MIT 6.S062 – Mobile and Sensor Computing
Exam 1

There are 17 questions and 7 pages in this quiz booklet. To receive credit for a question, answer it according to the instructions given. *You can receive partial credit on questions.* You have **80 minutes** to answer the questions.

Don't forget to write your name on this cover sheet NOW!

Some questions may be harder than others. Attack them in the order that allows you to make the most progress. If you find a question ambiguous, be sure to write down any assumptions you make. Be neat. If we can't understand your answer, we can't give you credit!

THIS IS A CLOSED BOOK QUIZ.
YOU MAY USE 1 DOUBLE-SIDED PAGE OF NOTES.

Do not write in the boxes below

1-2 (10)	3-6 (20)	7-11 (27)	12-14 (16)	15-17 (17)	Total (90)

Name:

Positioning principles

1. *(4 points)* Order the relative accuracy of the following positioning technologies (from 1–4), in order from **least (1) to most (4)** accurate.

   __2__ Wi-fi triangulation

   __1__ Cellular triangulation

   __3__ GPS

   __4__ Cricket

   GPS accuracy is typically a few meters; Cricket 4 feet or less; cellular hundreds of meters to kilometers, and Wi-Fi tens of meters.

GPS

2. *(6 points)* Generally, acquiring a GPS "fix" for the first time involves a significant amount of signal processing work on the receiver, and a 12.5-minute waiting period while the satellites stream data at 50 bits per second. List three pieces of information that can be acquired through Internet or cellular connectivity to cut down on the time-to-first-fix.

   Time-to-first-fix can be reduced if the receiver knows the date and approximate time, the almanac data (satellite orbital position and velocity), the approximate location, or the exact microsecond time. Estimates of the time on these different orders of magnitude help in different ways: the approximate time (in addition to the approximate location and almanac data) allows the receiver to compute the current set of visible satellites, while the exact time allows the receiver to vastly narrow the search parameters for the phase of the received pseudorandom-noise sequences.

RADAR

3. *(5 points)* In the RADAR experiments, *multiple* signal strength samples were gathered at any given physical location. Why?

   Because the signal strengths are directionally-dependent; human obstruction.

4. *(5 points)* State one benefit of RADAR's approach to indoor location over Cricket.

   For instance, requires no extra hardware/runs on existing wireless LAN.

Cricket

5. *(5 points)* In Cricket, how does a listener obtain a distance estimate to a beacon?

   Cricket uses concurrent transmissions over radio and ultrasound and measures time-difference-of-arrival between the two signals, which propagate at vastly different speeds. The further away the beacon, the larger the time-difference-of-arrival (TDoA).

6. *(5 points)* Cricket uses active beacons on walls/ceilings and passive listeners attached to mobile devices. State one benefit of this architecture compared to a system with passive listeners on the walls and active beacons on mobile devices.

   For instance, scalability (the infrastructure does not need to grow to accommodate growth in the number of users in the same building); infrastructure does not track users (only users obtain location estimates).

IoT connectivity

7. *(6 points)* According to the lecture on IoT connectivity, the reason why we can't we use a single network technology for all IoT applications is because no single network technology meets all possible combinations of

   duty cycle/data rate,

   battery lifetime/energy, and

   communication range

required by IoT applications. (Fill in the blanks.)

8. *(4 points)* What is the "gateway problem" described in the paper "The Internet of Things Has a Gateway Problem"? (Circle True or False for each choice.)

   (a) **True** / False Many IoT applications are reinventing gateway functions.

   (b) **True** / False Many IoT applications re-invent every layer of the stack from sensors up to server apps, without sharing functionality.

   (c) True / **False** Many IoT applications don't use a gateway to the "cloud" and run into problems as a result.

ETX principles

9. *(4 points)* Which of the following assumptions does ETX make? (Circle True or False for each choice.)

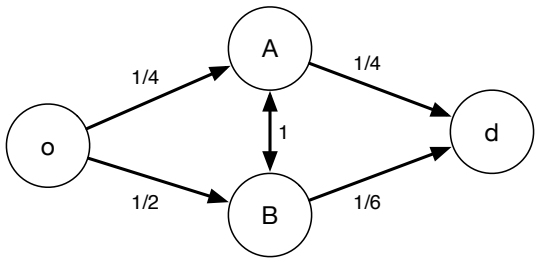
   (a) **True** / False A sending node must perform link-layer retransmissions if the link-layer ACK is not received.

   (b) True / **False** The application's traffic must run on TCP.

   (c) **True** / False The probability of successful packet delivery between neighboring nodes may not be the same in each direction.

   (d) True / **False** The routing protocol must be a distance-vector protocol.

10. *(6 points)* Consider the network topology below for a network using Wi-Fi links below. Suppose o wants to send a message to d, and o and d cannot communicate directly. The number on each edge is the probability that a forward transmission **and** an acknowledgment are successfully received on the link, i.e., it is the bidirectional probability of successful packet delivery. The network uses the ETX metric from the paper by DeCouto et al., which can be computed using the link success probabilities given.



Which path would the network use to send data between o and d? What is the ETX metric of this path?

The ETX metric of a link is the expected number of transmission attempts needed to secure an acknowledgement, which is one over the probabilities shown. So the network uses the path o-B-A-d, with metric 7 = 1/(1/2) + 1/(1) + 1/(1/4).

LEACH

11. *(7 points)*

    Which of the following ideas does LEACH use? (Circle True or False for each statement.)

    (a) **True** / False It rotates cluster-heads using a randomized, distributed algorithm.

    (b) True / **False** It uses Time-Division Multiple Access (TDMA) as the MAC protocol for communication between the cluster-heads and the base station.

    (c) **True** / False It uses Carrier Sense Multiple Access (CSMA) when nodes advertise their ability to become a cluster-head.

    (d) **True** / False It assumes that every node has a radio that can directly communicate with the base station.

    (e) True / **False** It uses Minimum Transmission Energy (MTE) routing to transmit data from the sensor nodes to the cluster-head to the base station.

    (f) **True** / False It uses in-network computation at each cluster-head to remove the redundancy in the signals transmitted from the sensor nodes, before sending the result to the base station.

    (g) True / **False** A node that has recently become a cluster-head will continue to remain one until its energy almost drains.

Tiny Aggregation

12. *(6 points)* List three techniques that that the TAG system described in the paper "TAG: A Tiny Aggregation System for Ad-hoc Sensor networks" uses to reduce power consumption when computing aggregation queries:

    1. in-network aggregation
    2. overhearing (min and max)
    3. coordinate wake-sleep schedules, a.k.a. time-division multiple access (TDMA)

Inertial Sensing

13. *(5 points)* "Dead reckoning" refers to a set of location estimation techniques that rely on velocity and acceleration estimates. Mobile phones have inertial measurement units that measure acceleration and rotation; why don't phones use dead reckoning to track their location?

    Sensors are not accurate enough; estimates exhibit drift; integration procedure amplifies errors; difficult to separate gravity from user acceleration.

Pothole Patrol

14. *(5 points)* How does the method described in the Pothole Patrol paper distinguish between true potholes on the road and railroad track crossings, expansion joints, and speed bumps?

    Potholes typically affect only one side of the car, so the authors of Pothole Patrol looked for asymmetric movement by measuring lateral acceleration of the car.

Map Matching

15. *(5 points)* Explain the problem that CTrack solves: i.e., what are the inputs to CTrack, and what are the outputs?

    Input: map, timestamped observations of cellular signal strengths

    Output: map-matched trajectory

16. *(6 points)* As described in the paper "Accurate, Low-Energy Trajectory Mapping for Mobile Devices", which of these techniques does CTrack use? (Circle True or False for each statement.)

    (a) True / **False** Radio fingerprints from Wi-Fi access points gathered by "war-driving".
    (b) **True** / False Radio fingerprints from cellular base stations gathered by "war-driving".
    (c) **True** / False Hidden Markov Models.
    (d) **True** / False Gridding into fixed-size cells.
    (e) True / **False** The use of speed data to improve accuracy.
    (f) **True** / False The use of data from the compass and accelerometer to improve accuracy.

Potpourri!

17. *(6 points)* Circle True or False for each statement below.

    (a) **True** / False Zebranet uses data muling to deliver data from sensor nodes to the base station.

    (b) **True** / False The map inferencing method in the paper by Biagioni and Eriksson uses map-matching to decide if certain road segments produced during an intermediate stage should be retained.

    (c) True / **False** The shooter localization paper uses microphones to detect the muzzle blast as well as the shockwave produced when a gun is fired.

    (d) **True** / False In the Glimpse system, an "active cache" is used on the mobile device to improve the accuracy of tracking.

    (e) True / **False** In the Glimpse system, "trigger frames" are used to improve the end-to-end latency of tracking.

    (f) True / **False** In Voxnet, all acoustic data is processed offline.

End of quiz!