Megabytes vs. Megatons

- Computing: 30,000,000 times increase in power since 1969
- Nuclear weapons?

If Nuclear Weapons followed Moore’s Law...

- 30M \times 50 \text{ Megatons} = 1.5 \text{ Teratons}
- 1 \text{ Megaton TNT} = 4.184 \times 10^{15} \text{ Joules}
- 1.5 \text{ Teratons TNT} = 6.3 \times 10^{21} \text{ Joules}
- Energy from Sun to Earth
  \quad = 4 \times 10^{18} \text{ Joules/Year}
- One bomb today \sim all the energy to reach the Earth from the Sun since 400 AD

Actual Nuclear Weapons

- Hiroshima (12kt), Nagasaki (20kt)
- Tsar Bomba (50Mt), largest ever
- B83 (1.2Mt), largest in currently active arsenal
If it takes 60 seconds to compute a photomosaic for Problem Set 1 today on a typical PC, estimate how long it will take CS150 students in 2010 to compute the same photomosaic? How long will it take in 2013?

\[
\frac{60 \text{ seconds today}}{2 \text{ doublings by 2010}} = \frac{60 \text{ seconds today}}{4 \text{ doublings by 2013}}
\]

According to Moore's Law, the number of doublings is roughly:

\[
\frac{\text{years} \times 12}{18} = \frac{\text{months}}{2}
\]

Running out of Ideas

"It's all been said before."

Eventually true for a non-recursive language.

Never true for a recursive language.

There is always something original left to say!

Post Production Systems

Production Systems

- Set of symbols
  - Primitives

- Set of rules for manipulating symbols
  - Hofstadter: Rules of Production, Rules of Inference
  - Also: Rules of Combination

The MIU System

- Symbols: \textcolor{red}{M}, I, U
- Rules of Production:
  - \textbf{Rule I}: If you have a string ending in \textcolor{red}{I}, you can add a \textcolor{red}{U} at the end.
  - \textbf{Rule II}: Suppose you have \textcolor{red}{Mx}. Then you may add \textcolor{red}{Mxx} to your collection.
  - \textbf{Rule III}: If \textcolor{red}{III} occurs in one of the strings in your collection you may make a new string with \textcolor{red}{U} in place of \textcolor{red}{III}.
  - \textbf{Rule IV}: If \textcolor{red}{UU} occurs inside one of your strings, you can drop it.
MIU System Example
Start with MUI, produce MIU

Rules of Production:
- Rule I: If you have a string ending in I, you can add a U at the end.
- Rule II: Suppose you have M_x. Then you may add M_x U to your collection.
- Rule III: If III occurs in one of the strings in your collection you may make a new string with U in place of III.
- Rule IV: If UU occurs inside one of your strings, you can drop it.

Survey Summary
- 53 Responses
  - 63 are registered
- Problem Set Partners
  - If you selected “Yes” for the question about wanting to be assigned a partner for PS1, you should have received an email from me telling you who your partner is
  - For PS2 everyone will be assigned a partner
  - For others, some you will choose, others you may be assigned

Very Diverse Class
- Years: 12 First, 15 Second, 18 Third, 7 Fourth+
- Majors:
  - 19 Computer Science
  - 11 Undecided
  - 7 Cognitive Science
  - 3 Economics, Math
  - 2 Psychology
  - 1 Anthropology, Architecture, Commerce, Foreign Affairs, Media Studies, Music, Philosophy, Systems Engineering

Survey Responses Continued
- Previous programming: 19 None, 32 Some
- Food: 28 Bodos, 11 Krispy Kreme, 10 pizza, 1 Korean Food, 1 Outback, 1 Paccino’s, 1 Arch’s, 1 Dunkin Donuts
- Topic: 18 Google Maps, 16 Facebook, 5 Second Life, 5 Java

What is a language?

Webster:
A systematic means of communicating ideas or feelings by the use of conventionalized signs, sounds, gestures, or marks having understood meanings.
Linguist’s Definition
(Charles Yang)

A description of pairs \((S, M)\),
where \(S\) stands for sound, or any
kind of surface forms, and \(M\)
stands for meaning.

A theory of language must specify
the properties of \(S\) and \(M\), and
how they are related.

Languages and Formal Systems

What is the difference between a formal
system and a language?

With a language, the surface
forms have meaning.

Caveat: computer scientists often use
language to mean just a set of surface forms.

What are languages made of?

- **Primitives** (almost all languages have these)
  - The simplest surface forms with meaning

- **Means of Combination** (all languages have these)
  - Like Rules of Production for Formal Systems
  - Ways to make new surface forms from ones you
    already have

- **Means of Abstraction** (all powerful languages
  have these)
  - Ways to use simple surface forms to represent
    complicated ones

Does English have these?

- Primitives
  - Words (?)
    - e.g., "antifloccipoccinihilipilification" — not a primitive
  - Morphemes — smallest units of meaning
    - e.g., anti- ("opposite")

- Means of combination
  - e.g., Sentence ::= Subject Verb Object
  - Precise rules, but not the ones you learned in
    grammar school

Ending a sentence with a preposition is
something up with which we will not put.
Winston Churchill

Does English have these?

- Means of abstraction
  - Pronouns: she, he, it, they, which, etc.
  - Confusing since they don’t always mean the
    same thing, it depends on where they are
    used.

The "these" in the slide title is an abstraction
for the three elements of language introduced
2 slides ago.

The "they" in the confusing sentence is an
abstraction for pronouns.

How should we describe languages?
**Backus Naur Form**

\[ \text{symbol ::= replacement} \]

We can replace \text{symbol} with \text{replacement}.

\[ A ::= B \text{ means anywhere you have an } A, \text{ you can replace it with a } B. \]

\[ \text{nonterminal} – \text{ symbol that appears on left side of rule} \]

\[ \text{terminals} – \text{ symbol that never appears on the left side of a rule} \]

---

**BNF Example**

\[ \text{Sentence ::= NP Verb} \]

\[ \text{NP ::= Noun} \]

\[ \text{NP ::= Noun and NP} \]

\[ \text{Noun ::= Dave} \]

\[ \text{Noun ::= Scheme} \]

\[ \text{Verb ::= rocks} \]

\[ \text{Verb ::= sucks} \]

How many different things can we express with this language?

4, but only 2 are true.

---

**Most Essential Scheme**

\[ \text{Expr ::= PrimitiveExpr} \]

\[ \text{PrimitiveExpr ::= Number} \]

\[ \text{PrimitiveExpr ::= + | * | <= | ...} \]

\[ \text{Expr ::= Name} \]

\[ \text{Expr ::= ApplicationExpr} \]

\[ \text{ApplicationExpr ::= (Expr MoreExprs)} \]

\[ \text{MoreExprs ::= Expr MoreExprs} \]

This is enough for everything you need to write for PS1.

---

**Charge**

- Problem Set 1: due Monday
- Lab Hours: posted on website
  - Now and Sunday 4-5:30, 8-9:30
  - Take advantage of them!
  - If you can, follow us to lab now