

A Data Logger for Wireless Sensor Network

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Abstract: Wireless sensor networks (WSN) are often used to monitor environmental data because of their low cost. However, writing applications for such a technology requires not trivial programming skills. Moreover it is not easy to find available general purpose tools that can be used to perform a monitoring task with a WSN because usually such tools are focused on a specific application scenario. In this paper we present a tool for the real-time acquisition of data from a set of Mote sensors and for the storage of the acquired data in the flash memory of the sensors. The tool provides functionalities to retrieve the stored data in the sink node, to insert them in a database and to visualize them by means of a graphical user interface that runs on a linux-based PC. The tool that we propose consists of both the software that runs on the PC and the software to be installed on Motes.

1 INTRODUCTION

Wireless sensor networks (WSN) are a technology suitable to monitor a wide range of environmental parameters such as pressure, temperature, acceleration, chemical composition, etc... and they are used for battlefield surveillance, habitat monitoring, home automation and health-care applications (Baronti et al., 2007; Culler et al., 2004; Romer and Mattern, 2004).

Monitoring/Logging services, in particular, focus on dissemination and collection of environmental data in order to monitor the flora, the fauna as well as natural and human-made elements. For example, (Yamamoto et al., 2012) provides an in-depth study of WSN applications to monitor and control the swiftlet habitat. Tolle et al. presents a query-based framework for temporal and spatial monitoring of a redwood tree for environmental monitoring (Tolle et al., 2005). Arora et al. builds a real-time surveillance system for target detection, classification and tracking using a central monitoring unit (Arora et al., 2004).

Sometimes, however, the only real time monitoring is not sufficient but it can be useful also to store the data for further analysis and processing at a later time. This implies that the sensors must be programmed to save the data locally and to send them successively to a coordinator node (hereafter called *sink*) to avoid congesting the communication channel with a huge amount of transmissions. Especially when the number of sensors is high.

We also want to be able to control the entire sensor network remotely without having to retrieve the sensors once they have been installed. In certain cases, for example in wildlife monitoring applications, once the sensor has been installed on the body of the animal is no longer possible to recover it if we do not want to disturb the observation.

The objective of this work is to provide a framework for remotely control a set of Motes for both real-time and off-line data acquisition. The tool is compatible with the IRIS, MicaZ and TelosB platforms. With this tool, the user can request a series of measurements related to surrounding environment (light, temperature, accelerometer, humidity, Pir - Passive infrared, Magnetic, RSSI- Radio Signal Strength Indicator, and microphone). The data collected by the Motes can be subsequently be forwarded to the sink, which can store them in a local database, enabling the user for off-line analysis and processing.

2 SYSTEM REQUIREMENTS

The system we have developed meets the following basic requirements:

- **Topology.** Figure 1 shows the network architecture of our WSN. The Motes acquire the requested data and send them to the sink Mote either in a real-time fashion, or on-demand when requested.

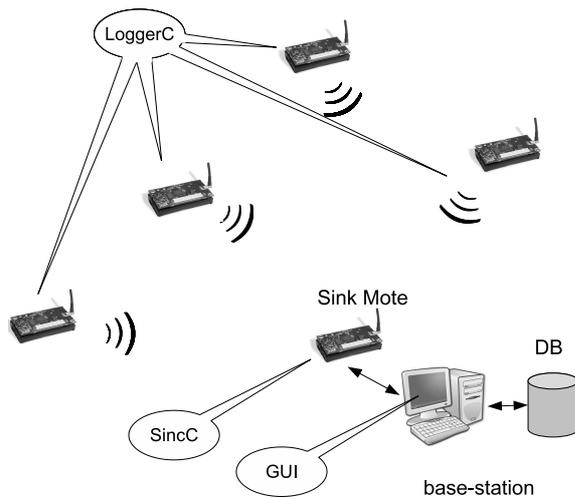


Figure 1: The topology of the data logger.

The sink interfaces the WSN with the user: it routes the data received from the other Motes to the base-station (the PC) where they are stored in a local database and visualized to the user by means of the GUI.

- Mote Management and Setting.** The number of Motes involved in the query can change over time, and each of them can be managed independently from the others. Each Mote must be able to be set up, turned on and off without affecting the operation of the other Motes in the network. At the same time, the system must allow the user to activate, deactivate or reset all Motes on the network simultaneously. The main parameters that can be set in mote are the following:
 - Sampling period. It indicates the period of time (expressed in milliseconds) between two consecutive readings of the transducers.
 - Type of transducer. It allows the user to choose which transducers of the sensor board the Mote has to sample.
- On-line and Off-Line Data Collection.** The monitor application on the Motes can be executed in two modalities: on-line and off-line. The on-line mode provides the data collected in real-time for being immediately stored in the central database when they are received by the base-station. In the off-line mode, on the other hand, the data are temporarily stored within the Mote flash memory and they can be downloaded at a later time, upon a specific request from the user.
- Data Storage.** - Each data detected by transducers mounted on Motes must be stored in a central database located on the base-station, allowing the

user to access the data and analyze them anytime. Note that in most WSN application scenario, the amount of acquired data can be very large, so this feature is particularly useful.

- Graphical User Interface.** The Graphical User Interface (GUI) allows the user to remotely setup all the needed parameters on the Motes and to activate/deactivate all the functionalities provided by the logger. Moreover, the GUI visualizes the received data while they are stored in the database, so a first quick analysis of the data can be executed without having to access the database. This is useful in particular for the real-time applications.

3 ARCHITECTURE

The Data Logger consists of four separate software components (see Figure 1):

- SincC** is the gateway between the WSN and the user that runs on Sink Mote.
- LoggerC** is the component designated to collect and store the data that runs on Motes.
- GUI** is the user interface that runs on the base-station.
- DB** is the database for the storage of the data collected that runs on the base-station.

3.1 SincC

The sink Mote is the access point to the network from the real world. This Mote, therefore, forwards the commands received from the base-station to the other Motes of the network through the wireless communication channel. It also routes all the data acquired from the Mores in the network towards the base-station to which it is connected through a serial channel. The nesC component, that implements such functionality similar to a hub, is called *SincC* and it has to be installed on the sink Mote.

3.2 LoggerC

The rest of the Motes in the network have the same nesC application installed on board called *LoggerC*. Their typical function is to read the values from the transducers integrated on the sensorboard, store the acquired data in their internal flash memory and/or send them to the sink.

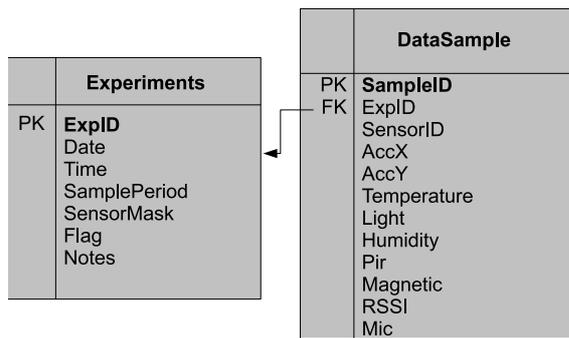


Figure 2: The Entity-Relationship diagram of the database.

3.3 GUI

Through the GUI the user is able to remotely instruct the LoggerC components to start/stop the sampling, to download the data stored in the flash memory of a Mote and to erase the memory after the download has been completed. The GUI also allows the user to specify the parameters needed for the monitoring task: sampling period at which the data have to be acquired, transducers to sample, acquisition modality (on-line and/or off-line), the ID of the target Mote or, in case of storing in the flash memory and erasing the flash memory content, to send the command in broadcast to all the Motes. The Sink connected to the base-station redirects the command specified in the GUI to the target Mote. In case of on-line mode, the acquired data are immediately sent back to the base-station and they are displayed on the GUI and stored in the DB. In case of off-line mode, instead, the data are only stored in the flash memory of the Mote. In order to get these data, a specific download command has to be sent and the data are received, stored in the DB and visualized in the GUI, as in the on-line scenario.

3.4 DB

The DB component is an SQL relational database. The tables created in the database regard the experiments performed (*Experiments* entity), and the data recorded by the sensors (*DataSample* entity). Figure 2 shows the entity-relationship schema of the Data Logger database. Each experiment is associated with an ID, called *ExpID*. Therefore we have a tuple for each experiment in the Experiments table and the association that links the two tables is provided by *ExpID*, which is a foreign key in the DataSample table.

Here is the list of attributes of tables with related information. Experiments table:

- *ExpID*. Unique identifier of the experiment (primary key).

- *Date*. Starting date of the experiment.
- *Time*. Starting time of the experiment.
- *SamplePeriod*. Sample Period of the experiment.
- *SensorMask*. A bit-mask used representing which transducers were active during the experiment.
- *Flag*. Indicates the choice of making an on-line/off-line communication.
- *Notes*. Contains any notes entered by the user when creating the experiment.

SampleDate table:

- *SampleID*. Unique identifier of the sample data (primary key).
- *ExpID*. Unique identifier of the experiment for which the sample belongs to (foreign key).
- *SensorID*. Unique identifier of the Mote in the network.
- *AccX*. Sampled value from the x-axis accelerometer.
- *AccY*. Sampled value from the y-axis accelerometer.
- *Temperature*. Sampled value from the thermometer transducer.
- *Light*. Sampled value from the light transducer.
- *Humidity*. Sampled value from the humidity transducer.
- *Pir*. Sampled value from the Pir transducer.
- *Magnetic*. Sampled value from the Magnetic transducer.
- *RSSI*. RSSI value of the communication between the sink and the target Mote.
- *Mic*. Sampled value from the microphone.

4 IMPLEMENTATION AND USAGE

4.1 Setting Up an Experiment

Here we describe the use of the GUI of the data logger shown in Figure 3.

- **New Experiment** button. This button is used to create a new entry in the *experiments* table in the DB.
- **Sampling Period** text box. It allows the user to setup up the sampling period of the transducers readings (expressed in msec).

- **Transducers** radio buttons. Eight radio buttons that allow the user to select which transducers activate on the Motes during the experiment.
- **Online Data** check button. If selected, the data are sent to the sink in real-time when they are acquired by the target Mote.
- **Store Info.** If selected, the acquired data are stored in the flash memory of the target Mote (these two last options can be jointly checked).
- **Target Mote** text box. Specifies the ID of the Mote from which to acquire data. Note that, in order to avoid collisions, only one mote is allowed if the *Online Data* modality is set, that is the real-time data can be received from one mote at a time.
- **Broadcast** checkbox. This option is available only for the *Store Info* mode and to erase the flash memory of the motes. By checking it, the storing of data in the flash memory, or its deletion, can be requested contemporarily on all the motes.
- **Note** textbox. It allows the user to associate the experiment entry with a textual comment.
- **Command buttons Start, Stop, Download, and Reset Flash.** Once a new experiment entry has been created, the sampling task is activated by clicking on the *Start* button. As consequence, the Mote specified in the *Target Mote* text-field will start sending its acquired data and they will be visualized in the GUI. If the *Store Info* modality was set, the blue LED toggling on the Motes notifies the writing of the acquired data into the flash memory. The *Stop* button terminates the sampling task. This command can also be sent in broadcast by checking the *Broadcast* checkbox. To download the data stored in a Mote into the database, the button *Download* is used. In order to avoid collisions, this operation is allowed for only one Mote at a time. The green LED toggling on the target Mote notifies the reading from the flash. The received data are stored in the *DataSample* table of the database in the same order as they have been acquired in the Mote and they are stored with the reference to the experiment in the table *Experiments* that contains the timestamps at which the sampling started and the sampling frequency. The *Reset* button erases the flash memory of the Mote. This operation may take a long time and its progress is signaled by the red LED on the Mote: it is on during the execution of the operation and it is turned off when it is completed. This command can also be sent in broadcast. It is important to execute this command in order to have always clean data.

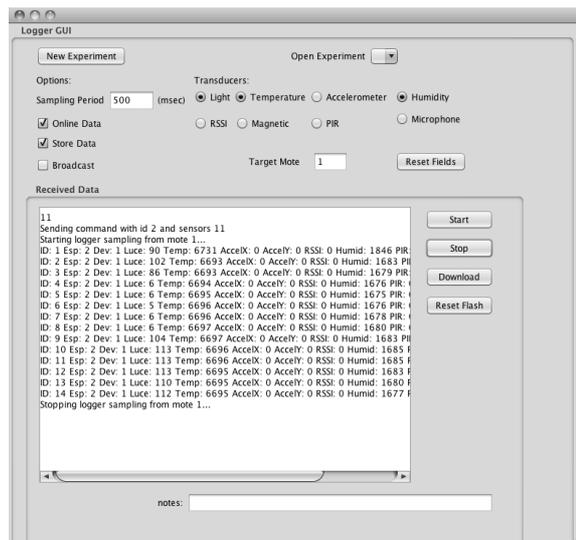


Figure 3: The GUI of the data logger.

5 CONCLUSIONS

In this article we have presented a data logger for WSN that allows both real-time data acquisition and storing on the acquired data in the flash memory of the Motes for off-line analysis. The software is freely downloadable at www.nmis.isti.cnr.it/gennaro/logger.zip and runs on Linux where Postgres DBMS (www.postgresql.org) is installed. As future developments, we aim at providing the possibility to execute the on-line data acquisition on all the sensors at the same time, by implementing a mechanism for avoiding the collision of the packets.

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