposed a new algorithm to further improve the location estimation. The main algorithm for estimating the location was then tested off-line in simulation. This does not realistically facilitate localisation in an IoT framework since location information must be logged in real time or on-line. One can arguably presume that an off-line based experimental test was used because of the complexity of their algorithm and the non-existence of a computationally capable wireless sensor node platform.

Stoleru et al.[9] presented a highly accurate, low-cost localisation system achieving a localisation accuracy of about 20 cm. Their system uses spatiotemporal properties of well-controlled events in the network to establish the position of a sensor node. Though they may have achieved high accuracy in implementation, their system only works well in the presence of direct Line of Sight (LOS) between a base station and the nodes, making this unsuitable for indoor and distributed localisation. Their system also requires an event from an aerial device to occur before sensor nodes can be localised, This, therefore does not provide autonomous localisation in a WSN and IoTs.

In[10], an ROCRSSI distributed localisation algorithm was proposed, which operates based on the comparison of RSSI values. Each and every node that needs to be localised receives a signal from neighbouring beacons from which an iterative boundary of the area where the node may be located is formulated. Their localisation algorithm is implemented on an EyesIFXv2 wireless sensor node platform which uses a 16-bit RISC architecture clocked at 8 MHz. This platform definitely does not provide the ability to run complex algorithms. Hence, in order to simplify their localisation algorithm so as to reduce complexity for implementation in hardware, an assumption was made that