Chi:A Scalable and Programmable Control Plane for Distributed Stream Processing Systems

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Agenda

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- Background
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- Implementation
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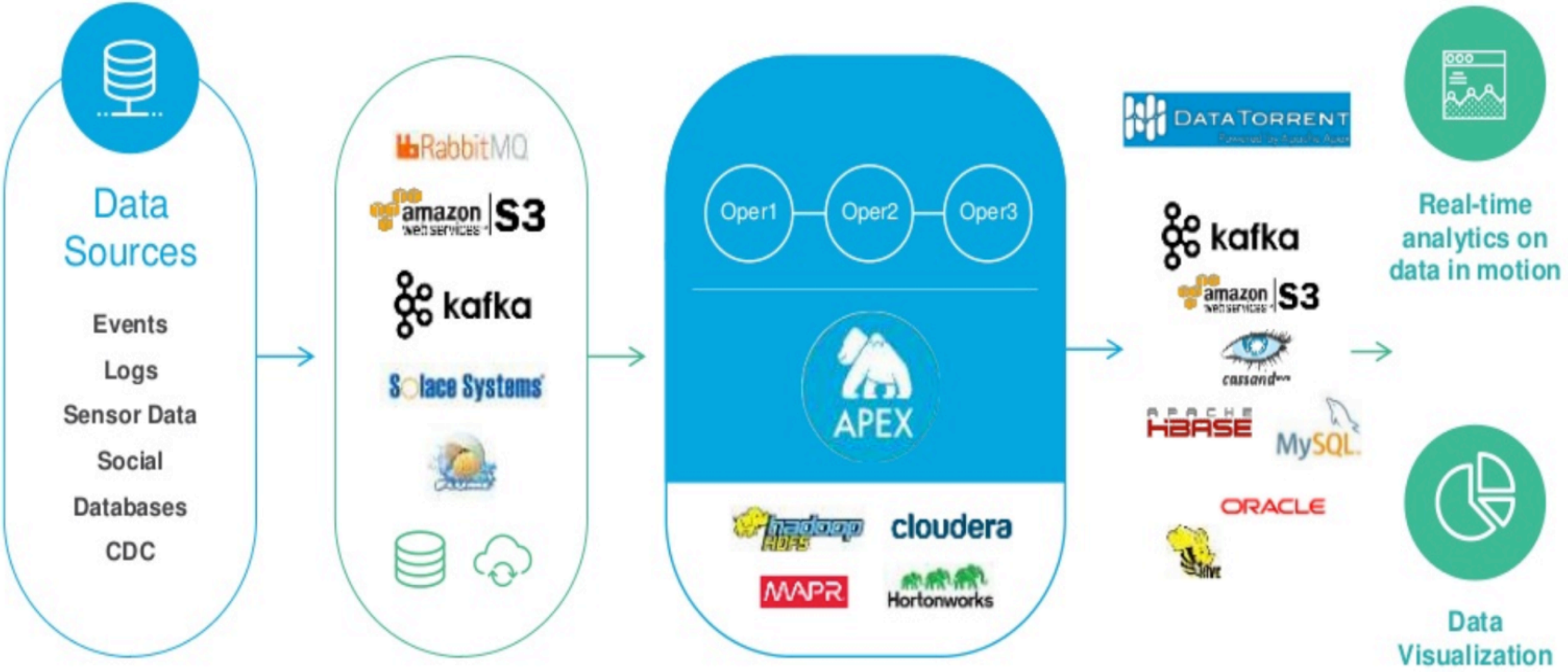
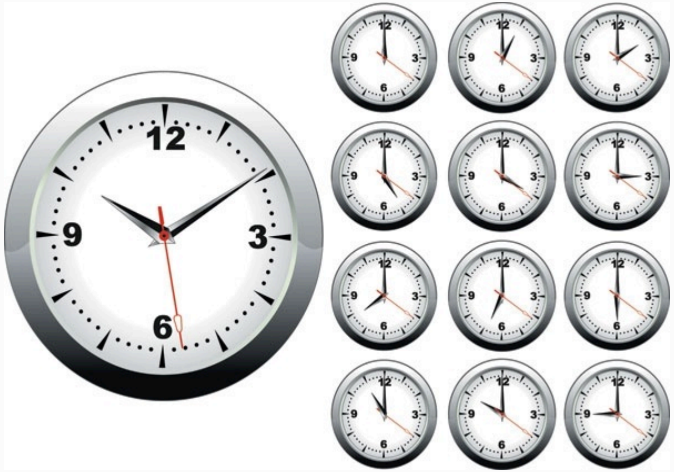
Introduction



Characteristics

Spatial Variability



Temporal Variability

Challenges

- Different Service Level Objectives
- Different expectations
- Usability vs Flexibility

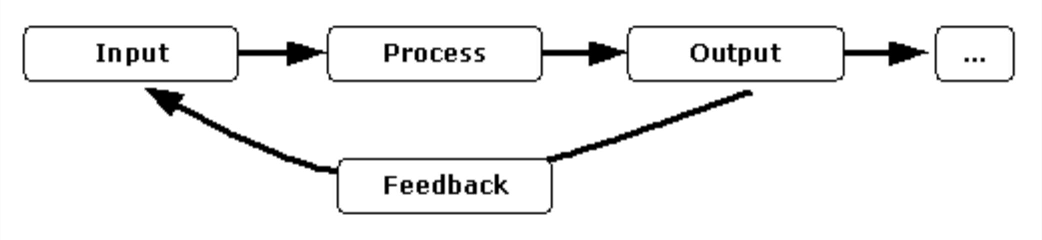
Problem

<u>Meet various objectives</u>

1. Dynamic Scaling
2. Auto – Tuning
3. Data Skew Management

Heron and Flink lack flexibility

How to solve?

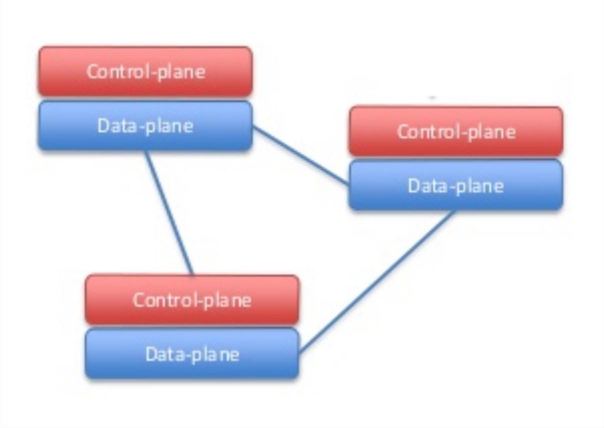


1. Efficient and extensible feedback-loop controls
2. Easy control interface
3. Minimal impact on the process

Background

Control plane: The control plane is the part of a network that carries signalling traffic and is responsible for routing. Functions of the control plane include system configuration and management

Data plane: The data plane is the part of a network that carries user traffic. Data plane traffic travels through routers, rather than to or from them.



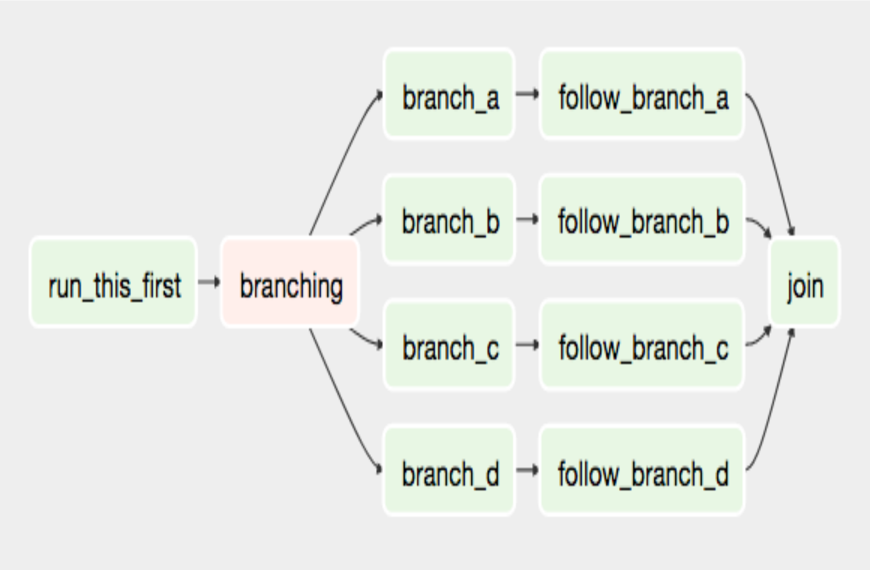
Streaming solutions: Naiad , StreamScope and Apache Flink

Dataflow Computation Model:

A dataflow program is a graph, where nodes represent operations and edges represent data paths.

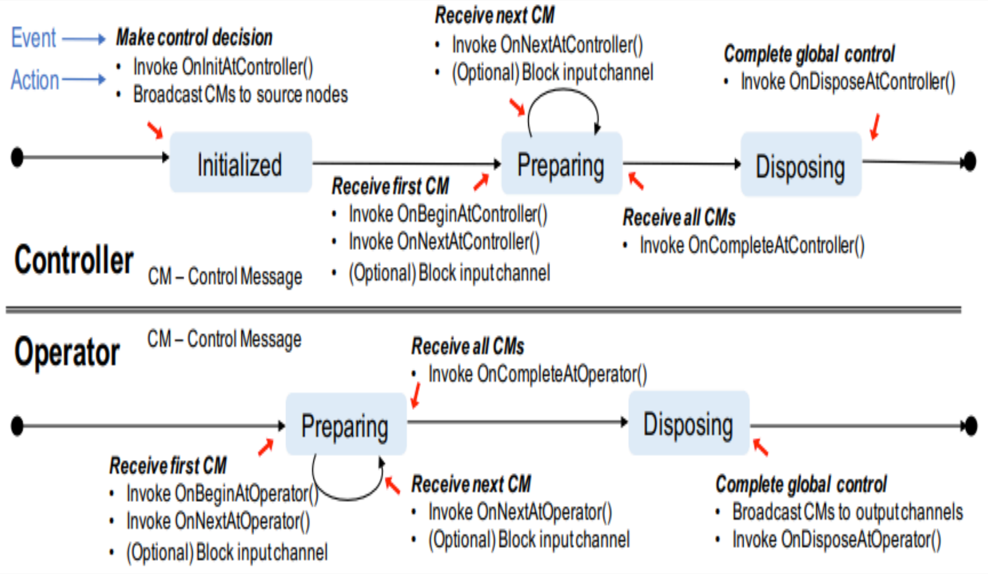
Each node in the graph is represented by triples
(s_v, f_v, p_v)

s_v : states of the vertex
f_v : defines the function which captures computation
p_v : properties associated with the vertex



Design

- Installable controller and operator API
- Define new custom control operations
- Minimum effort



Design

Embedding the control plane into the data plane

- Uses existing efficient data plane infrastructure
- No need of global synchronization
- Facilitate development of various asynchronous control operations

Overview

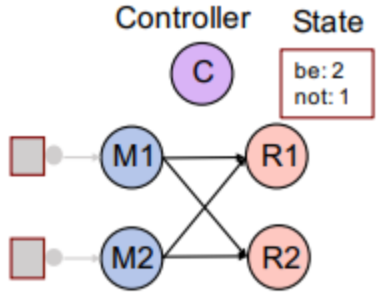
Control Operation: We can consider this as one feedback cycle comprising of a dataflow controller and the dataflow topology

Stages involved

- Control decision and instantiation
- Propagation of control messages along with data
- Control message reaches back to controller for post processing

Example: Word Count

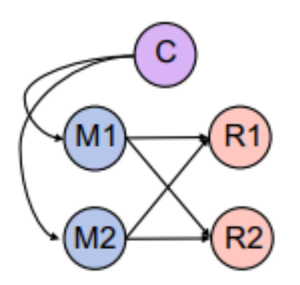
- Two map operators {M1,M2}
- Two reduce operators {R1,R2}
- R1 maintains the counts for all words starting with [‘a’-‘l’], and R2 maintains those for [‘m’-‘z’].
- Controller monitors the memory usage



What happens when we have to scale the service?

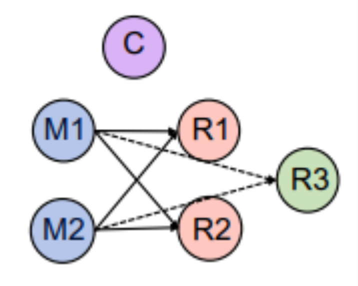
Control Decision and Instantiation

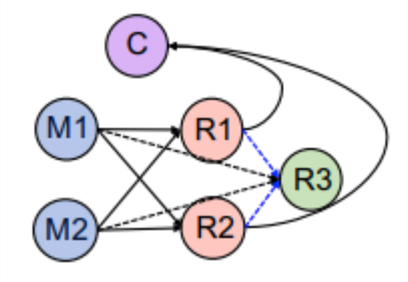
- Controller detects and makes reconfiguration decision
- Start new reducer R3
  - R1 - [‘a’-‘h’]
  - R2 - [‘i’-‘p’]
  - R3 - [‘q’-‘z’]
- Broadcast control message to all source nodes



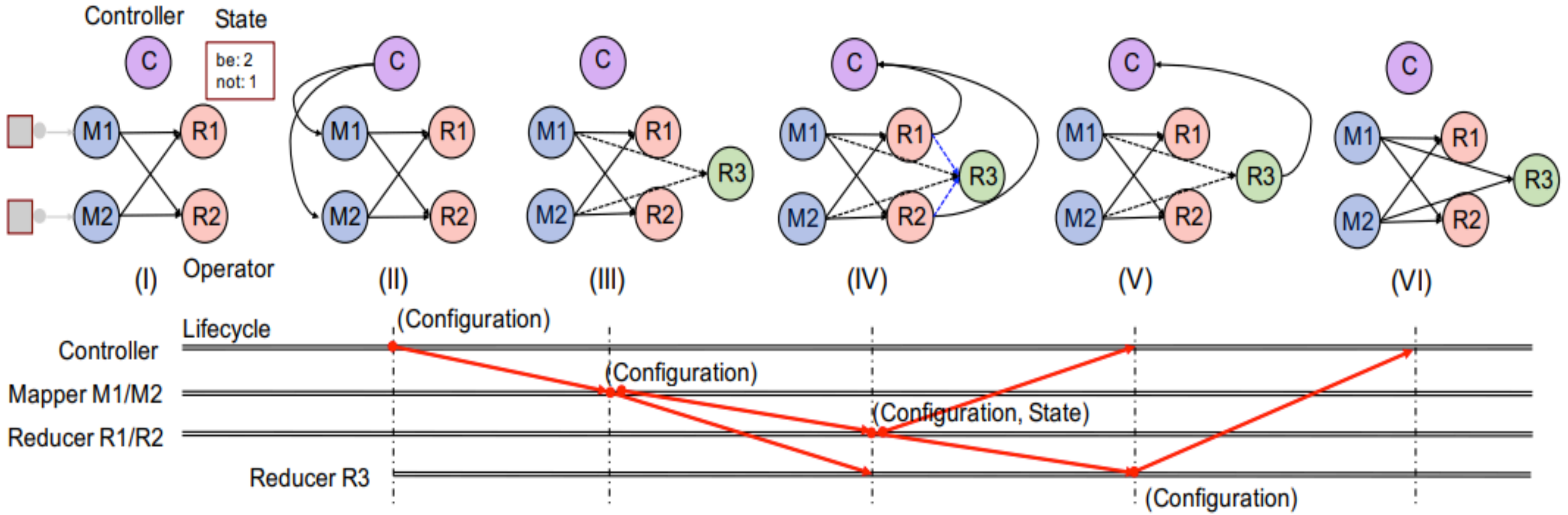
Control message propagation

- M1 and M2 receive and they block input channel and update their routing table.
- R1 and R2 receive and splits data
  - R1 - [‘a’-‘h’] and [‘i’-‘l’]
  - R2 - [‘m’-‘p’] and [‘q’-‘z’]
- Passes the information along with the control message
  - R1 - [‘i’-‘l’]
  - R2 - [‘m’-‘p’]





Control message lifecycle



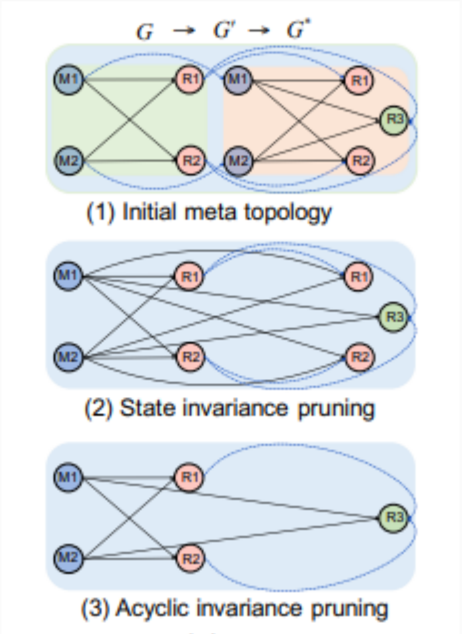
Graph Transition

Introduce a meta topology G`, to complete the transformation asynchronously.

State Invariance : No change in node's state, hence we collapse and merge

Acyclic Invariance: Aggressive merge old and new topology

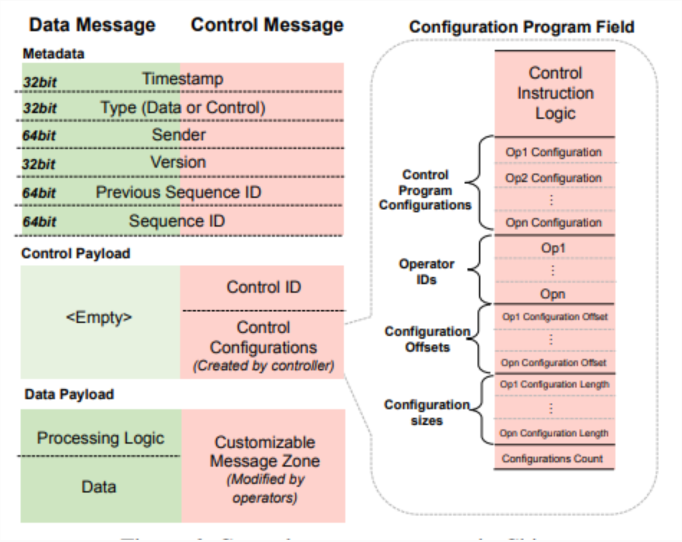
- Check for loops before and after

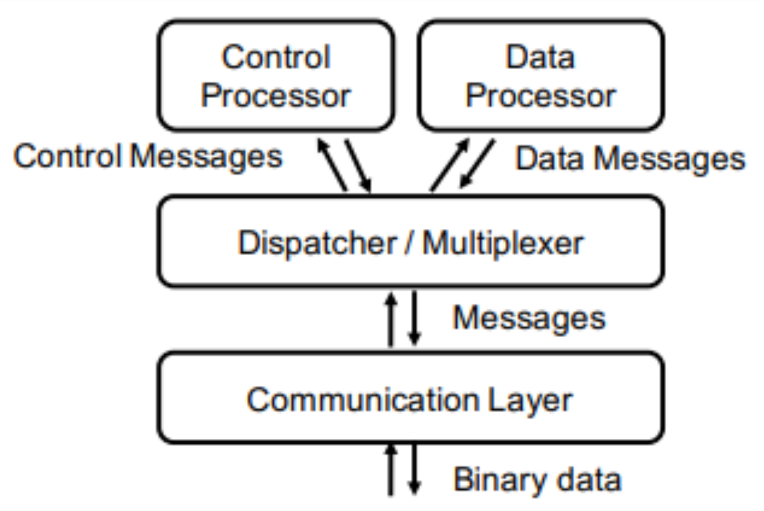


Operating at scale

- Multiple Controllers - concurrently run on multiple controllers at various stages. Also facilitate global controller
- Aggregation (Spanning trees) to avoid bottlenecks at source and sinks
- To deal with deadlocks we have separate queues
- Fault tolerance
  - Retransmission until acknowledgement
  - Timeout and restart mechanism in-case of network failure
  - Checkpoint and replay mechanism for operator and controller failures

Implementation





Evaluation

	Synchronous Global Control Models	Asynchronous Local Control Models	Chi
Consistency	Barrier	None	Barrier / None
Semantic	Simple	Hard	Simple
Latency	High	Low	Low
Overhead	High	Implementation – dependent	Low
Scalability	Implementation – dependent	Implementation – dependent	High

Thank You