Forward Chaining vs. Backward Chaining

Forward Chaining vs. Backward Chaining

Logical Rules can be applied in two directions

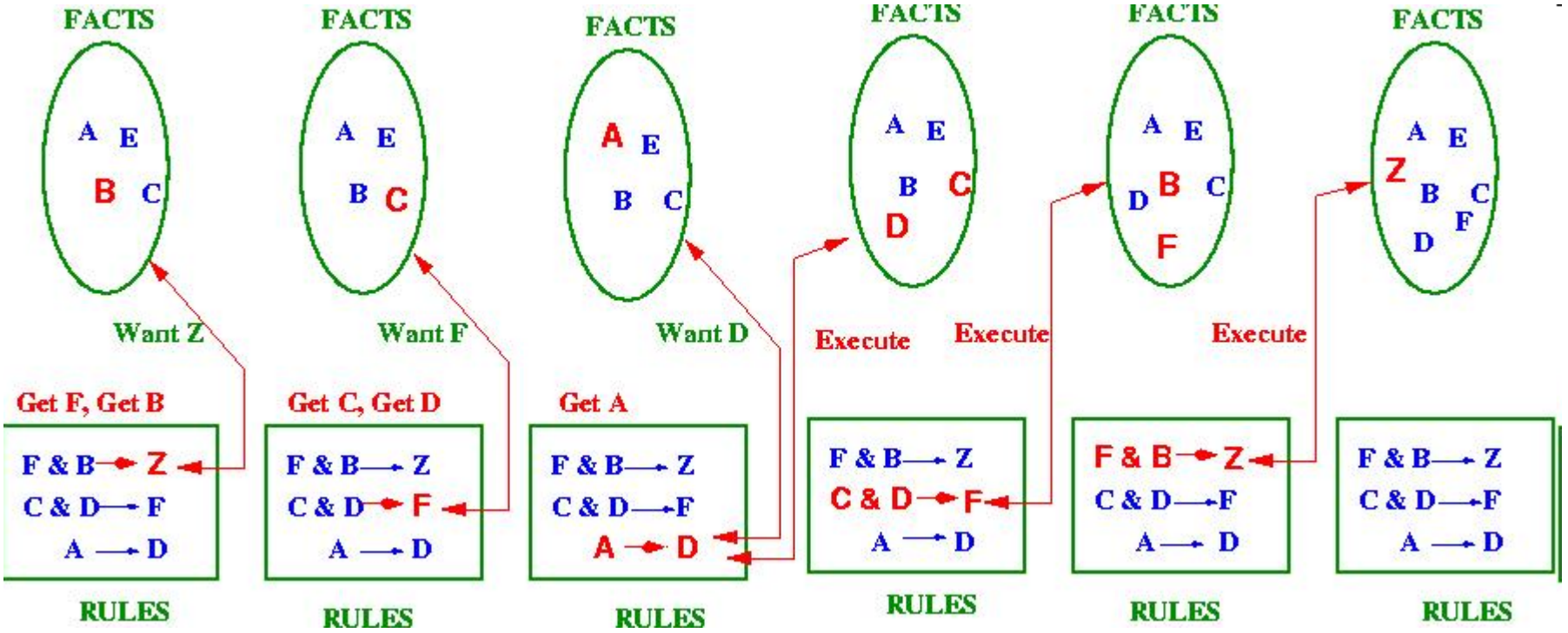
PROLOG

- Backward chaining
  - start with the desired conclusion(s)
  - work backwards to find supporting facts
  - corresponds to modus tolens
  - ➢ **goal-directed**

Decision Tables

- Forward chaining
  - Starts from the facts
  - apply rules to find all possible conclusions
  - corresponds to modus ponens
  - ➢ **data driven**

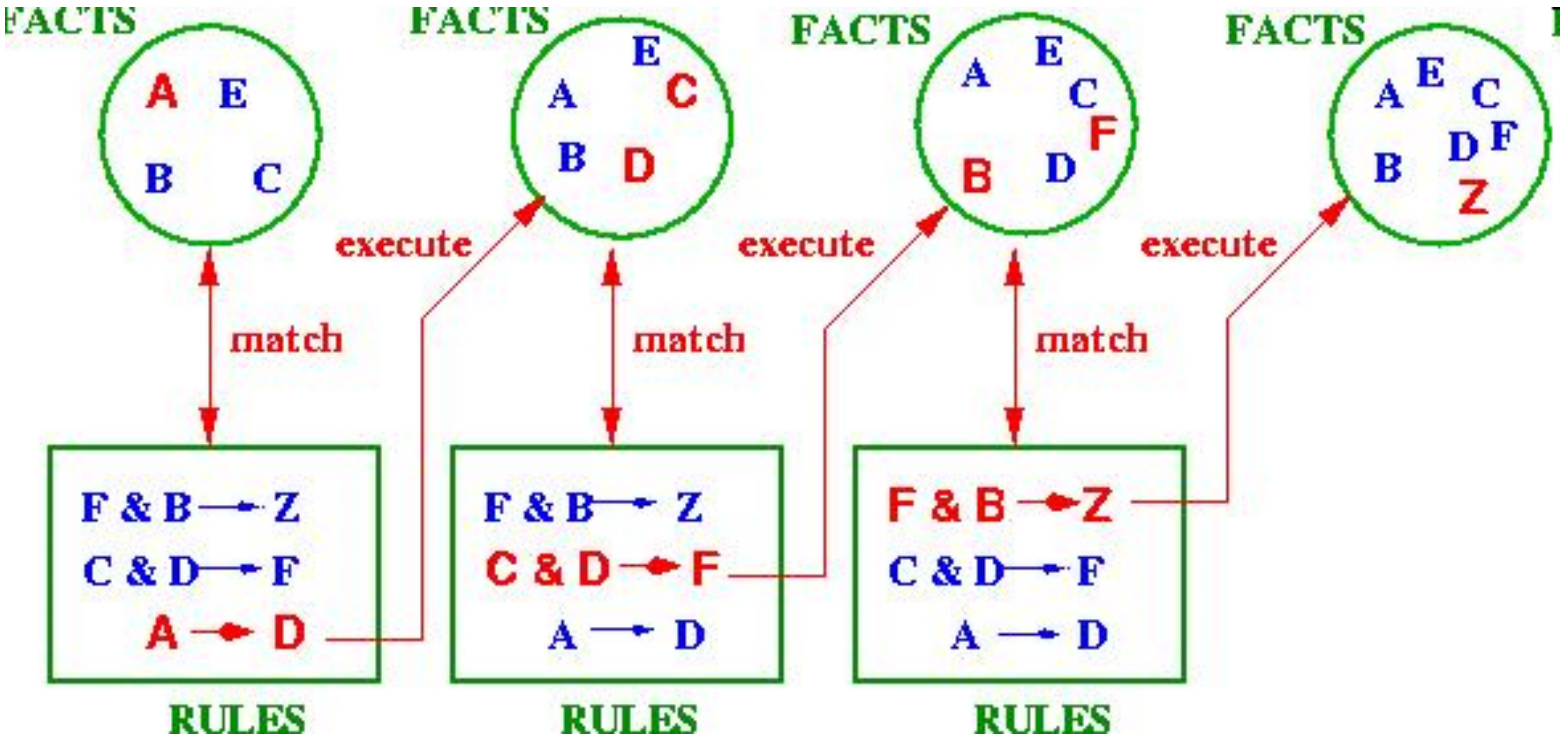
Illustrating Backward Chaining



Source: Kerber (2004), http://www.cs.bham.ac.uk/~mmk/Teaching/AI/l2.html

Illustration Forward Chaining

Goal state: Z
Termination condition: stop if Z is derived or no further rule can be applied



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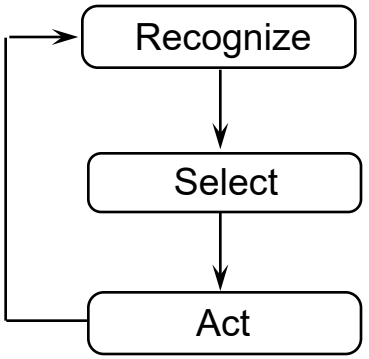
Forward Chaining: Deriving ground Facts

- Usually for forward chaining the facts are ground, i.e. they do not contain variables
- To ensure that the derived facts are ground, all the variables which occur in the consequence of the rule must occur in the antecedents of the rule
- Unification is thus restricted to matching (one of the expressions is ground):
  - The condition can contain variables
  - The matching fact does not contain variables

Forward Chaining Procedure: Recognise – Select – Act Cycle



Let the fact base consist of facts FB = $\{F_1, \ldots F_n\}$

1. **Recognise**: Match the conditions of the rules against the facts of the fact base, i.e. find all rules

   C_1 and C_2 and … and C_m -> H

   such that the conditions $C_1, C_2, \ldots, C_m$ can be unified with facts $F_1, F_2, \ldots, F_m$ with unifier σ

   (the set of applicable rules is called conflict set)

2. **Select**: If there is more than one rule that can be applied, **choose** one to apply. Stop if no rule is applicable

3. **Act**: Apply the chosen rule by adding adding $H\sigma$ to the fact base, i.e. FB = FB $\cup$ $\{H\sigma\}$

4. Stop if termination condition holds, otherwise and go to 1

Example of a Declarative Knowledge Base

F1: Father(peter,mary)
F2: Father(peter, john)
F3: Mother(mary, mark)
F4: Mother(jane, mary)

R1: Father(X,Y) AND Father(Y,Z) → Grandfather(X,Z)
R2: Father(X,Y) AND Mother(Y,Z) → Grandfather(X,Z)
R3: Mother(X,Y) AND Father(Y,Z) → Grandmother(X,Z)
R4: Mother(X,Y) AND Mother(Y,Z) → Grandmother(X,Z)
R5: Father(X,Y) AND Father(X,Z) → Sibling(Y,Z)
R6: Mother(X,Y) AND Mother(X,Z) → Sibling(Y,Z)

The rules can be used to

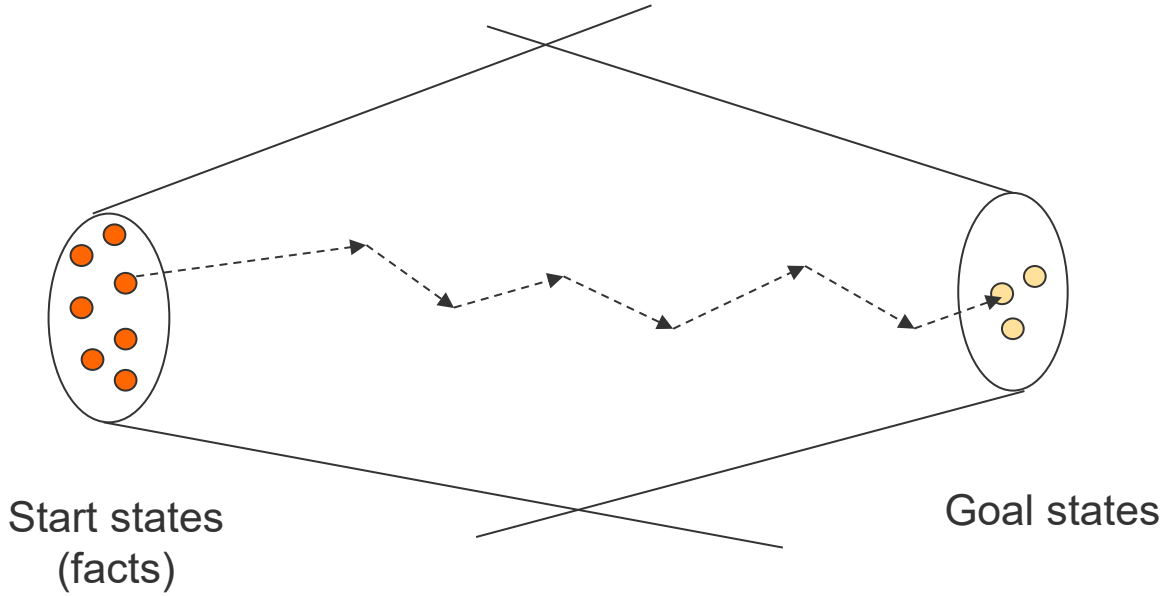
- Derive all grandparent and sibling relationships (forward chaining)
- Answer questions about relationships (backward chaining)

Forward Chaining Strategies

- Forward chaining computes all the facts that can be derived from the knowledge base
- Forward chaining strategies differ in step „Select“. Here are some examples of strategies:
  - Apply the rules sequentially
  - Randomly select a rule
  - Apply more specific rules first
  - Prefer rules where conditions match a recently derived fact
  - Derive consequences of a set of starting facts: Only apply rules where at least one condition matches either with a starting fact or a derived fact
    - Fact base contains facts that are generally true, e.g. insurance product
    - Starting facts describe a concrete situation, e.g. customer data

Choosing Forward or Backward Chaining

- Backward Chaining
  - If you already know what you are looking for
- Forward Chaining
  - If you don't necessarily know the final state of your solution



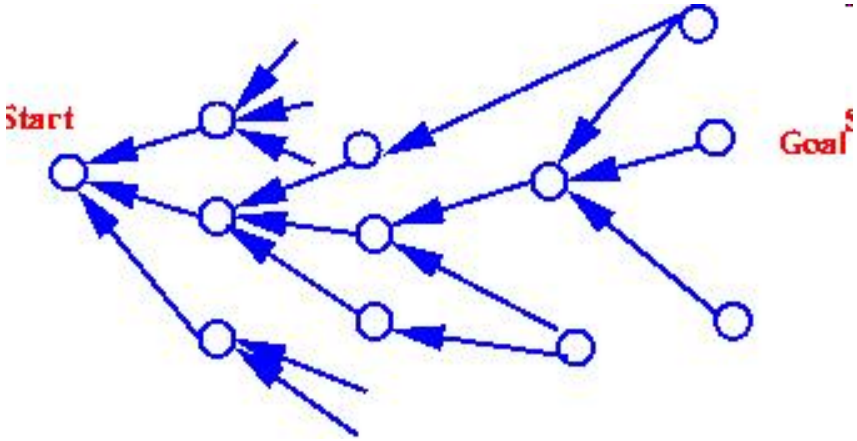
Decision Criteria for Forward or Backward Reasoning

- More possible goal states or start states?
  - Move **from smaller** set of states **to the larger**
- Is Justification of Reasoning required?
  - Prefer direction that corresponds **more closely to the way users think**
- What kind of events triggers problem-solving?
  - If it is **arrival of a new fact**, forward chaining makes sense.
  - If it is **a query to which a response is required**, backward chaining is more natural.
- In which direction is branching factor greatest?
  - Go in direction with lower branching factor

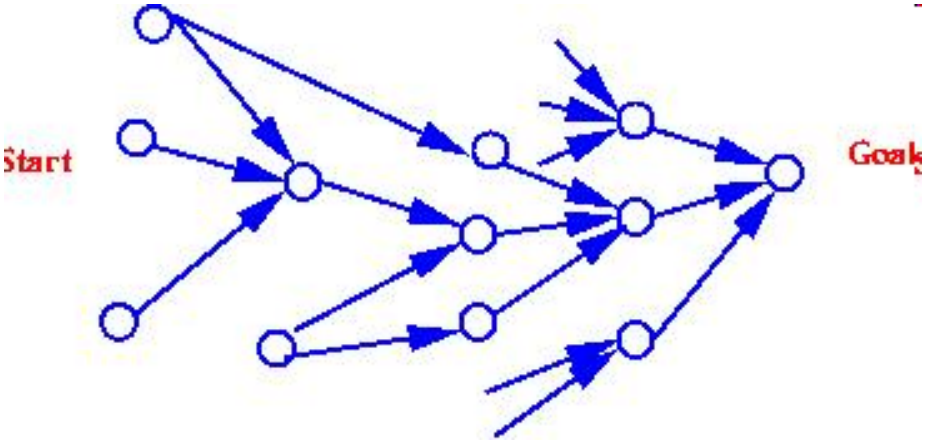
Source: Kerber (2004), http://www.cs.bham.ac.uk/~mmk/Teaching/AI/l2.html

Branching Factor

Backward chaining more appropriate



Forward chaining more appropriate



Forward or Backward Chaining?

Which reasoning strategy do you regard as appropriate in the following scenarios:

- Diagnosis of a machine defect. Rules have symptoms in the antecedent and defect in the conclusion. Given a set of symptoms derive the reason for the defect
- Check whether a patient is at risk for breast cancer. Rules have risks in antecedent and possible diseases in the head, e.g. „smoking -> lung cancer“
- Proving integrity constraints. Rules specify conditions when a database is inconsistent. Rules are checked at every update
- Check credit card accounts for possible occurrence of fraud as soon as a payment is made.