# How Minds Work
# Behavior Nets

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# Desired Characteristics

- Goal oriented
- Opportunistic
- Persistent
- Able to plan ahead
- Robust
- Reactive
- Fast

- Note lack of independence
- Tradeoffs needed
- Optimality not asked for
- Good enough will do

# Competence Modules

- Simple
- Interactive
- Mindless
- Each with a specific competence
- Like processors, codelets, demons, schema

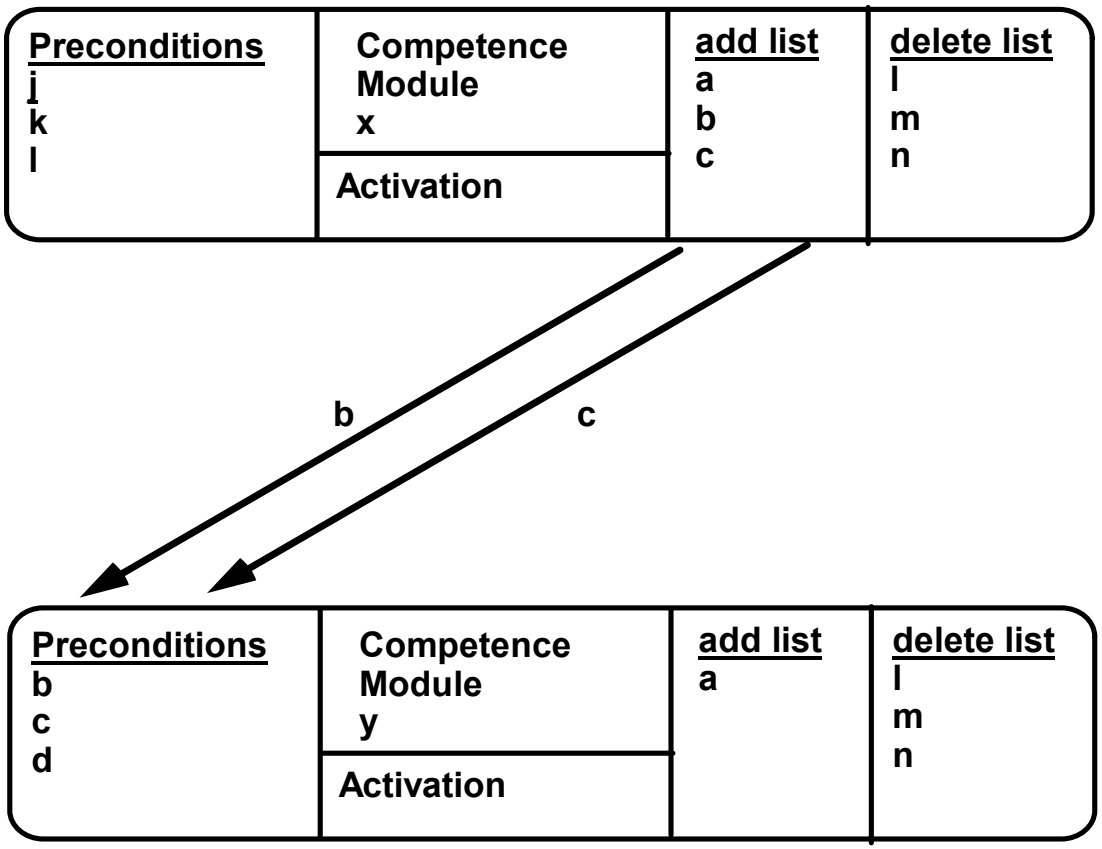
# A Competence Module

- Much like a production rule, demon, schema
- Preconditions — environmental facts required for the competence to be performed
- An action
- Additions and deletions — facts to be added or deleted after the action is taken
- Activation — a number, some kind of strength level

# The Behavior Network

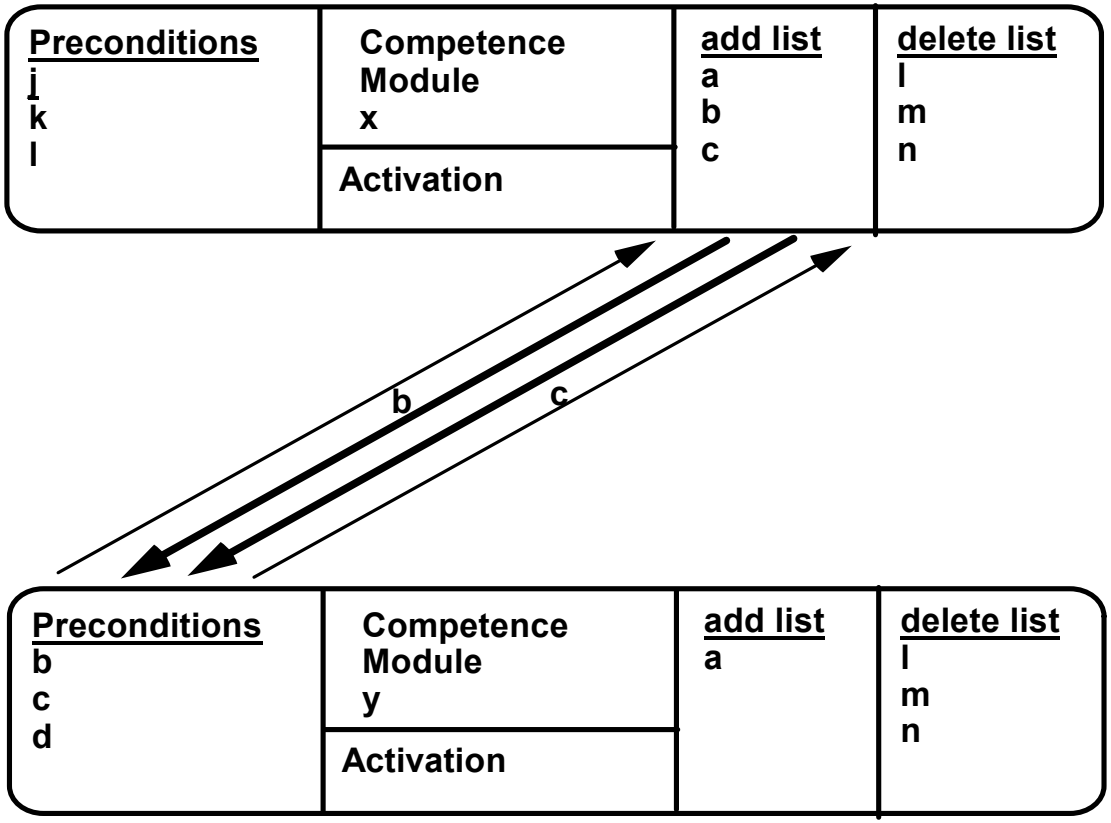
- Competence module = node of a digraph
- links are completely determined by the competence modules
  - Successor links
  - Predecessor links
  - Conflictor links

# Successor links




**successor links** →

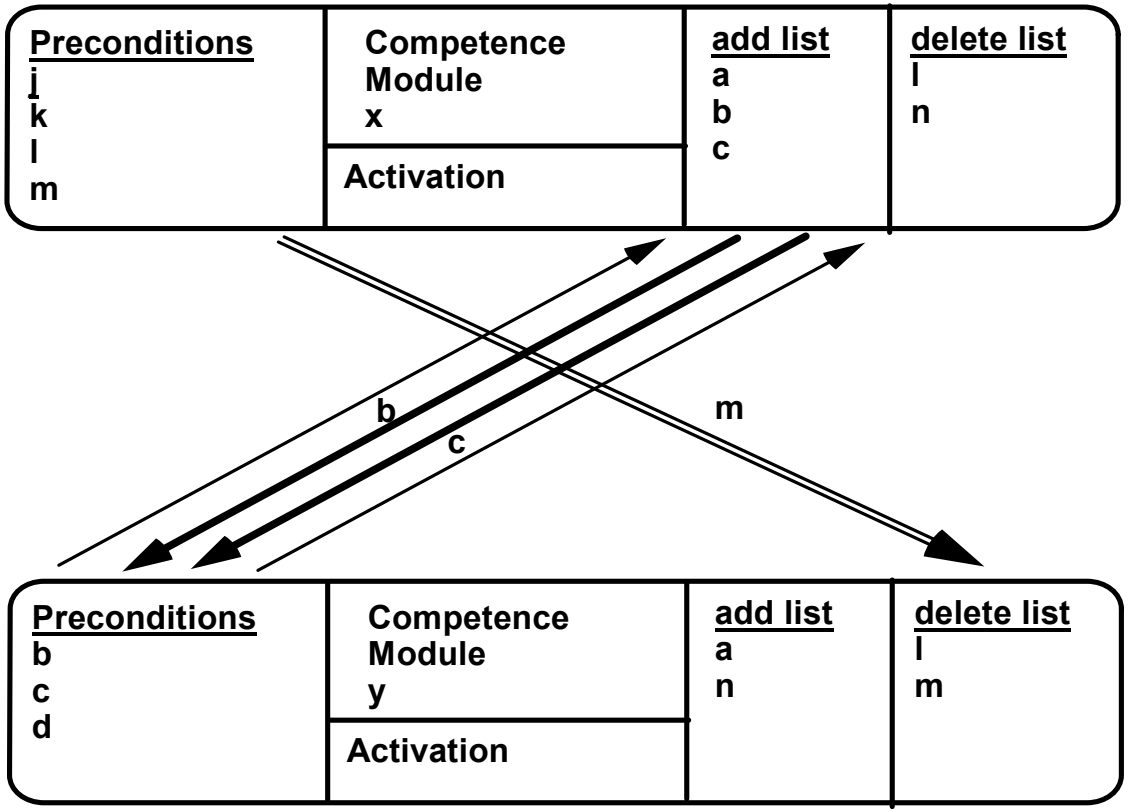
# Predecessor links




**successor links** →

**predecessor links** →

# Conflictor links




**successor links** →

**predecessor links** →

**conflictor links** ⇒

# Activation Comes From

- Activation stored by the competence modules
- from the environment
- from built-in, global goals

# Environmental Activation

- Environment activation for each true precondition
- The more true preconditions, the more relevant the competence is
- This source of activation allows the system to be opportunistic

# Goal Activation

- If a competence satisfies a goal, the goal will send activation
- This source of activation tends to make the system goal directed
- A completed goal inhibits any competence that will undo it

# Activation Along Successor Links

- Activation spread from competence to competence along links
- Along successor links, one competence strengthens those competencies whose preconditions it can help fulfill

# Activation Along Predecessor & Conflictor Links

- Along predecessor links, a competence strengthens any other that fulfills one of its own preconditions
- Along a conflictor link a competence inhibits any other that can undo one of its true preconditons
- Every conflictor link is inhibitory

# Executable Competence

- Call a competence module *executable* if all of its preconditions are satisfied
- The competence is ready to fire, although it may well not

# Behavior Net Loop

- Add activation from environment and goals
- Spread activation forward and backward among the competence modules
- Decay - total activation remains constant
- Competence fires if
  - it's executable and
  - it's over threshold and
  - it's the maximum such
- If one competence fires, its activation is zero, and threshold returns to normal
- If none fires, reduce threshold by 10%

# Global Parameters

- Activation threshold
  - Raising it makes the system more thoughtful,
  - Lowering makes it more reactive
- Activation added for each satisfied precondition
  - Increasing makes the system more opportunistic
- Activation for being able to satisfy a goal
  - Increasing leads to more goal-oriented behavior
- Last two parameters tradeoff, since goal orientation and opportunism are opposite
- Parameters remain constant during a run

# Plans

- Sequence of competencies transform present situation into desired one
- Sequence can become highly activated by forward spreading from current state & backward spreading from a goal state
- May occur in competition with other sequences striving towards other goals

# Really a Plan?

- An outside observer might call it a plan
- System doesn't use it as a plan
- Plan seems to exist only in the likelihood for execution of its competencies
- No centralized preprogrammed search processing results in cheaper operation than traditional planning methods

# Problems with Behavior Nets

- No variables — preconditions & add & delete list composed of propositions
- Causes computational explosion
- No learning — must be hand crafted
- Expensive to produce

# Readings

- Maes, P. 1989. How to do the right thing. *Connection Science* 1:291-323
- Franklin, S. 1995. *Artificial Minds*. Cambridge MA: MIT Press

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