Part 1: Modeling Concepts

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Modeling as a Design Technique

[The first four exercises emphasize that the content of a model is driven by its relevance to the problem to be solved. The first three exercises are hardware oriented. Exercise 2.4 is software oriented.]

2.1 In purchasing a tire for a car, size is generally constrained to fit the car. In selecting tires, many consumers pay close attention to cost and expected life. Tread design and internal construction are broadly matched to the expected service. For example snow tires provide extra traction in snow. Material and weight are generally not considered.

Size, material, internal construction, tread design, and weight are important physical parameters that would be taken into account in simulating the performance of a computerized anti-skid system for cars. Other physical parameters of the car itself would have to be considered. Cost and expected life would be irrelevant.

In building a tire swing for a child, cost would probably be the main consideration. A discarded tire would be a good candidate. Weight and size would also be relevant. You would probably not use a giant truck tire for a swing, although you might use it in constructing a playground

2.2 Cost, stiffness, availability, and strength would be considered in selecting a wire to unclog a drain. Depending on the urgency of the situation, you might prefer something immediately available. If you went out to buy something you would not want to pay more for the wire than what it would cost to hire a plumber. The wire would have to be stiff enough to push through the clog but would have to be flexible enough to follow the bends of the drain pipe.

We have not had much luck unclogging drains with most common wire such as coat hanger wire or electrical wire. We have had some modest success with a special coiled spring sold in some hardware stores and with chemical caustics. For really tough jobs you should hire a plumber.

2.3 a. For a transatlantic cable, resistance to saltwater is the main consideration. The cable must lie unmaintained at the bottom of the ocean for a long time. Interaction of ocean life with the cable and the effect of pressure and salinity on cable life must be considered. The ratio of strength/weight is important to avoid breakage while the cable is being installed. Cost is an important economic factor. Electrical parameters are important for power consumption and signal distortion.

b. Color, cost, stiffness, and availability are the main considerations. You would probably want an assortment of colors to make the artwork interesting. The wire should be stiff enough to hold its shape after being bent, but flexible enough to be shaped.

c. Weight is very important for wire that is to be used in the electrical system of an airplane, because it affects the total weight of the plane. Toughness of the insulation is important to resist chafing due to vibration. Resistance of the insulation to fire is also important to avoid starting or feeding electrical fires in flight.

d. Cost, stiffness, availability, and strength should be considered in selecting wire to hang a bird feeder. The wire should be flexible enough to work with and strong enough to hold the bird feeder. Another consideration not mentioned in the exercise that is important if bare wire is selected is resistance to corrosion.

e. Cost, stiffness, availability, strength, and resistance to stretching are important considerations in selecting wire for use as piano strings. Because the strings are under a great deal of tension, strength and resistance to stretching are important. Stiffness is important because it affects the way the strings vibrate.

f. Because the filament of a light bulb operates at a high temperature, resistance to high temperatures is important. Tungsten is generally used because of its high melting point, even though tungsten filaments are brittle.

2.4 Electrical noise, buffering and flow control, and character interpretation are relevant in designing a protocol for transferring computer files from one computer to another over telephone lines. Data transmission rate is a secondary factor since it limits the overall speed of the protocol.

Electrical noise determines how much error detection and correction is needed.

Buffering and flow control are techniques that are used in some protocols if the receiving computer cannot keep up with the incoming stream of data.

Control characters in the transmitted data could cause problems if the protocol is not designed with them in mind since they could be interpreted as part of the protocol or the receiving computer could interpret them as commands instead of as data.

2.5 [This exercise illustrates the importance of having multiple models or views of a problem.]

a. The electrical model is the most important model to determine how much electrical power is required to run a motor. It relates voltage, current, and perhaps frequency to the speed and torque requirements of the load. Mechanical and fluid models play secondary

roles. A mechanical model is used to compute friction and a fluid model is used to compute the energy needed to drive any fans that keep the motor cool. Waste heat is equal to the difference between the electrical input power and the mechanical output power.

b. The mechanical model is the only one needed to determine motor weight. The weight of each part can be determined from its mechanical dimensions and its density. The total motor weight is equal to the sum of the weights of all of its parts.

c. Electrical, mechanical, thermal, and fluid models must be considered to determine how hot a motor gets. Electrical, mechanical, and fluid models are used to compute waste heat. The amount of cooling air is determined from a fluid model. The temperature rise of the motor is determined from the waste heat, the thermal model, and the cooling air flow rate.

d. Vibration is computed from electrical and mechanical models. An electrical model is used to determine time variations in electrical torque and motor speed. A mechanical model is used to determine the dynamic mechanical behavior of parts of the motor driven by electrical torques, mechanical loads, and unbalance.

e. Bearing wear is computed from electrical, mechanical, thermal, and fluid models. The mechanical model is used to compute the forces on the bearing. Electrical, mechanical, thermal, and fluid models are used to determine bearing temperature. Fluid and mechanical models are used to analyze the lubrication of the bearing.

2.6 a. Class and state models are relevant to the user interface. A class model can be used to represent the pieces being moved. A state model is used to define the protocol of the user interaction. The interaction model would be less important because chess pieces are largely autonomous and mostly interact with the chess board.

b. A class model is used to show a board configuration.

c. The class model is most important because it represents the relationships among the pieces. There would also need to be significant algorithms for exploring the space of possible moves. These algorithms are not explicitly addressed by the three models and would require a supplemental notation.

d. Move validation involves the class model which represents the pieces.