Lecture 7
Finite State Machines

Kenneth M. Anderson

Foundations of Software Engineering

CSCI 5828 - Spring Semester, 2000

Today's Lecture

- Explore Finite State Machine issues
- Present a FSM-like language called SDL
- Discuss Homework 2

Finite State Machines (FSMs)

- Formal Definition

  $M = \{Q, I, \delta\}$, where

  Q is a finite set of *states*

  I is a finite set of *inputs*

  δ is a *transition function*

  $$\delta : Q \times I \rightarrow Q$$

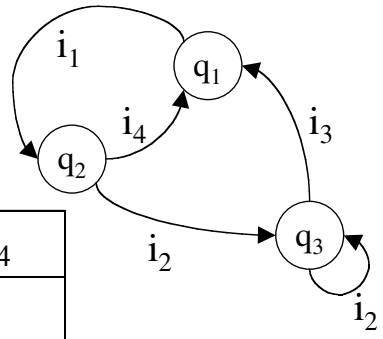
  δ can be a partial function

Finite State Machines (FSMs)

- Graph Representation
  - Nodes represent states
  - Arcs are directed and labeled with elements of I
  - Arc labeled i goes from state q_1 to state q_2 iff $\delta(q_1, i) = q_2$

An Example

- $Q = \{ q_1, q_2, q_3 \}$
- $I = \{i_1, i_2, i_3, i_4\}$
- $\delta =$



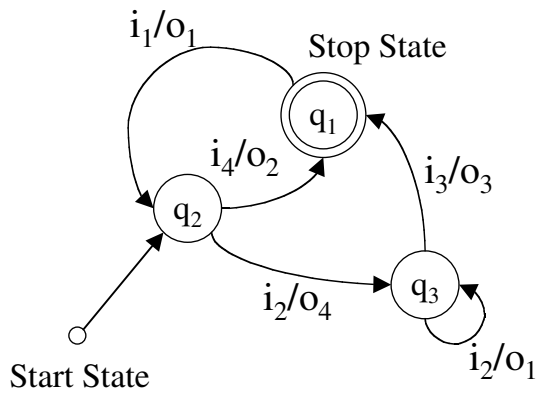
	i_1	i_2	i_3	i_4
q_1	q_2			
q_2		q_3		q_1
q_3		q_3	q_1	

Finite State Machines (FSMs)

- Execution Model
  - Machine in some state
  - Input causes state change according to δ
- Common Extensions
  - *Start* states and *stop* states
  - Output generated upon state transition
    - $\delta : Q \times I \rightarrow Q \times O$

Example

- $O = \{o_1, o_2, o_3, o_4\}$



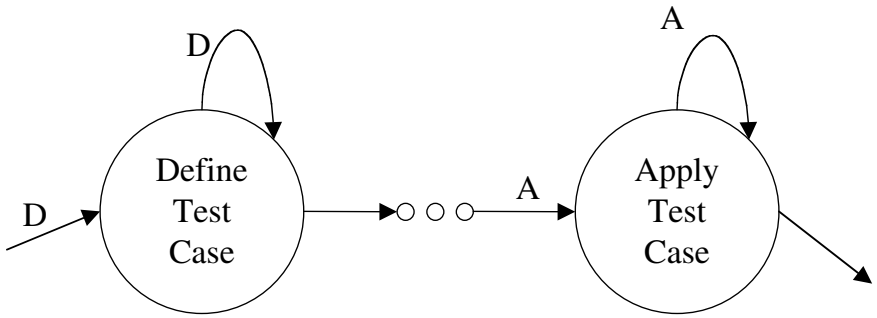
Advantages of FSM Model

- Simple
- Obvious graphical representation
- Easy to Build Support Tools
  - Transformers
    - Transform FSM Model into other representations
  - Analyzers
    - Will this FSM run forever? Is it possible for it to halt? Are the state sequences infinite?

Shortcomings of FSM Model

- Theoretical Limit on Computational Power
  - FSM has no "memory"
  - Using states as memory is inefficient
    - Consider modeling a cruise control system with states that model car speed
    - 8-bit register = 2^8 = 256 states!
- State Space Explosion for Large Problems

"No Memory" Problem

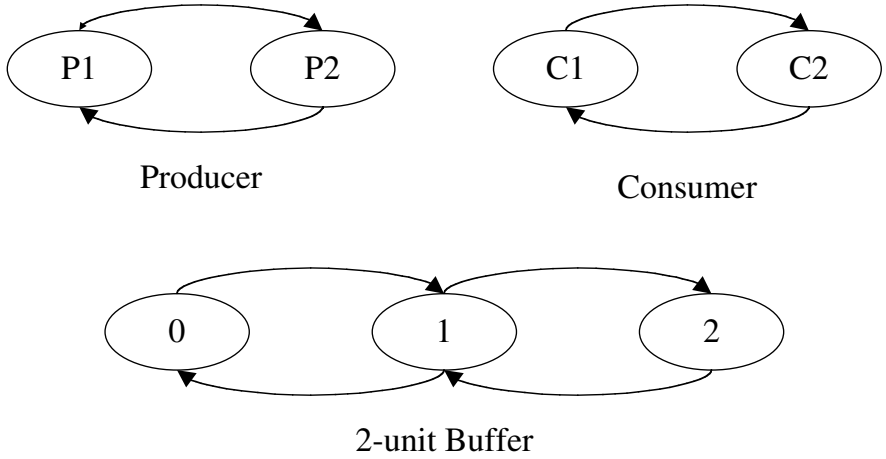


We would like to apply all of the defined test cases but a finite state machine cannot guarantee that $D^N=A^N$

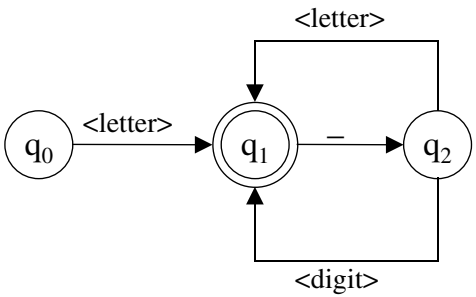
Shortcomings, continued

- Inherently Synchronous
  - FSM in single, global state at each time instant
- State Space Explosion for Composed FSMs
  - States are multiplicative
  - On next slide, imagine composing the producer/consumer/buffer state machines into one FSM. See the result in the textbook on page 173, Figure 5.16

Producer/Consumer Example



FSMs as Recognizers



Levels of Complexity

- Turing Machine
  - Unbounded tape
- Linear-Bounded Automata
  - Bounded tape
- Push-Down Automata
  - stack
- Finite State Machines
  - limited computational power but its simple to understand and program
- Programming Languages
  - Execution Semantics
- Context Sensitive Langs.
  - Language Semantics
- Context Free Grammars
  - Syntax
- Regular Expressions
  - Lexical Structure

An FSM-Based Tool: SDL

- Used Widely for Telephony Applications
- Extended FSMs
  - Modularity
  - Channel
- Tools
  - Analysis
  - Simulation
  - Code-generation

Homework 2

- Use a Finite State Machine to describe the possible state transitions for our home security system
  - Use only the notations presented in this lecture
- Retrieve the assignment from the Website
  - You may turn in hardcopy in class, or send the diagram via e-mail as a postscript or PDF attachment