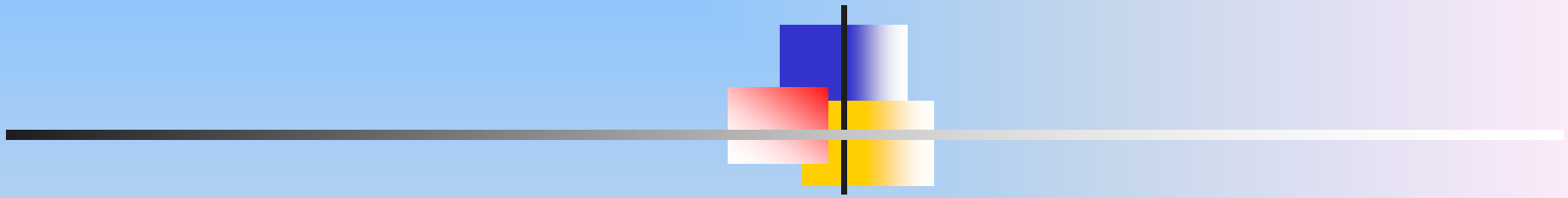
CSE498: Wireless Sensor Network Design



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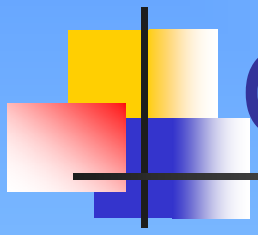
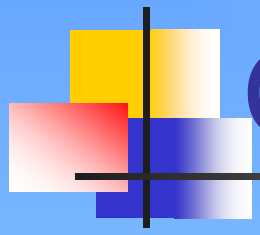


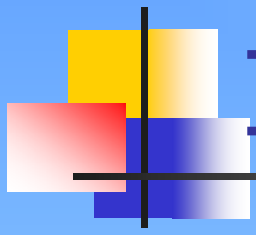
Outline

- Recap: Introduction to wireless sensor networks
- General network design
- Summary and homework



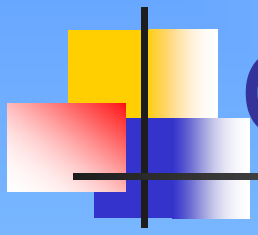
Group Project

- Will be decided after the individual projects are decided
- Hands-on components
  - Using ns-2 (or other popular network simulators) to simulate wireless sensor networks
  - Using nesC to program Crossbow wireless sensors



In-class Q&A

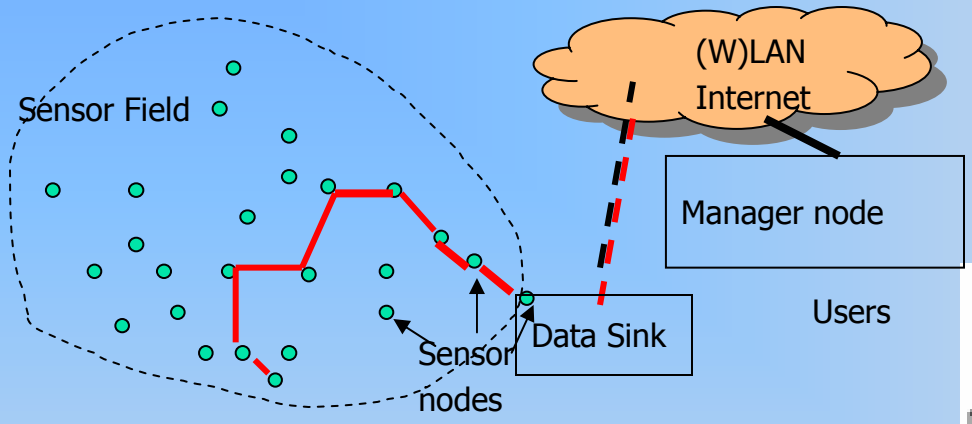
- When a question is raised
  - A random-number generator
  - 1 point if you answered it with justifications
    - At least 5 chances in total for each students in the semester
    - The percentage of the correctness of your answers will be considered when your final grade is marginal
- Two major purposes
  - Group-based discussion
  - More efficient in-class learning: learning pattern

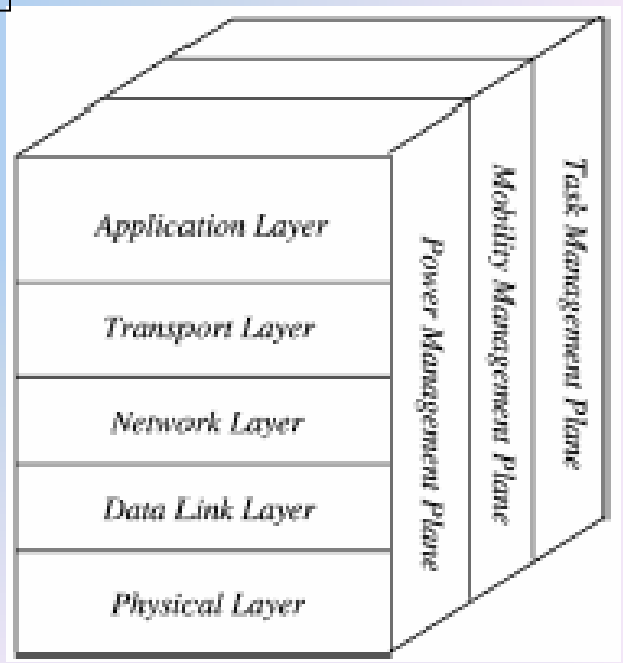


Grading

- In-class Q&A (5%)
- Homework: 10%
- Individual project (30%)
  - Presentation: 10%
  - A survey paper: 20%
- Take-home exam (15%)
- Group Project (30%)
  - Presentation: 10%
  - Demo: 10%
  - Report: 20%

WSN Communication Architecture





- Energy constraint vs. long network lifetime

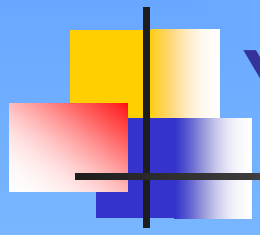
Network Layer Schemes

- SMECN
  - Creates a subgraph of the sensor network that contains the ME path
- Flooding
  - Broadcasts data to all neighbor nodes regardless if they receive it or not
- Gossiping
  - Sends data to one randomly selected neighbor
- SPIN
  - Sends data to sensor nodes only if they are interested (ADV, REQ, DATA)
- SAR
  - Creates multiple trees where the root of each tree is one hop neighbor from the sink; select a tree for data to be routed back to the sink
- LEACH
  - Forms clusters to minimize energy dissipation
  - Scalability vs. robustness
- Directed diffusion
  - Sets up gradients for data to flow from source to sink during interest dissemination

Data Link Layer

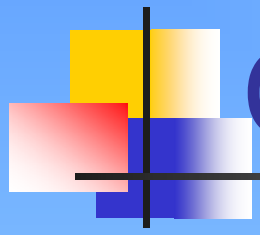
Category	Resource sharing mode	Application domain	Disadvantages
Dedicated assignment or fixed allocation	Pre-determined fixed allocation	Appropriate for continuous traffic and provides bounded delay	Inefficient for bursty traffic
Demand based	According to demand or user request	Useful for variable rate and multimedia traffic	Additional overhead and delay due to reservation process
Random access or contention based	Channel contention when transmission packets are available	Suitable for bursty traffic	Inefficient for delay-sensitive traffic

- Examples in each category



You should now be able to …

- Describe what a wireless sensor network is;
- List major application domains of wireless sensor networks;
- Discuss the WSN communication architecture and its design factors



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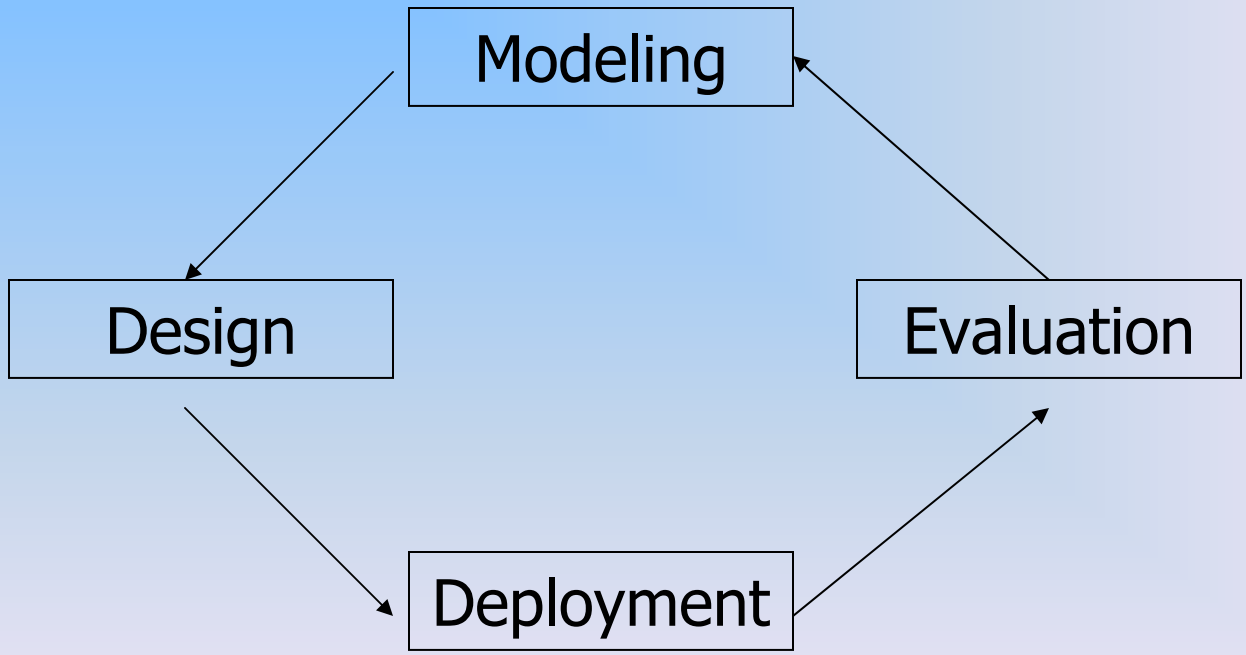
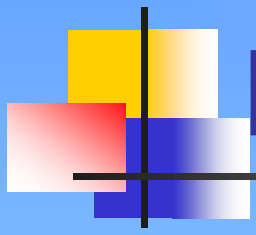
Network Design Cycle



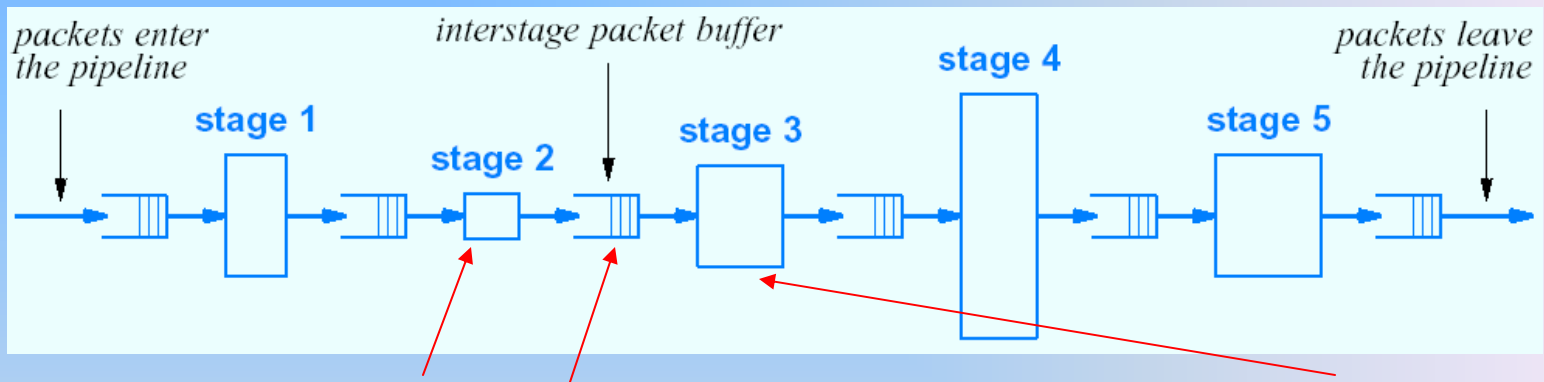


Modeling

- Various levels of modeling
  - Node-level
    - Process models
  - LAN-level
    - Resource sharing models
  - Network-wide level
    - Switching models

Node-level Modeling

- Pipeline model: a multi-stage switch or ?

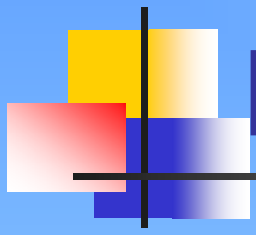


- A producer block that sends bytes to a consumer block via a FIFO
  - FIFO suspends the producer or consumer as necessary
- Problem
  - Given processing speeds of stage 2 and stage 3, find out the FIFO size to achieve a certain average overall processing speed or throughput of the stage2 and stage 3

An Example of Node-level Modeling

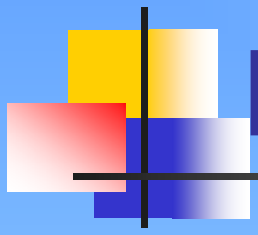
Network Design Cycle
- Modeling
- Design
- Deployment
- Performance Evaluation

- The consumer block (stage 3) will consume exactly one byte every 100 ns unless it is suspended waiting for input from the FIFO.
- The producer block (stage 2) produces between 1 and 19 bytes every 1000 ns unless it is suspended waiting to write to the FIFO.
- Determine the size of the FIFO needed to sustain a throughput of 1 byte per 110ns or 110 ns per byte



LAN-level Modeling

- Resource sharing models
  - Time-shared
  - Medium-shared
  - …
- Performance measures
  - Waiting time
  - Blocking probability
  - Fair resource utilization



LAN-level Modeling

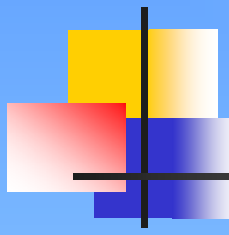
- What are the factors affecting the performance?
  - The number of users
  - The pattern of usage
  - The amount of resources
- Queuing theory

Network-wide Level Modeling

- Circuit switching networks
- Packet switching network
- Performance measures
  - E2E delay
  - Throughput
  - Utilization
  - Blocking probability
  - Losses

Network-wide Level Modeling

- What are the factors affecting the performance?
  - Topology
  - Routing mechanisms
  - Traffic patterns
    - QoS requirements
  - Network resources



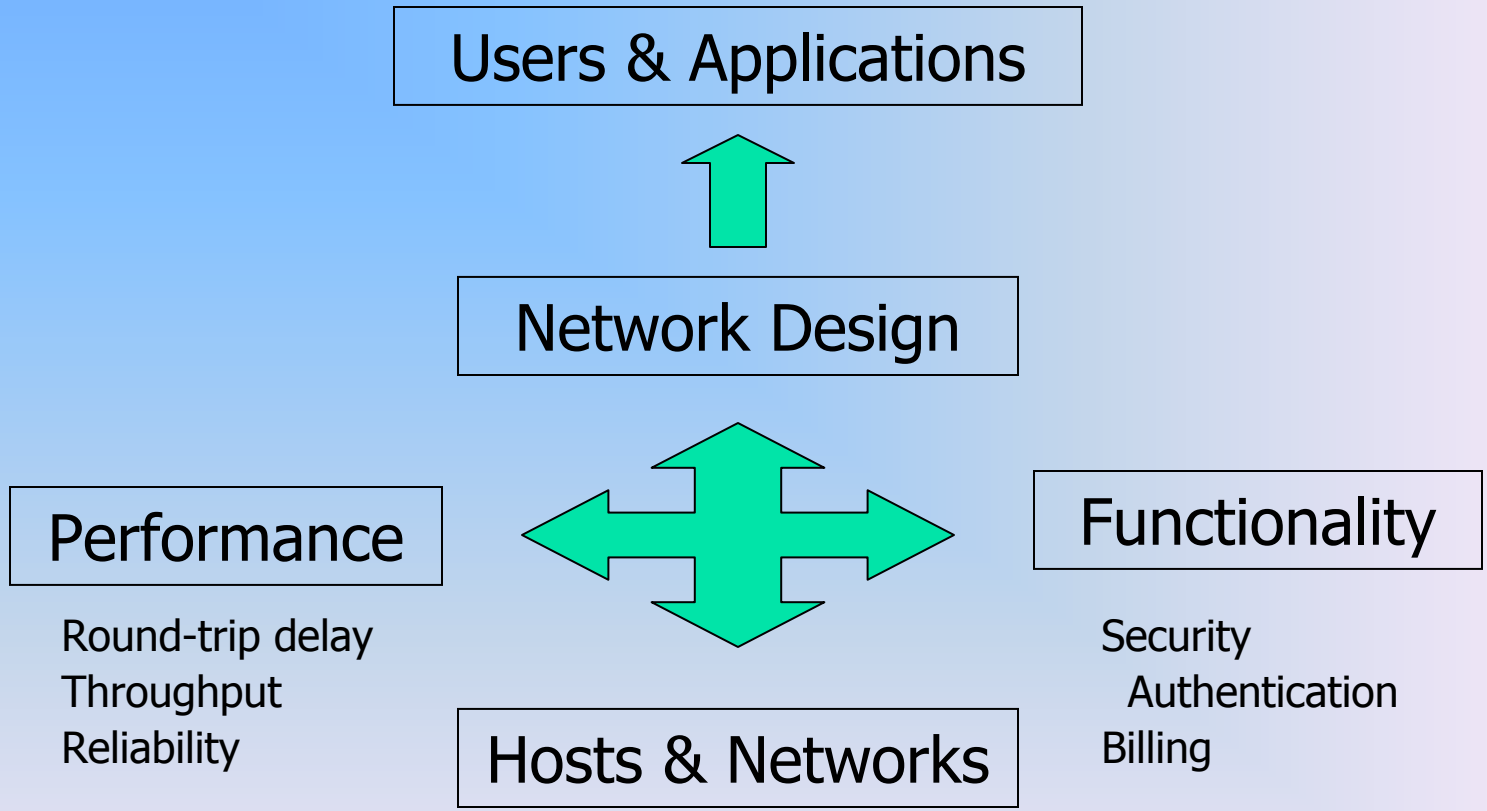
Design

- Bridge the gap or setup relationship between:
  - What does modeling tell us?
  - What are the user requirements or design goals?

Requirements Analysis:

Network Design Cycle

- Modeling
- Design
- Deployment
- Performance Evaluation

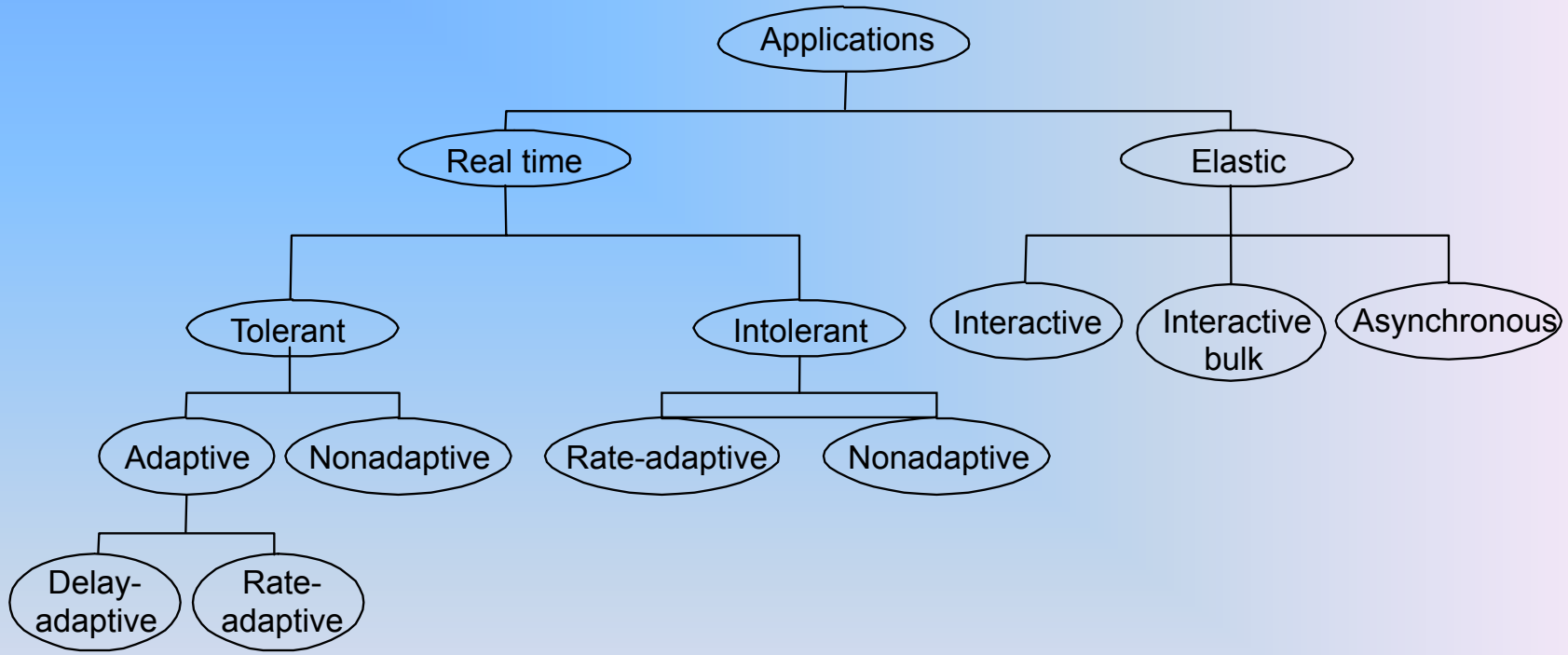


User Requirements

- Timeliness and interactivity
- Reliability and determinism
- Quality and tweakability
- Adaptability, robustness, and auto-configurability
- Security and manageability
- Affordability
- Coverage and scalability
- Expandability and migration

App. Requirements

Network Design Cycle
- Modeling
- Design
- Deployment
- Performance Evaluation



Deployment Phases

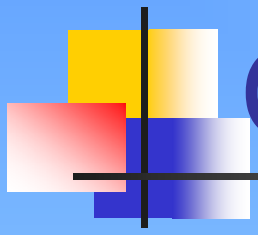
- Simulations
  - Analytical models, e.g., queuing models with closed form or numerical solutions
  - Simulation experiments, e.g., discrete-event simulation with statistical results
- Emulations
  - Trace-driven simulation
- Experiments
  - Empirical measurements
    - Instrumented code and network monitoring
- Deployment for evaluations
  - Time required, accuracy, trade-off evaluation, cost, sale-ability

Performance Evaluation

- What goals could be achieve in this?
  - System tuning guide
    - Identifying bottleneck(s)
    - Capacity analysis
    - Sensitivity study
      - Configuration planning and trade-offs
  - Detecting problem areas
  - Benchmarking

Performance Evaluation

- How to analyze and interpret results?
  - Results are random
  - Statistical techniques needed to compare results
- When to conduct it?
  - Architecture/system design
  - Detailed design and implementation
  - Operation



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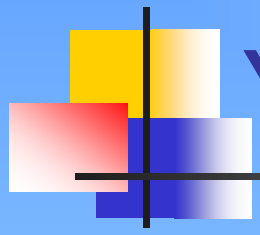
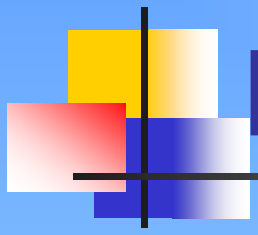


You should now be able to …

- Describe the network design cycle;
- List various levels of network modeling and their performance measures and the factors affecting the performance;
- List different deployment phases;
- Identify goals and time to conduct performance evaluations.



Reference

- James D. McCabe, *Practical Computer Network Analysis and Design*, Morgan Kaufmann, 1998

Homework (Due 01/23)

- 1.1 For each category of the WSN applications mentioned in the slides #11, identify a NSF/DARPA funded project, list its website, and provide a half-page summary about the project in your own words.
- 1.2. List three candidate topics for your individual project and the reasons why you are interested in these topics.
- Paper reading homework: Briefly read the SampleSurveyPaper.pdf available at the Blackboard System, which will be used as a template for your individual project survey paper.