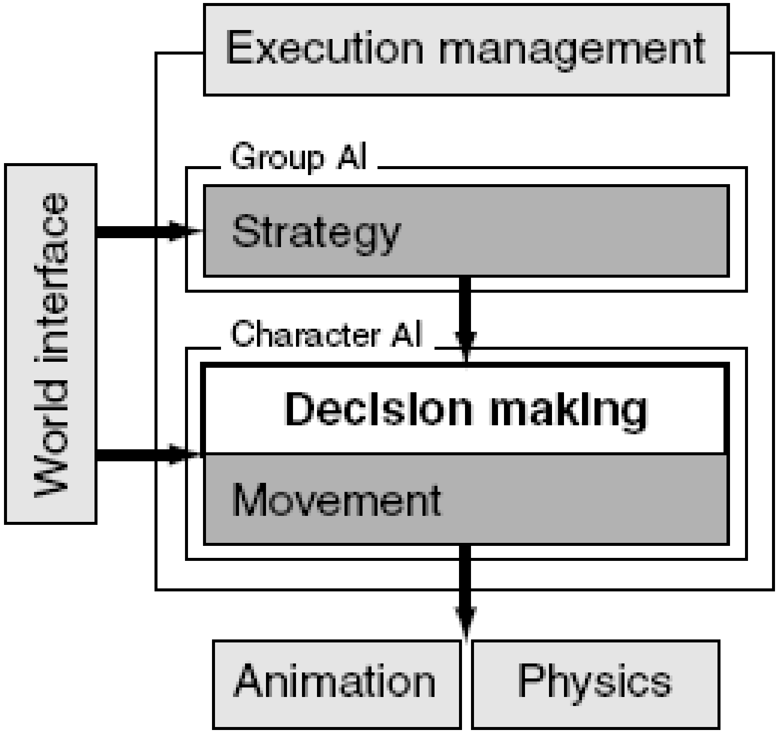
Intelligence I:
Basic Decision-Making Mechanisms

AI Architecture

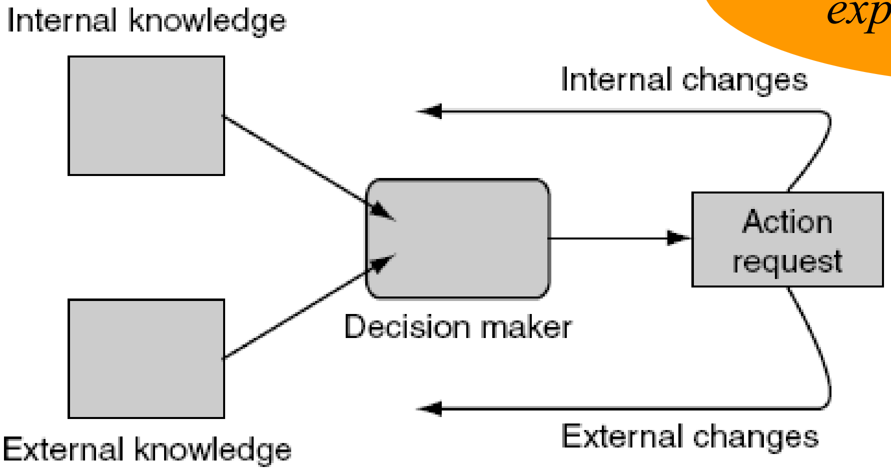


from “Artificial Intelligence for Games” by I. Millington & J. y ge

Decision-making Framework

e.g., health level, availability of ammunition, …

e.g., attack, flee, explore the sound, …



e.g., map, see enemy, hear sound, …

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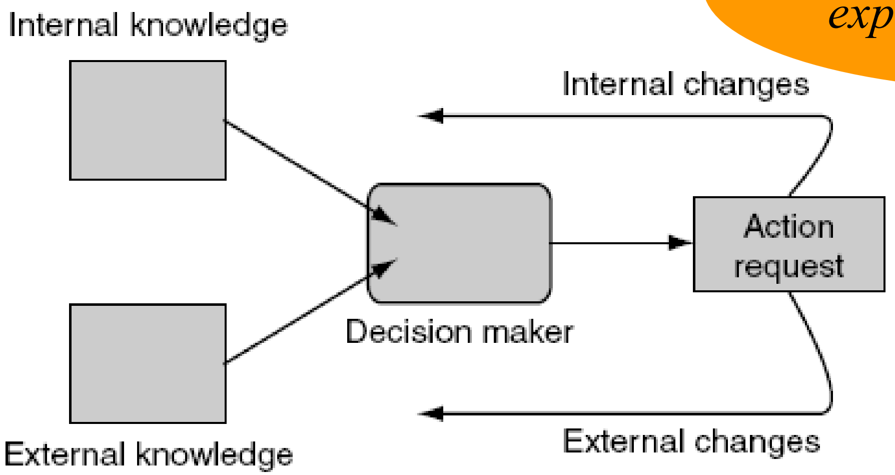

e.g., map, see enemy, hear sound, …

Any ideas for how to implement decision-making?

from "Artificial Intelligence for Games" by I. Millington & J. y ge

Basic Decision-making Mechanisms for this Class

- Decision Trees
- Finite-state Machines
- Basic Behavior Trees

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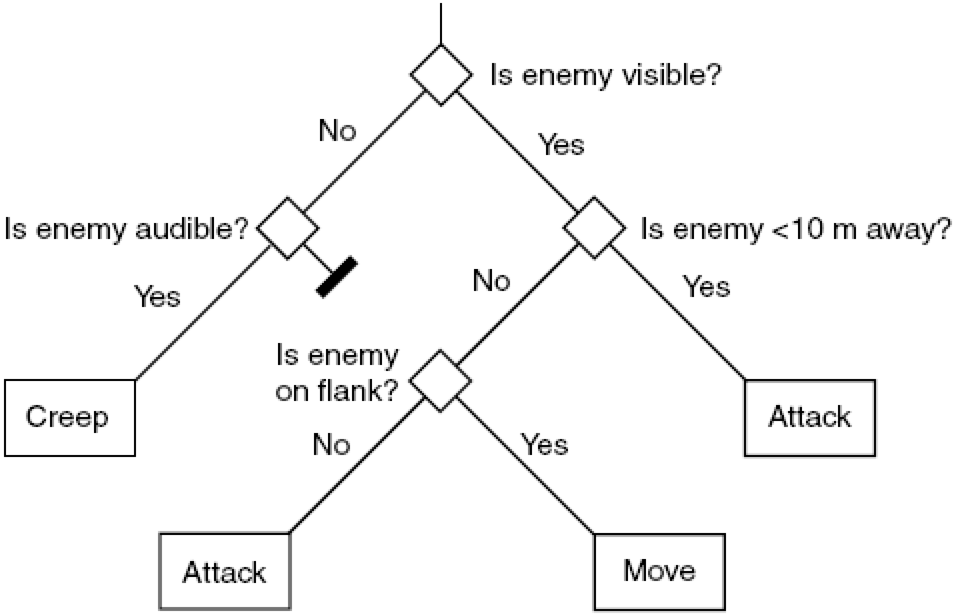
Decision Trees

- Formalization of a set of nested if-then rules
- Very popular: easy-to-implement, intuitive (=easy-to-debug) and fast
- Require careful manual design (theoretically, learning trees is also possible)



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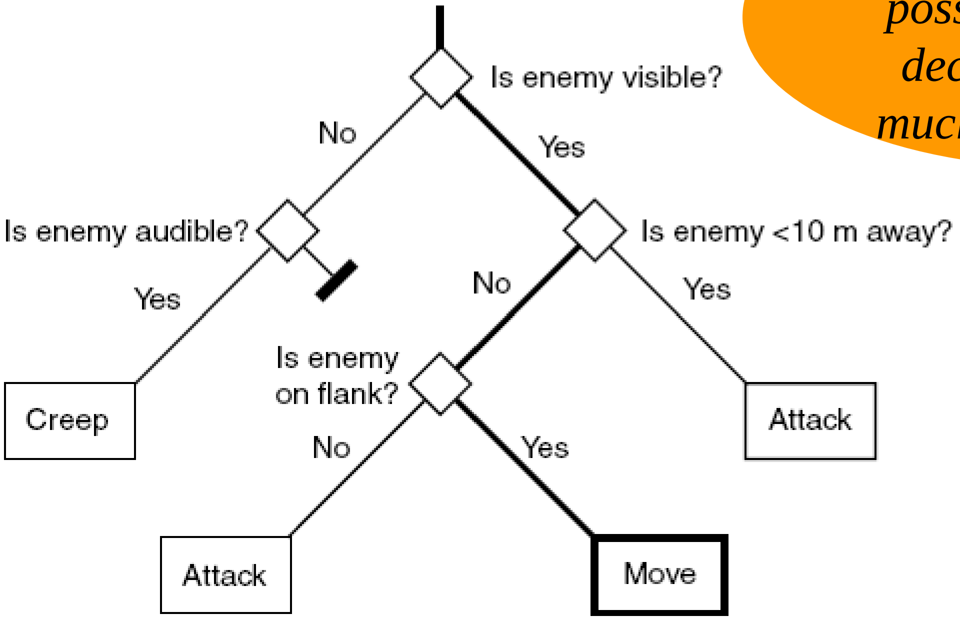
K-ary trees are possible but binary decision trees are much more common



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Decision Trees

- Support for multi-valued input variables in binary decision-trees

Example:

Depending on the size of the enemy troops,
attack, stand ground or retreat

How to implement in a binary decision trees?

Decision Trees

- Support for multi-valued input variables in binary decision-trees

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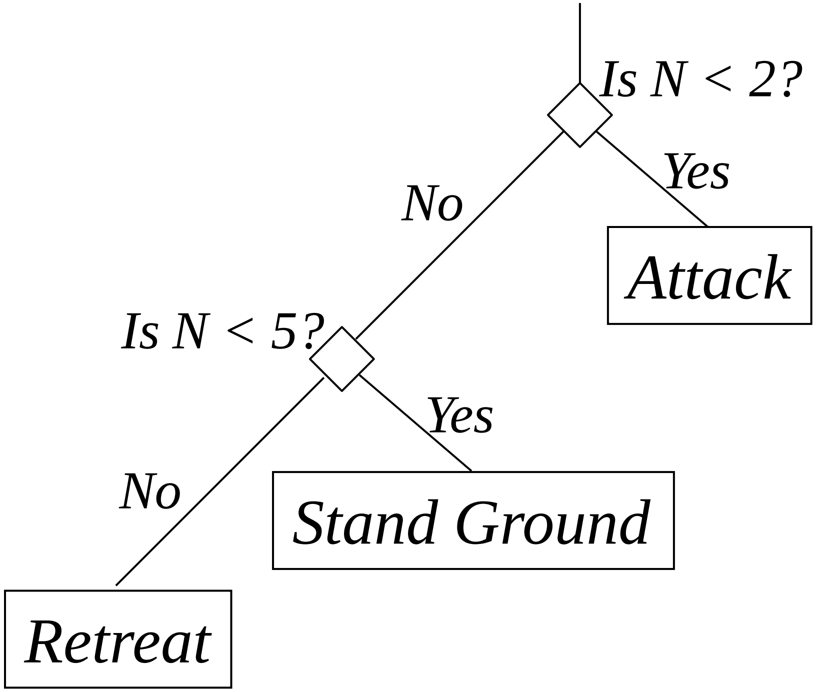

N=size of the enemy troops

Decision Trees

- Support for continuous input variables in binary decision-trees

Example:

Depending on the distance to the enemy,

hand-to-hand combat, shoot, hide

How to implement in a binary decision trees?

Decision Trees

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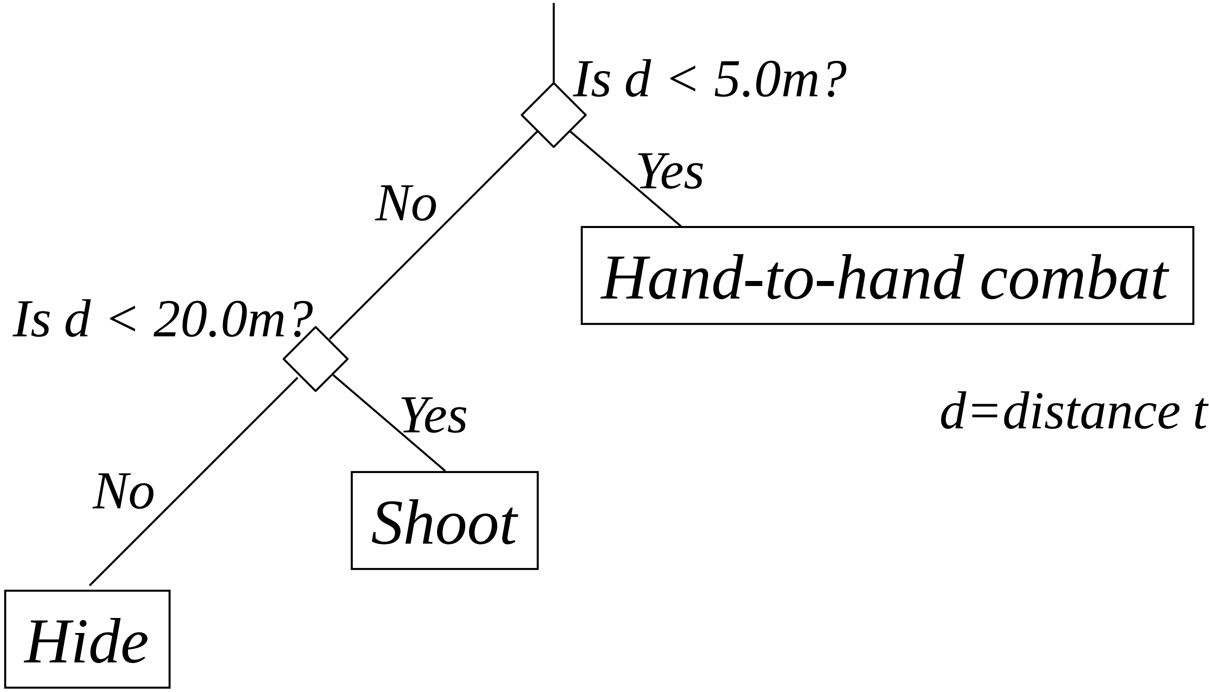


d=distance to enemy

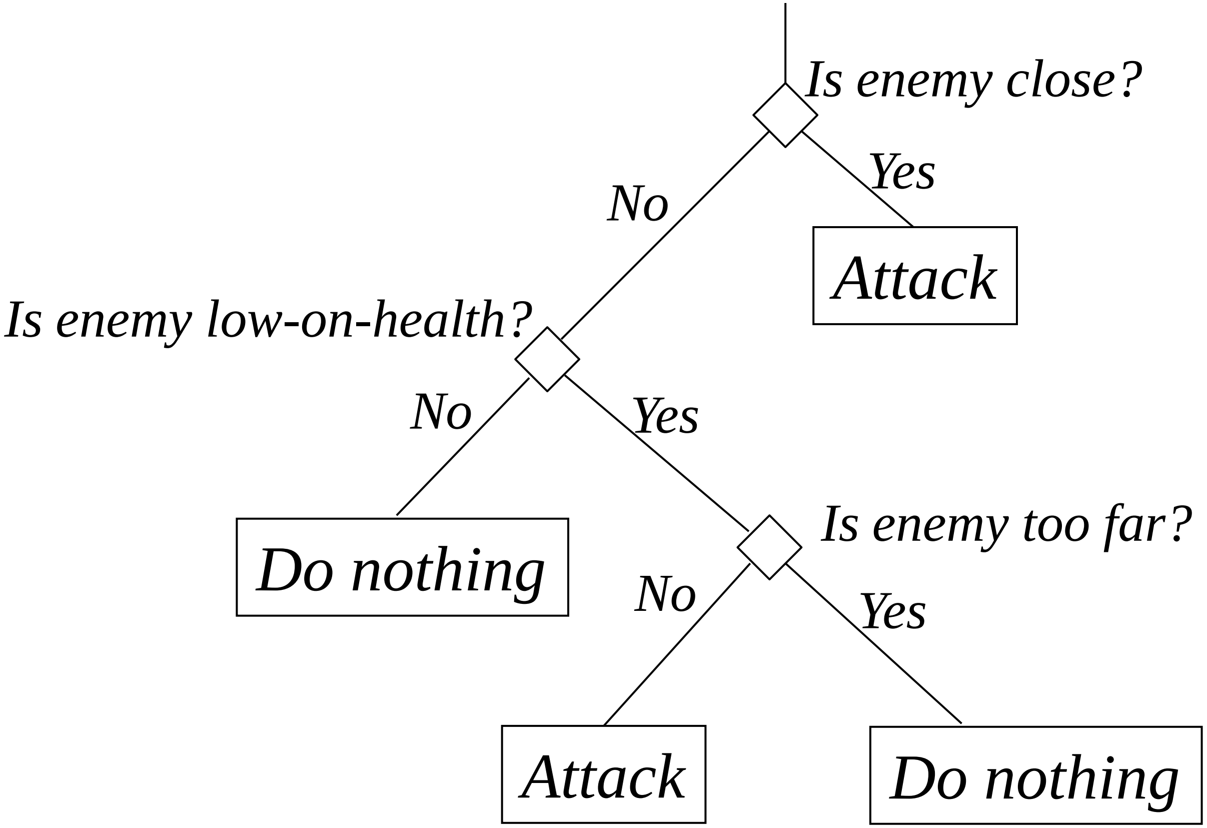
Decision Trees

- Support for complex decision formulae

Example:

Attack whenever

enemy is close OR (low-on-health AND not too far)



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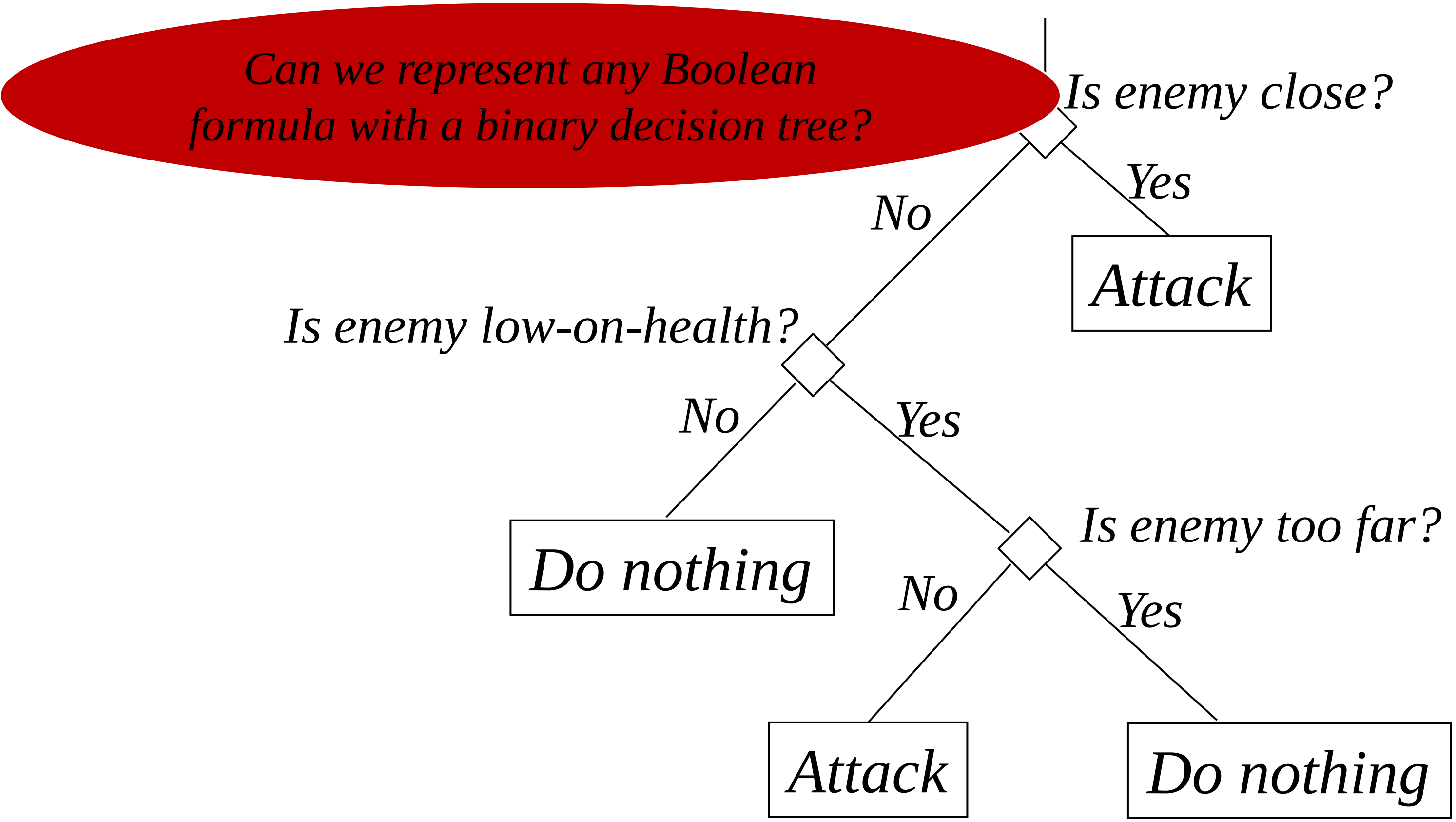


Can we represent any Boolean formula with a binary decision tree?

Decision Trees

- Support for complex decision formulae

Each row is a branch in the tree

True?

Example:

Attack whenever

enemy is close OR (low-on-health AND not too far)

‖

A OR (B AND C)

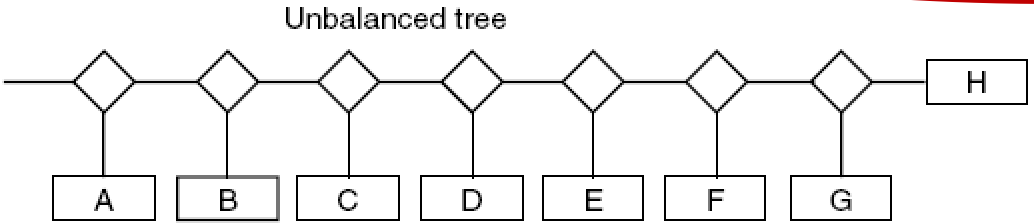
‖

A	B	C	Outcome
0	0	0	No
1	0	0	Yes
0	1	0	No
1	1	0	Yes
…	…	…	…

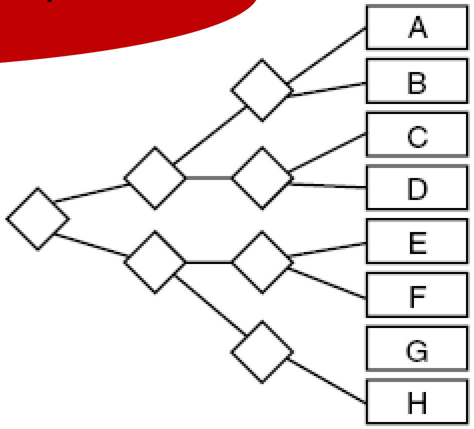
Decision Trees

- Making the decision tree traversal fast is important

Which decision tree is better for decision-making?



vs.



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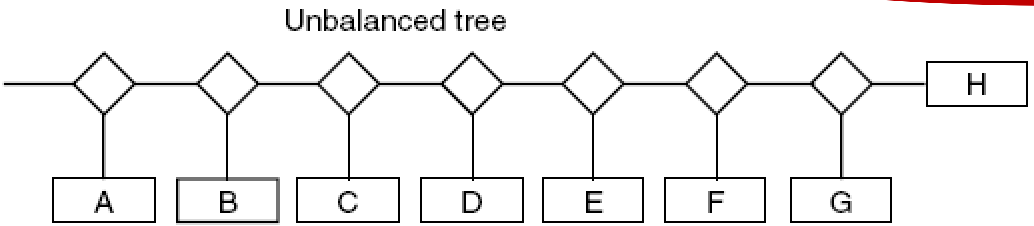

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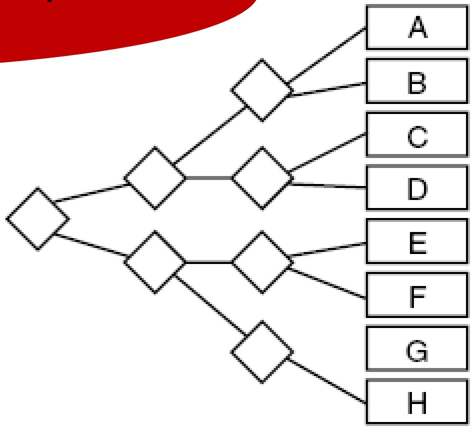

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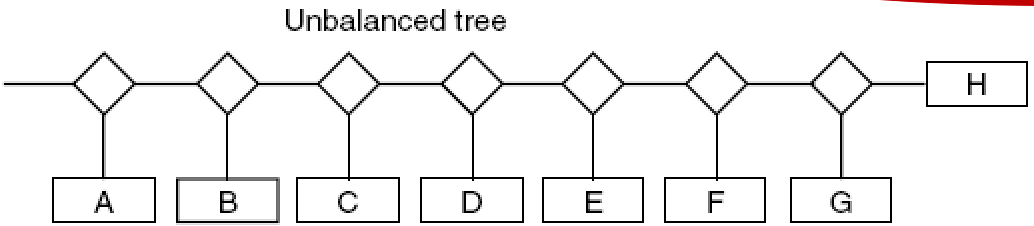

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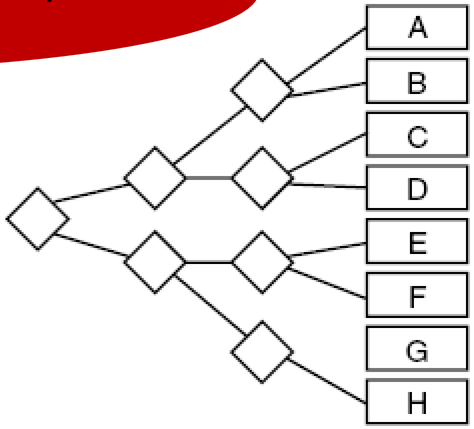

- Frequency (probability) of outcome (e.g., what if A happens 99% of the time)

- The computational complexity of the test (e.g., what if testing for G is very expensive)

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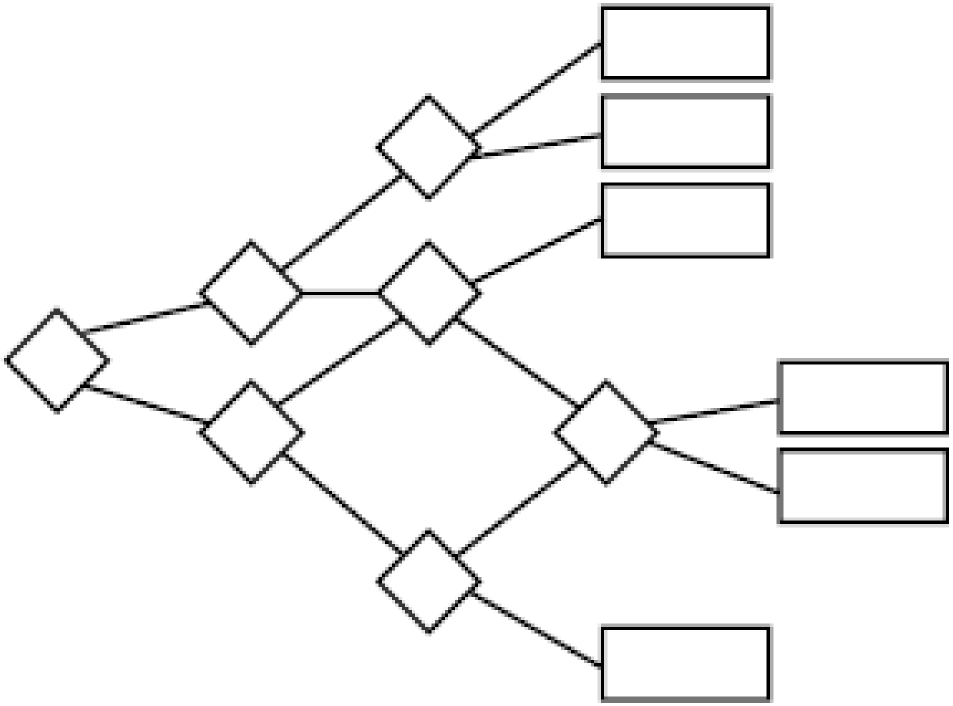
Decision Trees

- Making the decision tree traversal fast is important

Merging the branches:



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Decision Trees

- How to deal with the predictability of AI?

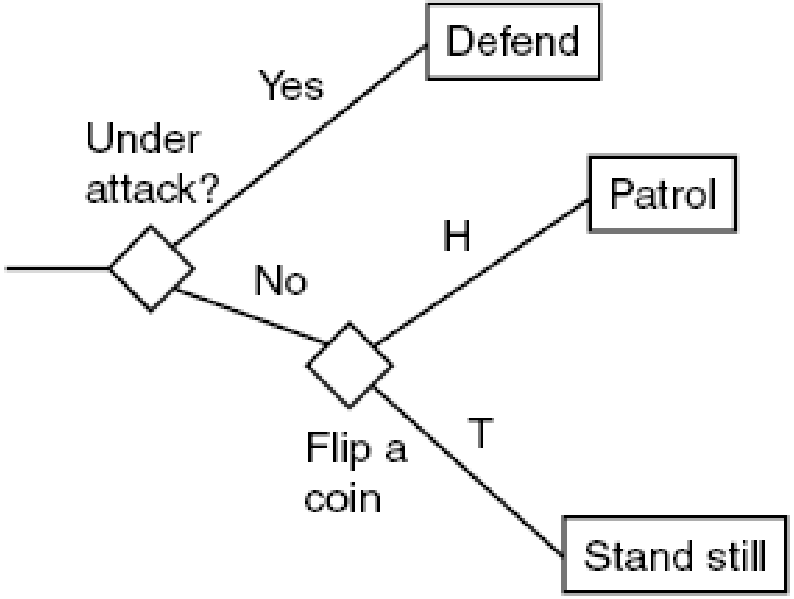
Any ideas?

Decision Trees

- How to deal with the predictability of AI?

  Random Decision Trees:

To avoid switching every frame: use hysteresis (memory)



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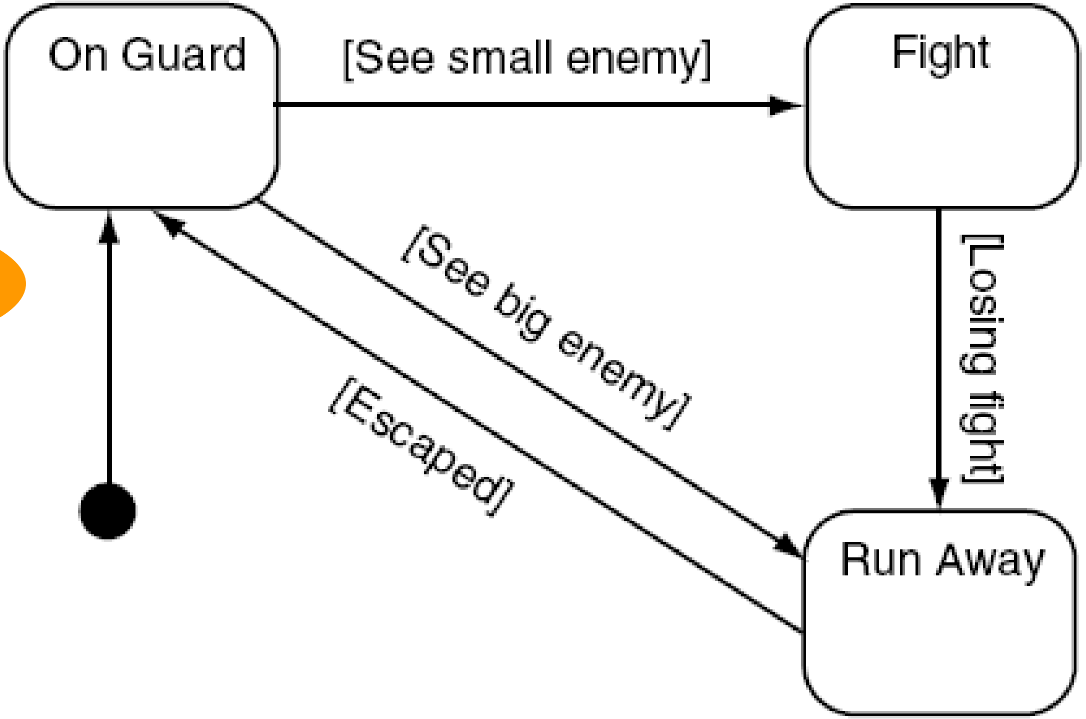
- Finite-state Machines
- Basic Behavior Trees

Finite State Machines

- Basic FSM



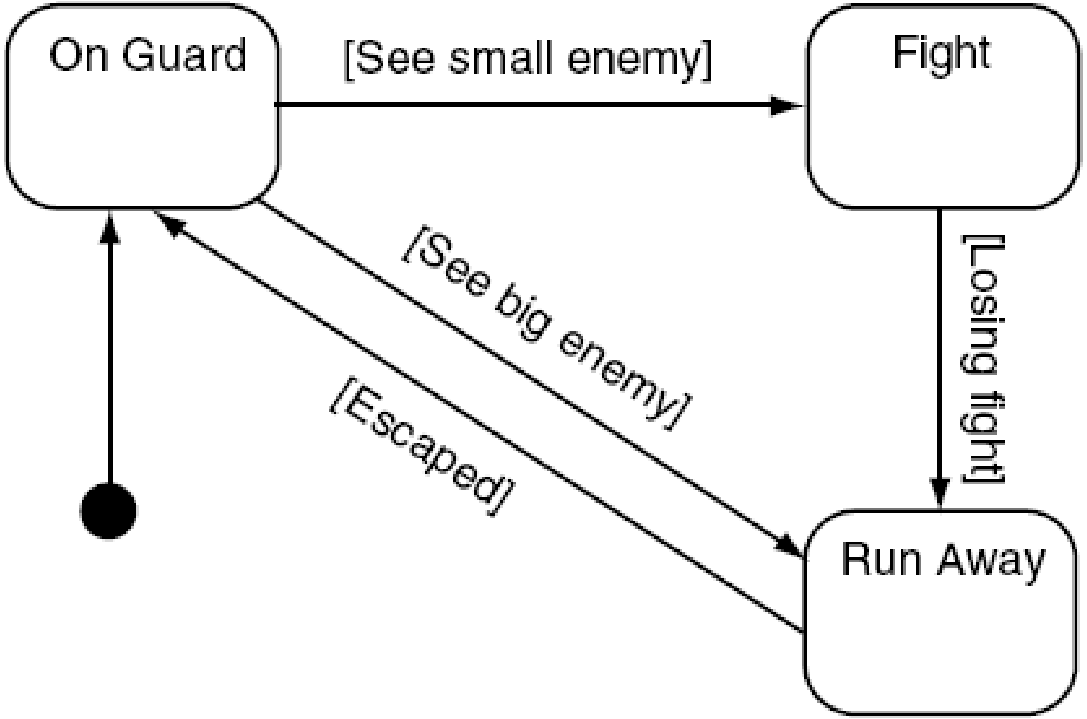
Initial State

from “Artificial Intelligence for Games” by I. Millington & J. y ge

Finite State Machines

- Basic FSM

Advantages over Decision Trees?



Disadvantages over Decision Trees?

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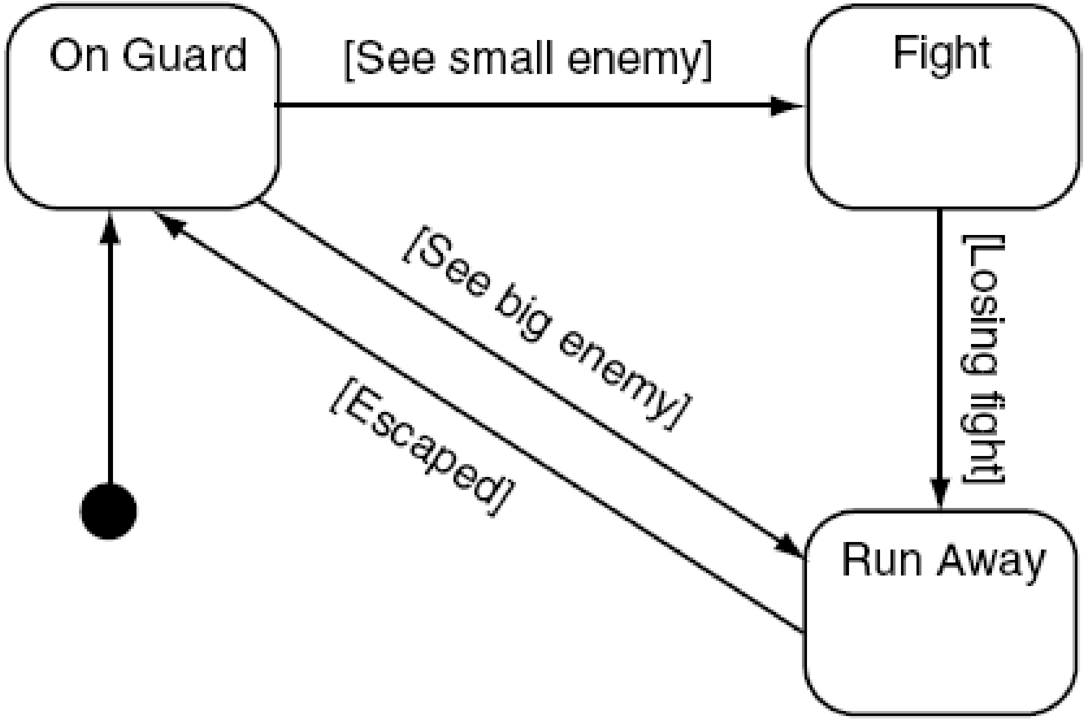
Finite State Machines

- Basic FSM

How to introduce unpredictability?



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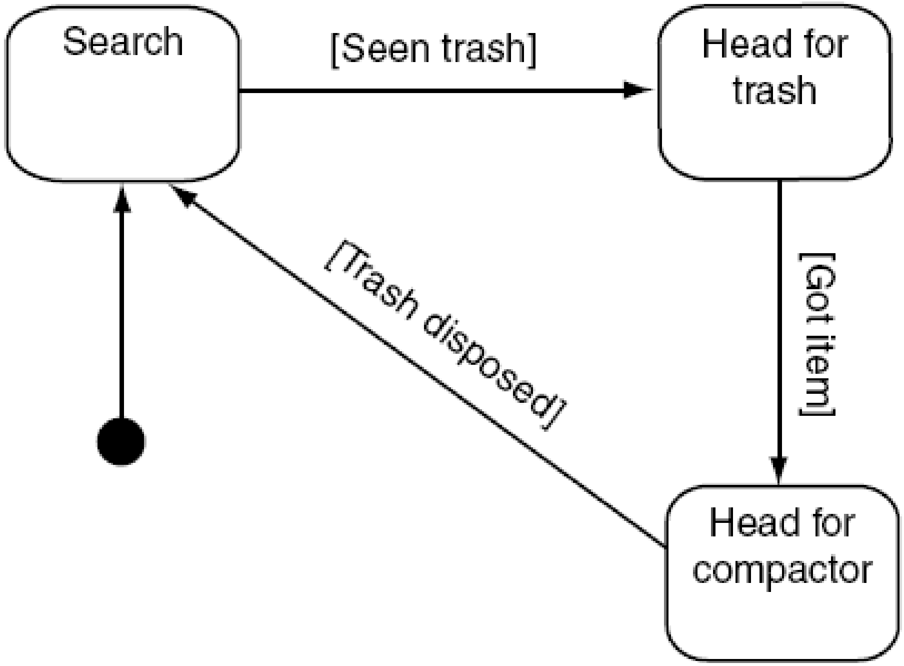
Finite State Machines

- Hierarchical FSM

How it changes to react to “re-charge now” alarm?



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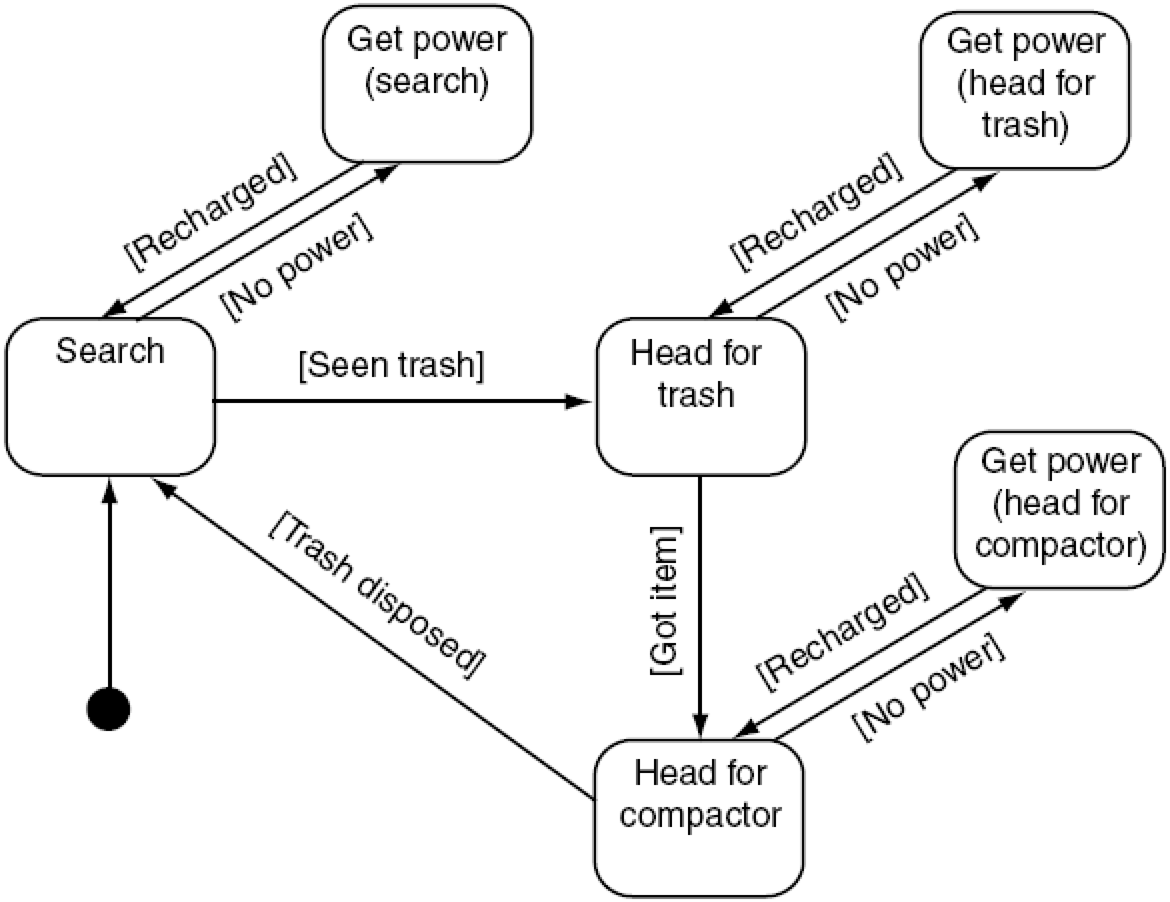

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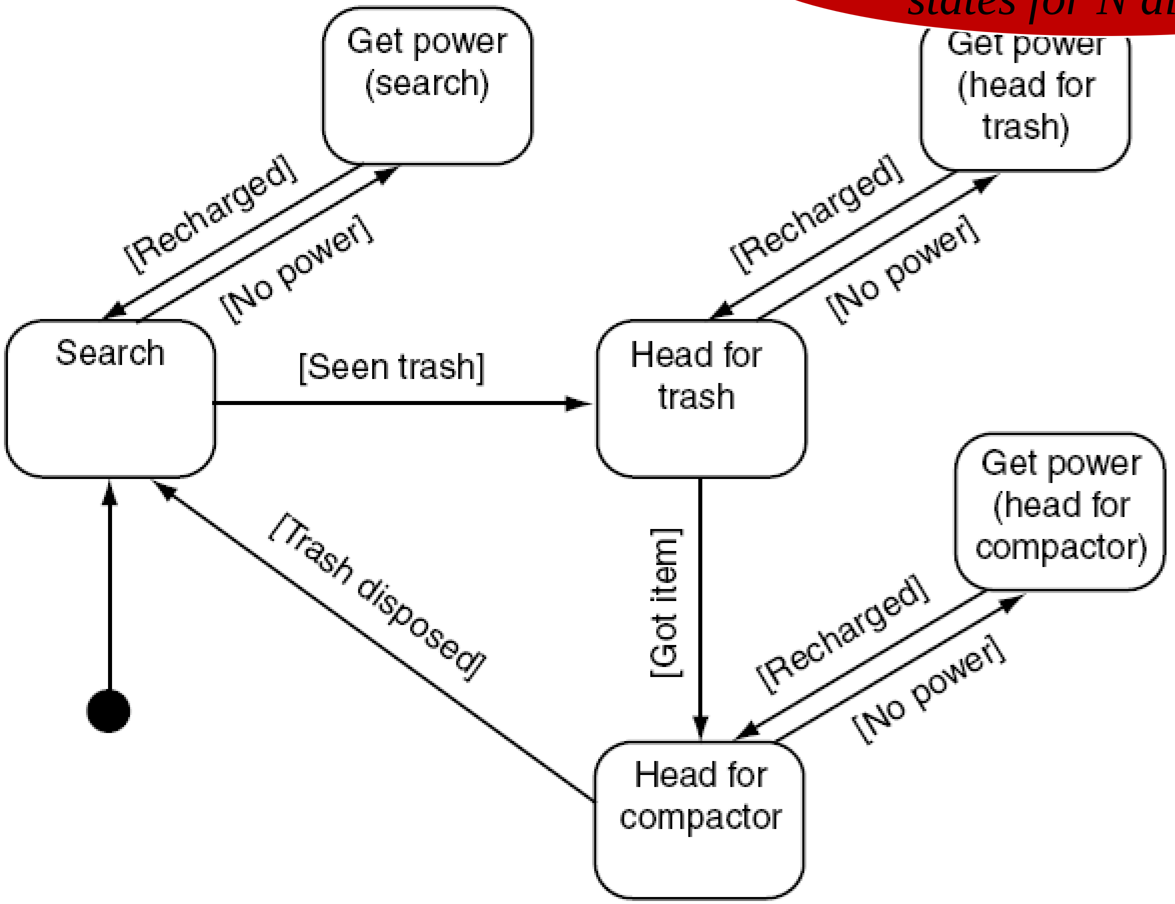
Finite State Machines

- Hierarchical FSM

What if an additional alarm?

Upper bound on # of states for N alarms?



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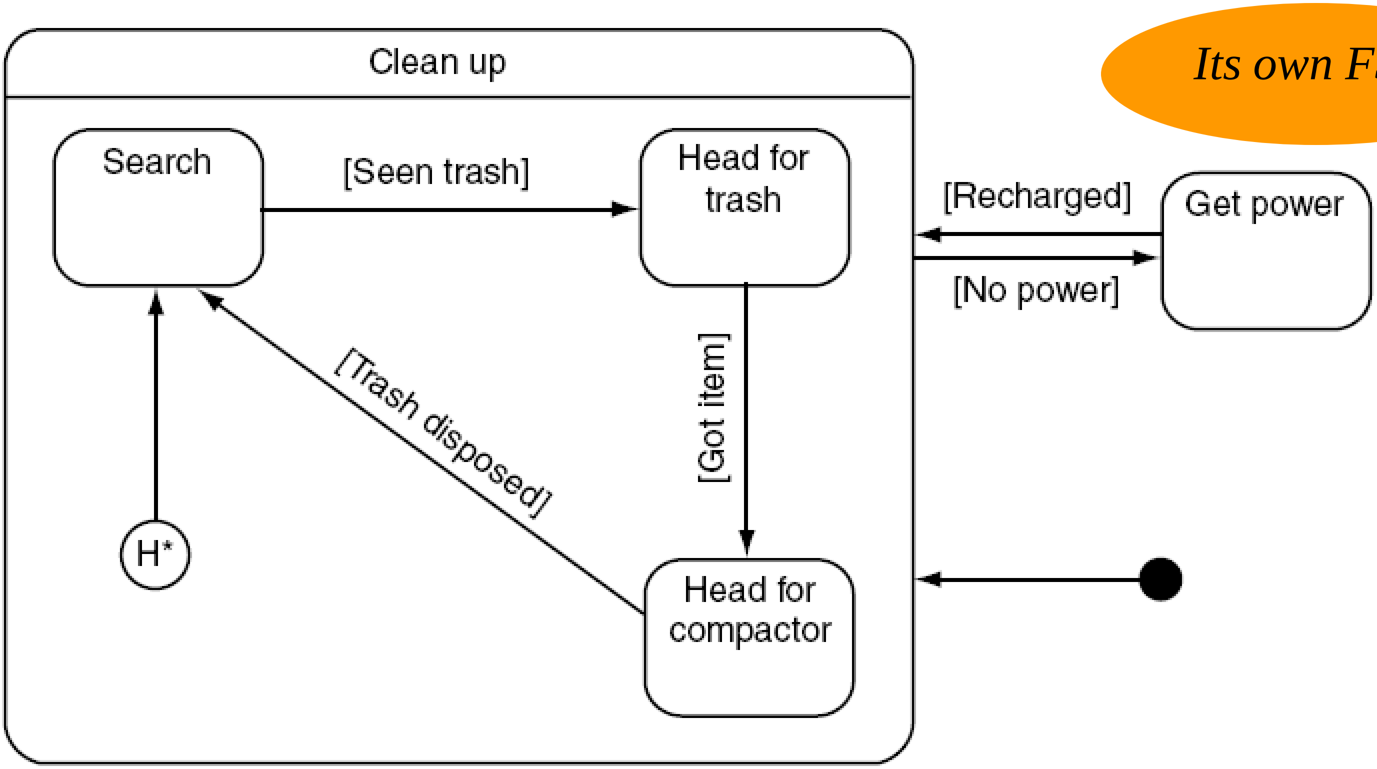
Finite State Machines

- Hierarchical FSM: strict hierarchy with only global alarms

State: [State at Level i, … State at Level 1] (for i ***active*** *FSMs)*
All triggers get acted upon by FSM at level i
Whenever FSM at Level i exits, FSM at level i-1 becomes dominant



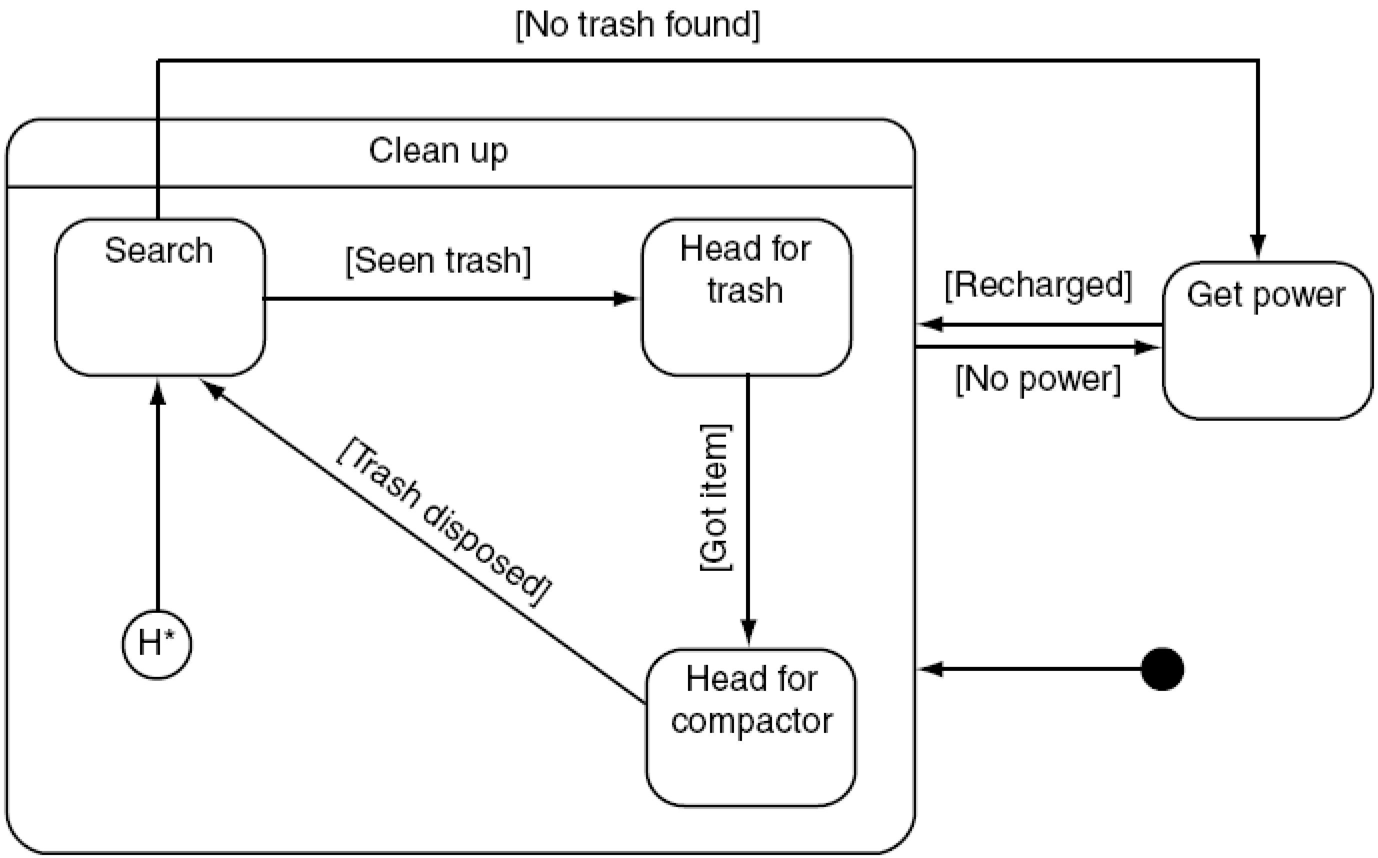
Its own FSM

from "Artificial Intelligence for Games" by I. Millington & J. y ge

Finite State Machines

- Hierarchical FSM: strict hierarchy with additional direct transitions

Direct transitions between levels allow to ***leave*** *the source state*



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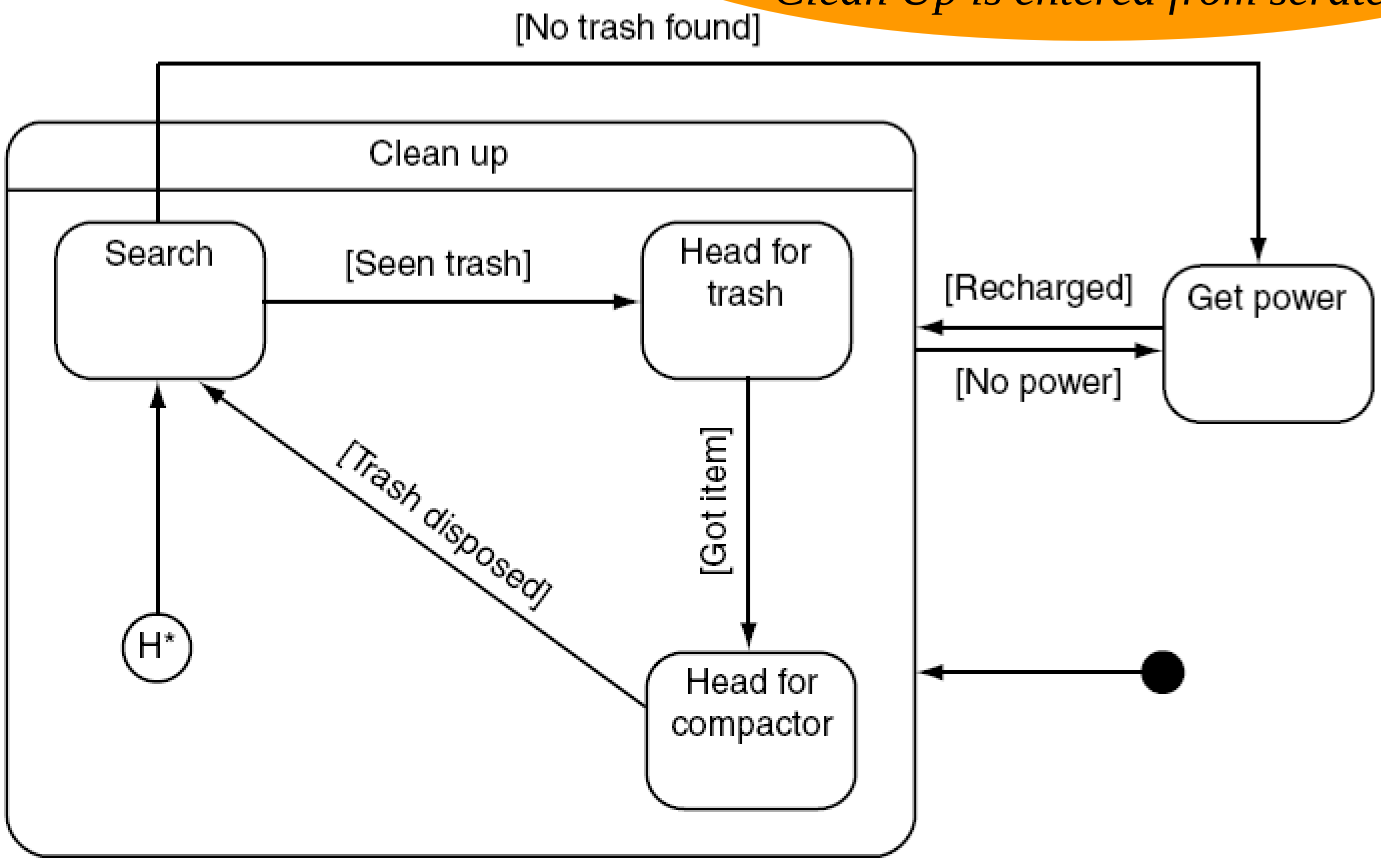
Finite State Machines

- Hierarchical FSM: strict hierarchy with additional direct transitions

Direct transitions between lev

Search state is left
When GetPower is done,
Clean Up is entered from scratch



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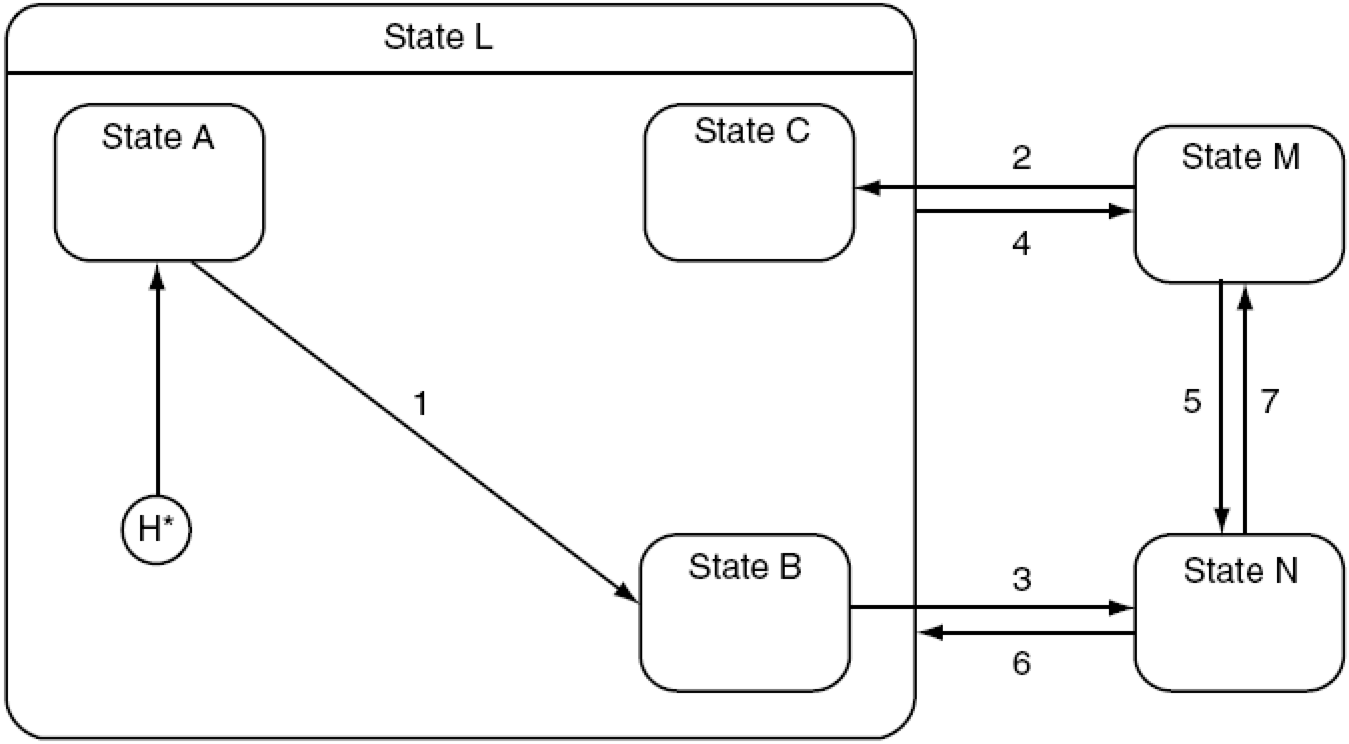
Finite State Machines

- Hierarchical FSM: strict hierarchy with additional direct transitions

More complex example:



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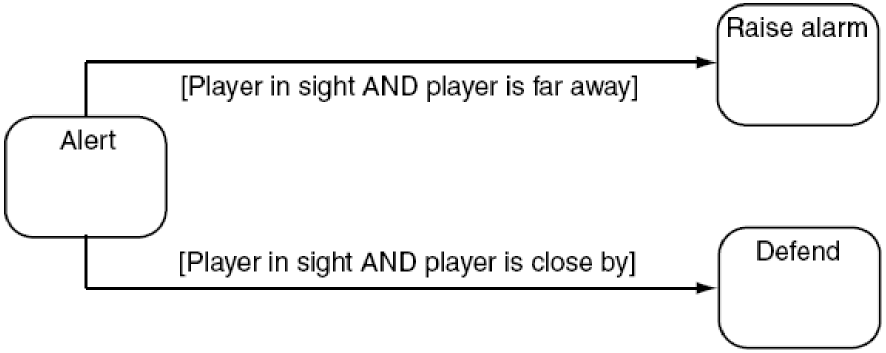
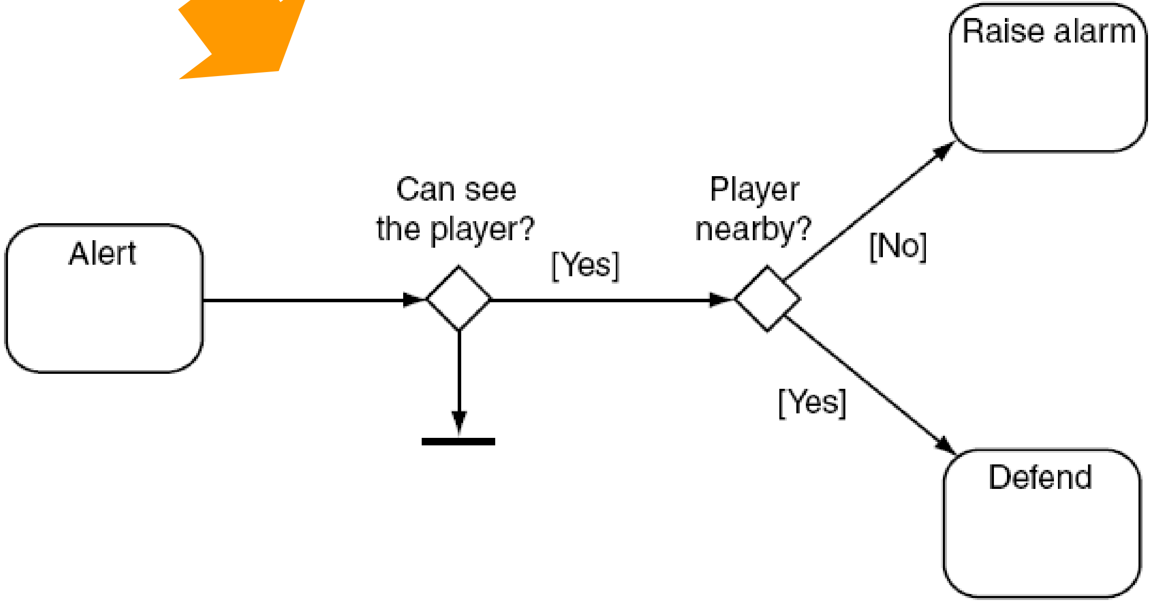
Finite State Machines

- Combining FSM and decision trees


Raise alarm
[Player in sight AND player is far away]
Alert
[Player in sight AND player is close by]
Defend

Why bother?



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Basic Behavior Trees

- Became very popular after Halo 2 game [2004]

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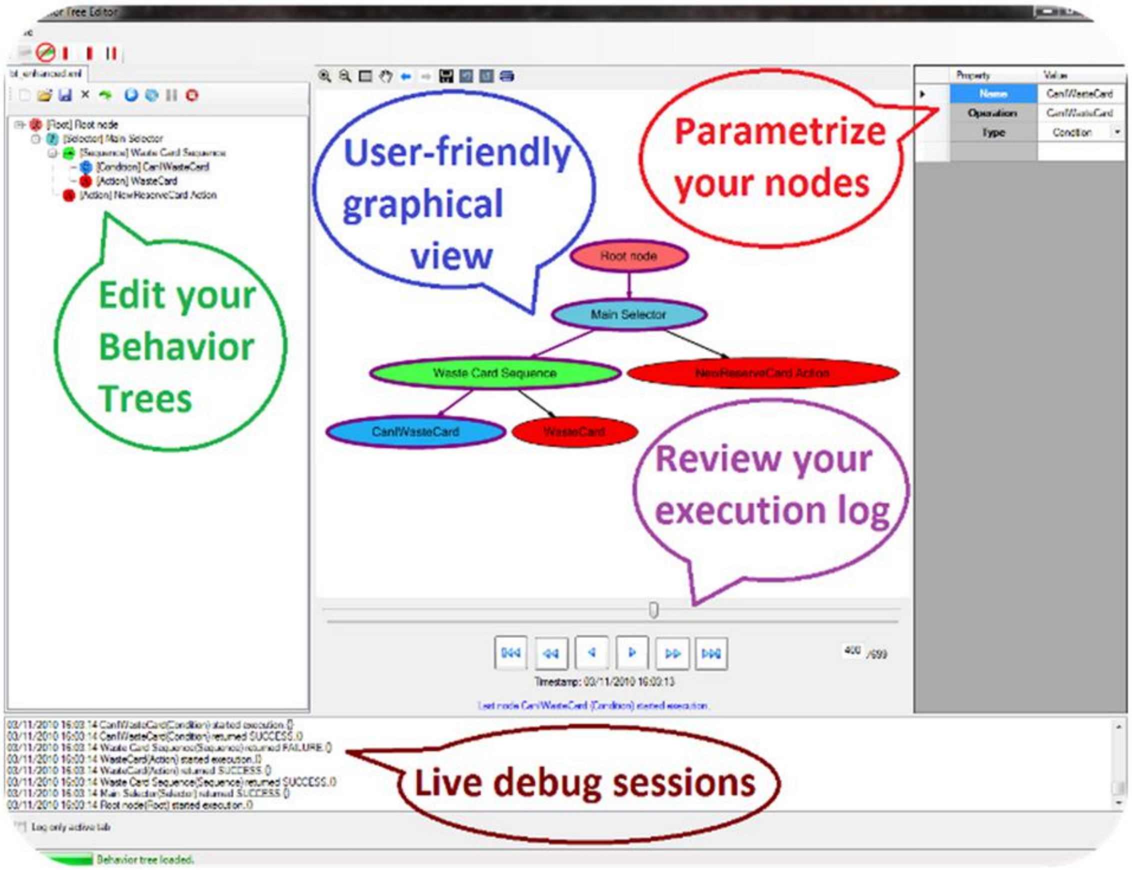
- Especially, when coupled with graphical interfaces to edit them



Property	Value
Name	CanIWasteCard
Operation	CanIWasteCard
Type	Condition

Timestamp: 03/11/2010 16:03:13

Last node CanIWasteCard (Condition) started execution.

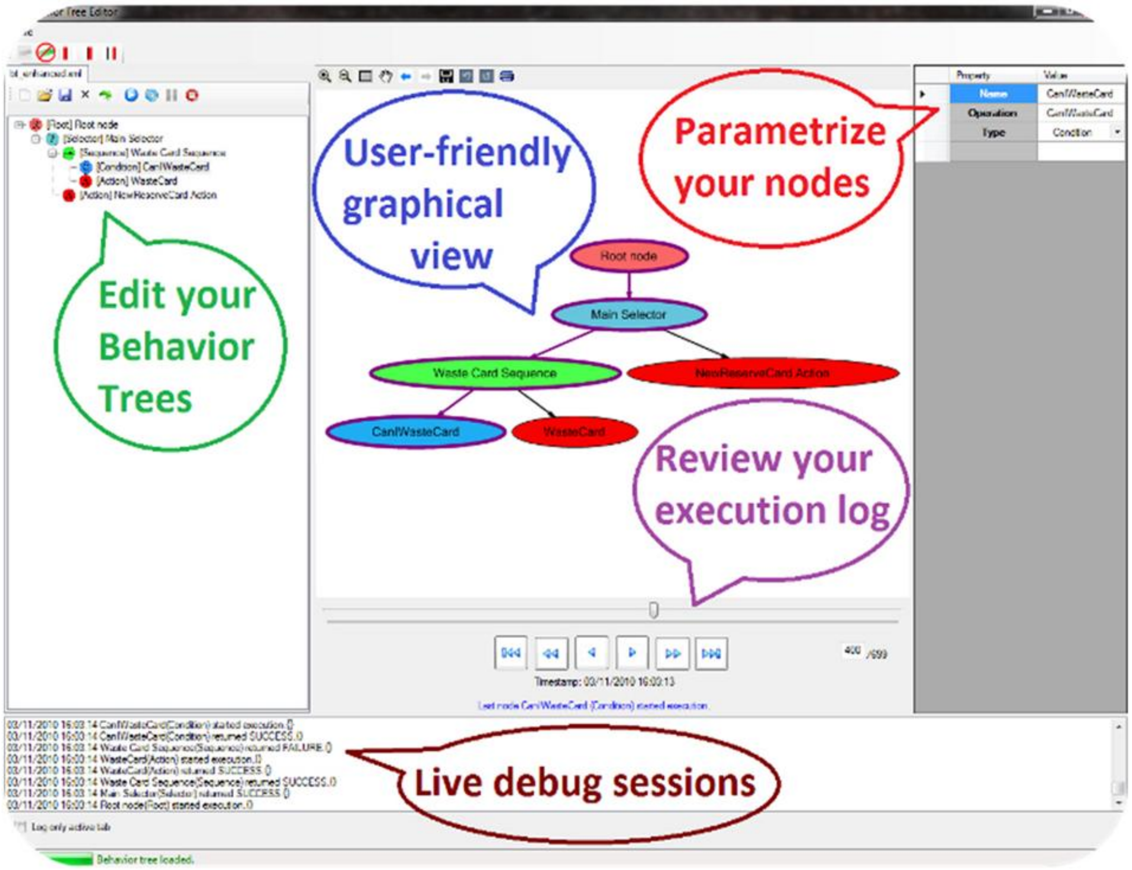
```
03/11/2010 16:03:14 CanIWasteCard(Condition) started execution.()
03/11/2010 16:03:14 CanIWasteCard(Condition) returned SUCCESS.()
03/11/2010 16:03:14 Waste Card Sequence(Sequence) returned FAILURE.()
03/11/2010 16:03:14 WasteCard(Action) started execution.()
03/11/2010 16:03:14 WasteCard(Action) returned SUCCESS.()
03/11/2010 16:03:14 Waste Card Sequence(Sequence) returned SUCCESS.()
03/11/2010 16:03:14 Main Selector(Selector) returned SUCCESS.()
03/11/2010 16:03:14 Root node(Root) started execution.()
```

Behavior tree loaded.

Screenshot of GameBrains GUI

Basic Behavior Trees

- Collection of simple tasks arranged in a tree structure
- One of the main advantages: Tasks and sub-trees can be reused!!!



[Root] Root node
[Selector] Main Selector
[Sequence] Waste Card Sequence
[Condition] CanIWasteCard
[Action] WasteCard
[Action] NewReserveCard Action

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☐ Log only active tab

Behavior tree loaded.

Screenshot of GameBrains GUI

Basic Behavior Trees

- Type of tasks: *Conditions, Actions and Composites*
- Each returning either success or failure

*“**Condition**” task tests for a condition*

Examples of behavior trees that consist of Conditions tasks only:

Door open?

Health level OK?

Enemy close-by?

…

Basic Behavior Trees

- Type of tasks: *Conditions*, *Actions and Composites*
- Each returning either success or failure

*“**Action**” task alters the state of the game*

Examples of behavior trees that consist of Actions tasks only:

Move to room *Find a path* *Play audio sound* *Talk to the player* …

Basic Behavior Trees

- Type of tasks: *Conditions, Actions and Composites*
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Condition and Action tasks are always at the leafs of the tree
*"**Composite**" task sequences through them*

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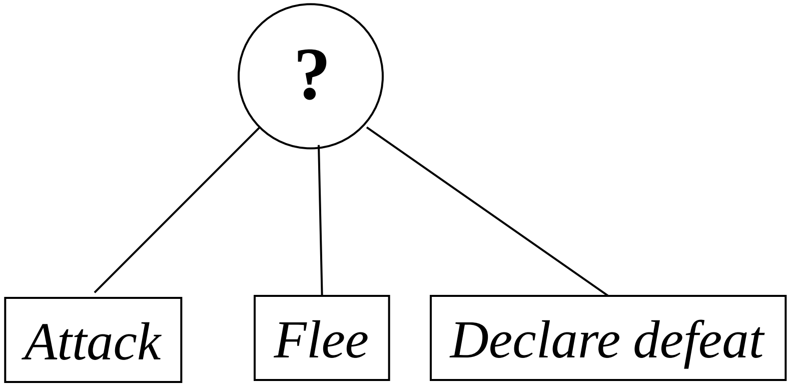
Two types of Composite tasks:

***Selector** returns as soon as the first leaf task is successful*



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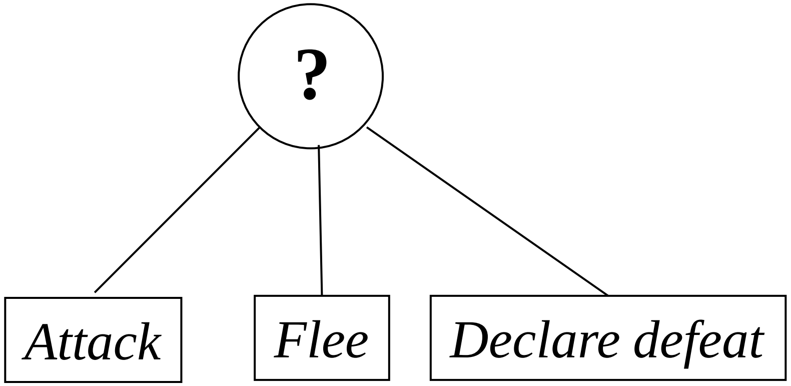

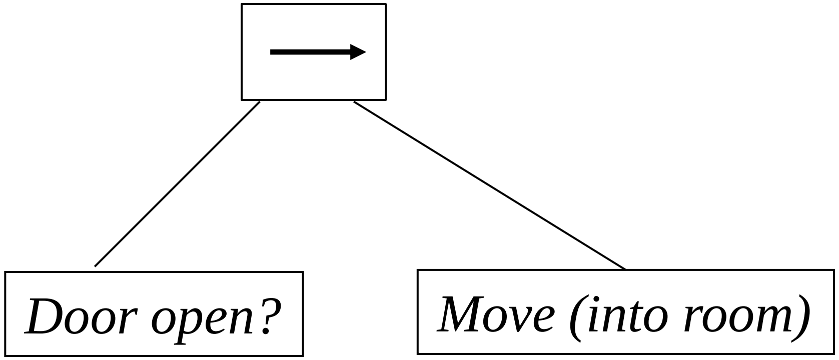

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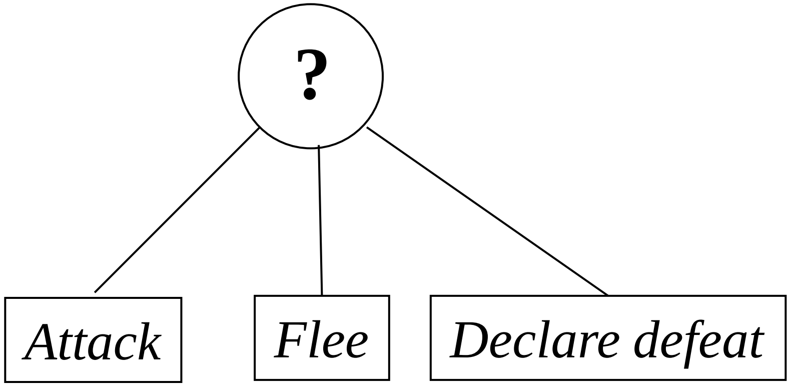
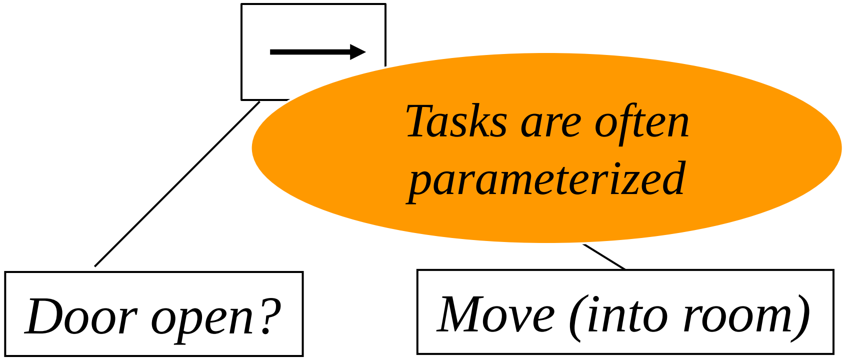


?

Attack

Flee

Declare defeat



⟶

Door open?

Move (into room)

Tasks are often parameterized

Basic Behavior Trees

- Type of tasks: *Conditions, Actions and Composites*
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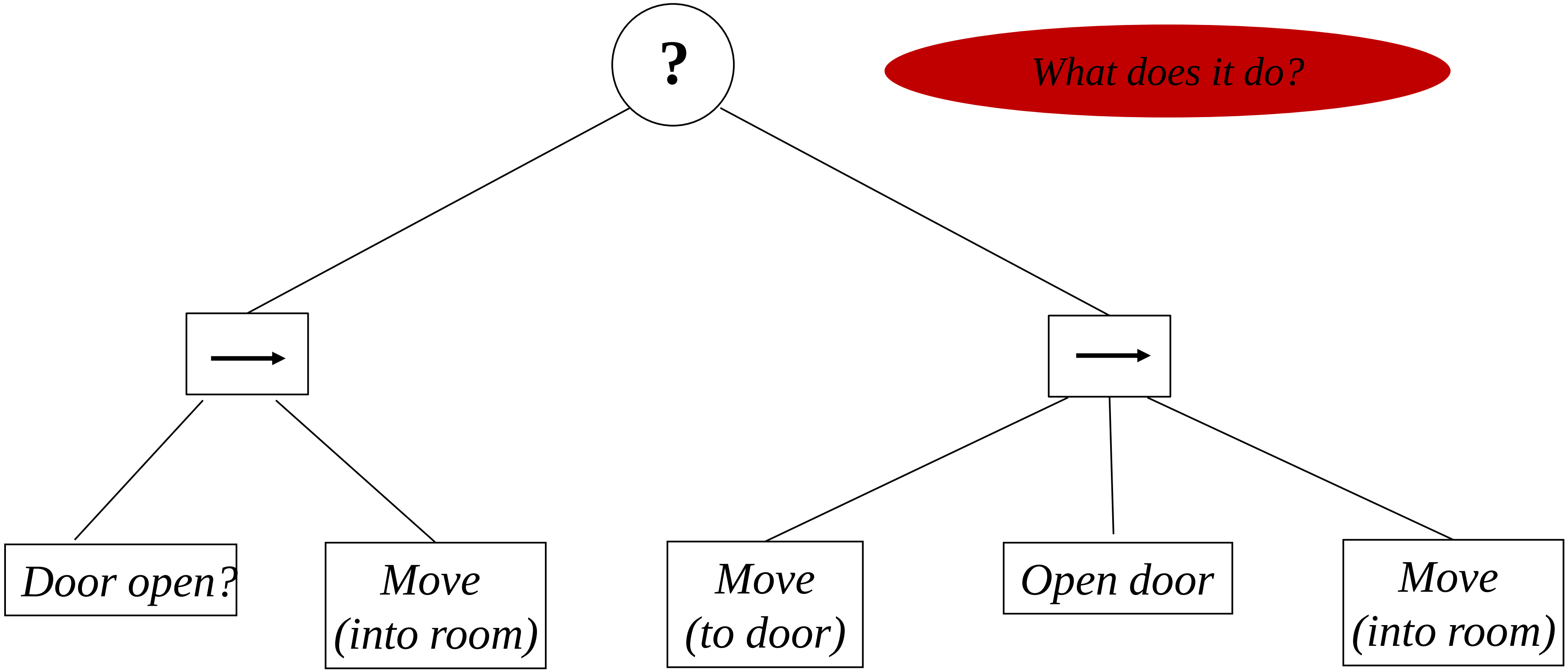
Example:



What does it do?

Basic Behavior Trees

- Type of tasks: *Conditions, Actions and Composites*
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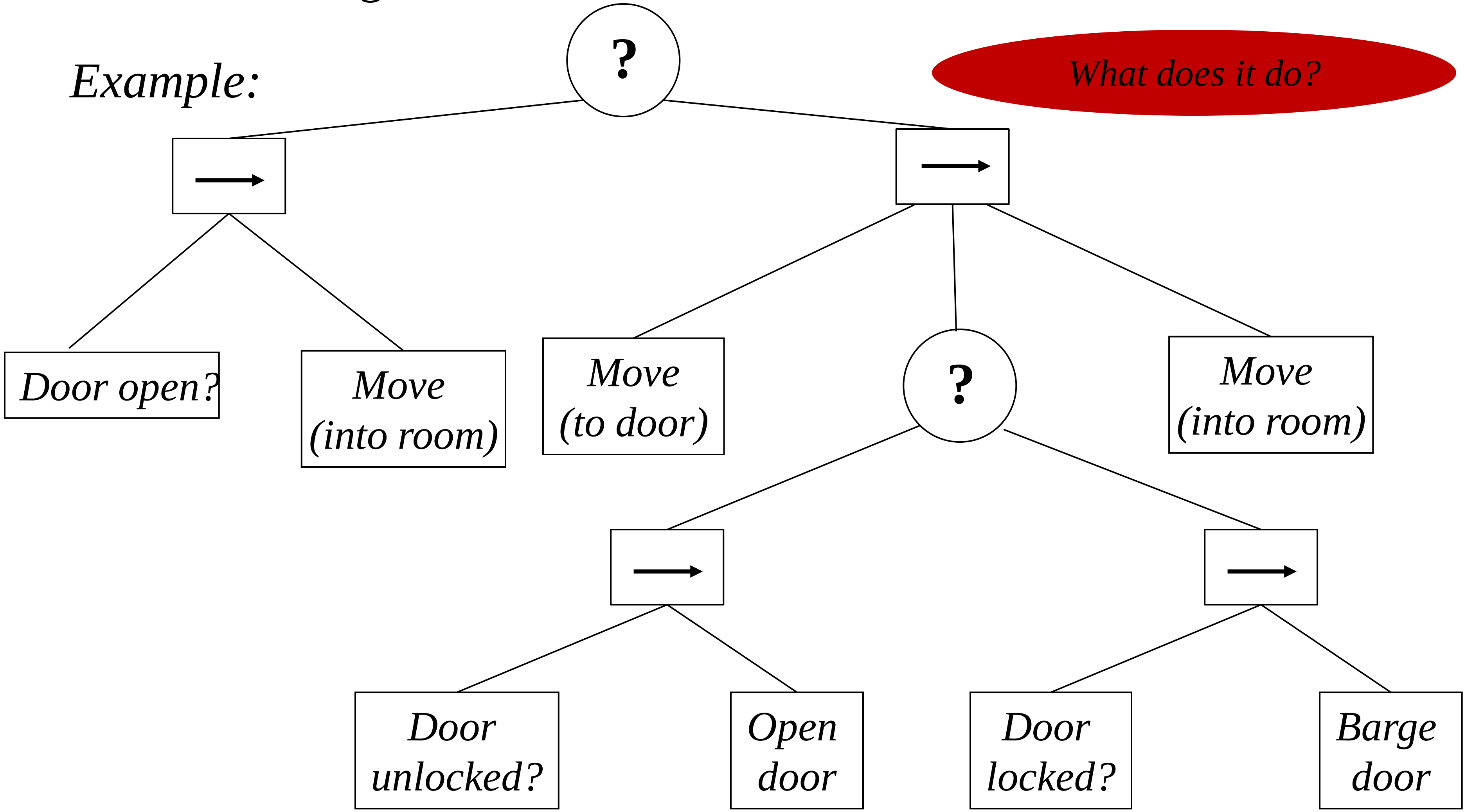
Example:



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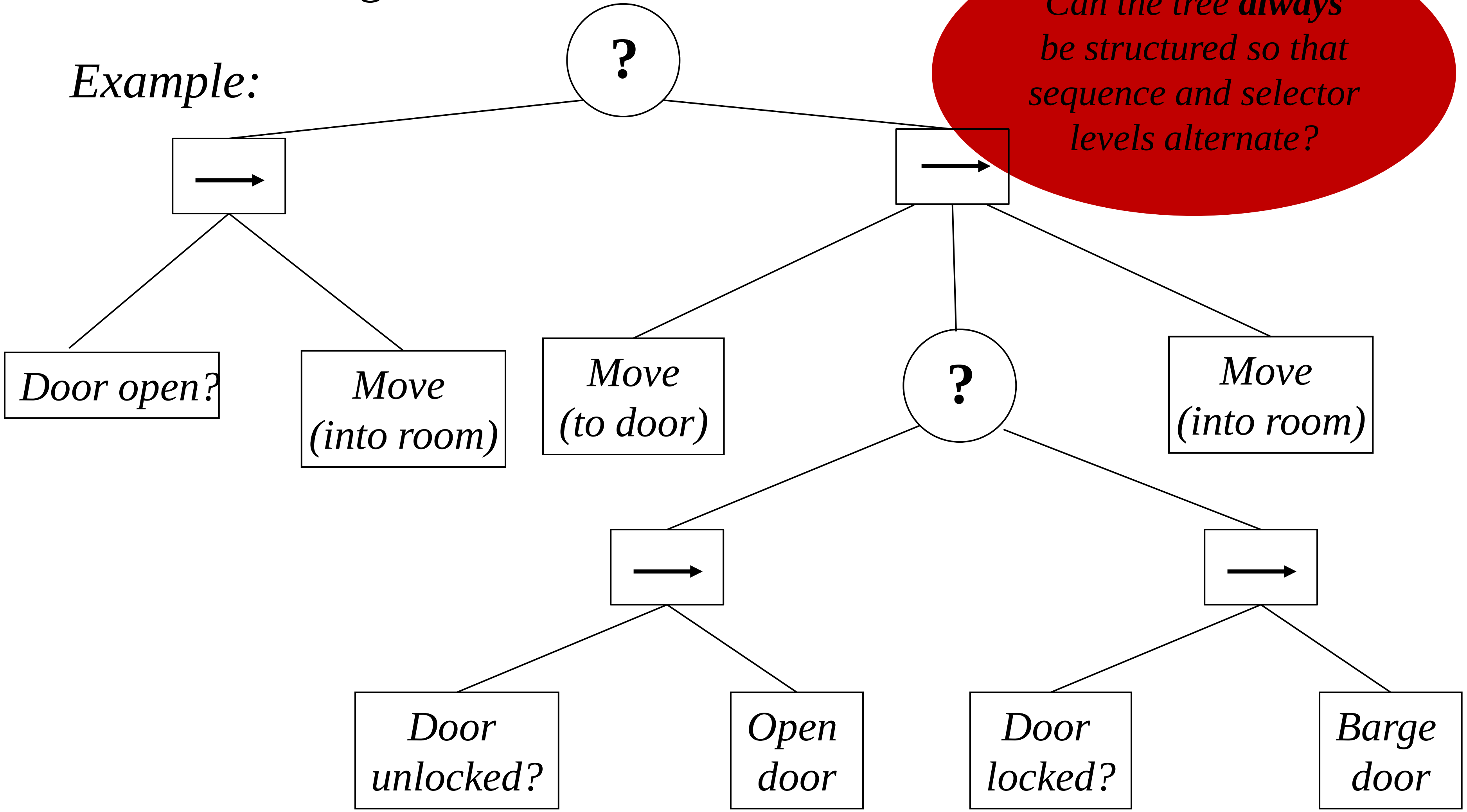

Can the tree ***always*** *be structured so that sequence and selector levels alternate?*

Basic Behavior Trees

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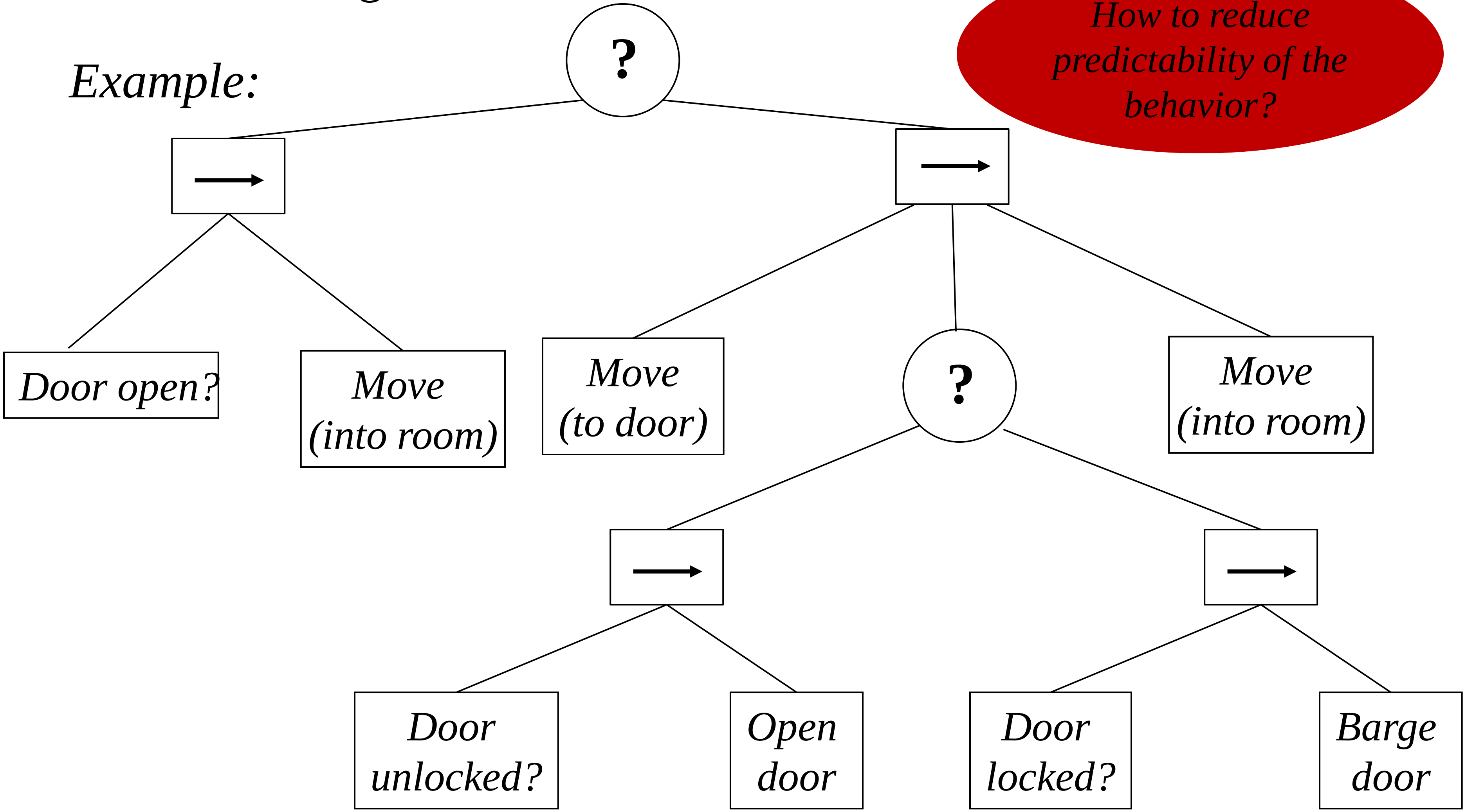
Example:



How to reduce predictability of the behavior?

Basic Behavior Trees

- Behavior trees with **Order Randomization for some Sequencers and Selectors**

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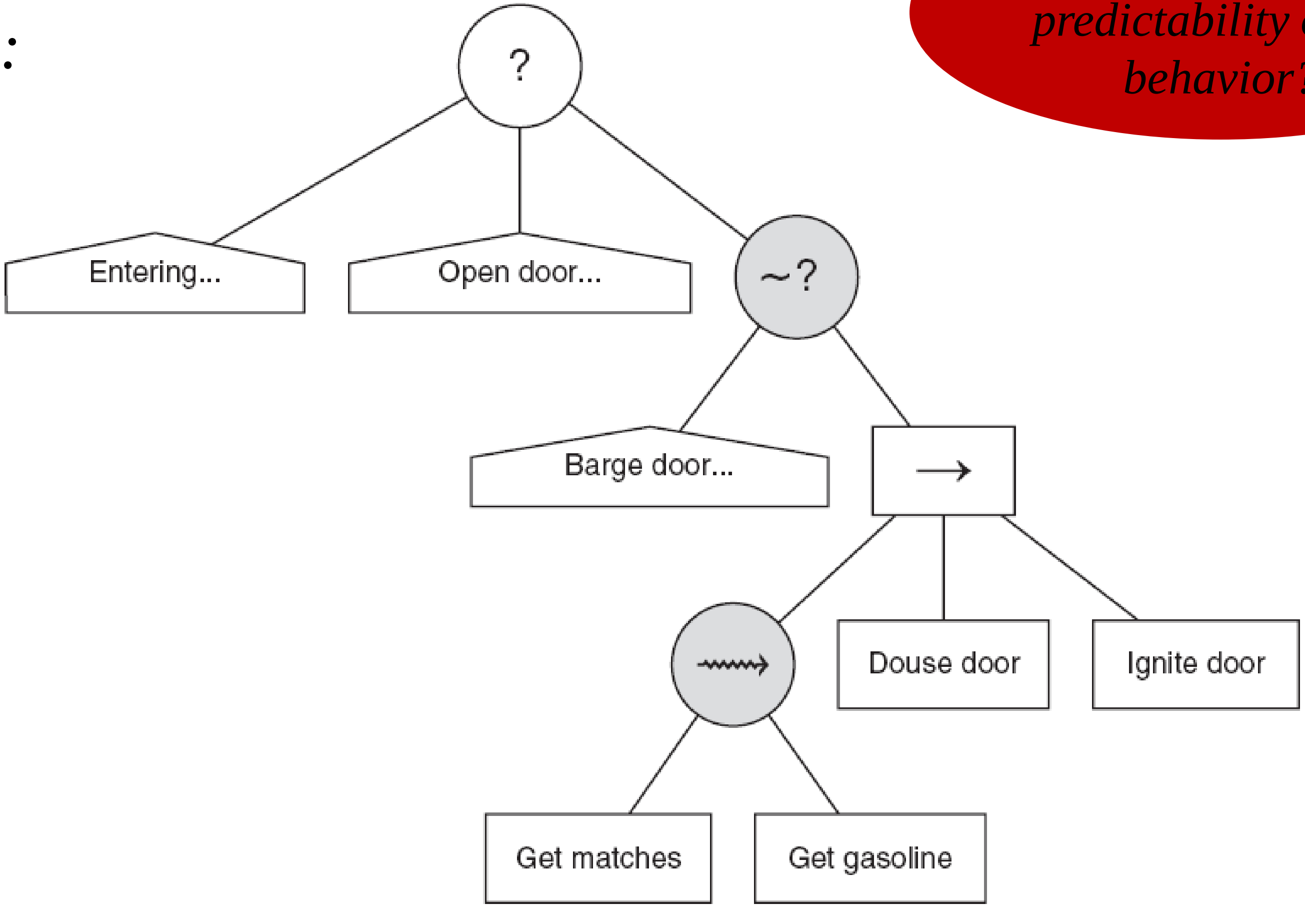
Example:



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