COMS22201: 2015/16

Language Engineering (Semantics)

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Tuesday 26th January, 2016 (9am!)

Linguistics

- The science of language is known as linguistics

- It recognises three key aspects of any language:

  Syntax

  Semantics

  Pragmatics

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  Syntax which expressions are allowed?

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  Semantics what do those expressions mean?

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Linguistics

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- It recognises three key aspects of any language:

Syntax	which expressions are allowed?
Semantics	what do those expressions mean?
Pragmatics	how are they useful?

Semiosis

- The study of signs more generally is known as semiosis

- It recognises three key aspects of any language:

  Syntax

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Semiosis

- The study of signs more generally is known as semiosis

- It recognises three key aspects of any language:

  Syntax relation of signs to other signs

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- It recognises three key aspects of any language:

  Syntax relation of signs to other signs

  Semantics relation of signs to their designata

  Pragmatics

Semiosis

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- It recognises three key aspects of any language:

Syntax	relation of signs to other signs
Semantics	relation of signs to their designata
Pragmatics	relation of signs to their interpreters

Natural Languages

- The study of natural languages like English is descriptive linguistics

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  Syntax e.g. someone says “Wow, that’s nice!”

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Syntax	e.g. someone says “Wow, that’s nice!”
Semantics	e.g. to convey the idea of liking something
Pragmatics	e.g. thereby lying in order to win a favour

Artificial Languages

- The study of artificial languages like C is pure linguistics

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  Syntax — e.g. someone writes "`z:=x;`"

  Semantics — e.g. in order to initialise a temporary variable

  Pragmatics — e.g. thereby finding a way to swap two values

Programming Languages

- The study of programming languages we call language engineering

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Programming Languages

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  Syntax — concerned with the form of expressions and whether or not the program compiles

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Syntax	concerned with the form of expressions and whether or not the program compiles
Semantics	concerned with the meaning of expressions and what the program does when it runs
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Programming Languages

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Syntax	concerned with the form of expressions and whether or not the program compiles
Semantics	concerned with the meaning of expressions and what the program does when it runs
Pragmatics	concerned with issues like design patterns, program style, industry standards, code complexity, compiler options, development environment, commenting, …

Language Issues

Syntactic Complexity

Jack built the house the malt the rat the cat killed ate lay in.

Language Issues

Syntactic Complexity

Jack built the house

the malt *lay in*

the rat *ate*

the cat killed

Language Issues

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Syntactic Complexity

Jack built the house the malt the rat the cat killed ate lay in.

Syntactic Ambiguity

Let him have it Chris!

Language Issues

Syntactic Complexity

Jack built the house the malt the rat the cat killed ate lay in.

Syntactic Ambiguity

Let him have it, Chris!

Language Issues

Syntactic Complexity

Jack built the house the malt the rat the cat killed ate lay in.

Syntactic Ambiguity

He's got a gun!

…

Come on, son, game's up.

Get back, copper!

Give that thing to me.

Let him have it, Chris!

…

(gunshots)

-- Excerpt from film “Let Him have it” which tells the story of Derek Bentley who was hanged in 1953 for the shooting of a police officer by Chris Craig

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It depends on what the meaning of the word "is" is

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Semantic Complexity

Whether or not Mr. Bennett knew of your relationship with Ms. Lewinsky, the statement that there was "no sex of any kind in any manner, shape or form, with President Clinton," was an utterly false statement. Is that correct?

It depends on what the meaning of the word "is" is … if "is" means is and never has been … that is one thing. If it means there is none, that was a completely true statement.

-- Excerpt from Bill Clinton's testimony to the Grand Jury where he tries to argue why he hadn't lied about not having relations with Monica Lewinsky

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Semantic Ambiguity

I haven't slept for ten days.

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Semantic Undefinedness

Colorless green ideas sleep furiously.

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Interaction of syntax and semantics

Time flies like an arrow; fruit flies like a banana.

Programming Issues

Syntactic Complexity

```
a = b < c ? * p + b * c : 1 << d ()
```

% spaghetti code

Programming Issues

Syntactic Complexity

a = b < c ? * p + b * c : 1 << d () % spaghetti code

Levels of precedence	C++ has 17	
	Java has 16	
	C has 15	Too many?
	Pascal has 5	Too few?
	Smalltalk has 0	

0 <= a and a <= 9

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Syntactic Ambiguity

```
if (..) if (..) .. ; else ..
```

% dangling if

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Semantic Complexity

```
y = x++ + x++
```
% sequence points

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(x%2==1) ? "odd" : "even"
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% undefined in C89 if x<0

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while (x/x)
```
% error (x=0) or infinite loop

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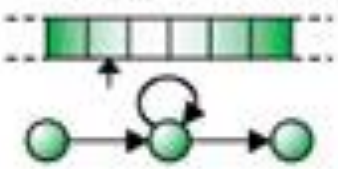
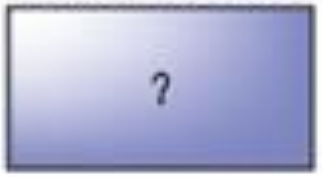
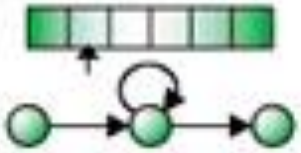
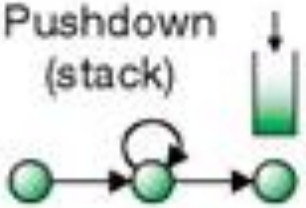
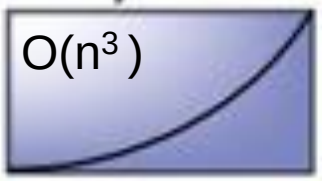
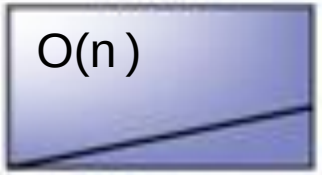
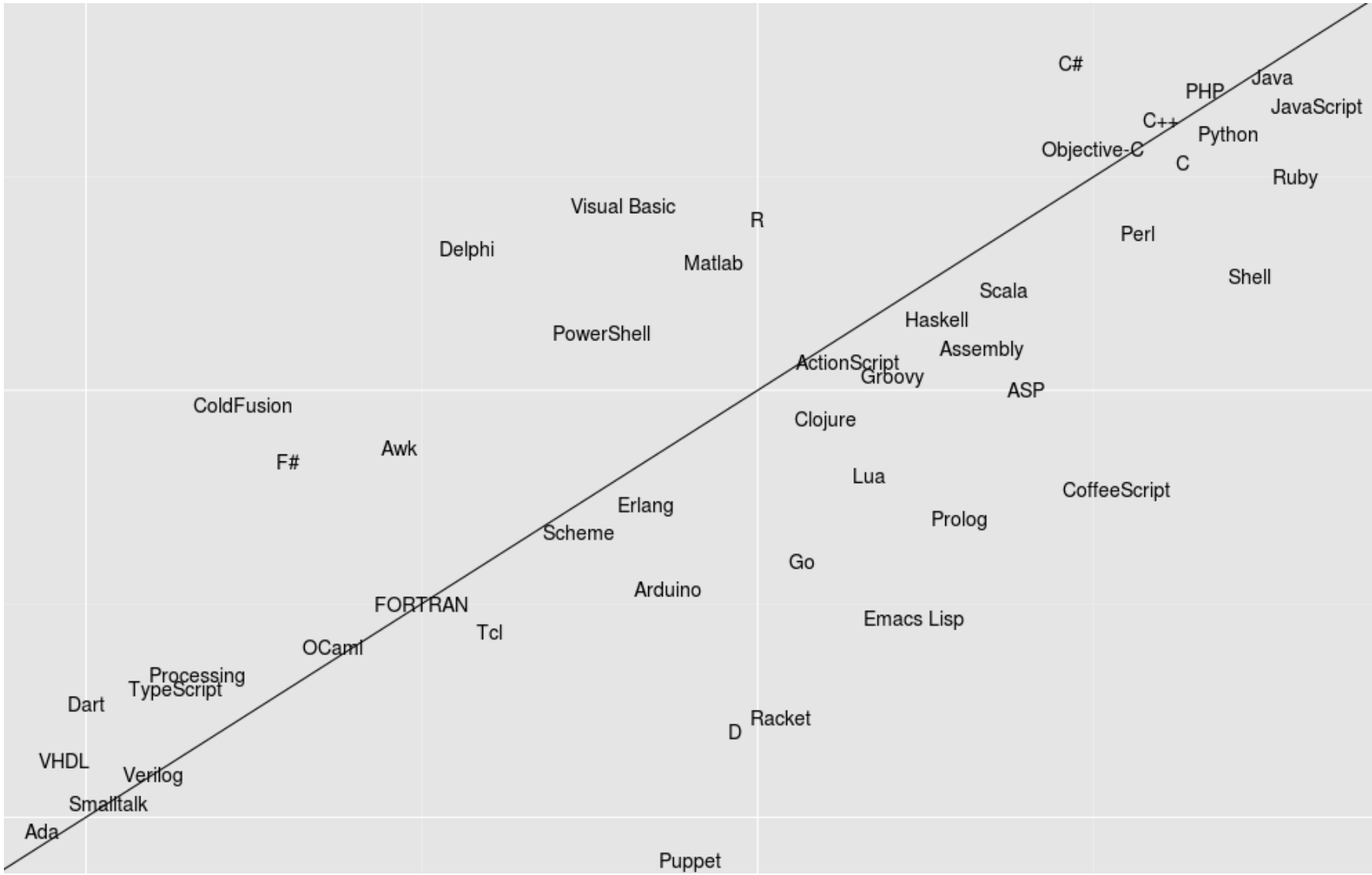
Interaction of syntax and semantics

```
A * B
```
% lexer hack

Formal Languages: by Expressivity

Grammar	Language	Automaton	Productions	Recognition	Example
Phrase structure grammar	Recursively enumerable languages	Turing machine 	Unrestricted $Baa \rightarrow A$	Undecidable 	…
Context sensitive grammar	Context-sensitive languages	Linear bounded 	Context sensitive $At \rightarrow aA$	Exponential? 	$a^n b^n a^n$
Context Free grammar	Context-free languages	Pushdown (stack) 	Context free $S \rightarrow gSc$	Polynomial 	$a^n b^n$
Regular Expression	Regular languages	Finite-state automaton 	Regular $A \rightarrow cA$	Linear 	$a^n b$

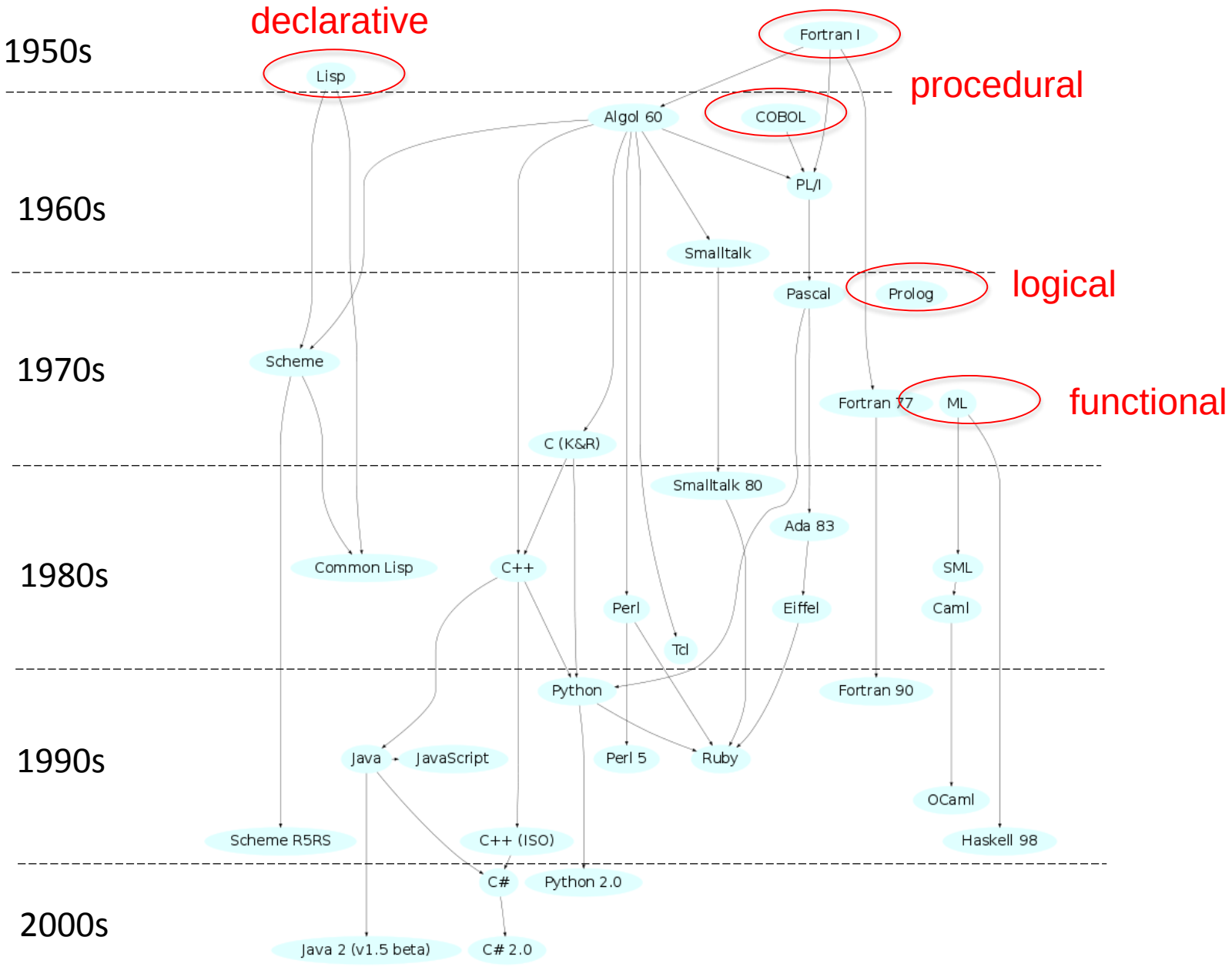
Programming Languages: by Popularity



Stack Overflow Rank (top 47 languages by no. of tags)

GitHub Rank (top 47 languages by no. of projects)

Programming Languages: by Type



Semantics

- In 1900, Breal defined semantics as the study of the way words change their meaning: e.g. the English word “nice” has evolved greatly:

kind, thoughtful	(mid 19c.)
agreeable, pleasing	(mid 18c.)
precise, careful	(late16c.)
fussy, fastidious	(mid 16c.)
coy, shy	(early 16c.)
strange, rare	(mid 15c.)
wanton, extravagant	(mid 14c.)
ignorant, foolish	(late 13c.)

- In 1939, Carnap: defined semantics as study of the relationships between expressions and their designata

What's in a Name?

The meaning of a string can be arrived at in any number of ways –

for example the string "1101" could mean any of the following:

- The number one thousand one hundred and one (if a decimal)
- The number thirteen (if binary)
- The number minus three (if in two's complement)
- The character represented by any of the above (if ASCII)
- The number two followed by the number one (if a unary encoding)
- I have completed three of the four tasks on my todo checklist

There can always be "imoret thani"

Overview of Course

Meaning of program statements represented by mathematical relations (of increasing abstraction) …