Introduction to Prolog

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Outline

- Prolog in a nutshell
- Basic constructs
- Answering queries with Prolog
- Practicals

Prolog in a nutshell (1)

- Prolog (programming in logic) is a logic-based programming language:
  - programs correspond to sets of logical formulas
  - uses logical methods to resolve queries.
- A declarative language
  - you specify what problem you want to solve rather than how to solve it.
- Useful in some problem areas, . . . , but pretty useless in others.
- lecture meant to introduce you to the most basic concepts of the Prolog programming language

Prolog in a nutshell (2)

- Conceived in Marseille, France, in the 70s
- First compiler written by David H. D. Warren in Edinburgh, Scotland
- Remains the most popular logical programming
- Used in:
  - natural language processing
  - theorem proving
  - expert systems
  - games
  - automated answering systems

Prolog in a nutshell (3)

How does Prolog work?

- Provide a set of facts and rules.
  - Think of the facts like a database.
  - The rules define relationships between different facts in order to build up complicated systems.
  - The rules are based on predicate logic.
- Present the system with a fact that has a variable in it.
- System finds all solutions for that variable (or multiple variables)
- In this lecture, we use the SWI prolog compiler

Prolog in a nutshell (4)

- Programs consist of procedures.
- Procedures consist of clauses.
- Each clause is a fact or a rule.
- Programs are executed by posing queries.

Basic constructs (1)

- Symbols
  - Prolog expressions are comprised of the following truth-functional symbols, which have the same interpretation as in the predicate calculus.
- Variables and Names
  - Variables begin with an uppercase letter. Predicate names, function names, and the names for objects must begin with a lowercase letter.
  - Rules for forming names are the same as for the predicate calculus.
    - mother_of(X,Y)
    - male(X)
    - female(Y)
    -

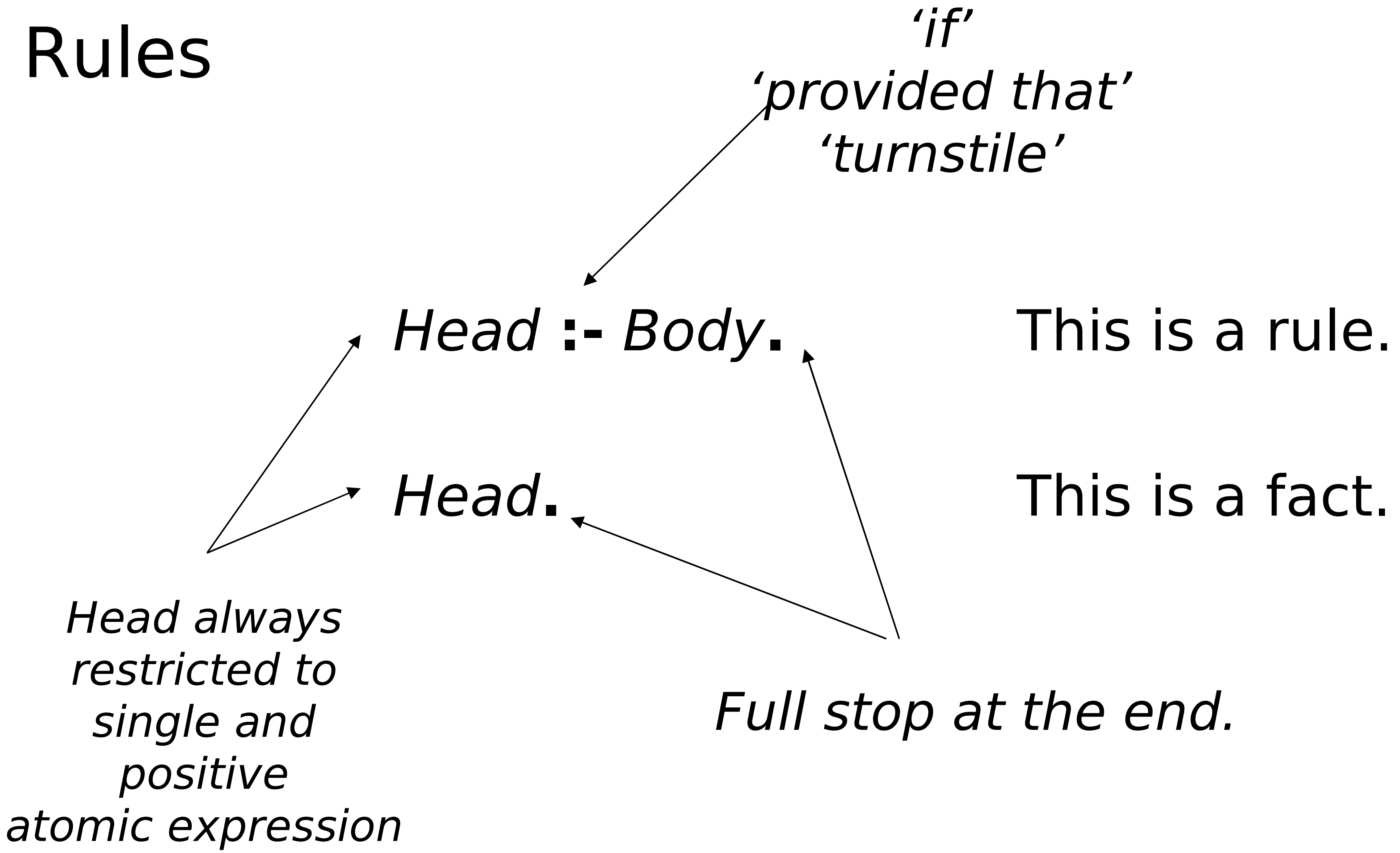
Basic constructs (2)

- A **fact** is a predicate expression that makes a declarative statement about the problem domain.
- Whenever a variable occurs in a Prolog expression, it is assumed to be **universally quantified**.
- Note that all Prolog sentences must **end with a period.**
- Examples:

```
likes(john, susie).           /* John likes Susie */
likes(X, susie).             /* Everyone likes Susie */
likes(john, Y).              /* John likes everybody */
```

Basic constructs (3)

Rules



‘if’
‘provided that’
‘turnstile’

Head **:-** *Body***.** This is a rule.

*Head***.** This is a fact.

Head always restricted to single and positive atomic expression

Full stop at the end.

Key differences between FOL and Prolog

FOL	Prolog
Conjunction	Comma ,
Disjunction	Or condition expressed using two rules
Negation ~	**not** or \+ *provable* *not*
If premises then conclusion →	Conclusion if premises :-

Negation as failure

- What is not provable (« \+ », not(.)) is false
- In real life rules have exceptions
  - FOL and Prolog handles them differently
- If you scratch a match, it will light up except if wet

$$\overbrace{\forall M. S(M) \rightarrow L(M), S(m) \wedge W(m), \neg L(m)}^{inconsistent}$$

This set of sentences entails everything in FOL

```
scratched(m).
lights(X):-scratched(X).
```

```
?- lights(m).
Yes
```

```
?-not(lights(m)).
No
```

```
?- wet(m),not(lights(m))
No
```

```
?-wet(m),not(lights(m)),
rains(a)
No
```

Sample exercises

Ex: are all these rules syntactically correct?

- friends(X,Y) :- likes(X,Y),likes(Y,X).
- left_of(X,Y) :- right_of(Y,X)
- hates(X,Y) :- not(likes(X,Y)).
- enemies(X,Y) :- not(likes(X,Y)),not(likes(Y,X)).
- likes(X,Y),likes(Y,X) :- friends(X,Y).
- not(likes(X,Y)) :- hates(X,Y).

Answering queries with Prolog (1)

Yes/No question

```
?-likes(john,mary).
yes/no
```

```
?-\+likes(john,mary).
yes/no
```

« Who » question

```
?-likes(john,X).        // Who does John like?
X=mary
?-likes(X,mary).        // Who likes Mary?
X=john
?-likes(X,Y).           // Who likes who?
X=john,
Y=mary
```

Answering queries with prolog (2)

- Query - a goal that most be proved, given a prolog program (knowledge)
- Prolog engine determines if query is a logical consequence of rules
- Backward reasoning:
  - If a goal matches with a fact, then it is satified
  - If a goal matches the head of a rule, then it is satisfied if the goal represented by the rule's body is satified

Example: mortal philosophers

- Consider the following argument:

  All men are mortal

  Socrate is a man

  Therefore Socrate is a mortal

  It has two premisses, and a conclusion
- The premisses can be expressed as a Prolog programme

```
mortal(X):- man(X).
man(socrate).
```

- The conclusion can be formulated as a query

```
?: mortal(socrate).
Yes
```

Answering queries

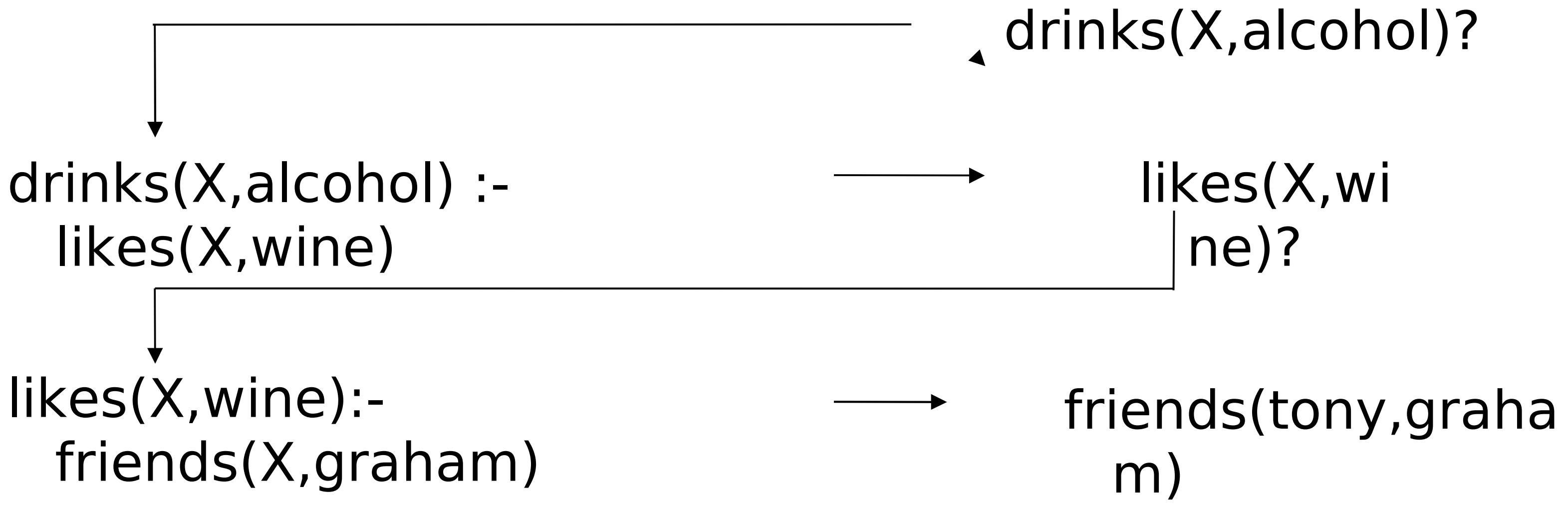
Goal execution

- The query mortal(socrates) is made the initial goal
- Prolog looks for the first matching fact or head of rule and finds mortal(X)
    - Variable instanciation: X=socrates
- This variable instanciation is extended to the rule's body, i.e. man(X) becomes man(socrates)
- New goal: man(socrates)
- Success, because man(socrates) is a fact
- Therefore, the initial goal also succeeds.

Answering queries

```
friend(tony,graham).
likes(X,wine):- friends(X,graham).
drinks(X,alcohol) :- likes(X,wine).
```

```
?-drinks(X,alcohol)
X=tony
```



drinks(X,alcohol)?

drinks(X,alcohol) :- likes(X,wine)

likes(X,wine)?

likes(X,wine):- friends(X,graham)

friends(tony,graham)

Sample exercise

- Suppose the database (e.g., movies.pl) contains facts of the following format:

  movie(M,Y). % movie M came out in year Y

  director(M,D). % M was directed by director D

  actor(M,A,R). % actor A played role R in movie M

- Write queries to answer the following questions
  - In which year was the movie American Beauty released?
  - Find a movie released in 2002
  - Find an actor who appeared in more than one movie?
  - Find a director who directed a movie in which the actress Scarlett Johansson appeared
  - Find an actor who also directed a movie

Prolog rules – recursion

List out the different cases, base case(s) first.

```
descendant(A,B) :- parent(B,A).  % B is A’s parent
descendant(A,B) :- parent(B,X), descendant(A,X).
```

This says: A is a descendant of B if B is A’s parent OR if there exists a person, X, for whom B is X’s parent and A is a descendant of X.