Expanding the Zoo

We have snakes and armadillos. Let’s add ants.

An ant has

- a weight
- a location in the zoo

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```
; An ant is
;  (make-ant num posn)
(define-struct ant (weight loc))
```

Expanding the Zoo

We have snakes and armadillos. Let's add ants.

An ant has

- a weight
- a location in the zoo

```
; An ant is
;  (make-ant num posn)
(define-struct ant (weight loc))

(make-ant 0.001 (make-posn 4 5))

(make-ant 0.007 (make-posn 3 17))
```

Programming with Ants

- Define **`ant-at-home?`**, which takes an ant and reports whether it is at the origin

Programming with Ants

Contract, Purpose, and Header

```
; ant-at-home? : ant -> bool
```

Programming with Ants

Contract, Purpose, and Header

```
; ant-at-home? : ant -> bool
; Check whether ant a is home
```

Programming with Ants

Contract, Purpose, and Header

```
; ant-at-home? : ant -> bool
; Check whether ant a is home
(define (ant-at-home? a)
  ...)
```

Programming with Ants

Examples

```
; ant-at-home? : ant -> bool
; Check whether ant a is home
(define (ant-at-home? a)
  ...)
```

```
(ant-at-home? (make-ant 0.001 (make-posn 0 0))) '= true
(ant-at-home? (make-ant 0.001 (make-posn 1 1))) '= false
```

Programming with Ants

Template

```
; ant-at-home? : ant -> bool
; Check whether ant a is home
(define (ant-at-home? a)
  ... (ant-weight a)
  ... (ant-loc a) ...)
```

```
(ant-at-home? (make-ant 0.001 (make-posn 0 0))) '= true
(ant-at-home? (make-ant 0.001 (make-posn 1 1))) '= false
```

Programming with Ants

Template

```
; ant-at-home? : ant -> bool
; Check whether ant a is home
(define (ant-at-home? a)
  ... (ant-weight a)
  ... (posn-at-home? (ant-loc a)) ...)
```

New template rule: data-defn reference ⇒ template reference

Add templates for referenced data, if needed, and implement body for referenced data

```
(ant-at-home? (make-ant 0.001 (make-posn 0 0))) '= true
(ant-at-home? (make-ant 0.001 (make-posn 1 1))) '= false
```

Programming with Ants

Template

```
; ant-at-home? : ant -> bool
; Check whether ant a is home
(define (ant-at-home? a)
  ... (ant-weight a)
  ... (posn-at-home? (ant-loc a)) ...)

(define (posn-at-home? p)
  ... (posn-x p) ... (posn-y p) ...)
```

```
(ant-at-home? (make-ant 0.001 (make-posn 0 0))) '= true
(ant-at-home? (make-ant 0.001 (make-posn 1 1))) '= false
```

Programming with Ants

Body

```
; ant-at-home? : ant -> bool
; Check whether ant a is home
; (define (ant-at-home? a)
;   ... (ant-weight a)
;   ... (posn-at-home? (ant-loc a)) ...)
; (define (posn-at-home? p)
;   ... (posn-x p) ... (posn-y p) ...)
(define (ant-at-home? a)
  (posn-at-home? (ant-loc a)))
(define (posn-at-home? p)
  (and (= (posn-x p) 0) (= (posn-y p) 0)))

(ant-at-home? (make-ant 0.001 (make-posn 0 0))) '= true
(ant-at-home? (make-ant 0.001 (make-posn 1 1))) '= false
```

Shapes of Data and Templates

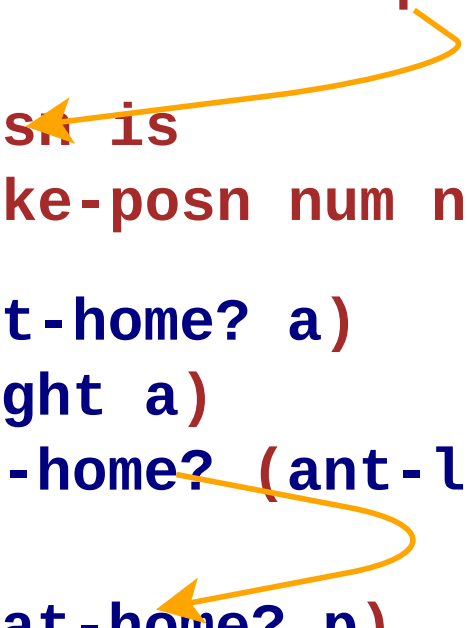
The shape of the template matches the shape of the data

```
; An ant is
;  (make-ant num posn)

; A posn is
;  (make-posn num num)

(define (ant-at-home? a)
  ... (ant-weight a)
  ... (posn-at-home? (ant-loc a)) ...)

(define (posn-at-home? p)
  ... (posn-x p) ... (posn-y p) ...)
```



Programming with Ants

- Define **`feed-ant`**, which feeds an ant 0.001 lbs of food
- Define **`move-ant`**, which takes an ant, an amount to move X, and an amount to move Y, and returns a moved ant

Animals

All animals need to eat...

- Define **`feed-animal`**, which takes an animal (snake, dillo, or ant) and feeds it (5 lbs, 2 lbs, or 0.001 lbs, respectively)

Animals

All animals need to eat...

- Define **`feed-animal`**, which takes an animal (snake, dillo, or ant) and feeds it (5 lbs, 2 lbs, or 0.001 lbs, respectively)

What is an **`animal`** ?

Animal Data Definition

```
; An animal is either
;   - snake
;   - dillo
;   - ant
```

Animal Data Definition

```
; An animal is either
;   - snake
;   - dillo
;   - ant
```

The "either" above makes this a new kind of data definition:

data with ***varieties***

Animal Data Definition

```
; An animal is either
;  - snake
;  - dillo
;  - ant
```

The "either" above makes this a new kind of data definition:

data with ***varieties***

Examples:

```
(make-snake 'slinky 10 'rats)

(make-dillo 2 true)

(make-ant 0.002 (make-posn 3 4))
```

Feeding Animals

```
; feed-animal : animal -> animal
; To feed the animal a
(define (feed-animal a)
  ...)
```

Feeding Animals

```
; feed-animal : animal -> animal
; To feed the animal a
(define (feed-animal a)
  ...)

(feed-animal (make-snake 'slinky 10 'rats))
"should be" (make-snake 'slinky 15 'rats)

(feed-animal (make-dillo 2 true))
"should be" (make-dillo 4 true)

(feed-animal (make-ant 0.002 (make-posn 3 4)))
"should be" (make-ant 0.003 (make-posn 3 4))
```

Template for Animals

For the template step...

```
(define (feed-animal a)
  ...)
```

- Is **a** compound data?

Template for Animals

For the template step...

```
(define (feed-animal a)
  ...)
```

- Is **`a`** compound data?

- Technically yes, but the definition **`animal`** doesn't have **`make-`***something*, so we don't use the compound-data template rule

Template for Varieties

Choice in the data definition

```
; An animal is either
;  - snake
;  - dillo
;  - ant
```

means **cond** in the template:

```
(define (feed-animal a)
  (cond
    [... ...]
    [... ...]
    [... ...]))
```

Three data choices means three **cond** cases

Questions for Varieties

```
(define (feed-animal a)
  (cond
    [... ...]
    [... ...]
    [... ...]))
```

How do we write a question for each case?

Questions for Varieties

```
(define (feed-animal a)
  (cond
    [... ...]
    [... ...]
    [... ...]))
```

How do we write a question for each case?

It turns out that

```
(define-struct snake (name weight food))
```

provides **snake?**

```
(snake? (make-snake 'slinky 5 'rats)) → true
(snake? (make-dillo 2 true)) → false
(snake? 17) → false
```

Template

```
(define (feed-animal a)
  (cond
    [(snake? a) ...]
    [(dillo? a) ...]
    [(ant? a) ...]))
```

New template rule: varieties ⇒ **cond**

Template

```
(define (feed-animal a)
  (cond
    [(snake? a) ...]
    [(dillo? a) ...]
    [(ant? a) ...]))
```

New template rule: varieties ⇒ **cond**

Now continue template case-by-case...

Template

```
(define (feed-animal a)
  (cond
    [(snake? a) ... (feed-snake a) ...]
    [(dillo? a) ... (feed-dillo a) ...]
    [(ant? a) ... (feed-ant a) ...]))
```

Remember: references in the data definition ⇒ template references

Template

```
(define (feed-animal a)
  (cond
    [(snake? a) ... (feed-snake a) ...]
    [(dillo? a) ... (feed-dillo a) ...]
    [(ant? a) ... (feed-ant a) ...]))
```

Remember: references in the data definition ⇒ template references

```
; An animal is either
;  - snake
;  - dillo
;  - ant
```

Shapes of Data and Templates

```
; An animal is either
;  - snake
;  - dillo
;  - ant

; A snake is
; (make-snake sym num sym)

; A dillo is
; (make-dillo num bool)

; An ant is
; (make-ant num posn)

; A posn is
; (make-posn num num)
```

```
(define (feed-animal a)
  (cond
    [(snake? a) ... (feed-snake a) ...]
    [(dillo? a) ... (feed-dillo a) ...]
    [(ant? a) ... (feed-ant a) ...]))

(define (feed-snake s)
  ... (snake-name s) ... (snake-weight s)
  ... (snake-food s) ...)

(define (feed-dillo d)
  ... (dillo-weight d)
  ... (dillo-alive? d) ...)

(define (feed-ant a)
  ... (ant-weight d)
  ... (feed-posn (ant-loc d)) ...)

(define (feed-posn p)
  ... (posn-x p) ... (posn-y p) ...)
```

Design Recipe III

Data

- Understand the input data

Contract, Purpose, and Header

- Describe (but don’t write) the function

Examples

- Show what will happen when the function is done

Template

- Set up the body based on the input data (and *only* the input)

Body

- The most creative step: implement the function body

Test

- Run the examples

Data

When the problem statement mentions **N** different varieties of a thing, write a data definition of the form

```
; A thing is
;  - variety1
;  ...
;  - varietyN
```

Design Recipe III

Data

- Understand the input data

Contract, Purpose, and Header

- Describe (but don’t write) the function

Examples

- Show what will happen when the function is done

Template

- Set up the body based on the input data (and *only* the input)

Body

- The most creative step: implement the function body

Test

- Run the examples

Examples

When the input data has varieties, be sure to pick each variety at least once.

```
                ; An animal is either
                ;  - snake
                ;  - dillo
                ;  - ant

(feed-animal (make-snake 'slinky 10 'rats))
"should be" (make-snake 'slinky 15 'rats)

(feed-animal (make-dillo 2 true))
"should be" (make-dillo 4 true)

(feed-animal (make-ant 0.002 (make-posn 3 4)))
"should be" (make-ant 0.003 (make-posn 3 4))
```

Design Recipe III

Data

- Understand the input data

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- Show what will happen when the function is done

Template

- Set up the body based on the input data (and *only* the input)

Body

- The most creative step: implement the function body

Test

- Run the examples

Template

When the input data has varieties, start with **cond**

- **N** varieties ⇒ **N** **cond** lines
- Formulate a question to match each corresponding variety
- Continue template steps case-by-case

```
(define (feed-animal a)
  (cond
    [(snake? a) ...]
    [(dillo? a) ...]
    [(ant? a) ...]))
```

Template

When the input data has varieties, start with **cond**

- **N** varieties ⇒ **N** **cond** lines
- Formulate a question to match each corresponding variety
- Continue template steps case-by-case

When the data definition refers to a data definition, make the template refer to a template

```
(define (ant-at-home? a)
  ... (ant-weight a)
  ... (posn-at-home? (ant-loc a)) ...)

(define (posn-at-home? p)
  ... (posn-x p) ... (posn-y p) ...)
```

Template

When the input data has varieties, start with **cond**

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When the data definition refers to a data definition, make the template refer to a template

```
(define (feed-animal a)
  (cond
    [(snake? a) ... (feed-snake a) ...]
    [(dillo? a) ... (feed-dillo a) ...]
    [(ant? a) ... (feed-ant a) ...]))
```