

λ -blocks: Data Processing with Topologies of Blocks

Matthieu Caneill, Noël De Palma

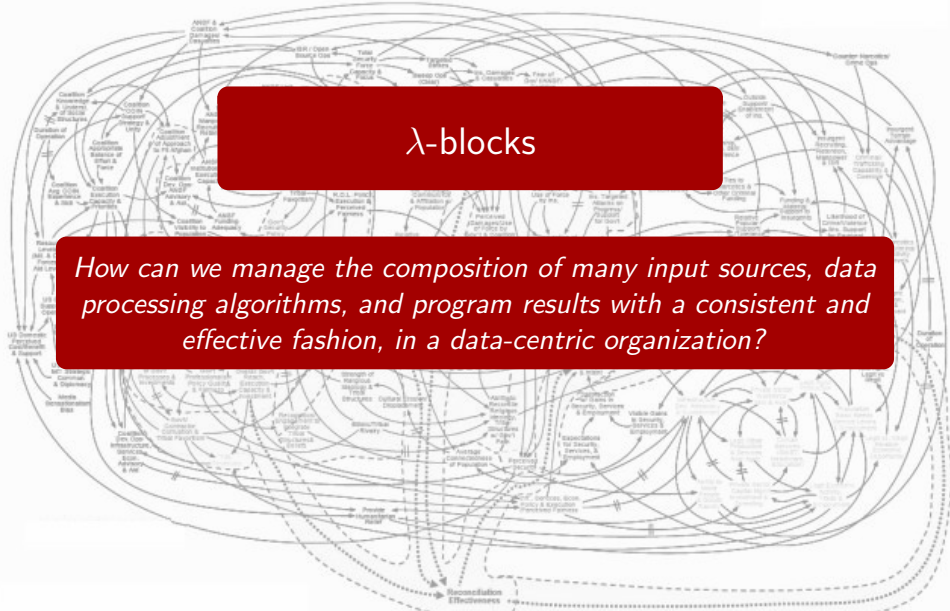
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λ -blocks

How can we manage the composition of many input sources, data processing algorithms, and program results with a consistent and effective fashion, in a data-centric organization?



Outline

Introduction

Architecture

Topologies and blocks

Graph manipulations

Evaluation

Conclusion



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Design goals

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- ▶ A **graph of code blocks** to represent an end-to-end processing system

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- ▶ **Graph manipulation** toolkit

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- ▶ Separation of concerns: low-level data operations, high-level data processing programs
- ▶ Maximize reuse of code
- ▶ Compatible with existing (specialized) frameworks and possibility to mix them
- ▶ **Graph manipulation** toolkit
- ▶ Bring simplicity to large-scale data processing



Outline

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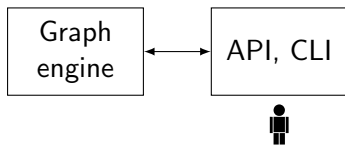
Architecture

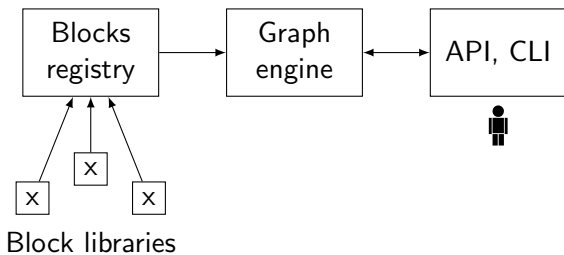
Topologies and blocks

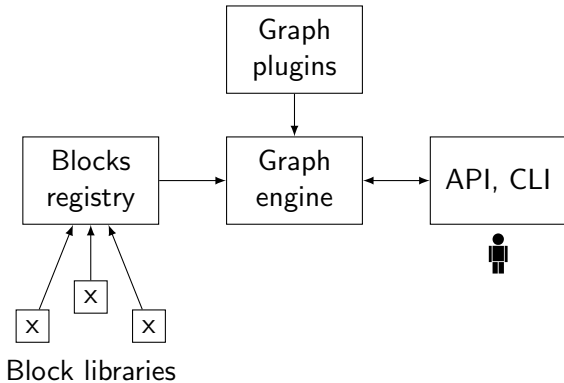
Graph manipulations

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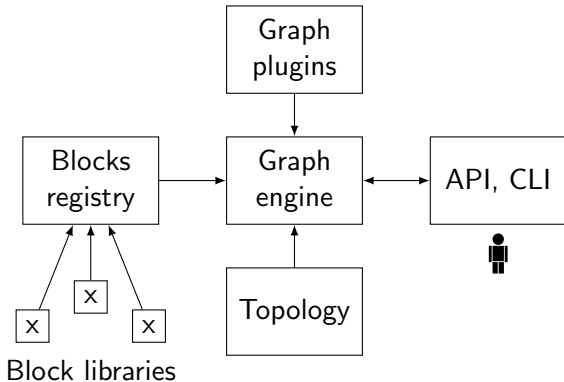
Conclusion







Architecture



Outline

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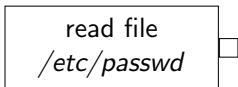
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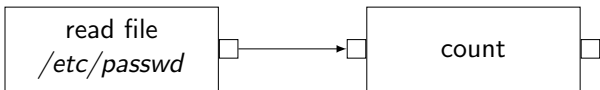
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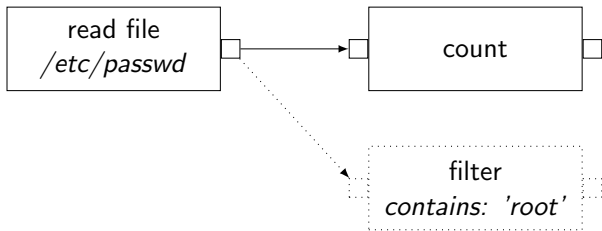
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```
"""Counts system users.
"""

def main():
    with open('/etc/passwd') as f:
        return len(f.readlines())

if __name__ == '__main__':
    print(main())
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$ wc -l /etc/passwd
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```



Topologies

```
---  
name: count_users  
description: Count number of system users  
modules: [lb.blocks.foo]  
---  
- block: readfile  
  name: my_readfile  
  args :  
    filename: /etc/passwd  
  
- block: count  
  name: my_count  
  inputs :  
    data: my_readfile.result
```




Blocks

- ▶ read_http
- ▶ plot_bars
- ▶ show_console
- ▶ write_line
- ▶ write_lines
- ▶ split
- ▶ concatenate
- ▶ map_list
- ▶ flatMap
- ▶ flatten_list
- ▶ group_by_count
- ▶ sort
- ▶ get_spark_context
- ▶ spark_readfile
- ▶ spark_text_to_words
- ▶ spark_map
- ▶ spark_filter
- ▶ spark_flatMap
- ▶ spark_mapPartitions
- ▶ spark_sample
- ▶ spark_union
- ▶ spark_intersection
- ▶ spark_distinct
- ▶ spark_groupByKey
- ▶ spark_reduceByKey
- ▶ spark_aggregateByKey
- ▶ spark_sortByKey
- ▶ spark_join
- ▶ spark_cogroup
- ▶ spark_cartesian
- ▶ spark_pipe
- ▶ spark_coalesce
- ▶ spark_repartition
- ▶ spark_reduce
- ▶ spark_collect
- ▶ spark_count
- ▶ spark_first
- ▶ spark_take
- ▶ spark_takeSample
- ▶ spark_takeOrdered
- ▶ spark_saveAsTextFile
- ▶ spark_countByKey
- ▶ spark_foreach
- ▶ spark_add
- ▶ spark_swap
- ▶ twitter_search
- ▶ cat
- ▶ grep
- ▶ cut
- ▶ head
- ▶ tail

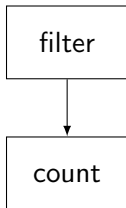


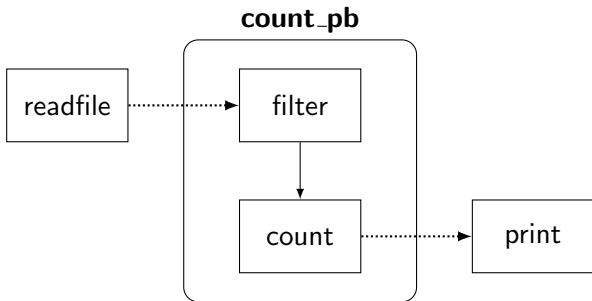
Blocks

```
@block(engine='localpython')
def take(n: int=0):
    """Truncates a list of integers.

    :param int n: The length of the desired result.
    :input List[int] data: The list of items to truncate.
    :output List[int] result: The truncated result.
    """
    def inner(data: List[int]) -> ReturnType[List[int]]:
        assert n <= len(data)
        return ReturnEntry(result=data[:n])
    return inner
```

count_pb







Sub-topologies

```
---  
name: count_pb  
---  
- block: filter  
  name: filter  
  args:  
    contains: error  
  inputs:  
    data: $inputs.data  
- block: count  
  name: count  
  inputs:  
    data: filter.result
```



Sub-topologies

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name: count_pb
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- block: filter
  name: filter
  args:
    contains: error
  inputs:
    data: $inputs.data
- block: count
  name: count
  inputs:
    data: filter.result
```

```
---
name: foo_errors
---
- block: readfile
  name: readfile
  args:
    filename: foo.log
- topology: count_pb
  name: count_pb
  bind_in:
    data: readfile.result
  bind_out:
    result: count.result
- block: print
  name: print
  inputs:
    data: count_pb.result
```



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- ▶ Instrumentation



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- ▶ Debugging tools



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Graph manipulations

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- ▶ Instrumentation
- ▶ Caching
- ▶ Debugging tools
- ▶ Optimizations
- ▶ Monitoring
- ▶ Program reasoning and semantics



- ▶ Reasoning on the computation graph as a high-level object



Graph manipulations

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- ▶ Plugin system



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- ▶ Hooks:
 - ▶ `before_graph_execution`
pre-processing, optimizations, verifications



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Graph manipulations

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 - ▶ `before_block_execution`
observation, optimizations

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observation, optimizations
 - ▶ `after_block_execution`
observation



Graph manipulation example: instrumentation (excerpt)

```
by_block = {} # timing by block: begin, duration

@before_block_execution
def store_begin_time(block):
    name = block.fields['name']
    by_block[name]['begin'] = time.time()
```

Graph manipulation example: instrumentation (excerpt)

```
by_block = {} # timing by block: begin, duration
```

```
@before_block_execution
```

```
def store_begin_time(block):  
    name = block.fields['name']  
    by_block[name]['begin'] = time.time()
```

```
@after_block_execution
```

```
def store_end_time(block, results):  
    name = block.fields['name']  
    by_block[name]['duration'] = \  
        time.time() - by_block[name]['begin']
```

Graph manipulation example: instrumentation (excerpt)

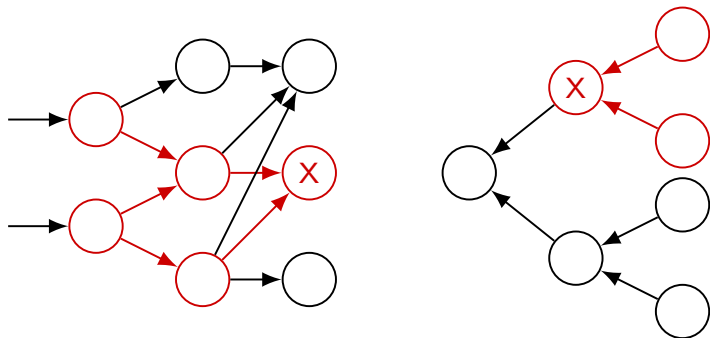
```
@after_graph_execution
def show_times(results):
    longest_first = sorted(by_block, reverse=True)
    for blockname in longest_first:
        print('{}\t{}'.format(
            blockname,
            by_block[blockname]['duration']))
```



Graph manipulation example: instrumentation

block	duration (ms)
read http	818
write lines	54
grep	49
split	20

Graph manipulation example: caching



$H(B) = h(B.name, \quad \text{block name (not instance name)}$
 $B.args, \quad \text{list of (name, value) tuples}$
 $B.inputs) \quad \text{list of (name, H(block), connector) tuples}$



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Setup

- ▶ Wordcount over https: local machine, 8 cores, 16 GB RAM
- ▶ Wordcount over disk: local machine, 8 cores, 16 GB RAM
- ▶ PageRank on Spark: Spark on 1 server (24 cores, 128 GB RAM)

Performances

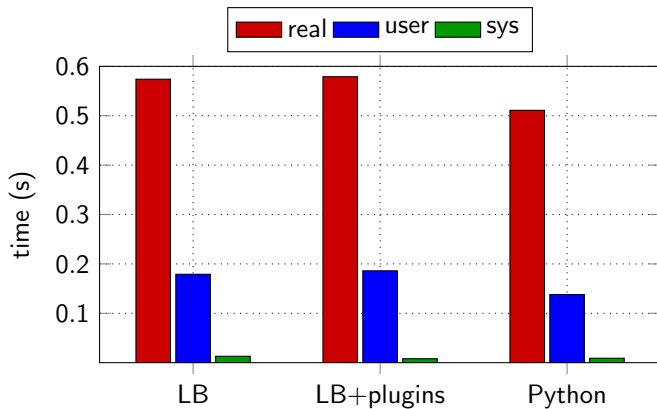


Figure: Wordcount over <https://twitter.com/> feed.

Performances

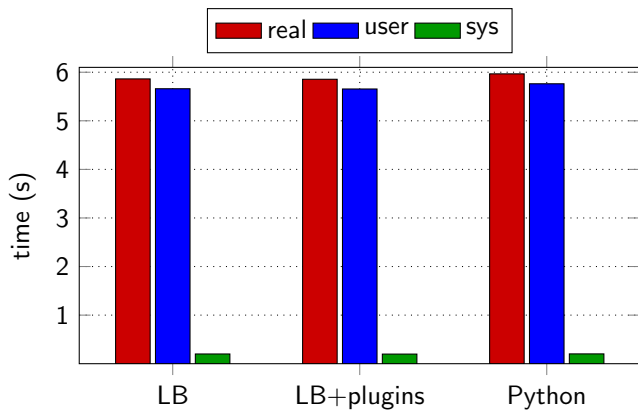


Figure: Wordcount over disk: Wikipedia dataset.

Performances

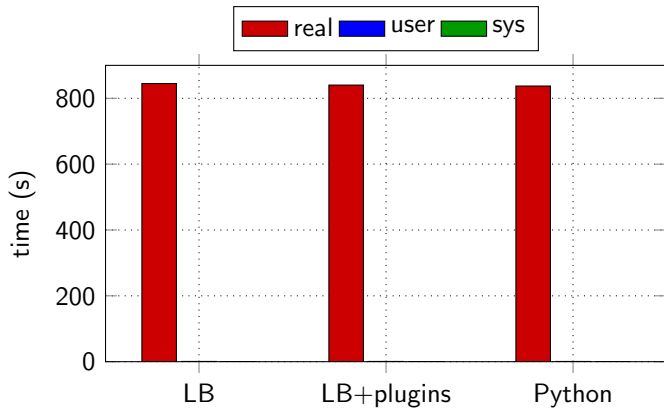
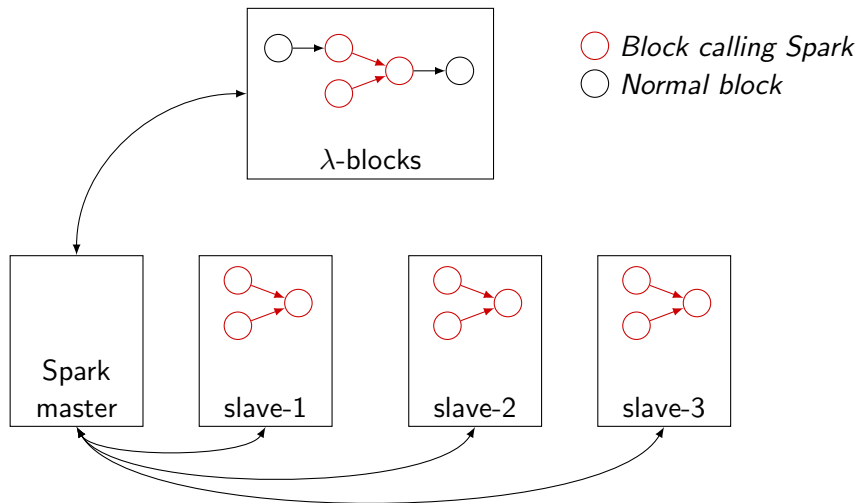


Figure: PageRank on Wikipedia hyperlinks with Spark.

Evaluation: using a Spark cluster





Maximum overhead measured per topology: 50 ms



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λ -blocks enables:

- ▶ decoupling between standalone pieces of code which transform data, and data processing algorithms;
- ▶ reasoning on a high-level abstraction of a data processing program;
- ▶ reusing everything (code, topologies, specialized frameworks).



Related work

Dataflow programming

- ▶ ML pipelines: scikit-learn [PVG⁺11], Spark [The17a], Orange framework [DCE⁺13]
- ▶ Real-time: Apache Beam [apa], StreamPipes [RKHS15]



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Graphs from configuration

- ▶ Pyleus [Yel16], Storm Flux [The17b]



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Other

- ▶ “Serverless” architectures and stateless functions [JVSR17]



- ▶ Explore more graph manipulation abstractions (complexity analysis, serialization, verification. . .)
- ▶ Streaming and online operations
- ▶ Tight integration with clusters (data storage, caches, etc)

Thanks! Questions?

- ▶ *Goto e spaghetti code*, <http://blogbv2.altervista.org/HD/il-goto-e-la-buona-programmazione-parte-ii/>



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