PERFORMANCE AND TRAFFIC MANAGEMENT

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BACKGROUND

1. Performance modeling and evaluation should consider new metrics for WSNs, such as system lifetime and energy effciency, and the introduction of new traffic attributes.
2. Sensor nodes have resource constraints: limited energy, limited communication and computational capabilities, and limited memory.
3. A sensor node may belong in one of four groups:
   - a specialized sensing platform such as Spec, which is small in size and memory, and has a narrow communication bandwidth and short radio distance.
   - a generic sensing platform such as the Bekeley mote, which is designed using off-the-shelf components and has a bandwidth of 100 kbps or so and more memory than Spec.
   - a highbandwidth sensing device such as iMote, which has a much broader bandwidth than the earlier ones (Bluetooth-based radio) as well as a larger memory.
   - a gateway-like sensor node such as Stargate, which is a gateway to directly connect mote (or iMote)-based devices.

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1. WSNs usually have a multihop physical topology.
2. This topology can result in more efficient routing, but the topology formation is an energy-consuming task and also increases the complexity of sensor nodes.
3. The topology is usually variable and has multiple paths from the source nodes to the sink.
4. The sensor nodes gather data and report to the sink according to the preconfigured rules.
5. This many-to-one traffic how is called convergecast which means many-to-one traffic how from sensor nodes to the sink.
6. The traffic how and specific functional requirements of the sensor deployment can be used to optimize networking protocols.

1. The basic service provided by WNSs is to detect certain events and report them.
2. The data related to the events are usually small, usually just a few bytes and in many cases just a few bits.
3. It may be possible to transmit more than one event in a single data unit if the application reporting frequency allows it.

Design factors for wireless sensor networks

Factor	Options
Node deployment	Random, manual, one-time, iterative
Mobility	Immobile, partly, all; occasional, continuous; active,
Network topology	Single-hop, star, networked stars, tree, graph
Coverage	Sparse, dense, redundant
Connectivity	Connected, intermittent, sporadic
Network size	Hundred, thousand, more
Communications	Laser, infrared, radio-frequency

1. MAC PROTOCOLS
   - MAC protocols affect the efficiency and reliability of hop-by-hop data transmission.
   - MAC protocols result in energy waste in the following ways:
     - wireless channel is shared in a distributed environment , so packet collision cannot be avoided. The collided packets require retransmission and result in energy waste.
     - Most distributed wireless MAC protocols require control messages for data transmission. Control messages consume energy.
     - Overhearing and idle listening can also result in energy waste.
   - MAC protocols for wireless sensor networks emphasize energy efficiency through design of effective and practical approaches to deal with the foregoing problems. For example, S-MAC (designs an adaptive algorithm to let sensor nodes sleep at a certain time)

1. ROUTING PROTOCOLS
   - Data-centric routing is more suitable for WSNs because it can be deployed easily, and due to data aggregation, it saves energy. To conserve energy, most routing protocols for WSNs employ certain technique to minimize energy consumption data-centric routing scheme with three phases in its operation:
     - A sink broadcasts its interest across the network in query messages with a special query semantic at a low rate.
     - All the nodes cache the interest. When a node senses that an event matches the interest, it sends the data relevant to the event to all the interested nodes. Sink will also get the initial data and "reinforce" one of source nodes by resending the interest at a higher rate.
     - After the reinforcement propagation, the source nodes send data directly on the reinforced path.

WSN Design Issues

1. TRANSPORT PROTOCOL
   - The following factors should be considered carefully in the design of transport protocols: a congestion control mechanism and especially, a reliability guarantee
   - Therefore, transport protocols should have mechanisms for loss recovery; to guarantee reliability, mechanisms such as ACK and selective ACK used in the TCP would be helpful
   - The hop-by-hop mechanism can also lower the buffer requirement at the intermediate nodes.
   - Transport control protocols for WSNs should also avoid packet loss as much as possible since packet loss translates to waste of energy

PERFORMANCE MODELING OF WSNs

1. Two important performance metrics, system lifetime and energy efficiency. Both of these metrics relate to energy consumption. In WSNs, new models are required to capture special characteristics of these networks which are different from the traditional networks.
2. Performance metrics:
   - System lifetime: This can be defined in many ways:
     - The duration of time until some node depletes all its energy.
     - the duration of time until the QoS of applications cannot be guaranteed.
     - The duration of time until the network has been disjoined.

PERFORMANCE MODELING OF WSN

- Energy efficiency:
  - Energy efficiency means the number of packets that can be transmitted successfully using a unit of energy.
  - Packet collision at the MAC layer, routing overhead, packet loss, and packet retransmission reduce energy efficiency.
- Reliability:
  - In WSNs, the event reliability is used as a measure to show how reliable the sensed event can be reported to the sink.
  - For applications that can tolerate packet loss, reliability can be defined as the ratio of successfully received packets over the total number of packets transmitted.
- Coverage:
  - Full coverage by a sensor network means the entire space that can be monitored by the sensor nodes.
  - If a sensor node becomes dysfunctional 288 PERFORMANCE AND TRAFFIC MANAGEMENT due to energy depletion, there is a certain amount of that space that can no longer be monitored.
  - The coverage is defined as the ratio of the monitored space to the entire space.

PERFORMANCE MODELING OF WSN

- Connectivity:
  - For multihop WSNs, it is possible that the network becomes disjointed because some nodes become dysfunctional.
  - The connectivity metric can be used to evaluate how well the network is connected and/or how many nodes have been isolated.
- QoS metrics:
  - Some applications in WSNs have real-time properties.
  - These applications may have QoS requirements such as delay, loss ratio, and bandwidth.

1. BASIC MODELS
   - Traffic Model The applications and corresponding traffic characteristics in WSNs are different from those of traditional networks.
   - For example, whereas the widely used applications for Internet include e-mail, Web-based services, the idle transfer protocol, and peer-to-peer services, wireless sensor networks have totally different ones.
   - As a result, traffic and data delivery models are also different.

1. Four models and the related performance aspects:
   - Event-Based Delivery:
     - In this case, sensor nodes monitor the occurrence of events passively and continuously.
     - When an event occurs, the sensor node begins to report the event, and possibly an associated value, to the sink.
     - When delivering event data to the sink, a routing protocol is often triggered in order to ?nd a path to the sink.
     - This routing method is called routing on-demand.
     - An alternative approach is to set up in advance a frequently used path. An adaptive routing protocol may be required to set up a path dynamically in advance if events occur frequently.

- Continuous Delivery:
  - The data collected by the sensors need to be reported regularly, perhaps continuously, or periodically.
  - In this situation, sensor nodes deployed inside the burrows and on the surface measure humidity, pressure, temperature, and ambient light level.
  - Once a minute, sensors report sample values to the sink.
- Query-Based Delivery:
  - Sometimes, the sink may be interested in a specific piece of information that has already been collected in sensor nodes. query messages to sensor nodes to get the up-to-date value for the information.
  - Query messages may also carry a command from the sink to the sensors about the information, reporting frequency and other parameters of interest to the sink.

- Hybrid Delivery:
  - In some WSNs, the types of sensors and the data they sense may be very diverse.

1. Energy Models:
   - The radio communication function of sensor nodes is the most energy-intensive function in the node.
     - The first approach : design a communication scheme that conserves energy inherently for example, turning off the transceiver for a period of time.
     - The second approach : reduce the volume of communications through in-network processing.
   - Model for Communication:
     - Model for Sensing Usually, the least amount of energy is consumed for sensing.
     - Let the sensing range be rs. It can be assumed that the power consumed to perform sensing over a circle with radius rs is proportional to r2 s or r4 s

- Model for Computation:
  - A sensor node usually has a microcontroller or microCPU performing computations.
- Node Model:
  - To conserve energy, a common approach is to let nodes sleep when they have no need to transmit or receive.
- The sensor nodes have two states: active (A) and sleep (S).
  - The length of the active and sleep period are geometrically distributed random variables with a mean value of p and q time slots, respectively.
  - A two-state discrete-time Markov chain (DTMC) model for the next-hop nodes, where the next-hop nodes represent the neighboring nodes relative to the node in mind.
  - The two states defined for the next-hop node are wait (W) andforwarding (F).