Review Homework 1

The objective of this (easy) homework is to help you review the important points from the lectures and lecture notes. Please answer the following questions and return your homework as a PDF through WebCourses before the due date noted online. Late submissions will incur a 30% penalty per day.

Try to be concise in responding to questions; a single paragraph or sentence suffices for many of the following questions:

1. **What are the main two communication standards in Wireless Sensor Networks, explain in which scenario each of these standards/technologies may be more useful? (5pt)**

   I. **IEEE 802.11:** In general, it is the most widely used WLAN protocols for wireless communications. It is mostly useful in applications where we do not have stringent energy constraints and we need to send data at higher rates and longer range.

   II. **IEEE 802.15.4:** It is designed specifically for short-range communications in WSNs. It is mostly useful for low data rates, low power consumption and is widely used in academic and commercial WSN solutions

2. **Name three "performance measures" that may be used in Cooperative Vehicle Safety Systems, Discuss the issues that each may have (if any). (10pt)**

   I. Message Reception Probability Issue: When the gap between the received messages are long, error also becomes very large, and we get a poor estimate of location.

   II. Inter - Packet Gap Issue: If faced with Inter-packet gap issue, we cannot track the error with respect to the position of car as it cannot capture the dynamic motion of the car.

   III. Analysis of State Estimation Error: The problem with tracking error is that it is not possible to track the car in real time (with apriori knowledge). Computing the tracking error rate is only possible after the time-step. Estimation is done using first-order models based on location, velocity, etc. If we know the apriori location of the car, we can estimate the current location of the car. But the future location of the car cannot be estimated.

3. **Explain why we need data from at least 4 satellites for positioning in GPS (10pt)**

   At least 3 satellites are needed to perform the triangulation. Which calculates the three co-ordinates of the location of the receiver. These 3 satellites cannot calculate the distance between the receiver and the satellite. To calculate the time the GPS signals took to arrive, the GPS receiver needs to know the time very accurately. The GPS satellites have atomic clocks that keep very precise time, but it's not feasible to equip a GPS receiver with an atomic clock. However, if the GPS receiver uses the signal from a fourth satellite it can solve an equation that lets it determine the exact time, without needing an atomic clock.
   That is why, we need data from 4 satellites for positioning in GPS. However, in reality, we need 6 satellites for accurate time and position measurements.

4. **What is the difference between intra-vehicle and inter-vehicle communication? name 2 standards for each, name 1 application for each type of communication. [refer to the early lectures] (5pt)**

   - Inter-Vehicular Communication stands for the communication that happens between vehicle to vehicle.

   Standards: DSRC (IEEE 802.11p), WiMax (IEEE 802.16)
   Application: Route Update with data from other vehicles

   - Intra-Vehicular Communication stands for the communication that happens between the sensors or other parts of a vehicle.

   Standards: Bluetooth (IEEE 802.15.1), ZigBee (IEEE 802.15.4)
   Application: Short/Long range sensors (forward vision system)

5. **Name a classic systems science or theory that is not suitable as a "cyber-physical" systems science; explain why such a theory is not useful. In other words, what features of a cyber-physical system cannot be properly modeled using most classical systems sciences [refer to the early lectures] (5pt)**

   Classic systems sciences are either too simple, or too abstract, or too narrow to deal with the following features of a cyber-physical system:
   I. Complexities of the CPSs
   II. Networked nature of the CPS challenges
   III. Heterogeneity of CPS components
   Hence, theories of network control systems, dynamical system modeling, software development tools and languages, networking methods, etc. cannot be modeled using most classical system sciences.

6. **What is the main issue with using IP in Energy Management and Control Systems (EMCS)? [refer to smart grid lectures] (10pt)**

   While IP may solve the problem for non-real-time applications, it may not be suitable for real-time applications. Energy Management and Control systems (EMCS) are critical installations and hence we need to use a reliable means of communication Most of the work on smart grid like demand response, smart charging of cars etc. are non-real-time in the communication sense, they are considered real-time from software perspective. QoS is needed to ensure bounded and low latency. The issue of QoS in internet has been researched for over 10-15 years, and eventually (almost) abandoned with no universal solution ever deployed. Therefore, can't really trust IP based solutions for real-time applications.

7. **Explain how differential GPS improves the positioning accuracy of GPS (5pt).**

   Differential GPS is essentially a system to provide positional corrections to GPS signals. DGPS uses a fixed, known position to adjust real time GPS signals to eliminate pseudo range errors. To obtain more accurate measurements than is possible from a single GPS unit, a GPS receiver broadcasts the signal it receives from a known position. The GPS unit in the field simultaneously receives data from the GPS satellites and the other GPS receiver on the ground through a radio signal. The GPS error from the known position is compared to that of the GPS receiver in the unknown location. These systems are known as SBAS (Space Based Augmented Systems). They are called WAAS (Wide Area Augmented System) in USA. These systems are easy to set up, and can be used at any location. Accuracy of 1m can be achieved using such systems.

8. **What is the job of IEEE 1609.3 ? Which protocol is replaced by Wave Short Messages? (5pt)**

   This specification of transport and network layer supports multi-channel wireless connectivity in WAVE. The job of IEEE 1609.3 is to support secure WAVE data exchange, network service defines transport and network layer services and it also includes addressing and routing . It also deals with Wave short message and how IPV6 support by application. Network services also include Logical Link control sub layer, for both IP and WSMP traffic. IPv6 was replaced by Wave Short Messages.

9. Compare Hidden Terminal problem to Exposed Terminal problem (refer to WSN MAC related lectures) (5 points)

- Hidden-terminal problem

In the diagram shown below, senders A and C can reach B, but cannot overhear each other's signals. Hence, it is possible for A and C to transmit data to B at the same time, thereby, causing a collision at B, without being able to directly detect this collision

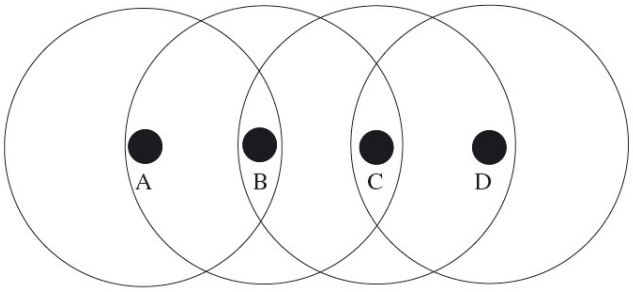

Figure: Hidden terminal and Exposed terminal problem

- Exposed-terminal problem

In the figure above, suppose C wants to transmit data D, but decides to wait because it overhears an ongoing transmission from B to A. B's transmission could not interfere with data reception at C. Hence, it leads to delay even though the transmission was possible without any delay.

10. Which OSI layers does the LonTalk protocol suite correspond to? (5pt)

LonTalk protocol suite corresponds to OSI layers 2 to 6. These layers are Data Link layer, Network layer, Transport layer, Session layer and Presentation layer.

11. What do BACnet objects model? (10pt)

BACnet objects model the following:

• Real Device and BACnet Objects: BACnet objects give the outside view onto device functions. Example: The BACnet loop object is defined in a way, that different loop algorithm e.g. PI, PID, sequence, predictive control can be mapped.

• Client-Server Relations: The client is claiming services of the server. The client subscribes for changes of values gives order for trend data registration defines alarm

limits. The server maintains an image of the device functionality and executes the services.

• Peer-to-Peer Communication: In COV Handling, Client subscribes for a value (i.e. data point) of the server. Server returns the value together with the acknowledgement. Server returns the value whenever it changes. Client have the option to either renew or cancel the subscription.

12. Explain virtual carrier sensing and network allocation vector (refer to WSN MAC lectures on 802.11, Wikipedia). (10 points)

Virtual carrier sensing: This is a collision avoidance(CA) in which nodes attempt to avoid collisions of packets by transmitting only when channel is sensed to be idle. It is designed to protect against hidden terminal problems. Before transmission, the node listens to shared medium to determine whether another node is transmitting or not. It goes into idle period and wait for a free communication channel, If another node is heard communicating. Virtual carrier sensing saves power by limiting the need for physical carrier sensing.

Network Allocation Vector: NAV is a virtual carrier sensing mechanism which is used in IEEE 802.11 (Wi-Fi) and IEEE 802.16(WiMAX). To avoid hidden terminal problem, each node set a NAV, which is an indicator for the node on how long it must wait to access the medium. To specify time required for frame transmissions, each MAC layer frame header contains a duration field. A counter is maintained by each station with amount of time that must be elapsed until the medium becomes free again. Until the NAV is zero, Station cannot transmit. Based on data rate and frame length, each station calculates how long it will take to transmit its frame. This information is included in the Duration field of the frame header.

13. In NIST framework for smart grid, "Service Provider" does not communicate to three other entities, name them and explain why. [refer to January lectures] (5pt)

The Service Provider does not communicate with:

- Bulk Generation entity
- Market entity
- Transmission Distribution entity

Operations entity uses enterprise bus to communicate with Service Providers. Which is why these aforementioned entities communicate with it easily. Bulk generation and market entities use internet and transmission distribution entity uses WAN, LAN to communicate with enterprise bus of operations entity.

14. What are the expected uses of WiMAX/LTE standards in safety applications (refer to ITS and vehicle safety system lectures). What performance criteria should be met If WiMAX/LTE are used in place of DSRC for active safety? (10pt)

In safety applications, the expected uses of WiMAX/LTE standards are in cooperative safety systems. These systems prevent accidents/crashes from taking place. Using electronic devices, they deliver alerts/warnings in real-time. To achieve situational awareness, the car has to be aware of its surroundings by being able to calculate the possibility of a collision or accident. Then it sends the data to the driver or some autonomous control mechanism inside the vehicle. This information could be gathered from various sensors in the vehicle. We can gather information from neighboring vehicles by performing calculations. These standards are also used in trip advisory. In trip Advisory applications, a road blockage, accident or congestion can be reported to the driver well ahead in time so that they can maintain their speed accordingly. WiMAX/LTE technologies are slow in alert reporting as compared to DSRC and Wi-Fi. System performance requirements of active road safety applications include lower latency (=100 ms), short to long coverage distance (300 m to 20 km), minimum transmission frequency of 10 Hz, and low-to-medium data rates (1 to 10 kbps).