Solution to Chapter 2

2.1 Multi-choice questions

(1) A sensor mote includes:

A. Analog / digital sensor chips;

B. RF transceiver;

C. CPU / Memory;

D. All of the above.

The answer should be D.

(2) The differences between analog sensors and digital sensors do not include which of the following aspects:

A. Analog sensors need standard chip-to-chip communication protocols to take with CPU board while digital sensors do not need them.

B. Analog sensors need compensation and linearization; but digital sensors do not need them.

C. Digital sensors are better choices than analog sensors from CPU interface viewpoint;

D. No ADC (Analog-to-Digital converter) is needed in digital sensor case.

The answer should be A. Digital sensors typically have chip-to-chip communications (such as CPU-RF communications).

(3) In a sensor network, most of the sensor mote's energy is typically consumed in:

A. Analog sensing part;
B. CPU local calculations on signal processing;
C. Wireless hop-to-hop communications;
D. Wake-up / sleeping transition.

The answer should be C.

(4) On the CPU in the sensor mote, which of the following is NOT correct?

A. The CPUs used in sensor mote have much weaker capability than general desktop's or laptop's ones. The sensor mote CPUs are often called microprocessors or microcontrollers.
B. The CPU working frequency in a sensor mote is typically below 100M Hz.
C. When the CPU is in idle/sleep mode, no energy consumption is involved.
D. The main duties of CPU are to execute communication protocols and locally process the data.

The answer should be C. Energy is still consumed even in sleep status in case receiving wake-up signals.

(5) Which of the following is NOT correct on the sensor mote memory?

A. Sensor nodes only require small amounts of storage and program memory.
B. If data is to be stored for long periods of time it is more efficient to use flash instead of SRAM.
C. The program execution occurs in the flash memory instead of in SRAM.
D. The typical SRAM size is less than 1M bytes so far.

The answer is D. SRAM could easily go beyond 1M bytes.

(6) The radios on the sensor mote have the following features:

A. Low power radios consume larger energy when in receive than in transmit mode.
B. The sending distance of a wireless system is controlled by several key factors. The most intuitive factor is that of transmission power.
C. Most RF transceivers on the market today use a VCO (Voltage Controlled Oscillator)-based radio architecture and have the ability to communicate at a variety of carrier frequencies.
D. Amplitude modulation (AM) is the simplest to encode and decode, and it is less susceptible to noise.

The answer is C. A is not correct since the send/receive energy consumption could be similar. B is not correct since several other factors (such as antenna gain, communication data amount) are also important. D is not correct since AM is very susceptible to noise.

(7) In the sender side, which of the following operations is NOT needed?

A. Wait for the receiver's acknowledgement before sending out next packet;
B. Encode the data by adding error detection bits;
C. Wait for collision free with the help of MAC protocols;
D. Organize sensor data to different packets.

The answer should be A since in some applications we do not wait for ACK from the receiver. B is needed since it is part of data link layer functions; C is needed since transmission collision can make data not able to go through. D is needed in any network.

(8) The reason(s) of decoupling between RF and processing speed could be:

A. When the speed of the microcontroller is coupled to the data transmission rate, both pieces of the system are forced to operate at non-optimal points.
B. A radio is most efficient when data transmissions occur at its maximum transmission rate. When coupling with CPU processing, such efficiency cannot be achieved.
C. RF and CPU are totally different chips and need to be decoupled in most cases.
D. Both A and B.

The answer should be D.

(9) Spec is better than Mica due to the following reasons:

A. The Mica nodes were constrained by existing inter-chip interfaces. Development of a custom ASIC allows us to tear down the artificial constraints imposed by commercial components.
B. It is possible to achieve orders-of-magnitude efficiency improvements on key communication primitives by using custom silicon.
C. Both A and B.
D. Spec could transmit signals for a longer distance than Mica does.

The answer should be C.

(10) Which of the following is NOT correct on Telos motes?

A. Telos uses the Bluetooth communication standard (an IEEE 802.15 series), which makes it suitable for short-range radio communications.
B. Telos uses the MSP430 microcontroller that has the lowest power consumption in sleep and active modes.
C. Instead of integrating the design into silicon, Telos uses COTS components with hardware accelerators to build a power efficient system that does not sacrifice performance.
D. Telos is programmed (either with the bootstrap loader or JTAG) through on-board USB that also provides power.

The answer should be A. It does not use Bluetooth standard. It uses 802.15.4 (Zigbee standard).

2.2 Do some Web research to find out the characteristics and design principle of Solar-based batteries.

http://www.wisegeek.com/how-do-solar-panels-work.htm introduces the solar panel working principle.

WiKi has some good explanations on solar cell. http://en.wikipedia.org/wiki/Solar_cell

2.3 What are the differences between "sensors" and "sensor motes"?

"Sensors" do not need to have RF communications. They could be analog ones or digital ones. While "sensor motes" have RF communication capabilities.

2.4 Read [Mateusz07] and provide more details on the integration of RFID into CargoNet sensor motes.

Hints: Make sure to talk about (1) hardware integration principle; (2) software architecture.

2.5 What advantages does the Telos mote have compared to others (such as Mica)?

(1) It has lowest power consumption in sleep and active modes (see Table 2.7).
(2) It can tolerate a low operation voltage of 1.8V. A low-voltage operation could help to extract all of the energy out of a power source. If we use AA batteries, they have a cut-

off voltage of 0.9V. A Telos mote uses two batteries. Then the system cut-off voltage will be 1.8V, which is exactly the minimum required voltage for the MSP430. If we use other CPUs, say ATmega128 MCU (Mica family), it can only run down to 2.7V, leaving almost 50% of the AA batteries unused.

(3) We know that a faster wake-up time helps to conserve energy. Table 2.8 shows that the MSP430 has the fastest wakeup time (it takes <6μs to transition from standby (1μA) to active mode).

(4) From memory viewpoint, Table 2.8 shows that the MSP430 has the largest on-chip RAM buffer (10kB). It is good for on-chip signal processing. A larger RAM allows more sophisticated applications.