Spotting Code Optimizations in Data-Parallel Pipelines through **PeriSCOPE**

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Microsoft Research Asia

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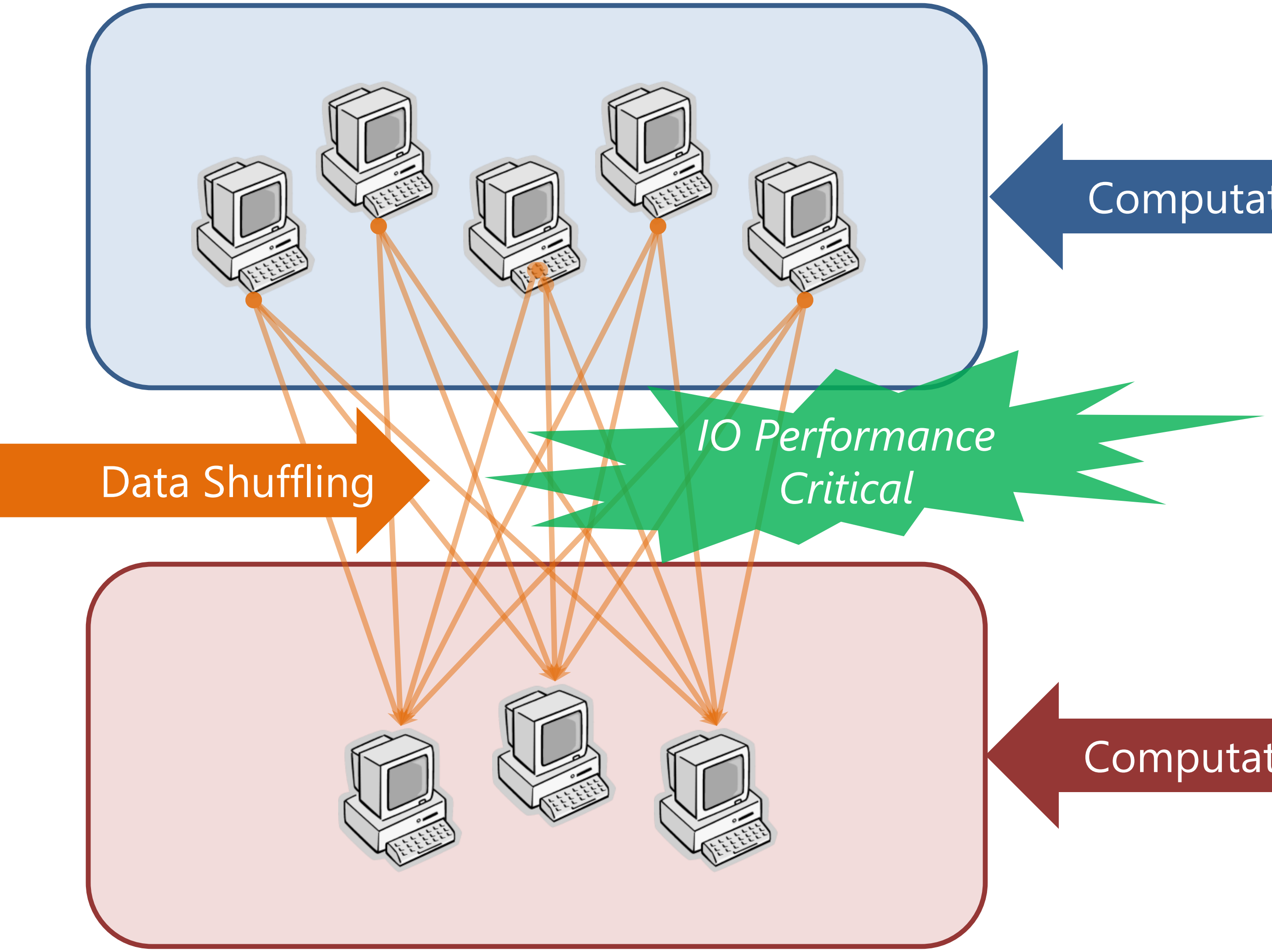
Distributed Data-Parallel Pipelines



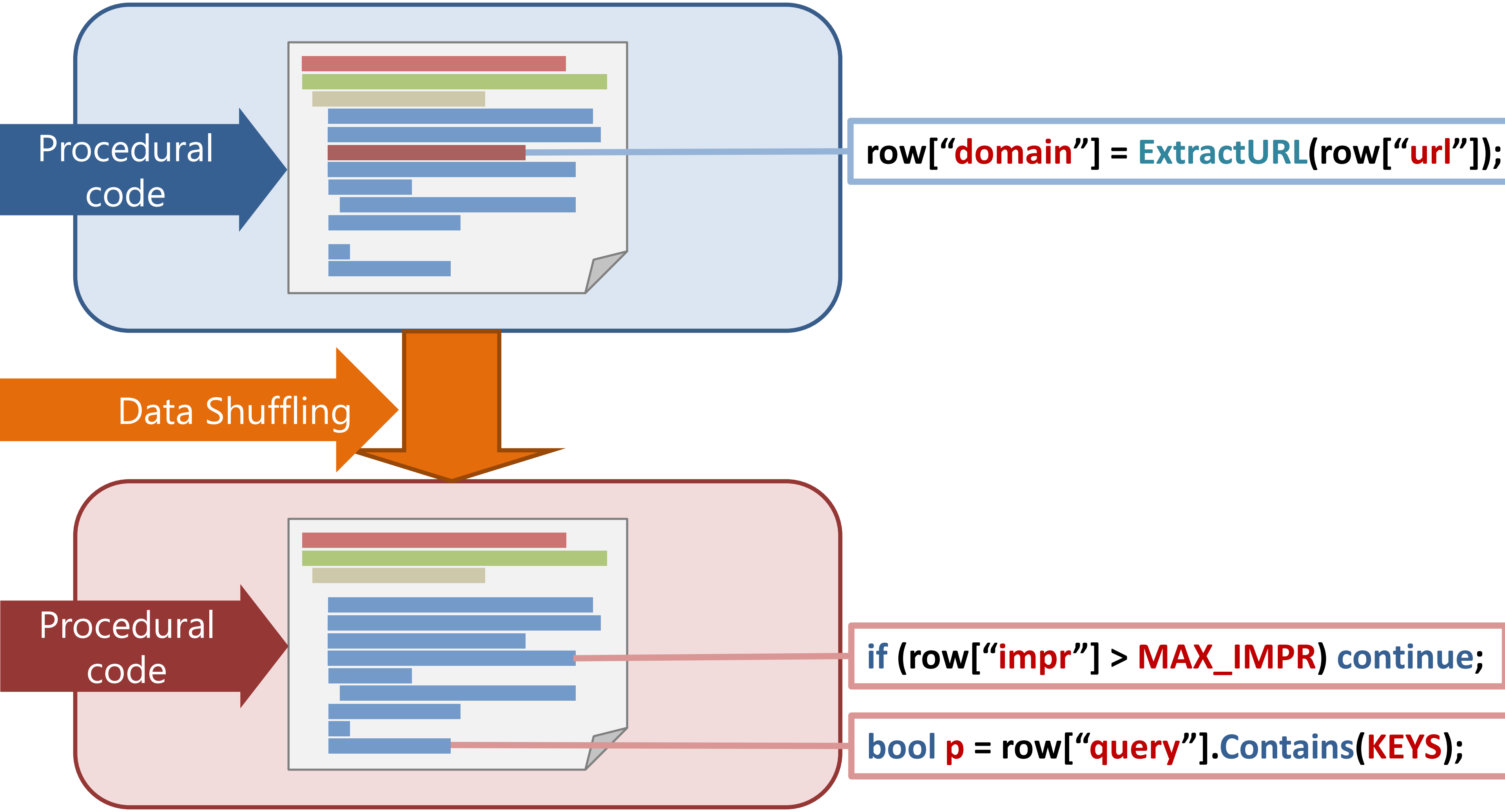
Computation Phase #1

Data Shuffling

IO Performance Critical

Computation Phase #2

Opportunities



Procedural code

Data Shuffling

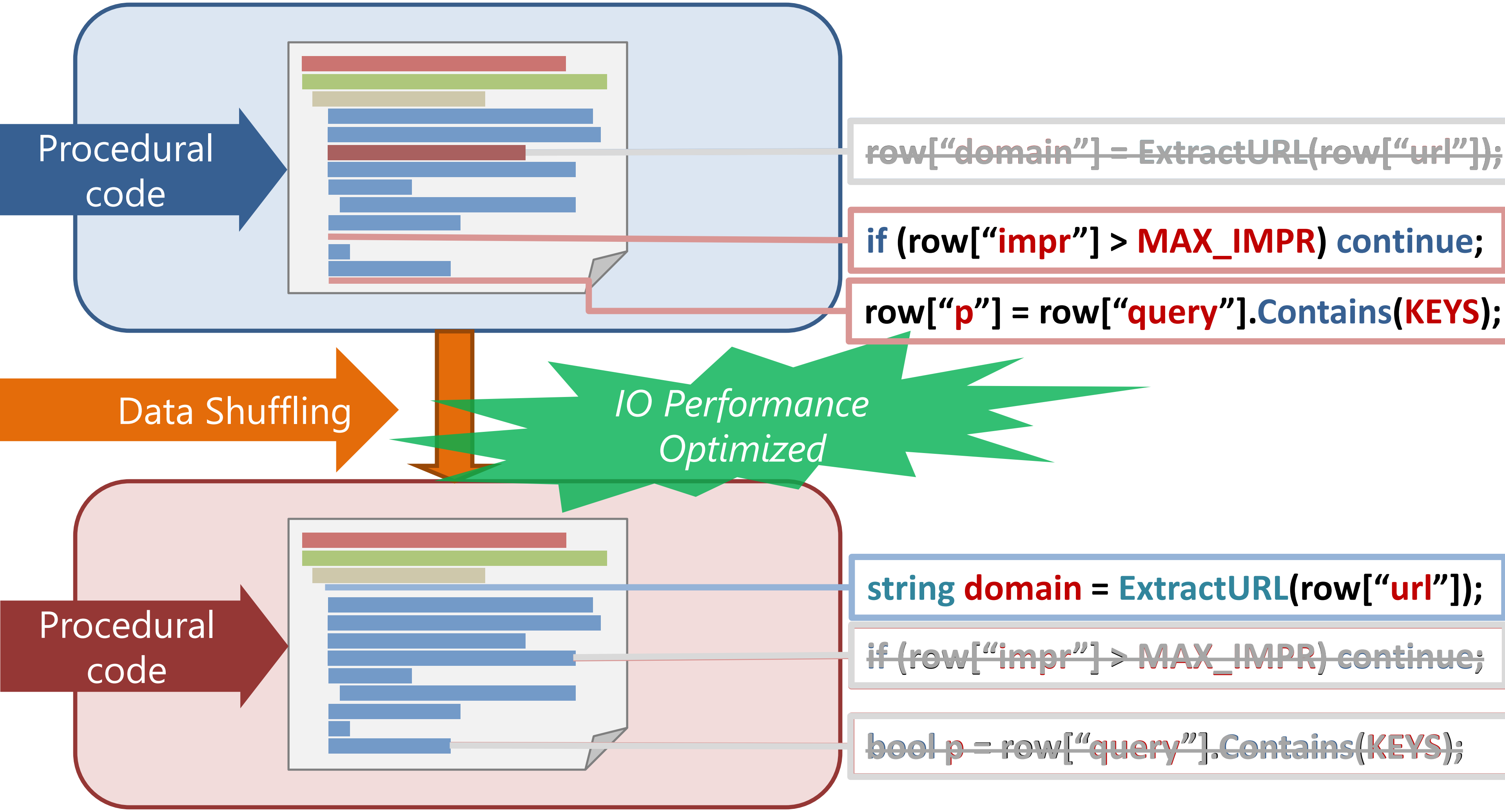
Procedural code

```
row["domain"] = ExtractURL(row["url"]);
```

```
if (row["impr"] > MAX_IMPR) continue;
```

```
bool p = row["query"].Contains(KEYS);
```

Opportunities



~~row["domain"] = ExtractURL(row["url"]);~~

if (row["impr"] > MAX_IMPR) continue;

row["p"] = row["query"].Contains(KEYS);

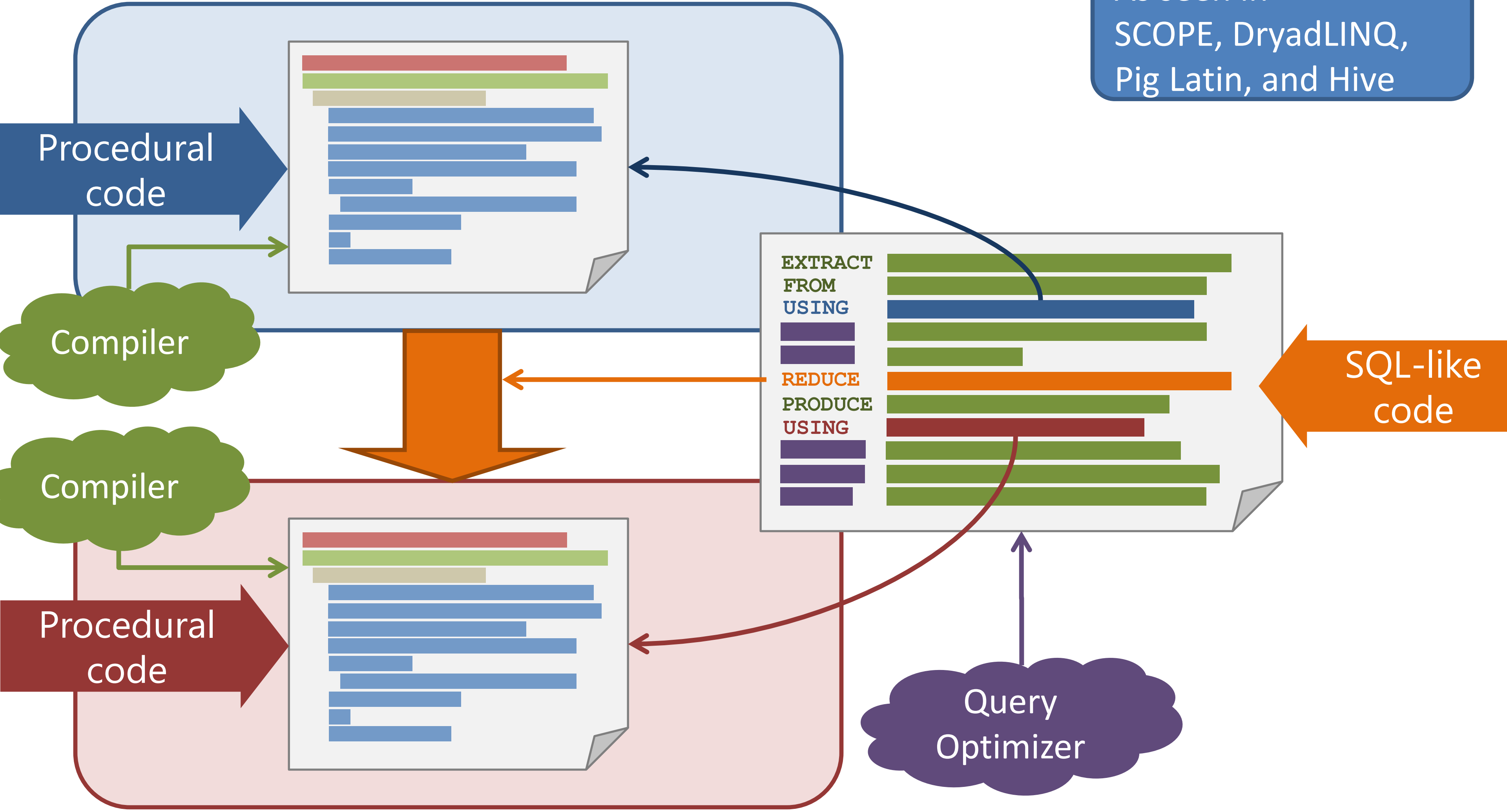
string domain = ExtractURL(row["url"]);

~~if (row["impr"] > MAX_IMPR) continue;~~

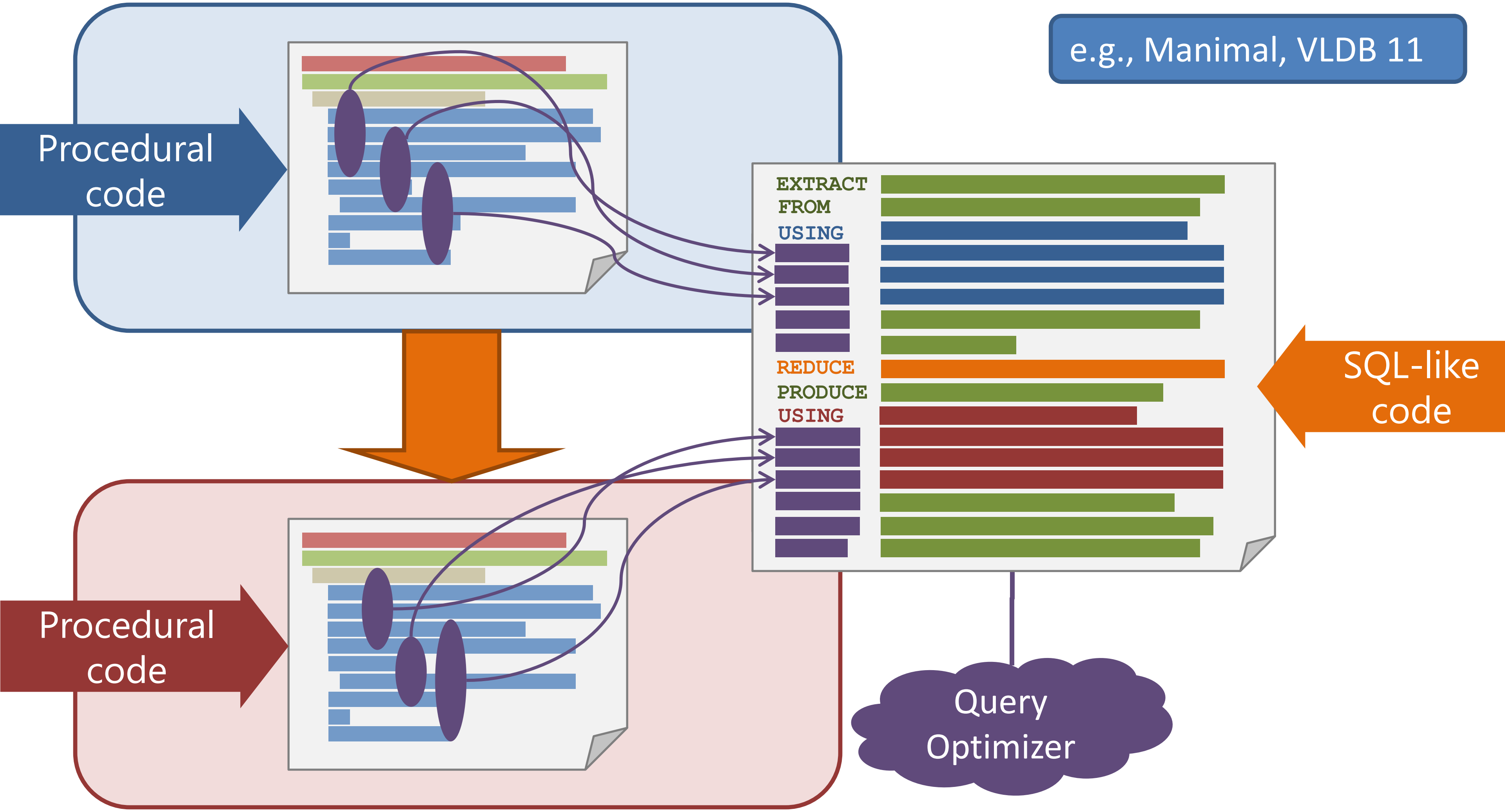
~~bool p = row["query"].Contains(KEYS);~~

Current Practice: Separated Optimization

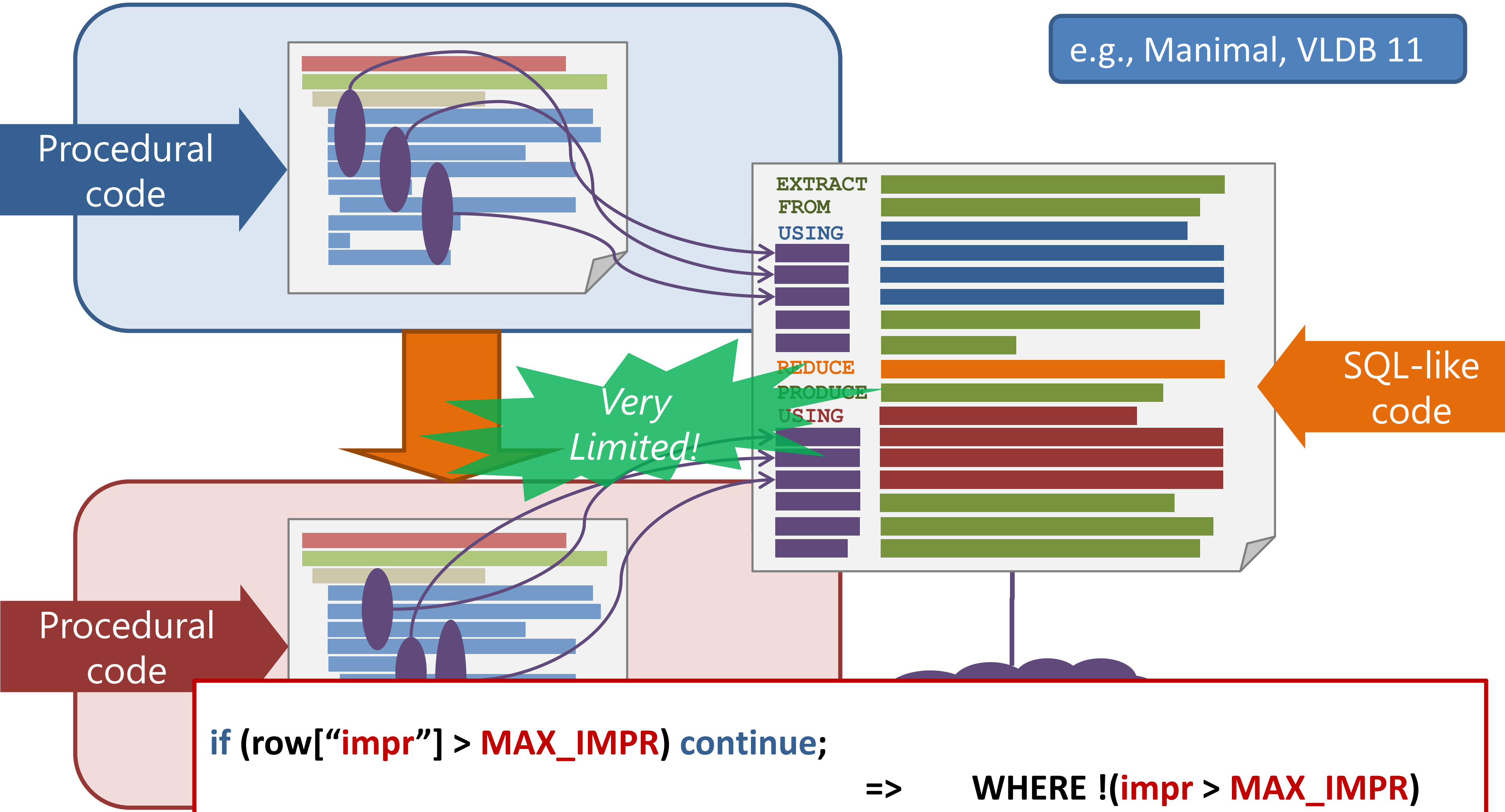
As seen in SCOPE, DryadLINQ, Pig Latin, and Hive



Holistic optimization using query optimizer



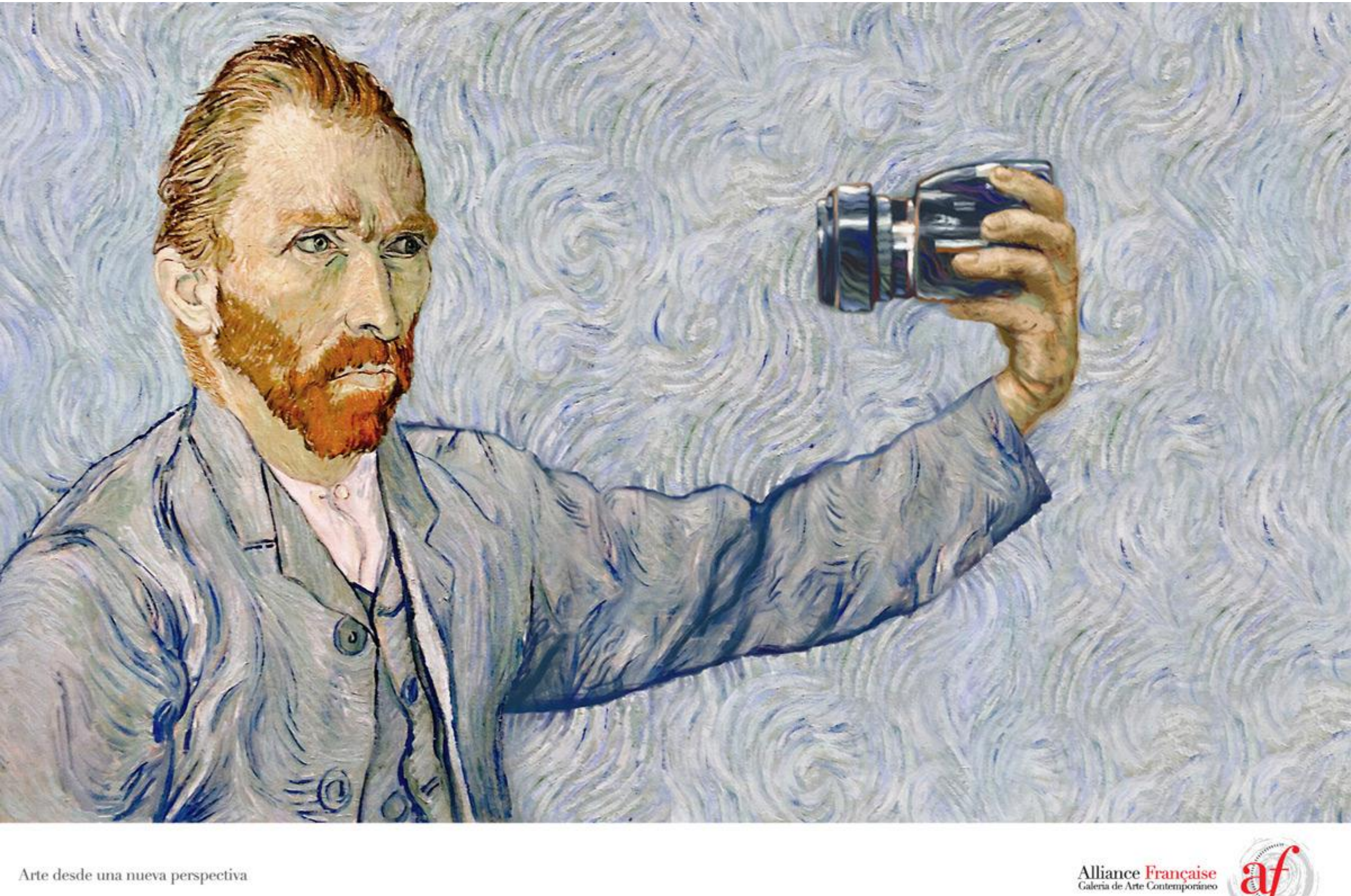
Holistic optimization using query optimizer



if (row["impr"] > MAX_IMPR) continue;

=> WHERE !(impr > MAX_IMPR)

A New Perspective


Arte desde una nueva perspectiva
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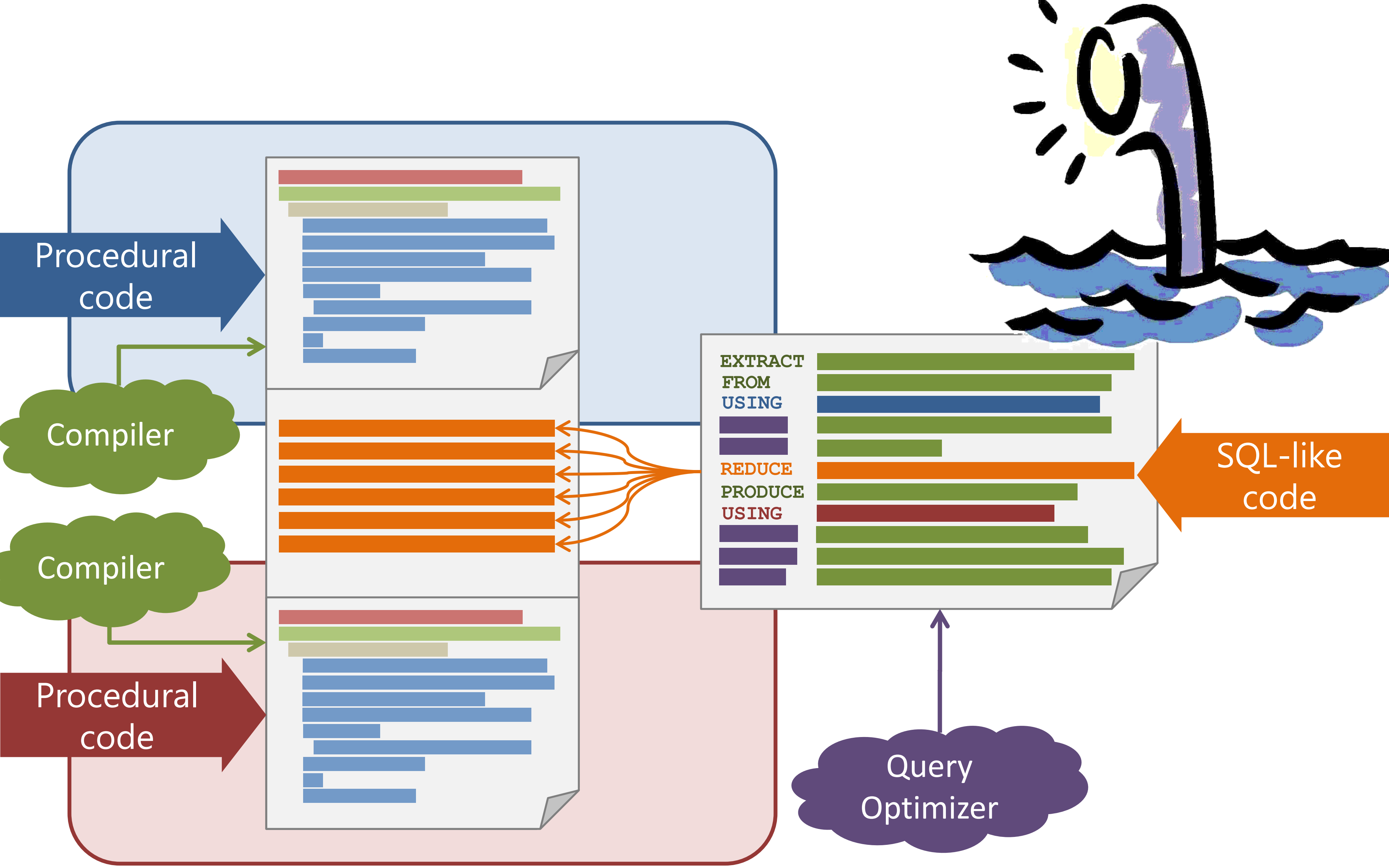
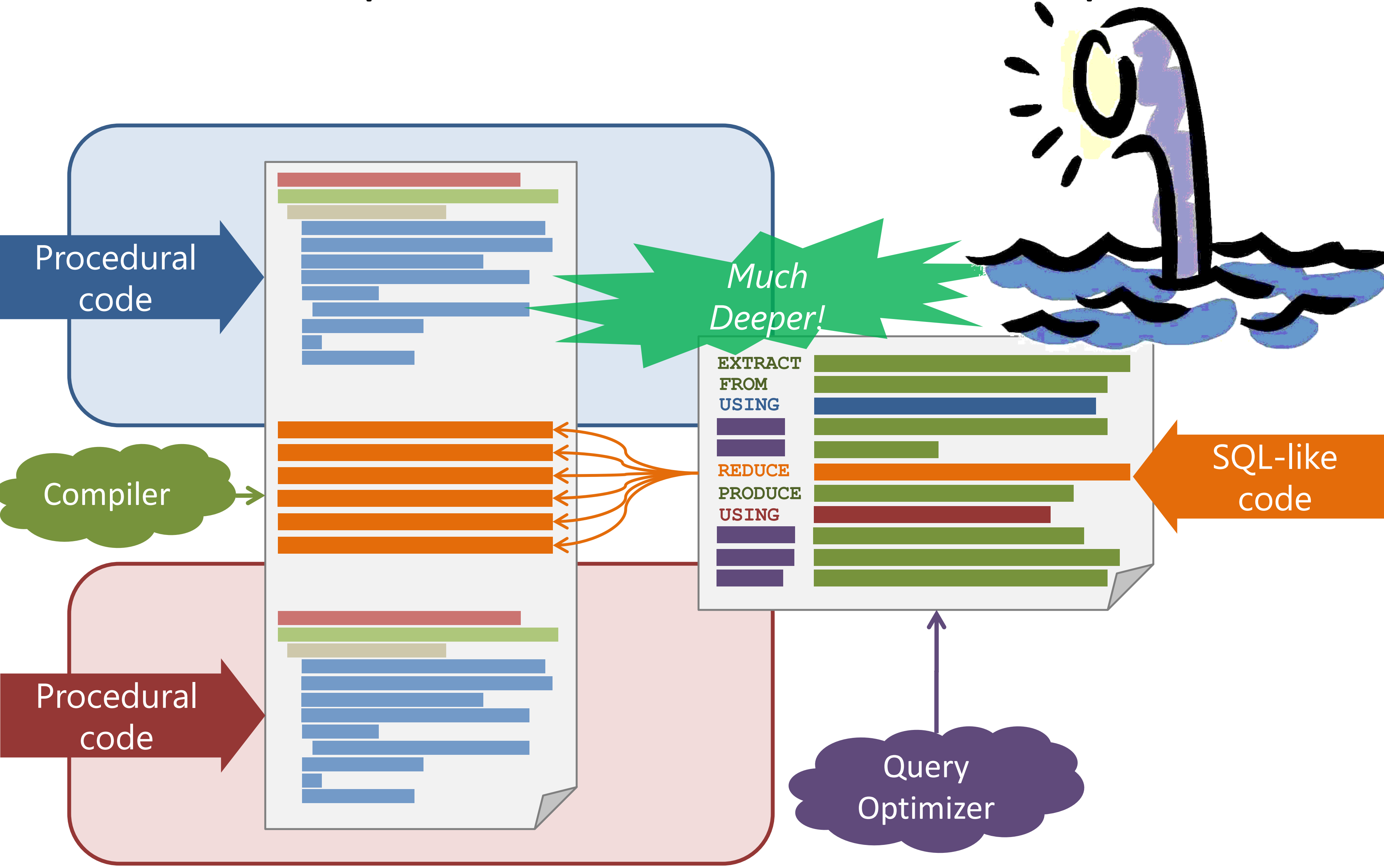
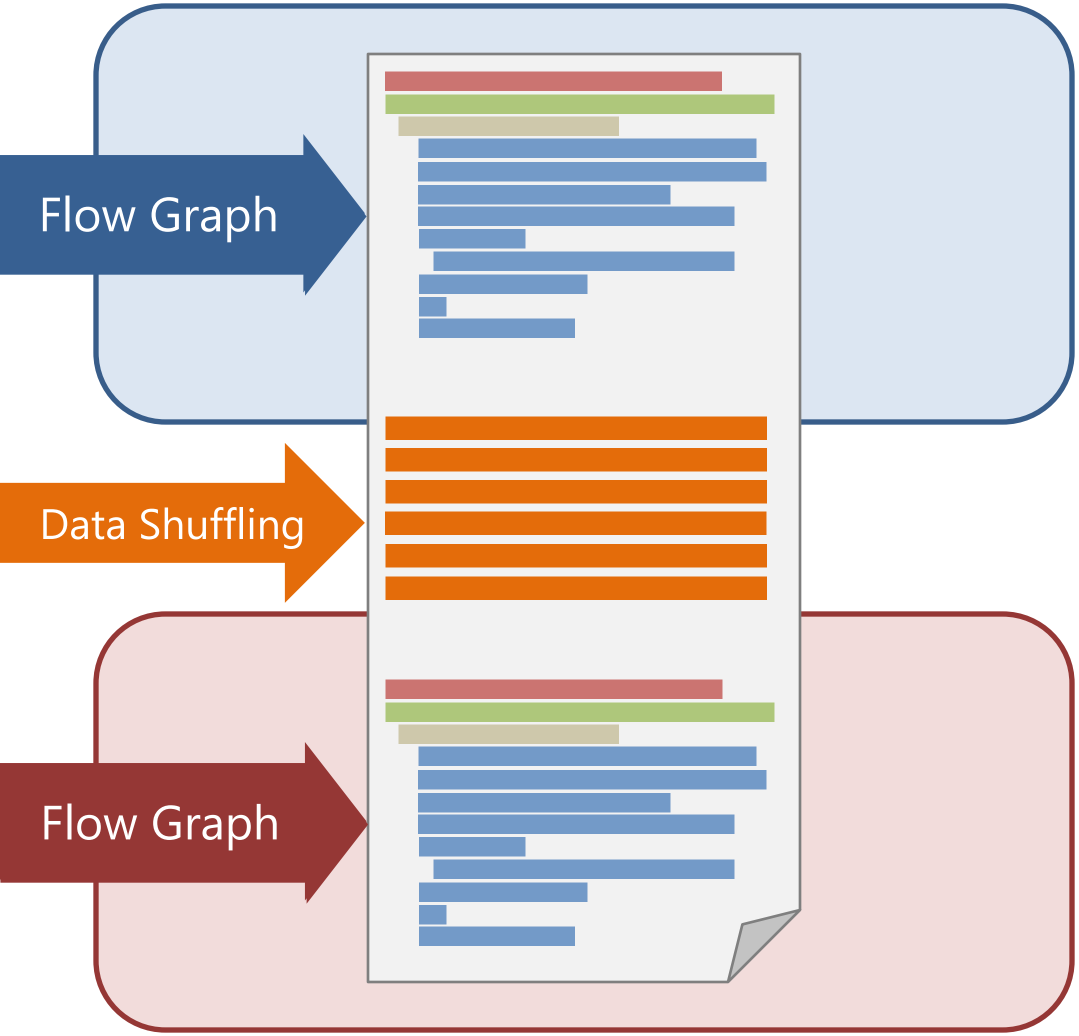
PeriSCOPE: Pipeline-aware Holistic Code Optimization



PeriSCOPE: Pipeline-aware Holistic Code Optimization

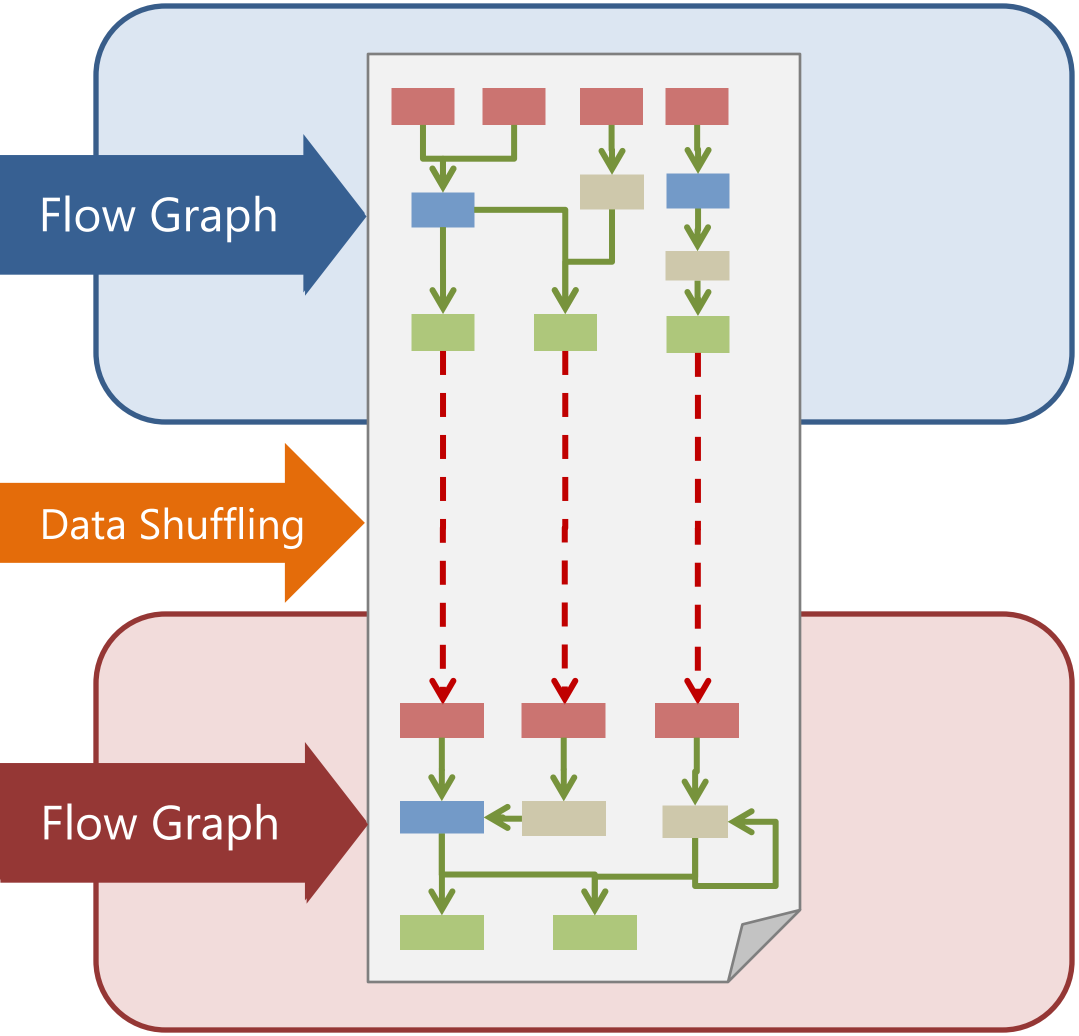


Optimization Steps



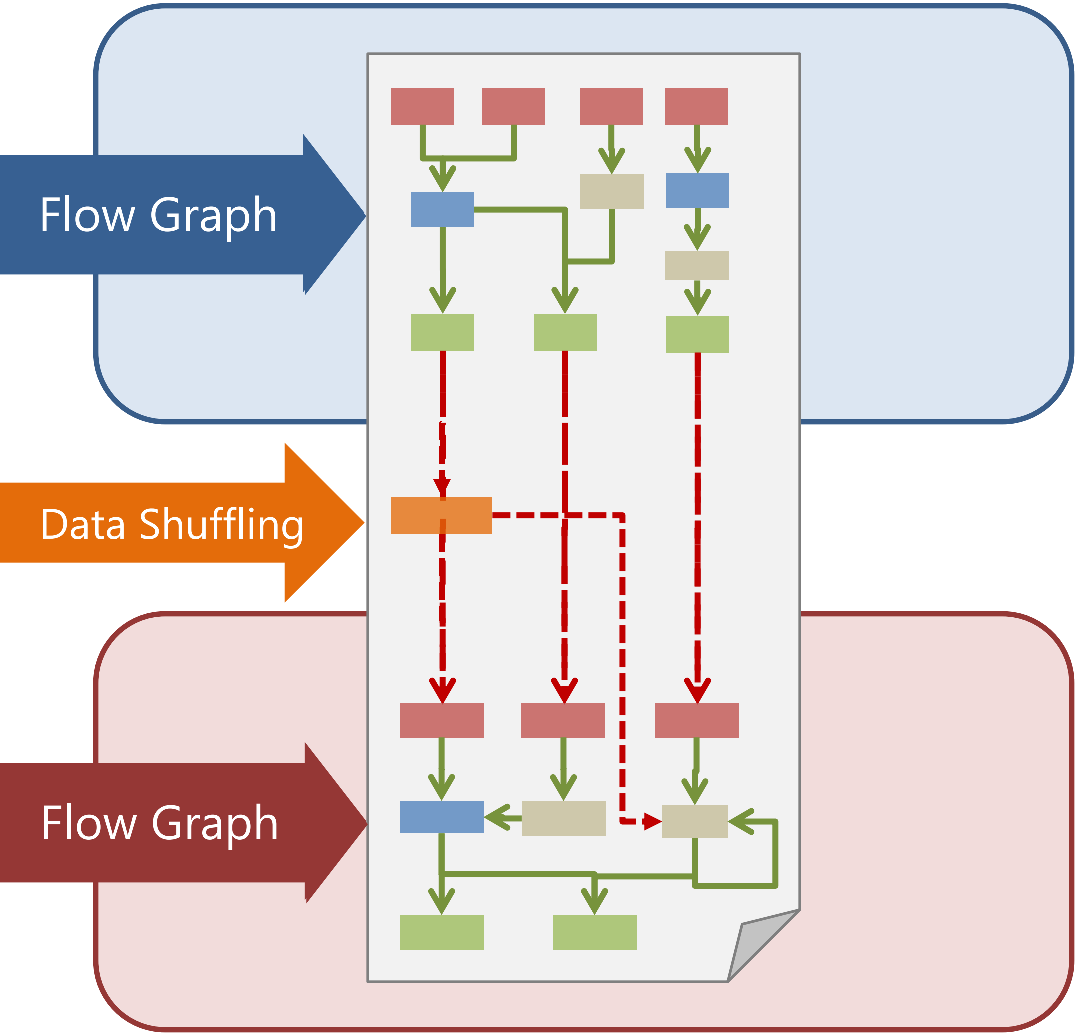
Step 1: Construct inter-procedural flow graph

Optimization Steps



Step 1: Construct inter-procedural flow graph

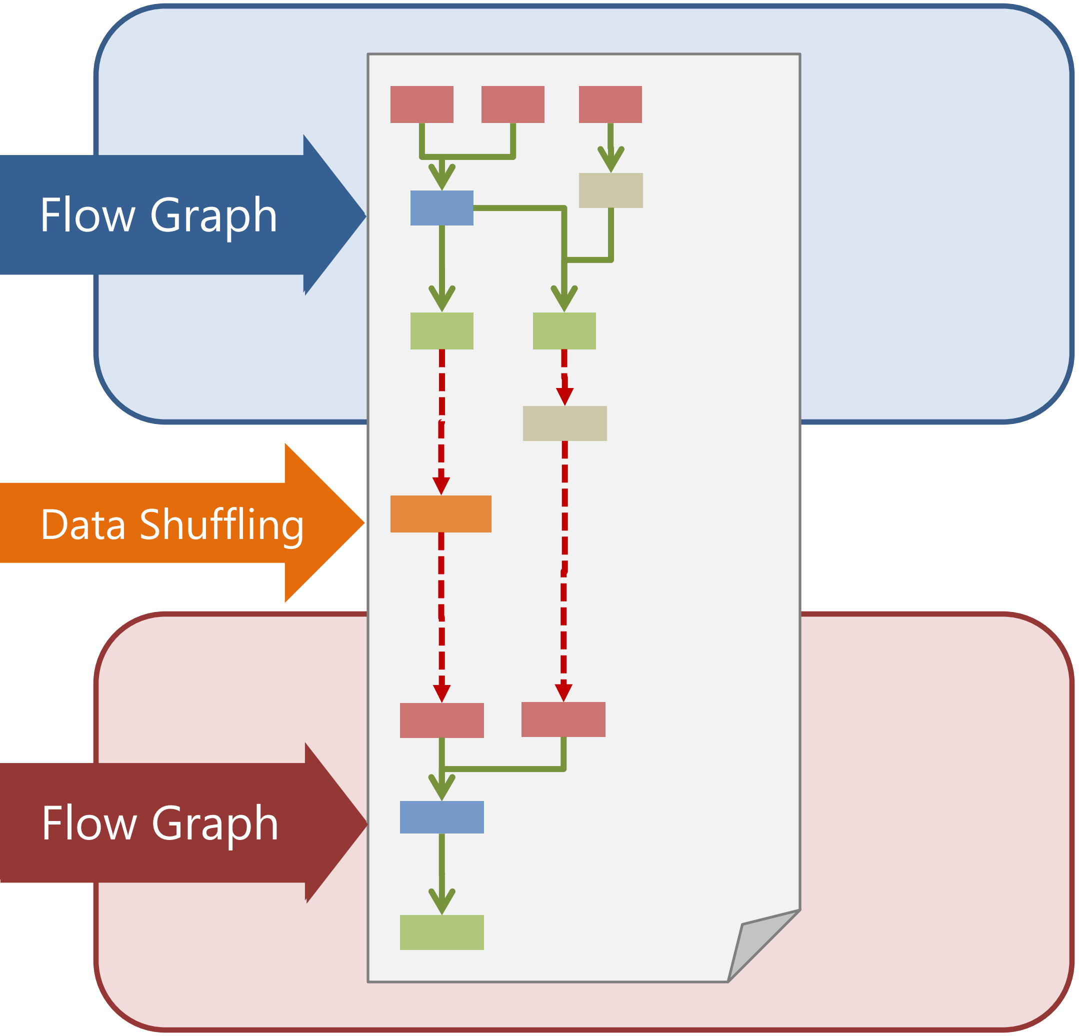
Optimization Steps



Step 1: Construct inter-procedural flow graph

Step 2: Add safety constraints for skipping shuffling code

Optimization Steps

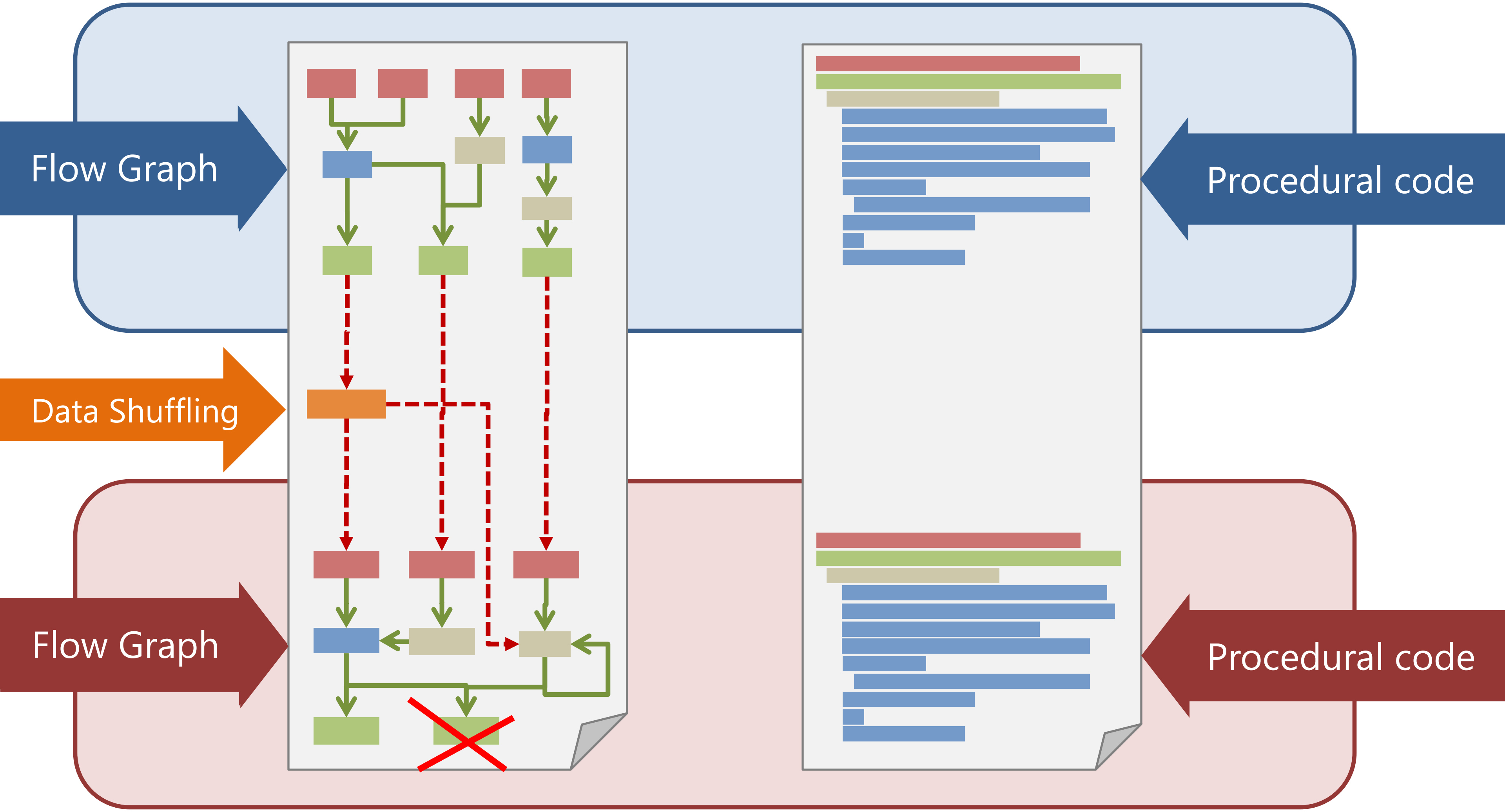


Step 1: Construct inter-procedural flow graph

Step 2: Add safety constraints for skipping shuffling code

Step 3: Transform code for reducing shuffling I/O

Column Reduction: Reduce Number of Columns



Flow Graph

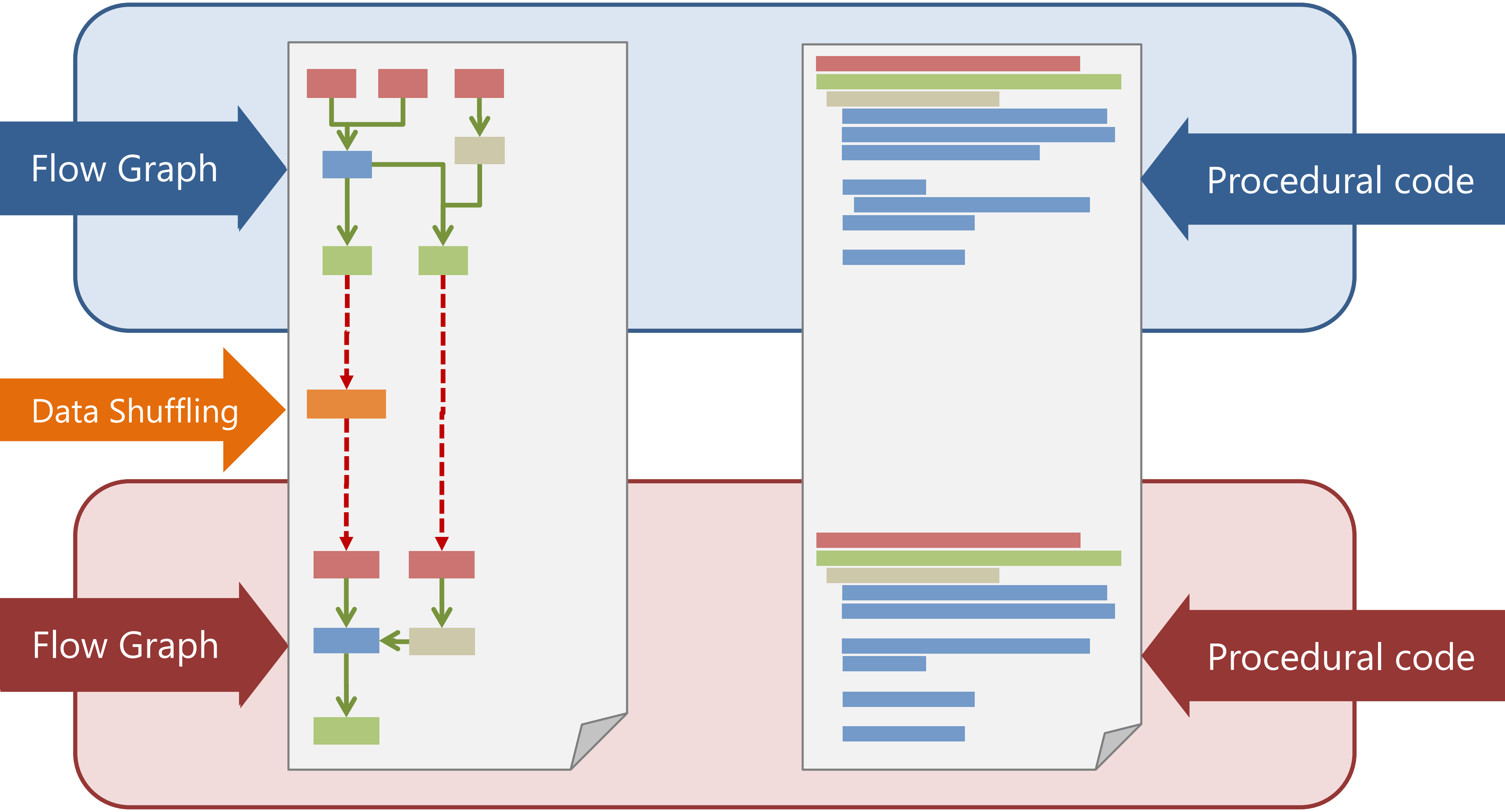
Data Shuffling

Flow Graph

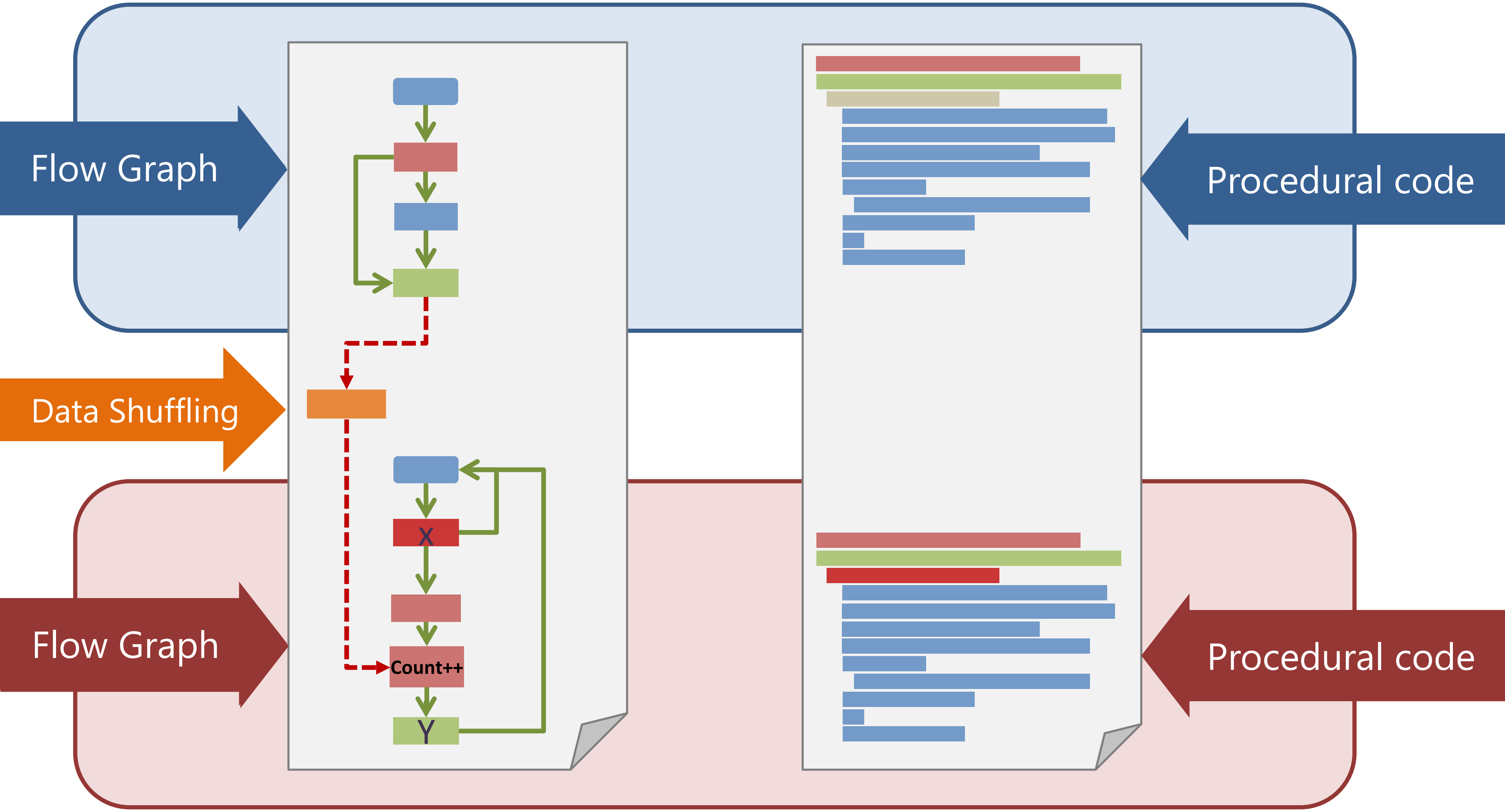
Procedural code

Procedural code

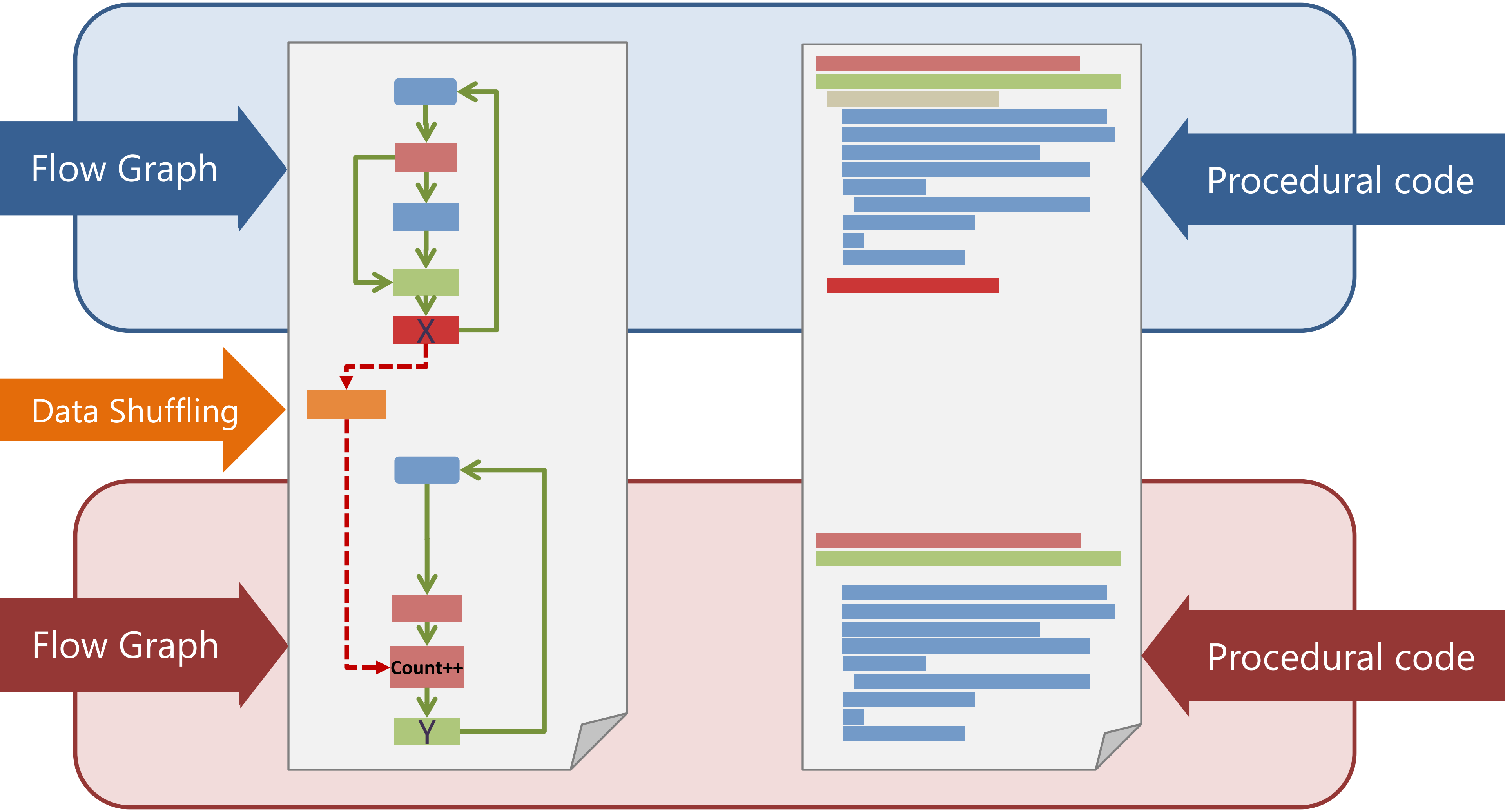
Column Reduction: Reduce Number of Columns



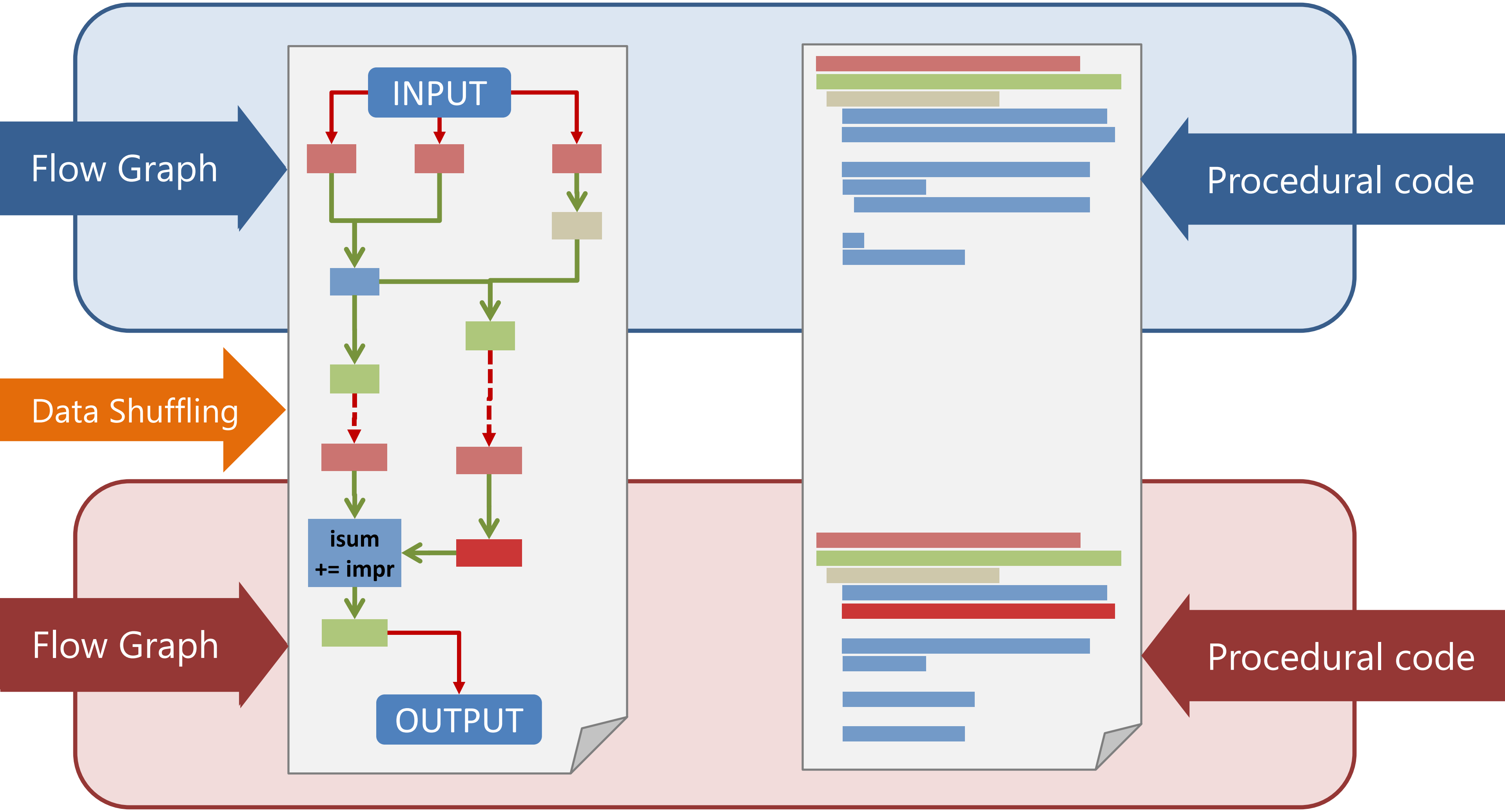
Early Filtering: Reduce Number of Rows



Early Filtering: Reduce Number of Rows



Smart Cut: Reduce Size of Each Row



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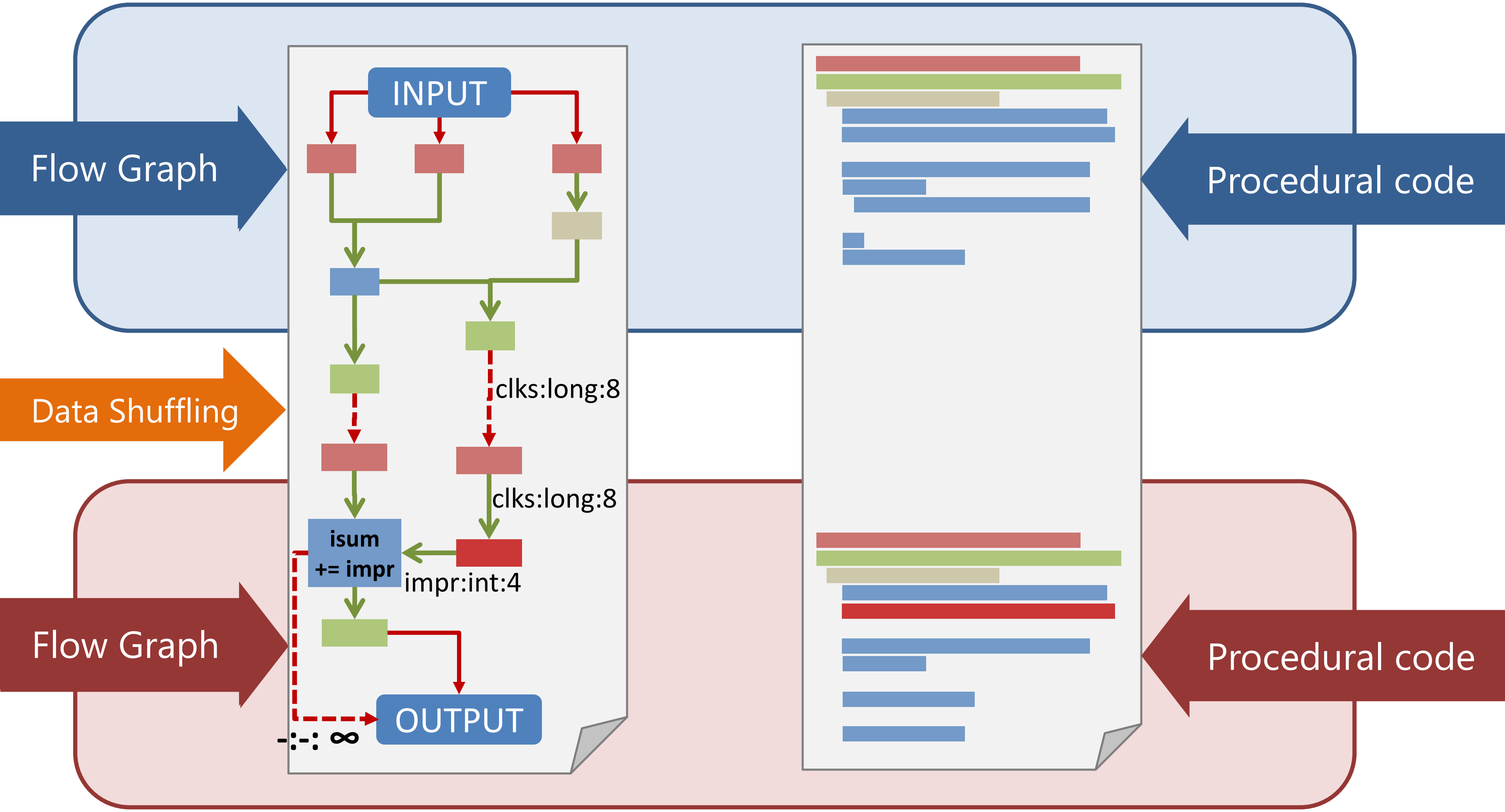

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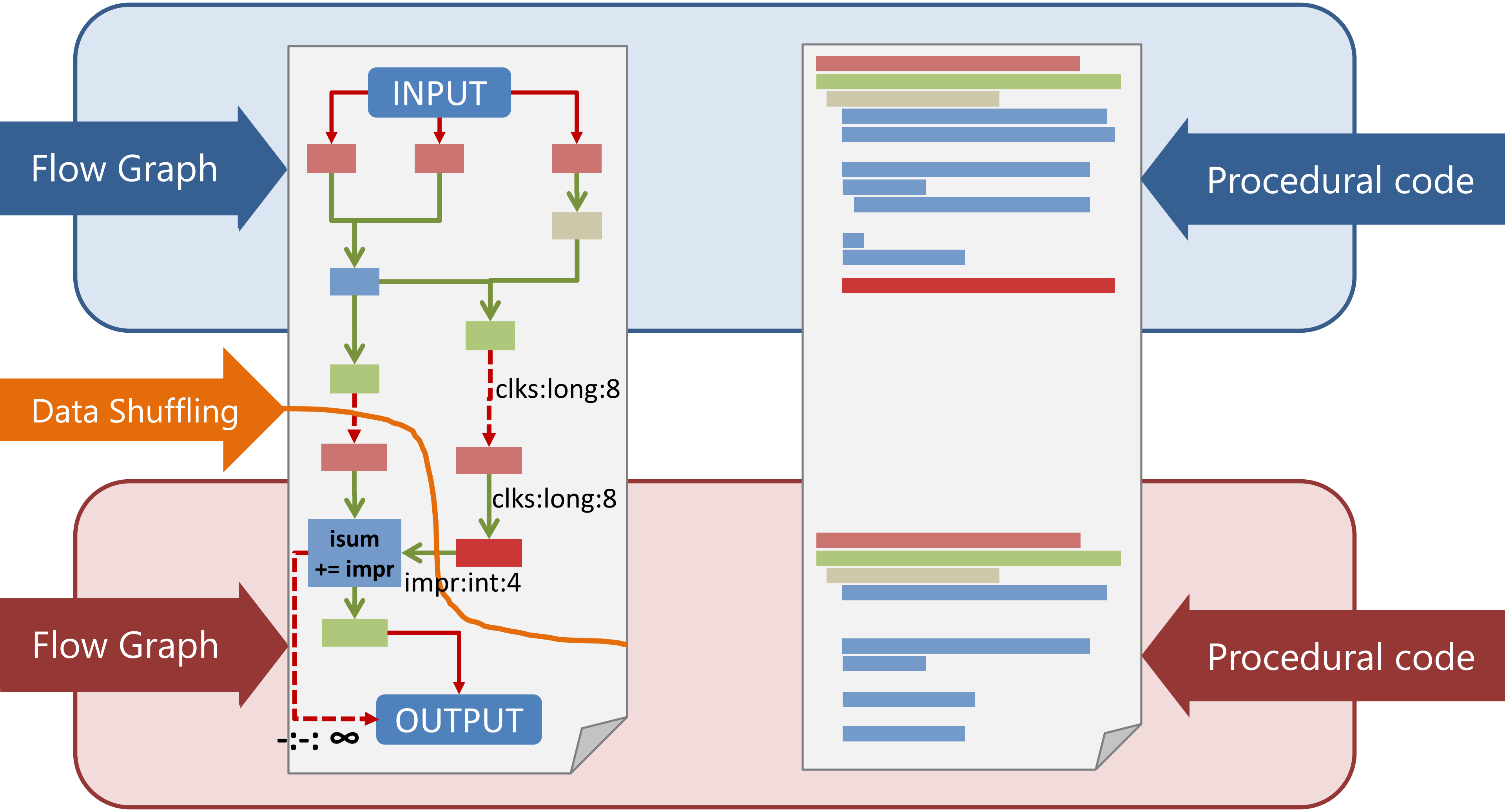
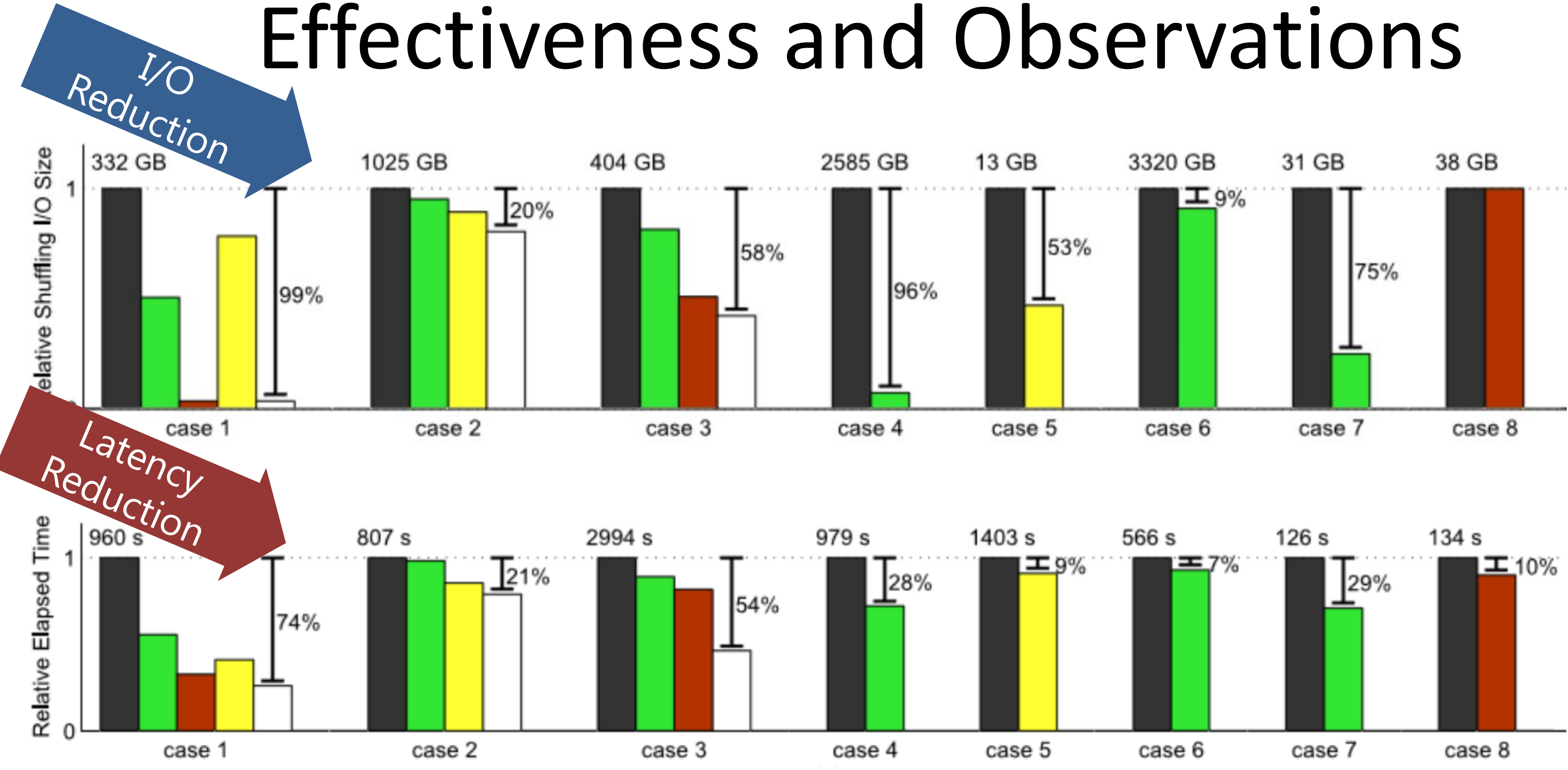


Coverage Study*

Optimization	Eligible jobs
Column Reduction	4,052 (14.05%)
Early Filtering	3,020 (10.47%)
Smart Cut	1,544 (5.35%)
Overlapped Total	6,397 (22.18%)

* Study on **28,838** jobs collected from SCOPE clusters in 2010/2011.

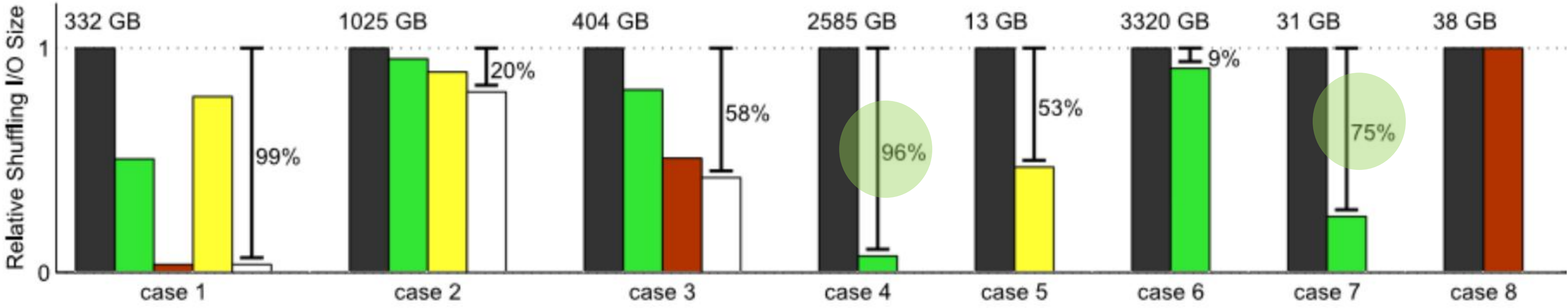
Effectiveness and Observations



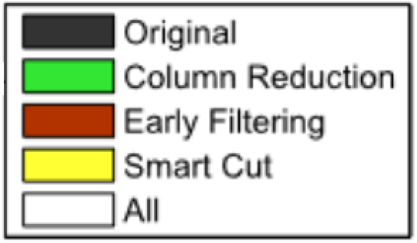
⬛ Original
🟩 Column Reduction
🟥 Early Filtering
🟨 Smart Cut
⬜ All

- I/O reduction is nice
- Latency reduction is generally smaller

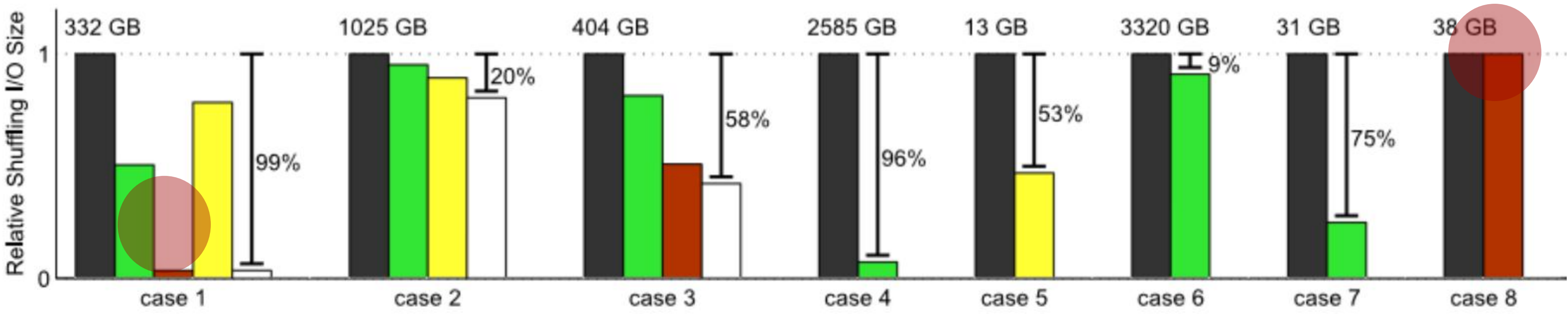
Effectiveness and Observations



- Column Reduction
  - Case 4: 18 in 22 columns are eliminated
  - Case 7: 29 in 31 columns are eliminated
  - Mostly due to UDF reuse
    - 80.2% of the functions eligible for column reduction are reused more than 13 times

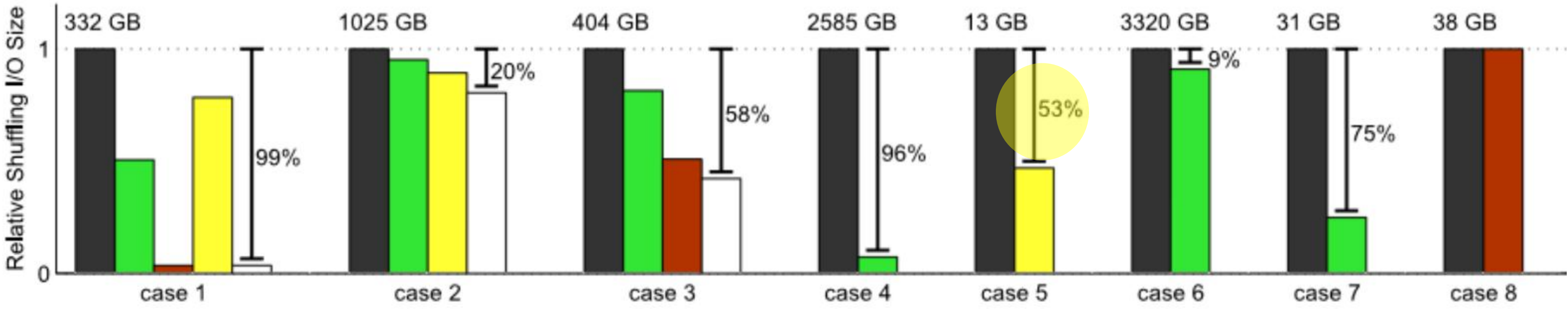


Effectiveness and Observations



- Early Filtering
  - Exclude rows with invalid format
    - Case 8: ~0% reduction
  - Exclude rows with certain unwanted values
    - Case 1: 99% reduction

Effectiveness and Observations



- Smart Cut
  - Unary operations
    - String to integer types
    - Trim, SubString
  - Binary operations
  - Case 5: DateTime.Parse(EndTs) - DateTime.Parse(StartTs)

⬛ Original
🟩 Column Reduction
🟥 Early Filtering
🟨 Smart Cut
⬜ All

Applicability to various data-parallel computation systems

- Generally applicable (e.g., Scope/DryadLINQ/Hive/Pig Latin)
- Impact factors to the coverage and effectiveness
  - Data model
    - Relational
    - Object
  - API interface
    - Map(List<Row> *rows*, …)
    - Map(Row *row*, …)

Future Directions

- Balance how easy it is for programming and how easy it is for automatic optimization
  - Extract common computation patterns
  - Redesign programming interface to achieve better trade-off
    - Interfaces higher than MapReduce?

Future Directions

- Explore other components other than distributed data-parallel computation systems in large scale internet service systems
  - e.g., automatic caching & prefetching for user-facing web service frameworks

Conclusion

- Pipeline-aware holistic code optimization is promising
  - Project pipeline information to procedural code
  - Add safety rules to ensure correctness
  - I/O driven compiler-like optimization
- Improve performance without sacrificing programmability

- Considering more about how easy it is for optimization when designing programming frameworks

Thanks!
Questions?

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