Homework 1

Due date: March 8, 2010.

Problem 1: Are you smarter than a (Systems Engineering) 5th Grader?

Review questions are a great way to test your knowledge of course material and identify and correct for points of weakness before an exam.

The attachment is a partially assembled list of review quetions for this course. Most of the questions come from early versions of the course material (prepared around 2000-2002) and do not cover ideas weaved into the course during the past five years – for example, industrial- and information-age systems, development concepts such as separation of concerns, function-to-structure mappings, design platforms, real-world networks, networks-of-networks, and so forth.

After reading the first two chapters of the notes, prepare lists of questions that you think your class colleagues should be able to answer – and, hey, failure to produce the corrent answer means you're not smarter than a Systems Engineering 5th Grader! Specifically,

1. Prepare a list of 15 new review questions covering systems concepts and challenges (i.e., pages 1-46 of the notes).

2. Prepare a list of 10 new review questions covering established approaches to system development (i.e., pages 50-61 of the notes).

3. Prepare a list of 10 new review questions covering emerging approaches to system development (i.e., pages 62-67 of the notes).

4. Prepare a list of 15 new review questions covering model-based systems development (i.e., pages 78-101 and 107-160 of the notes).

An exhaustive list of the best questions will be distributed to the class before the midterm exam.

Problem 2: Behavior Modeling for Gas Station Operations

Suppose that a gas station is setup to serve M customers who obtain gas by prepaying a cashier who activates one of N pumps to serve the customer. When the gas station has only one pump and two customers (i.e., M=2 and N=1), the class hierarchy of relevant concepts might be as illustrated in Figure 1.

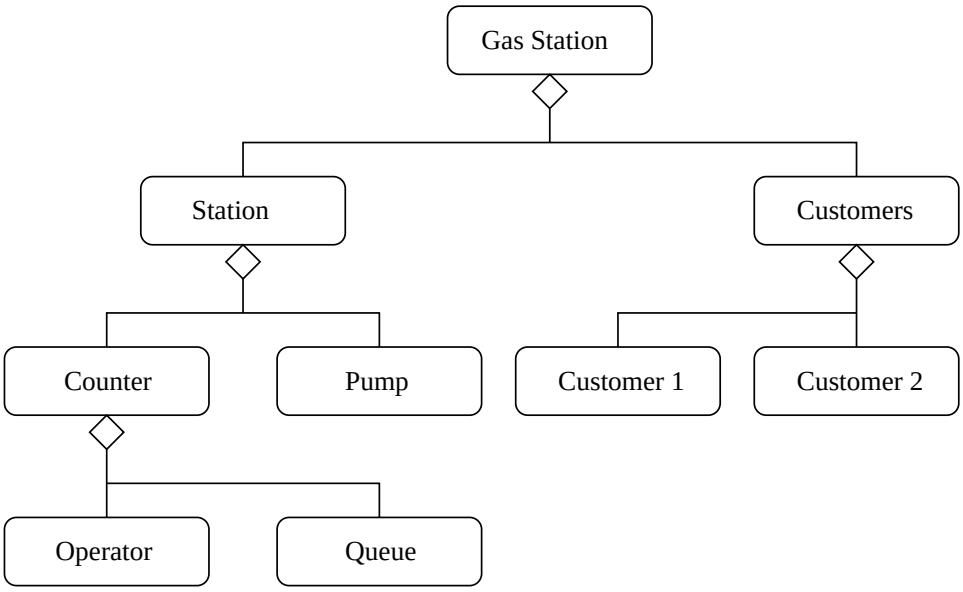

Figure 1: Class hierarchy for the simulation of behavior in a small gas station.

The main challenge in developing a behavior model for the gas station lies in defining the concurrent behaviors (i.e., Pump, Operator, Request Queue, Customer1, and Customer2) and coordinating and controlling their interactions.

Let us assume that the gas station operation will be subject to the following coordination and control constraints:

1. The operator accepts money from customers (Prepay) and according to the request queue, activiates pumps (Activate).

2. The pumping operation begins with a start operation and ends with a finish operation.

3. At the completion of the pumping operation, the Pump will send a Charge action to the operator, who will then provide Change to the customer and update the request queue.

4. A pump must be activated before the pumping (start, finish) and charge (Charge) operations can occur.

5. A pump can only serve one customer at a time.

Things to do:

1. Develop flowchart (activity diagram) and finite state machine (statchart) behavior models for the pump opeation, the customer behaviors, the state of the request queue operation, and behavior of the gas station operator. Be sure to clearly indicate entry and exit points, and the actions and/or guard conditions associated with state transitions.

2. Develop sequence diagrams to show the interaction of these entities.

3. Indicate whether or not the operator needs to keep track of the specific activities of each customer. What kinds of thing can go wrong if this doesn't happen?

4. Develop functional, temporal performance, and interface requirements for each of the behavioral and structure elements of this problem.

5. Identify performance attributes, and objects and their attributes (see Figure 1.48 of the class notes) needed for measuring the effectiveness of a system implementation.

If you are familiar with a UML tool (e.g., MS Visio, ArgoUML) then by all mean use it. Otherwise, tidy handdrawn shetches of behavior will also be acceptable.

Review Questions

Systems Engineering Concepts and Challenges

1. In what ways can a system be large?
2. List three factors that contribute to system complexity.
3. In typical U.S. production, what is the relationship between "rate of defects" and "cost of production?"
4. How does "extended project duration" complicate the development of a large system?
5. Briefly describe the six main steps in the lifecycle of a small engineering system.
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Economics of System Development

1. Draw a diagrams showing how "commitment of funds" and "funds expenditure" varies throughout the lifecycle of a typical project. What are the two key points to note from this graph?
2. How do concurrent design processes change the economics of system development?
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Established Approaches to System Development

1. Describe and compare the top-down and bottom-up approaches to design.
2. Briefly describe the role of "backtracking" in the engineering design process. Why is it sometimes necessary?
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Emerging Approaches to System Development

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Model-Based Systems Development

1. What is an emergent system property? Provide two or three examples of emergent system properties.

2. What roles to abstraction and validation play in the modeling of real-world systems?

3. Briefly describe network, layered, and hierarchical system structures.

4. What are the essential characteristics of a transformational system?

5. What are the essential characteristics of a reactive system?

6. What is the relationship between "systems of systems" and systems?

7. What is the difference between an object and a class?

8. What is inheritance? How can the modeling of systems benefit from inheritance?

9. How do state transition diagrams work?

10. What is encapsulation? What is modularity? What is abstraction? What is information hiding?

11. In the design of complex systems, why are the concepts of abstraction and information hiding important?

12. Draw and label a diagram showing the pathway of development for object-oriented models of engineering systems. Clearly indicate the relationship between system behavior and system structure.

13. Briefly describe the key steps you would work through in order to create an object-oriented software model.

Systems Engineering View of Modeling

1. Briefly describe the kinds of issues that engineering models try to address.

2. Briefly describe the kinds of issues that requirements models try to address.

3. Briefly describe the kinds of issues that organizational models try to address.

4. Why is the construction of organizational models difficult? How does the systems engineering community handle this problem?

5. How to requirements models enable communication between project engineers and the project's customers and stakeholders?

6. How does the balance of qualitative/quantitative information vary among engineering, requirements, and organizational models?

Systems Integration

1. What aspect of development does systems integrations focus on?

2. What do the terms "horizontal integration" and "vertical integration" mean?

3. How do middleware solutions simplify the implementation of multi-component systems?

4. Standards provide legitimacy to emerging technologies. Briefly describe four benefits of standards.

Visual Modeling of Systems with UML

1. What does the acronyn UML stand for?

2. What are the key goals of object technology and object-oriented system development? How are these goals achieved?

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Models of Systems Engineering Development

1. Draw and label a functional flow block diagram (FFBD) for a generic description of the systems engineering process (including technical and management process components).

2. Draw and label a functional flow block diagram (FFBD) for the core technical process (as practiced by General Electric). Clearly indicate on this diagram how defects are handled.

3. Briefly describe the Waterfall and Spiral Models of Systems Life Cycle Development.

4. When would you use the Waterfall Model? When would you use the Spiral Model?

5. Why are some segments of the engineering community advocating object-oriented models of systems development?

6. What are some of the benefits object-oriented life-cycle development is expected to bring?

7. Briefly describe the goals and features of the Capability Maturity Model developed by the SEI at Carnegie Mellon University.

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8. What incentives do companies have to comply with SEI Capability Maturity Model?

System Process and Workflow Modeling

1. How does a design structure matrix work? What is design partitioning and design tearing?

Advanced Behavior Modeling

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Requirements Engineering

1. What are the key limitations of textual requirements?

2. Draw and label a diagram showing the pathway from "goals" and "scenarios" to system behavior, system structure, and the system design. Clearly indicate on your diagram the role scenarios play in the refinement of a system design.

3. Briefly list some of the sources from which initial requirements are obtained.

4. Briefly explain how requirements are generated via engineering analysis.

5. Briefly describe how company and market factors can lead to fluctuating requirements.

6. What is a potential shortcoming of requirements questionnaires?

7. In the acquisition of requirements, what role to "direct" and "indirect" viewpoints play?

8. What is requirements traceability? Why are systems engineers interested in requirements traceability?

9. Briefly explain the difference between informal, semi-formal, and formal requirements. Why are systems engineers interested in maximizing their use of formal requirements?

10. Why are researchers interested in building models of requirements acquisition processes?

11. What are the goals of change control?

12. In the SLATE systems engineering tool, what are the purposes of: (1) Abstraction Block Hierarchies, and (2) Transition Mappings (TRAM's)?

System-Level Design

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Optimization-Based Design

1. Which stages of the systems engineering lifecycle can potentially benefit the most from optimization procedures?

2. Draw and label a diagram showing the relationship between the "design space" and the "performance space" for a constrained optimization problem.

- What role do the design variables play in the problem formulation?
- What role do the design constraints play in the problem formulation?
- What role do the design objectives play in the problem formulation?
- Briefly describe three strategies for searching the design space.

3. In high level terms, describe three techniques for searching an optimization space.

4. Why are design response surfaces needed for the optimization of some engineering systems.

5. How does the method of lagrange multipliers work?

Trade-Off Analysis

1. How does the weighting index formulation work?

2. How does the minimax formulation work?

3. What is a noninferior solution?

4. Which view of the feaible domain (design parameter or design objective) provides the clearer picture of the noninferior set?

5. What are the advantages and disadvantages of the constraint method of noninferior set construction?

6. Draw a picture to show how the weighting index method of noninferior set construction can fail?

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