An Experimental Framework for Data Gathering and Analysis in Wireless Sensor Networks

Stratos Keranidis, Iordanis Koutsopoulos, Thanasis Korakis and Leandros Tassiulas
Department of Computer and Communication Engineering, University of Thessaly, Greece
Centre for Research and Technology Hellas, CERTH, Greece
{efkerani, jordan, korakis, leandros}@uth.gr

ABSTRACT

In the last decade testbeds have been set-up to evaluate network protocols and algorithms under realistic settings. Moreover, wireless sensors have lately been integrated into testbeds in order to simulate application scenarios for low-power sensor networks, such as environment monitoring. Due to the fact that such scenarios are usually designed to run for a relatively long duration, long-term experiments are rarely executed, in order to avoid blocking of testbed facilities. Toward, this direction, we propose the NITOS Sensors Toolkit framework that provides for measurements storage in the testbed's database so that users do not have to run online experiments to generate data, but they can access real sensor records in an offline way. Moreover, online measurement gathering is automated and further simplified using the OMF management framework [1], so that it becomes a transparent process for the experimenter. The proposed framework is also accompanied by a web user interface that allows the user to get a graphical representation of the stored measurements and also extract various statistical measures. NITOS Sensors Toolkit allows for a more sophisticated way to setup and analyze experiments based on Wireless Sensor Networks.

1. INTRODUCTION

Application scenarios for Wireless Sensor Networks (WSNs), such as environment monitoring, are usually designed for a relatively long runtime. In order to avoid blocking of testbed facilities such long lasting experiments are rarely executed. To this end, NITOS has developed a specific framework that provides users with offline measurements that have been gathered from temperature and humidity sensors.

2. NITOS SENSORS TOOLKIT

In this demo, we will present a framework for online measurement gathering as well as offline measurement acquisition in WSNs. The tool was developed for NITOS testbed [2], which is a large scale wireless testbed that currently consists of 40 operational WiFi nodes. A view of the testbed topology, at the exterior of the University of Thessaly campus building, is shown in Fig. 1. The technologies that are available in NITOS for implementation and testing are WiFi, WiMAX and LTE. Moreover, the 10 ORBIT wireless nodes

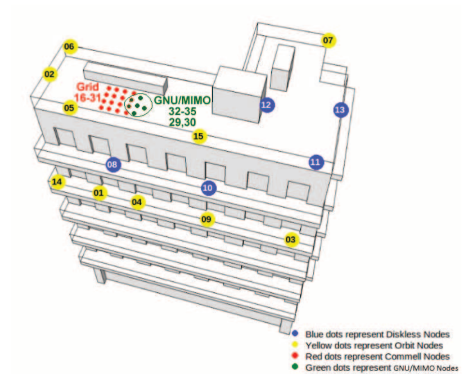


Figure 1: NITOS testbed topology representation.

(yellow dots) are equipped with Temperature & Humidity USB Sensor THUM (Temperature and HUmidity Monitor) [3]. This feature of the testbed allows for implementation and testing of routing and power optimization schemes for WSNs.

NITOS provides its users with the ability to run experiments using the temperature and humidity sensors (online) or even access real sensor records by using the NITOS Sensors Toolkit (offline). Figure 2 shows the web interface that

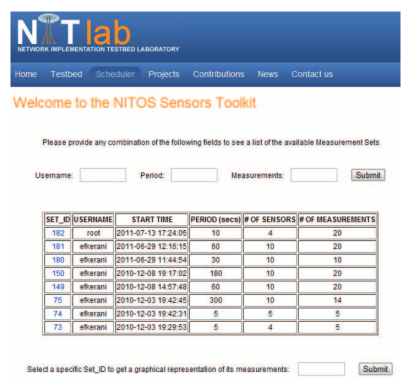
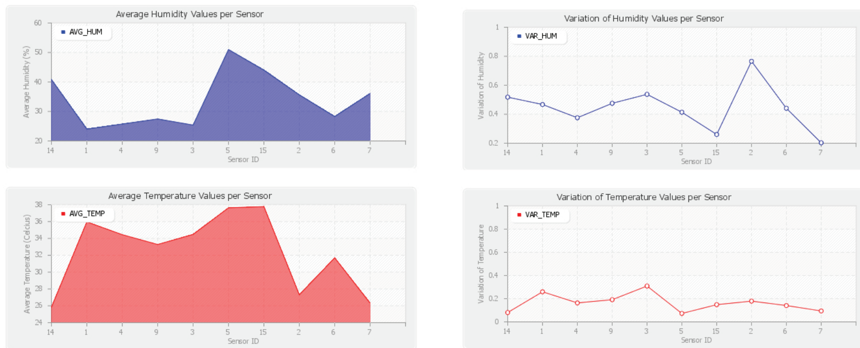


Figure 2: NITOS Sensors Toolkit web interface.

allows the experimenter to get a graphical representation of each measurement set stored in NITOS database. Moreover, the filesystem provided for sensor experiments contains OMF scripts that help the user easily setup an experiment,

WiNTECH'11, September 19, 2011, Las Vegas, Nevada, USA.
ACM 978-1-4503-0867-0/11/09.



(a) Average values representation (b) Variation representation

Correlation Matrix for Humidity Measurements

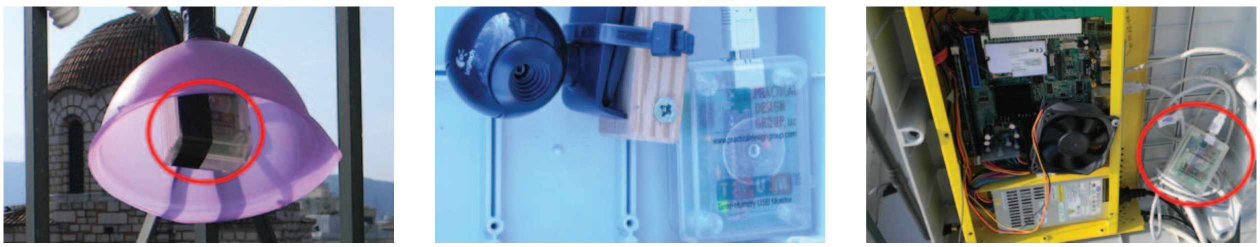
NODE_ID	14	1	4	9	3	5	15	2	6	7
14	1.000	0.600	0.902	-0.079	-0.274	0.377	0.216	-0.412	-0.139	-0.040
1	0.600	1.000	0.701	0.258	-0.289	0.560	0.572	-0.377	-0.035	-0.238
4	0.902	0.701	1.000	-0.051	-0.387	0.734	0.441	-0.183	0.167	-0.344
9	-0.079	0.258	-0.051	1.000	0.309	-0.011	0.481	-0.491	-0.436	-0.008
3	-0.274	-0.289	-0.387	0.309	1.000	-0.415	-0.061	-0.144	-0.279	-0.023
5	0.377	0.560	0.734	-0.011	-0.415	1.000	0.583	0.308	0.615	-0.675
15	0.216	0.572	0.441	0.481	-0.061	0.583	1.000	-0.154	0.153	-0.622
2	-0.412	-0.377	-0.183	-0.491	-0.144	0.308	-0.154	1.000	0.903	-0.493
6	-0.139	-0.035	0.167	-0.436	-0.279	0.615	0.153	0.903	1.000	-0.687
7	-0.040	-0.238	-0.344	-0.008	-0.023	-0.675	-0.622	-0.493	-0.687	1.000

Correlation Matrix for Temperature Measurements

NODE_ID	14	1	4	9	3	5	15	2	6	7
14	1.000	0.764	0.990	0.229	0.001	0.847	0.650	0.112	0.483	-0.137
1	0.764	1.000	0.794	0.462	0.026	0.704	0.715	-0.097	0.293	-0.435
4	0.990	0.794	1.000	0.293	0.006	0.884	0.689	0.099	0.480	-0.177
9	0.229	0.462	0.293	1.000	0.362	0.394	0.598	-0.092	0.133	-0.534
3	0.001	0.026	0.006	0.362	1.000	0.156	0.329	0.198	0.215	-0.090
5	0.847	0.704	0.884	0.394	0.156	1.000	0.793	0.437	0.731	-0.073
15	0.650	0.715	0.689	0.598	0.329	0.793	1.000	0.252	0.560	-0.551
2	0.112	-0.097	0.099	-0.092	0.198	0.437	0.252	1.000	0.897	0.527
6	0.483	0.293	0.480	0.133	0.215	0.731	0.560	0.897	1.000	0.315
7	-0.137	-0.435	-0.177	-0.534	-0.090	-0.073	-0.551	0.527	0.315	1.000

(c) Correlation Matrices.

Figure 3: Representation of provided statistical measures.



(a) External manufacture (b) Main node box (c) Camera box

Figure 4: Types of sensor placement

just by providing the reserved sensor IDs, the measurement period and the total number of measurements that will be gathered.

Various statistical measures can be extracted from the corresponding records, such as average and deviation values per sensor or per measurement round. Another important feature that the framework provides is the correlation matrix representation that provides an indication of how much the measurements of each sensor are correlated with each other. Figure 3 shows snapshots of the statistical measures that our framework supports.

To enable spatial diversity among the sensors, we have decided to place the sensors in three different ways. Sensors are placed in an external manufacture, inside the node's box, or inside the box that contains the camera. Figure 4 shows the three types of placement that are supported. This placement setup has been designed to generate spatial correlation among sensor measurements, which is also validated through the correlation measurements.

Another important feature that the framework supports is the extraction of measurements records from NITOS database. More specifically, though special scripts that the sensor filesystem contains the user can easily transfer database measurements to the corresponding nodes. Moreover, offline measurements can aid in the comparison among different protocols. More specifically, algorithms that exploit spatial correlation, such as the work in [4], can be compared with other protocols based on the transmission of the same set of measurements.

3. CONCLUSIONS AND FUTURE WORK

In this demo paper we presented a framework that enables gathering and analysis of measurements of WSNs. In particular, experimenters can select specific nodes and observe correlation among gathered measurements by navigating through a web interface that is built as an extension tool of NITOS testbed. Thus, users can benefit from the provided tools and better evaluate and compare protocols under consideration. Currently, we are in the process of extending the framework features by providing mechanisms able to estimate:

- contention per frequency among sensors,
- amount of transmitted data per experiment
- overall energy consumption per experiment.

4. REFERENCES

[1] *"OMF-cOntrol & Management Framework"*, http://omf.mytestbed.net/.

[2] *"NITOS Wireless Testbed"*, http://nitlab.inf.uth.gr.

[3] *"Temperature and Humidity USB Monitor"*, http://practsol.com/thum.htm.

[4] I. Koutsopoulos and M. Halkidi. Lifetime maximization in wireless sensor networks with an estimation mission. In *Proceedings of GLOBECOM*, 2009.