Introduction to Computer Science for Geographers

Scientific Programming Languages

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Time table

Time	Day 1	Day 2	Day 3	Day 4	Day 5
9:15 – 9:45	Introduction	Questions	Questions	Questions	Questions
9:45 - 10:45		Computer Hardware	Program Design	Errors, Debugging, Testing	APIs
10:45 - 11:00	BREAK	BREAK	BREAK	BREAK	BREAK
11:00 - 12:30	**Programming Languages**	Numpy	Program Design	Errors, Debugging, Testing	Open Space
12:30 - 13:45	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH
13:45 - 15:15	Vector data in Python	Raster data in Python	Documentation and code style	Profiling & Efficiency	Final Assignment
15:15- 15:30	BREAK	BREAK	BREAK	BREAK	BREAK
15:30 - 16:15	git session	git session	git collaboration	Profiling & Efficiency	
16:15 - 16:30	Questions + Feedback	Questions + Feedback	Questions + Feedback	Questions + Feedback	

Learning Goals

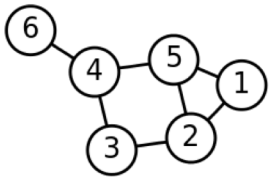
1. Explain the difference between compilation and interpretation of source code.
2. Name advantages and disadvantages of using C vs. Python.
3. Use the command line to navigate through the file system.
4. Set up a Python environment using Anaconda.

Agenda

1. Types of Programming Languages
2. Compilation vs. Interpretation
3. Comparison of C vs. Python
4. Virtual Python Environments using Anaconda

How to solve a problem using the computer

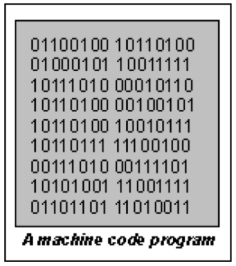
Problem | Instructions | Source code | Running instance | Output



1. Go to...
2. Do XY
3. ...

```
def add5(x):
    return x+5

def dotwrite(ast):
    nodename = getNodename()
    label=symbol.sym_name.get(int(ast[0]),ast[0])
    print '    %s [label="%s' % (nodename, label),
    if isinstance(ast[1], str):
        if ast[1].strip():
            print '= %s"];' % ast[1]
        else:
            print '"]'
    else:
        print '"];'
        children = []
        for  in n, childenumerate(ast[1:]):
            children.append(dotwrite(child))
        print ,'    %s -> {' % nodename
        for  in :namechildren
            print '%s' % name,
```



A machine code program

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Problem → Algorithm → Program → Process → Output

What is happening here?

A **programming language** is a formal language, which comprises a set of instructions that produce various kinds of output. [Wikipedia]

Might also be a real-world process
e.g. Hydrological run-off model

Generations of Programming Languages (GL)

Natural Language (high-level)

Level of Abstraction

Computer Language (low-level)

Self learning/stochastic Language (5.GL)

Machine determines a solution itself (not widely used)

High-Level Language (4.GL)

e.g. R, SQL, MATLAB

High-Level Language (3.GL)

e.g. C, C++, C#, Java

```
func sum(n: Int): Int = {
    n * (n + 1) / 2
}
```

Source code

Assembly language (2.GL)

specific to a certain processor

```
LEA $eax, n
ADD $eax, 1
MUL $eax, n
DIV $eax, 2
RET $eax
```

Assembly code

Machine Language (1. GL)

specific to a certain processor

```
10100111100
11110011001
10010010010
10110111001
11101111011
```

Machine code

Programming for Scientists

Scientists (or Non-Computer Scientist) usually use High-Level programming languages.

The question is usually just about whether to use a

compiled or interpreted

language.

C, C#, C++

Python

Do you know examples for compiled and interpreted languages?

Agenda

1. Types of Programming Languages
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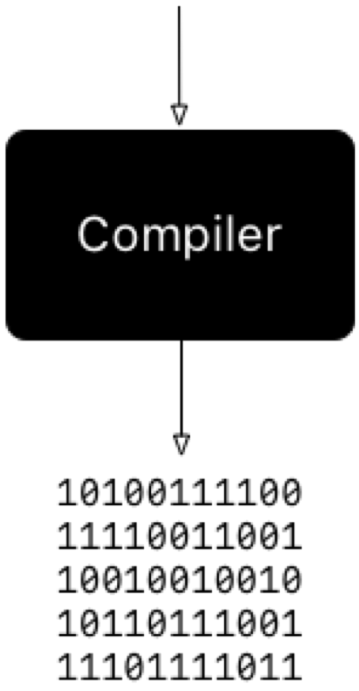
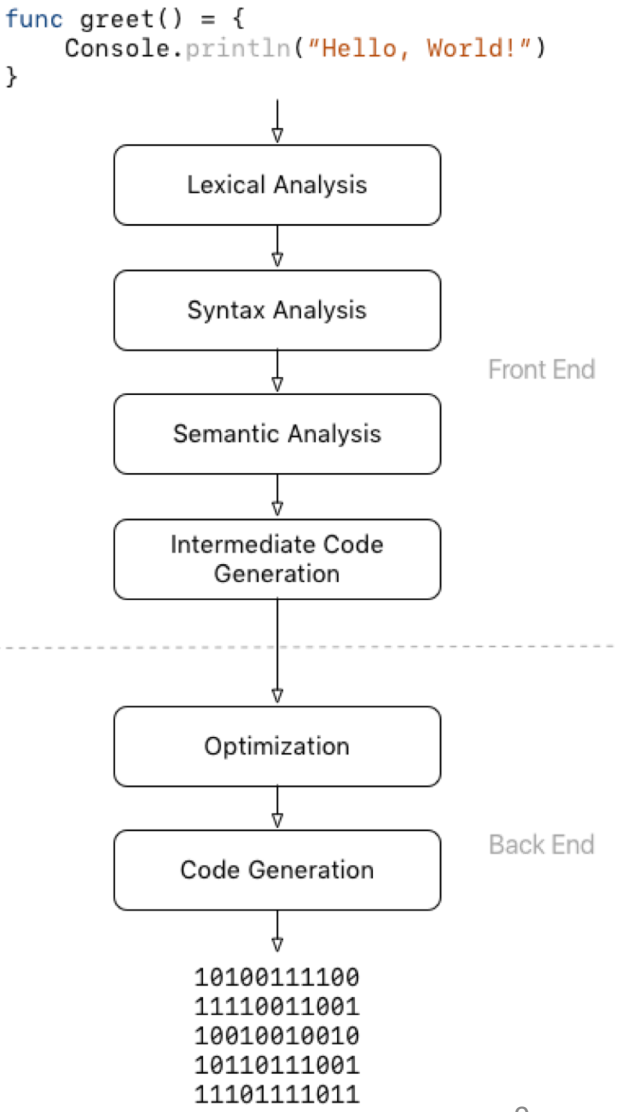
What is Compilation?

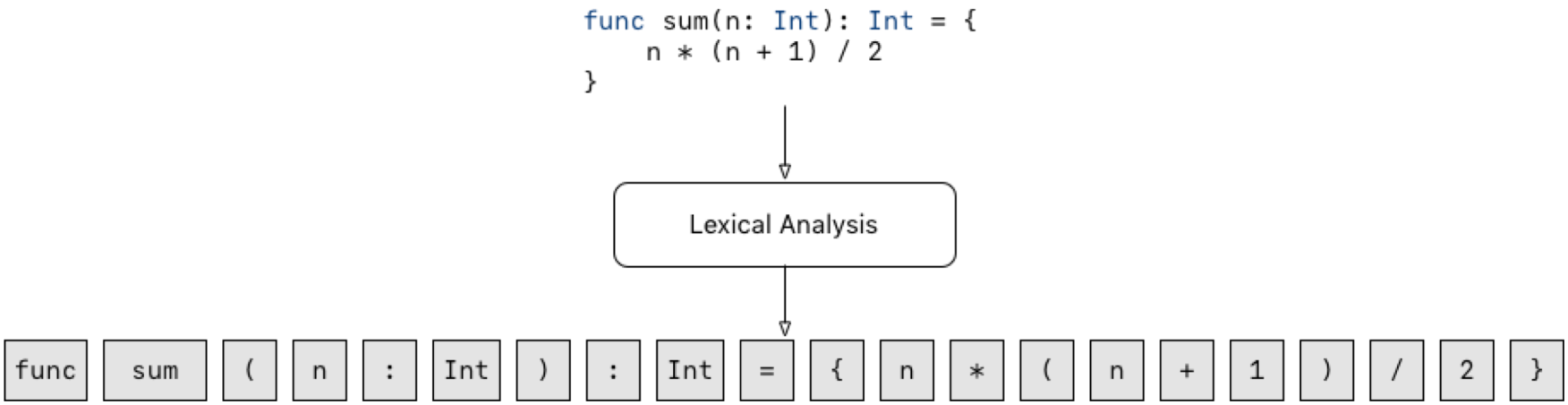
```
func greet() = {
    Console.println("Hello, World!")
}
```





https://hackernoon.com/compilers-and-interpreters-3e354a2e41cf

Compilation – Lexical Analysis



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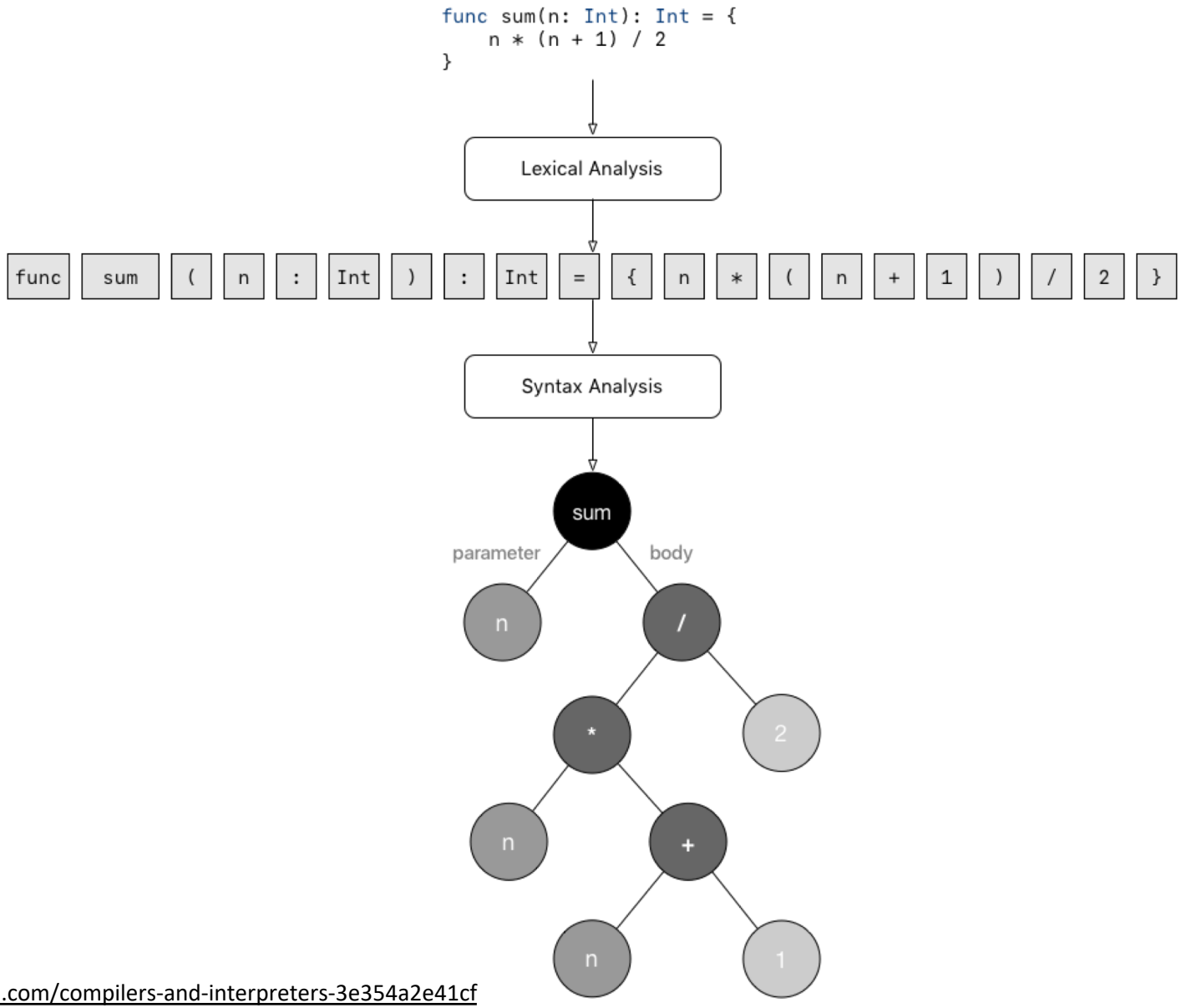
Compilation – Syntax Analysis



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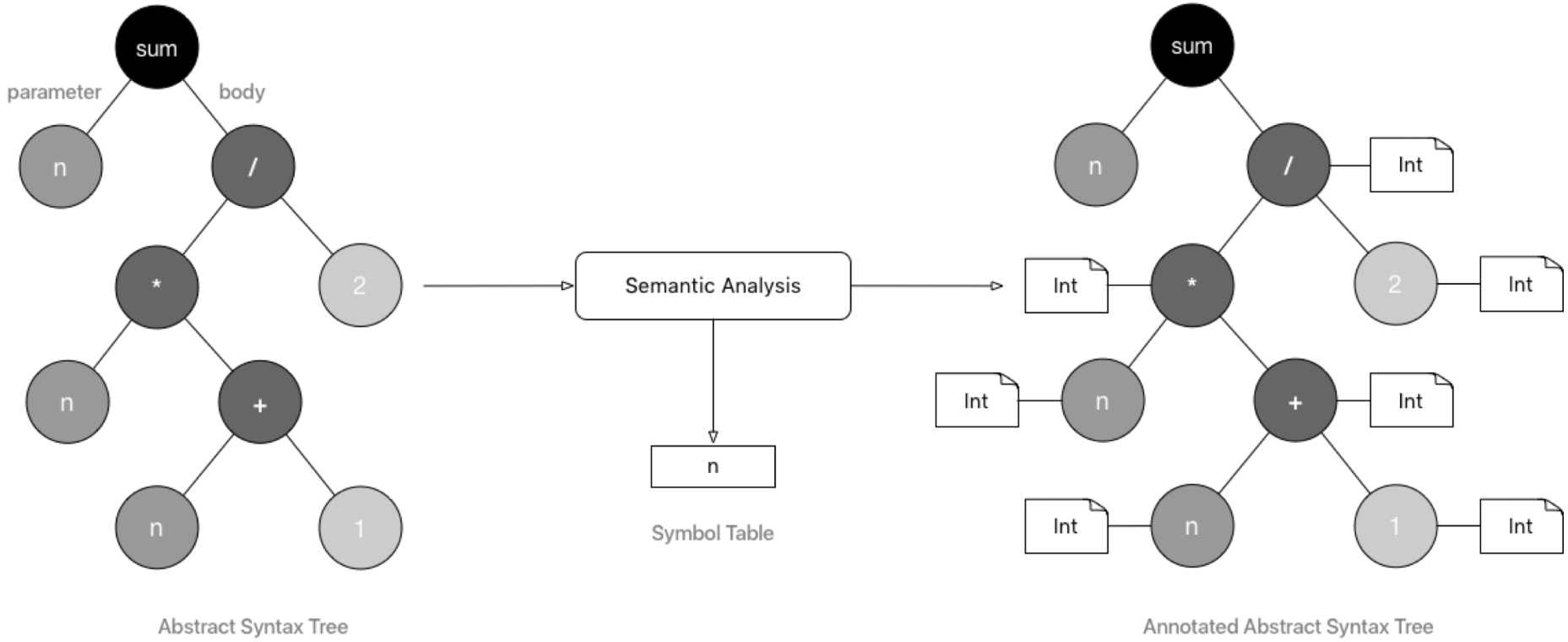
Compilation – Semantic Analysis



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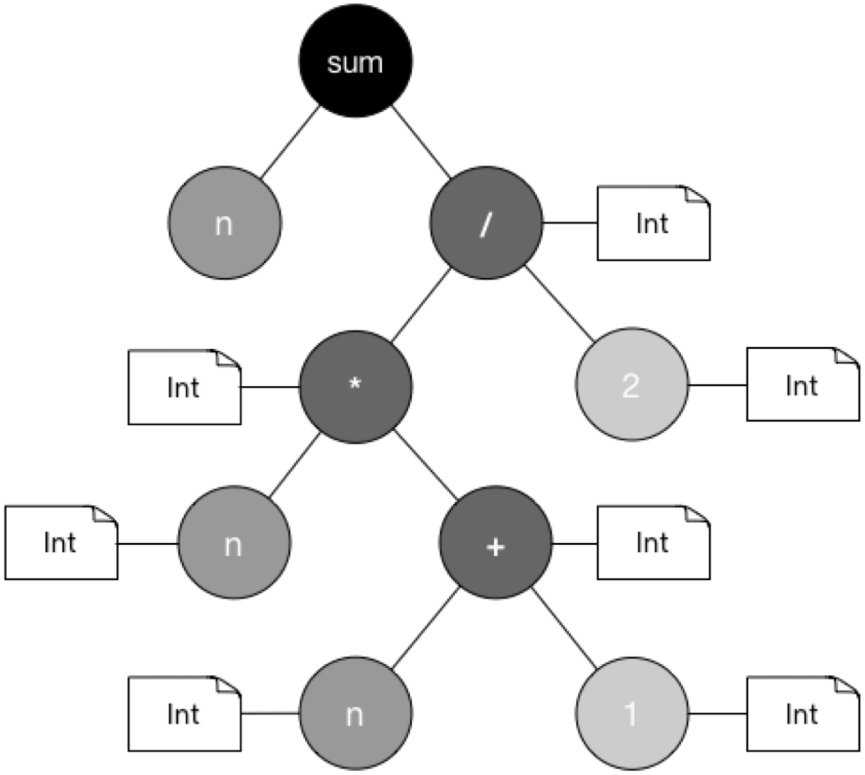
Compilation – Intermediate Code Generation



Annotated Abstract Syntax Tree

Intermediate Code Generation

```
t1  := n + 1
t2  := n * t1
t3  := t2 / 2
id1 := t3
```

Three-address code

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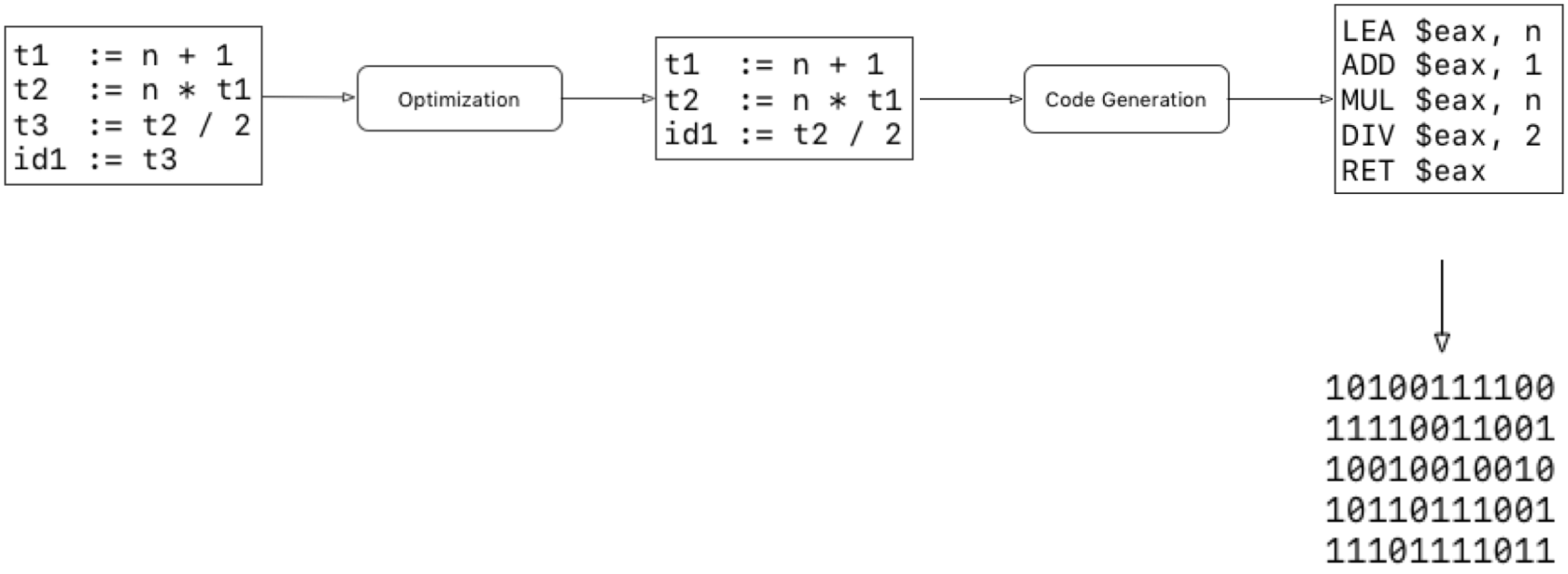
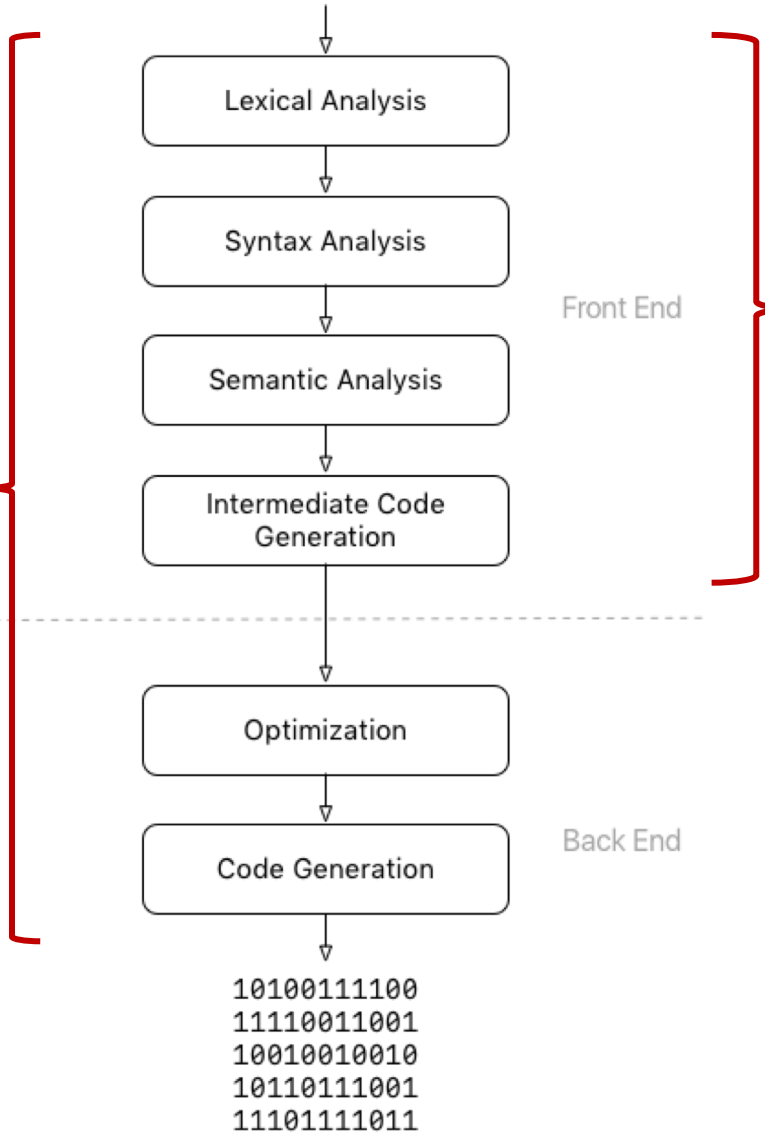
Compilation – Optimization & Code Generation



Explained in good blog post:
https://hackernoon.com/compilers-and-interpreters-3e354a2e41cf

Compiler vs. Interpreter

```
func greet() = {
    Console.println("Hello, World!")
}
```



Compilers execute all parts

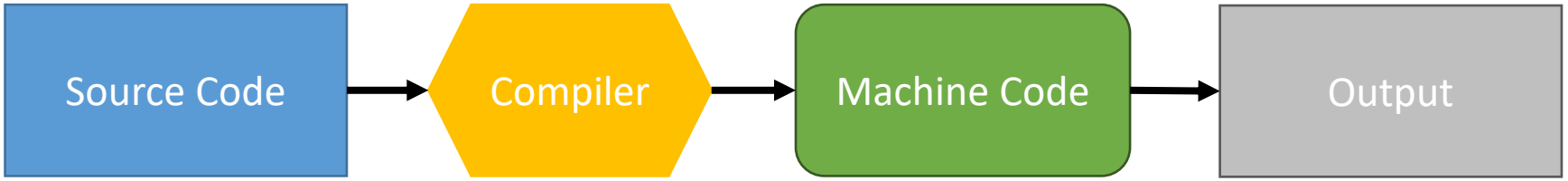
Interpreters only execute this part

```
t1  := n + 1
t2  := n * t1
t3  := t2 / 2
id1 := t3
```

→ No processor specific optimization

Compilers vs. Interpreters

How a compiler works (e.g. C) → Compilation before runtime




```
func greet() = {
    Console.println("Hello, World!")
}
```

```
10100111100
11110011001
10010010010
10110111001
11101111011
```

42

How a interpreter works (e.g. Python) → Compilation at runtime

Hands-On in Pairs!

Write a program in Python that prints:

“Hello World!”

(…or any other message that you would like to spread around)

Execute it in the command line.

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Python vs. C

C

- Compiled language

Python

- Interpreted language

Python vs. C

Python Source Code

```
x = 10
print(x)
```

```
x = “Hello World”
print(x)
```

No explicit type declaration
→ Dynamic typing
→ Type inference during runtime

C Source Code

```
int x;
x = 10;
printf(“%d”, x);
```

```
x = “hello world”
char *y;
y = “hello world”;
printf(“%s”, y);
```

Error

Explicit type declaration
→ Static typing

Python vs. C

Python

- Compilation at runtime
- Simple syntax
- Dynamic typing
- Many built-in functions
- Garbage collection

C

- Compilation before runtime
- More complex syntax
- Static typing
- Code everything from scratch
- Manual memory management

Discuss in Pairs

What are advantages and disadvantages of Python vs. C?

Python vs. C

Python

- Compilation at runtime
- Simple syntax
- Dynamic typing
- Many built-in functions
- Garbarge collection

→ Faster coding

→ Interactive coding and debugging

→ Slower computation

→ No type-safety

C

- Compilation before runtime
- More complex syntax
- Static typing
- No built-in functions
- Manual memory management

→ Slower coding

→ Compile after every change

→ Faster computation

→ Type-safety

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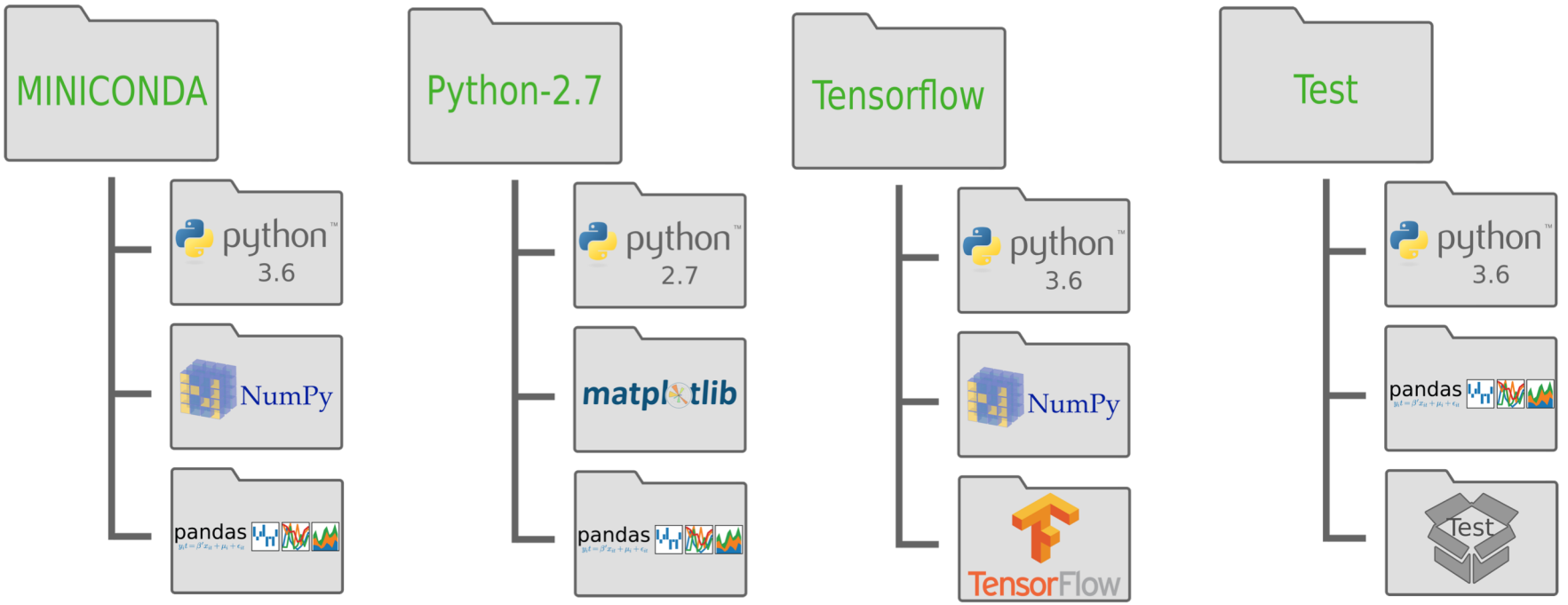
Python Virtual Environments

ANACONDA®



https://python-for-scientists.readthedocs.io/en/latest/_pages/environments.html

Python Environments

Hands-On in Pairs!

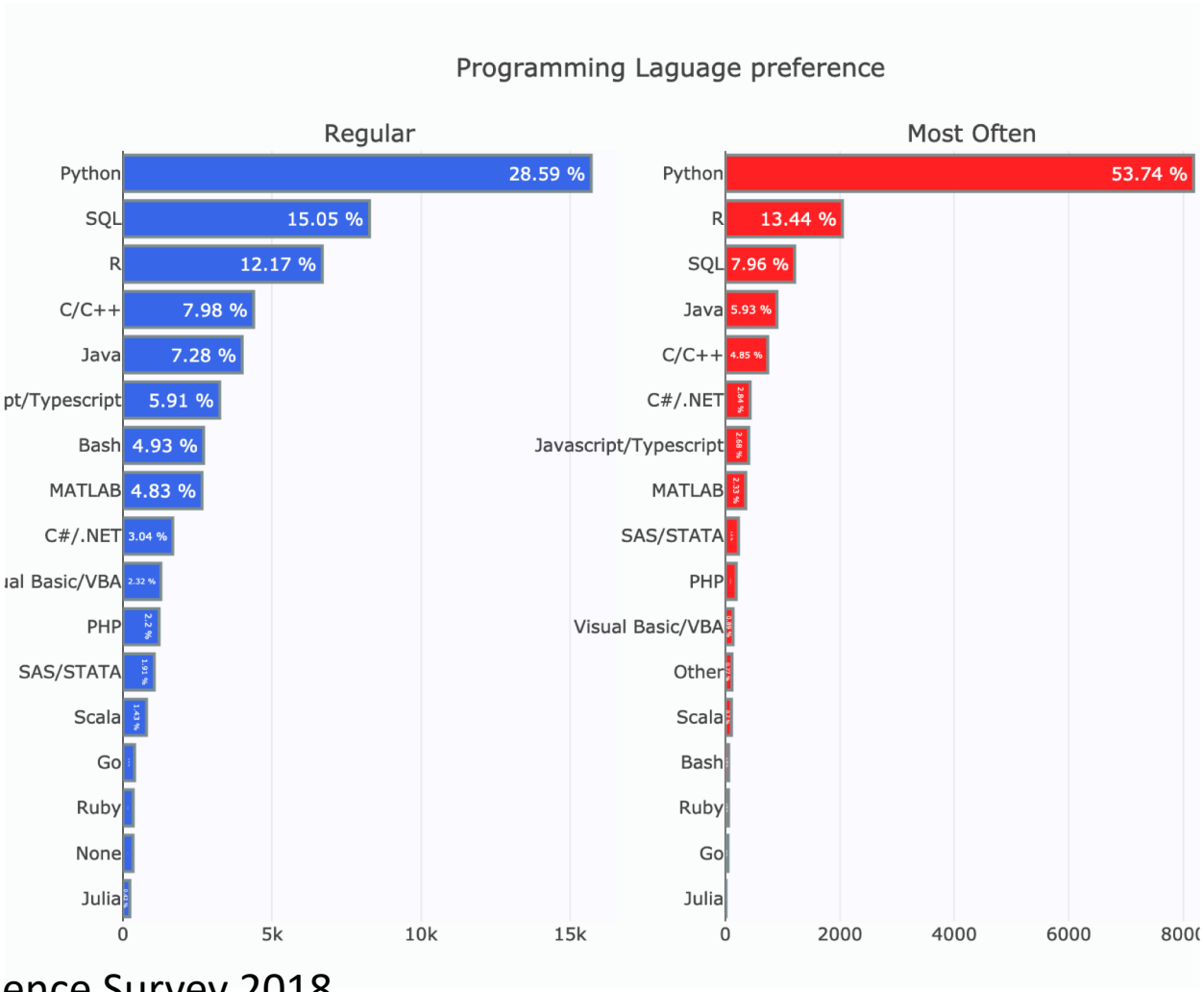
Set up a Python environment using Anaconda.

Summary

- There is no best programming language.
- Python requires more computation time than C, but the simple syntax, built-in functions and garbage collection saves the programmer a lot of time when writing code.
- Combination of Python and C exist
  - Many python functions are implemented in C
  - You can combine Python and C using Cython
- Anaconda allows you to create and manage multiple virtual Python environments, so you can configure Python for different applications.

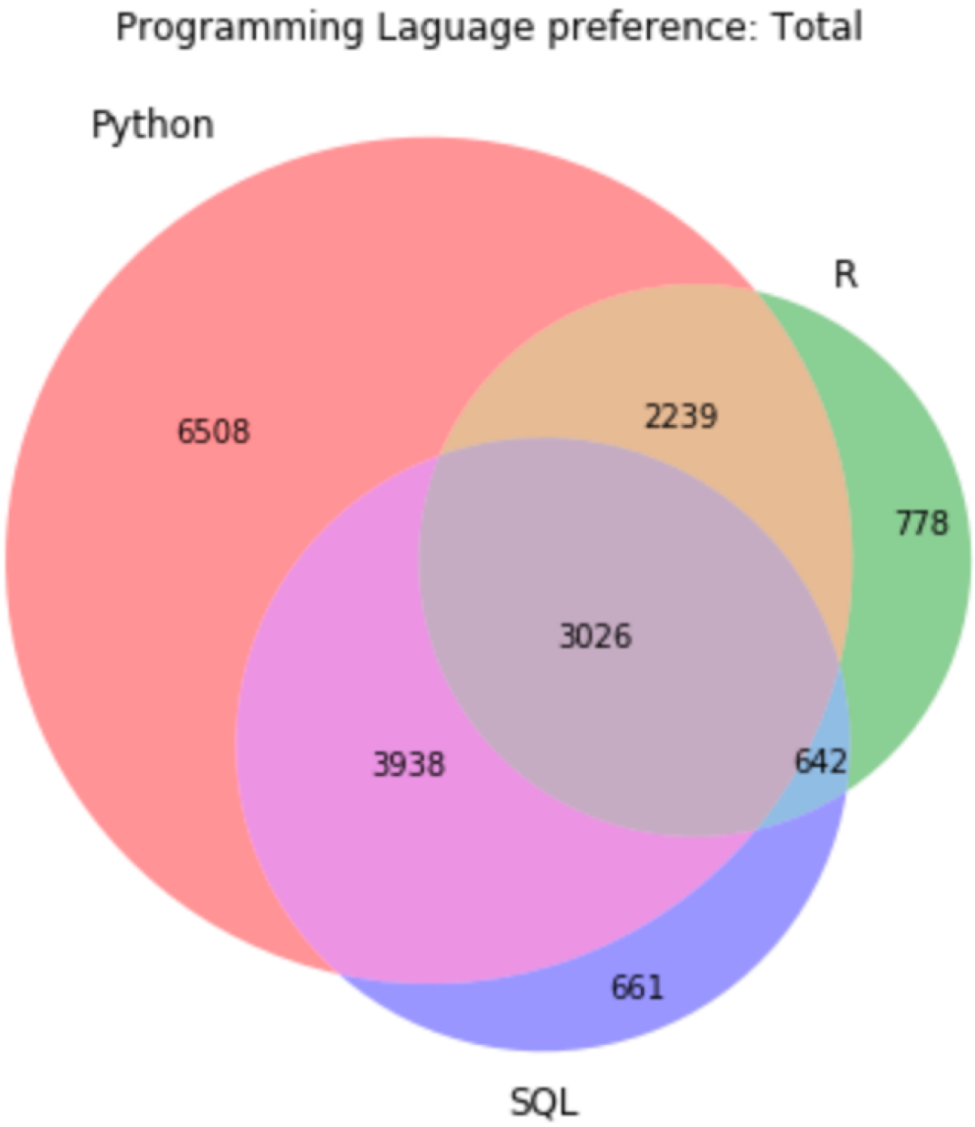
Python for Science

What programming languages do you use on a regular basis? (Select all that apply) - Selected Choice



Kaggle Data Science Survey 2018

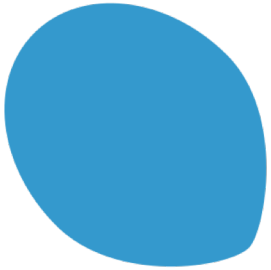
Python for Science



Kaggle Data Science Survey 2018

The world of Scientific Python

SciPy



software carpentry

PyData

Lunch Time!

Resources

Compilation: https://hackernoon.com/compilers-and-interpreters-3e354a2e41cf

Python Interpreter: https://indianpythonista.wordpress.com/2018/01/04/how-python-runs/