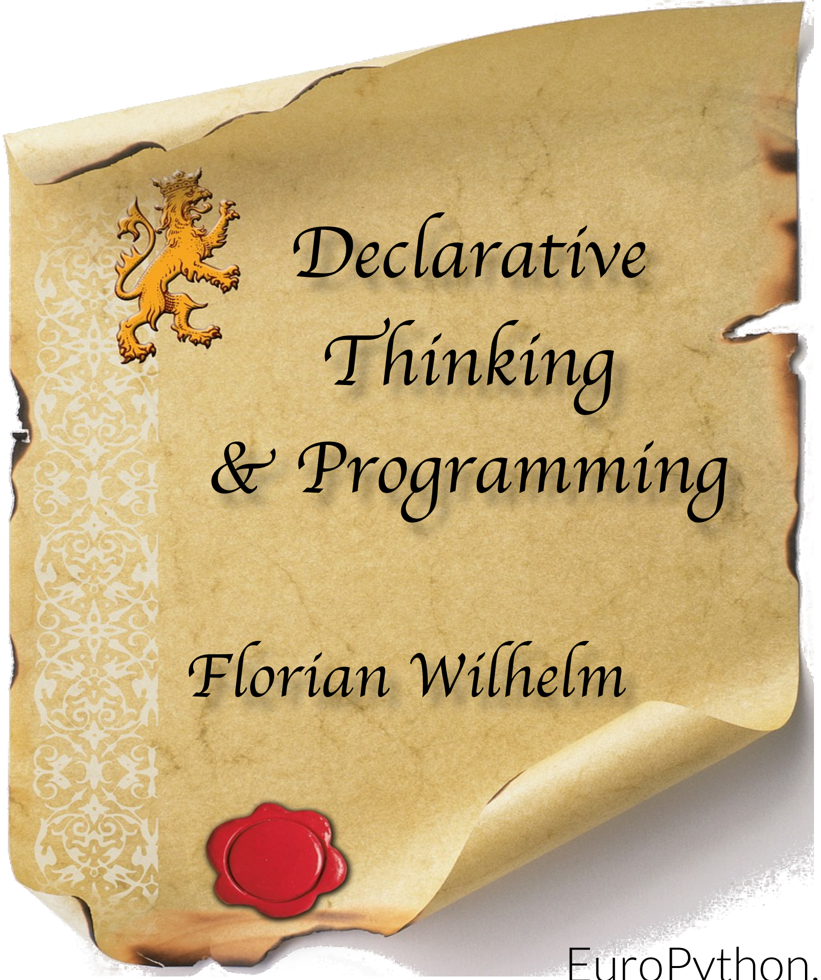

Declarative Thinking & Programming

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EuroPython, Rimini, 2017-07-13

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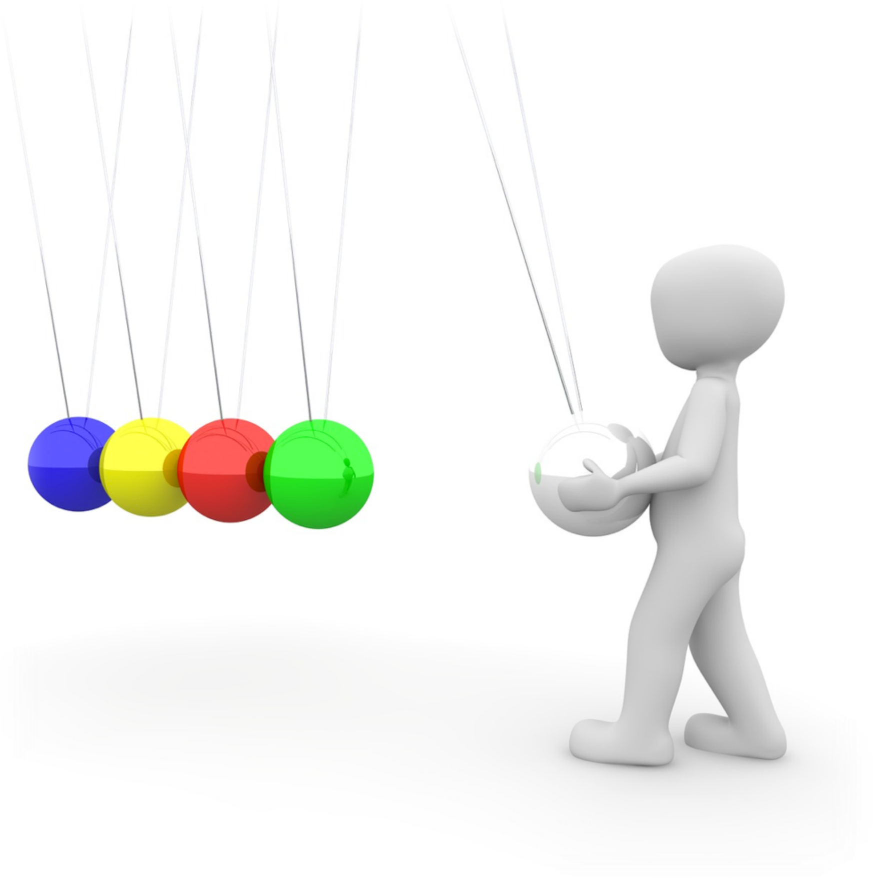
Creator of PyScaffold

Outline

1. **Motivation & Concept**
2. Examples
3. Math Riddle



Motivation

House-warming party with your friends

Motivation

What is the actual task?

clean up

find easy receipe

put boxes in basement

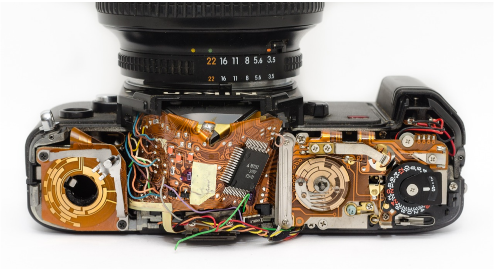
buy more beer

invite friends

Level of Abstraction

Right level of abstraction given a task

What is needed to describe the problem?



map & reduce

Imperative vs. Declarative

How vs. What

imperative

how

over-specification, detailed instructions, ...

declarative

what

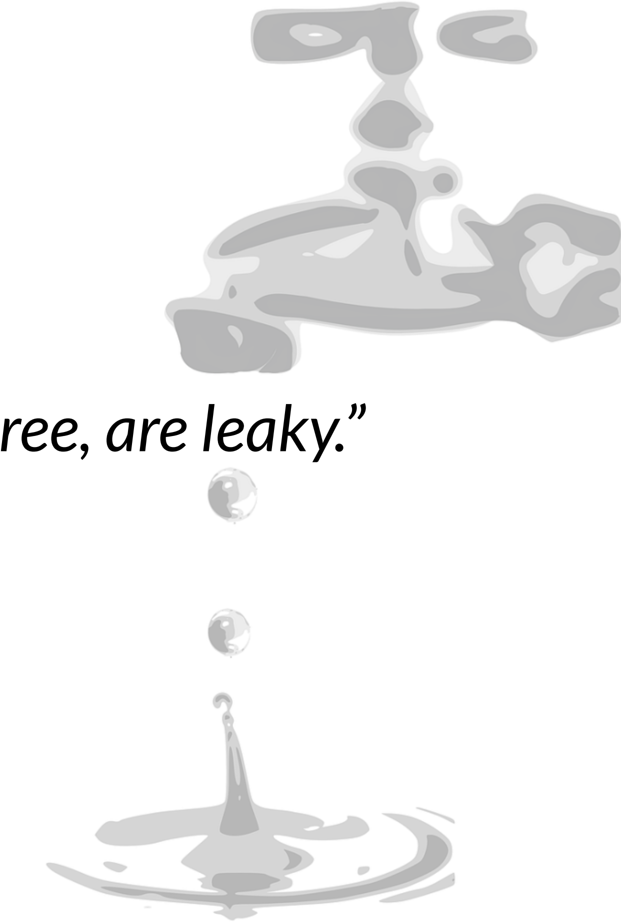
separation of concerns, single level of abstraction, ...

depending on the level of abstraction

Leaky Abstractions

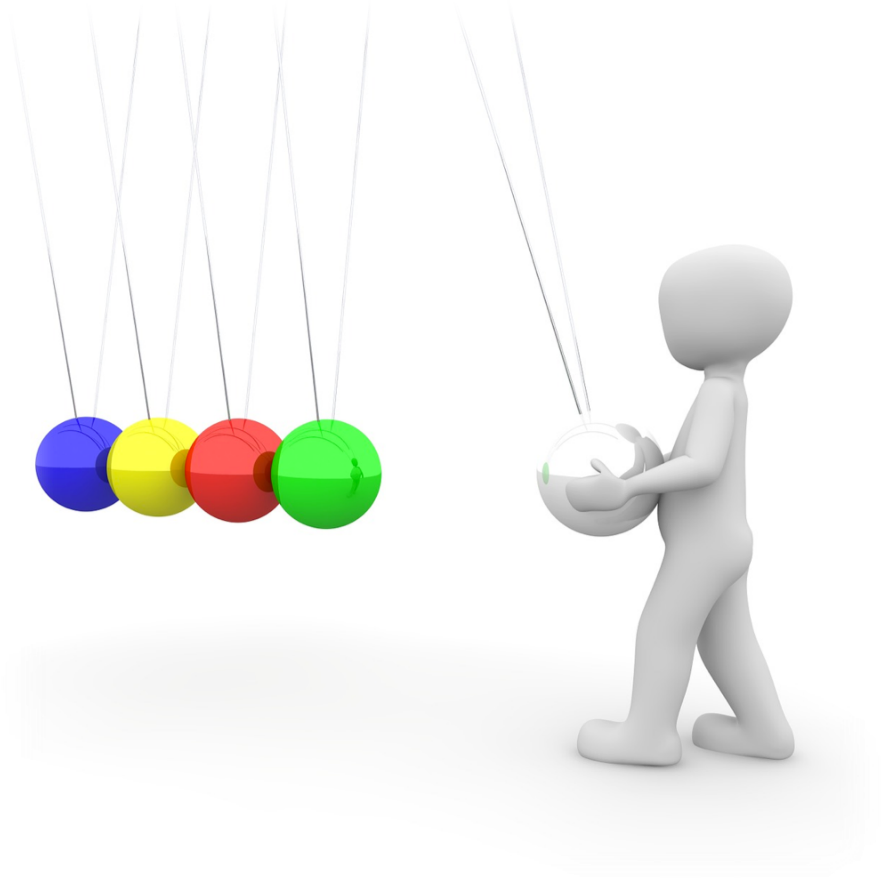
Law of Leaky Abstractions by Spolsky:

> *“All non-trivial abstractions, to some degree, are leaky.”*



Outline

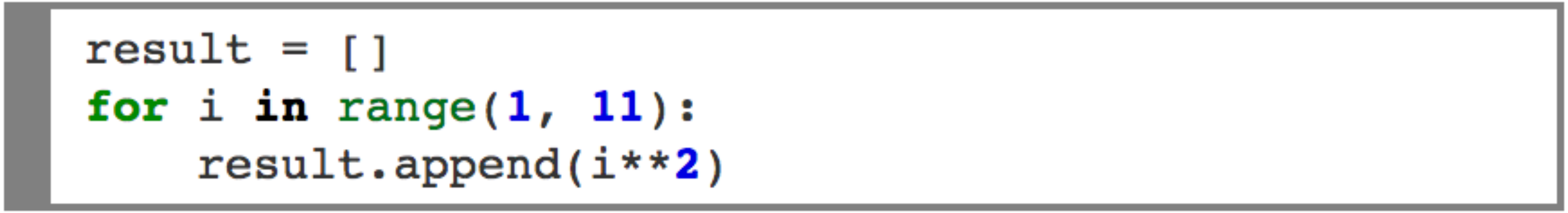
1. Motivation & Concept
2. **Examples**
3. Math Riddle



Example 1: List Comprehensions

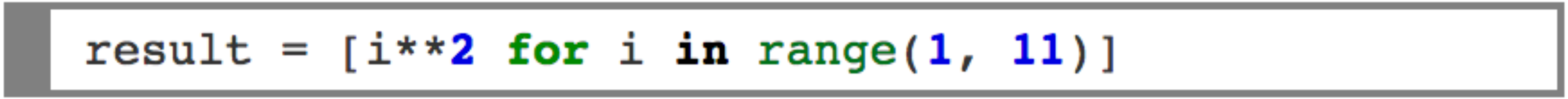
List of squared number from 1 to 10

imperative:



```
result = []
for i in range(1, 11):
    result.append(i**2)
```

declarative:

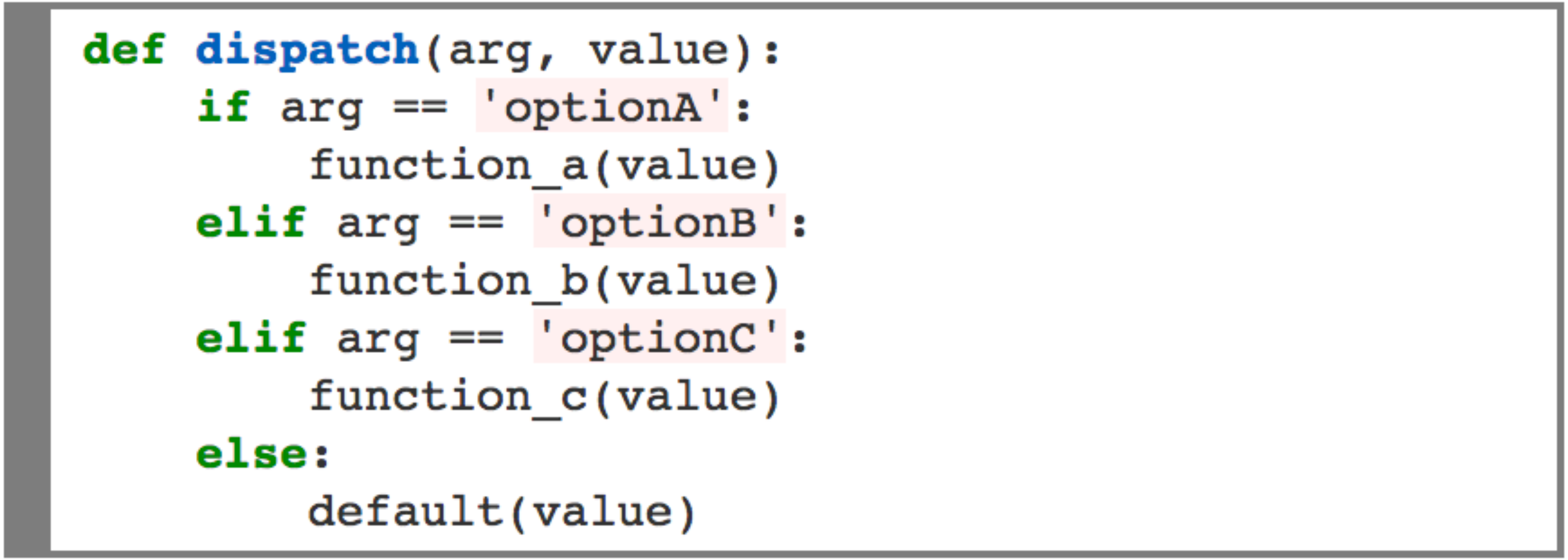


```
result = [i**2 for i in range(1, 11)]
```

Example 2:

Dispatching with respect to some argument

Imperative:

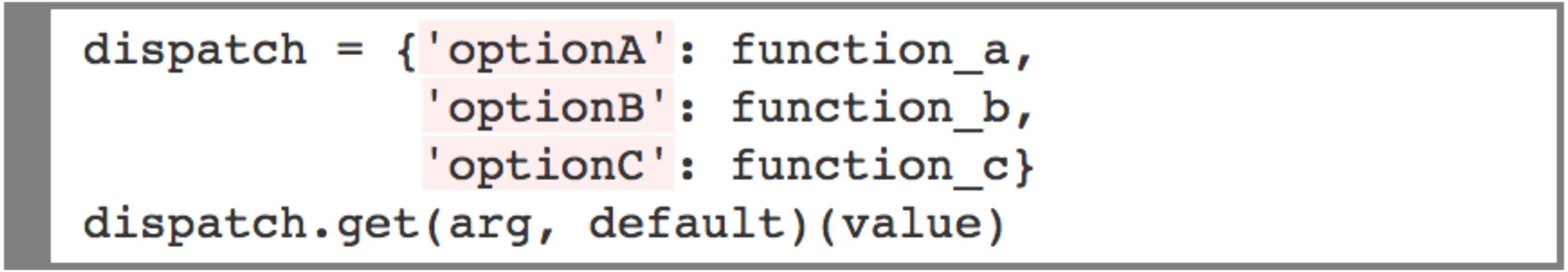


```
def dispatch(arg, value):
    if arg == 'optionA':
        function_a(value)
    elif arg == 'optionB':
        function_b(value)
    elif arg == 'optionC':
        function_c(value)
    else:
        default(value)
```

Example 2: Dictionaries

Dispatching with respect to some argument

Declarative:

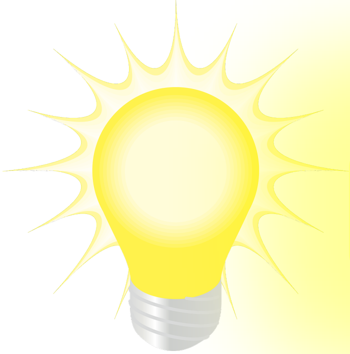


```
dispatch = {'optionA': function_a,
            'optionB': function_b,
            'optionC': function_c}
dispatch.get(arg, default)(value)
```

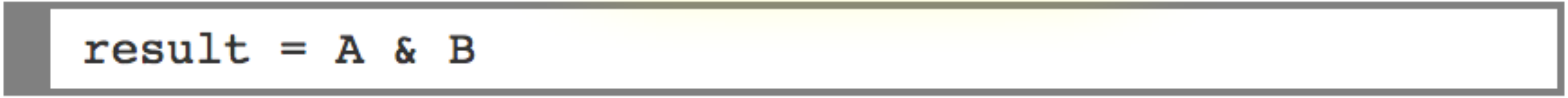
Example 3: Sets

Find Plagiarism

How many sentences of work A are equal to my work B?



Set Theory



```
result = A & B
```

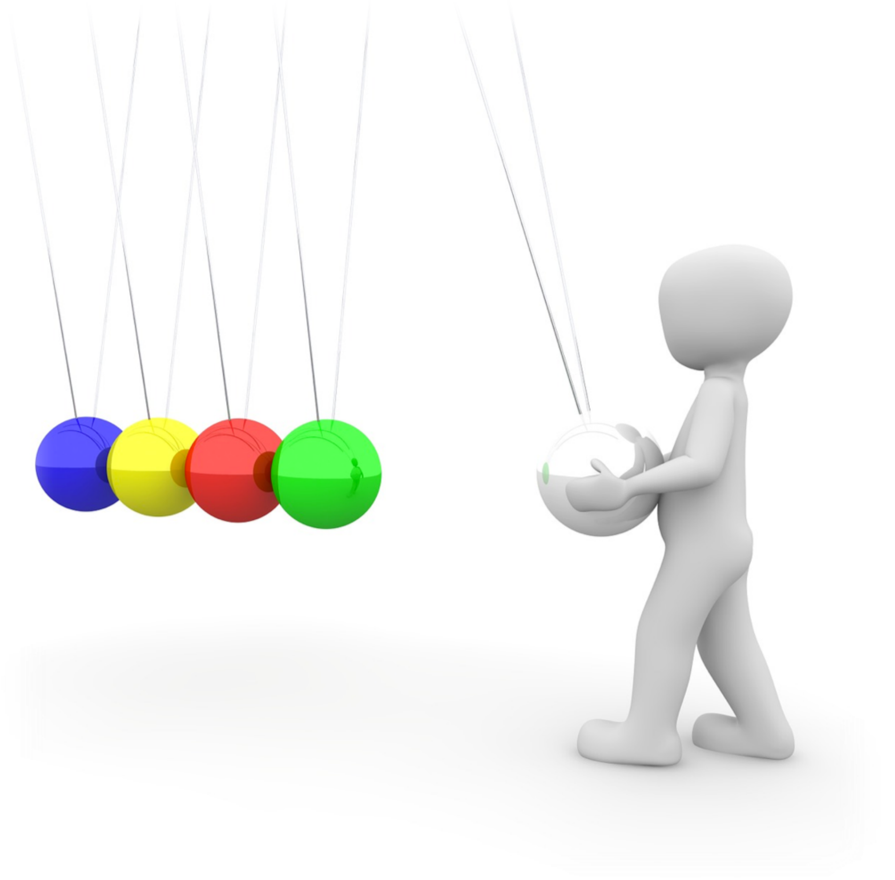
Example 4: Configuration Files

Python modules vs markup languages

vs

Outline

1. Motivation & Concept
2. Examples
3. **Math Riddle**



Math Riddle

horizontal:
A: digit sum of horizontal C,

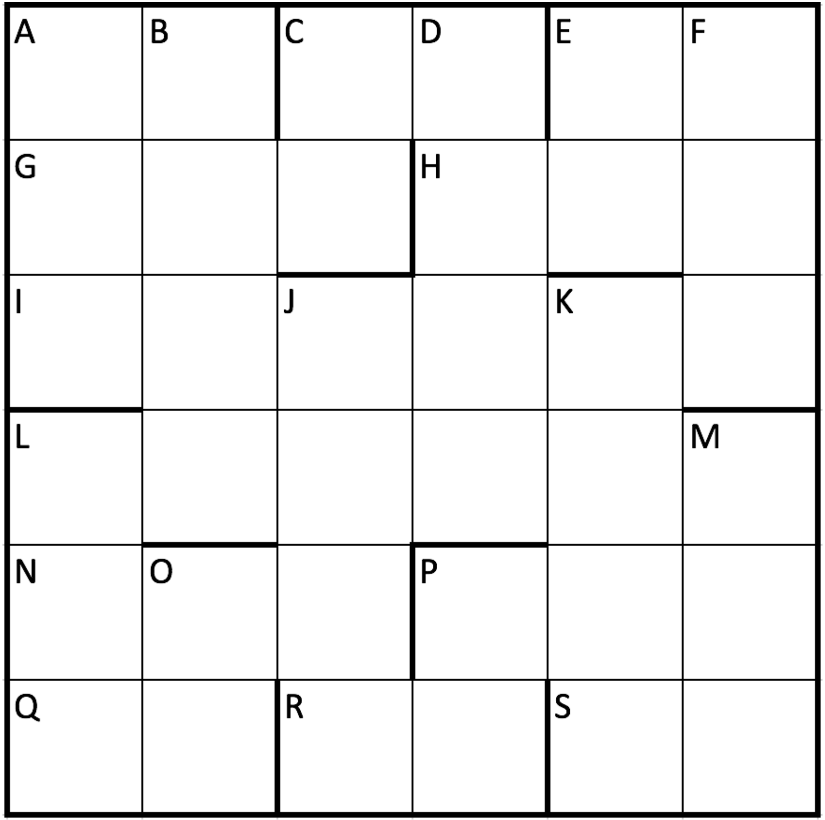
C: prime number,

E: palindrome,

G: multiple of the backward number of horizontal A,

...

vertical:
All numbers are square numbers.



Quelle: Die Zeit, Logelei 52, http://www.zeit.de/2016/52/spiele-logelei-52

Datalog

Features

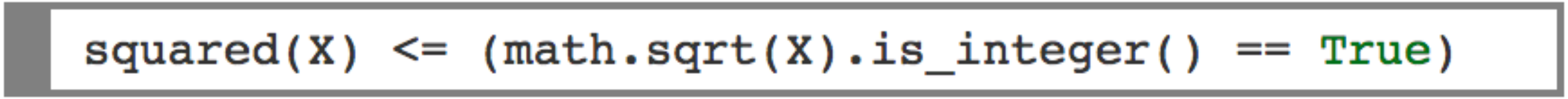
- declarative logic programming
- subset of Prolog
- query language for deductive DBs
- other use-cases: security, data integration, information extraction, networking, program analysis etc.

PyDatalog: https://sites.google.com/site/pydatalog/home

PyDatalog

Rules & Facts

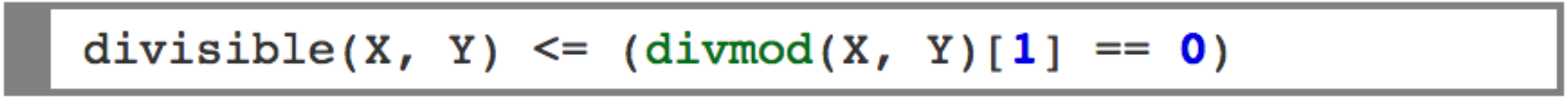
Is X a square number?



```
squared(X) <= (math.sqrt(X).is_integer() == True)
```

Read the leftmost **<=** as **if**

Is X divisible by Y?

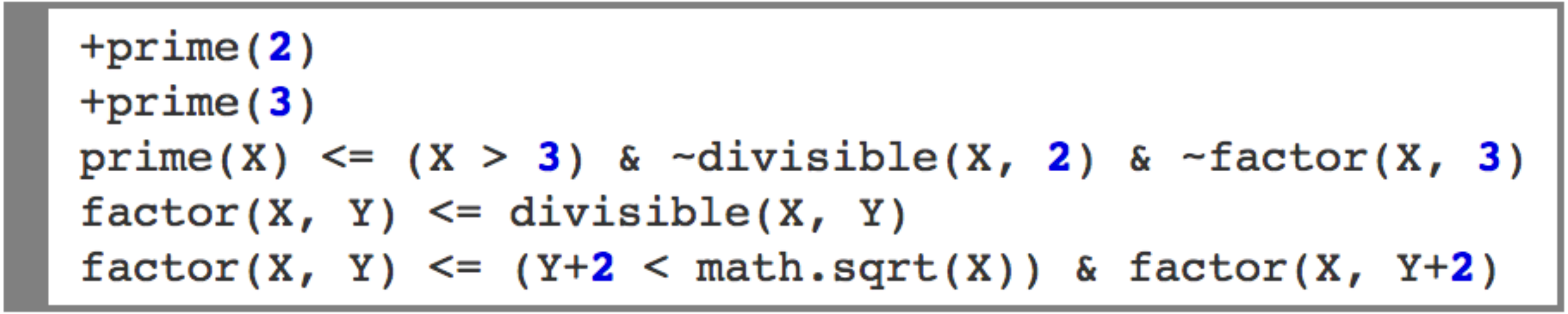


```
divisible(X, Y) <= (divmod(X, Y)[1] == 0)
```

PyDatalog

Rules & Facts

Is X prime?

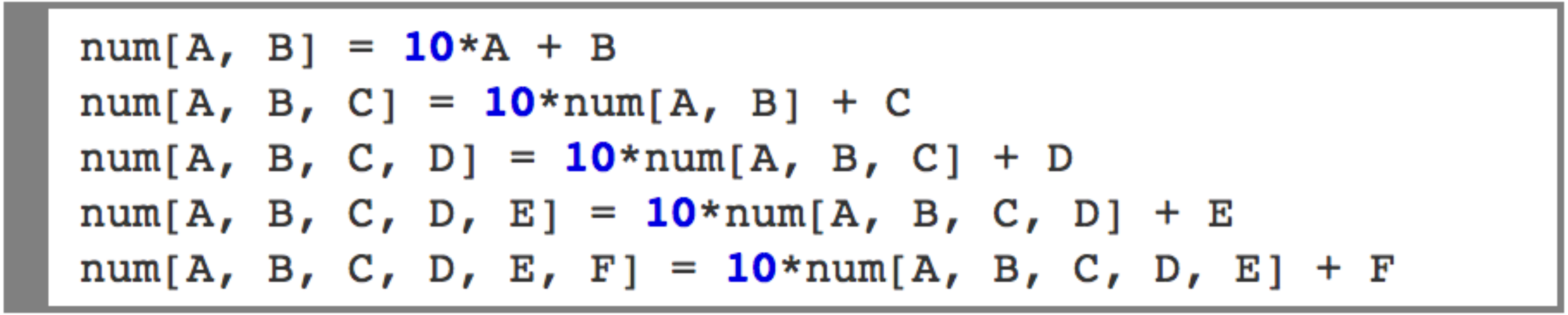


```
+prime(2)
+prime(3)
prime(X) <= (X > 3) & ~divisible(X, 2) & ~factor(X, 3)
factor(X, Y) <= divisible(X, Y)
factor(X, Y) <= (Y+2 < math.sqrt(X)) & factor(X, Y+2)
```

PyDatalog

Rules & Facts

Map digits to number

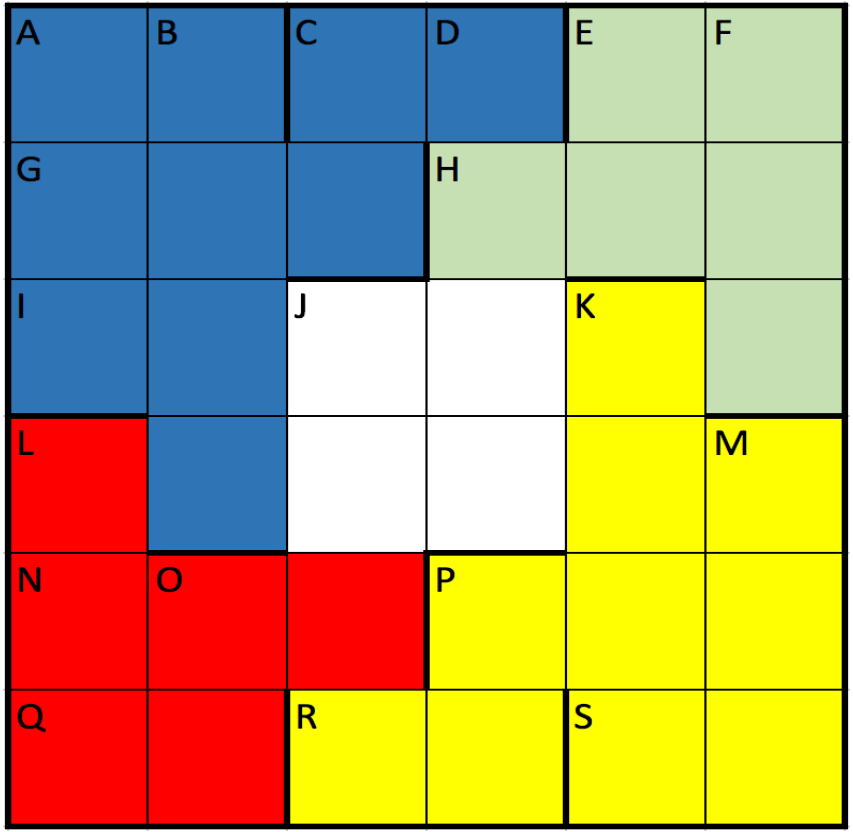


```
num[A, B] = 10*A + B
num[A, B, C] = 10*num[A, B] + C
num[A, B, C, D] = 10*num[A, B, C] + D
num[A, B, C, D, E] = 10*num[A, B, C, D] + E
num[A, B, C, D, E, F] = 10*num[A, B, C, D, E] + F
```

Math Riddle

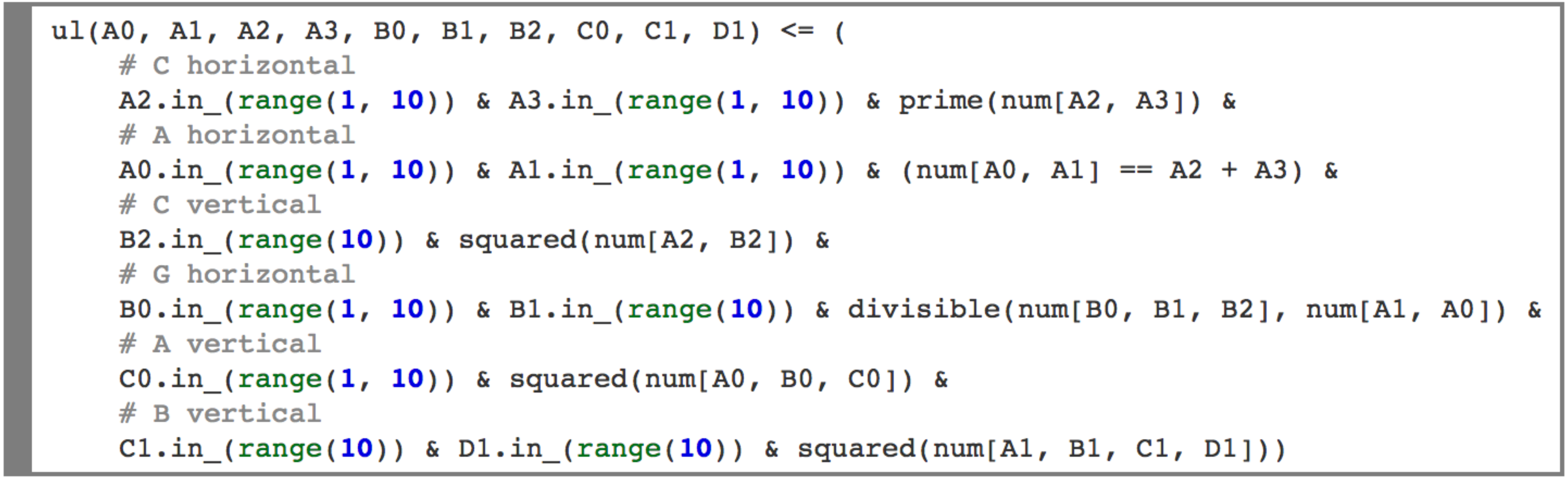
Leaky Abstraction

Keep the number of solutions low at all times



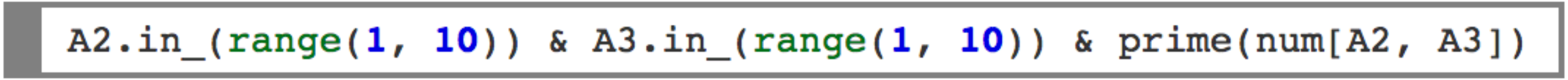
Math Riddle

Upper left corner



```
ul(A0, A1, A2, A3, B0, B1, B2, C0, C1, D1) <= (
    # C horizontal
    A2.in_(range(1, 10)) & A3.in_(range(1, 10)) & prime(num[A2, A3]) &
    # A horizontal
    A0.in_(range(1, 10)) & A1.in_(range(1, 10)) & (num[A0, A1] == A2 + A3) &
    # C vertical
    B2.in_(range(10)) & squared(num[A2, B2]) &
    # G horizontal
    B0.in_(range(1, 10)) & B1.in_(range(10)) & divisible(num[B0, B1, B2], num[A1, A0]) &
    # A vertical
    C0.in_(range(1, 10)) & squared(num[A0, B0, C0]) &
    # B vertical
    C1.in_(range(10)) & D1.in_(range(10)) & squared(num[A1, B1, C1, D1]))
```

A2, A3 are digits from [1...9] and number A2 A3 is prime

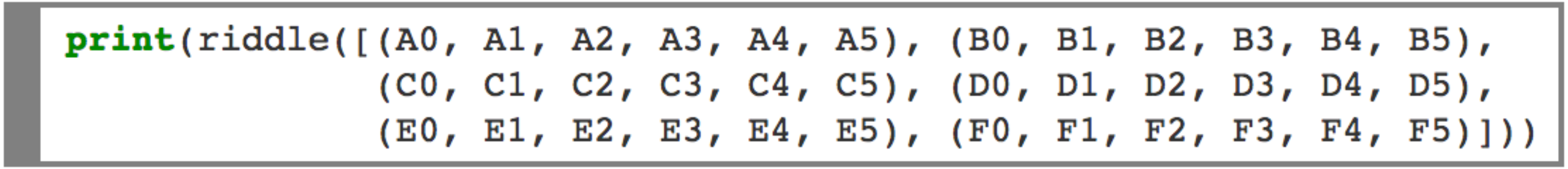


```
A2.in_(range(1, 10)) & A3.in_(range(1, 10)) & prime(num[A2, A3])
```

Math Riddle

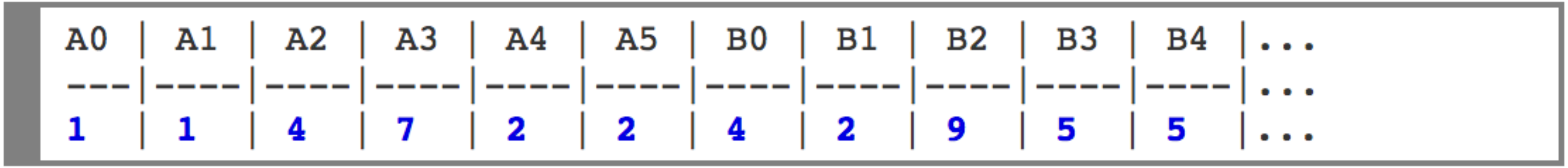
Solution

Querying the knowledge base:



```
print(riddle([(A0, A1, A2, A3, A4, A5), (B0, B1, B2, B3, B4, B5),
              (C0, C1, C2, C3, C4, C5), (D0, D1, D2, D3, D4, D5),
              (E0, E1, E2, E3, E4, E5), (F0, F1, F2, F3, F4, F5)]))
```

Solution:



```
A0 | A1 | A2 | A3 | A4 | A5 | B0 | B1 | B2 | B3 | B4 |...
---|----|----|----|----|----|----|----|----|----|----|...
1  | 1  | 4  | 7  | 2  | 2  | 4  | 2  | 9  | 5  | 5  |...
```

Other Applications

Summary

Advantages of Declarative Programming

- improved readability of our code
- reduced number of errors
- increased performance
- separation of concerns

„Declarative programming means finding the right abstraction level describing the problem“

Thanks for your Attention!

Questions?

Find more details under http://florianwilhelm.info/2017/07/declarative_thinking_and_programming/