Problems and Solutions (Chapter 15)

1. How is UWB different from frequency hopping used in Bluetooth? Explain.

   [Solution]

   The difference between UWB and bluetooth networks is that UWB systems operates across a wide range of frequency spectrum by transmitting a series of extremely narrow and low power pulses. Therefore, essentially, the whole frequency spectrum is used by the transmitter and the data is sent in bursts. Therefore, we have a burst of data across the channel and then for some time period there is no data transmission.

   On the other hand, bluetooth employs frequency hopping for data transmission. That means that data is sent on a channel in a particular frequency range and then the transmitter hops on to the next frequency spectrum and again transmits data. Therefore, the data transmission in bluetooth networks is continuous whereas it occurs in bursts in UWB. Moreover, bluetooth uses a part of the frequency spectrum whereas UWB uses the whole spectrum. The amount of data transmitted (at an instant) in UWB is also much more than it is in bluetooth networks.

2. Multimedia services have two components of video and voice data. Can you characterize them as non real-time and real-time traffic? Explain clearly.

   [Solution]

   Multimedia services have two types of data that is transmitted to the user – video data and voice data. Basically, both of these data types are real-time in the sense that the receiver should get the data frame by frame in order as it was transmitted by the sender in real-time. Hence both voice and video data can be characterized as real-time. However, between the two, it is more desirable for voice data to be transmitted in real-time. In other words, a little latency can be tolerated while transmitting video data while this is not the case with voice data. Therefore, we can categorize in some cases video data as non real-time traffic and voice data as real-time traffic.

3. Can you use PTT technology to process multimedia traffic? Explain clearly.

   [Solution]

   Since PTT (Push-To-Talk) is one of the potential IP multimedia services, it can process multimedia traffic. Push-to-talk technology is a prime area for expansion of the Session Initiation Protocol in 2004 and exhibits the walkie-talkie mode of radio communication between preset speakers. Since PTT technology uses the capabilities of the IP Multimedia Subsystem (IMS) (as specified by 3GPP which enables IP connections between mobile phones) it can definitely support multimedia traffic.

4. Assume that traffic is assigned four different priority levels taking into account real-time and handoff traffic. How can you handle such traffic while supporting mobility?

   [Solution]

   If we have a wireless system in which the traffic has four priority levels, then essentially we have to take mobility management into account in the design phase of such a system. The traffic could be real-time or non-real time. In general, real-time traffic has a higher priority than non-real time traffic. We basically have to do the handoff management in an efficient fashion for such a system with four priorities. In other words, the handoff process will be service dependent.

   Channel reservation

   One design consideration in this system would be the reservation of channels. We can give priority reservation to traffic with high priority so that a fixed number of channels are always reserved for such high priority traffic requests. We would have queues for all the priority level traffic and the particular priority traffic request would wait in its assigned queue. The number of channels reserved could depend on the actual traffic priorities assigned.

   Therefore, we could reserve channels for each of the four priorities. We could also use a preemptive scheme in which a higher priority request would have the right to preempt the execution of a lower priority request. The preempted low priority request would then resume execution at a later stage. The higher priority request would preempt only if it finds no channel available. The preempted request would also have to be stored in a queue so that it can be executed later.

   Additionally, we could also consider the transmission delay. Ideally, we would like to minimize the delay for the traffic request that has the highest priority as compared to a request with a lower priority. Hence, high priority requests need to be executed as fast as possible in such a network.

5. What are the pros and cons of employing satellite communication for multicasting? Explain.

   [Solution]

   The pros of employing satellite communication for multicasting are:

   (a) Providing uniform accessibility is easy via satellite, because the signals sent via the satellite may be received by any receiver within the coverage area of the satellite (known as the satellite "footprint"). Typically, this allows the same signal to be received across a whole continent, if transmitted by satellites covering the whole surface of the earth.

(b) A satellite solution also minimizes the number of multicast-capable routers required in the core network, which will simplify initial deployment and operations/maintenance.

(c) No bottlenecks from low speed connections and no waiting for busy servers.

The cons are:

(a) Difficulties in providing the multicast service across a wide geographical area.

(b) Difficulties in upgrading existing deployed network routers.

(c) The frequency bands normally used for satellite data services have become very congested and there is not sufficient capacity for a major new service. To achieve wide area coverage will require a new generation of satellites operating in the Extra High Frequency band.

(d) High power operation too costly.

6. Can you do multicasting in a MANET? If yes, how and if no, why not? Explain clearly.

[Solution]

A MANET consists of a dynamic collection of nodes with sometimes changing topologies that are composed of low bandwidth wireless links.

Since each node has limited transmission range, not all packets may reach their destinations. As the nodes are battery powered, the multicast protocols also need to limit the amount of control information that is passed through them.

Multicast protocols used in static networks do not perform well in wireless ad-hoc networks because multicast tree structures are fragile and must be reconfigured as topology changes. The frequent exchange of routing vectors or link state tables, triggered by continuous connectivity changes, yields excessive channel and processing overhead. Hence, the tree structures used in static networks must be modified or a different topology between group members need to be deployed for efficient multicasting in wireless mobile ad hoc networks.

Multicast can improve the efficiency of the wireless link when sending multiple copies of messages by exploiting the broadcast property of wireless transmission. Hence, we can do multicasting in a wireless medium but a lot of challenges need to be addressed.

7. If preemption is allowed in Problem 15.4, how would you do the scheduling and what are the relative advantages and disadvantages?

[Solution]

In a preemptive scheme, a traffic request with a higher priority can preempt a request with a lower priority. The execution of the lower priority

request is halted and the higher priority request is allowed to execute if it finds no channel available. Queues may be present for both types of requests. The lower priority request resumes execution at a later time.

Advantages:

(a) Probability of packet loss is minimized for real-time transmission as such a request can be transferred from the queue of the current BS to that of another.

(b) High priority requests that otherwise not be allowed to execute are entertained.

(c) Forced termination probability of real-time requests is decreased.

Disadvantages:

(a) Tough to determine the level of priority calls that are to be preempted. Need to define a fixed level of priority for preemption.

(b) Need to reserve queues for the requests that are preempted so that they can resume execution later.

8. If you are given a choice of using either reactive or proactive routing protocol, which one would you prefer for Problem 15.7 with ad hoc network and why?

[Solution]

For the above problem, a proactive protocol would be preferred because you know the path for the high priority call that causes preemption. Such knowledge helps in doing preemption of existing call, if a new path for a higher priority call, is feasible to make at a given time. Otherwise, you do preemption of an existing call without being successful in setting up a new call.

9. Using your favorite MANET simulator, create an arbitrary MANET and find disjoint paths between an arbitrary source-destination pair. Assume all needed parameters.

[Solution]

To be done by student.

10. Compare the time requirements in Problem 15.9, if

(a) The number of MSs is doubled.

(b) The radio coverage area is doubled.

(c) The node connectivity is doubled.

(d) Both parts (a) and (b) are done.

[Solution]

To be done by student.

11. For what applications, are direct-diffusion based flat architectures or cluster-based sensor networks useful? Explain in detail.

    [Solution]

    Applications for a cluster based sensor network:

    (a) Security system consisting of an ad hoc network of video and acoustic sensors.

    (b) Wireless parking lot sensor networks to determine which spots are occupied and which spots are free.

    (c) Monitoring room temperature and turning on the A/C only if the temperature crosses a threshold value.

    Applications for flat topology sensor networks:

    (a) Military sensor networks to detect enemy movements, the presence of hazardous material (such as poison gases or radiation), explosions, etc.

    (b) Environmental sensor networks (such as in plains or deserts or on mountains or ocean surfaces) to detect and monitor environmental changes.

    (c) Wireless traffic sensor networks to monitor vehicle traffic on a highway or in a congested part of a city.

    (d) Wireless surveillance sensor networks for providing security in a shopping mall, parking garage, or other facility.

12. What are the uses of different types of queries in sensor networks? Explain clearly.

    [Solution]

    The various types of queries in a sensor network are

    (a) Historical queries (ask about past information, e.g., readings of pressure for the past week.)

    (b) Snapshot queries (query the sensor network at a given point of time, e.g., the pressure reading at a particular time instant).

    (c) Future queries (query a sensor network over a future time interval, e.g., in the next one hour, if the temperature reading exceeds 70, takes appropriate action).

    (d) Long running queries, e.g., those that deal with status over a user defined time period.

13. Using your favorite MANET simulator, create a sensor network. Assuming appropriate parameters, simulate a sensor network with 100 nodes. Find the query propagation time from one end of the network to another end if:

(a) A flat architecture is used?

(b) A cluster architecture is used?

[Solution]

Student to do this.

14. Using your favorite website, find different type of sensors if the idea is to explore the following applications:

(a) Nuclear plant.

(b) Under water project.

(c) Noise level in a campus.

(d) Air pollution over an industrial area.

(e) Maintenance of a large bridge.

(f) Speeding on a freeway.

(g) Industrial discharge to a lake or a river-bed.

(h) Contamination due to an industrial chimney.

(i) Ozone level determination in an area.

(j) Flood-level monitoring.

(k) Rock-falling (snow-mountain falling) in a mountainous area.

(l) Underground earth movement determination.

(m) Movement of ore and manpower in an underground mine.

[Solution]

(a) Nuclear plant

A nuclear plant has numerous built-in sensors to watch temperature, pressure, water level, and other indicators important to safety. The sensors are connected to control and protect systems that adjust or shut down the plant, immediately and automatically, when pre-set safety parameters are approached or breached. In addition to these, some sensors are also fitted for security purposes. Intrusion detection sensors are fitted at all the emergency exits. they annunciate and record in a continuously staffed central alarm station to provide for the monitoring and assessment of alarms and the facility management and response force.

More information is available at the following web sites:

- www.nei.org/index.asp?catnum=2&catid=55
- www.gepower.com/dhtml/reuterstokes/en_us/ sensors/nuclear_ sensors/index.jsp
- www.kinemetrics.com/condor.html

- www.control.com/1026146121/index_html

(b) Under water project

Some sensors used in under water projects are described below:

Hydrophones are underwater acoustic sensors, which most commonly utilize piezoelectric technology. They can be used singly or in arrays that can contain dozens or hundreds of individual units. They are used in marine geological and biological research, undersea mapping and navigation, and various commercial and military applications. Acoustic sensing instruments used sound waves in a wide variety of applications, including distance, proximity, level, nondestructive evaluation, web break detection, counting, and security. Acoustic sensors can also be used in underwater procedures. Hydrophones and arrays, microphones, sound and noise level dosimeters, and ultrasonic and underwater transducers are included in this family. Underwater acoustic transducers contain both transmitters and receivers. They sense reflected sound and use distance and directional data for communication, mapping and navigation. They have an operational range, but are usually designed to operate at their resonance frequency to maximize output power. They are most typically single frequency transmitters, but they may contain multiple transmitters and receivers for different frequencies.

More information is available at the following web sites:

- www.globalspec.com/ProductGlossary/Sensors_Transducers_Detectors/Acoustic_Sensing
- www.watersensors.com/
- www.greatmonitoring.com/
- www.dt.navy.mil/pao/excerpts%20pages/ 2000/rov12_00.html

(c) Acoustic sensors and other microphone sensors can be deployed around the campus to measure the noise level. Along with amplifiers they can act as sound collectors. Microphone sensors AWA14423 and four preamplifiers AWA14602 can be used. Sound level sensor PS-2109 can also be used to measure sound level. Characteristics of PS-2109 are:

i. Three switch-selectable ranges (from 30 dB to 110 dB) provides greater functionality and flexibility

ii. Displays both dBA (matching the sensitivity of the ear) and dBC (responding equally to all frequencies)

iii. Measures both sound level and sound intensity

(d) Air pollution over an industrial area

Some sensors for countering air pollution are as follows:

The air quality sensor, located near the fresh air inlet, serves to reduce the amount of pollution entering the vehicle cabin through

the HVAC system by sending a signal to close the fresh air inlet door/ventilation flap when the vehicle enters a high pollution area. By performing this function, the air quality sensor provides a key health benefit to drivers and occupants of motor vehicles.

* GASMAN II

Manufactured by Nortech GSI Inc., the GASMANII is Crowcon's newest personal single gas monitor. Available to monitor different gases such as H2S, CO, CH4, or O2 the rugged and lightweight GASMANII offers highly visible and audible alarms, data logging capability with Windows compatible PC interface and intrinsic safety for use in hazardous areas.

* CEA Gas Monitors

CEA Series U portable gas monitors use unique, patented sensors that are highly specific, fast responding, poison resistant and are unaffected by moisture or temperature changes. Sensors are available for ammonia, hydrocarbons, freons, ethylene oxide, hydrogen combustibles, sulfur dioxide, hydrogen sulfide, carbon monoxide and others. Ranges are available to detect these gases in the low ppm, high ppm or %LEL levels without sensor damage. Described as compact, durable, and easy to maintain and operate, standard accessories include a leather instrument case, remote sensor wand and padded transportation case. Other features include user adjustable alarms and a built-in battery charger with low battery light.

* UniMax Single-Point Gas Monitor

UniMax, a compact, pocket sized, single gas microprocessor controlled monitor continuously detects and displays gas concentration on a large, easy to read digital display. The UniMax can be configured to monitor oxygen or a wide range of toxic gases including carbon monoxide, hydrogen sulfide or sulfur dioxide, chlorine, and chlorine dioxide. The unit uses state of the art electrochemical, interchangeable, offering easy adaptability and versatility for monitoring a wide variety of areas.

* BC Carbon Dioxide Detector

Designed for immediate response of excessive concentrations of CO2, this detector (manufactured by Bacharach Corp and supplied by Willer Engineering Ltd.) and warning device will provide detection capability for workers in many industries including: agriculture; horticulture, nuclear power plants; the food processing and the beverage industry.

* Air Samplers

MiniVol Portable Air Sampler manufactured by Airmetrics is a portable ambient air sampler for particulate (PM10, PM2.5 and TSP) and/or non-reactive gases (CO, NOx). This instrument was jointly developed by EPA and the Lane Regional Air Pollution Authority LRAPA) to address the need for portable survey sampling.

PAQS Personal Air Sampler, from Levitt Safety is ideal for industrial, hospital and personal hygiene applications. The PAQS can offer long-term air quality measurements. The mean average results obtained over extended period provide more meaningful information. This approach ensures that an air contaminant event is not missed, as would be the case using a simple, single point measurement.

* YES IAQ Monitor

An indoor air quality monitor, YES-206 Falcon from Young Environmental Systems is ideal for walk-through surveys in building and long term data logging with trend analysis. It monitors carbon dioxide, temperature and relative humidity. Using interchangeable sensors, it can be used to monitor gas levels including oxygen, carbon monoxide, sulfur dioxide, hydrogen sulfide, chlorine, nitrogen dioxide, nitric oxide, hydrogen cyanide, ammonia or ethylene oxide. An extra channel can allow for monitoring sensors and analyzers with a linear output.

Additional information is available at

- www.utoledo.edu/~aprg/courses/iap/text/APINSTRU.html
- www.oit.doe.gov/sens_cont/pdfs/ factsheets/nrc2_fact.pdf
- www.sensorsmag.com/resources/ businessdigest/sbd0201.shtml
- www.buscom.com/waste/E049U.html

(e) Maintenance of a large bridge

The hazards of ice, wind and low visibility are compounded on bridges. For this reason, Vaisala delivers a package of products and services to help road authorities to manage the special hazards of bad weather on bridges. These include a specially designed bridge-deck sensor that measures bridge surface state, temperature and depression of freezing point. There are sensors that process standard parameters (average, gust, direction, speed) and trigger alarms when they are exceeded. Vaisala's present weather sensor, the PWD11, provides both roadside visibility measurement and precipitation classification (e.g. frozen/non-frozen). The IceCast system can also be brought into play to monitor bridge data in real-time, archiving it for future reference.

Options include our Thermal Mapping service, which is especially useful in finding locations for bridge sensors. Vaisala NowCasting offers a fully automated, 3-hour forecast of bridge surface conditions (temperature and state) so that operators can deal with icing hazards in good time, before they become serious. Sensors to monitor the following parameters may also be needed

- Air temperature
- Relative humidity
- Precipitation
- Moisture on deck surface

- Deck surface temperature
- Chemical presence on deck surface

More information is available on

- matrix.vtrc.virginia.edu/DATA/NOVA766/
- www.jhuapl.edu/newsEvents/highlight/ aplNews/highway.htm
- www.hygrometrix.com/Sensors%205-00.pdf
- mfeng.eng.uci.edu/feng's%20Group/optical/OPTICAL%20FIBER%20SENSORS.html

(f) Speeding on a freeway

Some sensors for checking speeding on a highway are:

Passive Infrared Detectors

Passive infrared detectors can supply vehicle passage and presence data, but not speed. They use an energy sensitive photon detector located at the optical focal plane to measure the infrared energy emitted by objects in the detector's field of view. Passive detectors do not transmit energy of their own. When a vehicle enters the detection zone, it produces a change in the energy normally measured from the road surface in the absence of a vehicle. The change in energy is proportional to the absolute temperature of the vehicle and the emissivity of the vehicle's metal surface (emissivity is equal to the ratio of the energy actually emitted by a material to the energy emitted by a perfect radiator of energy at the same temperature).

Active Infrared Detectors

Active infrared detectors function similarly to microwave radar detectors. The most prevalent types use a laser diode to transmit energy in the near infrared spectrum (approximately 0.9 micrometer wavelength), a portion of which is reflected back into the receiver of the detector from a vehicle in its field of view. Laser radars can supply vehicle passage, presence, and speed information. Speed is measured by noting the time it takes a vehicle to cross two infrared beams that are scanned across the road surface a known distance apart. Some laser radar models also have the ability to classify vehicles by measuring and identifying their profiles. Other types of active infrared detectors use light emitting diodes (LEDs) as the signal source.

Ultrasonic Detectors

Ultrasonic vehicle detectors can be designed to receive range and Doppler speed data. However, the most prevalent and low-cost ultrasonic detectors are those that measure range to provide vehicle passage and presence data only. The ultrasonic Doppler detector that also measures vehicle speed is an order of magnitude more expensive than the presence detector. Ultrasonic detectors transmit sound at 25 kHz to 50 kHz (depending on the manufacturer). These frequencies lie above the audible region. A portion of the transmitted

energy is reflected from the road or vehicle surface into the receiver portion of the instrument and is processed to give vehicle passage and presence. A typical ultrasonic presence detector transmits ultrasonic energy in the form of pulses. The measurement of the round-trip time it takes for the pulse to leave the detector, bounce off a surface, and return to the detector is proportional to the range from the detector to the surface. A detection gate is set to identify the range to the road surface and inhibit a detection signal from the road itself. When a vehicle enters the field of view, the range from the detector to the top of the vehicle is sensed, and being less than the range from the detector to the road, causes the detector to produce a vehicle detection signal.

Passive Acoustic Detectors

Vehicular traffic produces acoustic energy or audible sound from a variety of sources within the vehicle and from the interaction of the vehicle's tires with the road surface. Arrays of acoustic microphones are used to pickup these sounds from a focused area within a lane on a roadway. When a vehicle passes through the detection zone, the signal-processing algorithm detects an increase in sound energy and a vehicle presence signal is generated. When the vehicle leaves the detection zone, the sound energy decreases below the detection threshold and the vehicle presence signal is terminated.

Video Image Processors

Video image processors (VIPs) identify vehicles and their associated traffic flow parameters by analyzing imagery supplied by video cameras. Using personal computer-type architectures, the images are digitized and then passed through a series of algorithms that identify changes in the image background, that is changes in the quiescent contrast level between the pixels (picture elements) that make up the image. Information about vehicle passage, presence, speed, length, and lane change movement can be supplied, depending upon the type of image processing technique used. Some VIPs insert vehicle detection zones into the field of view and detect changes in pixel contrast in these areas caused by vehicle passage; others track vehicles through the entire field of view by identifying and following the path produced by the changes in pixel contrast. Artifacts such light reflected from wet pavement and shadows have historically affected the performance of VIPs. Since the VIP processes an image that can encompass several lanes or images from multiple cameras, it is often a cost-effective approach for monitoring traffic flow in multiple lanes and in multiple zones within a lane.

Additional information available at

- www.itsonline.com/detect_pt1.html
- www.transport.gov.za/projects/arrive/msspeed.html

- paleale.eecs.berkeley.edu/~varaiya/papers_ps.dir/PeMSTutorial.pdf

(g) Industrial discharge to a lake

Some typical sensors that monitor this application are as follows:

There are single parameter sensors to measure pressure/level, pH, conductivity/salinity, ORP/redox, turbidity, dissolved oxygen and temperature. They are suitable for use with control systems or as stand-alone units with built-in datalogging capabilities. The multi-parameter range of equipment provides the option of combining required parameters into one compact unit, suitable for a variety of demanding applications. Sensors with a built-in logger can store other information such as rainfall or trigger sampling equipment to collect a water sample for further analysis. These sensors can also be configured with modem options for remote data collection.

There are also pressure sensors that can be used in many different projects. Designed for a rugged environment, the PS100 is suitable for use in monitoring sewer wet wells, while the PS310 can be used in applications from borehole monitoring to rising mains studies. Greenspan also supply re-rangeable level sensors that can be used in one location, then re-ranged for use in another project. With an outer diameter of only 22 mm, the PS700 is ideal for measuring level in small borehole applications. The soon-to-be-released PS2100 is the ideal pressure/temperature sensor for small boreholes where logarithmic sampling is required.

The Greenspan AQUALAB is an automatic analysis system sensor, based on technology developed by the CSIRO and other research institutions. Designed to provide water quality analysis in remote locations and communicate laboratory comparable data in near real time, Greenspan analyzers can provide a total solution for online analysis. The analyzers are designed to meet the analysis requirements of the user and the harsh environment of remote locations. AQUALAB offers multiple physical and chemical parameters housed in an environment controlled enclosure.

More information is available on the following web sites:

- www.water-technology.net/contractors/monitoring/greenspan/
- www.lakeshore.com/magnetics/magnetic_mainpage.html
- www.state.fl.us/nwfwmd/pubs/apal_stormwater_inputs/4wq.pdf
- ww.des.state.nh.us/factsheets/ws/ws-26-7.htm

(h) Contamination due to an industrial chimney

Information is available at the following sites:

- www.hoentzsch.com/.../Exhaust_gas_measurement_toxic/hauptteil_exhaust_gas_measurement_toxic.htm

- www.sprl.umich.edu/GCL/notes2/urban_indust_I.html

(i) Ozone level determination in an area

The following lines describes in brief some of the sensors used for measuring the ozone level:

The A-21ZX portable ozone sensors provide a reliable and inexpensive way of checking generators, valves, piping and general environments for detecting leaks and for estimating concentration levels. It can be used as permanent indoors when concentrations average below 0.1 ppm or outdoors for studies in moderate temperature conditions. The range is $0-10$ ppm in 0.01 ppm increments. The internal battery lasts 8 hours and recharges overnight.

The EZ-1X sensor which is ideal for checking concentration levels near small generators. It is ideal for light commercial applications such as bars and restaurants, hotels, photocopy centers, water bottlers, fumigation, research projects, light manufacturing, swimming pools, and residential wherever exposure or gas leaks in the environment is possible.

The model C-30ZX is for permanent monitoring equipment in water treatment plants, water bottlers, pulp bleaching mills, generators, photocopier centers, HVAC and indoor air quality systems, research labs, and industrial processes such as plastic film treatment. It has an audio alarm, outputs for external data logging and lower power relay contacts for external equipment control. The range is $0 - 0.14$ ppm.

The C-12 sensor which is for checking indoor ambient air quality of solvent vapors in the workplace. This low cost VOC sensor with P-20 AC adapter is the same as the C-21 but with visual display only and replaces the C-11. Range is $50 - 100$ ppm for most solvent based volatile organic compounds.

The C-21 sensor which is for checking indoor ambient air quality of solvent vapors in the workplace. Typical applications are for auto repair facilities, dry cleaners, woodworkers, electronics assembly areas, chemical labs, printers, and light manufacturing where solvents are used. The instrument has an audio alarm, relay contacts, and data logger output. The C-21 may be run permanently from the AC mains or from its internal rechargeable battery, which lasts for 2 hours. Range $50 - 100$ ppm.

More information is available at:

- www.appliedozone.net/sensors.html
- npoesslib.ipo.noaa.gov/techlib/doc155/doc155.pdf
- www.ozoneapplications.com/ecosensors.htm
- www.powersourcing.com/se/ozonesensors.htm

(j) Flood level monitoring

Some of the sensors used in flood monitoring are:

LISS-I (Linear Imaging self Scanner) is a payload sensor for the IRS-1A satellite. This camera operates in four spectral bands. It operates in a push-broom scanning mode using a CCD array. Each band used 2 CCD's which were staggered in the focal plane. It is also used in IRS-1B. It uses 7 bit quantization, and has a swath of 148 kms. Images of LISS-I are extensively used in flood monitoring.

In addition SAR (Synthetic Aperture Radar Sensors) are very popular in flood monitoring. Synthetic Aperture Radar (SAR) image data provide information different from that of optical sensors operating in the visible and infrared regions of the electromagnetic spectrum. SAR data consist of high-resolution reflected returns of radar-frequency energy from terrain that has been illuminated by a directed beam of pulses generated by the sensor. The radar returns from the terrain are mainly determined by the physical characteristics of the surface features (such as surface roughness, geometric structure, and orientation), the electrical characteristics (dielectric constant, moisture content, and conductivity), and the radar frequency of the sensor. By supplying its own source of illumination, the SAR sensor can acquire data day or night without regard to cloud cover.

Some other sensors that are deployed for flood monitoring are NOAA Polar Orbiter-hosted AVHRR, NASA's Landsat 7 ETM, and Radarsat.

More information available at:

- www.dartmouth.edu/artsci/geog/floods/comparison.html
- webben.nve.no/hydrologi/bre/remote/ewra97.html
- www.ccrs.nrcan.gc.ca/ccrs/eduref/ tutorial/chap5/c5p13e.html
- az.water.usgs.gov/floodrpt.html

(k) Rock/Snow falling from the mountains

Some sites that contain the relevant information are

- www.sensorsmag.com/articles/0302/14/main.shtml
- www.sicop.net/ANNALS-PAPER%20TOTAL .pdf
- www.vision.ee.ethz.ch/projects/Saralp/overview.html

(l) Underground earth movement determination

Some relevant sites are

- hpwren.ucsd.edu/news/010124.html
- www.netl.doe.gov/publications/proceedings/01/ carbon_seq/p37.pdf
- www.millerchitty.com/newpage11.htm
- www.engineer.ucla.edu/stories/qknet.htm

15. Use your favorite search engine to find out what is meant by the "self-organizing property of sensor networks"?

    [Solution]

    Self-organizing sensor networks may be built from sensor nodes and may spontaneously create impromptu network, assemble the network themselves, dynamically adapt to device failure and degradation, manage movement of sensor nodes, and react to changes in task and network requirements. Self-organizing sensor networks can be built using reconfigurable smart sensor nodes that enables sensor devices to be self-aware, self-reconfigurable and autonomous. The main benefits of these features are:

    - To provide capabilities for sensor network nodes used in tactical and surveillance applications for forming impromptu network, deploying sensors incrementally, and to assemble themselves without any central administration.
    - To provide capabilities for sensor networks to adapt dynamically to device failure and degradation and changes in task and network requirements.
    - To change network topologies by switching between sensors in sleep mode and work mode, thus increasing the life of the whole network due to reduced overall power usage.
    - To integrate various network and system services provided by mixed types of sensor nodes and embedded defense applications.

    Information can obtained from:

    - www.eng.auburn.edu/users/lim/sensit/page2.html

    More information available at:

    - http://dtsn.darpa.mil/ixo/psum2001/K286-0.html, and also at
    - www.home.cs.utwente.nl/~havinga/sensor.html

16. You can envision potential use of wireless technology in having robots with decentralized decision making capability. Can you think of at least five different applications? What are the limitations and how can you approach to address them? Explain.

    [Solution]

    Some applications of robots in wireless networks are:

    (a) Using robots to lay down optical fibre cables throughout the city. Robot works at a speed of 800 meters per day.

    (b) Sending robots to outer space to collect useful space data. Extreme atmospheric conditions that prevent human presence.

(c) Using robots for the mapping of hostile terrain.

(d) Using robots to perform jobs in various industries.

(e) Forming a sensor network with robots and monitoring the environmental conditions.

(a) Installing cameras and sensors in the side mirrors to alert the driver of blind spots.

(b) Sensors to show what is exactly behind the vehicle to avoid collision.

(c) A camera that projects night vision images on a screen in the front panel.

(d) Sensors that measure the location of the driver's eyes, then adjust the seat, pedals, console and steering wheel accordingly.

(e) Sensors on the front of your car detect another vehicle pulling in too closely in front of you and automatically adjust the cruise control speed downward.

(f) A wireless vehicle-to-vehicle warning system under development allows drivers to alert each other of road conditions up to a mile away.

(g) Sensors and instruments are used to measure road conditions and environmental factors. This information is fed to decision-making software that will not only alert the driver to hazards in the vehicle's forward path, but also adjust the car's adaptive cruise control to slow down the vehicle.

(h) A heartbeat sensor that warns if someone is hiding in or left behind in the car.

(i) An array of sensors that recognize who is in a seat if a small child, for example, the airbags are adjusted accordingly.

(j) Sensors detect when the driver falls asleep and wake him or her up with alarms. Or, the car does all the driving.

17. Can you think of ten important parameters that ought to be sensed in a futuristic automobile? What type of sensors do you need to monitor them constantly?

[Solution]

Tire pressure, engine speed, road friction, safe turn angle, exhaust system, oil level ganges, belt condition, battery charging, thermostect, fuel pump, air intake, air and oil filters, cooling system, vibrations, etc.

18. In Problem 15.17, can you comment on the possible use of:

(a) Ad hoc network.

(b) Sensor network.

(c) Bluetooth devices.

(d) HomeRF.

(e) 802.11 enabled devices.

(f) WiMax

[Solution]

(a) There is a possible use of ad hoc networks, especially when vehicle in a group, and confined to a region. Ad hoc can be used as personal area network.

(b) There would be a possible use of sensor networks in the above application as various kinds of sensors will operate and form a network. The user would send queries to the network and then take the appropriate action. For example, if there is a grocery cart just behind the automobile, the driver would remove the cart first in order to avoid colliding with it.

(c) There is an immense scope of Bluetooth devices. For example,on approaching an amusement park, the map would be displayed in the car in addition to the daily visitor schedule. Or a speakerphone could be installed in the car. This could be used to receive messages. The driver could also be reminded of his daily schedule when he/she gets into the car in the morning.

(d) We could have voice and data transfer between the various devices in the car. For example,if there is internet access in the car, then one can download data from the net onto one's palm pilot. Moreover,we can use HomeRF technology that will wirelessly link a computer with home and car stereos, allowing all three to share music files. Therefore, the driver can choose the programs he/she wants to hear in advance. The user can also be warned about impending bad weather if the car is connected to the home wireless network.

(e) This can be used to create network between vehicles, or between devices installed in the vehicles.

(f) The IEEE 802.16e WiMAX (Worldwide Interoperability for Microwave Access) mobile technology provides high capacity wireless broadband coverage and services of upto 30 miles from a central tower. Automobiles have large space and battery power to support both cellphone networks and WLAN networks like WiMAX in the same vehicle. WiMAX will provide enriched multimedia experience to mobile users like allowing users to IM or check stock quotes while riding in a car. Any WiMAX enabled device employs the IEEE 802.16 upper-layer MAC, scheduler, drivers, protocol stacks, and user application software. By employing WiMAX, high speed transactions with increased QoS and efficiency is possible occur in futuristic automobiles lie a high performance bus.

19. In an amusement park, wireless devices are used to post the queue length and wait time for each of the rides. Can you think of an infrastructure that could enable patrons to do online interaction? Assume appropriate requirements and a potential solution.

    [Solution]

    The network would be kind of a sensor network.

    - The nodes would be represented by the visitors.
    - These nodes would move around the network in an undefined ad hoc manner.
    - There would be a centralized authority that would maintain a kind of database such as average queue length for each ride, average wait time for each ride, total number of rides etc.
    - The nodes would submit queries to the network. They could be in the form of questions like "What is the wait time for such and such queue?" or "How many people are in a particular queue?". Based on the response got from the network,the users would take appropriate action. For example, if the queue length is too long, they could choose another ride.

20. For Problem 15.19, you do need some software support. Can you think and outline, how you would go about doing this? Explain.

    [Solution]

    Yes, software support would definitely be needed in this system.

    (a) The nodes in the network need some kind of software to pose queries to the network and also to see the query replies. It could be in the form of a Java based user interface or it could be using SQL.

    (b) In addition, the user interface would also allow the user to obtain the status of the other users in the network for example their current location. This would help them in making their next decision.

    (c) Additionally, the system manager also needs to maintain a kind of database for all the rides in the network. There would be functions to perform specific tasks. Certain parameters such as the average wait time per ride, the queue length could be stored in this database.

21. For Problem 15.19, you do need some forms of authentication and encryption. What are the most important parameters you would be concerned with? Explain clearly.

    [Solution]

    Some security issues also need to be addressed for such a system. First of all, proper authentication of the users needs to be done in order to avoid unauthorized usage. If this is not done, then users from outside the

network can get into the network and cause considerable damage. Hence we need to have a scheme to authenticate each user in the system. One way could be to give passwords to each user so that each time the user queries the network in its wireless device,the network would ask the user to punch in the password.

Moreover, public/private key cryptography could be used to achieve increased security.

(a) One option would be to use the same key for both encryption and decryption purposes. Therefore, as long as the key is known only to the sender and the receiver, this scheme works perfectly. But if someone else gets hold of the key, then there is a threat to security.

(b) In a more elegant scheme, we could have a public key that is known to all the nodes (even the intruder nodes). The message to be sent would be encrypted using a public key. But in order to decrypt the message, the receiver would need a private key. In this way the intruder node would not be able to access the message as it does not know the private key.

22. In a center for mentally challenged people, a decision was made to monitor each individual person using wireless devices. Can you comment on the relative advantages and disadvantages of such an infrastructure?

[Solution]

Conceivable wireless system advantages

(a) The advantage of using checklists on computers is that they can be done individually. The information on the list is specific to a particular person. The checklist forces the user to think through factors that otherwise might be considered uninteresting. This relieves the memory load.

(b) These systems demand that one states concepts and methods clearly. You have to be specify what you mean by different expressions. This results in all who work in the residence having a common base to start from.

(c) By expressing thoughts in plain, clear language, they are easy for all to understand and use as topics for discussion.

(d) The system is educational. New employees can benefit from the knowledge that an experienced care provider or the relatives have accumulated over a long period of time.

(e) Such system can continually be improved through the addition of new information. We can gain from the knowledge of others and do not have to start all over.

(f) Important information is collected in one place. This is much easier than having to look through different files or talk to different people.

Conceivable wireless system disadvantages

(a) The gathering of so much information about a person in such an accessible format can be seen as an invasion of privacy.

(b) Instead of using the program as a support and intellectual reinforcer, the staff instead interpret the system's statements as truth.

(c) That the system gives such elementary decision-making suggestions that it is considered useless.

(d) That it is perceived as being so difficult to add new information that it cannot be depended on to be up-to-date.

(e) The system forces one to formalize knowledge that it is really impossible to formalize. Fewer contacts with specialists who have approaches that differ from the expert system's.

23. In Problem 15.22, what kind of personal information would you like to maintain in the database and why are they important? Explain clearly.

[Solution]

The information specific to a patient that would need to be added into the system would include:

(a) The names of the patients and their deficiencies.

(b) Their eating habits.

(c) Their violent behaviors.

(d) Their list of friends/relatives.

(e) Patient vital statistics.

(f) List of allergies, if any.

(g) Their treatment methodologies.

24. In Problem 15.22, what are the security concerns you would have and how can you address them? Explain with suitable examples.

[Solution]

The security issues involved in this system would be:

(a) We would not want an intruder to hack the computer system and gain access to all the patient records. Hence, the data should not be accessible to anyone outside the system. It may be the case that the intruder is not altering the data in any way. Therefore, the prevention of such intrusions is desired as opposed to their detections.

(b) In case, the intruder alters the system data the problem is more grave. In this scenario, we need to take preventive action depending on the type of security flaw that occurs. For example, if use encryption, then it will make the system more secure.

(c) There will be a need to authenticate the system user to ensure that he/she is not an intruder. Every member can be assigned a password which can either be entered into a computer or can be punched in the form of a code to gain access of the system resources.

(d) Smart sensors/Surveillance cameras can be employed to detect any suspicious behavior.

25. Is it desirable to assign priority to traffic in a MANET? Explain.

[Solution]

Yes, it is definitely desirable to prioritize traffic in a MANET. The control messages such as route request/route repair messages should be assigned a higher priority as opposed to data transfer. That is because it is only after we find a route/repair a broken route that we can send data on that route. For example, we may stop a file transfer on a route if we discover that a different route has been broken. The file transfer can be resumed later.

26. For Problem 15.4, can you use normal voltage level for VLSI devices in handling high priority traffic, while a lower voltage level for low priority traffic? Explain clearly.

[Solution]

Yes, voltage scaling can be used for traffic of different priorities. In a wireless network,we have a limited battery power available. A higher supply voltage means more power. Therefore, if we are given a high priority traffic and a low priority traffic, then it would make sense to use a high (or normal) voltage for the higher priority traffic. Likewise, the lower priority traffic could be made to operate on a lower voltage and it would consume lesses power than it would otherwise consume. This results in some power saving.

27. From your favorite website, find the differences between MIMO and smart antennas? What are their relative advantages? Explain clearly.

[Solution]

MIMO	Smart Antenna
1 In MIMO, signals on the transmit antennas on one end and that of the receive antennas on the other end are combined to improve the quality (Bit Error Rate) or the data rate (Bit/Sec) of communication.	1. Smart Antenna uses standard signals and multiple transmit and/or multiple receive antennas.
2. For a complete characterization of the channel, in MIMO double-directional channel measurements and models are used by taking into account directional information at both base station and mobile station.	2. It needs channel models that include the directional nature of the channel.
3. MIMO eliminates the adverse effects of multipath propagation to increase user's data rate.	3. Smart Antenna does not eliminate fully the adverse effects of multipath propagation.
4. In MIMO, multiple radios can be used on the same channel.	4. In Smart Antenna, multiple radios cannot be used on the same channel.

MIMO employs spatial multiplexing which helps reducing interference, extending range, increasing data rates, and improving quality. Thus it can improve the overall user experience and system capacity in any wireless system. It provides extremely high spectral efficiencies in multipath channels by simultaneously transmitting multiple independent data streams in the same channel unlike common Smart Antenna which cannot transmit independent data streams in the same channel. Thus MIMO provides higher peak speed compared Smart Antenna. However, Smart Antenna provides better coverage than MIMO antenna.