

Lecture 4: Lists

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- Theory
 - Introduce lists, an important recursive data structure often used in Prolog programming
 - Define the member/2 predicate, a fundamental Prolog tool for manipulating lists
 - Illustrate the idea of recursing down lists
- Exercises
 - Exercises of LPN chapter 4
 - Practical work

Lists

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- A list is a finite sequence of elements
- Examples of lists in Prolog:

```
[mia, vincent, jules, yolanda]
[mia, robber(honeybunny), X, 2, mia]
[]
[mia, [vincent, jules], [butch, friend(butch)]]
[[ ], dead(z), [2, [b,c]], [ ], Z, [2, [b,c]]]
```

Important things about lists

- List elements are enclosed in square brackets
- The length of a list is the number of elements it has
- All sorts of Prolog terms can be elements of a list
- There is a special list:
the empty list `[]`

Head and Tail

- A non-empty list can be thought of as consisting of two parts
 - The head
 - The tail
- The head is the first item in the list
- The tail is everything else
 - The tail is the list that remains when we take the first element away
 - The tail of a list is always a list

Head and Tail example 1

- [mia, vincent, jules, yolanda]

Head:

Tail:

Head and Tail example 1

- [mia, vincent, jules, yolanda]

Head: mia

Tail:

Head and Tail example 1

- [mia, vincent, jules, yolanda]

Head: mia

Tail: [vincent, jules, yolanda]

Head and Tail example 2

- [[], dead(z), [2, [b,c]], [], Z, [2, [b,c]]]

Head:

Tail:

Head and Tail example 2

- `[[], dead(z), [2, [b,c]], [], Z, [2, [b,c]]]`

Head: `[]`

Tail:

Head and Tail example 2

- `[[], dead(z), [2, [b,c]], [], Z, [2, [b,c]]]`

Head: `[]`

Tail: `[dead(z), [2, [b,c]], [], Z, [2, [b,c]]]`

Head and Tail example 3

- [dead(z)]

Head:

Tail:

Head and Tail example 3

- [dead(z)]

Head: dead(z)

Tail:

Head and Tail example 3

- [dead(z)]

Head: dead(z)

Tail: []

Head and tail of empty list

- The empty list has neither a head nor a tail
- For Prolog, [] is a special simple list without any internal structure
- The empty list plays an important role in recursive predicates for list processing in Prolog

The built-in operator |

- Prolog has a special built-in operator | which can be used to decompose a list into its head and tail
- The | operator is a key tool for writing Prolog list manipulation predicates

The built-in operator |

```
?- [Head|Tail] = [mia, vincent, jules, yolanda].
```

```
Head = mia
```

```
Tail = [vincent,jules,yolanda]
```

```
yes
```

```
?-
```


The built-in operator |

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?- [X|Y] = [mia, vincent, jules, yolanda].

X = mia

Y = [vincent,jules,yolanda]

yes

?-

The built-in operator |

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?- [X|Y] = [].

no

?-

The built-in operator |

```
?- [X,Y|Tail] = [[ ], dead(z), [2, [b,c]], [ ], Z, [2, [b,c]]] .
```

```
X = [ ]
```

```
Y = dead(z)
```

```
Z = _4543
```

```
Tail = [[2, [b,c]], [ ], Z, [2, [b,c]]]
```

```
yes
```

```
?-
```

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Anonymous variable

- Suppose we are interested in the second and fourth element of a list

```
?- [X1,X2,X3,X4|Tail] = [mia, vincent, marsellus, jody, yolanda].
```

```
X1 = mia
```

```
X2 = vincent
```

```
X3 = marsellus
```

```
X4 = jody
```

```
Tail = [yolanda]
```

```
yes
```

```
?-
```

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Anonymous variables

- There is a simpler way of obtaining only the information we want:

```
?- [_,X2,_,X4] = [mia, vincent, marsellus, jody, yolanda].
```

```
X2 = vincent
```

```
X4 = jody
```

```
yes
```

```
?-
```

- The underscore is the anonymous variable

The anonymous variable

- Is used when you need to use a variable, but you are not interested in what Prolog instantiates it to
- Each occurrence of the anonymous variable is independent, i.e. can be bound to something different

Exercises

- Exercise 4.1 of LPN
- Exercise 4.2 of LPN

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Member

- One of the most basic things we would like to know is whether something is an element of a list or not
- So let's write a predicate that when given a term X and a list L , tells us whether or not X belongs to L
- This predicate is usually called `member/2`

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member/2

```
member(X,[X|T]).  
member(X,[H|T]):- member(X,T).
```

?-

member/2

```
member(X,[X|T]).  
member(X,[H|T]):- member(X,T).
```

?- member(yolanda,[yolanda,trudy,vincent,jules]).

member/2

```
member(X,[X|T]).  
member(X,[H|T]):- member(X,T).
```

```
?- member(yolanda,[yolanda,trudy,vincent,jules]).  
yes  
?-
```

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member/2

```
member(X,[X|T]).  
member(X,[H|T]):- member(X,T).
```

```
?- member(vincent,[yolanda,trudy,vincent,jules]).
```

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member/2

```
member(X,[X|T]).  
member(X,[H|T]):- member(X,T).
```

```
?- member(vincent,[yolanda,trudy,vincent,jules]).  
yes  
?-
```

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member/2

```
member(X,[X|T]).  
member(X,[H|T]):- member(X,T).
```

```
?- member(zed,[yolanda,trudy,vincent,jules]).
```

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member/2

```
member(X,[X|T]).  
member(X,[H|T]):- member(X,T).
```

```
?- member(zed,[yolanda,trudy,vincent,jules]).  
no  
?-
```

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member/2

```
member(X,[X|T]).  
member(X,[H|T]):- member(X,T).
```

```
?- member(X,[yolanda,trudy,vincent,jules]).
```

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member/2

```
member(X,[X|T]).  
member(X,[_|T]):- member(X,T).
```

```
?- member(X,[yolanda,trudy,vincent,jules]).  
X = yolanda;  
X = trudy;  
X = vincent;  
X = jules;  
no
```

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Rewriting member/2

```
member(X,[X|_]).  
member(X,[_|T]):- member(X,T).
```

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Recurring down lists

- The member/2 predicate works by recursively working its way down a list
 - doing something to the head, and then
 - recursively doing the same thing to the tail
- This technique is very common in Prolog and therefore very important that you master it
- So let`s look at another example!

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Example: a2b/2

- The predicate a2b/2 takes two lists as arguments and succeeds
 - if the first argument is a list of as, and
 - the second argument is a list of bs of exactly the same length

```
?- a2b([a,a,a,a],[b,b,b,b]).  
yes  
?- a2b([a,a,a,a],[b,b,b]).  
no  
?- a2b([a,c,a,a],[b,b,b,t]).  
no
```

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Defining a2b/2: step 1

a2b([], []).

- Often the best way to solve such problems is to think about the simplest possible case
- Here it means: the empty list

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Defining a2b/2: step 2

a2b([], []).

a2b([a|L1],[b|L2]):- a2b(L1,L2).

- Now think recursively!
- When should a2b/2 decide that two non-empty lists are a list of as and a list of bs of exactly the same length?

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Testing a2b/2

a2b([], []).

a2b([a|L1],[b|L2]):- a2b(L1,L2).

?- a2b([a,a,a],[b,b,b]).

yes

?-

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Testing a2b/2

a2b([], []).

a2b([a|L1],[b|L2]):- a2b(L1,L2).

?- a2b([a,a,a,a],[b,b,b]).

no

?-

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Testing a2b/2

$a2b([], [])$.
 $a2b([a|L1], [b|L2]) :- a2b(L1, L2)$.

?- $a2b([a,t,a,a], [b,b,b,c])$.
no
?-

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Further investigating a2b/2

$a2b([], [])$.
 $a2b([a|L1], [b|L2]) :- a2b(L1, L2)$.

?- $a2b([a,a,a,a], X)$.
 $X = [b,b,b,b]$
yes
?-

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Further investigating a2b/2

a2b([], []).
a2b([a|L1],[b|L2]):- a2b(L1,L2).

?- a2b(X,[b,b,b,b,b,b]).
X = [a,a,a,a,a,a]
yes
?-

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Summary of this lecture

- In this lecture we introduced list and recursive predicates that work on lists
- The kind of programming that these predicates illustrated is fundamental to Prolog
- You will see that most Predicates you will write in your Prolog career will be variants of these predicates

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Next lecture

- Introduce **arithmetic** in Prolog
 - Introduce Prolog's built-in abilities for performing arithmetic
 - Apply them to simple list processing problems
 - Introduce the idea of accumulators