Module: Internet of Things	2016
Lab Session 6: Power Consumption	
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6.1 Introduction

In this session we are going to analyse the power consumption of a sensor node. We run a powertrace as a background process on the sensor node.

The powertrace reports the power consumption and resource utilisation of a node, and it prints the statistics to the console.

6.2 Powertrace Application[1]

The following source code (power.c) demonstrates the use of powertrace.

```
#include "contiki.h"
#include "random.h"
#include "powertrace.h"

#include <stdio.h>

PROCESS(power, "powertrace example");
AUTOSTART_PROCESSES(&power);

PROCESS_THREAD(power, ev, data)
{
  static struct etimer et;

  PROCESS_BEGIN();

  /* Start powertracing */
  int n = 1; // 1 second reporting cycle
  powertrace_start(CLOCK_SECOND * n);

  printf("Ticks per second: %u\n", RTIMER_SECOND);

  while(1) {
    /* Delay 2-4 seconds and then perform some tasks */
    float t = 2*((float)random_rand()/RANDOM_RAND_MAX) + 2;
    etimer_set(&et, CLOCK_SECOND*t);
    PROCESS_WAIT_EVENT_UNTIL(etimer_expired(&et));

    // Put your tasks here...
  }
  PROCESS_END();
}
```

[1] See also: A. Dunkels, J. Eriksson, N. Finne, N. Tsiftes, "Powertrace: Network-level Power Profiling for Low-power Wireless Networks," *SICS Technical Report T2011:05*, March 2011.

To compile the source code, you need to include powertrace app in the Makefile (see line 2 below).

```
1 CONTIKI_PROJECT = power
2 APPS += powertrace
3 all: $(CONTIKI_PROJECT)
4
5 CONTIKI = ../..
6 include $(CONTIKI)/Makefile.include
```

When running the program, the console will show power consumption statistics on the screen every second. An example of the output and the explanation are given as follow:

```
2408 P 193.250 17 11309 578542 0 2574 0 2574 689 32078 0 144 0 144
(radio 0.43% / 0.43% tx 0.00% / 0.00% listen 0.43% / 0.43%)
```

Parameter and value	**Explanation**
clock_time() = 2408	clock time
rimeaddr = 193, 250	rime address
seqno = 17	sequence number
all_cpu = 11309	accumulated CPU energy consumption
all_lpm = 578542	accumulated Low Power Mode energy consumption
all_transmit = 0	accumulated transmission energy consumption
all_listen = 2574	accumulated listen energy consumption
all_idle_transmit = 0	accumulated idle transmission energy consumption
all_idle_listen = 2574	accumulated idle listen energy consumption
cpu = 689	CPU energy consumption for this cycle
lpm = 32078	LPM energy consumption for this cycle
transmit = 0	transmission energy consumption for this cycle
listen = 144	listen energy consumption for this cycle
idle_transmit = 0	idle transmission energy consumption for this cycle
idle_listen = 144	idle listen energy consumption for this cycle

Powertrace tracks the duration of activities of a node being in each power state. In other words, the outputs show the fraction of time that a node remains in a particular power state. In the above example, there are 6 defined power states: CPU, LPM, TRANSMIT, LISTEN, IDLE_TRANSMIT, IDLE_LISTEN.

Power states are measured with a hardware timer. The clock frequency is defined in `RTIMER_SECOND` (or 32,768 Hz for XM1000). We can check that summing all power states in the above example gives 33,055 ticks which are close to 32,768.

Use the following command to divert the output to a file.

```
$ make TARGET=xm1000 login > power.csv
```

Instead of showing the statistics on the screen, the statistics are now saved into a file named 'power.csv'. As usual, to stop the process, press CTRL+C. The directory should now contain a file named 'power.csv' with the power consumption statistics. Using the saved data, you may even create a plot showing the power consumption of the node.

6.3 Exercise

Modify the program by adding some computation and/or communication tasks in the source code and observe the changes in power consumption.