Lecture 6
Operational Specifications

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Today's Lecture

- Continue to discuss the Make example
  - It illustrates each of the three specification styles introduced in lecture 5
- Begin to explore Operational Specifications in more detail

The Make Example

- Lecture 5
  - We worked on an example specifying some properties of Make
- However, Make *is* a specification language itself
  - It specifies dependencies between artifacts
  - It specifies rules for creating new artifacts
  - It specifies actions to carry out the rules

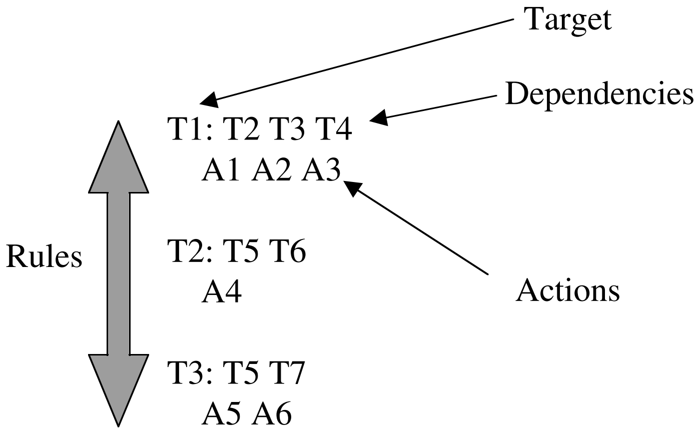
Make Specification Language

- Dependencies are Relational
  - Described according to desired relationships
  - Usually given in terms of multi/hyper graphs
- Rules are Declarative
  - Described according to desired properties
  - Usually given in terms of axioms or algebras
- Actions are Imperative
  - Described according to desired actions
  - Usually given in terms of an execution model

More on Make

- Make is well-integrated into a Unix/C environment
  - – Primitive Components are Files
  - – Actions are "shell commands"
  - – Rules are placed in a file and denote the "specification"
    - Rules make explicit the dependencies of the system and what to do about them

Example "Makefile"



Target

Dependencies

Actions

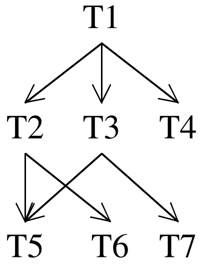
Rules

T1: T2 T3 T4
  A1 A2 A3

T2: T5 T6
  A4

T3: T5 T7
  A5 A6

Rules can have interdependencies



… and shared dependencies!

Questions

- What is the concept of dependence in this system? How is it modeled?
- Why are rules considered declarative?

Hybrid Style Issues

- Consider programming languages
  - They are primarily operational
    - What about them are declarative or relational?
- Most languages will have a chief modeling style
  - Contrast statements in a program with Make’s
    - S1 S2 S3… operational, do these statements in this order
    - Rules in a makefile: declarative, achieve this target
  - One style will lead you to ask different sorts of questions than with another style
    - Is there a unique way to achieve the target? Is a target feasible?

Operational Specification

- Focuses on Control Aspects
  - Here we choose to look at control issues rather than data issues
- Examples
  - Control the flight path of an airplane
  - Control the speed of a car
- Of course, there are data aspects to these problems. However we view them more as parameters that influence the actions of the system

Formalisms and Foundations

- Formalisms
  - Finite State Machines (FSMs)
  - Petri Nets
  - Statecharts - used in UML
  - Communicating Sequential Processes (CSP)
    - Latter three are different attempts to add concurrency to FSMs
- Mathematical Foundations
  - Graph theory, automata theory, modal logic

Preview of Finite State Machines

- Informal Problem Description
  - When turned on by the driver, a cruise-control system automatically maintains the speed of a car over varying terrain. When the brake is applied, the system must relinquish speed control until told to resume. The system must also steadily increase or decrease speed to reach a new maintenance speed when directed to do so by the driver.

Example Continued

- There are seven inputs:
  - System on/off: If on, denotes that the cruise-control system should maintain the car speed.
  - Engine on/off: If on, denotes that the car engine is turned on; the cruise-control system is only active if the engine is on.
  - Pulses from wheel: A pulse is sent for every revolution of the wheel.

Example Continued

- Accelerator: Indication of how far the accelerator has been pressed. Note: The accelerator does not turn off the cruise-control system, it "pauses" the system
- Brake: On when the brake is pressed; the cruise-control system temporarily reverts to manual control if the brake is pressed.
- Increase/Decrease Speed: Increase or decrease the maintained speed; only applicable if the cruise-control system is on.
- Resume: Resume the last maintained speed; only applicable if the cruise-control system is on.

In-class Example

- We will now develop a finite state machine to help formalize the problem description
- Method
  - Identify states
  - Identify transistions between states
  - Keep it simple, if it starts to get too complex, we are heading down the wrong path
- <See class video for rest of example.>