

FORMAL GRAMMARS

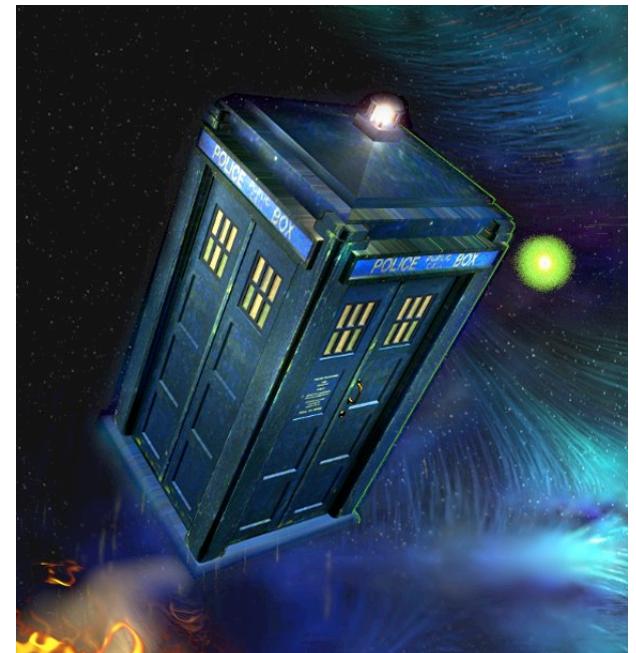
- Backus-Naur Form (BNF)
- Express syntax using patterns
- Expression and value domains

HALTING PROBLEM

- **Incompleteness:**
 - Any sufficiently complex language can express truths it cannot prove
 - Non-computable functions
 - Many interesting program properties are non-computable
 - “Does $P(x)$ halt?”
 - “Does $P(x)$ read user input?”

CONTINUATIONS

- call/cc
- Time machine
- Browser back button
- Lecture recap 2:30 pm today, TCL 308

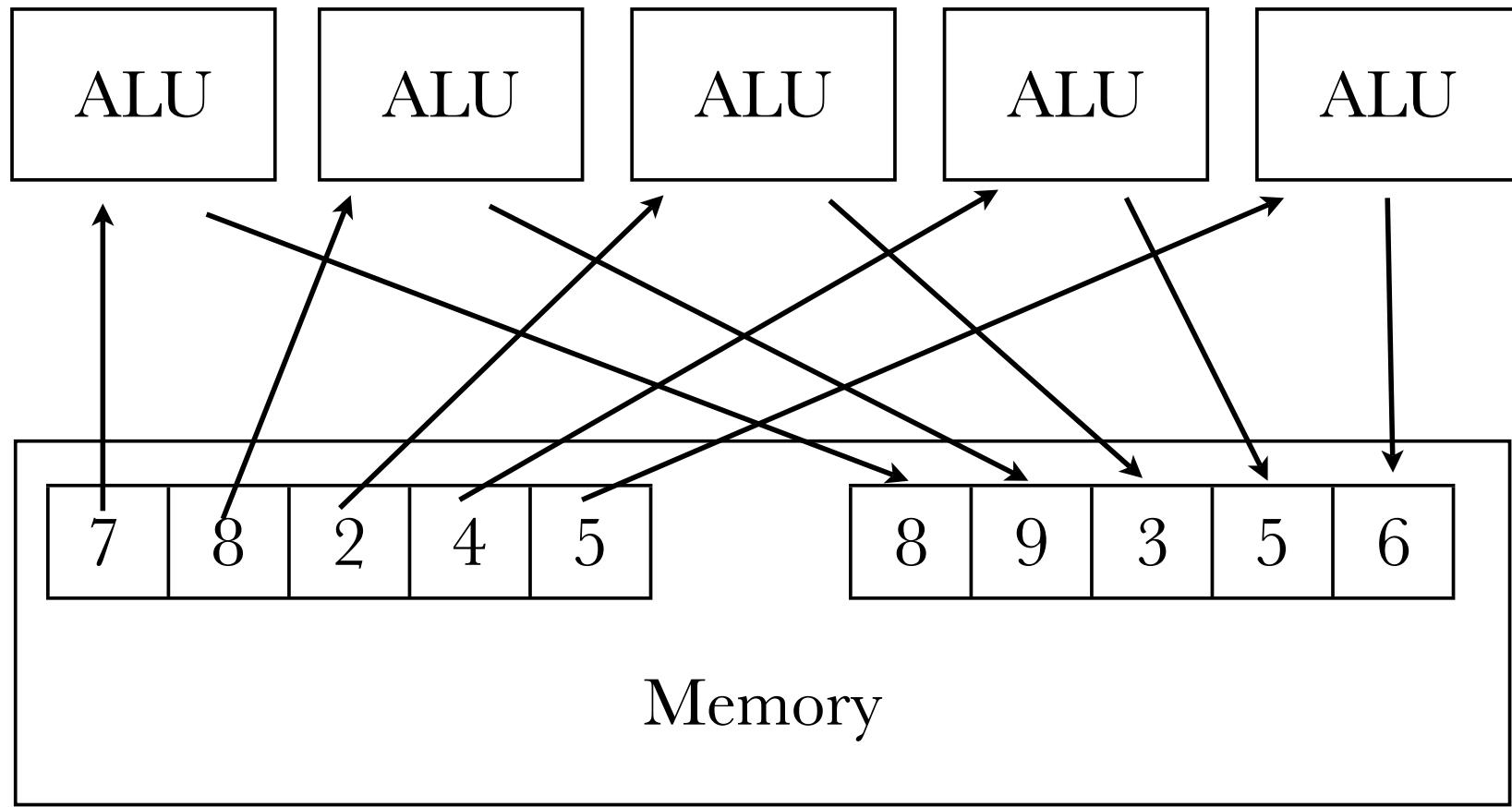


FUNCTIONAL PROGRAMMING

- Easier to understand and analyze
- Enables lazy evaluation
- Enables high-performance stream computing

STREAM PROGRAMMING

Arithmetic Logic Units



WRAP

```
(define (wrap scheme-proc)
  (BUILTIN-PROC
    (λ (eph-values)
      (->VAL
        (apply scheme-proc
          (map ->Scheme eph-values))))))
```

λ

- Abstract computation
- Delay computation
- Capture variables

Y-COMBINATOR

$$Y = (\lambda\ (g)\ ((\lambda\ (z)\ (z\ z))\ (\lambda\ (x)\ (g\ (\lambda\ (y)\ ((x\ x)\ y))))))$$
$$\text{factorial} = (Y\ (\lambda\ (f)\ (\lambda\ (n)\ (\text{if}\ (\text{zero?}\ n)\ 1\ (*\ n\ (f\ (\text{sub1}\ n)))))))$$

MACROS

- Parser plugins
- Extend syntax of language
- e.g., (OR a b) => ?

LEARNING A LANGUAGE

- Delay computation Closure
- Capture variables
- Apply delayed computation Apply
- Mutate variables Set!
- Control flow Continuation
- Extend syntax Macro