COMP6733 IoT Design Studio Problem Set

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Question 1: IoT Design

Achieving efficient use of energy and water resources is a complex issue, as countries face different challenges and conditions. However, it is possible to develop a program to monitor/control energy and water use to meet the goals set out in UNSW's "Race to Zero".

Plan

a) Choose of hardware

Sensor type:

- Smart meters: Schneider Electric's iEM 3000 series smart meters for monitoring energy usage in buildings.
- Smart water meters: Kamstrup's MULTICAL 302 smart meter for monitoring water usage in buildings.
- Temperature and humidity sensors: DHT22 digital temperature and humidity sensors for real-time monitoring of temperature and humidity in buildings.
- Body sensing sensors: PIR (Passive Infrared) body sensing sensors for detecting whether there is human activity in the building.

Actuator Type:

- Smart Water Valve: Belimo's LRB24-SR Smart Water Valve for controlling water supply based on monitoring results.
- Smart appliance switches: e.g., TP-Link's smart sockets to remotely control the on/off status of appliances.

b) Protocols for different communication layers

- Physical/MAC layer: For communication between sensors and actuators, low-power IoT communication protocols such as Zigbee or BLE can be selected.
- Routing layer: It is recommended to use 6LoWPAN protocol that supports low power consumption
- Transport layer: TCP and UDP are used to ensure reliable data transfer and fast data transmission.
- Application layer: MQTT is recommended.

c) Sensing strategy

- Set appropriate sampling frequencies and thresholds to ensure that data on energy/water use, temperature and humidity, occupancy, HVAC and lighting are captured in a timely manner.

d) Backend handling

- Sensor data is uploaded to AWS for storage and processing, and data analytics and machine learning algorithms are used to optimize and predict energy/water usage.

e) Cost of solution

Based on the equipment and services recommended above, after checking the internet for relevant prices:

- Hardware costs: approximately $850
- Communication costs: $10 per month per building, assuming 10 years of operation: 10 * 12 * 10 = approximately $1,200.
- Back-end processing costs: $30 per month per building, assuming 10 years of operation: 30 * 12 * 10 = approx. 3600 USD.

f) Assumptions

- It is assumed that information on energy/water usage, temperature and humidity, occupancy, HVAC and lighting in the building can be accurately accessed by sensors.
- It is assumed that the communication of the IoT cloud platform is stable and reliable to ensure timely uploading of sensor data and transmission of control commands.
- It is assumed that smartphones can be readily connected to the IoT cloud platform for manual inspection and remote control.

The details of the solution may need to be refined, but the above provides an initial infrastructure for realizing the goals set forth in UNSW's "Race to Zero."

Question 2: Routing

We need to calculate the ETX between each pair of neighboring nodes using the following formula:

$$ETX = \left(\frac{1}{Quality_{forward}}\right) * \left(\frac{1}{Quality_{backward}}\right)$$

The following new diagram can be obtained:

S -> c:	ETX = 1 / (0.2) * 1 / (0.2)	=	25
S -> f:	ETX = 1 / (0.75) * 1 / (0.65)	=	2.051
S -> b:	ETX = 1 / (0.9) * 1 / (0.7)	=	1.587
b -> a:	ETX = 1 / (0.75) * 1 / (0.35)	=	3.810
b -> c:	ETX = 1 / (0.9) * 1 / (0.9)	=	1.235
f -> e:	ETX = 1 / (0.3) * 1 / (0.85)	=	3.922
c -> e:	ETX = 1 / (0.75) * 1 / (0.7)	=	1.905
c -> f:	ETX = 1 / (0.9) * 1 / (0.9)	=	1.235
c -> D:	ETX = 1 / (0.6) * 1 / (0.5)	=	3.333
a -> c:	ETX = 1 / (0.9) * 1 / (0.8)	=	1.389
a -> D:	ETX = 1 / (0.9) * 1 / (0.3)	=	3.704
e -> D:	ETX = 1 / (0.85) * 1 / (0.75)	=	1.569

The shortest path from node S to node D can be found by running Dijkstra's algorithm once on this new graph.

The answer is D -> c -> b -> S, distance = 6.155

Question 3: Localisation

Using the following formula can calculate the distance between two points:

$$\left(t_{A,r} - t_{A,u}\right) * V_u, where\ V_u = 340ms^{-1}$$

The distance from A1, A2, A3 to X is obtained by this equation:

$$D_1 = (11.5 - 11.56) * 340 = -20.4$$
$$D_2 = (48.5 - 48.55) * 340 = -17$$
$$D_3 = (27.9 - 27.98) * 340 = -27.2$$

Using the Pythagoras Trilateration as matrix equation formula and substituting the positions of A1,A2,A3 can be obtained:

$$2\begin{bmatrix} 60-40 & 30-50 \\ 60-30 & 30-25 \end{bmatrix}\begin{bmatrix} x_u \\ y_u \end{bmatrix} = \begin{bmatrix} (20.4^2 - 27.2^2) - (40^2 - 60^2) - (50^2 - 30^2) \\ (17^2 - 27.2^2) - (30^2 - 60^2) - (25^2 - 30^2) \end{bmatrix}$$
$$= 2\begin{bmatrix} 20 & -20 \\ 30 & 5 \end{bmatrix}\begin{bmatrix} x_u \\ y_u \end{bmatrix} = \begin{bmatrix} 76.32 \\ 2524.16 \end{bmatrix}$$

Thus

$$x_u = 36.332$$
$$y_u = 34.424$$

Therefore the position of point X should be (36.332, 34.424)