Basic Game AI

Technical Game Development II

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With material from: Millington and Funge, *Artificial Intelligence for Games*, Morgan Kaufmann 2009. (Chapter 5)

Definitions?

- What is artificial intelligence (AI) ?
  - subfield of computer science ?
  - subfield of cognitive science ?
- What is “AI for Games” ?
  - versus “academic AI” ?

In games, ***everything*** (including the AI) is in service of the ***player’s*** experience (“fun”)

- What does it mean for a game AI to “cheat”?

Resources: introduction to Buckland, www.gameai.com, aigamedev.com, www.aiwisdom.com, www.ai4games.org

IMGD 4100, B? Term 2013

What’s the AI part of a game?

- Everything that isn’t graphics (sound) or networking... ☺
  - or physics (though sometimes lumped in)
  - usually via the non-player characters
  - but sometimes operates more broadly, e.g.,
    - Civilization-style games (sophisticated simulations)
    - interactive storytelling (drama control)

"Levels" of Game AI

- *Basic*
  - decision-making techniques commonly used in almost all games
- *Advanced*
  - used in practice, but in more sophisticated games
- *Future*
  - not yet used, but explored in research

This course

- ***Basic*** game AI
  - decision-making techniques commonly used in almost all games
    - basic pathfinding (A*) *(IMGD 3000)*
    - decision trees *(today)*
    - (hierarchical) state machines *(today)*
- ***Advanced*** game AI
  - used in practice, but in more sophisticated games
    - advanced pathfinding *(next Thurs)*
    - behavior trees (in Halo 3) *(next Fri)*

Future Game AI ?

- Take IMGD 4100 in 2013 (B?) [alt yr course] "AI for Interactive Media and Games"
  - fuzzy logic
  - more goal-driven agent behavior
- Take CS 4341 "Artificial Intelligence"
  - machine learning
  - planning

Two Fundamental Types of AI Algorithms

- *Non-Search* vs. *Search*
  - *Non-Search:* amount of computation is predictable
    - e.g., decision trees, state machines
  - *Search:* upper bound depends on size of search space (often large)
    - e.g., minimax, planning
    - scary for real-time games
    - need to otherwise limit computation (e.g., threshold)
- Where's the "knowledge"?
  - *Non-Search:* in the code logic (or external tables)
  - *Search:* in state evaluation and search order functions

How about AI Middleware (“AI Engines”)?

- Rercent panel at GDC AI Summit: “Why so wary of AI middleware?”
- Only one panelist reported completely positive experience
  - Steve Gargolinski, Blue Fang (Zoo Tycoon, etc.)
  - Used Havok Behavior (with Physics)
- Most industry AI programmers still mostly write their own AI from scratch (or reuse their own code)
- So we are going to look at coding details

AI Coding Theme (for Basic AI)

- Use *object-oriented* paradigm

instead of...

- A tangle of *if-then-else* statements

First Basic AI Technique:

Decision Trees

See code at:

https://github.com/idmillington/aicore

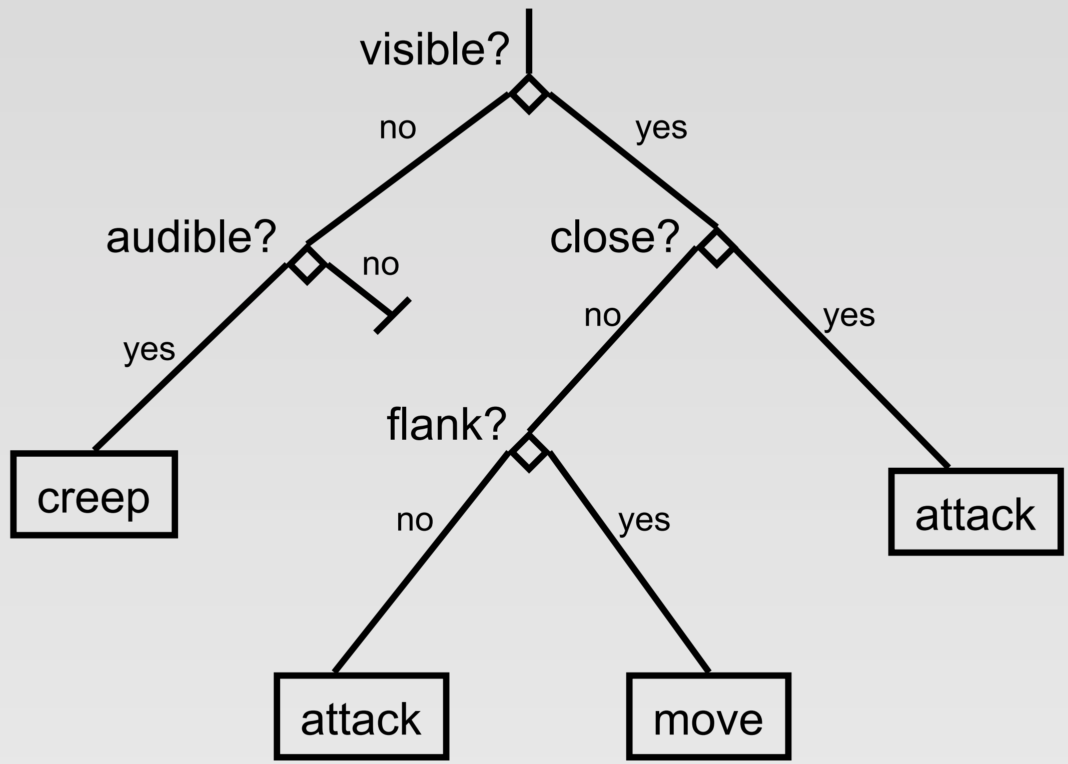
src/dectree.cpp and src/demos/c05-dectree

Decision Trees

- The most basic of the basic AI techniques
- Easy to implement
- Fast execution
- Simple to understand

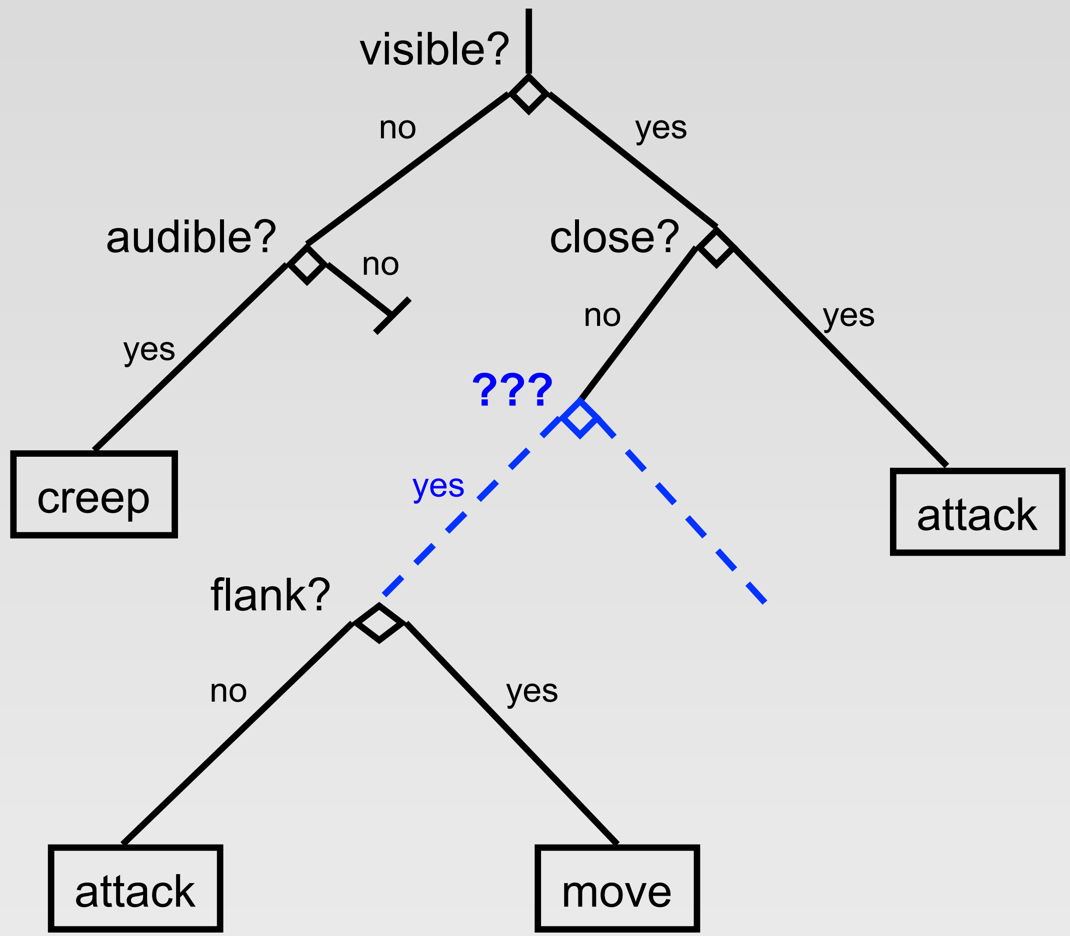
Deciding how to respond to an enemy

```
if visible? {
   if close? {
      attack;
   } else {
      if flank? {
         move;
      } else {
         attack;
      }
   }
} else {
   if audible? {
     creep;
   }
}
```

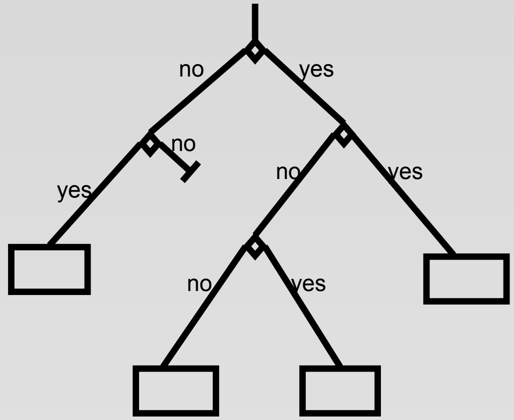


Which would you rather modify?

```
   if visible? {
      if close? {
         attack;
      } else if flank? {
???      move;
      } else {
         attack;
      }
   } else if audible? {
      creep;
   }
```



O-O Decision Trees (Pseudo-Code)

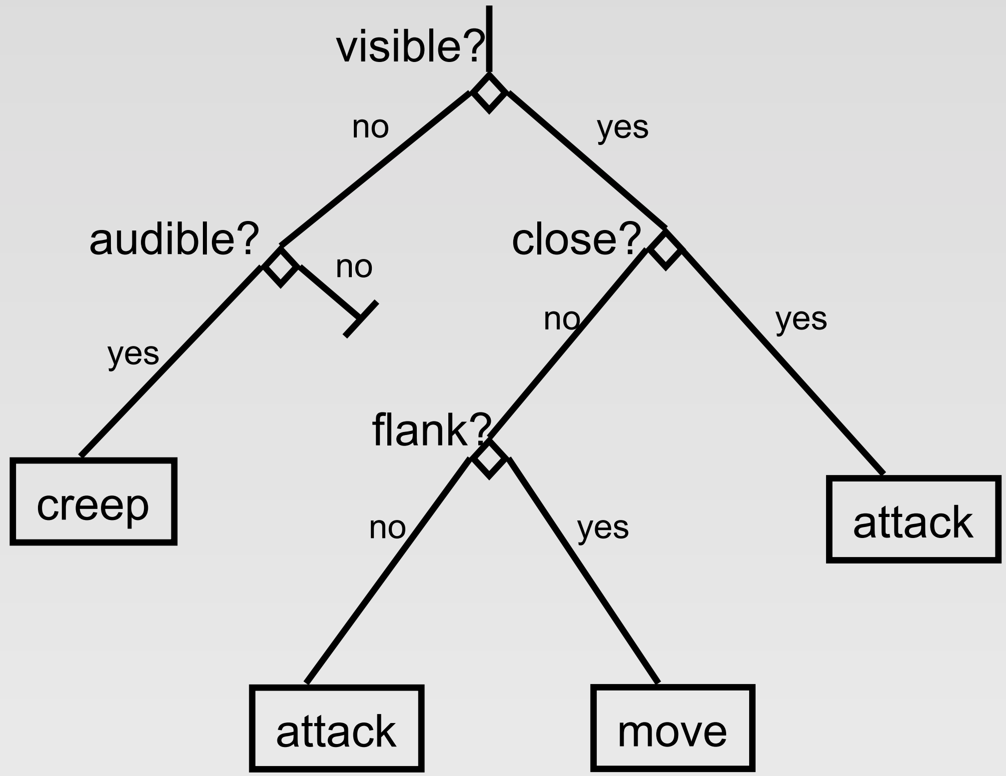



```
class Node
  def decide() //return action

class Decision : Node
  def getBranch() //return node
  def decide()
   return getBranch().decide()

class Action : Node
  def decide() return this
```

```
class Boolean : Decision
  yesNode
  noNode

class MinMax : Boolean
  minValue
  maxValue
  testValue

  def getBranch()
   if maxValue >= testValue >= minValue
      return yesNode
   else return noNode
```

Building an O-O Decision Tree

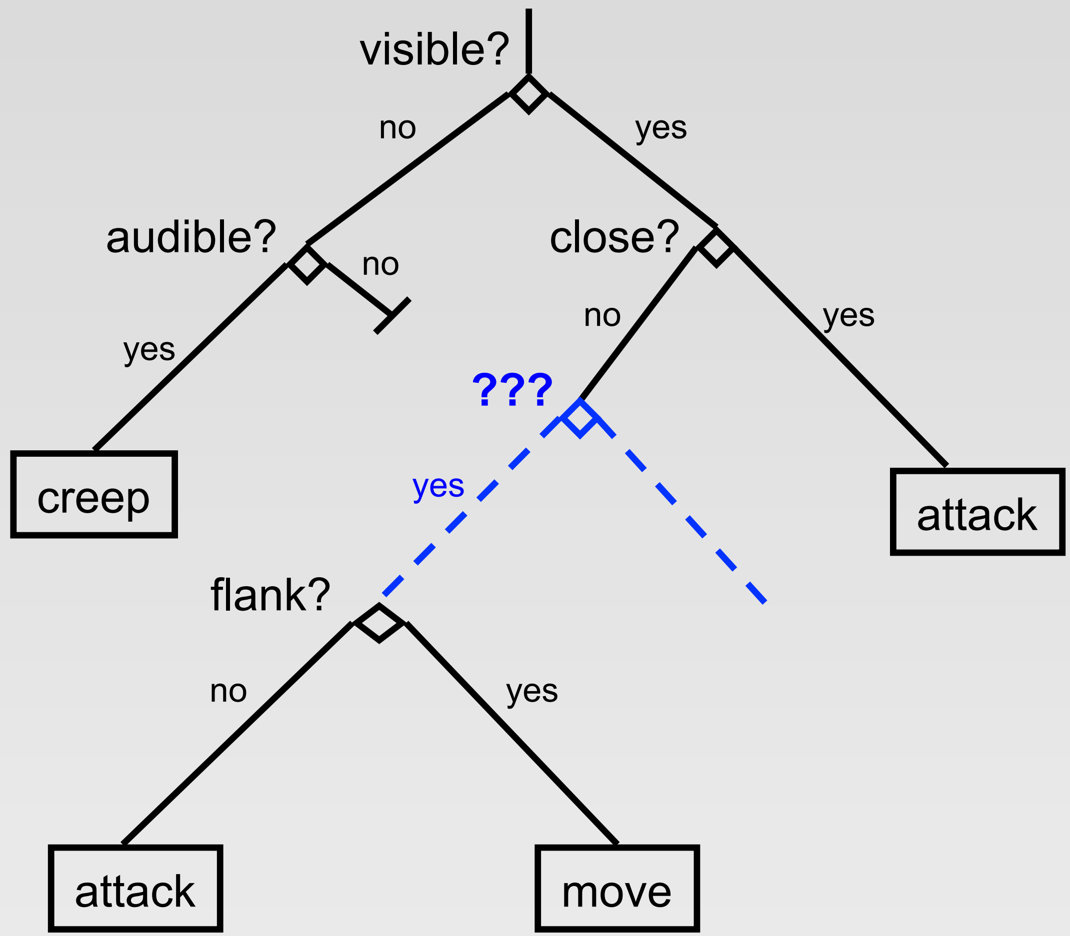
```
visible = new Boolean...
audible = new Boolean...
close = new MinMax...
flank = new Boolean...

attack = new Move...
move = new Move...
creep = new Move...

visible.yesNode = close
visible.noNode = audible

audible.yesNode = creep

close.yesNode = attack
close.noNode = flank

flank.yesNode = move
flank.noNode = attack
...
```



...or a graphical editor

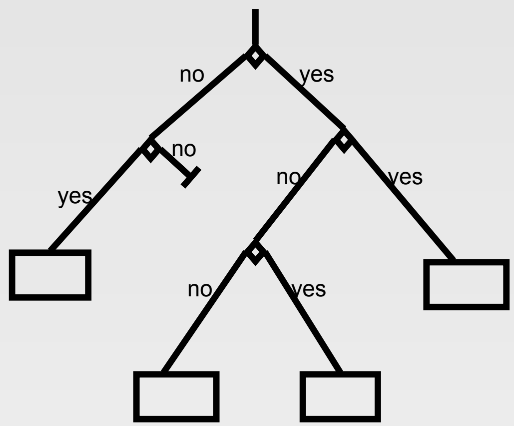
Modifying an O-O Decision Tree

```
visible = new Boolean...
audible = new Boolean...
close = new MinMax...
flank = new Boolean...
??? = new Boolean...

attack = new Move...
move = new Move...
creep = new Creep...

visible.yesNode = close
visible.noNode = audible

audible.yesNode = creep

close.yesNode = attack
close.noNode = ???
???.yesNode = flank

flank.yesNode = move
flank.noNode = attack
...
```



Decision Tree Performance Issues

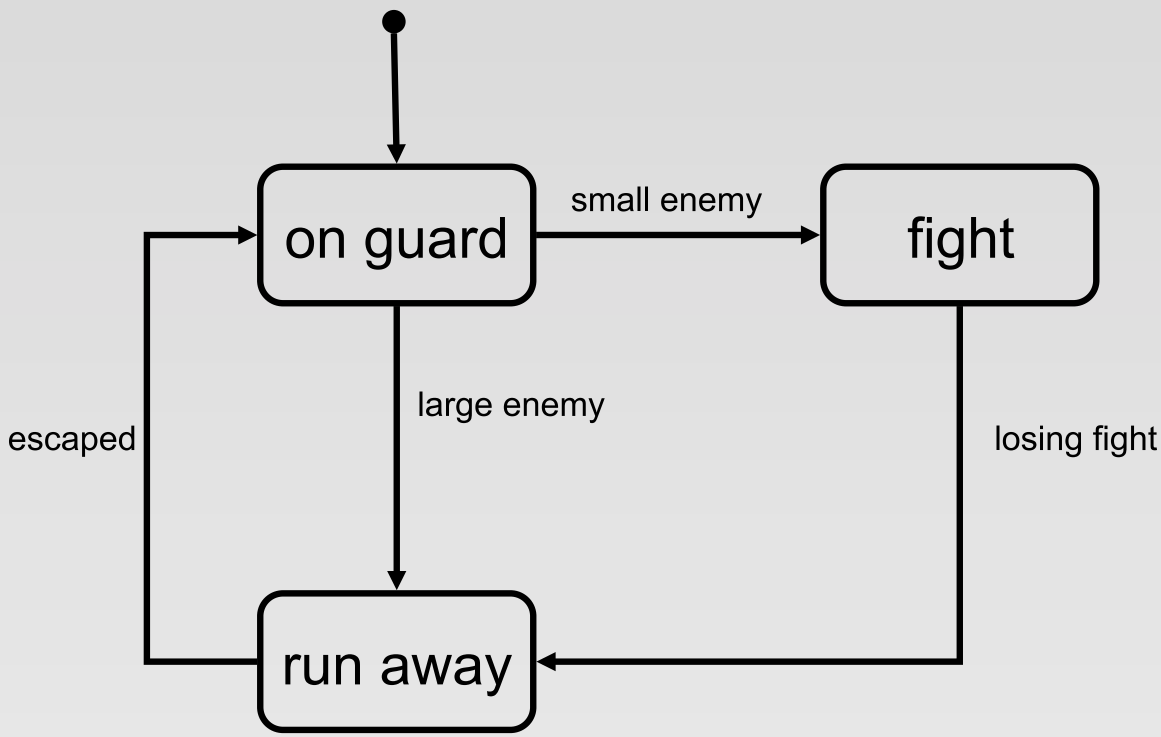
- individual node tests (`getBranch`) typically constant time (and *fast*)
- worst case behavior depends on *depth* of tree
  - longest path from root to action
- roughly "balance" tree (when possible)
  - not too deep, not too wide
  - make commonly used paths shorter
  - put most *expensive* decisions late



Second Basic AI Technique:

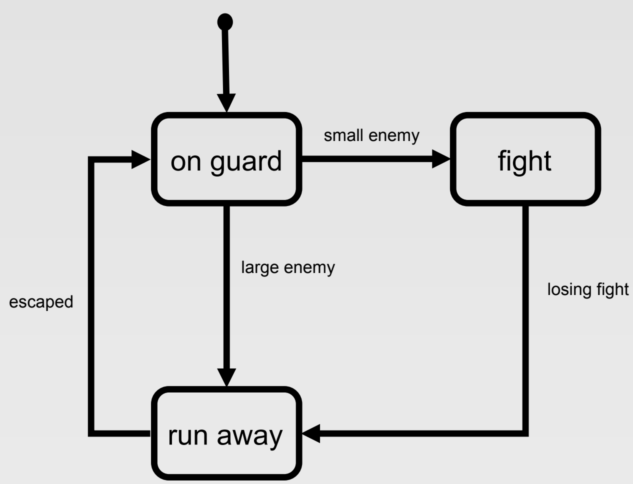
(Hierarchical) State Machines

State Machines



Hard-Coded Implementation

```
class Soldier

  enum State
    ON_GUARD
    FIGHT
    RUN_AWAY

  currentState
```




```
def update()
  if currentState == ON_GUARD {
    if small enemy {
      currentState = FIGHT
      start Fighting
    } else if big enemy {
      currentState = RUN_AWAY
      start RunningAway
    }
  } else if currentState == FIGHT {
    if losing fight {
      currentState = RUN_AWAY
      start RunningAway
    }
  } else if currentState == RUN_AWAY {
    if escaped {
      currentState = ON_GUARD
      start Guarding
    }
  }
```

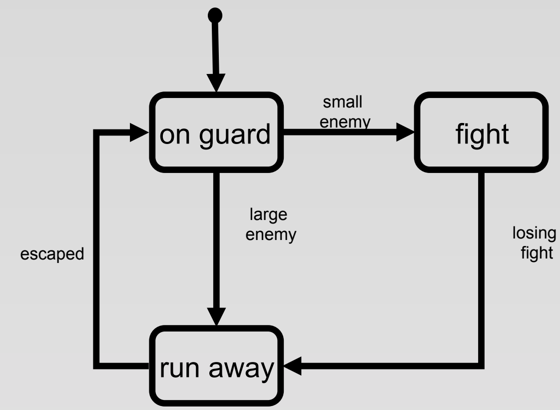
Hard-Coded State Machines

- Easy to write (at the start)
- Very efficient
- Notoriously hard to maintain (e.g., debug)

Cleaner & More Flexible O-O Implementation

```
class State
    def getAction()
    def getEntryAction()
    def getExitAction()
    def getTransitions()

class Transition
    def isTriggered()
    def getTargetState()
    def getAction()
```

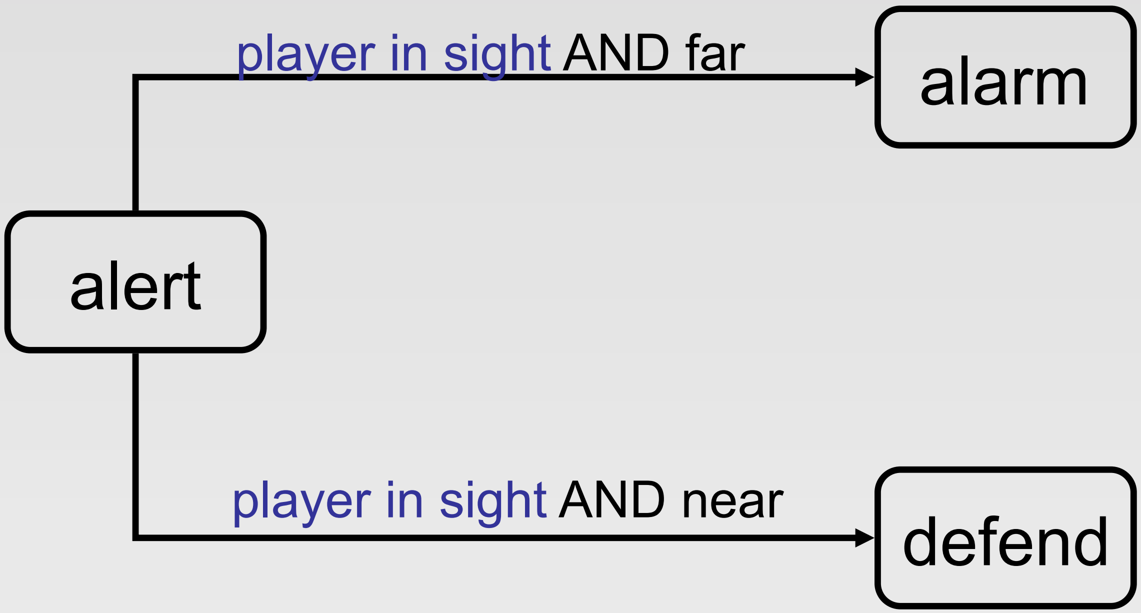
```
class StateMachine

   states
   initialState
   currentState = initialState

   def update()

      triggeredTransition = null

      for transition in currentState.getTransitions() {
         if transition.isTriggered() {
            triggeredTransition = transition
            break
          }
      }
      if triggeredTransition != null {
         targetState = triggeredTransition.getTargetState()
         actions = currentState.getExitAction()
         actions += triggeredTransition.getAction()
         actions += targetState.getEntryAction()
         currentState = targetState
         return actions
      } else return currentState.getAction()
```



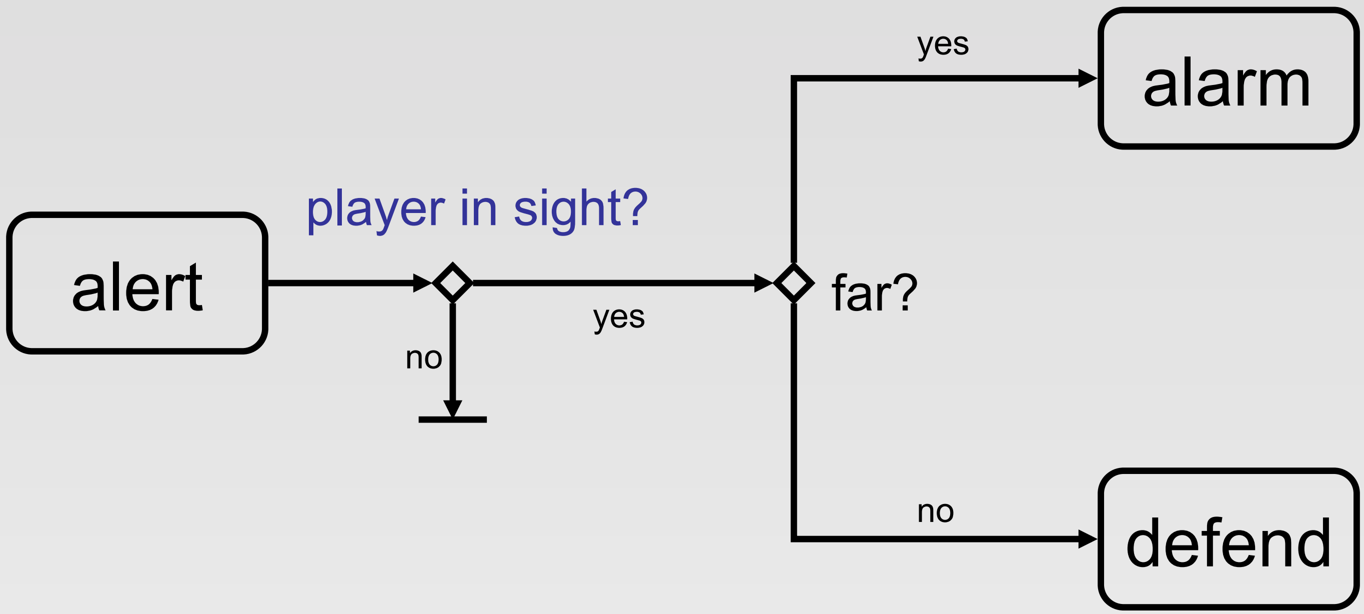
...add tracing

Combining Decision Trees & State Machines

- Why?
  - to avoid duplicating expensive tests in state machine:

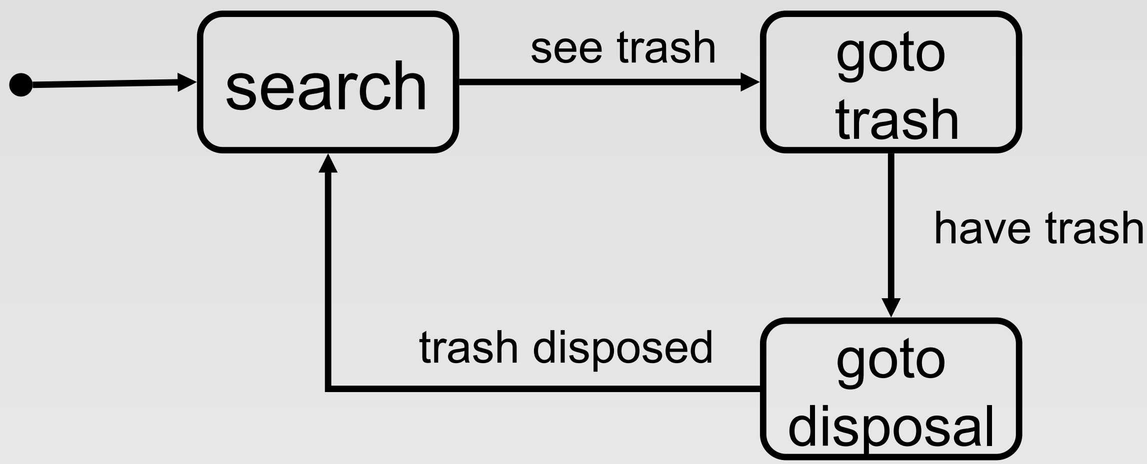


Combining Decision Trees & State Machines

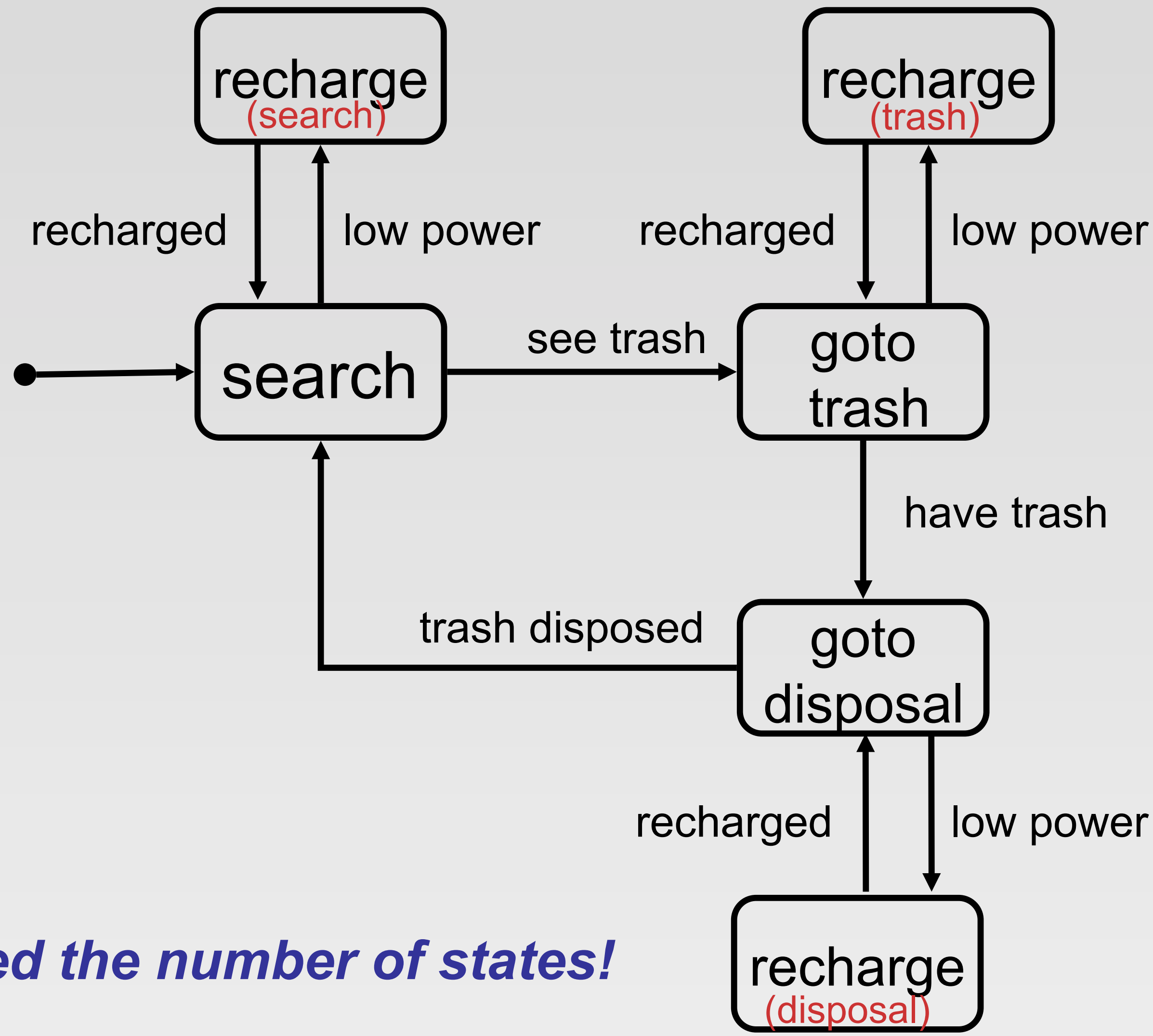


Hierarchical State Machines

- Why?

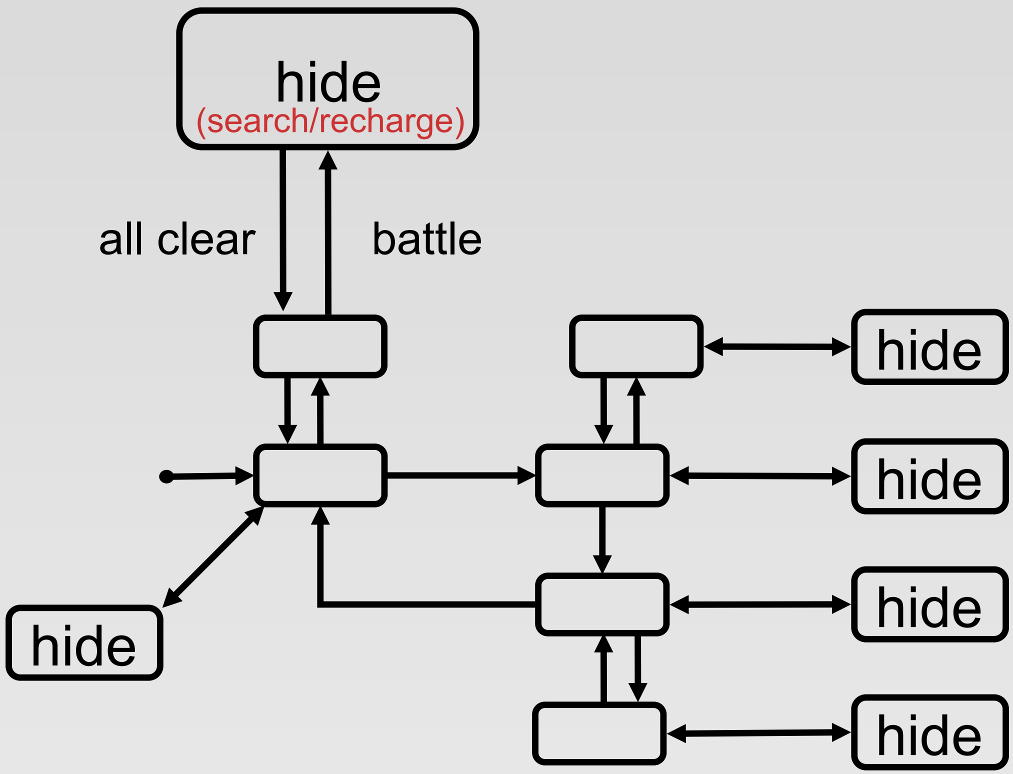


Interruptions (Alarms), e.g., Recharging?



6 - doubled the number of states!

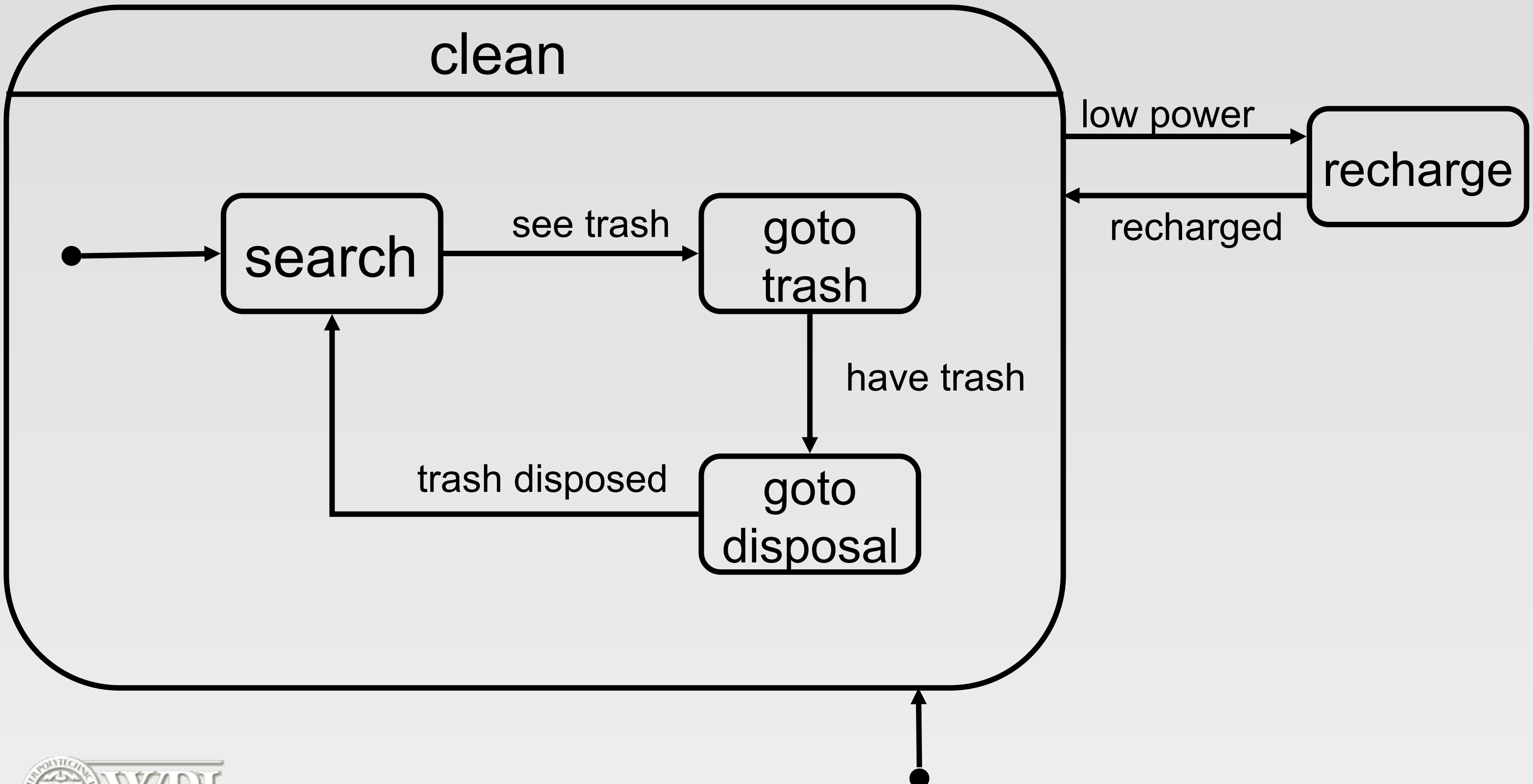
Add Another Interruption Type?



12 - doubled the number of states again!

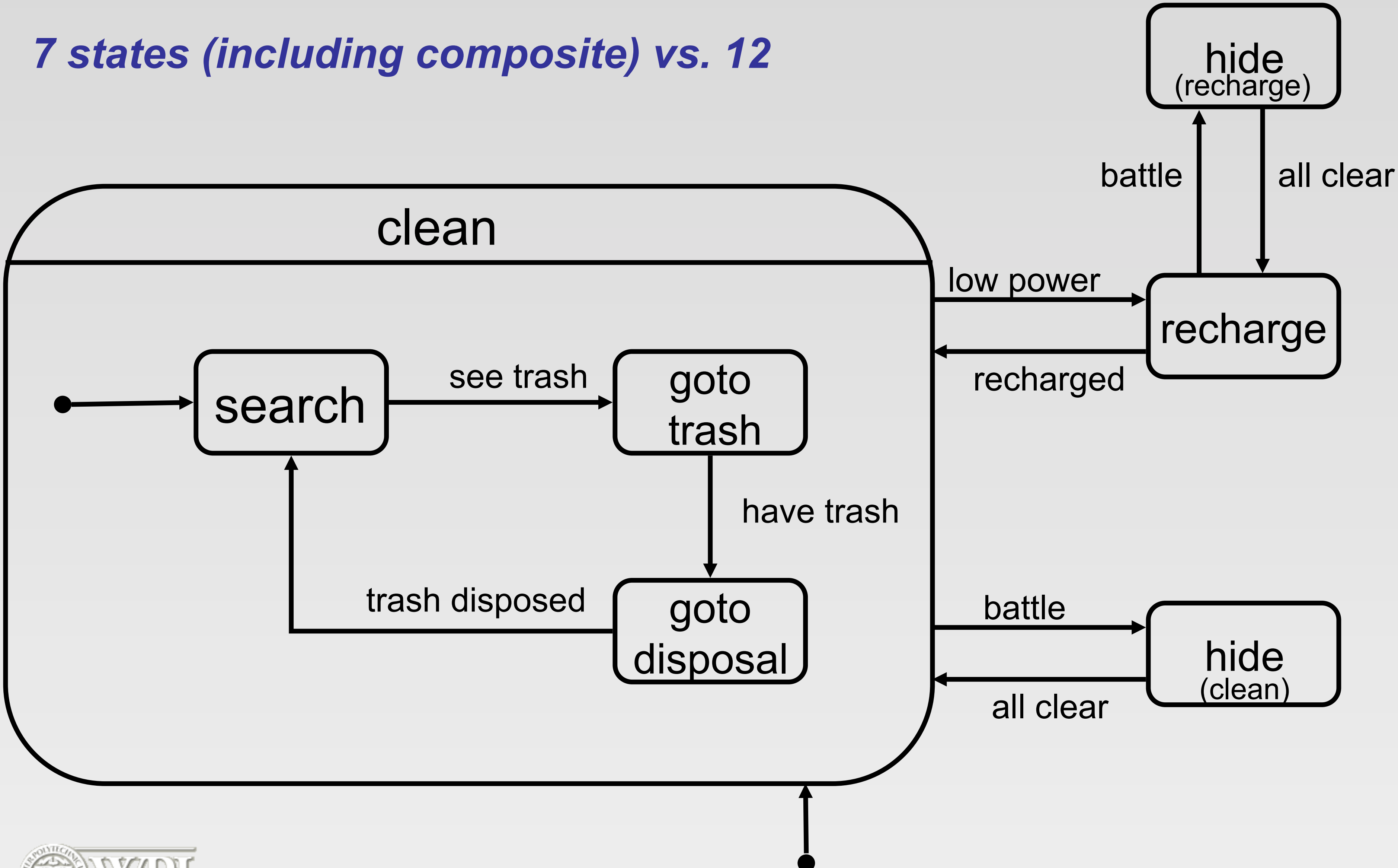
Hierarchical State Machine

- *leave any state in (composite) 'clean' state when 'low power'*
- *'clean' remembers internal state and continues when returned to from "recharged"*



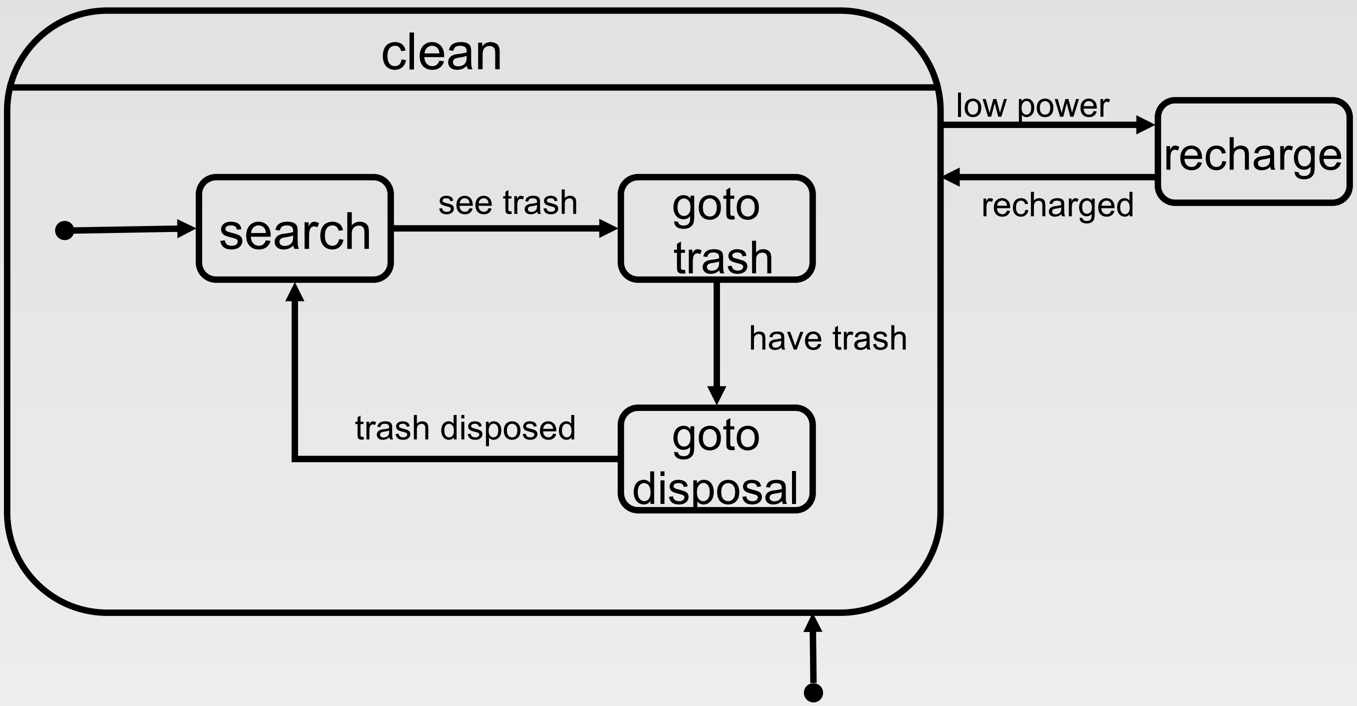
Add Another Interruption Type?

7 states (including composite) vs. 12

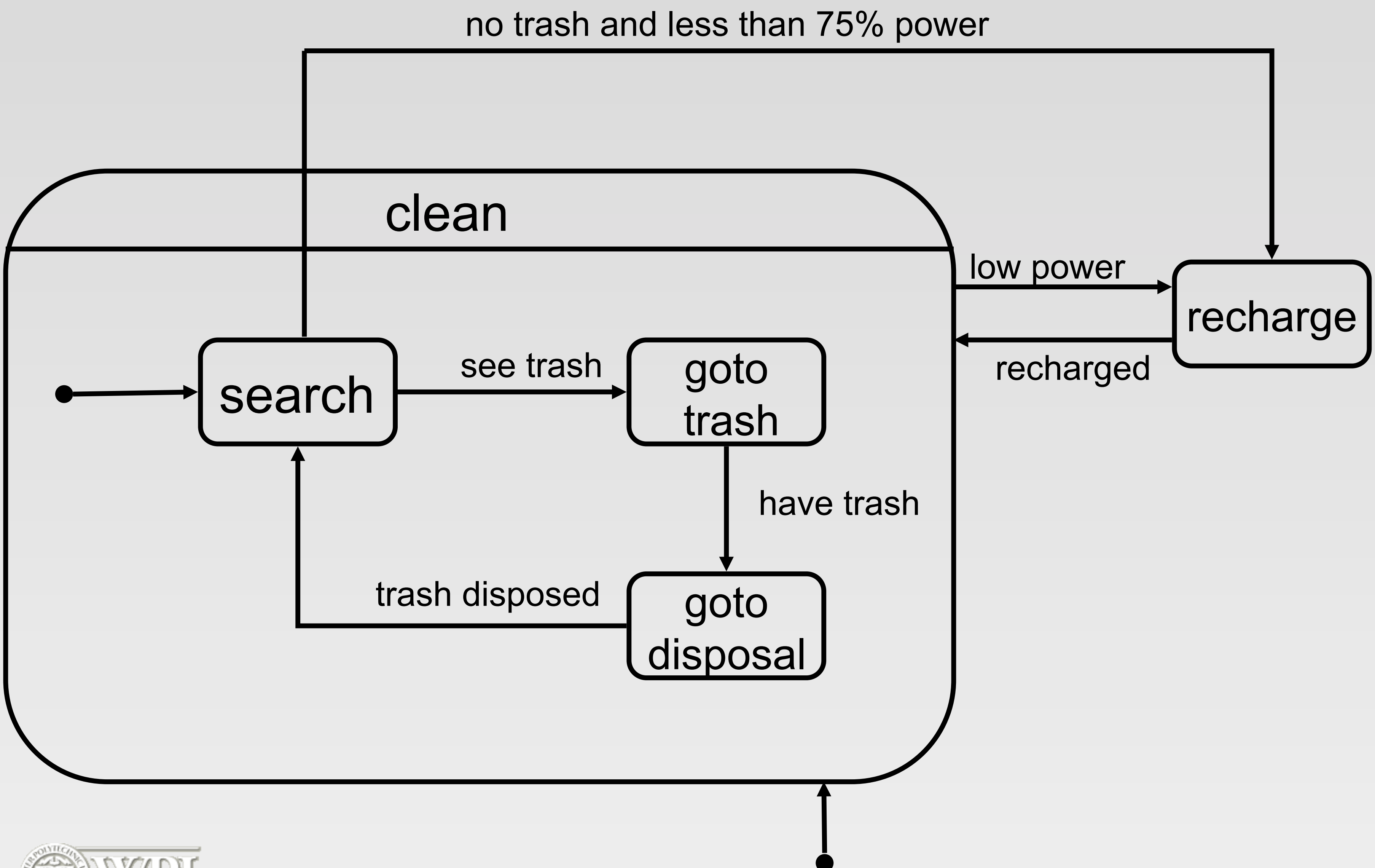


Cross-Hierarchy Transitions

- Why?
  - suppose we want robot to “top off” battery (even if it isn’t low) when it doesn’t see any trash



Cross-Hierarchy Transitions



HFSM Implementation Sketch

```
class State

   // stack of return states
   def getStates() return [this]

   // recursive update
   def update()

   // rest same as flat machine

class Transition

   // how deep this transition is
   def getLevel()

   // rest same as flat machine

struct UpdateResult // returned from update
   transition
   level
   actions // same as flat machine
```

```
class HierarchicalStateMachine

   // same state variables as flat machine

   // complicated recursive algorithm*
   def update ()


class SubMachine : HierarchicalStateMachine,
                   State

   def getStates()
      push this onto currentState.getStates()
```

*See full pseudo-code at *http://www.cs.wpi.edu/~rich/courses/imgd4000-b12/hsm.pdf

Add tracing/debug code!!