λ-blocks: Data Processing with Topologies of Blocks

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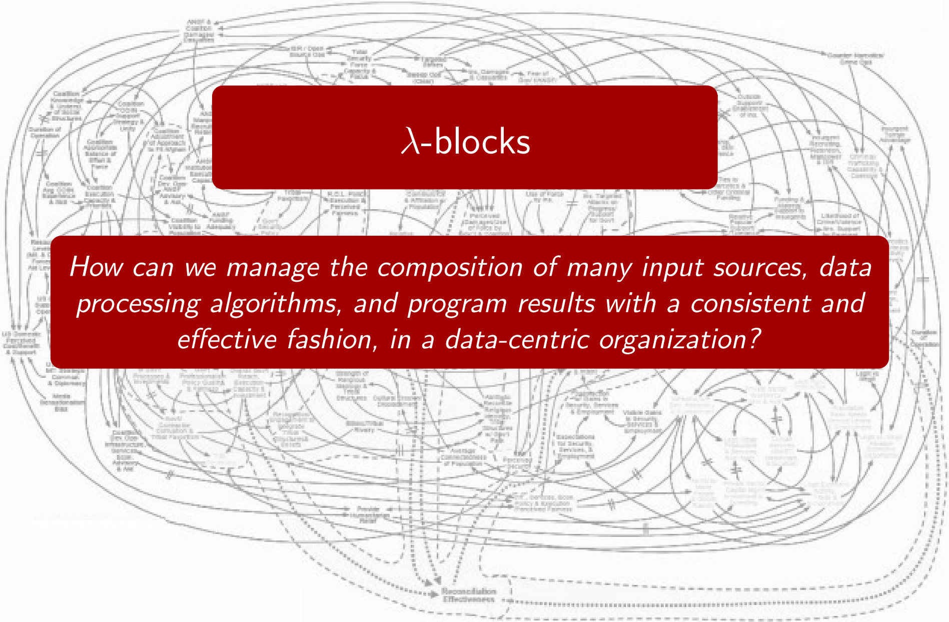
GOTO E SPAGHETTI CODE



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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- Maximize reuse of code
- Compatible with existing (specialized) frameworks and possibility to mix them
- Graph manipulation toolkit
- Bring simplicity to large-scale data processing

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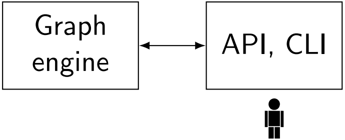
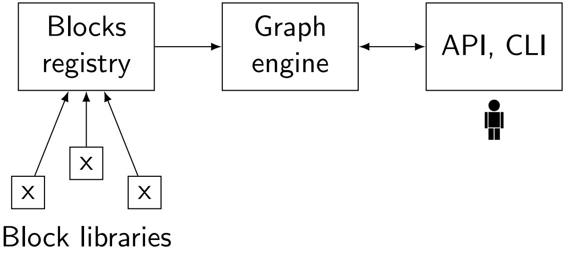


Architecture



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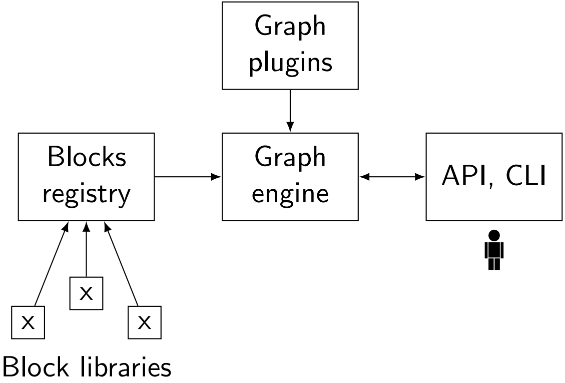

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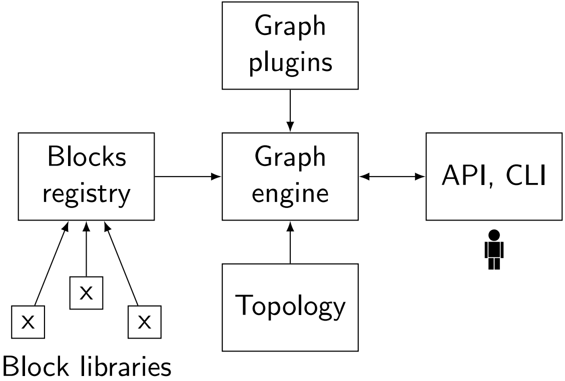

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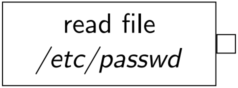
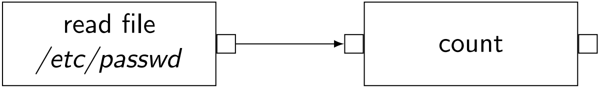


read file
/etc/passwd

Topologies



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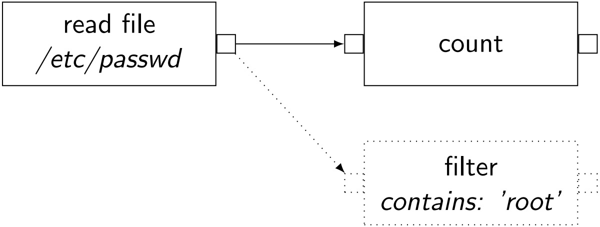

Topologies

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

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

if __name__ == '__main__':
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~~$ wc -l /etc/passwd~~

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

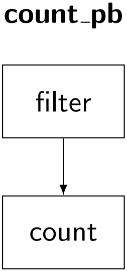
- read_http
- plot_bars
- show_console
- write_line
- write_lines
- split
- concatenate
- map_list
- flatMap
- flatten_list
- group_by_count
- sort
- get_spark_context
- spark_readfile
- spark_text_to_words
- spark_map
- spark_filter
- spark_flatMap
- spark_mapPartitions
- spark_sample
- spark_union
- 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

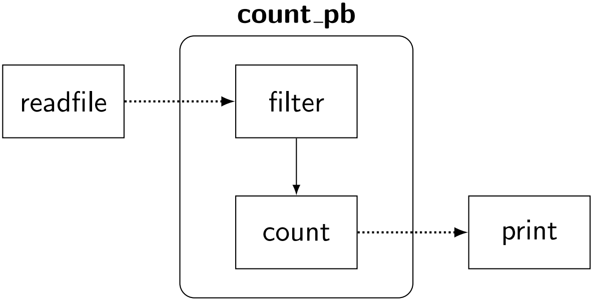
```python
@block(engine='localpython')
def take(n: int=0):
    """Truncates a list of integers.

    :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
```

Sub-topologies



Sub-topologies



Sub-topologies

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

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name: count_pb
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```

```
---
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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- Verification (e.g. type checking)

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- Program reasoning and semantics

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  - `before_block_execution`
    observation, optimizations

Graph manipulations

- Reasoning on the computation graph as a high-level object
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- Hooks:
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  - `before_block_execution`
    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)

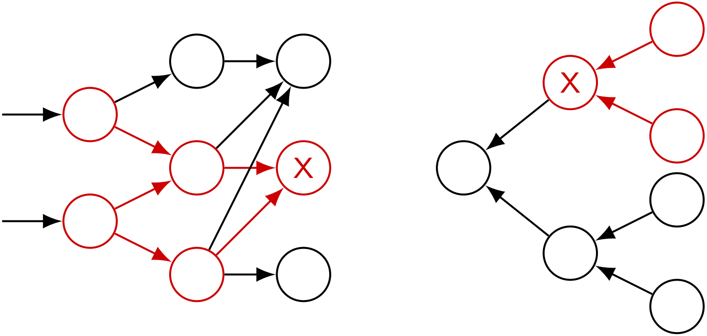
```python
@after_graph_execution
def show_times(results):
    longest_first = sorted(by_block, reverse=True)
    for blockname in longest_first:
        print('{}\t{}'.format(
            blockname,
            by_block[blockname]['duration'])
```

Graph manipulation example: instrumentation

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

λ-blocks

Graph manipulation example: caching



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

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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)

Evaluation

Performances

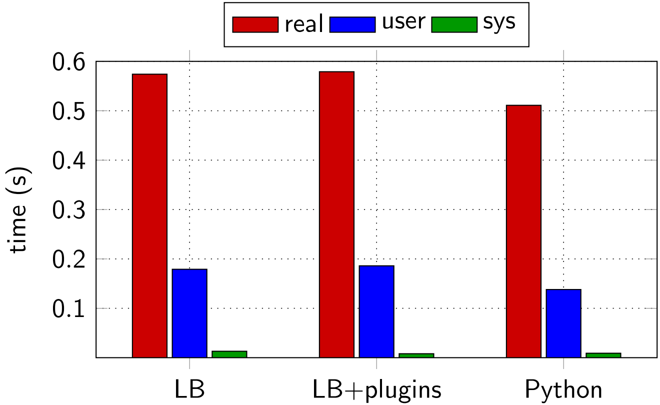

Figure: Wordcount over https: Twitter feed.

Performances

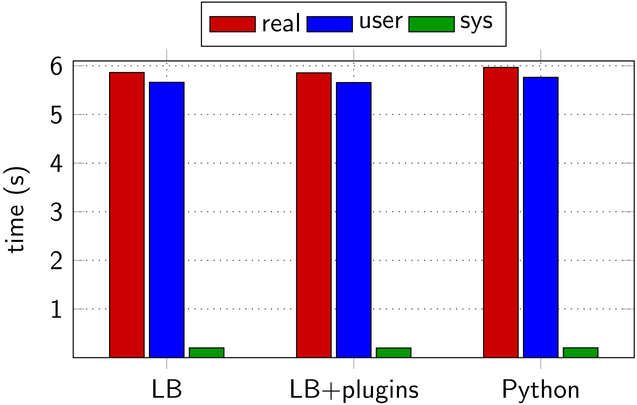

Figure: Wordcount over disk: Wikipedia dataset.

Evaluation

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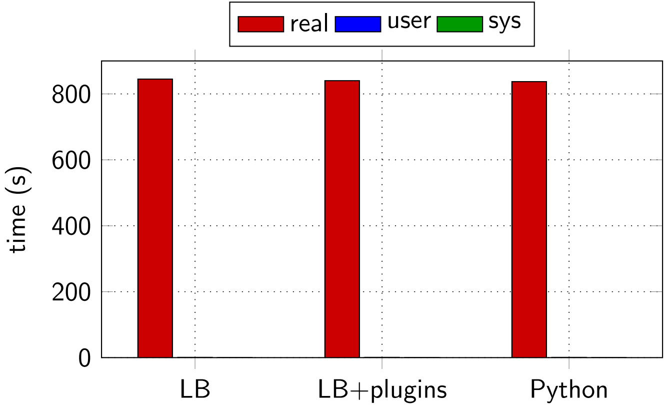
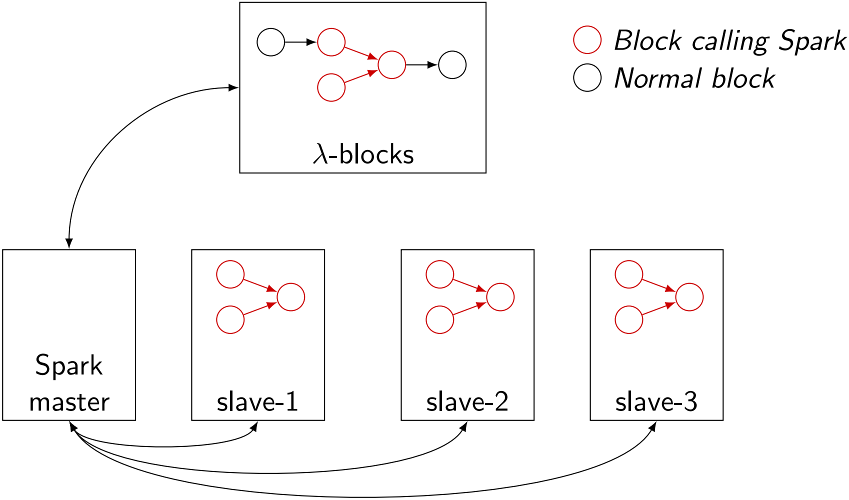


Figure: PageRank on Wikipedia hyperlinks with Spark.

Evaluation: using a Spark cluster



Evaluation

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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- Pyleus [Yel16], Storm Flux [The17b]

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Other

- “Serverless” architectures and stateless functions [JVSR17]

Future work

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

Thanks! Questions?

Images credits

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

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