The columnar roadmap:

Apache Parquet and Apache Arrow

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dremio

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- Architect at @DremioHQ dremio
- Formerly Tech Lead at Twitter on Data Platforms.
- Creator of Parquet
- Apache member
- Apache PMCs: Arrow, Kudu, Incubator, Pig, Parquet

Agenda

- Community Driven Standard
- Benefits of Columnar representation
- Vertical integration: Parquet to Arrow
- Arrow based communication

Community Driven Standard

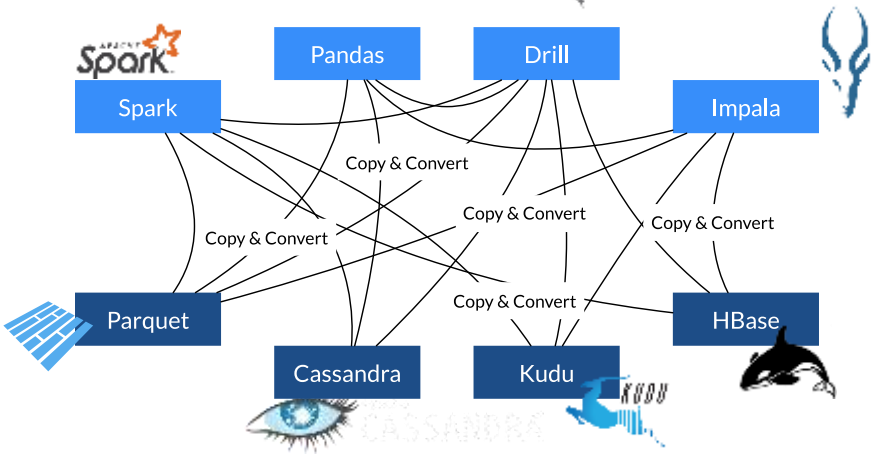
An open source standard

- **Parquet**: Common need for **on disk** columnar.
- **Arrow**: Common need for **in memory** columnar.
- Arrow is building on the success of Parquet.
- Top-level Apache project
- Standard from the start:
  - Members from 13+ major open source projects involved
- Benefits:
  - Share the effort
  - Create an ecosystem

Calcite
Cassandra
Deeplearning4j
Drill
Hadoop
HBase
Ibis
Impala
Kudu
Pandas
Parquet
Phoenix
Spark
Storm
R

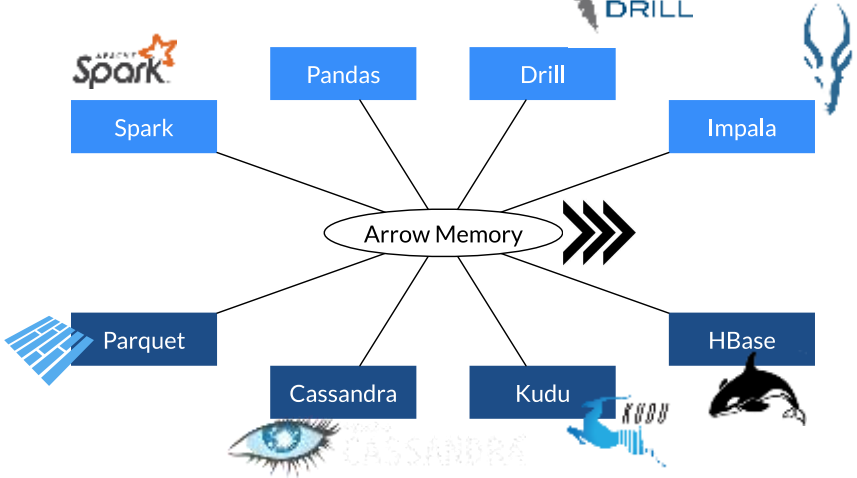
Interoperability and Ecosystem

Before

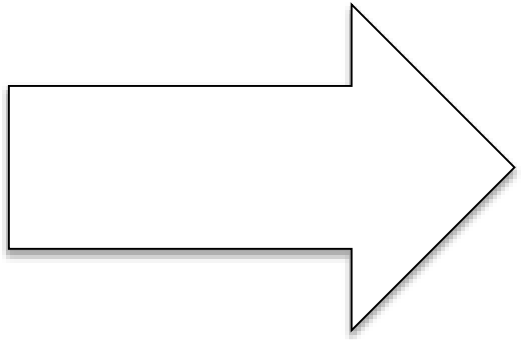


- Each system has its own internal memory format
- 70-80% CPU wasted on serialization and deserialization
- Functionality duplication and unnecessary conversions

With Arrow



- All systems utilize the same memory format
- No overhead for cross-system communication
- Projects can share functionality (eg: Parquet-to-Arrow reader)



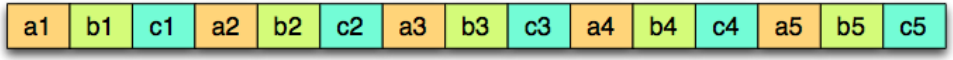
Benefits of Columnar representation

Columnar layout

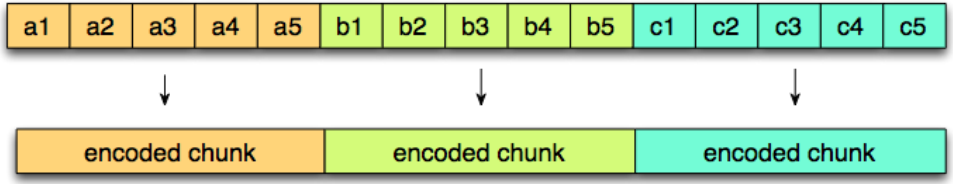
Logical table representation

a	b	c
a1	b1	c1
a2	b2	c2
a3	b3	c3
a4	b4	c4
a5	b5	c5

Row layout



Column layout



@EmrgencyKittens

On Disk and in Memory

- Different trade offs
  - On disk: Storage.
    - Accessed by multiple queries.
    - Priority to I/O reduction (but still needs good CPU throughput).
    - Mostly Streaming access.
  - In memory: Transient.
    - Specific to one query execution.
    - Priority to CPU throughput (but still needs good I/O).
    - Streaming and Random access.

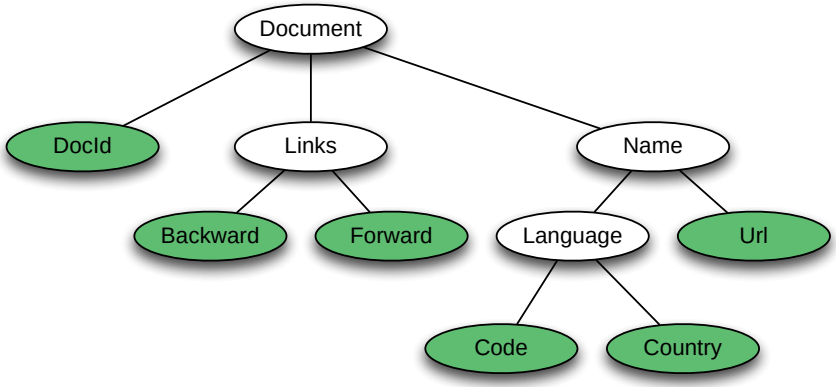
Parquet on disk columnar format

Parquet on disk columnar format

- Nested data structures
- Compact format:
  - type aware encodings
  - better compression
- Optimized I/O:
  - Projection push down (column pruning)
  - Predicate push down (filters based on stats)

Parquet nested representation

Borrowed from the Google Dremel paper



Columns:
docid
links.backward
links.forward
name.language.code
name.language.country
name.url

https://blog.twitter.com/2013/dremel-made-simple-with-parquet

Access only the data you need

Columnar

a	b	c
a1	b1	c1
a2	b2	c2
a3	b3	c3
a4	b4	c4
a5	b5	c5

+

Statistics

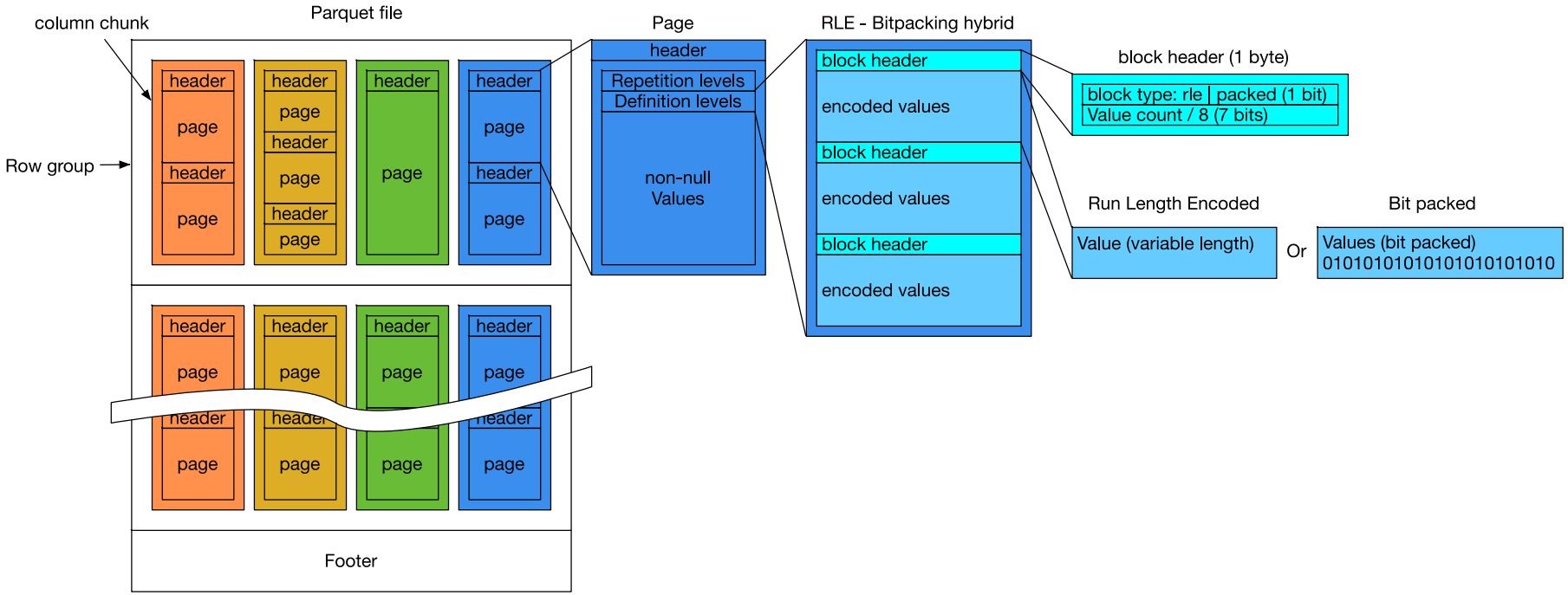
a	b	c
a1	b1	c1
a2	b2	c2
a3	b3	c3
a4	b4	c4
a5	b5	c5

=

Read only the data you need!

a	b	c
a1	b1	c1
a2	b2	c2
a3	b3	c3
a4	b4	c4
a5	b5	c5

Parquet file layout



Arrow in memory columnar format

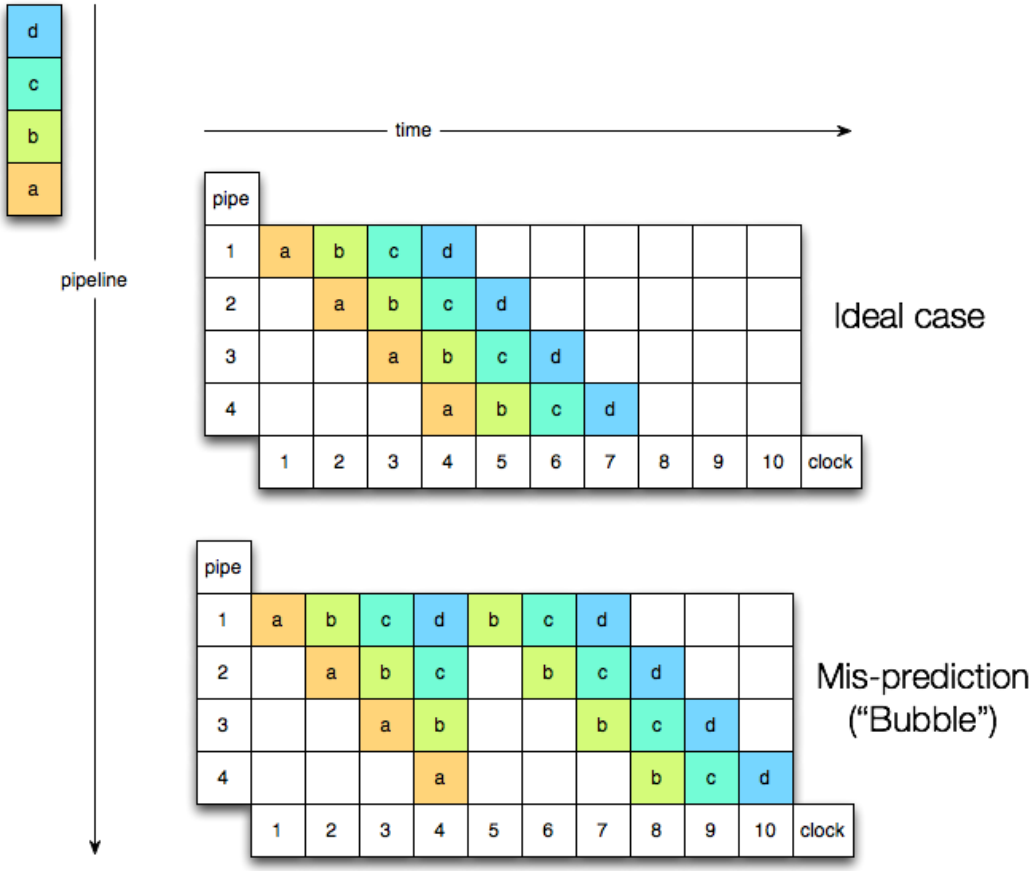
Arrow goals

- Well-documented and cross language compatible
- Designed to take advantage of modern CPU
- Embeddable
  - in execution engines, storage layers, etc.
- Interoperable

Arrow in memory columnar format

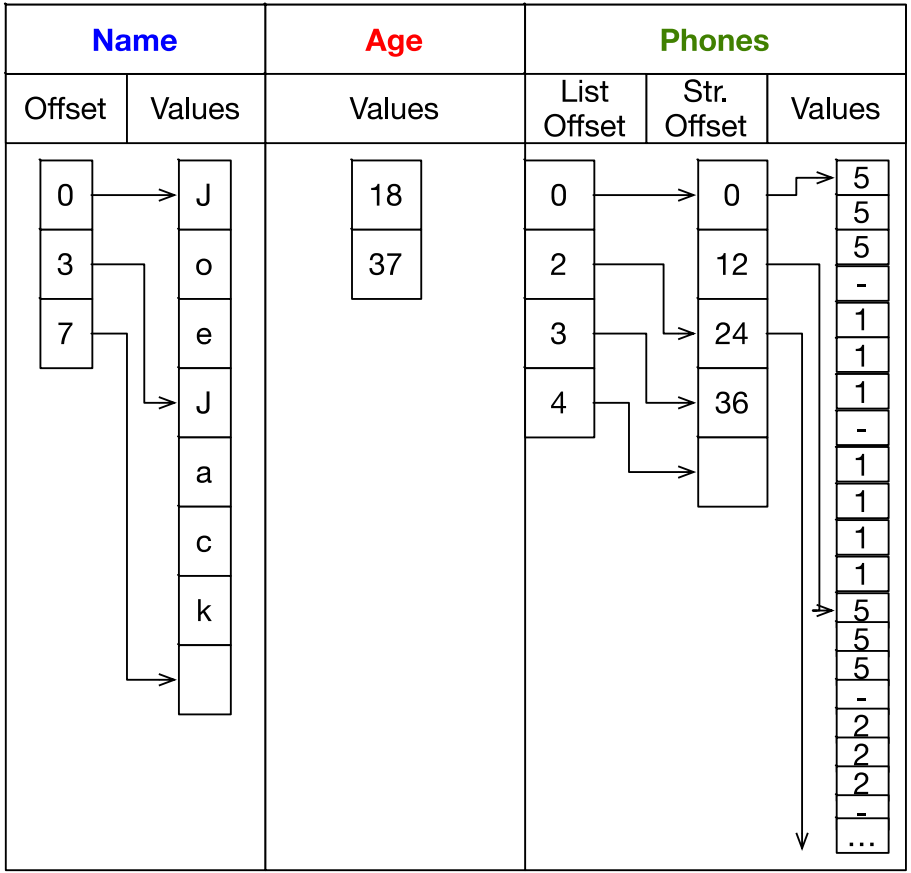
- Nested Data Structures
- Maximize CPU throughput
  - Pipelining
  - SIMD
  - cache locality
- Scatter/gather I/O

CPU pipeline

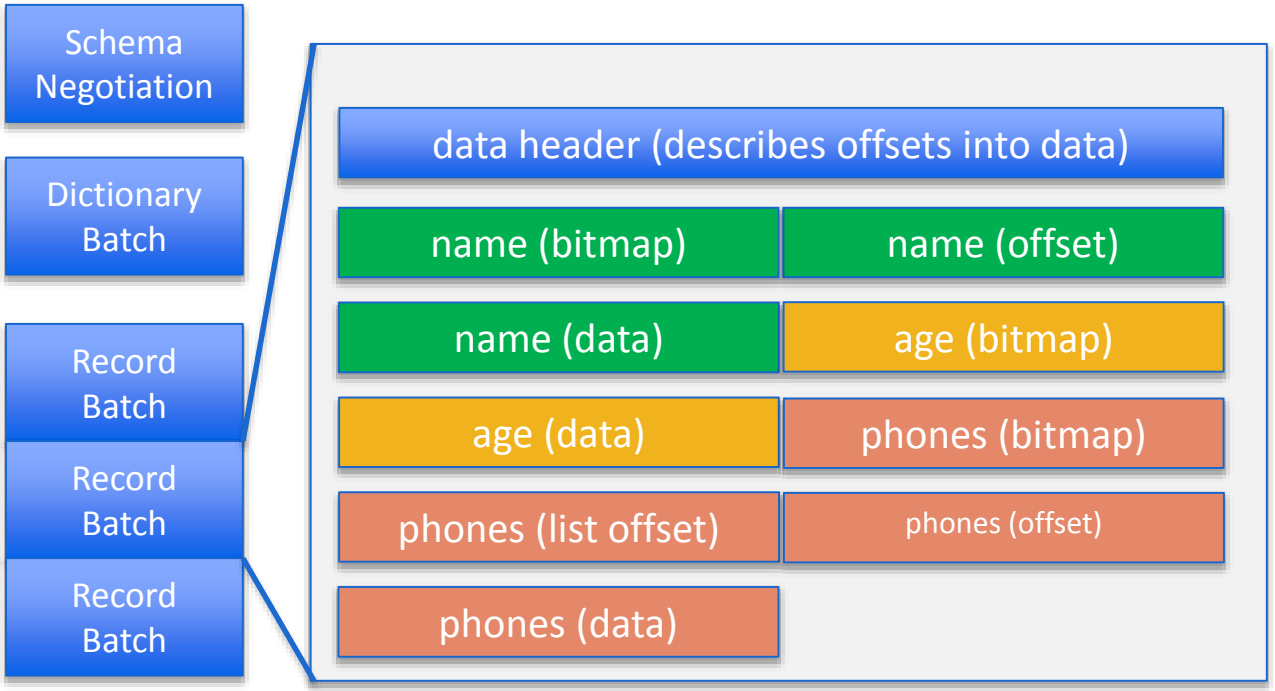


Columnar data

```
persons = [{
    name: ’Joe',
    age: 18,
    phones: [
        ‘555-111-1111’,
        ‘555-222-2222’
    ]
}, {
    name: ’Jack',
    age: 37,
    phones: [ ‘555-333-3333’ ]
}]
```



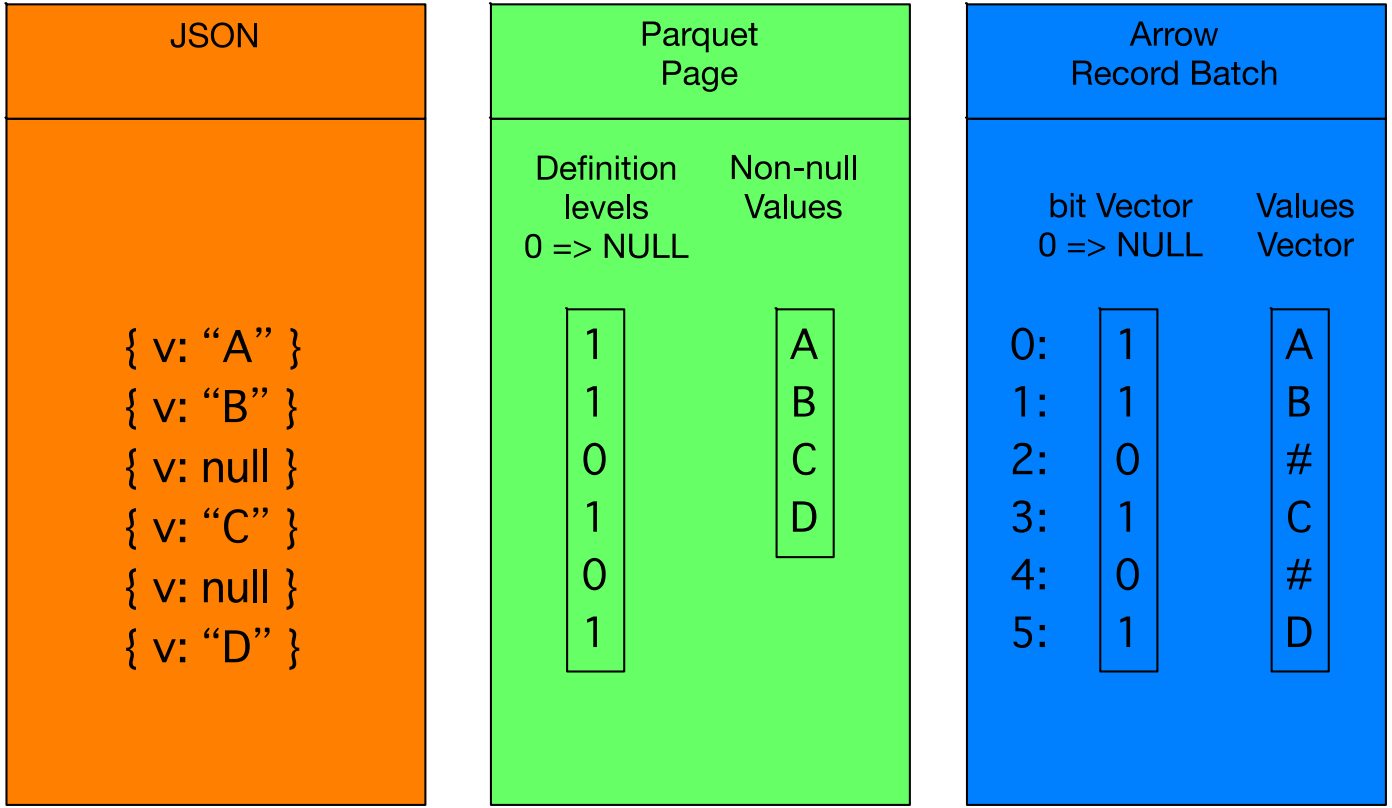
Record Batch Construction



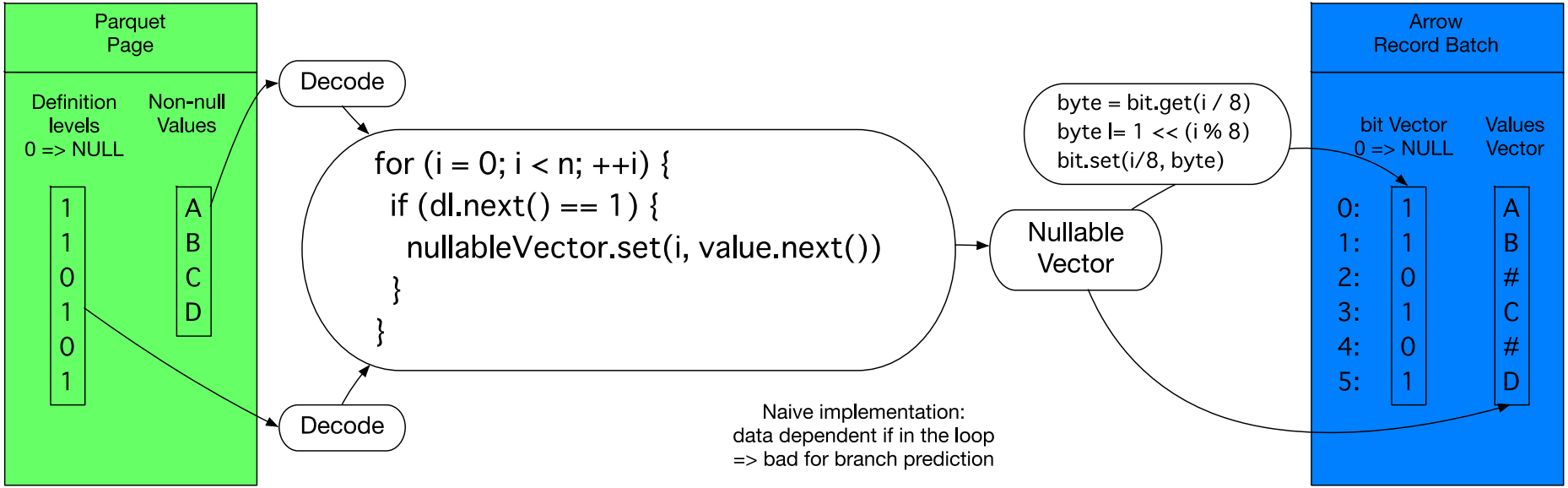
Each box (vector) is contiguous memory
The entire record batch is contiguous on wire

Vertical integration: Parquet to Arrow

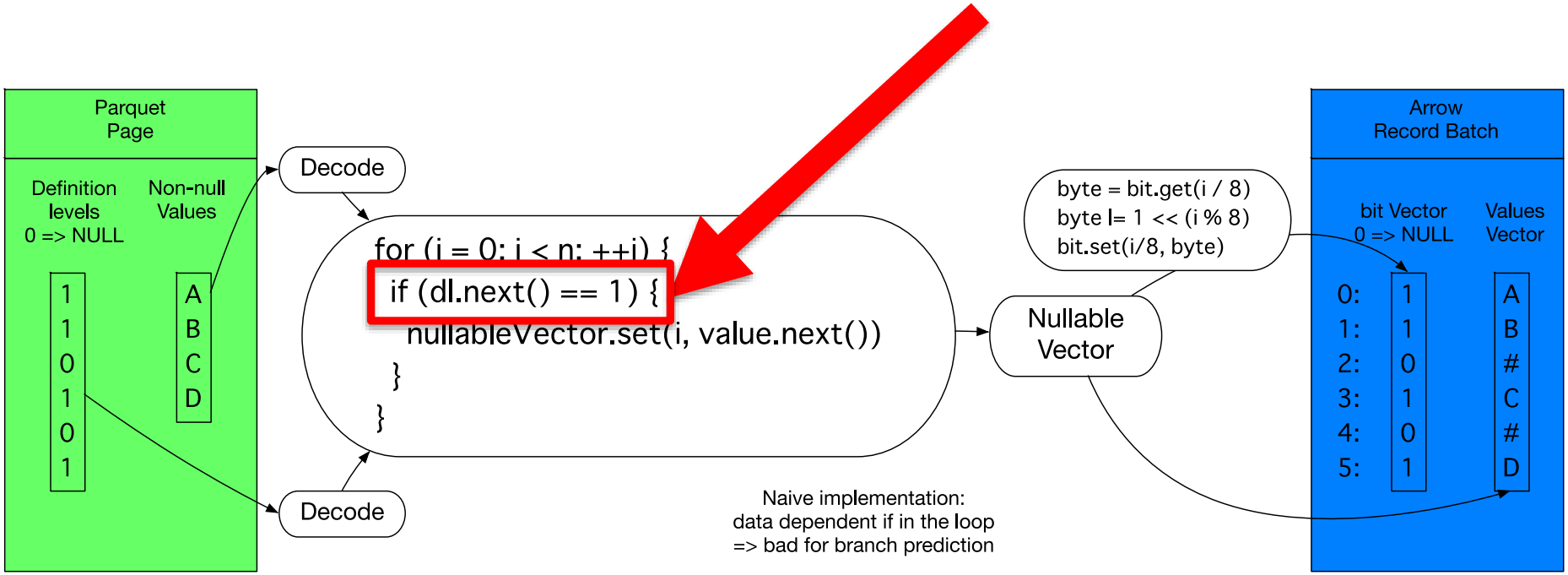
Representation comparison for flat schema



Naïve conversion



Naïve conversion



(They have layers)

Peeling away abstraction layers
Vectorized read

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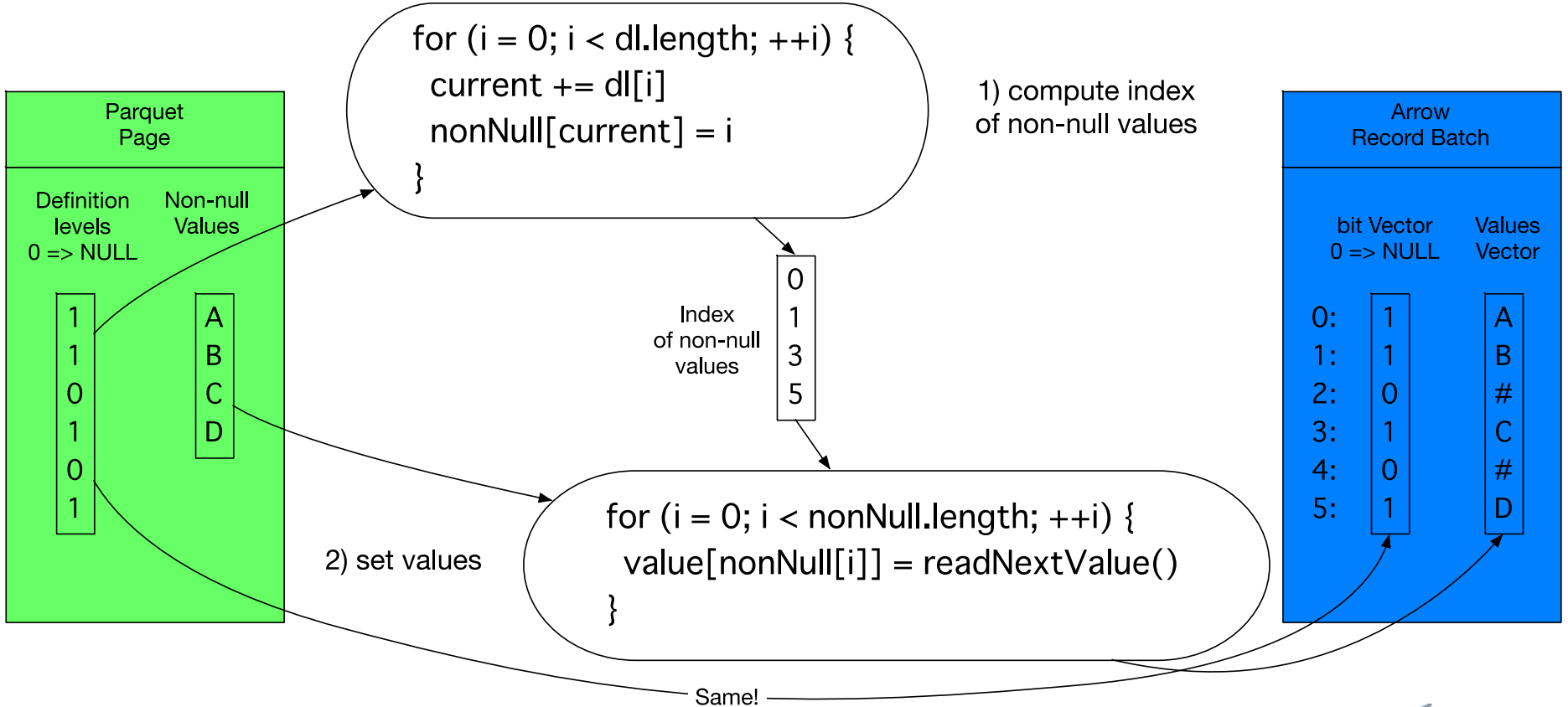
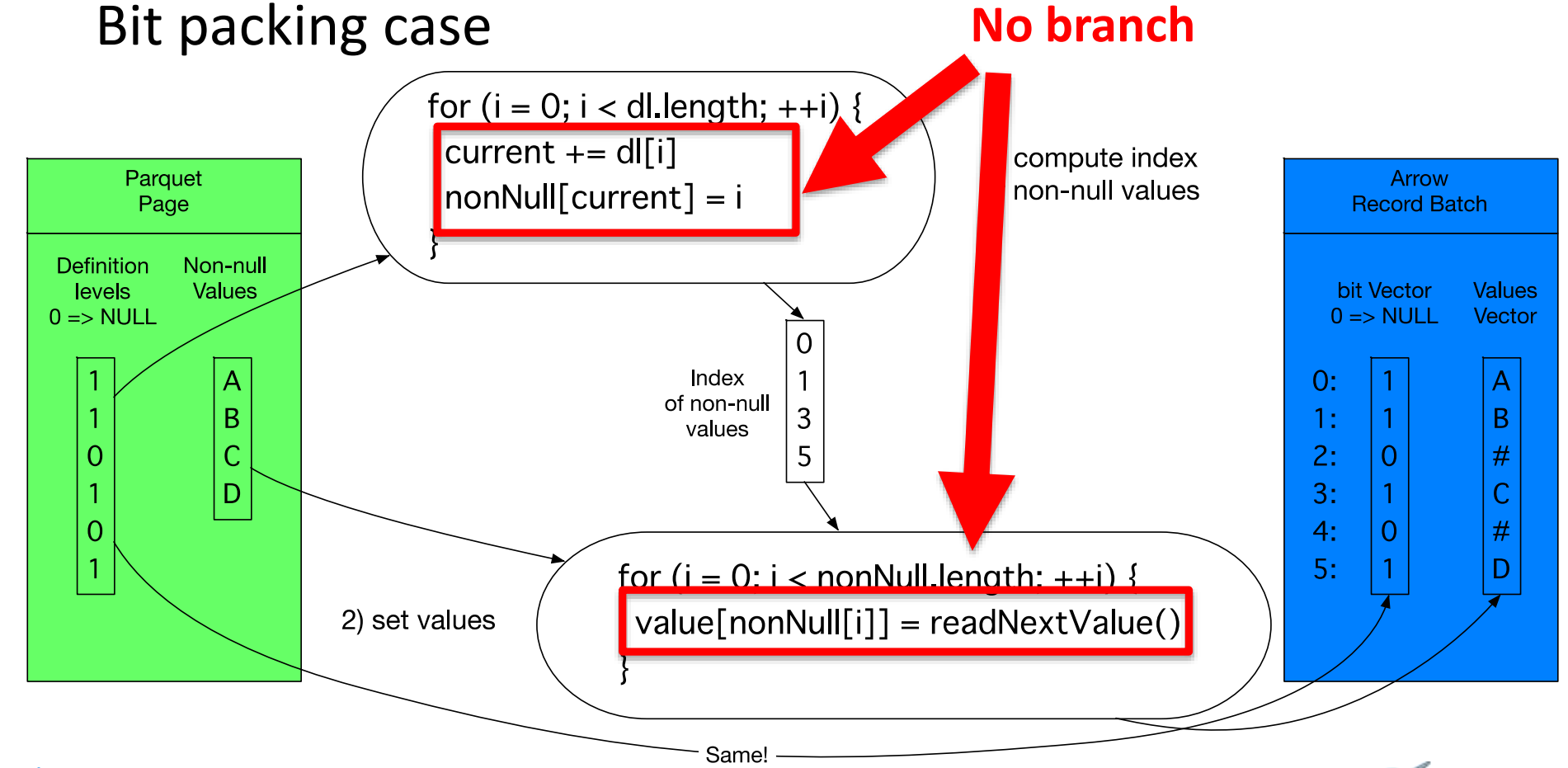
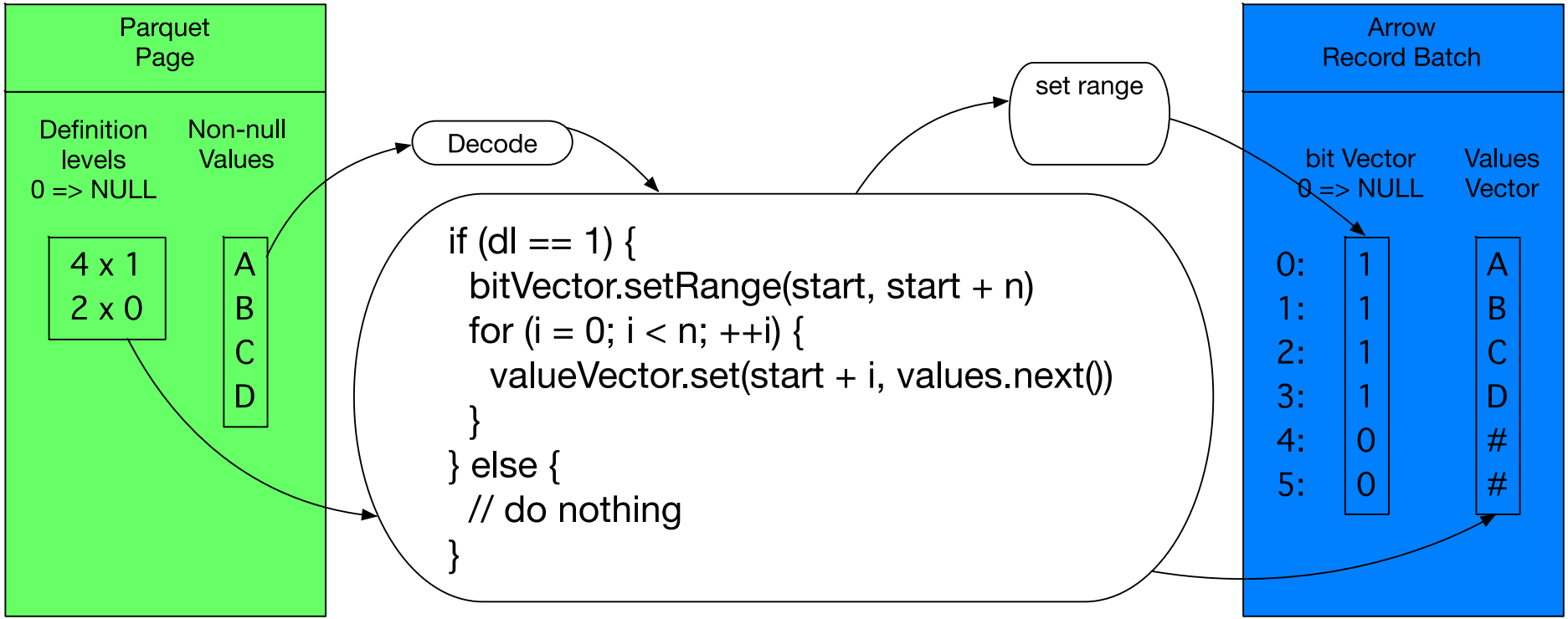
Bit packing case



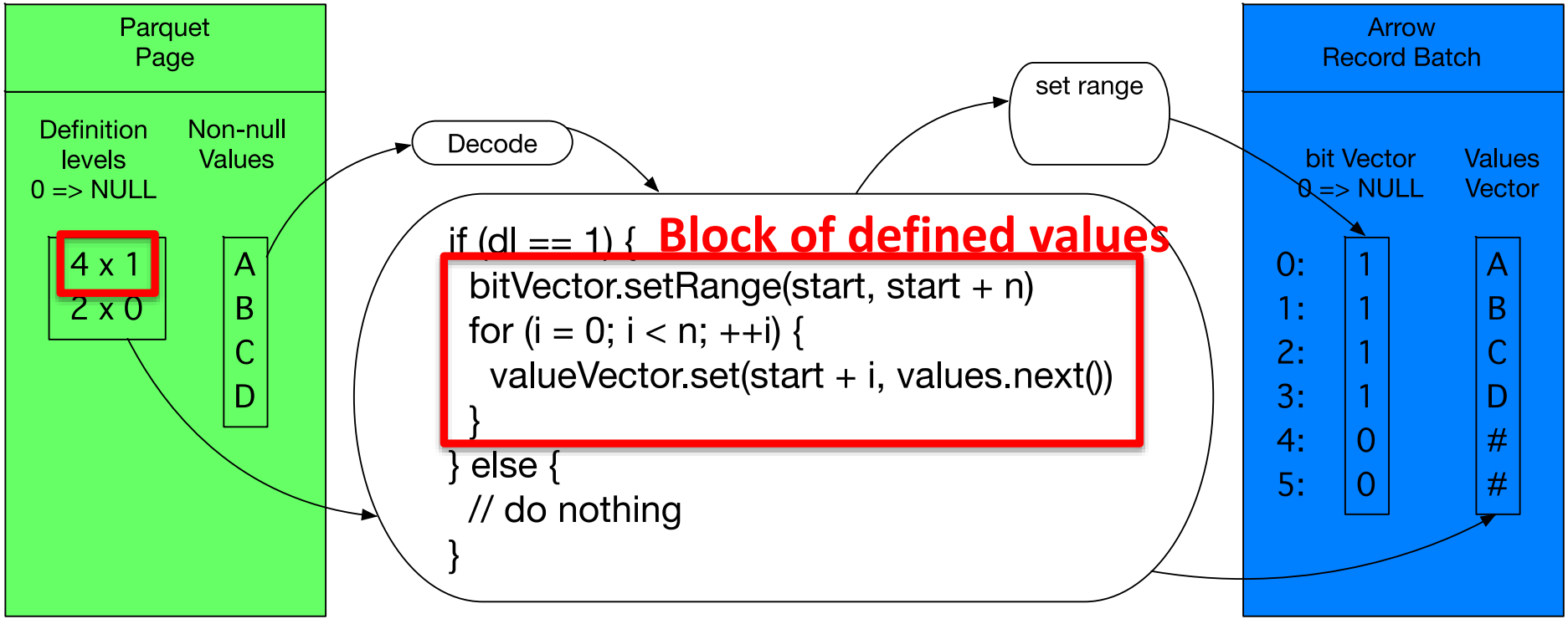
Bit packing case



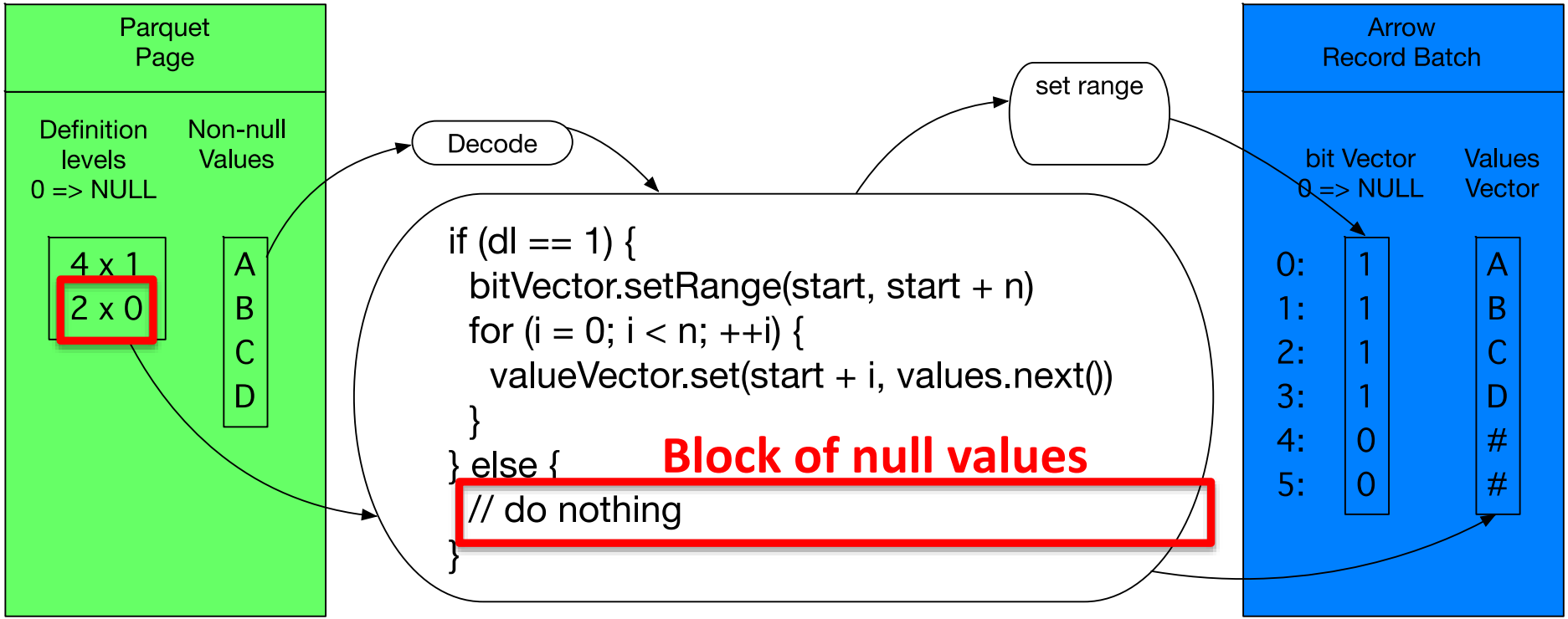
Run length encoding case



Run length encoding case

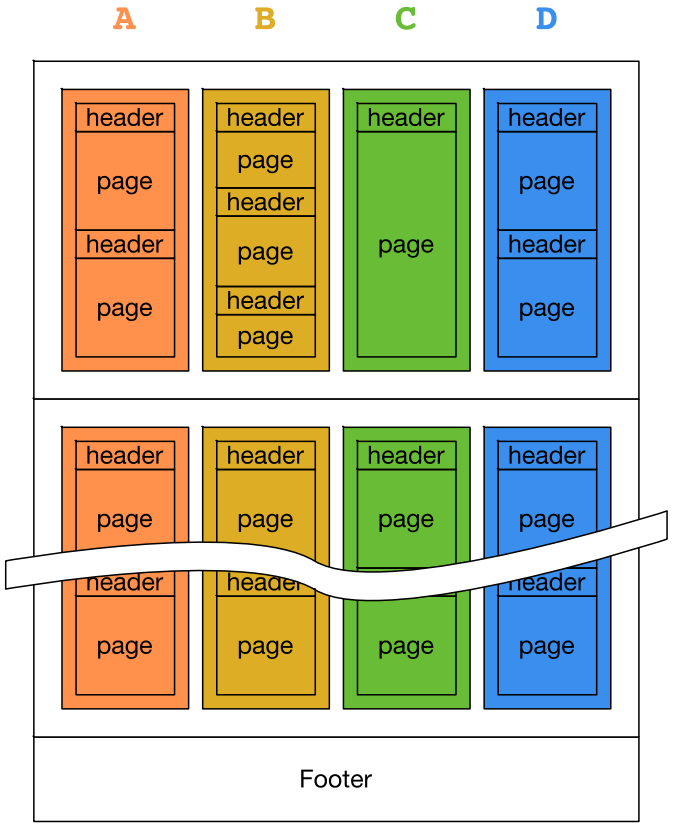


Run length encoding case



Predicate push down

Example: filter and projection




```
Select
   B, C, D
 FROM TABLE
 WHERE A = 3
```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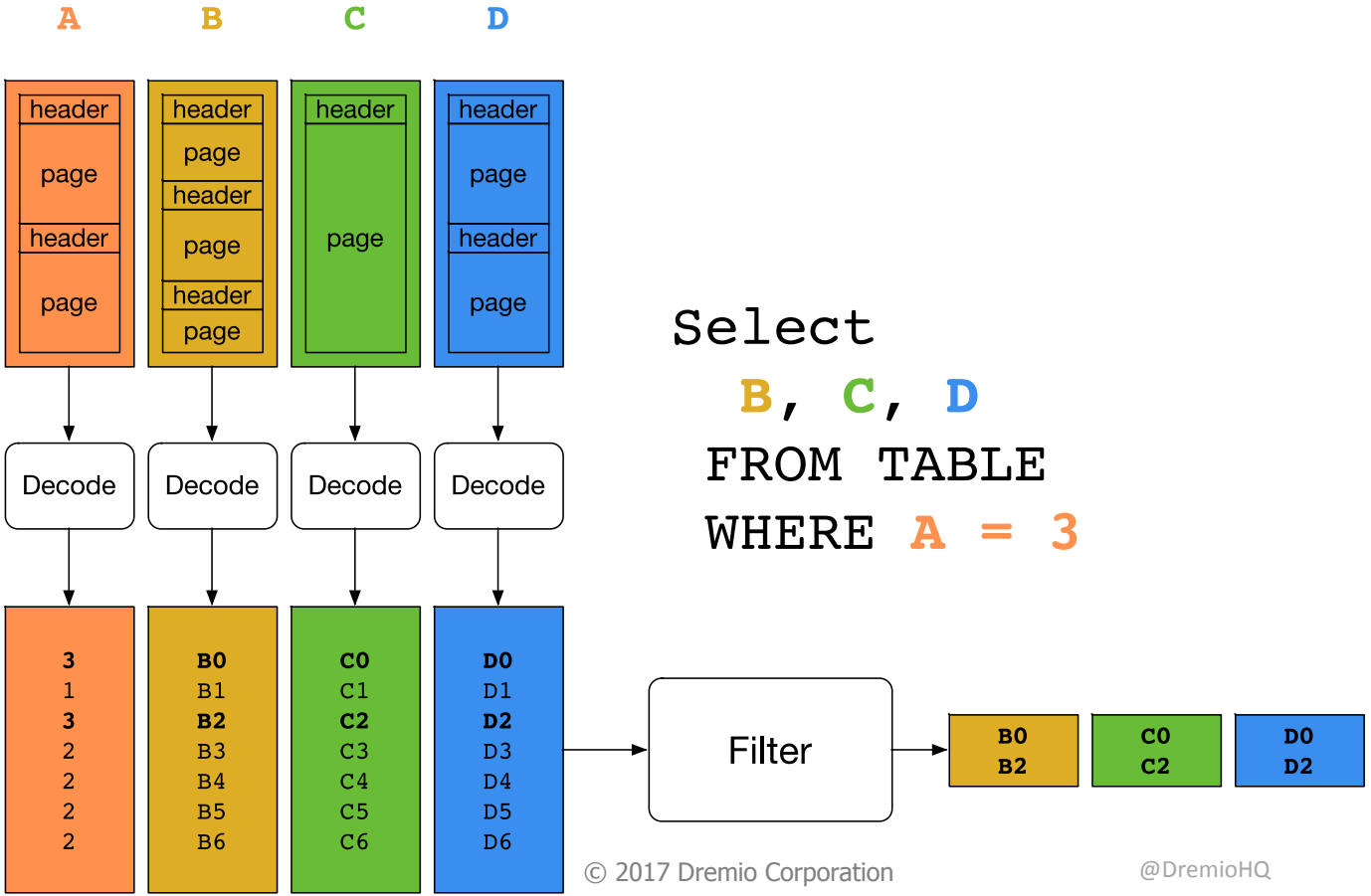
Naive filter and projection implementation




```
Select
  B, C, D
 FROM TABLE
 WHERE A = 3
```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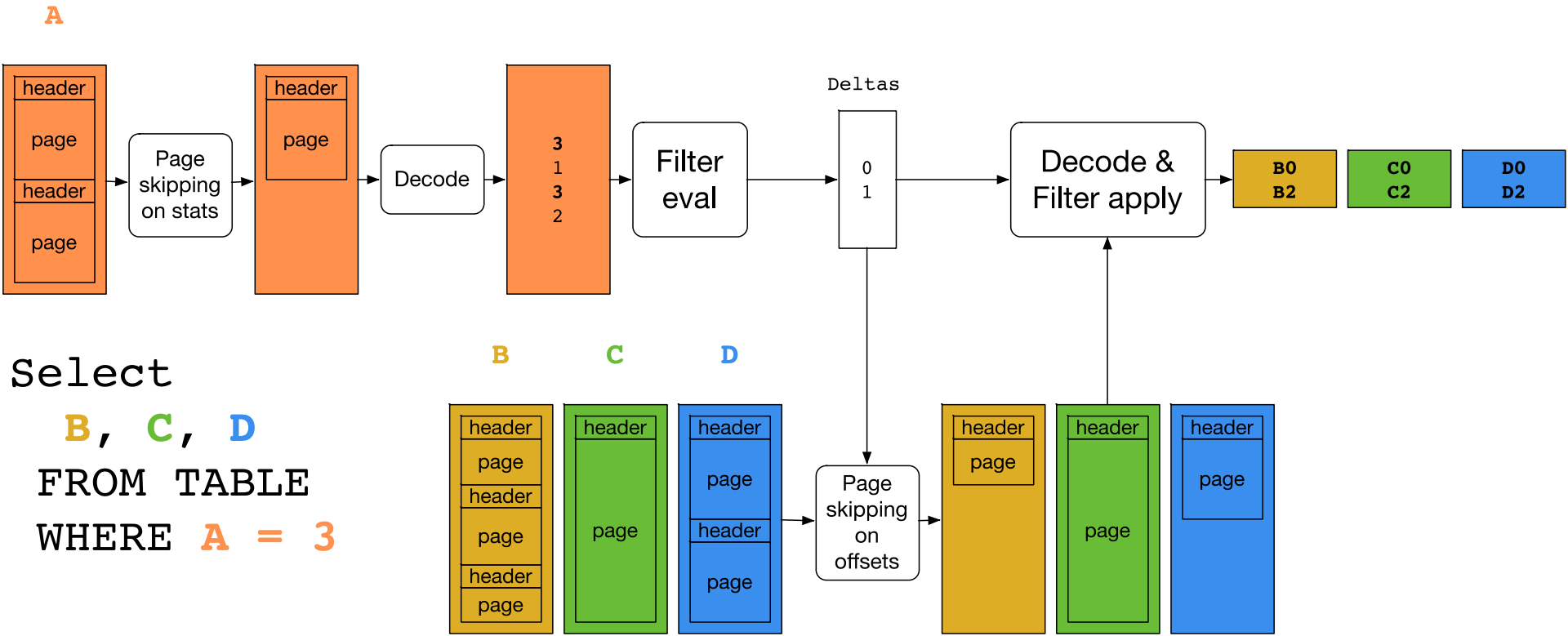
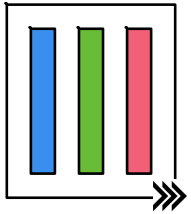
Peeling away abstractions



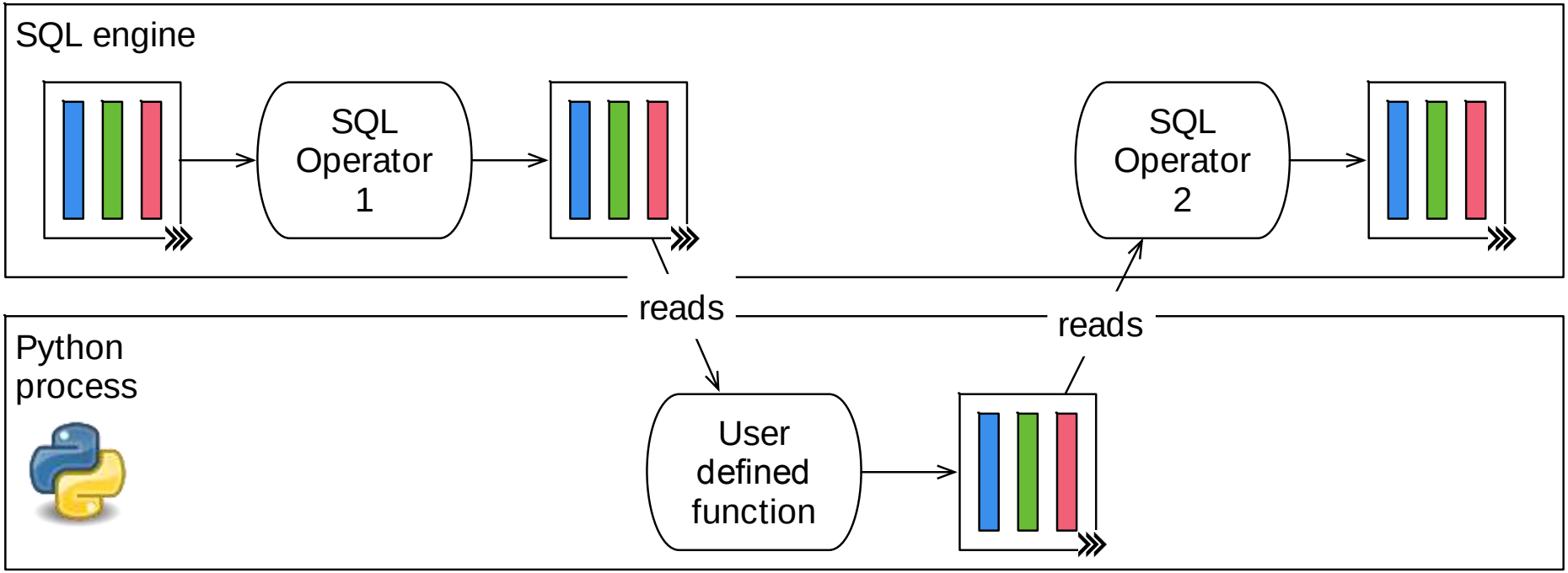

```
Select
  B, C, D
FROM TABLE
WHERE A = 3
```

Arrow based communication

Universal high performance UDFs



Immutable Arrow Batch



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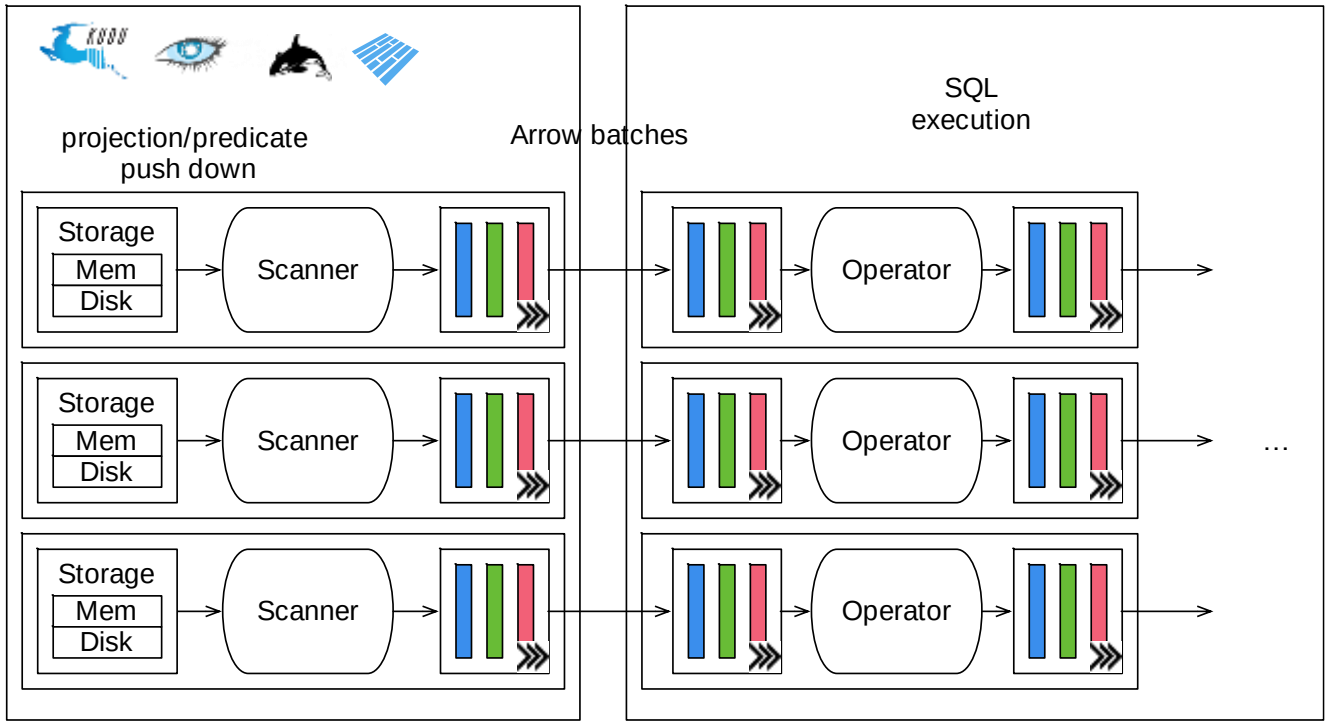
Arrow RPC/REST API

- Generic way to retrieve data in Arrow format
- Generic way to serve data in Arrow format
- Simplify integrations across the ecosystem
- Arrow based pipe

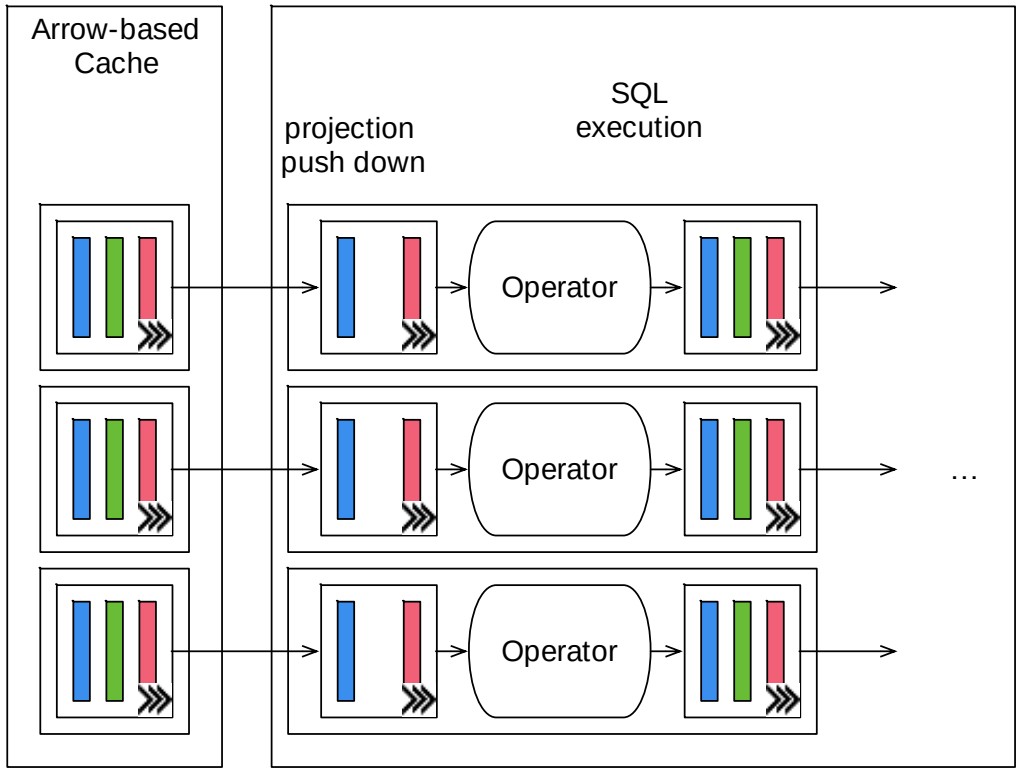
RPC: arrow based storage interchange

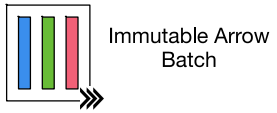


The memory representation is sent over the wire.

No serialization overhead.

RPC: arrow based cache

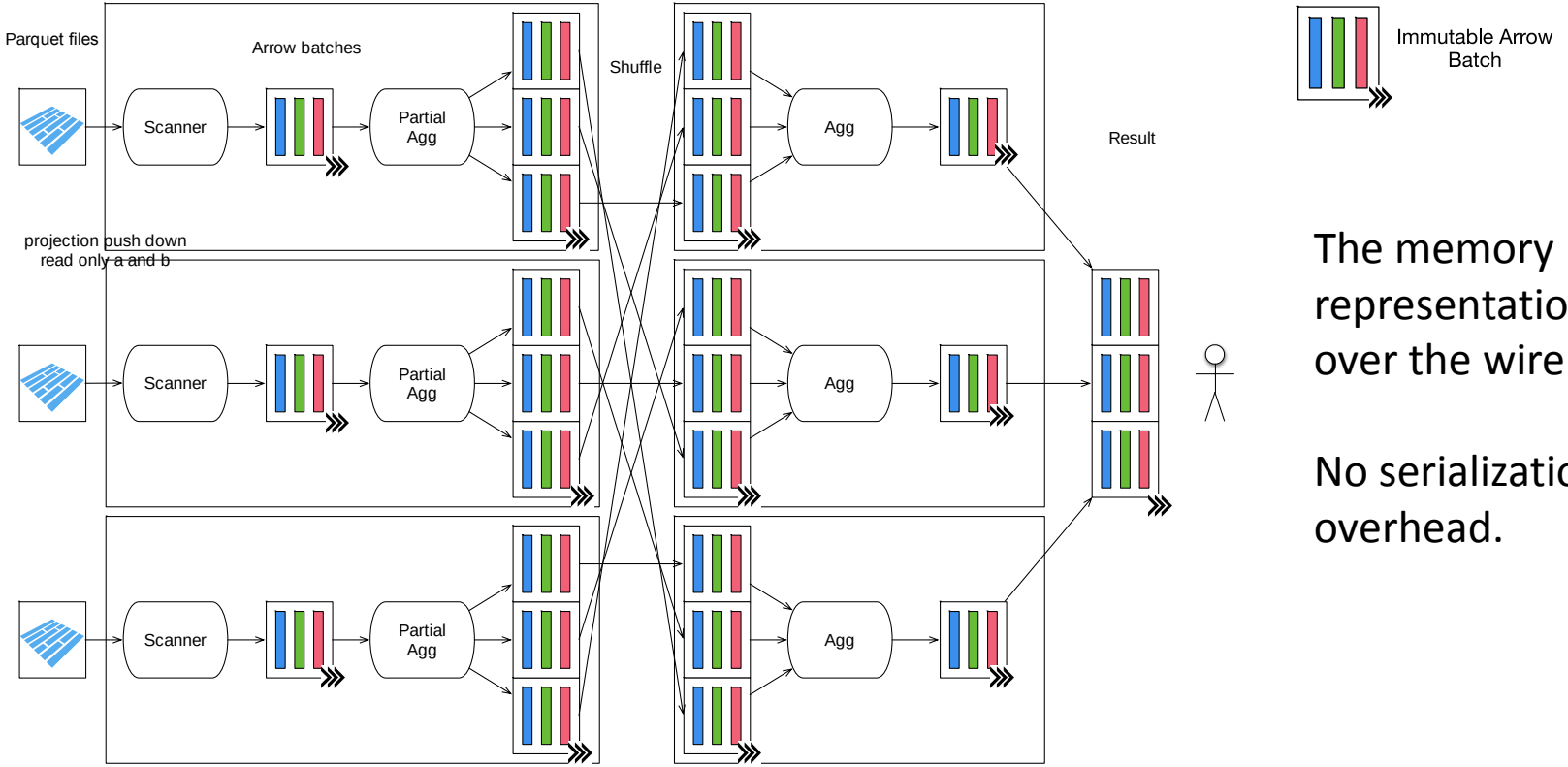




The memory representation is sent over the wire.

No serialization overhead.

RPC: Single system execution



SELECT SUM(a) FROM t GROUP BY b

The memory representation is sent over the wire.

No serialization overhead.

Results

- PySpark Integration:
  53x speedup (IBM spark work on SPARK-13534)
  http://s.apache.org/arrowresult1

- Streaming Arrow Performance
  7.75GB/s data movement
  http://s.apache.org/arrowresult2

- Arrow Parquet C++ Integration
  4GB/s reads
  http://s.apache.org/arrowresult3

- Pandas Integration
  9.71GB/s
  http://s.apache.org/arrowresult4

Language Bindings

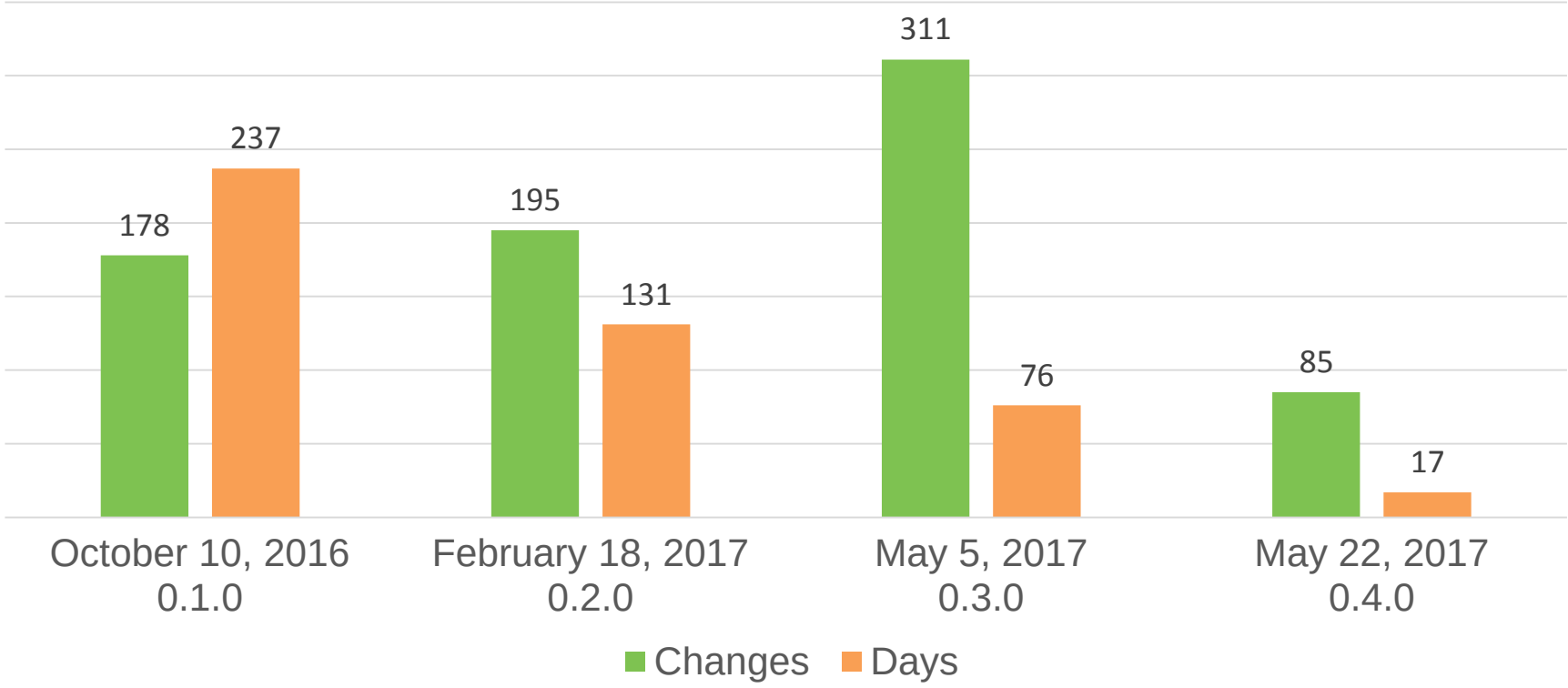
Parquet

- Target Languages
  - Java
  - CPP
  - Python & Pandas
- Engines integration:
  - Many!

Arrow

- Target Languages
  - Java
  - CPP, Python
  - R (underway)
  - C, Ruby, JavaScript
- Engines integration:
  - Drill
  - Pandas, R
  - Spark (underway)

Arrow Releases



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Current activity:

- Spark Integration (SPARK-13534)
- Pages index in Parquet footer (PARQUET-922)
- Arrow REST API (ARROW-1077)
- Bindings:
  - C, Ruby (ARROW-631)
  - JavaScript (ARROW-541)

Get Involved

- Join the community
  - dev@{arrow,parquet}.apache.org
  - Slack:
    - Arrow: https://apachearrowslackin.herokuapp.com/
    - Parquet: https://parquet-slack-invite.herokuapp.com/
  - http://{arrow,parquet}.apache.org
  - Follow @Apache{Parquet,Arrow}

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