Demo Abstract: An Infrastructure for Automated BAN Experimentation

Mikolaj Chwalisz, Jan-Hinrich Hauer, Jasper Büsch, Vlado Handziski

Telecommunication Networks Group
Technische Universität Berlin, Germany
{chwalisz,hauer,buesch,handziski}@tkn.tu-berlin.de

Abstract. We demonstrate an infrastructure for experimenting with Body Area Network (BAN) communication protocols and applications without the involvement of human test-person. The core of our infrastructure consists of a mobile robot, on which a simplistic human structure equipped with BAN nodes is located. This set-up can emulate human movements within a controlled RF interference in-door environment. Both, the robot movements and the RF environment, can be remotely controlled via standard Internet access. As a representative usage example, we compare different frequency selection schemes for BAN communication.

1 Introduction

A Body Area Network (BAN) consist of a set of sensors attached to the human body. The sensors monitor physiological parameters such as temperature, blood pressure, heart action, muscle activity etc. The sensor readings are typically transmitted wirelessly to a central master node to be processed or forwarded to a remote medical server for storage and analysis. Such set-up is useful for numerous medical and recreation scenarios. Due to the miniaturization of the sensors and requirements for their longevity, low power consumption is a must — leading to low power transmission with small number of transmission repetitions / losses between the sensors and the master. Unfortunately, due to human movements, the RF interference environment change much faster and much stronger than in stationary networks. — The BAN may pass by several interference sources within short time. An increasing interest in developing communication protocols for BANs targeting these specific operating conditions is clearly visible.

While the evaluation of BAN communication protocols may to some extent be performed in simulation, the final stages in protocol evaluation have to be done with a real hardware in realistic environment. However, performing BAN experiments with human subjects is tedious and should be regarded the last step of the evaluation process. To simplify the early experimental stage, we have developed an automated, remotely accessible testing infrastructure.

2 BAN Testing Infrastructure

In this section we provide an overview of the main components of our infrastructure.

TWISTbot The core of our infrastructure is an iRobot Roomba mobile robot (Fig. 2). It can move with up to human walking speed and was extended by a structure that allows placing additional objects on top of it. We have mounted a Microsoft Kinect camera together with laptop on the robot. We utilize the Robot Operating System (ROS) software framework to control the robot's movement and all devices on the robot. ROS is accompanied by several contributed software packages including hardware drivers and a navigation stack for our robot. It also includes a graphical user interface that allows to define target positions or movement trajectories that the robot will follow.

BAN Emulation We have mounted on the robot a simple wooden pole (This can be replaced by a better structure as long as the weight limits are respected!) and equipped it with two Shimmer2r [1] sensor nodes. One node is placed on a plate at the height of 30 cm (Fig. 2). This node is connected over USB to the laptop to extract statistics or control the node application in realtime. The second node is attached to a vertical wooden pole, which allows to adjust the inter-node distance between about 0.2 m and 1.5 m. The nodes currently have line-of-sight communication (we ignore the human body attenuation). In future we plan to add an artificial body (phantom) to better emulate the human body characteristics. The nodes can be programmed with user-defined program image, for example, a TinyOS or Contiki application.

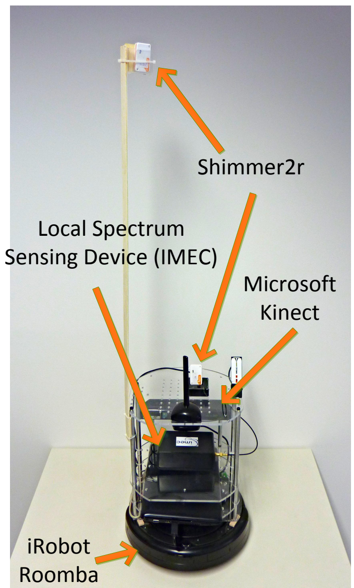

Fig. 1. TWISTbot with two BAN nodes

RF Environment Monitoring and Control Our testing infrastructure allows to monitor the RF environment during an experiment, by utilizing parts of an existing co-located sensornet testbed called TWIST [2]. TKN Wireless Indoor Sensor network Testbed (TWIST) nodes are placed in the building's office rooms with spacing ca. 3 m. We have implemented an RF energy measurement application, that measures 2.4 GHz RF noise by continuously sweeping over the entire band and installed it in TWIST. In our demonstration we visualize in real-time the spatial RF energy distribution in our building as shown in Fig. 2. Finally, we have a controlled RF jammer (both WLAN and sensor nodes). In the demonstration a node that outputs a continuous carrier on a selected IEEE 802.15.4 channel will be used.

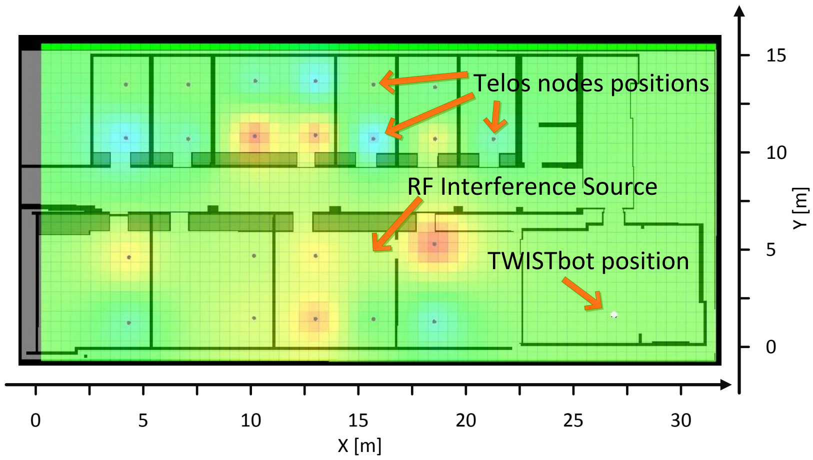

Fig. 2. RF energy distribution over an office floor

3 Demo Description

In the demo we use our infrastructure to show four experiments remotely over the Internet. In all experiments the BAN periodically exchanges packets at 10 Hz; we visualize in real-time the BAN's packet reception rate (PRR) as well as its current position inside our building. We also activate a RF jammer at a certain location in the building, which is visualized in real-time through RF spectrum maps (Fig. 2). As result in certain locations the BAN will be faced with strong RF interference. The four experiments differ in the way the BAN's MAC protocol deals with this interference as described in the following.

No channel hopping In the first variant the BAN always transmits on the same channel. Consequently, as the robot passes close to the RF jammer the BAN's PRR reduces to a point where no communication is possible at all.

Reactive channel hopping In this variant the BAN coordinator node monitors the packet reception rate and changes (blindly) to the next higher channel when it detects a PRR below 10%, denoting loss of connectivity, on the current channel. This variant can avoid continuous packet loss, but cannot prevent a short (and visible) period of decreased performance.

Local sensing (with IMEC sensing engine) We use a sophisticated spectrum sensing device (IMEC sensing engine [3]) to continuously provide the BAN with an overview of the channel utilization information, as seen by the mobile platform. The device is mounted on the robot and its output is transmitted over USB to the BAN's coordinator node. The BAN is periodically (every second) using the spectrum measurement information to select the least utilized channel.

Infrastructure-supported sensing In the last variant the sensing infrastructure in the building provides the BAN's coordinator node with the spectrum utilization map. Whenever the TWIST nodes detect a BAN in their vicinity, they broadcast a IEEE 802.15.4 packet with the latest spectrum sensing measurement information. Then, the BAN coordinator can receive this packet and use the knowledge to select the least utilized channel.

4 Conclusion

Our infrastructure for remote BAN experimentation provides an easy way to perform automated BAN experiments. A relatively complex experimental setup with multiple components, can be bootstrapped in less than half an hour. The user can control robot movement over a simple graphical user interface. Currently, to store or visualize the data from the BAN in real-time, the user has to provide python conversion scripts that interact will with ROS. We plan to extend our framework with automated conversion and visualization of generic user data. We plan to extend our setup by an artificial body (phantom) to emulate human body shadowing.

Acknowledgment

The research leading to these demonstration has received founding from the EU's FP7 under Grant Agreement N^o258301 (CREW Project).

References

[1] Shimmer Research, *Shimmer2 capabilities overview*, `http://www.shimmer-research.com/wp-content/uploads/2010/08/Shimmer-2R-Capabilities-Overview.pdf`, 2010.
[2] V. Handziski, A. Köpke, A. Willig, and A. Wolisz, "TWIST: a scalable and reconfigurable testbed for wireless indoor experiments with sensor network," in *Proc. of the 2nd Intl. Workshop on Multi-hop Ad Hoc Networks: from Theory to Reality, (RealMAN 2006)*, 2006.
[3] S. Pollin, E. Lopez, A. Antoun, P. Van Wesemael, L. Hollevoet, A. Bourdoux, A. Dejonghe, and L. Van der Perre, "Digital and analog solution for low-power multi-band sensing," in *New Frontiers in Dynamic Spectrum, 2010 IEEE Symposium on*, 2010.