TVAKSHAS - An Energy Consumption and Utilization Measuring System for Green Computing Environment

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Abstract. There is a large difference between the power draw from the mains and the actual utilization of commercial devices like CPU, as some amount of the power is bound to be wasted. In this paper, the technique that can be implemented for measuring the difference between the actual power draw and the utilized power draw, the steps to reduce the amount of power draw and hence saving the energy costs is mentioned. TVAKSHAS is an energy analytical device that measures the efficiency and performance of CPU and consists of a real time power measurement circuit that reads the real time power drawn from the mains by the CPU and sends it to the wireless sensing and communicating device, i.e. sensor node, TelosB in our project. It also consists of a software based power measurement tool that measures the performance of the CPU in terms of Watts. Hence by analysis of these two data, the difference between power obtained and power utilized can be obtained on base station in the wireless sensor network.

Keywords: Power consumption · Energy consumption · Utilization
Wireless sensor network

1 Introduction

The use of commercial devices like desktop computers, LCD displays, etc. and also the home appliances like oven, refrigerators, etc. are increasing day by day. Hence the energy utilization keeps on increasing day by day which also effects on the electricity bills every month. But the matter of concern is that the amount of energy consumed is not totally utilized for the devices. Some amount of energy is bound to be wasted in some other form of energy. Hence it should be made aware to the users about how much energy is wasted, how much amount of energy is actually utilized. The difference between the values of the amount of energy drawn and amount of energy utilized by any commercial device defines the efficiency of the commercial device, in terms of the power draw. In this paper, various techniques that have been implemented to measure this difference are being focused upon. PowerNet [3], a hybrid sensor network, monitors the power and utilization of the computing systems on the basis of a large scale deployment. SmartMeter.KOM [1] combines the abilities of taking measurements of the electric current flow, switching the mains connection of the attached load, etc.

N. Kumar and A. Thakre (Eds.): UBICNET 2017, LNICST 218, pp. 37–45, 2018.
https://doi.org/10.1007/978-3-319-73423-1_4

1.1 PowerNet Project

The PowerNet project [3] is a hybrid sensor network developed for computing the power consumption and utilization of various systems. It comprised of approximately 140 wired and wireless meters and almost 23 software sensors that monitored PCs, laptops, LCD screens, etc. This project was active for 14 months and the wireless meters for 3 months. The deployment environment had a large number of diverse set of devices that had large variations in workload and configuration. To improve the efficiency of this type of computing system needs the detailed and accurate data of energy consumption and energy waste. The overall design of the PowerNet deployment that measures the power usage and utilization of individual devices and also transmitting the data over the network to store on a central server is as shown in Fig. 1.

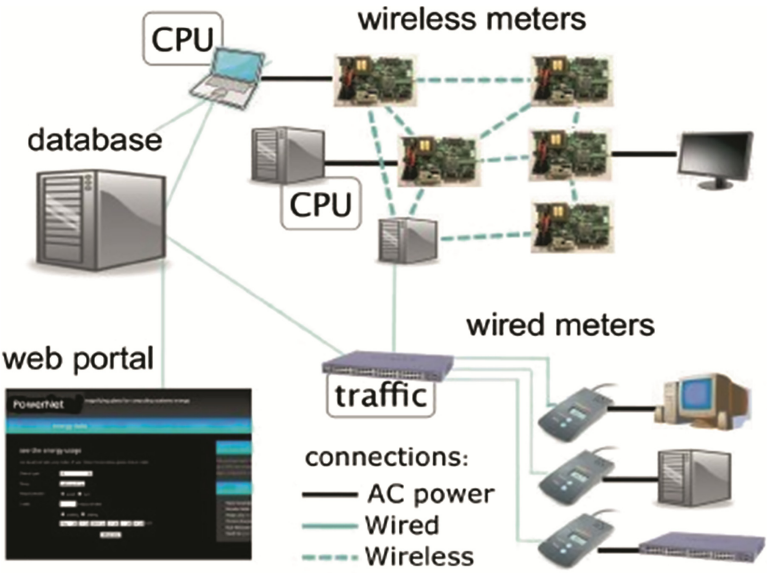

Fig. 1. Deployment of PowerNet project [3].

1.2 The SmartMeter.KOM Project

The SmartMeter.KOM project [1] is a combination of the abilities to take high resolution measurements of the electric current flow, switching the mains connection of the attached load, and a wireless communication device to exchange readings with other nodes in the sensor networks. These devices have the capability to deactivate the devices when the users are absent, the generation of events when operating modes change, or the automatic disconnection of faulty devices. To deploy this system, the sensor used is Allegro Microsystems, AC5712, a precise, low offset current sensor based on Hall Effect. As a communication device, MicroChip MRP24J4DMA is used as it combines a radio transceiver chip with an onboard antenna and all required external components

on a single circuit board. These devices are located in always a position where connection to the mains is available. The architecture of the Smartmeter.KOM device is as shown in Fig. 2.

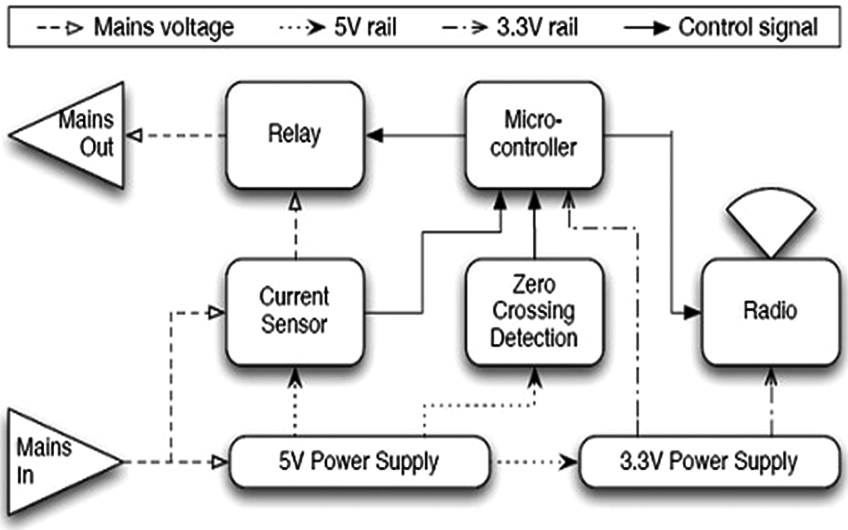

Fig. 2. Deployment of SmartMeter.KOM project [1].

2 The Project TVAKSHAS

The project TVAKSHAS is meant to be developed for the purpose of the quantitative as well as qualitative analysis of the difference between the amount of energy consumed by the commercial device and the actual amount of energy utilized by that device. It is a general tendency that the device does not utilize the amount of energy it is consuming at its whole. Some amount of energy is bound to be wasted and hence there is a variation between the amount of energy consumed by the device and its actual utilization. Also, the project TVAKSHAS aims to give the qualitative analysis like learning about how much power is drawn by which computer at the micro level i.e. measuring the CPU utilization in terms of the active CPU cycle, number of active processes, the amount of CPU consumed by each process in terms of power draw, and then taking the sum of these values to find out the total CPU utilization in terms of power draw. Based on these values, the difference between the consumed power and the utilized power can be derived. These observations can be useful to create awareness to the users for the purchase of different devices.

The deployment of this project is to be done using the wireless sensor network technology. The sensor node, TelosB, can be attached to the CPU whose utilization is to be measured. The measurements can be taken using the TelosB mote that collects these data and sends it to the base station node that can be again be a TelosB mote.

This TelosB mote can be connected to the laptop or other PC to store the data, to perform various analyses through graphs, etc. The TelosB motes need to be configured with the CPU for measuring the data and also receiving the measured data at other PC. The configuration and implementation of algorithm are to be done using the latest version of TinyOS and programming in the nesC language.

The routing protocol used can be the Collection Tree Protocol that routes the measured data from the TelosB mote to the base station TelosB mote. This protocol is considered to be efficient and robust protocol for TinyOs in Wireless sensor network deployment. To collect the data from the CPU, we need to configure the TelosB mote with external power measuring amplifier circuit that takes the readings of the power drawn by the device from the mains and also the power utilized by the CPU.

Using the ADC and DAC convertors in TelosB, the data can be sent to the mote and then to the base station using the CTP routing protocol.

2.1 Architecture of TVAKSHAS

Figure 3 given below describes the overall architecture of Project TVAKSHAS.

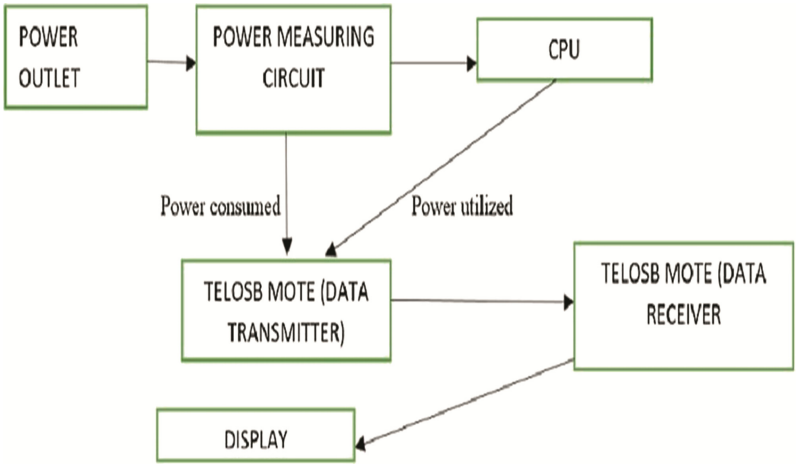

Fig. 3. General architecture of project TVAKSHAS.

As shown in the above figure, the power measuring circuit that measures the real time power consumed by the CPU from the mains and is been connected between the CPU and the mains supply. The circuit has also been connected with the TelosB mote so a\that the power measurements can be read by the TelosB mote and sent through the network to the base station. Hence, the real time values for power consumption can be obtained by this circuit and segregated to the TelosB mote. The next module in this project is development of the tool for power utilization measurement of the CPU in nesC language.

This code or we can say API collects the micro level data of CPU like CPU cycles per second, number of interrupts per second, etc. and based on these observations the

amount of CPU utilized in Watts can be obtained which can again be sent through the telosB mote and then to the sensor network to the base station using the CTP protocol.

At the base station, once the data from the telosB mote having power consumption. And utilization values are received, using appropriate GUI, we have the analysis of the difference between the power consumption and the utilization of the CPU on real time basis.

2.2 Working Module of TVAKSHAS

The project TVAKSHAS has been divided into sub modules as follows:

1. Module 1- Hardware based power consumption measurement
2. Module 2-Software based power utilization measurement
3. Module 3- Assembling above data at base station and analysing it using graphs and tables. basis. the attached load, etc.

2.2.1 Hardware Based Power Consumption Measurement

The hardware based power consumption measurement of the project TVAKSHAS includes designing of a power sensor on a circuit board and attaching it to the telosB mote so that the mote can be treated as a power sensor.

The design of the following circuit is influenced from [4].The circuit diagram of this circuit is as shown in the following Fig. 4.

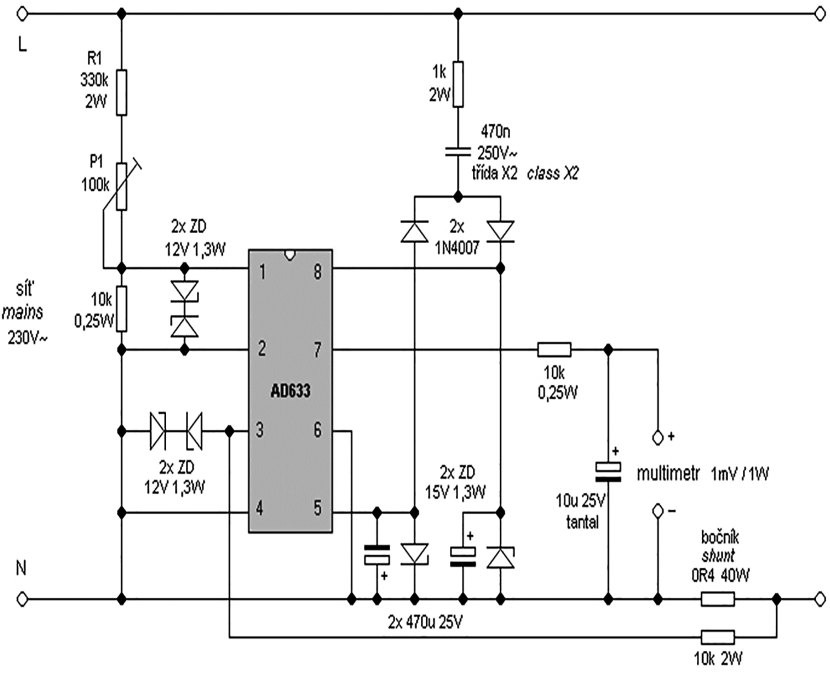

Fig. 4. Power consumption measuring circuit.

The above circuit is directly connected to the TelosB mote which communicates with the base station using the CTP [2] protocol to send the data sensed by the above circuit.

2.2.2 Software Based Power Utilization Measurement

The Software based power utilization measurement module consists of coding of an API that measures the actual power utilization of the CPU by magnifying the micro level consumption of power in different processes like context switches, interrupts, etc. and finally total power utilized can be calculated.

The actual flow of the second module is as shown in the following Fig. 5.

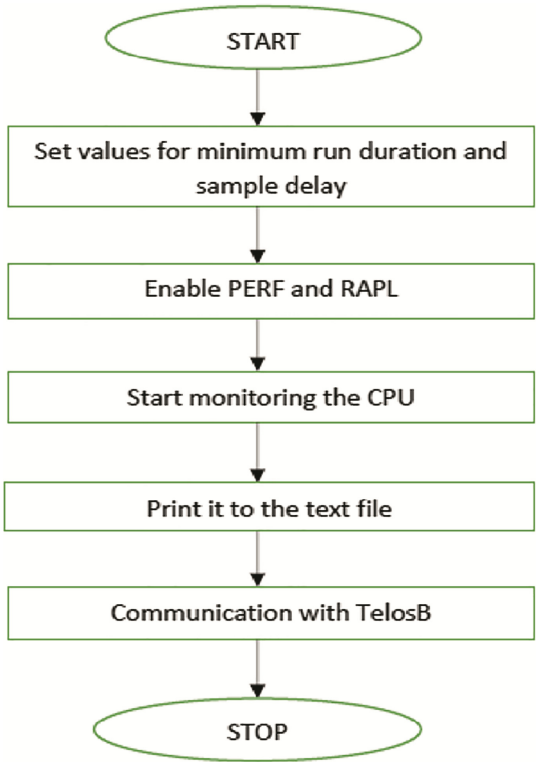

Fig. 5. Flowchart of TVAKSHAS power utilization tool.

2.3 Assembling Above Data at Base Station and Analyzing It Using Graphs and Tables

The results obtained from the above tool are as shown in the following screen shot i.e. Fig. 6. As we can see from the snapshot given below, the tool measures the number of CPU working, the number of users working parallel, the amount of seconds the system remains idle, number of context switches per second, number of interrupts per second, number of active CPU cycles per second, etc.

CPU load	User	Sys	Idle	Run	Ctxt/s	IRQ/s	Ops/s	Cycl/s	Inst/s	Watts
0% x 1	0.4	0.8	98.6	1.0	1675.8	826.7	0.0	2.2K	383.4	3.091
0% x 2	0.1	0.7	99.1	1.0	1474.7	644.1	0.0	7.3K	2.4K	2.650
0% x 3	0.3	0.4	99.1	1.1	511.1	144.2	0.0	7.0K	2.5K	2.627
0% x 4	0.1	0.2	99.6	1.0	374.7	116.1	0.0	9.9K	2.9K	2.473
10% x 1	3.3	0.5	95.5	1.2	878.4	389.7	20.0M	115.8M	280.0M	3.328
10% x 2	18.5	1.7	77.1	2.3	4387.5	1164.1	70.8M	420.4M	1.0B	6.904
10% x 3	23.1	1.7	73.1	1.6	3239.4	1363.9	83.9M	0.5B	1.2B	6.338
10% x 4	16.3	1.1	81.0	1.7	3578.2	1199.2	125.4M	0.8B	1.8B	6.101
20% x 1	14.8	1.2	80.0	2.2	3894.6	1217.0	86.2M	0.5B	1.2B	7.491
20% x 2	15.6	1.3	82.3	2.4	3990.2	1223.8	174.3M	1.0B	2.4B	7.578
20% x 3	23.2	1.1	73.7	2.4	4165.1	1159.3	234.0M	1.5B	3.3B	7.996
20% x 4	25.6	1.1	72.1	2.0	4507.9	1684.1	312.8M	2.0B	4.4B	8.176
30% x 1	14.4	1.2	79.0	1.4	4563.8	1287.4	131.0M	0.8B	1.8B	7.732
30% x 2	34.7	2.9	50.4	2.2	5134.8	1643.3	238.1M	1.4B	3.3B	9.559
30% x 3	29.6	1.7	67.0	2.0	4150.7	1356.7	346.3M	2.2B	4.9B	8.732
30% x 4	35.1	1.0	63.2	2.7	3954.5	1435.9	467.9M	3.0B	6.6B	9.034

Fig. 6. Power utilization of the processes when downloading process is ON.

Total power consumed by all these micro level processes are assembled, summed u and finally the amount of power utilized by the CPU is obtained as a magnifier of utilization of these micro level processes.

2.3.1 Analysis Obtained from Project TVAKSHAS

The analysis results obtained using this tool and the power measuring circuit for a computer lab in the department of computer engineering in an engineering college, consisted of similar configurations of CPUs and almost similar workload is as follows.

The following analysis is done using the core i5 7B generation computer for temporary basis. The final outcome of this project will be the readings of the high end PCs of the whole computer department that consists of 6 labs, containing 30 PCs in each. It is assumed that all the PCs in a lab are in ideal conditions and all PCs are running the same program during lab hours According to the lab manual provided online [91], the power ratings for the core i5, 7th generation quad core processor desktop PC is 91 W per hour.

The analysis done using the project TVAKSHAS are as follows:

Consumed Power according to manual available: 91 W
Power Consumption Calculated using the Current Sensor Circuit per hour: 96
Utilization calculated using TVAKSHAS-Util tool: 49.6 W
1-h consumption 96 W
1-h utilization = 49.6 W
Therefore, on working hours (8 h)
8 h consumption = 768 W
8 h utilization = 396.8 W

By extrapolating, we get following results (Table 1):

Table 1. Analysis obtained in project TVAKSHAS.

Property	Example i5	Core 2	Difference
Total consumption	4140 units	2808 units	1310 units
Utilization	2160 units	2160 units	–
Consumption cost	Rs. 33,120	Rs. 22640	Rs. 10,480
Utilization cost	Rs, 17,280	Rs. 17,280	–
Total cost of system	Rs. 40,000	Rs. 30,000	Rs. 10,000

The above results are extrapolated for an hour. The per minute results obtained in TVAKSHAS and sent through the network end then opened the data in an excel sheet and then the analysis is as shown in Fig. 7.

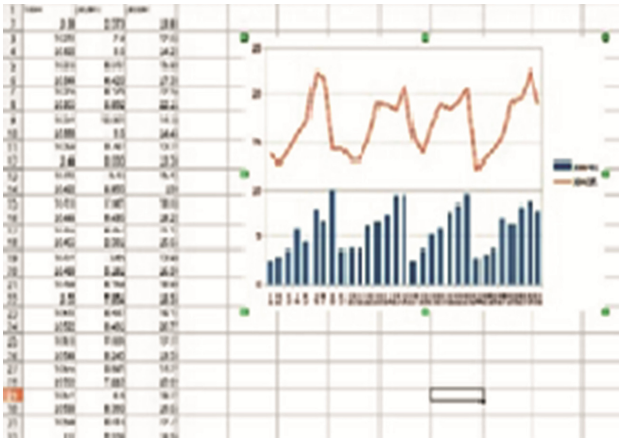

Fig. 7. Output of project TVAKSHAS.

3 Advantages

1. It measures the CPU utilization along with its power consumption.
2. It calculates and analyses of the difference between energy utilization and energy consumption.
3. Qualitative analysis at the process level.
4. To measure how much our conventional methods to reduce energy utilization are useful.
5. To find the best suited CPU depending on the user inputs.
6. Real time measurements.

4 Future Work

From this work, we came to know about the differences in the power consumed by the CPU and actual power utilized by it. In the future, we focus on the reason where the extra power is being wasted and how to overcome that difference using various techniques.

5 Conclusion

The project TVAKSHAS is meant to be developed for the purpose of the quantitative as well as qualitative analysis of the difference between the amount of energy consumed by the commercial device and the actual amount of energy utilized by that device. It is a general tendency that the device does not utilize the amount of energy it is consuming at its whole. Some amount of energy is bound to be wasted and hence there is a variation between the amount of energy consumed by the device and its actual utilization. Also, the project TVAKSHAS aims to give the qualitative analysis like learning about how much power is drawn by which computer at the micro level i.e. measuring the CPU utilization in terms of the active CPU cycle, number of active processes, the amount of CPU consumed by each process in terms of power draw, and then taking the sum of these values to find out the total CPU utilization in terms of power draw. Based on these values, the difference between the consumed power and the utilized power can be derived. These observations can be useful to create awareness to the users for the purchase of different devices.

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