Class 20: Objects

I invented the term *Object-Oriented*, and I can tell you I did not have C++ in mind.
— Alan Kay

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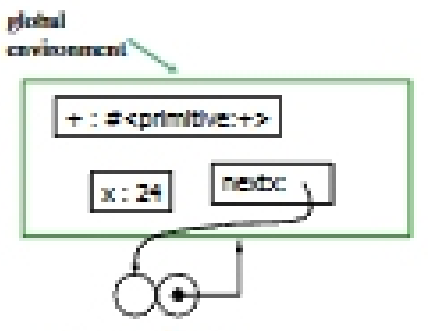
Menu

- A better counter
- Finishing Fish
- Programming with Objects

nextx from Class 18

```
(define x 0)
(define (nextx)
  (set! x (+ x 1))
  x)
> (nextx)
1
> (set! x 23)
> (next x)
24
```



A Better Counter

- The place that keeps track of the count would be part of the counter, not part of the global environment
- Can we do this?

Recall from Lecture 19:

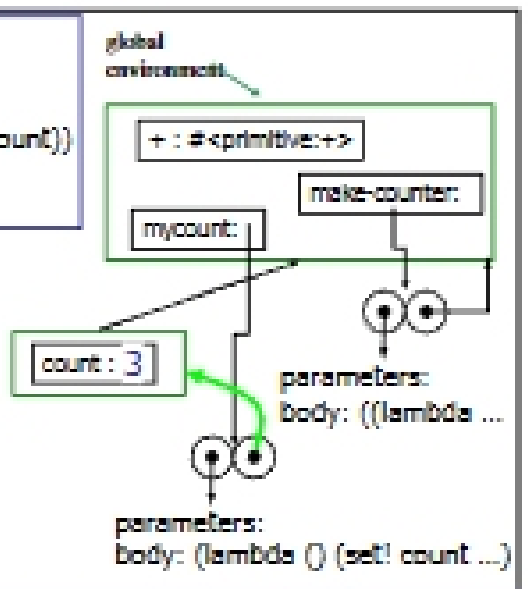
Application

1. Construct a new frame, enclosed in the environment of this procedure
2. Make places in that frame with the names of each parameter
3. Put the values of the parameters in those places
4. Evaluate the body in the new environment

A Better Counter

```
(define (make-counter)
   ((lambda (count)
      (lambda ()
        (set! count (+ 1 count))
        count))
      0))
```

```
(define (make-counter)
  ((lambda (count)
     (lambda ()
       (set! count (+ 1 count))
       count))
   0))
```




```
> (define mycount
    (make-counter))
> (mycount)
1
> (mycount)
2
> (mycount)
3
```


An Even Better Counter

```
(define (make-ocounter)
  ((lambda (count)
     (lambda (message)
       (if (eq? message 'reset) (set! count 0)
           (if (eq? message 'next)
               (set! count (+ 1 count))
               (if (eq? message 'how-many)
                   count)))))
   0))
```


Using Counter

```
> (define bcounter (make-ocounter))
> (bcounter 'next)
> (bcounter 'next)
> (bcounter 'next)
> (bcounter 'how-many)
3
> (bcounter 'reset)
> (bcounter 'how-many)
0
```


Objects

- When we package state and procedures together we have an *object*
- Programming with objects is *object-oriented programming*

Finishing Fish

Recap (through class 17)

- May 1941: Nazis start using Lorenz cipher to communicate between conquered European capitals
  - Allies know Baudot code, 2 sets of 5 wheels from test messages
- August 1941: Operator retransmits message (with abbreviations)
  - Allies learn one 4000-character key by XORing intercepted messages and then guessing possible plaintexts to find a pair that makes sense
- ~Feb 1942: Bill Tutte determines structure of Lorenz machine by analyzing key

Double Delta

- Combine two channels:

$$\Delta Z_{1,I} \text{ XOR } \Delta Z_{2,I} =$$
$$\Delta M_{1,I} \text{ XOR } \Delta M_{2,I} \quad > \tfrac{1}{2}$$
$$\text{XOR } \Delta X_{1,I} \text{ XOR } \Delta X_{2,I} \quad = \tfrac{1}{2} \text{ (key)}$$
$$\text{XOR } \Delta S_{1,I} \text{ XOR } \Delta S_{2,I} \quad > \tfrac{1}{2}$$

Message is in German, more likely following letter is a repetition than random

S-wheels only turn some of the time (when M-wheel is 1)

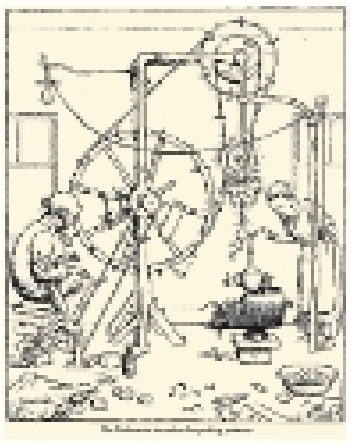
Prob[$\Delta Z_{1,I}$ XOR $\Delta Z_{2,I}$ XOR $\Delta X_{1,I}$ XOR $\Delta X_{2,I}$ = 0] = 0.55
So, if guess of initial configuration is correct, generated X will have this property and we will see more 0s than 1s

Using the Advantage

- If the guess of X is correct, should see higher than ½ of the double deltas are 0
- Try guessing different configurations to find highest number of 0 double deltas
- Problem:
  - # of double delta operations to try one config
  - = length of Z * length of X
  - = for 10,000 letter message = 12 M for each setting * 7 XOR per double delta
  - = 89 M XOR operations

Heath Robinson

- Dec 1942: Decide to build a machine to do these XORs quickly, due June 1943
- Apr 1943: first Heath Robinson machine is delivered!
- Intercepted ciphertext on tape:
  - 2000 characters per second (12 miles per hour)
  - Needed to perform 7 XOR operations each ½ ms

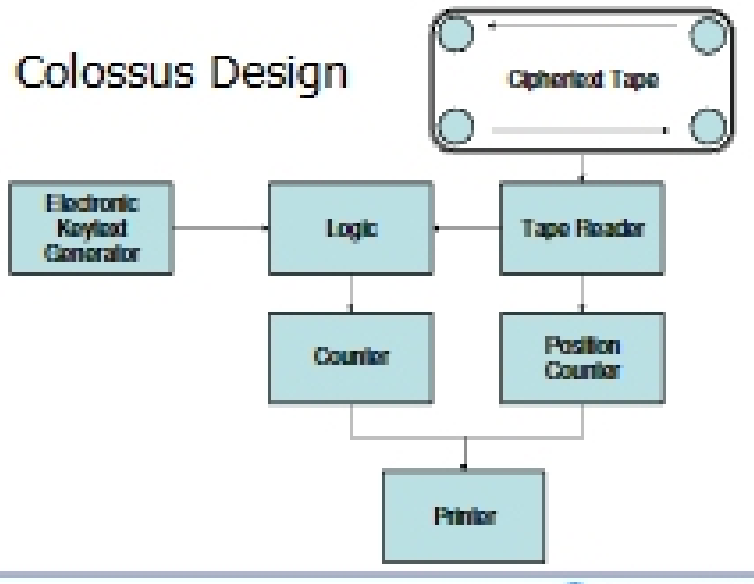


Heath Robinson, British Cartoonist (1872-1944)

Colossus

- Heath Robinson machines were too slow
- Colossus designed and first built in Jan 1944
- Replaced keytext tape loop with electronic keytext generator
- Speed up ciphertext tape:
  - 5,000 chars per second = 30 mph
  - Perform 5 double deltas simultaneously
  - Speedup = 2.5X for faster tape * 5X for parallelism

Colossus Design



Colossus

- 10 Colossi machines operating by end of WWII
- Decoded messages (63M letters total) that enabled Allies to know German troop locations to plan D-Day
- Destroyed after war, kept secret until 1970s, documents released in late 90s