Introduction to Belief Desire Intention Agents

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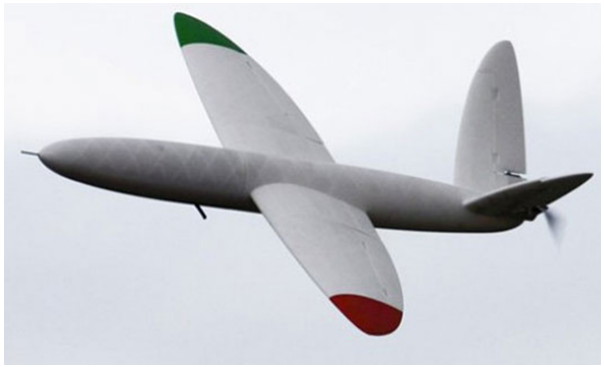
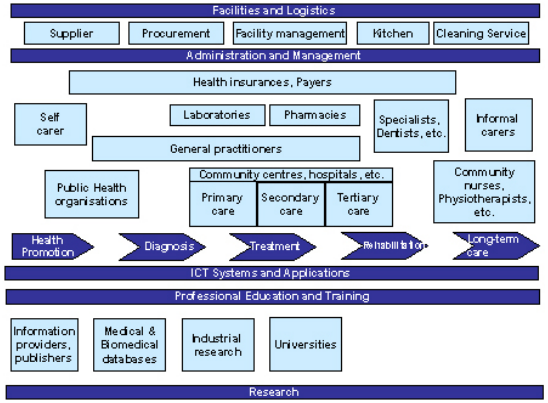
BDI Agent Systems Useful in Many Applications



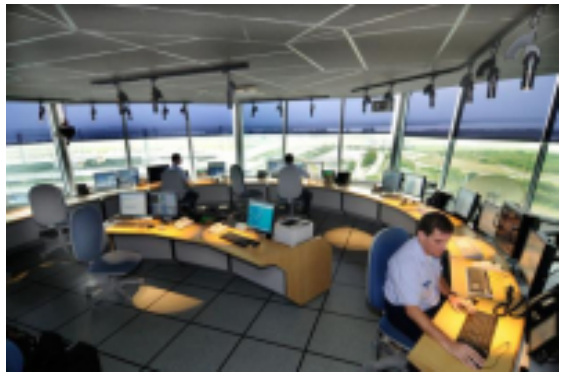
Unmanned (Aerial) Vehicles

Logistics



E-Health

Trading Agents

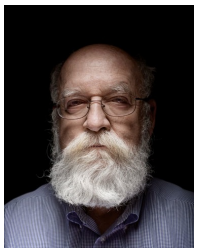


Air Traffic Control

BDI (Belief Desire Intention) agents have been used in many successful applications in complex environments.

Belief Desire Intention Model of Agency

- BDI is a framework for describing the behaviour of rational agents.
- Based on work in the philosophy of mind:



Dennett

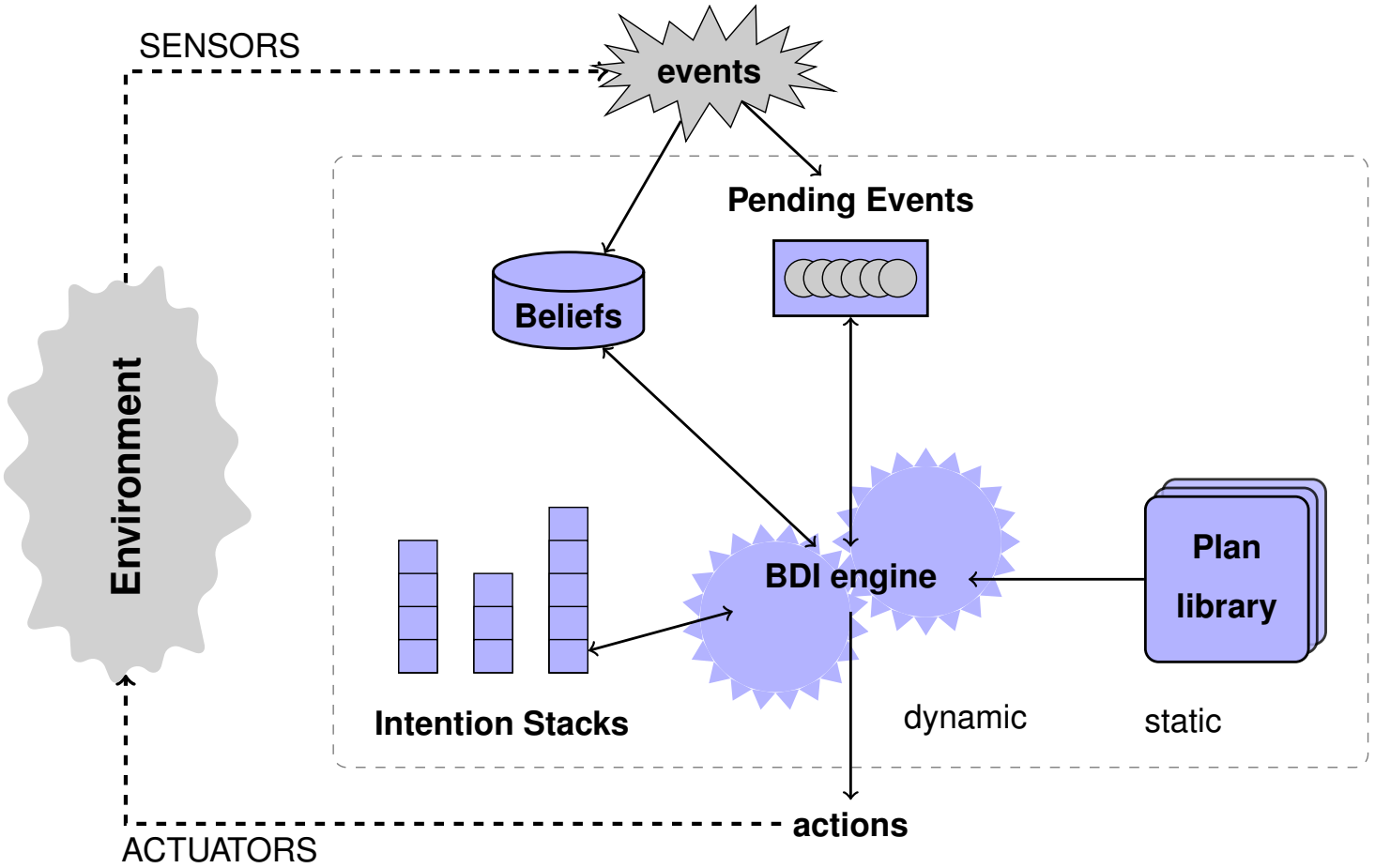
Intentional systems:
"[..] whose behavior can be predicted by the method of attributing belief, desires and rational acumen."

Bratman

Practical reasoning:
"[..] a matter of weighing conflicting considerations [..] provided by what the agent desires [and] believes."

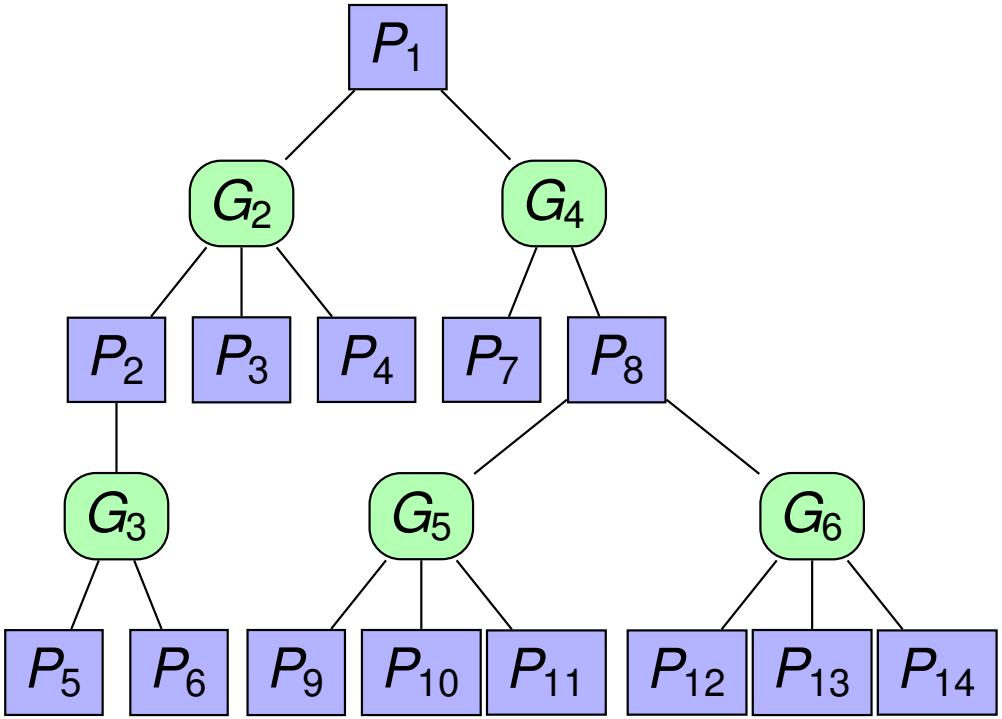
- Human practical reasoning consists of two activities:
  - Deliberation: deciding what to do i.e., form intentions.
  - Means-ends Reasoning: deciding how to do it i.e., form plans.

Belief-Desire-Intention (BDI) Agent Architecture



A plan is a *programmed* recipe for achieving a goal in some situation.
A BDI execution engine selects from a plan library, based on the situation.

Goal-Plan Tree: Decomposition and Selection

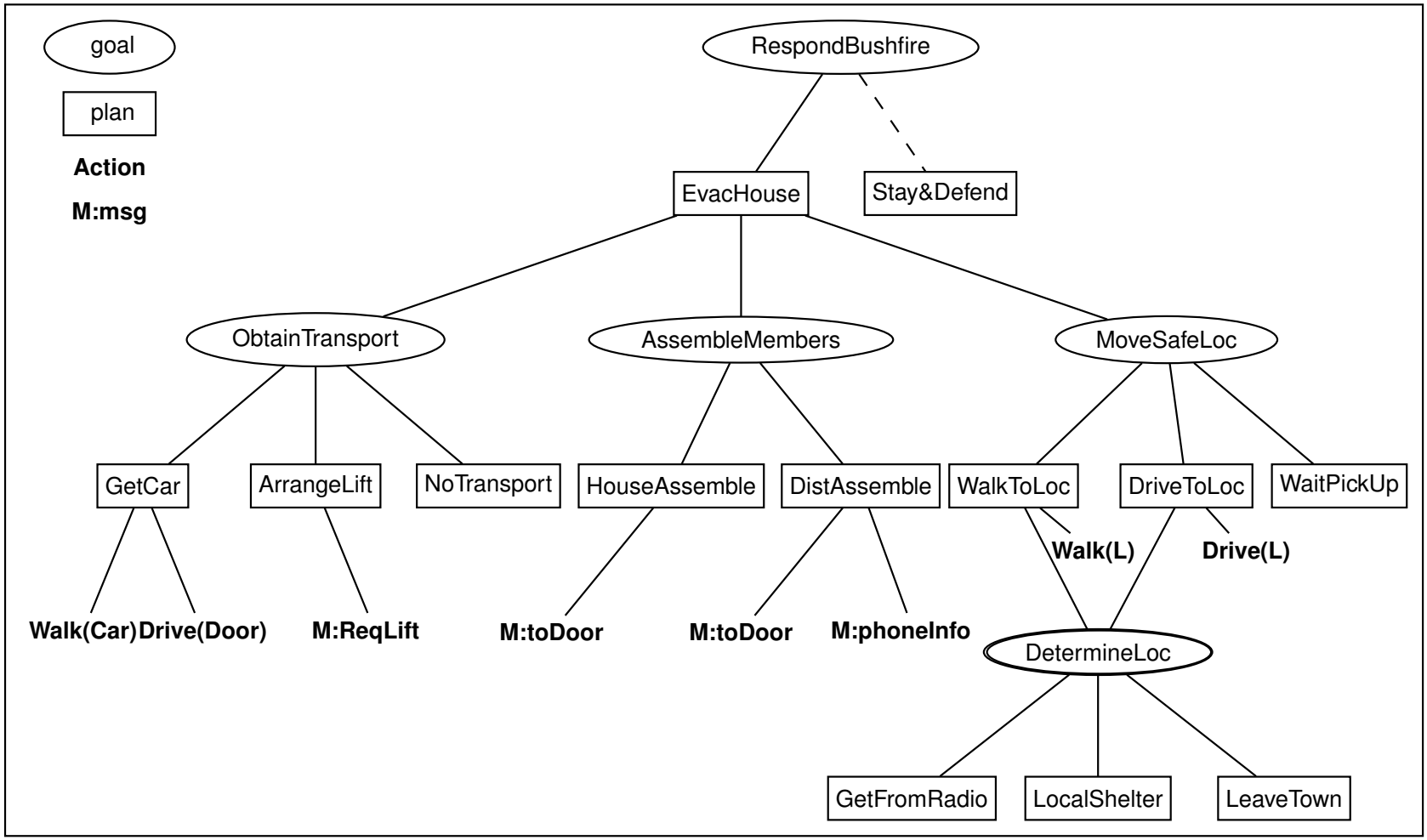


- A plan typically has a number of (sub)goal steps.
- Each sub-goal generates an (internal) event which has some relevant plans.
- So the plan library can be seen as a set of goal-plan trees.
- At each goal node a plan must be selected (OR).
- At each plan node the goals must be accomplished (AND).

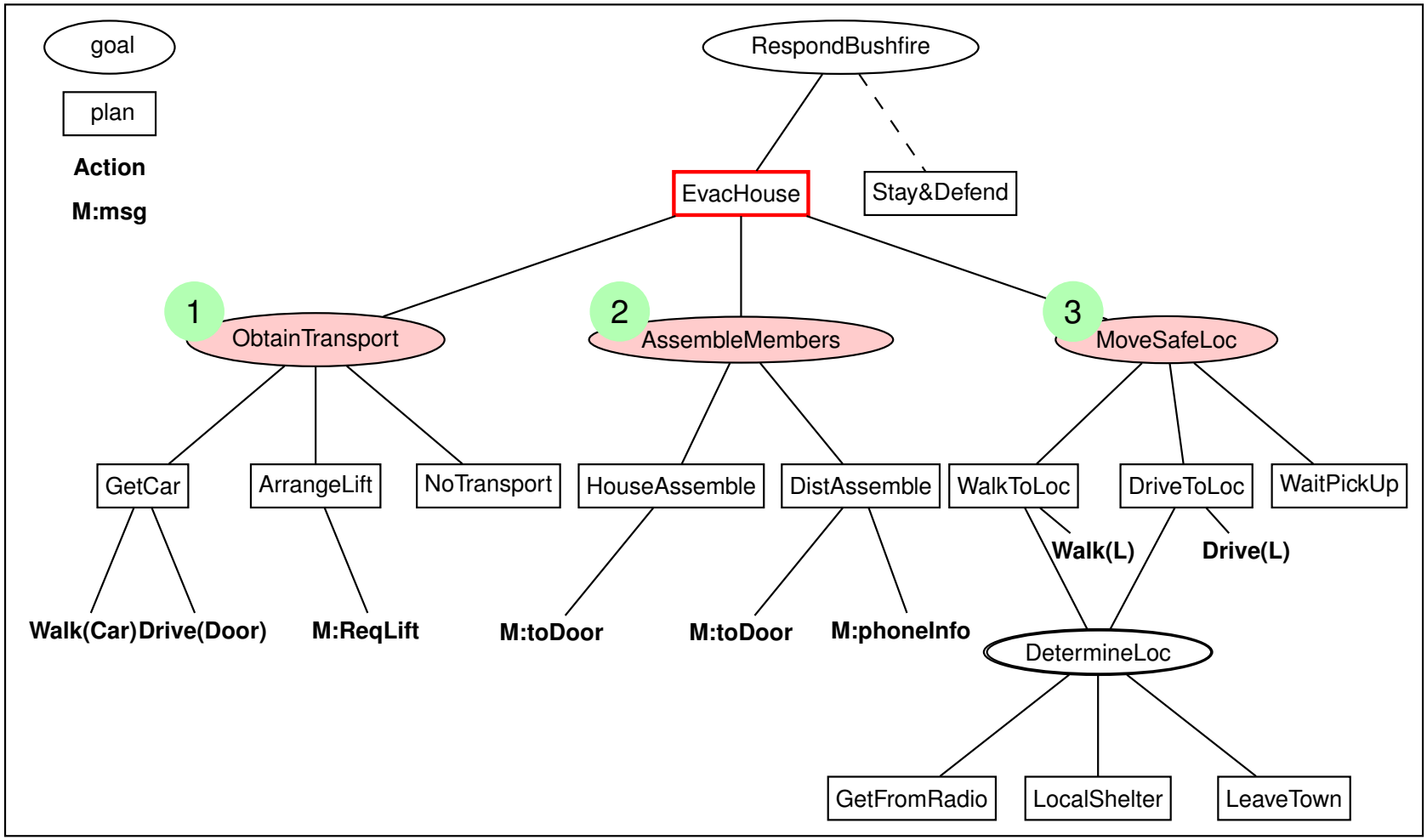
BDI Agent Oriented Programming

- BDI Agent-Oriented Programming provides abstraction at the level of mental attitudes to explain the operation of a system. Beliefs, Desires, Intentions.
- The modularity of plans makes it easy to develop complexity incrementally.
- The goal oriented approach makes it suitable for use in dynamic environments.
- Many efficient and powerful development environments available. JACK, Jadex, Jason, PRS, 2APL, ...
- BDI agent programs are fast to develop. A 2006 study showed:
  - Gain compared to Java programming 500%.

Example Plan Structure

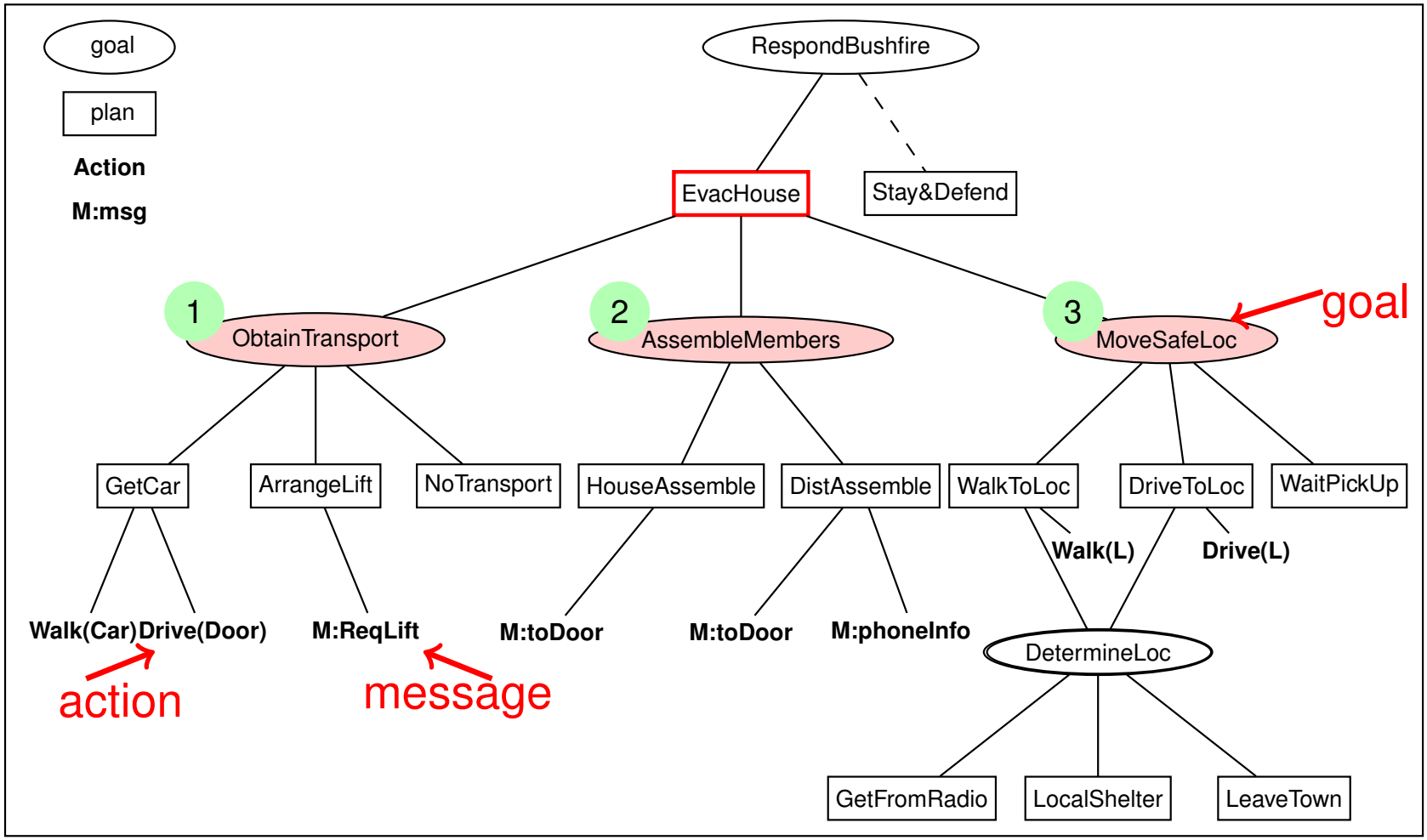


Example Plan Structure



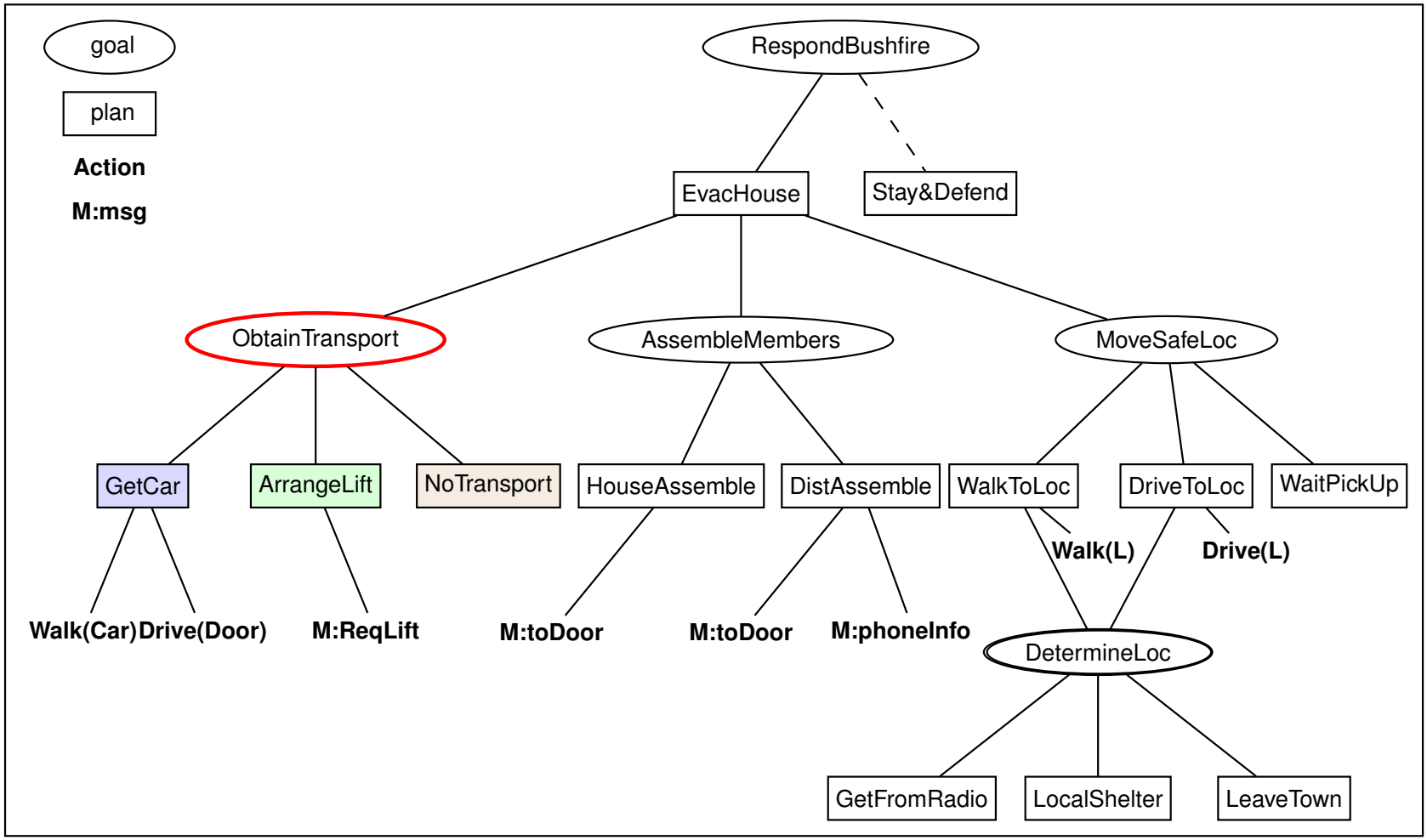
A plan is a sequence of steps

Example Plan Structure



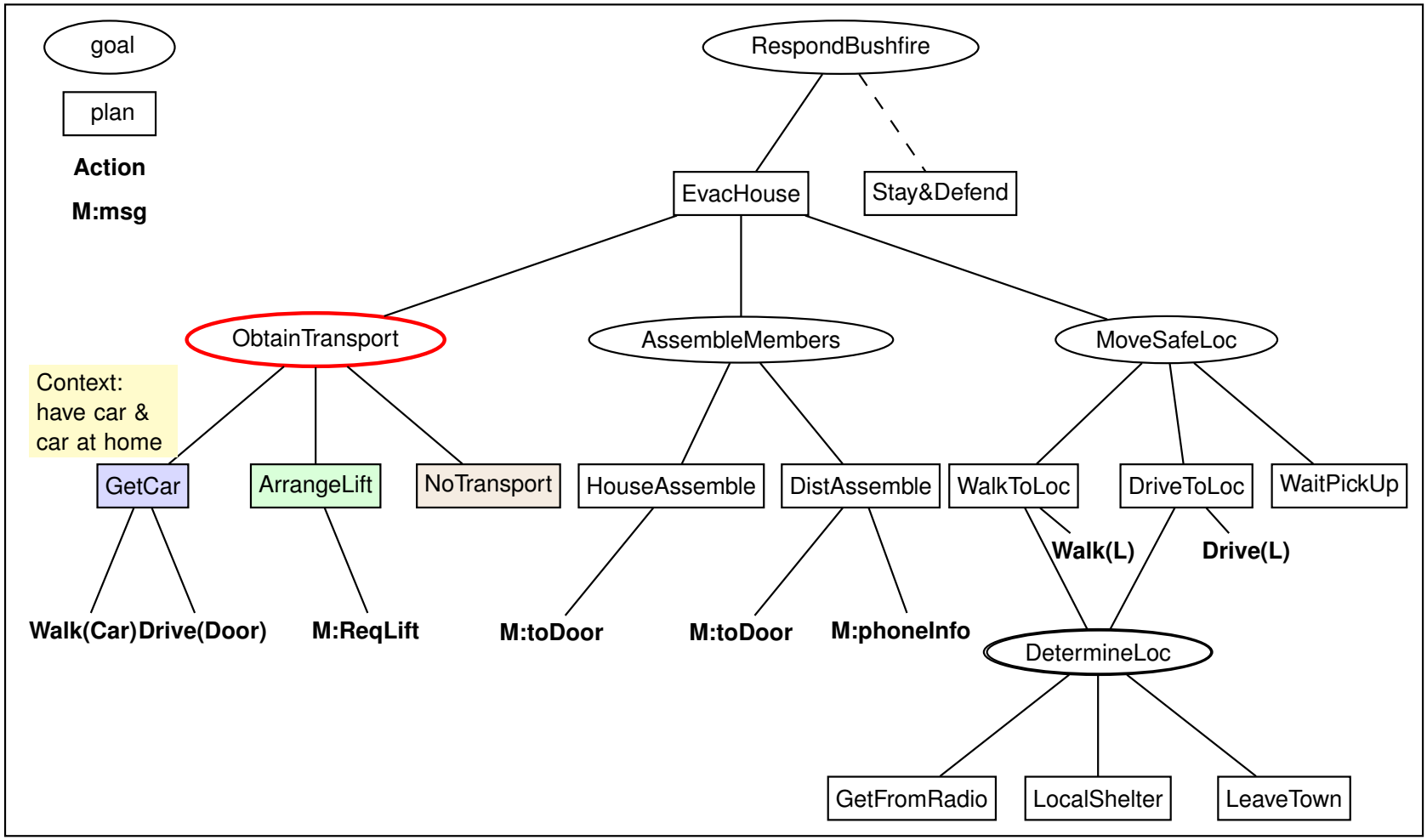
A step can be a goal, an action, a message to another agent, or some computation.

Example Plan Structure



A goal may have different plans, for achieving it in different situations.

Example Plan Structure



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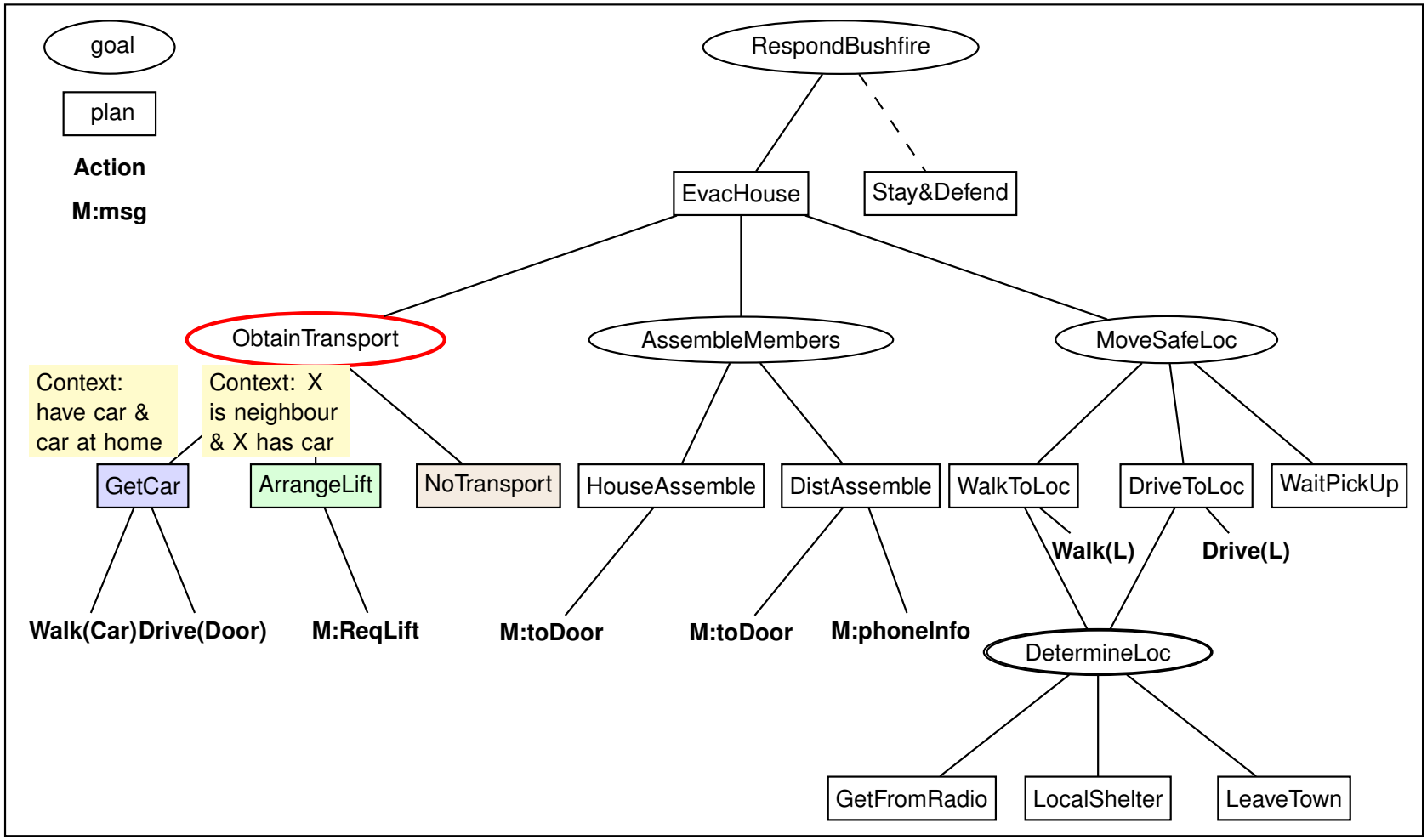

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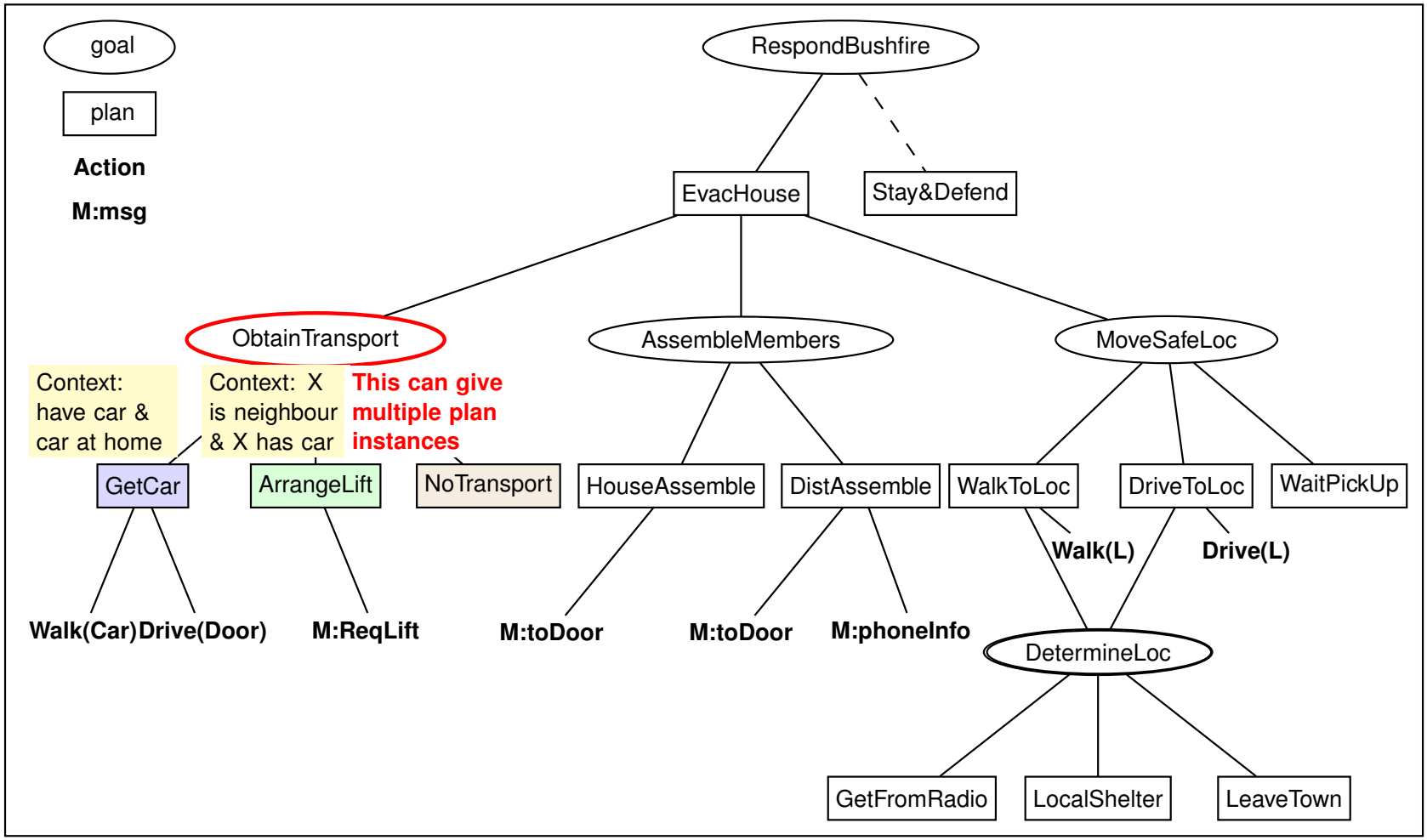

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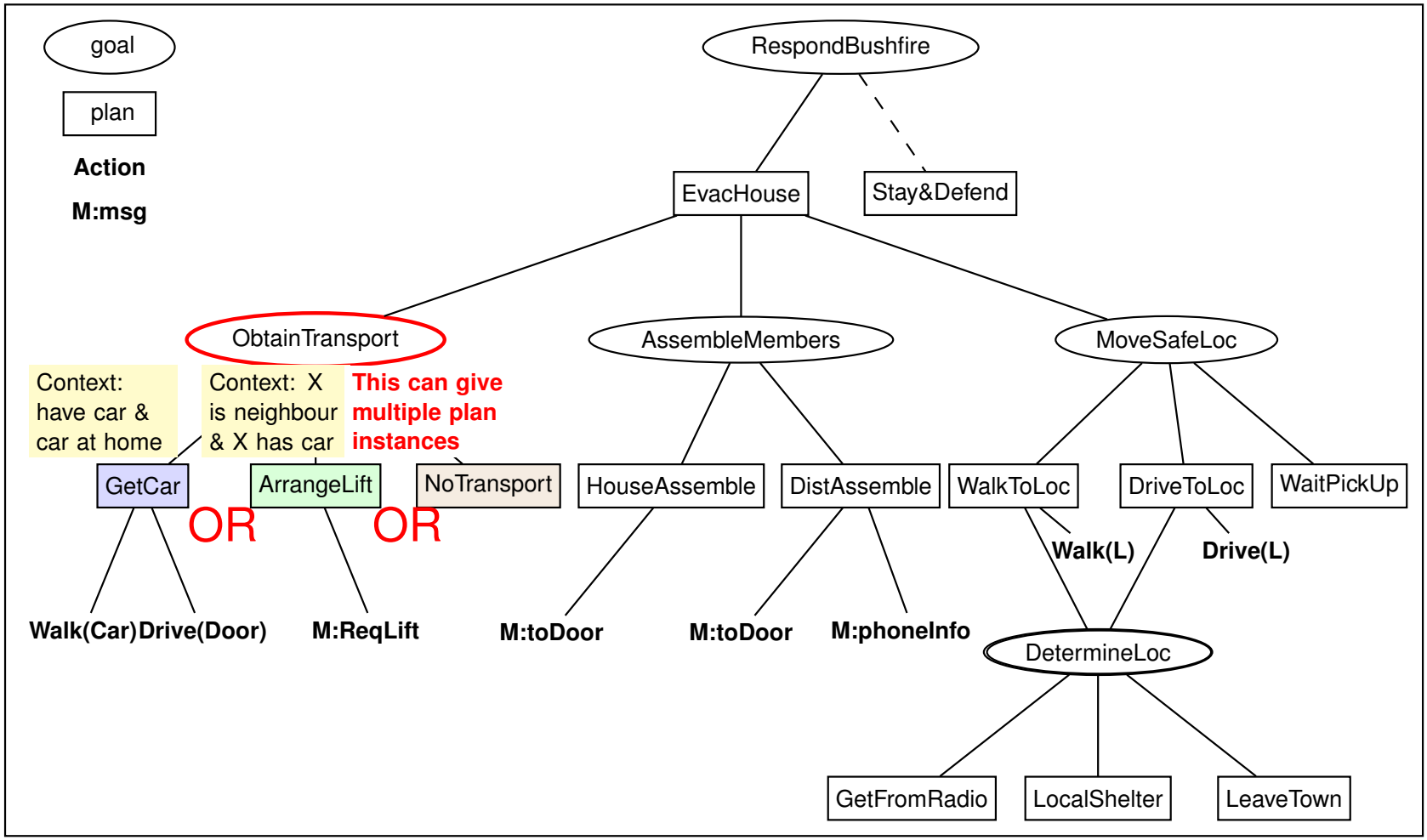
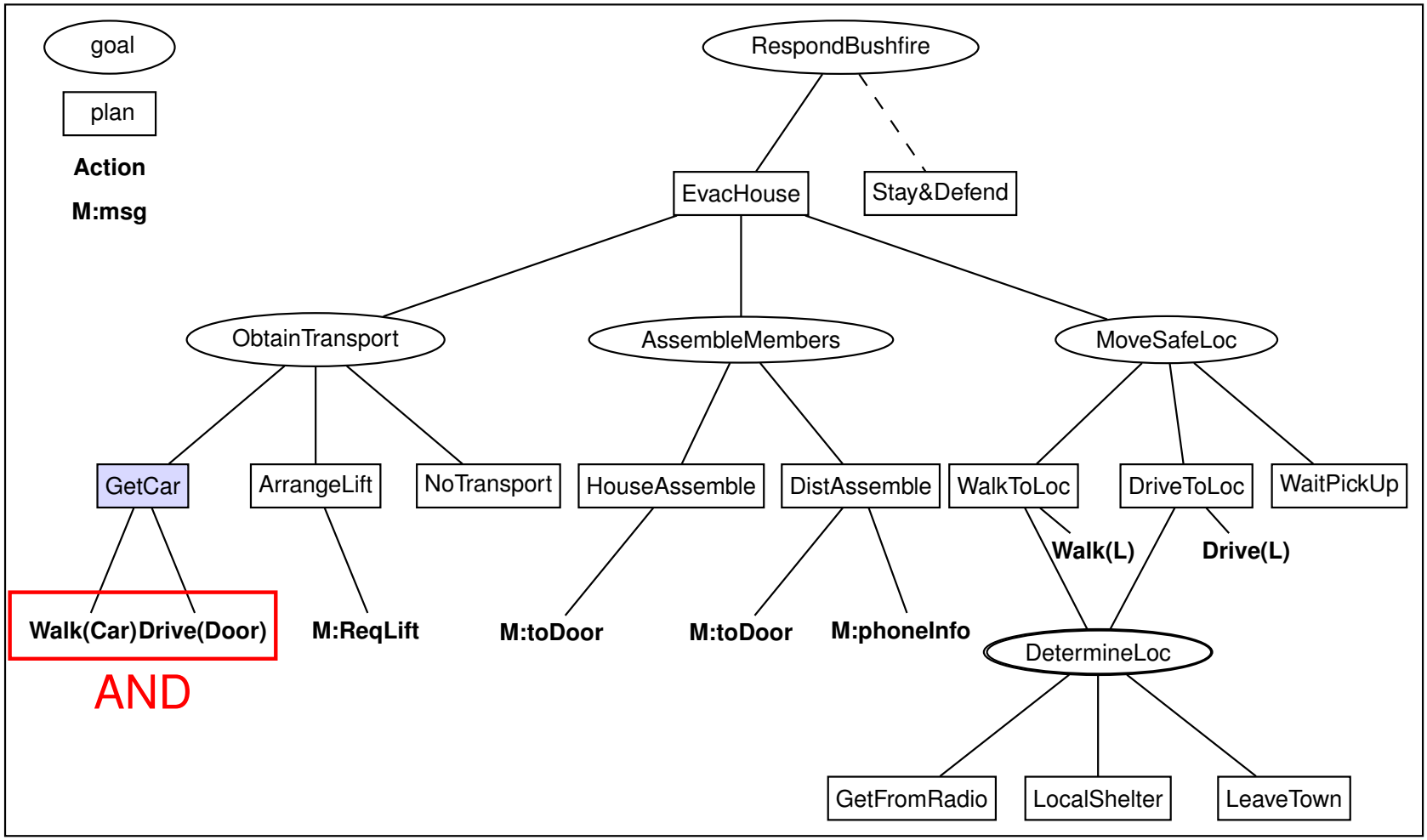


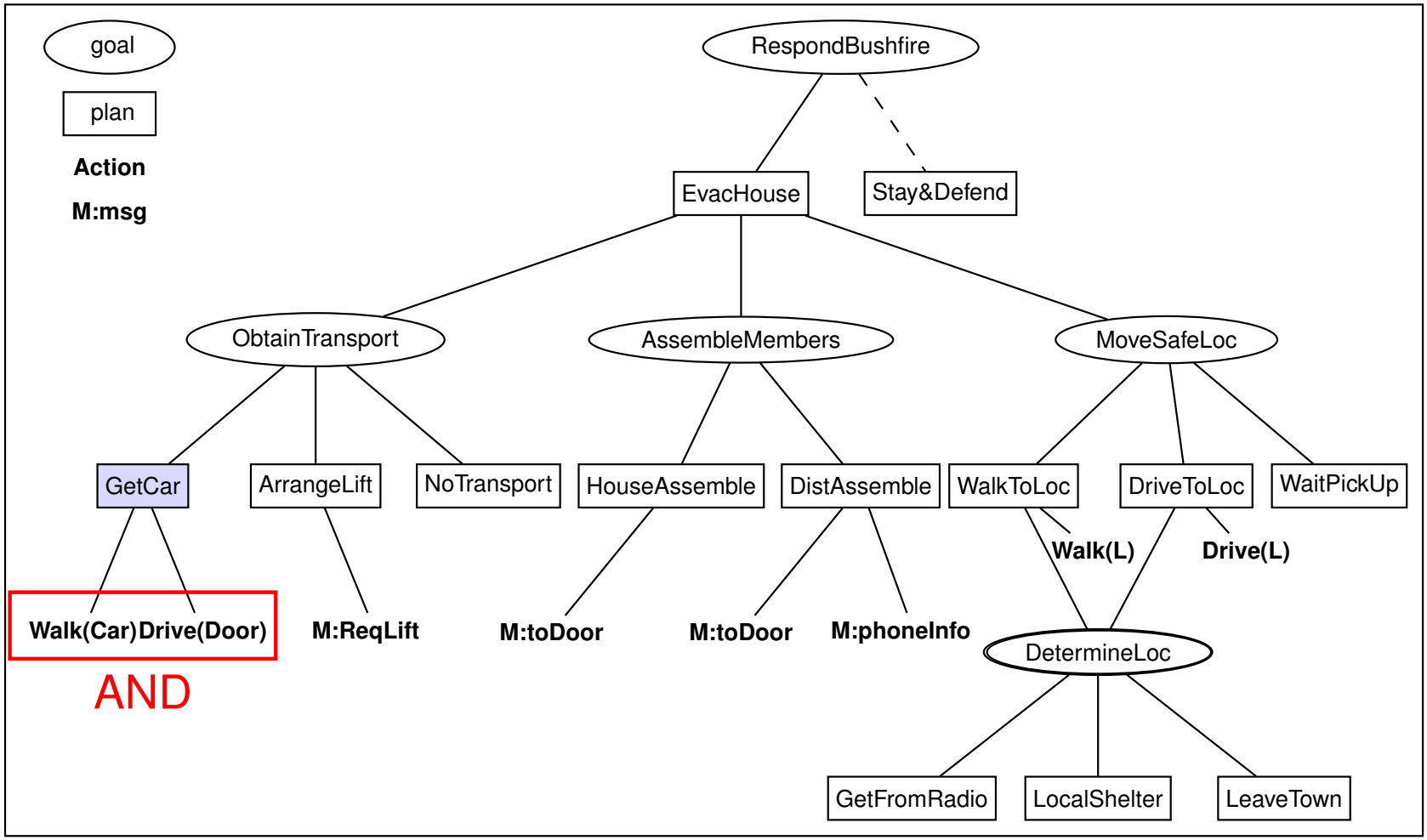
For a goal to succeed one of the plans must succeed. If one fails try another.

Example Plan Structure



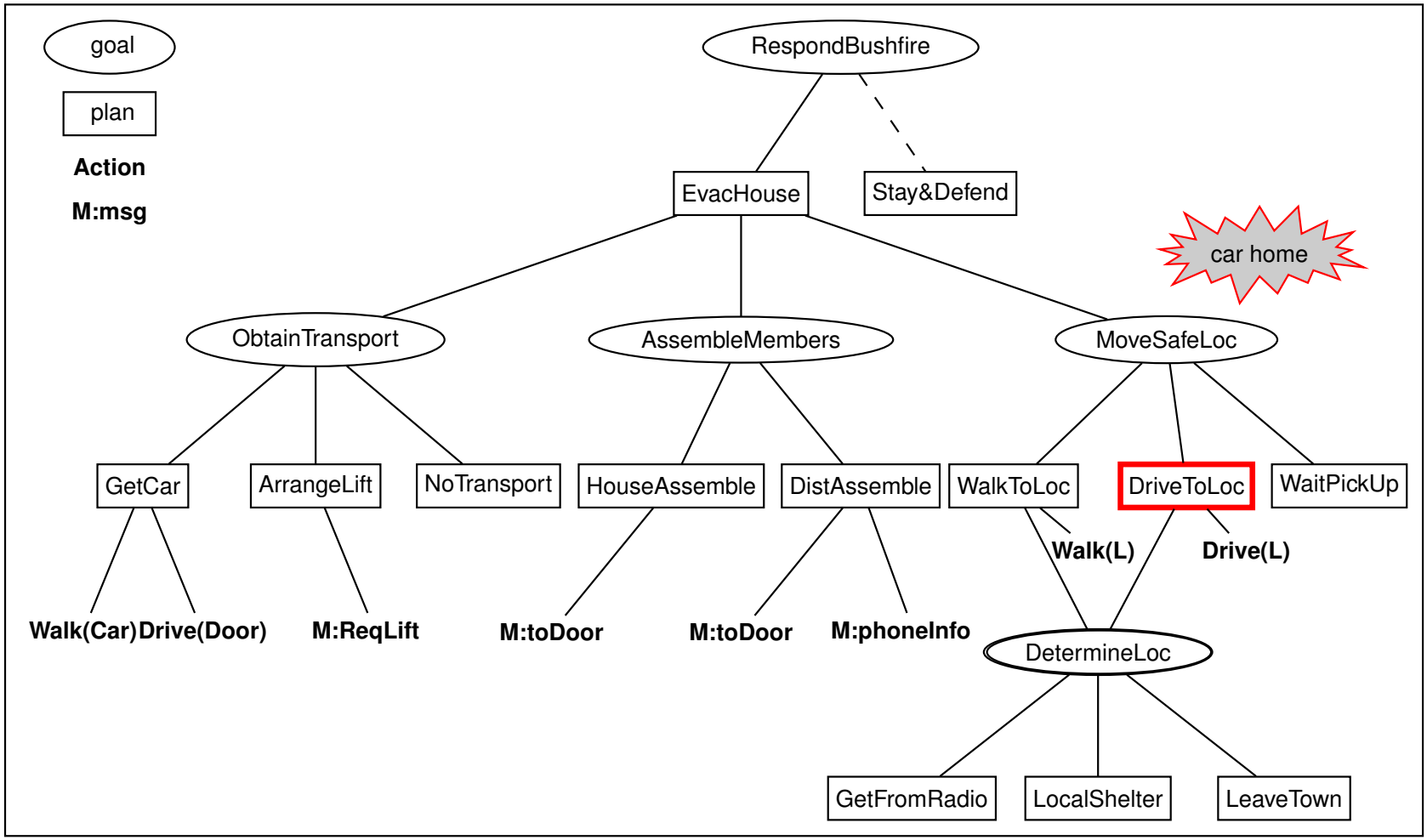
For a plan to succeed, all steps must succeed.

Example Plan Structure



If things fail, recovery happens as locally as possible

Example Plan Structure



Plan selection responsive to changing environment.

Advantages

- Intuitive representation
- Late selection: situation aware...
- Plan failure - retry new plan. Committed to choices, like humans.
- Agent is responsive to environmental changes.
- Huge number of options possible - over 2 million for modest tree. (Subgoal steps 4, Choices 2, Depth 3)