Demo: Online Energy Consumption Monitoring of Wireless Testbed Infrastructure through the NITOS EMF Framework

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ABSTRACT

Development of energy-efficient protocols and algorithms requires in-depth understanding of the power consumption characteristics of real world devices. To this aim, energy efficiency analysis is performed by the research community, mainly focusing on the development of power consumption models. However, recent studies [1] have highlighted the inability of existing models to accurately estimate energy consumption even in non-composite scenarios, where the operation of a single device is analyzed. In order to overcome the inability of such models, energy efficiency evaluation under complex configurations and topologies, should be experimentally investigated, using online energy monitoring solutions. In this work, we present the innovative NITOS Energy consumption Monitoring Framework (EMF) and demonstrate how online and distributed energy monitoring can facilitate energy performance assessment of realistic testbed experiments.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design - Wireless Communications

Keywords

Energy, Power, Monitoring, 802.11a/g/n, Experimentation

1. INTRODUCTION

Several recent research studies [2, 3, 4] in the field of wireless networking have focused on reducing the total amount of energy consumed during the wireless medium access and communication operations. Towards enabling accurate energy efficiency evaluation of proposed protocols, under real world scale and settings, advanced methodologies and solutions need to developed. Our work in [5] proposes the innovative NITOS EMF Framework that is able to characterise

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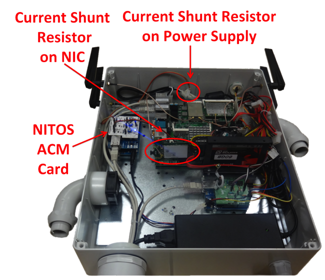


Figure 1: Installation of the ACM card in NITOS nodes

the instantaneous power consumption of wireless testbed infrastructure. In this demo, we present a wireless experiment that is remotely executed in NITOS testbed [6] and more specifically show how energy efficiency evaluation can be performed in parallel with experiment execution.

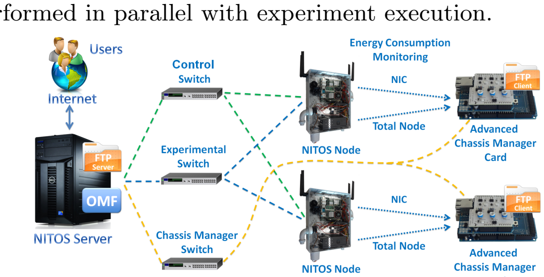
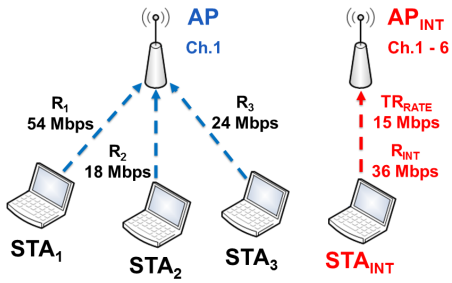


Figure 2: Integration of NITOS EMF with the overall testbed architecture

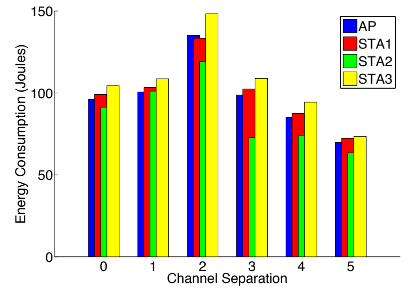
2. NITOS EMF FRAMEWORK

The NITOS EMF framework is built on a distributed network of low-cost, but highly accurate energy monitoring devices, named NITOS Advanced Chassis Manager Cards (ACM) and is fully integrated with the large-scale wireless NITOS testbed. NITOS ACM acts as a fast voltage sampling device that is able to accurately monitor voltage drop on low-impedance current-shunt resistors that are placed in series with the wireless Network Interface Card (NIC) and the power supply of each tested node. Fig. 1 illustrates the connectivity of the card with the components of NITOS nodes that are being monitored. The developed NITOS ACM card, which is based on the Arduino Mega board and features several both open-source and custom-made hardware components, is able to gather samples of 10-bit resolution at the high sampling rate of 63KHz.

The proposed framework has been directly integrated with the network architecture of NITOS testbed that currently



(a) Experimental Topology



(b) Energy Consumption per NIC on each channel

Figure 3: Demonstrated experiment that will be remotely executed in NITOS testbed

offers 50 wireless nodes and provides open remote access to any researchers who would like to test their protocols in a real-life wireless network. Two Gigabit Ethernet switches interconnect the nodes with NITOS server, namely the *Control* switch that provides for control of experiment execution and measurement collection and the *Experimental* switch, which can be used for conducting wired experiments. A third Gigabit Ethernet, namely the *Chassis Manager* switch, is dedicated in controlling the operation of the NITOS ACM cards and also for transferring of power consumption measurements through the developed FTP service. Integration of NITOS EMF with the overall testbed architecture is illustrated in Fig. 2. Moreover, in order to enable ease of use of the developed framework, we integrated its functionalities into the OMF cOntrol and Management Framework [7] that NITOS has adopted, since its early stages.

3. EXPERIMENTAL DEMONSTRATION

In this section, we analyse a representative experiment that demonstrates the innovative potentiality of monitoring energy consumption, in parallel with realistic wireless experimentation. For the purposes of this experiment, 6 wireless nodes from NITOS testbed will be remotely employed. Furthermore, 2 wireless nodes equipped with the ACM card will be used for local demonstration of the framework's hardware equipment. This experimental scenario includes 3 stations (STAs) that are associated with the same access point (AP), which is operating on Ch.1 of the 2.4 GHz band. The 3 associated STAs are simultaneously uploading a file of 25MBs, while using different PHY-layer Transmission Rates (TX_R). Another pair of collocated nodes is generating interference, with the station node (STA_{INT}) constantly transmitting on uplink at the application layer traffic load of 15Mbps. Fig. 3(a) illustrates the experimental topology along with the PHY-layer rate settings of each node. The experiment is repeated 6 times, where in each different run we configure the AP_{INT} to operate on a different channel between Ch.1 and Ch.6 of the 2.4 GHz band. Among the various executions of the experiment, we monitor the energy consumption of each testbed node and its NIC. The aim of this demonstrated experiment is to showcase how frequency and PHY-layer Transmission Rate configurations, as well as interaction between collocated wireless nodes affect the overall energy expenditure.

Having previously executed the same experiment, we identified three different phases related to the resulting energy consumption and below we report the key conclusions that were reached. The energy consumed by each NIC is plotted in Fig. 3(b). In the first phase, while AP_{INT} operates on Ch.1 and Ch.2, all transmitters are contending for channel use, as they are all able to sense ongoing transmissions of other nodes. During the second phase, while AP_{INT} operates on Ch.3, the 3 STAs are no longer able to sense the transmissions of STA_{INT} and as a result frame collisions occur, resulting in subsequent frame retransmissions. In this phase the energy consumption of all testbed nodes is increased, due to the prolonged file transmission duration. In the third phase and as long AP_{INT} moves from Ch.4 to Ch.6, the impact of STA_{INT} is decreased, as the interfering link is isolated due to the increasing channel separation and thus energy consumption tends to decrease for all NICs. In this demonstration, we will execute the aforementioned experiment and plot the consumption of each testbed node and its NIC, in parallel with the experiment execution.

4. CONCLUSIONS

In this demo paper, we demonstrate the novel NITOS EMF framework that is able to characterise the consumption of wireless testbed infrastructure in an online way. In particular, we present a wireless experiment that is remotely executed in NITOS testbed [6] and more specifically show how the proposed framework facilitates energy efficiency evaluation in parallel with the experiment execution.

5. ACKNOWLEDGEMENTS

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

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