INSTITUTE “JOŽEF STEFAN“

PROSENSE Seminar Presentations

Editors:
Aleksandar Crnjin
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Ljubljana, December 18 – 21, 2008

Editorial

The PROSENSE seminar in Ljubljana, in December 18th - 21st, was aimed at an interchange of research and application experiences and ideas in the area of Wireless Sensor Networks (WSN). The PROSENSE partners from the West Balkans, primarily Serbia and Macedonia with guest participation from Croatia and Hungary, and from the convergence region, Slovenia, attracted 31 participants from these regions, with most of them having presentations of the status of their current WSN related work inspired by the PROSENSE project.

There was a wide range of institutions engaged from Serbia, either as regular partners of the PROSENSE project: School of Electrical Engineering (ETF), University of Belgrade, or as associated invited partners from other Universities in Serbia: Novi Sad, Kragujevac, Niš and Subotica, the latter with a cooperating partner from Hungary (University of Szeged). The members of the Serbian group have reported about their research and application ideas in the area of the WSN with 12 talks. Five talks have been presented by associated members of the Belgrade group.

The Macedonian group, from Faculty for Electrical Engineering (FEEIT), University of Skopje, which is one of the partners of the PROSENSE project, reported within 5 talks, about their work in the area of Vehicular Sensor Networks (one of the possible topics for the future STREP proposal by the members of PROSENSE consortium), and their progress in establishing of the future WSN test and evaluation platform in Macedonia.

The PROSENSE seminar was hosted by Jožef Stefan Institute (JSI), which is also a regular member of the PROSENSE consortium. The 4 contributions have been reported by JSI group's members and 2 reports have been given by the cooperating group from the Faculty of Electrical Engineering, University of Ljubljana.

The leaders of all three partners have analyzed some options on how to proceed with concrete actions required for the ordering and installation the WSN equipment in Belgrade and Skopje. It was decided that JSI will help with purchasing some of the WSN devices. Beside the technical part, the seminar was also an opportunity to build a stronger cooperation between all members of the working groups.

This document contains the abstracts of project presentations, given in this PROSENSE seminar. The aim of this proceeding is to record the current state of the project initiatives in order to follow and evaluate their evolution and developments during the second phase of the PROSENSE project.

Editors:
Aleksandar Crnjin,
Veljko Milutinovic,
Liljana Gavrilovska,
Roman Trobec

Ljubljana, January 20, 2009

Seminar Program

Thursday, December 18, 2008

14:00 – 15:00 Welcome Lunch

15:30 – 17:00 Ljubljana session I

- Introduction by Roman Trobec (IJS)
- "Hierarchical Feature Scheme for Object Recognition in Visual Sensor Networks”
  Vildana Sulic, Janez Pers, Matej Kristan, Stanislav Kovacic
  Presented by Vildana Sulic (EF)
- "SensiNode network - practice and experience"
  Presented by Matej Kristan (EF)
- "Wireless ECG measurement - a real example"
  Presented Viktor Avbelj (IJS)
- "NevroEKG, from raw data to information"
  Presented by Matjaz Depolli (IJS)

17:00-17:30 Belgrade session I

- "Overview of Belgrade ProSense activities"
  Presented by Stanislava Stankovic

Friday, December 19, 2008

9:30 – 10:30 Ljubljana session II

- “Research evaluation criteria in Slovenia”
  Presented by Monika Kapus Kolar (IJS)
- “Some interdisciplinary WSN-relevant research ideas”
  Presented by Roman Trobec (IJS)

10:30 – 13:00 Skopje session

- "Vehicular Sensor Networks: General Aspects"
  Students: Milan Zahariev, Sanja Bonevska
  Supervisors: Liljana Gavrilovska, Vladimir Atanasovski, Aleksandra Mateska
  Presented by Milan Zahariev
- "Vehicular Sensor Networks: Implementation Issues"
  Students: Jankuloska Bisera, Mihajlo Pavlovski, Paunkovska Natasa, Temelkova Simona

Supervisors: Liljana Gavrilovska, Vladimir Atanasovski, Aleksandra Mateska
Presented by Bisera Jankuloska and Mihajlo Pavlovski

- "Preparation of a new FP7 STREP proposal: SOA and new directions"
  Prepared by the FEEIT team
  Presented by Liljana Gavrilovska
- "GUI for Monitoring Sensors' Activity"
  Bojan Seirovski
  Supervisors: Aleksandra Mateska, Vladimir Atanasovski, Liljana Gavrilovska
  Presented by Vladimir Atanasovski
- "Sensors' Mobility Towards WSN Performances Improvement"
  Aleksandra Mateska, Liljana Gavrilovska
  Presented by Aleksandra Mateska

13:00 – 14:00 Lunch

14:00 – 16:00 Belgrade session II

- "SUN SPOTs – An Introduction"
  Presented by Miloš Solujić
- "State of the Art in Medical Applications of Wireless Sensor Networks"
  Presented by Stanislava Stanković
- "Interactive Street Sensing as Monitoring Framework"
  Presented by S. Stanković and M. Stanković
- "WSNs in Enhancing Exercise Experience in Personal Fitness"
  Goran Rakočević, Aleksandar Crnjin
  Presented by Goran Rakočević
- "Smart Running Track: A Step Toward Real Life Social Networking"
  Aleksandar Crnjin, Goran Rakočević
  Presented by Aleksandar Crnjin

16:00 – 16:30 Coffee break

16:30 – 19:00 Belgrade session III

- "Common Health Gateway"
  Presented by Zoran Babović
- "Wireless Sampler"
  Žarko Perić, Predrag Ćirković
  Presented by Žarko Perić
- "Processing of Medical Signals in Wireless Sensor Networks"
  Presented by Andja Aleksić, Predrag Ćirković
- "WSN In Precision Agriculture"
  Presented by Branko Pavlović
- "Applying Design Patterns to WSN-s"
  Presented by Marko Novakovic

- "Business Implications of WSN-s"
  Marko Novakovic, Vladimir Radojevic
  Presented by Marko Novaković

19:00 – 20:00 Guest session

20:30 – 22:00 Dinner at Lovec Restaurant

Saturday, December 20, 2008

9:00 – 20:00 Social event

- Outdoors team-building activity (mountain walking in Planica)
- Lunch at Lake Bled

Sunday, December 21, 2008

12:00 – 14:00 Final meeting and desert

Alphabetical Lists of Participants

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Contents
(in alphabetical order of presentation titles)

Common Health Gateway – Towards Semantic Sensor Net

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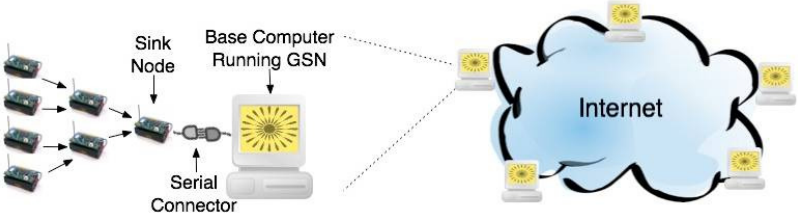
Introduction

Starting as an effort to integrate all Personal Body Area Networks with purpose of personal health care, the Common Health Gateway has become a middleware software component with aim to offer an infrastructure for integrating various wireless sensor networks to one global sensor network. The main idea is to create a layer between user applications and various wireless sensor networks, and to enable to those applications access to sensor data deployed everywhere.

Existing approaches in the WSN are very application and user oriented. In such approaches, sensor networks are isolated from other networks and it is supposed that known users will access sensor data in expected way. There is no possibility that other users, or other applications access to sensors deployed in that homogeneous network.
With this project we try to integrate various wireless sensor networks in one global sensor network. User applications will be offered a common interface based on XML messages, in order to retrieve sensor data from that global sensor network. With this approach, sensor data would become more visible on the internet, and many applications could potentially use sensor data from wireless sensor network, deployed with other goals. The main issue is adaptation of specific WSN message format to the common internal format, and thus integration of that WNS to the global network. All sensor observations are annotated with semantic data regarding spatial, temporal and theme information. Using this semantic information it is possible to search such virtual global sensor network for wished data.

There are several other projects that try to solve the same problem: integration of all available sensor networks. Projects like GSN [2], SANY EU FP6 [3], SenseWeb by Microsoft Research [4] have their own specific solution, although the final goal is more or less the same. The lack of common accepted standards in this area implies that all of these solutions deal with different interfaces either to the users or to the deployed WSN that should be integrated in the global network.



However, there are efforts for standardization in this field in order to offer better interoperability while working with sensor data. The most serious work has done by OGC working group and the result is the set of seven specifications as a part of SWE – Sensor Web Enablement initiative [1].

The other efforts are work of Semantic Web Activity by W3C and Sensor Standards and Data Harmonization Working Group at NIST.

In our proposed architecture we identified the four main components that should achieve wished functionality:

1. Request/Response Handler is the component responsible for communication with user applications that request some sensor data. The main issue in this component is working with XML message parsers and creation of appropriate XML response according to some specifications.
2. Sensor Data Engine is the core of the Common Health Gateway project. It deals with storing and retrieving of gathered sensor data. In the same time, it must to offer a flexible interface to the other components of the system
3. Protocol Connectors are translators to/from WSN application specific message format. It performs the most important role of the projects, because flexibility of this part implies efficiency of the whole component
4. Monitoring and Analyzing Component is responsible for controlling of the Common Health Gateway.

Current Status

The main barrier for efficient development at this moment is impossibility of testing the Common Health Gateway with various WSN platforms in order to create as flexible as possible framework for an easy connection with deployed WSN-s. The current development goes in the direction of the efficient storage of gathered sensor data that will enable an easy search for desired sensor observations. Also, the interface that will be published to the user applications is considering, and the current accepted solution is SOS (Sensor Observation Service) specification, which is a part of SWE work of OGC [1].

Expected Results

The complete project is expected to be completed by December 2009. The plan is to offer several demonstration applications together with middleware component that will show some potentials of the Common Health Gateway infrastructure. If conditions permit that, our solution will be deployed in one real situation in the domain of telemetry and remote control system for public heating system of the small town in Serbia.

References

[1] http://www.opengeospatial.org/projects/groups/sensorweb , OGC Sensor Web Enablement Working Group, 2008
[2] http://gsn.sourceforge.net/ GSN Middleware for Sensor Networks
[3] http://www.sany-ip.eu/, SANY Sensors anywhere, EU FP6, 2008
[4] http://research.microsoft.com/apps/pubs/default.aspx?id=76844 SenseWeb, Microsoft Research 2008
[5] http://knoesis.wright.edu/research/semsci/application_domain/sem_sensor/
Semantic Sensor Web, Knoesis 2008

GUI for Monitoring Sensors' Activity

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Introduction

Sensor networks are becoming increasingly popular with a variety of emerging applications. As a result of their intensive deployment, a need for solutions capable of managing sensor networking environments (often remote) is required. These solutions must be simple (because of the sensor nodes' low complexity), yet efficient enough to allow for complete users' control over the monitored environment, i.e. allow for *remote access*, *data storage* and *real-time notification* [1]. This paper presents a Graphical User Interface (GUI), being developed at FEEIT – Skopje within the ProSense project, that is specifically tailored to meet the above mentioned demands. It satisfies most of the requirements for monitoring sensor networking environments and can:

- remotely monitor sensor networks (both wired and wireless);
- record relevant sensor data and
- perform proper and real time event-triggered notification to a user defined list of specified recipients.

Users using the GUI are able to see (remotely) current sensor situation of the monitored environment in real time by simply connecting to a server.

Topology, Architecture, Components

The targeted topology for the GUI being developed is shown in Figure 1a), while Figure 1b) shows the architecture of the actual application. The communication within is a classical client-server communication, where the client is the user behind the GUI and the server is a computer with sensors connected to it. The complete solution comprises:

- a *user GUI*, which consists of a Java applet (the actual interface) and a Java servlet (a middleware for forwarding data from the sink to the applet);
- a *database reader component*, which is an independent Java servlet part of the package used to read database records and display them in a table;
- an *application*, invisible for the user and responsible to log the changes in the sensed environment and send warning/alert messages by e-mail;
- a *database*, used to host relevant data from the sensed environment.

The web-oriented components in the solution are hosted by an Apache Tomcat Java servlet/JSP container, whereas the database is hosted by a MySQL database server. All mentioned applications and hosting applications are running under Xubuntu Linux.

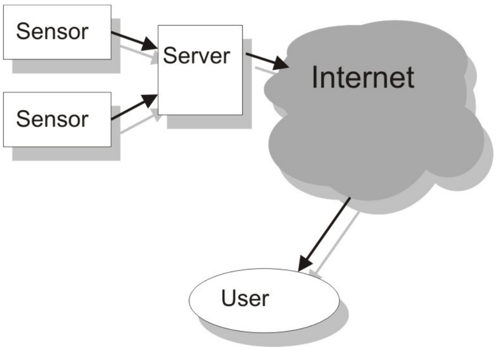

Figure 1a): Targeted topology

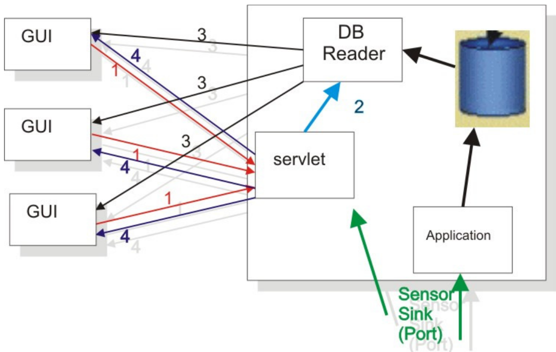

Figure 1b): Application architecture overview

Current Status

A fully functional beta version of the GUI (Java based) has already been developed. The sensors used are wired infra-red motion-detection sensors (PIR sensors) connected to the PC hosting the server via parallel port using optocuplers and potentiometers for lowering the voltage. The server PC runs on Linux, with a database and a Java servlet/JSP container installed. The GUI is used from a web browser (either locally or remotely) by simply typing the IP address of the server. The data acquisition application is called whenever there is a change in the sensed environment (i.e. motion detection) and these changes are written in the database. In addition, this application allows a user to specify up to 6 e-mail addresses to which the changes can be sent.

Expected Results

The proposed GUI for monitoring sensors' activity will be used throughout the ProSense project within FEEIT – Skopje's group which main focus is to use sensor networks for aid and resolve of emergency situations [2]. Therefore, proper solution for monitoring and alerting from a sensed environment is necessary. The presented GUI is extendable, open for further development and compatible with any Java platform and therefore, once all wireless sensors networking equipment procurement is done, this GUI will be adapted to support a real wireless sensor network monitoring.

References

[1] H. R. Nagelly, "Monitoring Wireless Sensors Readings Through Graphical User Interface," *Master's project report*, Computer and Information Science Department, University of Massachusetts, available at: http://www.umassd.edu/engineering/cis/reports/
[2] M. Bortenschlager, E. Haid and A. Wagner "Rapid Prototyping of Sensor-Based Applications with SunSPOTs," *ERCIM News No. 76*, Special theme: The Sensor Web. January 2009.

Hierarchical Feature Scheme for Object Recognition in Visual Sensor Networks

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Introduction

Visual sensor networks (VSN) are the meeting point of two significantly different technologies. One is distributed sensor approach with low power, low computational and storage capabilities and the other is image processing and computer vision. As it is already known, one of the main characteristics of computer vision algorithms is a large amount of data that has to be processed, stored or transmitted.

Despite those limitations, we would like to use one of the frequent tasks in computer vision - object recognition in VSNs. We want to implement it in a way that network would be able to recognize objects that have been previously seen by any of the nodes in that network.

In this respect, we have focused specifically on the issue of knowledge propagation in distributed VSNs. We propose an approach, based on hierarchical feature vector distribution. The key of our approach is the principle that individual nodes in the network hold only a small amount of information about objects seen by the network, however, this small amount is sufficient to efficiently route queries through the network.

Our approach aims to make network more efficient by using hierarchical image encoding to efficiently route recognition queries only to those nodes (cameras), that have enough information to perform object recognition. Conceptually, the most closely related work is:

- Leistner *et al.* [1], where authors show that using on-line learning classifiers on smart cameras can reduce memory and bandwidth requirements and therefore can be appropriate for embedded systems.
- Park *et al.* [2], where authors show that using distributed look-up tables for selecting a subset of cameras, that is likely to carry out the current requested task, is most effectively.

Differently from many other authors, we do not deal with implementation or low level issues in data transmission or with the specifics of actual recognition algorithms.

Current Status

We outlined a set of requirements, which have to be fulfilled by the object recognition method to be used in our framework. We tested examples of three simple object recognition methods, which can be adapted for use in such feature distribution scheme. The proposed approach has been tested using our own distributed network simulator on a standard COIL-20 database. Preliminary results suggest that amount of data transmitted through the network can be significantly reduced in comparison to naive feature distribution schemes.

Expected Results

So far, only extremely simple object recognition methods were used. For these methods we can be reasonably sure that they satisfy the full set of requirements of our feature distribution method, which results in unchanged recognition performance when they are used in our hierarchical framework. However, the real challenge lies in adaptation of state-of-the art recognition methods to such distributed framework. It is unlikely that the requirements of our scheme would be fulfilled in general for those methods. However, even if those requirements are satisfied most of the time and only for reasonable input data (e.g. natural images), we expect that use of such methods in our hierarchical scheme would result in only a minor decrease in recognition performance. This is the future focus of our research.

References

[1] C. Leistner, P. M. Roth, H. Grabner, H. Bischof, A. Starzacher, and B. Rinner. Visual on-line learning in distributed camera networks. In *Second ACM/IEEE International Conference on Distributed Smart Cameras, ICDSC 2008*. IEEE, 2008.

[2] J. Park, P. C. Bhat, and A. C. Kak. A look-up table based approach for solving the camera selection problem in large camera networks. In *Workshop on Distributed Smart Cameras, in conjunction with ACM SenSys'06*, 2006

Interactive Street Sensing as a monitoring framework

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Introduction

This application offers an upgrade for the existing street infrastructure in order to achieve higher living standards by implementing newest technology. It presents a new approach to the act of street walking, from the medical as well as from the human daily life perspective. The entire system is wireless sensor networks (WSN) based. Software for this architecture includes Java components, because of the existing hardware prerequisites. The main principle in the system implementation is to provide stable and functional framework, with good and scalable capabilities.

Current status

At the moment of writing (mid-January 2009), we still do not have the hardware needed (WSN nodes). So far, we have projected system architecture (fig. 1), tested parts of the software on the Sun SPOT Emulator and created a "Bill of Materials".

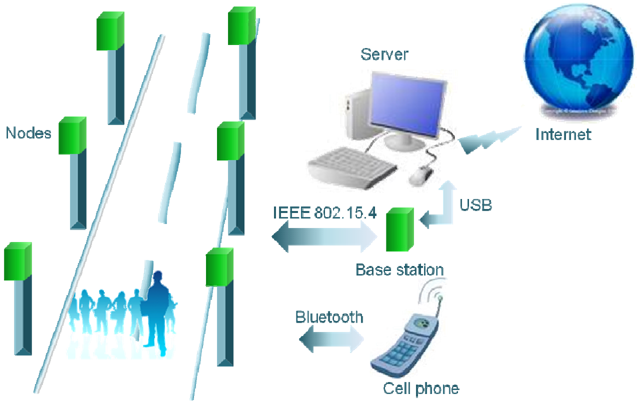

Figure 1. System architecture

Expected results

The main concept is to deploy stable and functional framework, installed in the street, by using sensor network infrastructure and human interaction. People accept new things if they are provided with good enough and interesting enough possibilities. Many aspects need to be considered. Each new technology has chances of success and failure, and it's up to system designers to make a functional framework. Besides system development, we have to take care about system visibility and accessibility, so the ISS network assumes integration into a larger one, the Internet.

System architecture

System architecture (fig 1.) implies usage of sensor equipped small programmable devices in order to provide the necessary support for network implementation. *Sun's SPOT* (Small Programmable Object Technology) was selected as the basic hardware platform. These devices are particularly suitable for system implementation because of their good processing capabilities and transmission power. Typical communication range for the devices is 50-100m, so all gathered information can be transferred through the network, by a multihop mechanism. The architecture relies on sensor nodes, as the main devices. Nodes gather data, do some basic processing and transfer data to each other by using IEEE 802.15.4 standard. They also communicate to a base station through the same protocol, but for communication to mobile devices nodes use Bluetooth. Base station is connected to a server via USB link, and that forms the channel through which information flow to Internet. Server is in charge for advanced data processing and presentation. Mobile phones use received data and present it in the best suitable way to people, they do “on the spot” kind of representation. The number of sensors on a single device is also limited, so the sensors have been selected in order to track the necessary parameters. ISS architecture includes sensors for light, temperature, humidity, CO and noise. The measurements of two parameters are particularly interesting. Noise level is very indicating parameter and quite significant for different analysis. CO gas is one of the most hazardous substances in a number of areas. This gas is known as “silent killer” because it is odorless and is a very common cause of death in the indoor environment, but in the street it can be used as fire detector. Other parameters were selected as interesting from different point of views.

System software

Software for the ISS application is entirely *Java* based. *Sun SPOTs* run on *Java VM*, called *Squawk*, so there is no need for operating system. Plan is to implement similar software components for nodes and the base station, since the base station in essence is a node without sensors. Mobile phones are used as the platform for deployment of a simple MIDlet, with advanced graphic capabilities. Server should run a servlet component and act as a gateway to large network, Internet.

Conclusion

The ISS application is not a new concept in the world of sensor networks, but it offers new approach to the similar problem statements. The main principle is to develop a small, but scalable system. Good and functional framework offers great capabilities for future enlargement, so the concept of ISS can be easily spread to the city level. This scenario is also easily adoptable for indoor monitoring. For the end, is good to say that ISS is designed to eventually satisfy four points: engineering issues, human effort, remarkable outcome and feasible price. Four stated principles will be discussed in detail in some future iteration.

Preventive Body Posture Monitoring and Computer Modeling to Reduce Risk of Back Injury and Low Back Pain and Educate People for correct body posture

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Introduction

Low back pain is a major health and socioeconomic problem across Europe. Low back pain is usually classified as acute (less than 6 weeks), subacute (up to 3 months) and chronic if it occurs episodically within a 6-month period or with duration of more than 3 months. It is estimated that 12-30% of adults have low back pain at any time and the lifetime prevalence in industrialised countries varies between 60% and 85%. The prevalence of specific causes is estimated in most industrialised countries as ranging between 2% and 8% and therefore much lower than the prevalence of non- specific back pain.

We propose the development of an intelligent patient-centric framework for the prevention of back injuries and the prevention of case worsening, by addressing the need of patients for prompt medical advice at the required time and place, and the need of medical professionals for remote and continuous monitoring for the provision of better and more informed health care services.

Our idea is to develop a **Smart Wearable SUN-spot Assistant (SWSA)** which is used to monitor and educate patients as well as people at risk, and a **Health Professional Assistant** which is used to assist in the management of chronic back pain. The **final product** can be customized to a **single wearable accessory for the patient** or the people at risk, or a **complete management clinic platform** which will be easily adapted to existing health care systems. The wearable SUN spot system will be of such form that can either be attached to existing posture aids currently available in the market or easily attached to everyday use garments (e.g underwear, shoes, etc.)

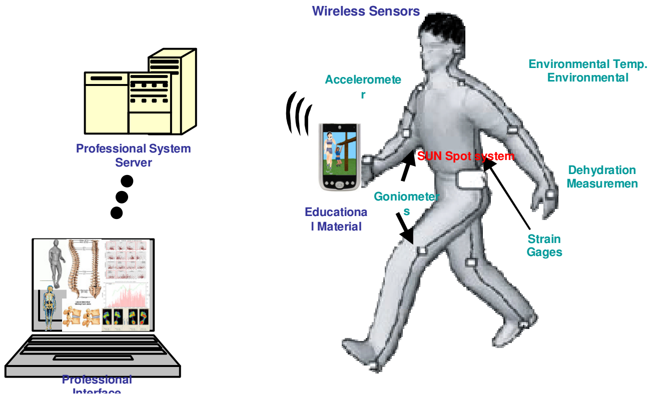

Fig. 1 SUN spot system application for specific patient

Current Status

As the equipment necessary for completion of the project hasn't been commissioned yet, development has so far been focused on software aspects of the project. We have developed also software for finite element analysis in order to make coupling of these hardware and software systems.

Expected Results

The **Health Professionals** will collect these information and using knowledge discovery techniques it will provide the health professionals on trends and evolving patterns that might need further medical intervention. They will also be provided with alerts that require immediate interventions and changes to treatment regimes.
On the other hand, for the **Health Professional System**, emphasis in on developing appropriate data mining techniques which are able to recognize previously unknown relations between events, recognize new patterns which indicate case worsening and suggest appropriate intervention. This module will gradually become a significant research tool which will allow us the better understanding of various back pain conditions. Another significant tool for the monitoring of the patient situation is on providing **on-time alerts for new treatment regimes**.
After receiving information from SWSA the finite element modeling will be done inside **Health Professional System** in order to optimize spine motion as well as to learn a patient for better spine moving and conditioning.

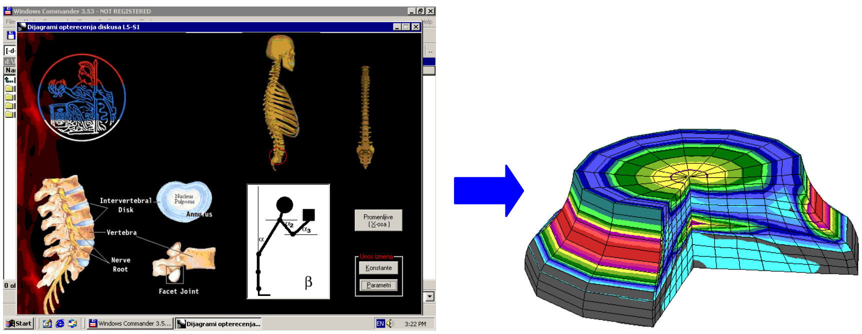

Fig. 2 FE modeling of spine and spine motion segment from specific patient

References

[1] Kojic M., Filipovic N., Mijailovic S." A Large Strain Finite Element Analysis of Cartilage Deformation with Electrokinetic Coupling", *Comput. Methods Appl. Mech. Engrg.*, Vol 190, pp. 2447-2464, 2001.

[2] Filipovic N., Mijailovic S., Tsuda A. and Kojic M." An Implicit Algorithm Within The Arbitrary Lagrangian-Eulerian Formulation for Solving Incompressible Fluid Flow With Large Boundary Motions", *Comp. Meth. Appl. Mech. Eng.* 195: pp.6347-6361, 2006.

Processing of Medical Signals (ECG) in Wireless Sensor Networks

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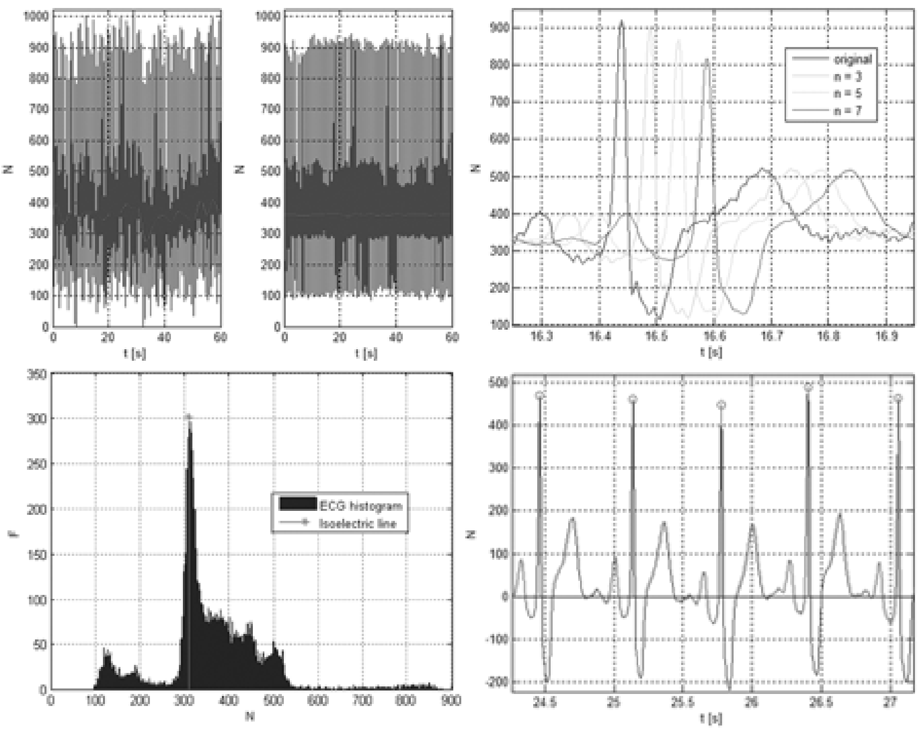
Introduction

The main culprits for about 60% of deaths in the world are cardiovascular diseases. Some of them are atherosclerosis, acute cardiac infarction, arrhythmias etc. This was the reason why we choose this area of science for researching. We want to form the system for Wireless ECG monitoring. The aim is getting valid information from processed ECG signal, as much as it is possible, and to make feasible obtaining an appropriate diagnose of arrhythmia from it. That system requires paying attention to processing of bioelectrical signals. This research refers mainly to preparing the ECG signals for analyzing and diagnostics.



Signal processing implies:

1. Analog signal amplifying

2. Noise elimination
    a. LF noises avoiding (such as baseline wonder noise)
    b. HF noises avoiding (such as power line 50 Hz / 60 Hz noise)
    c. Muscle noises avoiding
3. Compression
4. Analysis and diagnostics

Current Status

Functional system for wireless acquisition of data from arbitrary sensor, and system for analog processing of bioelectrical signals are already developed. There are few algorithms for basic processing and noise avoiding from sampled signals and algorithm for ECG signal analyzing in order to get values of RR intervals that are necessary for getting the diagnose of arrhythmia. These algorithms are tested on chosen signals from *PhysioNet* online database, collection of recorded ECG signals [1].

Expected Results

It is planned to upgrade the application *Wireless Sampler* for acquisition of ECG signals and further developing of algorithms for signal analyzing and diagnostics of heart rhythm disorder. It is required to detect P waves, for heart rhythm type decision (sinus or nodal), Q and S waves in combination with already detected R waves, which are good for prediction of left/right Hiss bundle branch block, and to measure PQ intervals for the first, second and third degree of AV blocks. It is planned further testing on patients and determination of referent values (tables) for specific arrhythmias.

References

[1] *PhysioNet*, the research resource for complex physiologic signals, http://www.physionet.org/.

Sensinode network – practice and experience

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Introduction

At the Faculty of electrical engineering, University of Ljubljana, we were looking into enhancing a pre-graduate course on remote control systems by introducing laboratory exercises with wireless networks. We have chosen the Sensinode's Devkit [1] since it provides an insight into the protocols used in wireless networks, and can also act as a good example of a platform with a potential to be used in real-life applications. This is indeed an attractive point, since students would not only benefit from the theory of the course, but would also gain experience with applications-oriented hardware. In this letter we summarize our experience with using the Sensinode's wireless network solutions for pedagogic purposes (Figure 1, left).

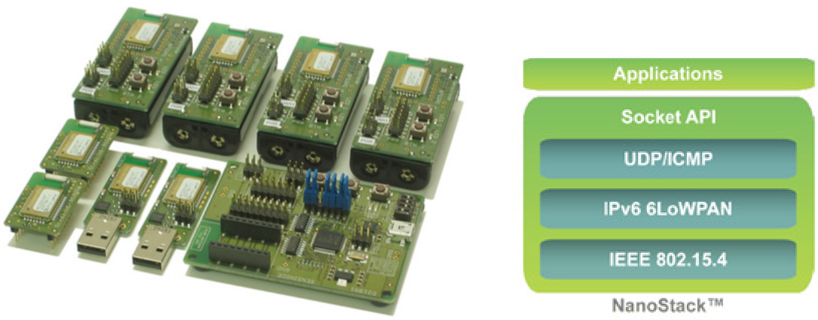

Figure 1: Sensinode Devkit (left) and the NanoStack layers (right) [2].

Sensinode Devkit in a nutshell

The Sensinode's Devkit includes a set of nine hardware components: four nano-nodes, two Zigbee-ready radio-frequency (RF) transceiver modules, two nano routers and a devboard for programming the modules (see Figure 1, left). All the nodes and the nano routers are based on the Radiocrafts RC2301AT module, which essentially combines a 8051 microcontroller with an RF transceiver. The center of the Sensinode's products is the 6LoWPAN protocol stack called the NanoStack (Figure 1, right) which runs on the embedded wireless nodes. It includes 6LoWPAN IPv6 and UDP implementations, ICMP, the IEEE 802.15.4 MAC, and the Simple sensor interface protocol. A NanoMesh multihop forwarding is built-in to provide automatic multihop capabilities. Forwarding is not implemented through explicit route discovery and path setup, but rather uses a combination of overhearing and limited flooding. It also supports self healing and the discovery of gateways. NanoStack is built on FreeRTOS [3], an open-source realtime microcontroller operating system. FreeRTOS provides a microkernel with a scheduler, microcontroller specific-code, memory allocation, queues, and semaphores along with system timer functionality. NanoStack is executed as a single task in the FreeRTOS environment. This allows reduced RAM usage and provides an effective way of flow control: protocol modules are always executed sequentially. The wireless network can be accessed through a personal computer using the nano routers, (USB interfaces). The nRoute protocol provides means of communication between the nano router and the PC via serial ports. The Devkit comes with a set of examples which demonstrate basic functionalities of the NanoStack as well as skeleton codes for rapid development of customized applications. The nodes are programmed using the supplied devBoard programmer, which connect to the PC using a standard USB serial port. The application code is written in C language and a *sdcc* cross-compiler is used to generate binaries, which are then transferred to a node via the programmer. A typical binary code transfer cycle takes approximately 5min.

Impressions from a classroom

The Sensinode's Devkit is indeed attractive because it allows a high level of insight into the raw structure and protocols of a working wireless network. However, the very idea that the Sensinode's products are industry-oriented comes at a cost. In conclusion we point out below some positive as well as some negative features that we have experienced with using the Devkit as a part of classroom exercises.

Positive features:

1. Supports development under Linux as well as Windows (CygWin).
2. Provides deeper insight into workings of a wireless network and access to source code.
3. Provides a set of examples which demonstrate some functionality of the NanoStack.
4. Provides a good hands-on experience for the students.
5. Satisfactory debugging tools using UART (e.g., HyperTerminal under Windows).

Negative features:

1. Poor documentation of the API and installation guidelines.
2. Lack of pedagogically-structured examples and description of the system. Students will spend quite some time to get acquainted with the system before they can even start to program.
3. The code development cycle is extremely long. It takes nearly 4min to program a 200kB binary file to the node.

References

[1] Sensinode, Development Kit, available at: http://www.sensinode.com/media/flyers/sensinode-k210-flyer-web.pdf, Last visited: 13.1.2009
[2] NanoStack Manual, Sensinode Ltd., 2008
[3] FreeRTOS™, available at: http://www.freertos.org/, Last visited: 13.1.2009

Sensors' Mobility towards WSN Performances Improvement

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Introduction

Mobility is lately emerging as an important research aspect in Wireless Sensor Networks (WSNs). Mobile entities (i.e. sensors, sinks and/or relays) can follow diverse mobility patterns which lead to different performances improvement in terms of coverage, connectivity, network lifetime etc. However, the sensors' mobility, despite its numerous advantages, imposes many challenges when designing appropriate algorithms and protocols.
This paper presents a survey on sensors' mobility. In addition, some state-of-the-art solutions for network topology and coverage improvement, as well as for sensing improvement, are also mentioned. Finally, some solutions for data propagation and cooperative communication are introduced.

Sensors' mobility (State-of-the-Art Solutions)

The design of sensors' mobility models faces two important research trends, i.e. approaches for *network topology* and *coverage improvement* and for *sensing improvement*. Representative examples for the former trend comprise approaches that use potential fields (where nodes are treated as virtual particles subject to virtual forces that repel the nodes from each other and from obstacles) [2], approaches exploiting Voronoi diagrams for moving the sensors towards coverage holes [3] and "quorum based" approaches with cascaded sensors' movements from densely to sparsely deployed areas [4]. The latter trend is usually focused on sensors' moving towards events that occur in the network which need to be captured in real time [5].
These examples for sensors' mobility are only a small subset of the possible models found in the literature. More detailed overview of different mobility models for WSNs can be found in [1].

Mobility Issues

Mobility in WSNs is a challenging issue. It causes frequent network topology modifications, necessity of new routing and data dissemination techniques and, consequently, requirement for appropriate mobility models [6]. The specifics of the sensors' mobility require more appropriate and novel algorithms and protocols to be designed.
One of the most prominent research aspects in mobile WSNs is the *efficient data propagation*. Various solutions can be found in the literature. For example, simple and efficient data delivery

scheme for special kind of a mobile WSN, called DFT-MSN (Delay-Fault Tolerant Mobile Sensor Network), based on delivery probability and fault tolerance is given in [7]. Ref. [8] presents a more efficient approach, where adaptive data dissemination protocol is specifically tailored for diverse sensors' mobility. Furthermore, efficient data propagation can be obtained using *cooperative transmission* techniques. The cooperative transmission allows for a group of nodes to combine its emission power, thus achieving higher emission power in total and overcoming the connectivity problems of multi-hop networks aroused due to the mobility [9].

Conclusion

There are still many open issues evoked in the area of sensors' mobility. Some of these issues comprise designing novel algorithms and protocols, providing adequate performance metrics and performance analysis and designing new and appropriate mobility models. Additional complexity is introduced by allowing different mobility models to have different influence on the performance metrics.

Nevertheless, sensors' mobility is an important aspect in future WSNs. Sensor movements may help improve the monitoring capabilities and coverage in WSNs, achieve effective communication and accommodate new applications. Therefore, the research community is actively working towards solving many of the open challenges.

References

[1] A. Mateska and L. Gavriloska "An Overview of Mobility Models in Wireless Sensor Networks," presented at *PhD NOW '08*, Sophia Antipolis, France, September 2008.

[2] Z. Vincze et al., "Electrostatic Modelling of Multiple Mobile Sinks in Wireless Sensor Networks," in *IFIP Networking Workshop on Performance Control in Wireless Sensor Networks*, Coimbra, Portugal, pp. 30-37, May 2006.

[3] G. Wang et al., "Movement-Assisted Sensor Deployment," in *IEEE Transaction of Mobile Computing*, Vol. 5, Issue 6, pp. 640-652, 2006.

[4] J. Teng et al., "Sensor Relocation with Mobile Sensors: Design, Implementation and Evaluation", *IEEE MASS 2007*, Pisa, 8-11 Oct. 2007.

[5] Butler and D. Rus, "Event-based Motion Control for Mobile-sensor Networks," *IEEE Pervasive Computing*, vol. 2, no. 4, pp. 34–42, 2003.

[6] L. Gavrilovska and R. Prasad, *Ad-Hoc Networking Towards Seamless Communication*, Springer, 2006.

[7] Y. Wang and H. Wu, "DFT-MSN: The Delay/Fault-Tolerant Mobile Sensor Network for Pervasive Information Gathering," *INFOCOM* 2006.

[8] A. Kinalis and S. Nikoletseas, "Adaptive Redundancy for Data Propagation Exploiting Dynamic Sensor Mobility," *MSWiM 2008*: 149-156.

[9] A. Krohn et al., "Increasing Connectivity in Wireless Sensor Network using Cooperative Transmission," *INSS 2006*, Chicago, USA, May 31 - June 2, 2006.

Smart Running Track
Towards Real Life Social Networking
With Wireless Sensor Networks

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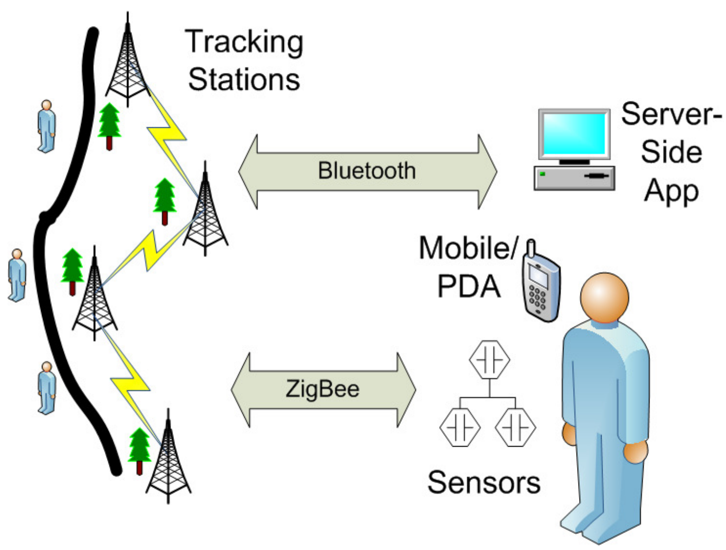
Introduction

The Smart Running Track (SRT) is a wearable computing project seeking to apply the technology of Personal Body Area Networks (PBAN) to enhance personal fitness and to enable remote monitoring of body parameters of its users. The goal is to encourage more people to take part in running activity by providing permanent infrastructure in public parks and trim tracks and at the same time provide remote tracking in order to prevent possible accidents resulting from over-exercise. Participants would be able to join in at any time, as new ranking metrics will be used, such as calorie count and average speed of running. The project differs from existing projects such as FitFone [1] and Nokia SportsTracker [2] through its emphasis on the social component (SRT focus is on the interaction between runners, rather than interaction between a single runner and the remote computer which provides feedback)



In the architecture of the system, four different device classes are used:

1. Sensor nodes, worn by the runners, which track body parameters;

2. Mobile phones, also worn by the runners, through which feedback is provided to the runners;
3. Tracking stations, which track the moving runners along the path and form a stationary infrastructure through which collected data are disseminated;
4. Server computer, used by a physician to supervise the race.

For each of these device classes, special software will be written to enable the desired functionality.

Current Status

As the equipment necessary for completion of the project hasn't been commissioned yet, development has so far been focused on software aspects of the project. A small scale simulator of a real world setting has been developed in order to test the message exchange between (imaginary) sensor nodes, and to provide input to the server side application, which will continue to be used unmodified with the actual equipment.

Expected Results

The Smart Running Track project is expected to be completed by December 2009. In the course of development, it will be tested in a real life setting in a public park in Belgrade.

References

[1] http://www.fitfone.ie, University College Dublin, Ireland, 2008.

[2] http://sportstracker.nokia.com, Nokia Corp., 2008.

Smart ZigBee wireless sensors medical therapy scheduler for the older people

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Introduction

Better care for older people should be one of European health care priority, but may reflect relevant issues in other parts of the world. The government health and social institutions, the nongovernmental, academic and private sectors and health professionals working to improve care for older people. All these groups will need to work to integrate efforts more widely across health services. Proposed system is based on wireless sensor network standard, IEEE 802.15.4. The smart tablets bottle shank, named End device, monitors bottles moving and sends wirelessly information to master, Coordinator node.
End device is based on CC2420 or CC2480 IEEE 802.15.4 wireless transmitter and low power microcontroller TI MSP430Fxxxx family able to communicate with the transmitter and battery savings. Smart Wearable SUN-spot Assistant (SWSA) is used as a master node, preprogrammed for certain patient therapy scheduler which sends a voice information, alert or prevention to older people. The battery life time for a ZigBee End Device is heavily dependent on poll rate and how often it will receive a data packet. A higher poll rate will result in higher power consumption. In cases with interfering traffic on the channel in use, retransmissions of either data requests, acknowledgement packets or data packets may occur. When retransmission occurs it will influence the power consumption to an extent that is dependent on how often packets need to be retransmitted in average. The battery life time may be extended by decreasing the poll rate when this is acceptable in the application. In the above examples it is assumed that the data traffic goes only one way, from the Coordinator to the End Device. The length of the data packets transmitted from the Coordinator also influences the power consumption, because it directly influences the time used to receive the packet. The complexity of the application, and which peripherals that are used, will also influence the power consumption

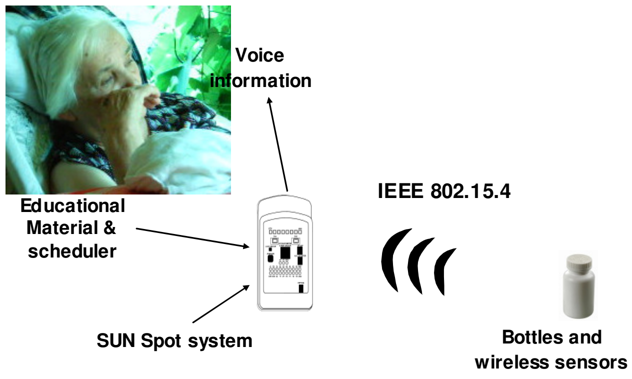

Fig. 1 Wireless system for specific patient/older people

Current Status

Sensor wireless network was proposed as a combination of centralized network. Considering primarily application requirements and these are acquisition and controlling procedures, it is necessary to have one base station which would control and monitor sensor work and actuator devices from application level. Proposed network is based in a way that the node which is used in proposed algorithm in this network implies the group of nodes surrounding one master node. Cell network is organized in a following way:

1. In the beginning configuration communication is set up (set up stage). Each node is presented to network by sending its temporary byte, ID, which is returned back by master if the channel is free which means that it can be used by registered node.
2. Master generates the list and assigns the address by the order of registration
3. Procedure of sending measured data is done in a way that slave which recognizes its address sends the data to master t sends the data ends with the address of slave which is next in a row for sending data;
4. Frame in which the data are sent ends with the address of slave which is next in a row for sending data
5. The procedure is repeated until it is turn for the last slave so based on instructions received in initialization phase and communication with master, it transfers the address again to first slave or master

Expected Results

. We propose the development of an intelligent patient-scheduler system for the prevention of medical therapy missing or wrong tablets taking. Our system will inform the patients for at the required time for therapy, for number of rest tablets in the bottle and eventually misunderstandings like double tablets taking and similar.

References

[1] U. Pesovic, **A. Peulic**, Z. Cucej: ***MAC Protocols for wireless sensor networks***, Electrotechnical review, Ljubljana, Slovenia, Number 1-2, 2008, ISSN: 0013-5852, (**ref. citation *Scientific and Technical Aerospace Reports* (*STAR*), Vol. 46, No.14, 21. July 2008**)

[2] **A. Peulic**, U. Pesovic, K. Benkic and Z. Cucej, ***Performance Analysis of Improved ZigBeeWireless Network by Simulation,*** 15th International Conference on Systems, Signals and Image Processing, IWSSIP 2008, 25-28 June 2008, Bratislava, Slovak Republic, **IEEE Conference, IEEE Catalog Number: CFP0855E-PRT, ISBN: 978-80-227-2856-0**

[3] **A. Peulic**, U. Pesovic, Ž. Čučej, ***ZigBee wireless network performance analysis and electromagnetic fields modeling**,* 978-961-248-029-5/07 © 2007 UM FERI, 2007 IWSSIP & EC-SIPMCS, Slovenia, **IEEE Conference**

Some Interdisciplinary WSN-relevant Research Ideas

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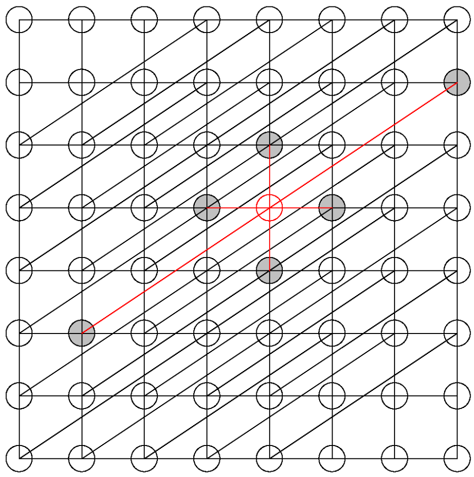
Introduction

This contribution intends to trigger some new Wireless Sensor Networks (WSN)-related research on the interdisciplinary area between the theoretical research of parallel and distributed computing, parallel computer simulations and network computing and advanced bio-signal processing with the final goal of implementing some practical demonstrations and experiments that could results in some practical applications in the area of sensor networks.

The above mentioned research could be supported significantly with two important pieces of research equipment: parallel computing cluster and multi-channel ECG, both developed at the Department of Communication Systems on Jožef Stefan Institute. The devices are available for scientific cooperation for all interested researches. While the computing cluster is used mostly for the computer simulation and modeling in bio-medicine, the multi-channel ECG is a source of valuable medical measurements of the heart activities.



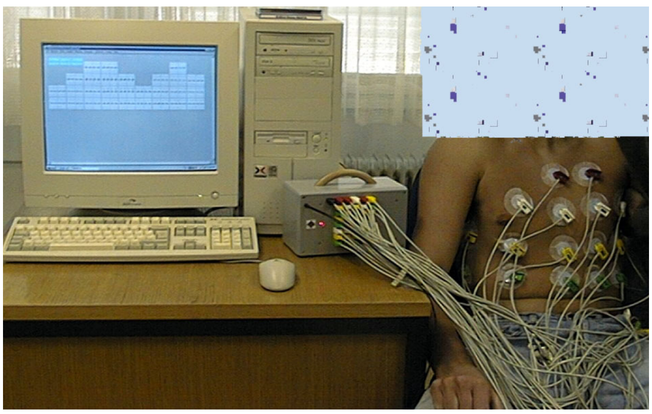


Figure: Left – Optimal 6-mesh topology of 64-node computing cluster for parallel computer simulations. Right – 32-channel ECG for high precision measurements of heart activities.

Current Status

We are developing mathematical models - partial differential equations (PDE) – and numerical methods for their solution. Usually, geometric models of part of a human body, which are by its nature irregular, have to be developed. To incorporate all details, these models are usually composed from millions of voxels in 3-D, consequently, parallel computers are needed for the simulation. Efficient parallel computing is possible only with efficient communication topologies. We have developed optimal d-meshes with better maximal and average intermodal distances as by competing topologies, like k-ary n-cubes or arrangement graphs.

The simulated results have to be verified by real measurements, where multichannel ECG could be of great help. For example, the reconstruction of a standard 12-channel ECG must be implemented from a small set of electrodes in order to be efficient in WSN environment. Multichannel ECG can help in testing different research hypothesis and simulated results. Additionally, the simulated results and new knowledge obtained can be used in the design and construction of advanced bio-sensors, body sensor networks or medical assisting WSN.

Expected Results

Several future WSN-related activities are possible on the area of parallel computing, simulations, and medicine, for example:

- Development of 3-D dynamic [1, 2] models (>10^6 nodes) of a human body parts (beating heart, knee under active stress, forearm, eye, foot under thermal treatment, etc.) Simulation of medical treatments [3], electrical cell activities [4], etc. in order to support personalized diagnostics and therapy. Sensors are needed for the verification of simulated results.
- Computer assisted non-invasive (robotic) surgery needs sensor networks for device positioning, visualization and control. Efficient sensor topologies could be developed and tested for such applications.
- Exploring of solution alternatives for the reconstruction of the standard ECG with just two electrodes, some centimeters apart (on the body surface), with four electrodes some tenth of centimeters apart, or with several pairs of differential electrodes, etc. In a combination with other body sensors (breathing, temperature, etc.) the heart rate variability reflects personal health, emotions, controlling mechanisms, moving, and others.

References

[1] Šterk M. Trobec R. Meshless solution of a diffusion equation with parameter optimization and error analysis. *Eng. anal. bound. elem.* 32, 2008, 567-577.
[2] Trobec R. Šterk M. Robič B. Computational complexity and parallelization of the meshless local Petrov-Galerkin methods. *Comput. struct.* 87, 2008, 81-90.
[3] Depolli M. Avbelj V. Trobec R. Computer-simulated alternative modes of U-wave genesis. *J. cardiovasc. electrophysiol.* 19, 2008, 84-89.
[4] Trobec R. Šterk M. Almawed S. Veselko M. Computer simulation of topical knee cooling. *Comput. biol. med.* 38, 2008, 1076-1083.

State of the art in Medical Applications of Wireless Sensor Networks

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Introduction

During the past decade various researches have been done in the field of wireless sensor networks (WSNs). These analyses lead to the development of the new technology which can be used in different areas. History of wireless sensor networks begins at University of California (UC), Berkley, with Smart Dust project which was funded by Defense Advanced Research Projects Agency (DARPA). The aim of this project was to develop self-organized, millimeter-scale hardware platform for distributed WSNs. Primary, this was a military application which resulted in development of relatively large sensor nodes. Later miniaturization process brought much smaller devices, with solid sensing and communication capabilities. One of the key points in the history of wireless sensor networks was the implementation of energy-efficient software platform, Tiny OS, operating system, also developed at UC. Today, thanks to different devices in use, and to the development in the area of communication protocols WSNs meet extraordinary capacities in various fields, medicine above all.

ProSense project has an obligation to develop use-cases in the domain of personal health. In order to achieve appointed goals, some study had to be done. This paper briefly discovers important points of the provided research by emphasizing the existing medical applications, based on WSNs.

The status of today's healthcare system

Today's healthcare system faces problems which must be pointed out before any serious implementation of WSNs in this domain. We are witnessing a time when world's population is aging. Number of elderly people is growing. Number of people suffering from diseases is growing, so the number of medical mistakes is growing. All these facts lead to a conclusion that the healthcare system of today is highly complex and expensive. The technology which is able to address and answer these open questions of current health system is the technology which could be the most powerful weapon of modern healthcare. WSNs have such kind of ability.

Important issues which also must be considered before some real implementation of WSNs include engineering, social, and patients' well being issues.

Wireless sensor networks vs. existing infrastructures

Great advantage of WSNs lies in their compatibility with existing infrastructures (Figure 1). Sensor nets, in general, rely on services like radio-frequency identification (RFID), general packet radio service (GPRS), and wireless local area network (WLAN). By using the mentioned services, sensor networks provide the necessary interface to more sophisticated networks like wireless body area networks (WBANs) and wireless personal area networks (WPANs).

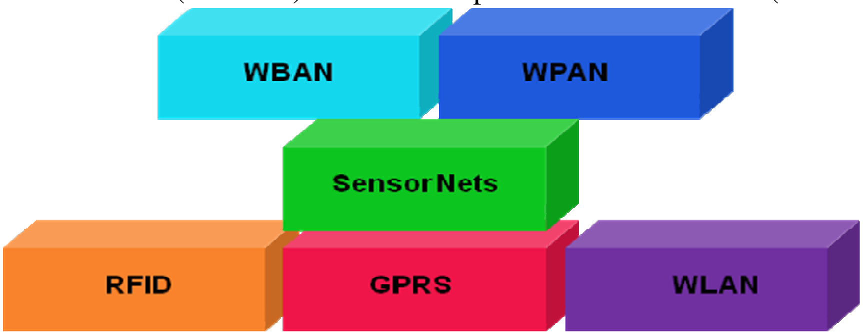

Figure 1 Hierarchy of WSNs and existing infrastructures

Short comparison of some existing WSN-based medical applications

Since WSNs offer great capacity for deployment of various medical applications, different projects are being developed all over the world. In this section ten applications have been compared in term of project goals. The comparison is done in table form (Table 1), since the work itself is page limited.

Projects	*Goals*
CodeBlue	Development of emergency care and disaster response system
SMART	Development of medical alert response system
MobiHealth	Development of lightweight monitoring system
MyHeart	Development of WSN for cardio vascular diseases' detection and prevention
WIISARD	Development of urgent medical response system
MIThril	Development of wearable platform for physiological sensing
Satire	Development of software architecture for recording owners activity
UbiMon	Development of WSN for ubiquitous patients' monitoring, detection and prevention of potential abnormalities
AlarmNet	Development of WSN for assisted living and residential monitoring
BikeNet	Development of WSN for exploration of personal, bicycle and environmental sensing

Table 1 Comparison table of some existing medical applications based on WSNs

With all new technologies we have pros and cons, and how things will evolve future will certainly show. Many of mentioned projects are already part of the industry development. Their potential is being exploited in order to achieve the ultimate goal, improvement of people's lives. This paper is page limited so important facts were only addressed. Further analysis will be a matter of some future paper iteration.

Sun SPOT
Introduction with example application

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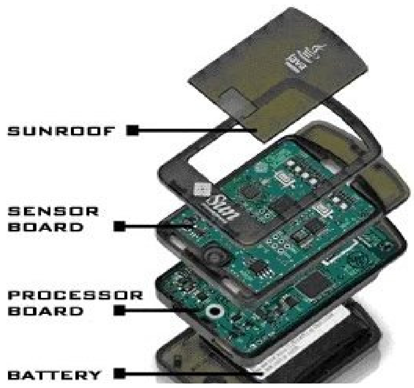
Introduction

SPOT stands for **Small Programmable Object Technology**. It is developed in Sun Microsystems labs as one platform that is aim to put Java in Wireless Sensor Networks world. It is Java ME, CLDC and MIDP compatible, so applications for SPOT are formaly wery close to those build for mobile devices like modern mobile phones.

Technical details



PICTURE 1: CROSS-SECTION OF SPOT

As from Picture 1 it can be seen that design of SPOT is layered and that sensor board can be easily replaced if needed. Core of SPOT is ARM920T, 180 MHz 32 bit processor, 512KB ram and 4MB flash storage.
It has USB and 2.4 GHz IEEE 802.15.4 radio interfaces. Sensor board that is shiped in default package has on it sensors for acceleration, temperature and light, 8 three-color LEDs, 6 analog imputs, 2 momentary switches, 5 general purpose I/O pins, 4 high current output pins.
For this hardware to be alive there is Squawk, Java virtual machine designed to run in extremely resource constrained environments, like SPOT. Squawk manages power and other issues so application programmer can focus on actual application logic instead on plumbing, then it is supported concept of isolates, software construct that represents multiple independent execution space, which make easier to deploy multiple applications on SPOT at same time. It is planned that in future Squawk VM should be fitable in 16kB of memory. Besides Squawk, there is a lot of Java libraries available in basic development kit, written by Sun labs that be layer over hardware platform and drivers for bunch of hardware components on SPOT like on-board LED, PIO, AIC, USART, IEEE 802.15.4 and so on. SPOT without Sensor board can be used for base station, or any other SPOT with board that is set to work in base station mode. Base station is connection point between SPOT WSN and PC, connected with PC with USB and using IEEE 802.15.4 protocol to communicate with WSN. Sun has developed simulation tool for SPOT called Solarium that enables that applications written for SPOT can be deployed and tested without physical devices involved.
Pros for SPOT:

- Java enabled

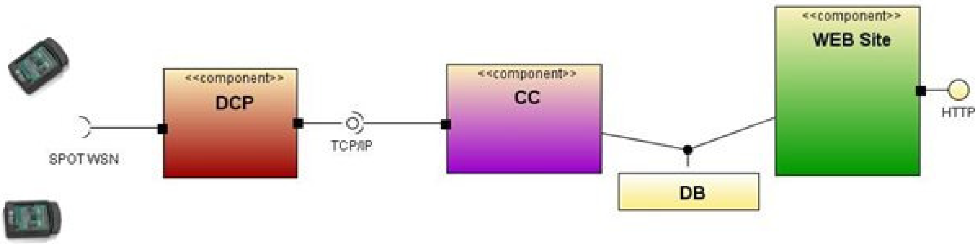
- Low steep curve of learning
- Good documentation and relatively big community
- Existence of simulator

Cons for SPOT:

- Not so small physically (33 grams, 63.5mm x 38mm x 25mm)
- Security is issue
- Some issues working with Linux

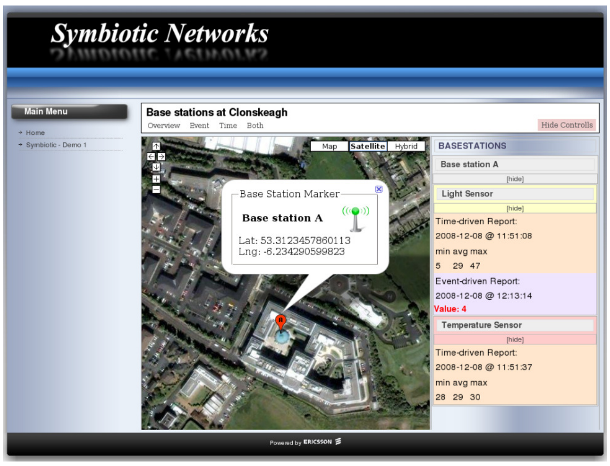
Example application: Symbiotic networks

Main idea of symbiotic networks application is to use existing communication infrastructure in mobile telecommunications for new services in WSN domain. It is introduced by Srdjan Krčo and David Loftus, Ericsson Ireland and designed and implemented in form of prototype by author of this paper. For prototype, Sun SPOT is used as WSN, and basic sensor board with temperature and light sensor readings. Reporting is realized in three modes: time-driven, event-driven and on demand. System component overview is presented on Picture 2.



PICTURE 2: SYMBIOTIC NETWORKS PROTOTYPE COMPONENT OVERVIEW

On Picture 2 DCP stands for Data Collection Point – serving as interface to appropriate WSN, buffering and other preprocessing of collected data before reporting to CC which is Control Centre, one point for many DCPs that are connected to it for final gathering reports and storing in permanent fashion; database is one option. CC is also responsible for commanding to all DCPs that are assigned to it. Commands that are implemented are: start, pause, resume DCP reporting, and other operations related to specifics of WSN type and application on it.



PICTURE 3: WEB INTERFACE OF SYMBIOTIC NETWORKS PROTOTYPE

On Picture 3 it is presented web interface of prototype, which can be recognized as “WEB site” component on Picture 2. For every base station or DCP it is generated list of all sensors that are installed on it, current reporting modes that are active for that sensors and values of last readings.

Current status

Symbiotic Networks are implemented as prototype, using Java technology for DCP and CC components and XAMPP platform for web presentation.

Expected results

Next step in evolution of Symbiotic Networks is implementation of some additional functionalities of system like support for more WSN types and implementation using Java EE platform using design best practices for scalability, security and reliability.

References

1. www.sunspotworld.com – home page of SPOT project
2. Sun SPOT Developer’s Guide, August 2008, Sun Microsystems, Inc.
3. Using the SPOT Emulator in Solarium, June 2008, Ron Goldman

Vehicular Sensor Networks: General Aspects

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Introduction

Development of sensors' and sensor networks' technologies makes road and vehicle phenomena sensing, as well as sending sensor data to relevant entities (e.g. users, institutions etc.), feasible. This gives rise to the concept of *Vehicular Sensor Networks* (*VSNs*). VSNs are a subset of Vehicular Ad-Hoc Networks (VANETs) placed either in vehicles or alongside roads creating an end-to-end reliable traffic efficient network for sensor data. This paper gives a short overview of general aspects of VSNs discussing the layering architecture and the applications of VSNs.

General Characteristics

VSNs can be broadly classified into two groups, i.e. *intra-vehicle VSNs* (a "single vehicle" VSN used for giving diagnostics to the driver) and *inter–vehicle VSN* (used for sharing the sensor data with other vehicles or infrastructure components). In–vehicle connectivity in an intra–vehicle VSN is enabled by wireless standards for ad-hoc communications such as Bluetooth, ZigBee [1] and UWB. Inter–vehicle VSNs are based on different DSRC (Dedicated Short Range Communication) standards at physical and data link layer and can be either fully–distributed or centralized.

VSNs are characterized by a dynamic environment (due to the high nodes' mobility) where *routing* and preserving *end–to–end connectivity* are major concerns. In addition, *reliability* can be improved by using specific techniques for data dissemination [2] and harvesting as well as data prioritization. *Scalability* and *data security* should also be addressed. Unlike in other wireless sensor networks, power consumption in VSNs is not an issue. More on different constraints and prerequisites that lead to a number of challenges in VSNs can be found in [3].

Layered Architecture

The general layered architecture of VSNs is shown on Figure 1. Same DSRC standards at physical and data link layer that are used in VANETs can also be used for VSNs. The *vehicular network layer*, based on a geo-positional routing, resides above. Transport layer mechanisms depend on applications requirements, i.e. safety critical ones require a reliable transport protocol

suitable for work in real time whereas others can use the standard TCP/IP model. The application layer depends on the actual application.
A variety of DSRC standards are currently standardized [4]. IEEE 802.11p (in use in USA) is becoming de–facto standard for VSNs at physical and data link layers. It is a WLAN standard very similar to 802.11a optimized for high mobility of nodes. It works in the 5.9 GHz band and its main characteristics are OFDM at the physical layer and SDMA at the data link layer.

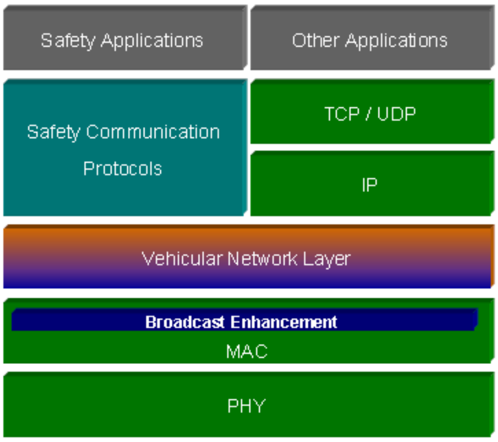

Figure 1: Layer Architecture in VSNs

The applications of vehicular sensor networks can be divided into *safety applications* (potential killer applications) and *non–safety applications*. Some of the safety applications include cooperative forward collision warning, pre-crash sensing/warning, approaching emergency vehicle warning and safe lane change maneuvers. Non–safety applications are mostly represented with traffic efficiency. More information about these and many other applications can be found in [2, 5].

Conclusion

A large number of projects have been conducted in the VSN area in the past. The interest ranges from developing innovative telematics applications to defining an open architecture and processing multisensorial signals [6]. However, many issues are yet to be resolved. Future development will be concentrated on improving the channel modeling, scalability, modulation and coding techniques, mobility and network management, routing mechanisms etc.

References

[1] H.-M. Tsai et al. "ZigBee-based Intra-car Wireless Sensor Network," *IEEE ICC2007*, 2007.
[2] K. W. Lim, et al "Multi-hop Data Dissemination with Replicas in Vehicular Sensor Networks," 2008.
[3] M. Nekovee "Sensor networks on the road: the promises and challenges of vehicular ad hoc networks and grids," *Workshop on Ubiquitous Computing and e-Research*, 2005.
[4] K. Bilstrup, "Vehicular Communication Standards," *Telematics Valley Conference*, Göteborg, Sweden, November 2007.
[5] Car – 2 - Car Communication Consortium manifesto 2007.
[6] L. Strandén et al, "Wireless Communications Vehicle-to-Vehicle and Vehicle-to-Infrastructure," *SAFER PRE-STUDY NO. AD4*, SAFER Vehicle and Traffic Safety Centre, 2008-04-10.

Vehicular Sensor Networks: Implementation Issues

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Introduction

The popularity of Vehicular Sensor Networks (VSNs) emphasizes the practical aspects in their implementation. This state-of-the-art survey addresses possible implementation solutions in VSNs by identifying the necessary equipment for a VSN system structure deployment. In addition, the paper discusses various sensors and technologies and links them with examples of implementation.

VSN System Structure and Implementation

Proper system architecture is needed in order to implement a VSN. The system structure usually consists of *measuring sensors*, *signal conditioning*, *Central Processing Unit* (CPU), *communication devices* and various *peripheral devices*.

Sensors have a key roll in VSN system structure. They should be accurate, reliable and provide fast response. Used sensors are broadly divided into *roadside* sensors and *intra-vehicle* ones. Roadside sensors comprise weather, smog and laser sensors as well as the most commonly used Anisotropic Magneto Resistive (AMR) sensors [1] which use the disturbance of the magnetic field of the earth in order to determine the presence or absence of a vehicle. AMR sensors are used to provide information about the speed, direction, quantity of vehicles per unit time etc. An example of the magnetic sensors implementation is the use of the AMR sensors in order to prevent unreasonable overtaking or speeding at a very curved road, where a vehicle cannot be seen by other vehicles traveling from the opposite direction (Figure 1) [2]. The warning system is used to reduce danger by notifying the invisible and unexpected risk in advance. Other applications using magnetic sensors comprise traffic monitoring, automatic door/gate opening,

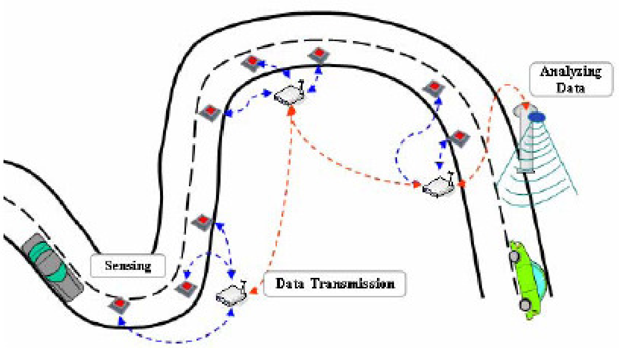

Figure 1: The components of collision warning system

parking lot space detection, drive through retail and many others.
As for the intra-vehicle sensors, they can perform a variety of measurements (e.g. distance, speed, traveled path, tilt, operation time etc.). The most popular ones today are distance and speed sensors. They both work on the same principle of calculating the frequency shift between an emitted signal and a one reflected from the target object. Appropriate examples are the Doppler radar speed sensor [3], as well as some ultrasonic distance sensors.

Evolution towards RFID

Another emerging technology that is foreseen to play an important role in future VSNs' implementations is RFID (Radio Frequency Identifier). It represents a significant element in mobile computing and automatic data collection systems adding many features to traditional automatic identification and data capture applications. The system's advantages are: multiple sensor readings, faster data acquisition, interoperability, reusability and flexibility which offer great potential and can be very useful in a vehicular network implementation. However, RFID must be considered with great caution as it can devolve into proprietary-based single-use applications that ultimately limit its potential. A practical implementation of the VSN evolution towards RFID can be found in the Taiwanese's Fleet Management System, based on a VITA-350 platform, winner of the 16th Taiwan Excellence Award in April 2008 [4].

Conclusion

Implementations of VSNs among modern vehicle and transportation systems are numerous. Their careful study shows that used sensors must be small sized, independent of temperature and electromagnetic fields, interoperable and capable of multiple sensor reading. VSNs will inevitably become an integral part of future traffic management solutions. In addition, RFID can become fully integrated into current and emerging standards based automatic information collection systems.

References

[1] Application Note-AN218, "Vehicle Detection Using AMR Sensors," *Honeywell International Inc.* 2005. Available at: http://www.honeywell.com
[2] KyungBok Sung, JaeJun Yoo and DoHyun Kim, "Collision Warning System on a Curved Road using Wireless Sensor Networks," *IEEE* International Symposium on Wireless Vehicular Communications, Baltimore, 2007
[3] Application Note - "Fundamentals of Non-Contact Speed Measurement Using Doppler Radar," *GMH Engineering,* 2003. Available at: http://www.gmheng.com
[4] "Vehicle and Fleet Management Solutions" – *Advantech Co.,* 2006. Available at: http://www.advantech.com

Wireless ECG measurement - a real example

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Introduction

An electrocardiogram (ECG) is a record of electrical activity of the heart. Whether the measurement of this activity is stored locally, transmitted to a remote location on-line or processed locally while transmitting only the results of the analysis is a matter of choice. Wireless ECG means that no wires are needed for the transmission of data, but do we still need wires on the body? It is certain that a few centimeters long leads are enough for monitoring heart rate (plaster like ECG device) and it is also certain that ECG machine cannot be a one point device. Medical diagnostics can be obtained from ECG if it is recorded with reasonable accuracy from several distant positions on the body. Whether the positions can be changed to suit a small plaster-ECG is the question, not answered yet. The analysis of multi-channel ECG recordings can answer this question. Real ECGs from wireless sensor nodes in real environment should be used to develop the missing knowledge (Figure 1).

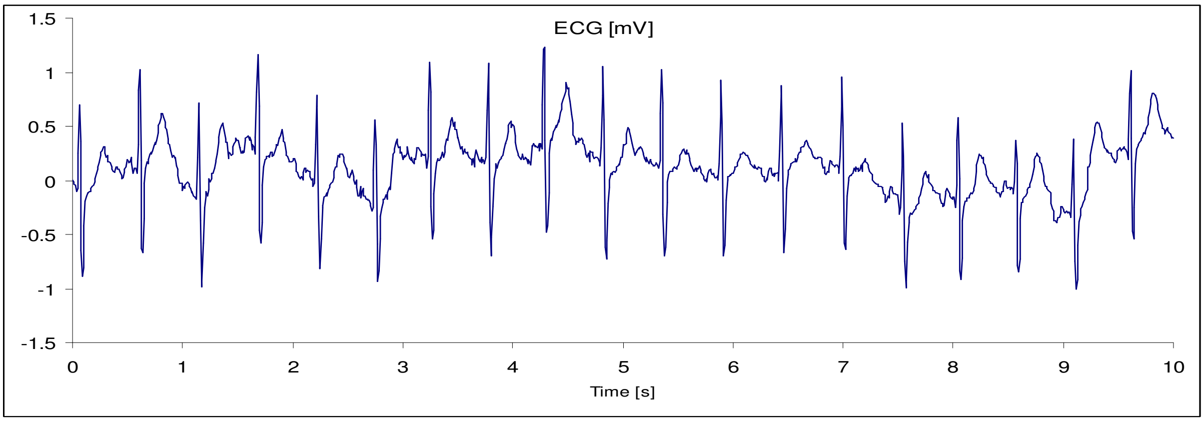
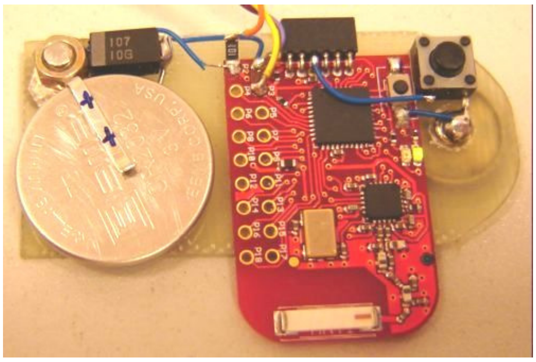


Figure 1: First seconds of ECG measured and shown in real-time to the participants of ProSense Seminar during presentation

Current Status

A wireless ECG prototype node (Figure 2) specially designed for high quality recordings, together with the application on personal computer was developed. The node contains a new active electrode with low-noise, low-power ECG amplifier on the electrodes' connector. The first results concerning network accessibility and quality of recordings was obtained in real environment.



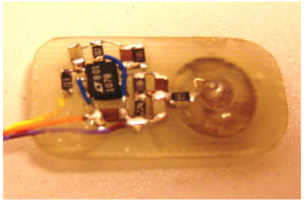


Figure 2: Wireless ECG prototype module with electrodes' connector and battery (left);
Active electrode - ECG amplifier on the connector (right)

Expected Results

We are interested in the development of ECG sensor nodes that could be used after cardiac surgery for prolonged monitoring of patients. The top questions and themes are:

- In what conditions high quality recordings from ECG sensor nodes can be obtained?
- Characterization of wireless communication of ECG sensor node in real environment regarding network accessibility
- Analysis of power used for ECG sensor node operation: local processing versus immediate transmission of raw data

References

[1] Avbelj V, Trobec R, Gersak B, Vokac D: Multichannel ECG measurement system, *Computer-Based Medical Systems, 1997. Proceedings., Tenth IEEE Symposium on Volume , Issue , 11-13 Jun 1997,* 81-84.

[2] Avbelj V, Trobec R, Gersak B: Beat-to-beat repolarisation variability in body surface electrocardiograms. *Med Biol Eng Comput.* 2003 Sep;41(5):556-60.

[3] Depolli M, Avbelj V, Trobec R: Computer-simulated alternative modes of U-wave genesis. *J Cardiovasc Electrophysiol.* 2008 Jan;19(1):84-9. Epub 2007 Oct 4.

Wireless Sampler

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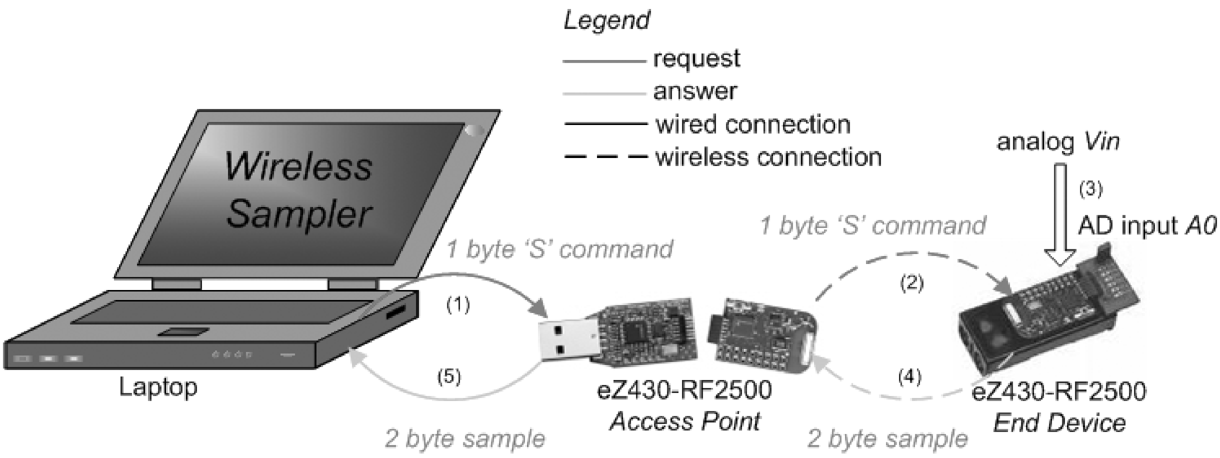
Introduction

Wireless sampler is wireless acquisition system which can be used for collecting data from a distant place. It is developed so that user can define sampling period and start time and the application starts collecting raw data from distant process (sensor attached to it). Which parameter we are tracking depends of the applied sensor. The application can store this raw data in simple format file, and this data can be used for further signal analyses with some third party software. Small dimensions, low power consumption and low cost are basic characteristics of this system. With its wide range of sampling period it is suitable for most WSN applications, as some of them requires large sampling periods (even few days for agriculture) and some of them very small (few milliseconds for sensing human body e.g. ECG signal). We have full sampling control, and correct representation of the collected data. Hardware platform used to develop this system is Texas Instruments TI [1] eZ430-RF2500 Development Tool. Software is developed using National Instruments [2] software programming tool CVI 8.5



System architecture consists of four different types of devices:

1. *End device* (sensor node), with its sensor attached to a process we want to track;

2. *Range extender* (like sensor node, but without sensors), which retransmits data toward *Access point* and in this way extends distance from witch the *End device* sends its data;
3. *Access point*, attached to a computer, collects data sent by *End device*, controlled by *Software application*;
4. *Software application*, installed on a computer, controls the whole system, stores data in appropriate form.

Current Status

Project has been developed. Some tests were made. System needs some improvement before it is used for real application.

Expected Results

The *Wireless sampler* project is expected to be completed by December 2009. It is required to improve system performance, and to test it in real case scenario.

References

[1] http://www.ti.com, Texas Instruments Corp, 2008.

[2] http://www.ni.com, National Instruments Corp, 2008.

Wireless Sensor Network for Monitoring Passengers Riding Quality in Public Transportation Vehicles

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Introduction

The public transportation service is becoming increasingly market-driven. Consequently, it is important that passengers are provided with a comfortable environment. Many factors have contributed to an increase in interest in the evaluation of comfort experienced by passengers in public transportation vehicles. Due to rising mobility, the time that people spend in public transportation vehicles has grown substantially. The criteria applied by passengers have changed on account of generally heightened expectations, resulting in a growing demand for enhanced riding comfort [1]. So, the riding comfort can be analyzed in three different respects: dynamic factors, related to vibration, shocks and acceleration; ambient factors, where thermal comfort, air quality, noise, pressure gradients, etc, are considered; and spatial factors, dealing with the ergonomics of the passenger's position. These factors are at the same time important for the health of passengers and drivers. According to the duration of a journey prolonged exposure to different kinds of stimulus that can be detected by human senses as a sensation of discomfort may cause anxiety, stress and health damage.

In the present project the special attention is dedicated to consider the problems inherent in the monitoring aforementioned factors in the field of comfort parameters measurements in public transportation vehicles (buses, trams and railway vehicles) with special emphasis on ambient and dynamic factors. The project work is structured into different sections (thermal comfort, air quality, noise and vibration), each one related to a given kind of stimulus. The final project effort contains considerations about the importance of introducing a new approach in dealing with measuring data through a wireless sensor network.

Assuming that the passenger area of a public transportation vehicle can be considered as a moderate environment, according to ISO Standard 7726 [2], the following fundamental physical variables should be used to characterize its thermal comfort: the air temperature, the air velocity and the relative humidity. In our project only the first parameter will be considered. The air temperature is usually measured with liquid-in-glass, pressure bulb and bimetallic thermometers or with thermo couples, thermistors or resistance temperature devices. We will use one of the last three because they are more convenient for measuring processes with automatic data acquisition, because of their electrical outputs.

The presence of people in confined spaces that are not adequately ventilated results in a degradation of the indoor air quality. Bio-effluent gases resulting from breathing and other organic functions are the main cause of this loss of quality, according to the European recommendation with the reference No CEN CR 1752 [3]. However, some other factors can also cause an increasing of the pollutant level inside a public transportation vehicle, e.g. the presence of moisture, volatile organic compounds, combustion products, particles, bio-aerosols and so on. In the scope of this project electrochemical sensors, usually targeted on a certain gas, are predicted for concentration measuring. The main goals of the work, besides the development of the monitoring system itself, are the identification of driving conditions that can result in poor air quality in a public transportation vehicle and the establishing of threshold and sensation algorithms for the air quality monitoring. A suggested concept should have some alarm system based on continuous monitoring of oxygen and carbonmonoxide that can alert the driver or trigger some automatic procedure (open the windows, stop the engine, etc) to avoid health risks to passengers.

In a moving public transportation vehicle there are many sources of noise that should be analyzed using different approaches to reduce their effect or to change the nature of the sound to a more pleasant one. Depending on the way in which the noise is generated and propagated, it should be considered as airborne or structural noise. The sources of strictly airborne noise are the aerodynamic noise, generated by the interaction of the moving car body with the surrounding air volume, and the fuel injection system noise. Transmission and suspension resonances, body structural resonances, interior acoustic resonances and gear box rattling are predominantly structural. Noises due to the air inlets, the cooling fans, the exhaust system and the engine can be considered as a mix of air borne and structural noises. In the sound measuring equipment that will be used within this project, the primary sensor element will be a microphone. There are different types of microphone: capacitor or condenser, crystal, electrodynamic or carbon, with a very large price range varying as a function of the quality of the sensing element and the analysis capabilities available.

The overall sensations of vibration discomfort depend upon the sensing as well as the frequency content of the stimulus producing them. The standard ISO 2631 [4] considers the evaluation of human exposure to vibration. In public transportation vehicles, various systems have been engineered to contribute minimization of the discomfort perception of vibration by passengers, e.g. the tyres, main suspension, engine suspension, car body and seat. Automotive researchers and design engineers have substantially improved the behaviour of the components and systems to enhance their capability of filtering the vibrations transmitted to riding passengers. The primary sensor element in a vibration measuring chain that will be used in this project is an accelerometer of different kinds: capacitive, inductive, variable reluctance, piezoelectric, piezoresistive or with strain gauges.

Current Status

As the necessary equipment for the completion of the project has not been provided yet, we have been analyzing so far theoretical statements and different sensors and measuring methods that could be used for monitoring passengers riding quality in public transportation vehicles.

Expected Results

It is expected to install all the necessary equipment on a few public transportation buses in Niš for testing the sistem of wireless sensor network in real circumstances up to December, 2009.

References

[1] Alcobia C., Silva M. C. G., 1999, A comfort field study in public transportation buses, International conference on air distribution in rooms N°6, Stockholm.
[2] ISO 7726, 1985, Thermal Environments - Instruments and Methods for Measuring Physical Quantities.
[3] CEN CRENV 1752, 1996, Ventilation for Buildings: Design Criteria for the Indoor Environment.
[4] ISO2631, 1997, Evaluation of the Human Exposure to Whole-Body Vibration.

WSNs in Enhancing Exercise Experience in Personal Fitness

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Introduction

The authors propose development of a smart exercise environment that would monitor a person exercising, and provide feedback in order to keep him motivated, collect data that could be used to enhance his exercise routine and to keep track of physical condition and vital parameters.

Details of the proposed approach

Three major parts can be identified within a system for exercise monitoring: User Body Area Network (UBAN), Exercise Environment Sensor Network (EESN), and the Central Server.

User Body Area Network

UBAN subsystem consists of a number of devices that monitor users physical parameters and deliver information to him. The number and type of devices can vary, but some of the typical elements of this subsystem are a wireless ECG monitor, a pedometer to monitor user's movement, a blood pressure and monitor, pulse oximeter, devices for monitoring muscle strain etc., a cell phone, pda or a similar device to display information to the user.

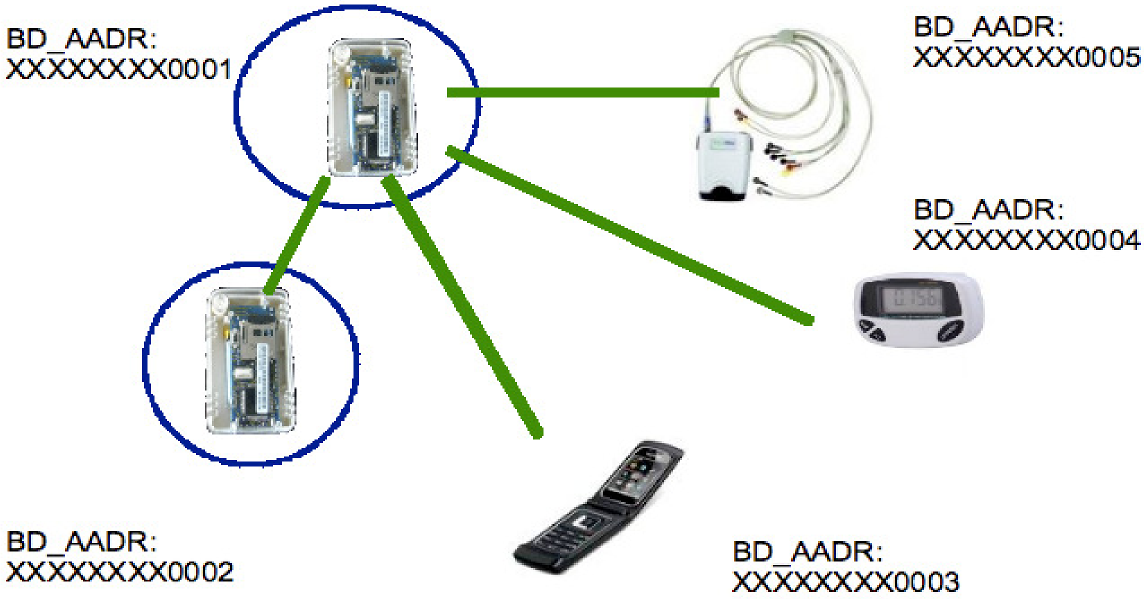
Devices within the UBAN communicate through a wireless network, with the bluetooth as the ideal technology for this subsystem. One of the nodes should serve as a gateway, aggregating and sending information to the Central Server for processing. This fits into the Bluetooth PAN profile, in a configuration with a Bluetooth Network Access Point (NAP) (with the gateway node being the Bluetooth Network Access Point (NAP) and the rest of the nodes being the PAN Users (PANUs)).

Ad-hoc Bluetooth BAN formation

A Bluetooth BAN consists of up to eight Bluetooth devices. Some of these may be able rely information to an outside network (NAP candidates). The goal of network formation procedure described here is to form a network, in the ad-hoc manner.
Three types of NAP candidates are assumed: Local Network NAPs that have outside access through local infrastructure, mobile phones and other devices that connect to the outside network through GPRS or 3G, and High Capacity Storage that can store data when there is no connection.

Network formation

In the initial step of the network formation procedure all of the NAP candidates start the devices start a symmetric inquiry procedure (SRI) to detect all of the other NAP candidates. Once all of the NAP candidates have information about all of the others, they can form a table and choose one of them as a master node (future NAP).
PANU only devices start the Inquiry procedure, followed by service discovery. If a PANU finds a working NAP it starts a connection, followed by a master/slave role switch, making the NAP master. If no master is found, PANU waits for a certain amount of time and retries to find a working NAP. New NAP candidates join the network in the same manner as non-NAP PANUs, but must additionally notify the NAP of their ability to provide outside connection.



Picture 1: A formed BAN network

Exercise Environment Sensor Network

Exercise Environment Sensor Network (EESN) is a network of sensors incorporated into the exercising environment. These sensor monitor the conditions of the environment, such as the temperature, humidity, air quality, etc. Gathered data are propagated through the network to the Central Server for further processing.
In some systems this network may also be used as the local infrastructure to propagate data from users BANs to the Central Server and back.

Central Server

Central Server is an application that runs on a desktop or a server computer. This application collects and processes the data from all of the sensors in the system. Some of the data should be stored for later review. Finally, entire system is monitored and controlled through the Central Server application.
Gathered data and processing procedures vary greatly from a system to a system, and much of this application must be custom made for a specific system.

Wireless Sensor Networks in Precision Agriculture

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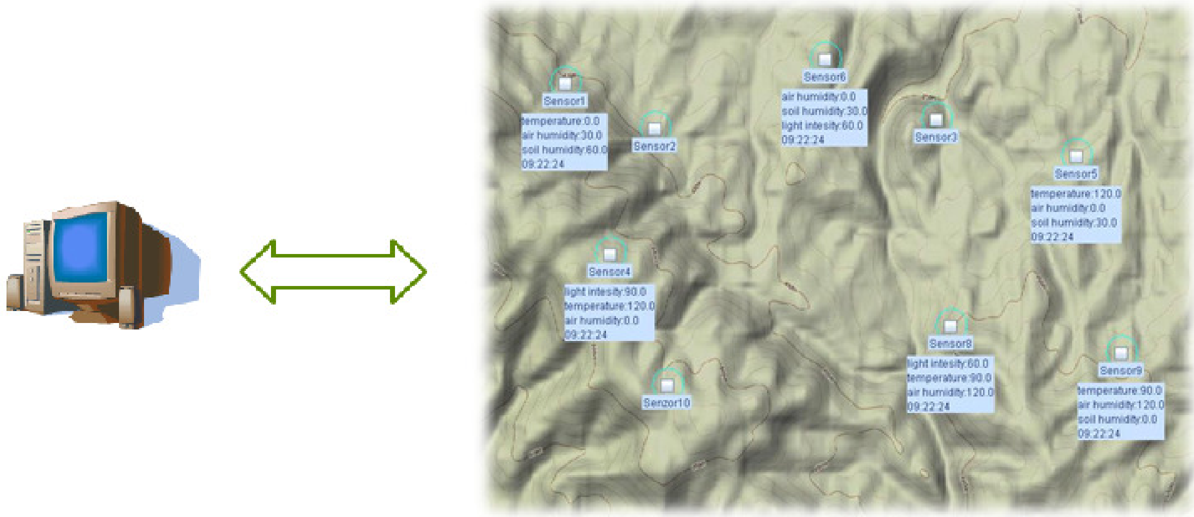
Introduction

Informal definition of precision agriculture (PA) is that is an agricultural concept relying on the existence of in-field variability (spatial or temporal). Basic idea of precision agriculture rests on doing the right thing, in the right place, in the right way, at the right time. In other words: accurate measurements, smart decision-making algorithm and appropriate reaction. It is obvious that precision agriculture requires use of new technologies. And wireless sensor networks (WSN) are ideal platform for this kind of application.

Field of precision agriculture supplements traditional agriculture but also corrects some of the most important drawbacks of traditional approach. In traditional agriculture, whole field is observed as homogeneous and treated at approximately the same way. That approach leads to higher money/effort investments (economical aspect); results are not linear function of investments and may vary greatly. Another problem in traditional agriculture rises because of inappropriate using of chemicals, such as pesticides, without deep and precise analyzing of real needs of soil and plants for them (ecological aspect). Precision agriculture provides information to act on in real time. Lower input costs and better and more predictable results can be achieved. Reduced using of chemicals also can be achieved, which is desired from both aspects, economical and ecological. Data provided by monitoring system can be collected and analyzed, allowing evaluation of new agricultural methods.

For collecting accurate and real time data needed in precision agriculture in development is application WESNA (WirEless Sensor Network in Agriculture). Hardware parts of WESNA are wireless sensor network placed in field to be monitored and server computer. Software parts are: desktop server application, communication protocols and applications on each sensor node.



WESNA application for field monitoring

Current Status

Software design and communication protocols of WESNA are completely developed. Desktop server application is partially implemented. Some basic tests are applied to sensor nodes. Work on connecting of wireless sensor network and desktop application via virtual COM port is in progress.

Expected Results

Fully operational application should be tested in real environment, on agricultural field. Smart algorithms for analyzing of collected data should be implemented (need assistance of professionals in sphere of agriculture).

References

[1] http://en.wikipedia.org/wiki/Precision_agriculture
[2] http://www.css.cornell.edu/research/precisionag