Correctness in Stream Processing

Challenges and Opportunities

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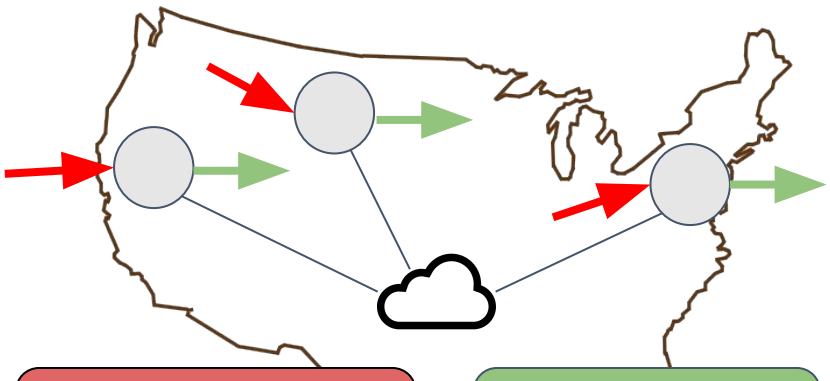
Stream Processing



Streaming Data

Real-Time Decisions

Applications

databricks

aws KINESIS

Materialize

Companies

Spark

Apache Flink

APACHE STORM™

Systems

Stream Processing

Apache Flink

Formal correctness support?

"The nature of debugging is therefore post-mortem. Developers are notified of runtime failures or incorrect outputs after many hours of wasted computing cycles on the cloud."

- [Gulzar et. al, Bigdebug, 2016]
- [Vianna et. al, testing in data stream processing applications, 2019]

Challenges

No unified language standard

- Dataflow graph edges: ordered or unordered?
- Stream partitioning: annotated or inferred?
- Complex features:
  - stateful operators, external services, iterative computation

(Contrast with: traditional relational algebra)

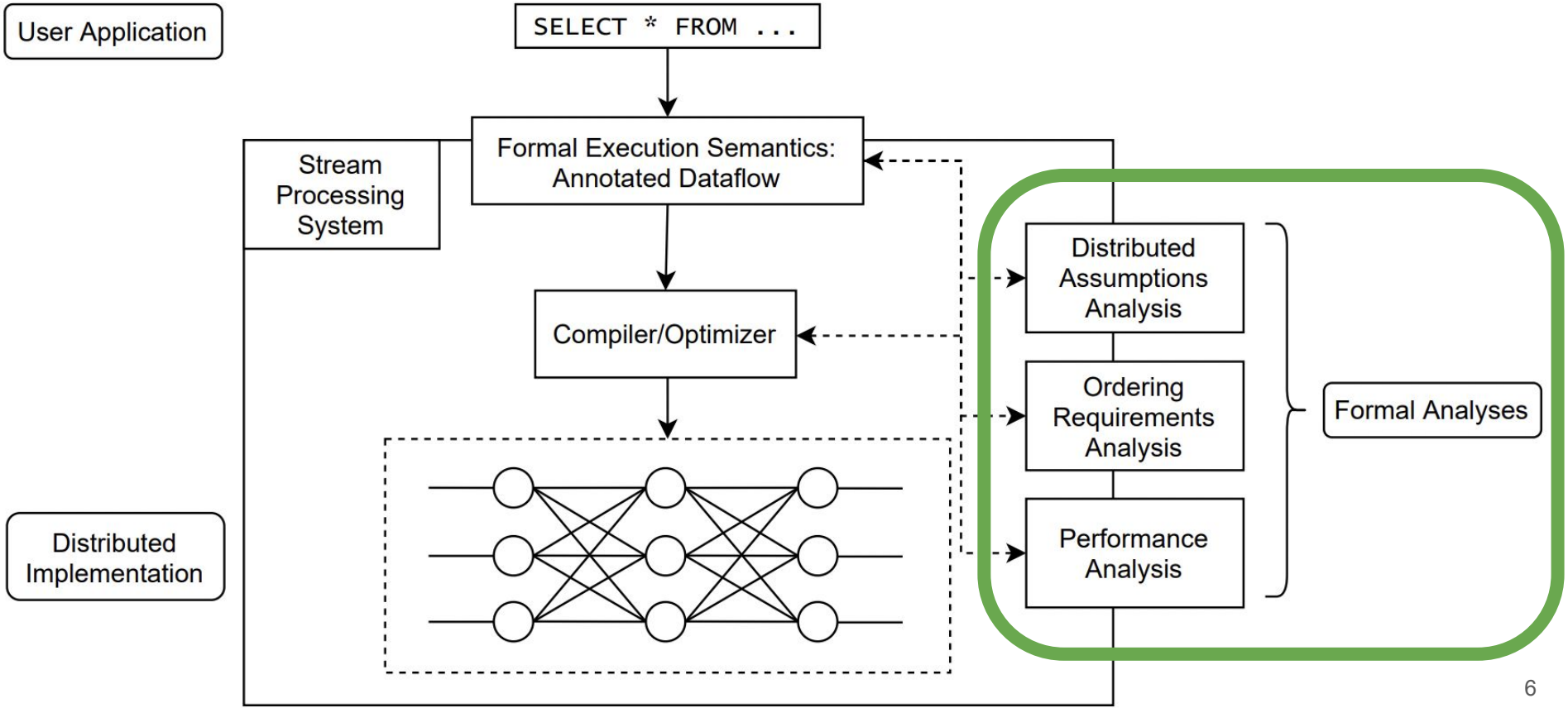
Unified semantics is a precursor to all verification tools

Opportunities

Correctness dimensions common to all systems

1. Order-aware computation
2. Correct distribution (beyond sharding)
3. Performance guarantees
4. Fault tolerance

Vision


User Application
SELECT * FROM ...
Stream Processing System
Formal Execution Semantics: Annotated Dataflow
Compiler/Optimizer
Distributed Implementation
Distributed Assumptions Analysis
Ordering Requirements Analysis
Performance Analysis
Formal Analyses