Fries: Fast and Consistent Runtime Reconfiguration in Dataflow Systems with Transactional Guarantees

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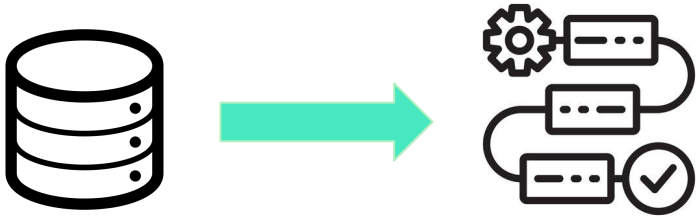
UCIrvine

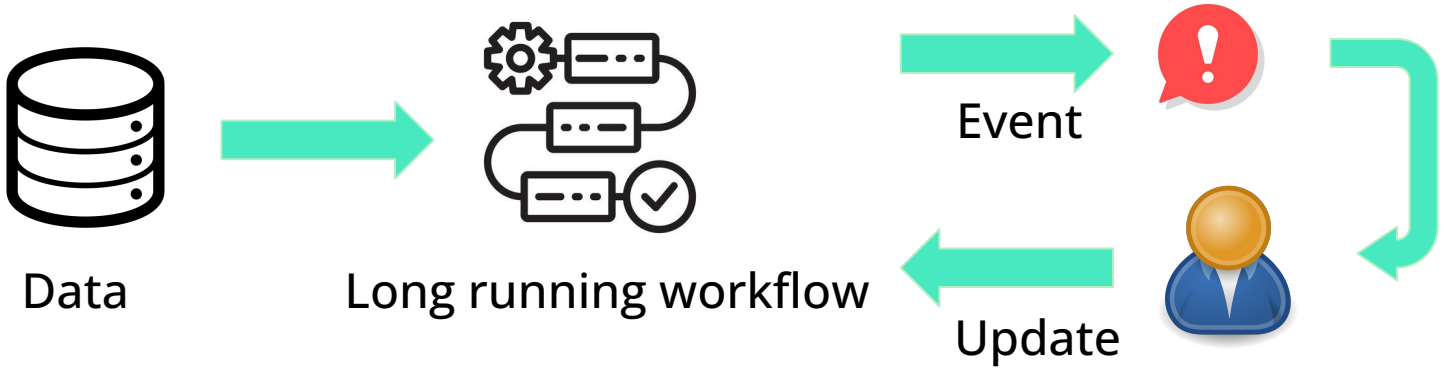
Big Data Workflows



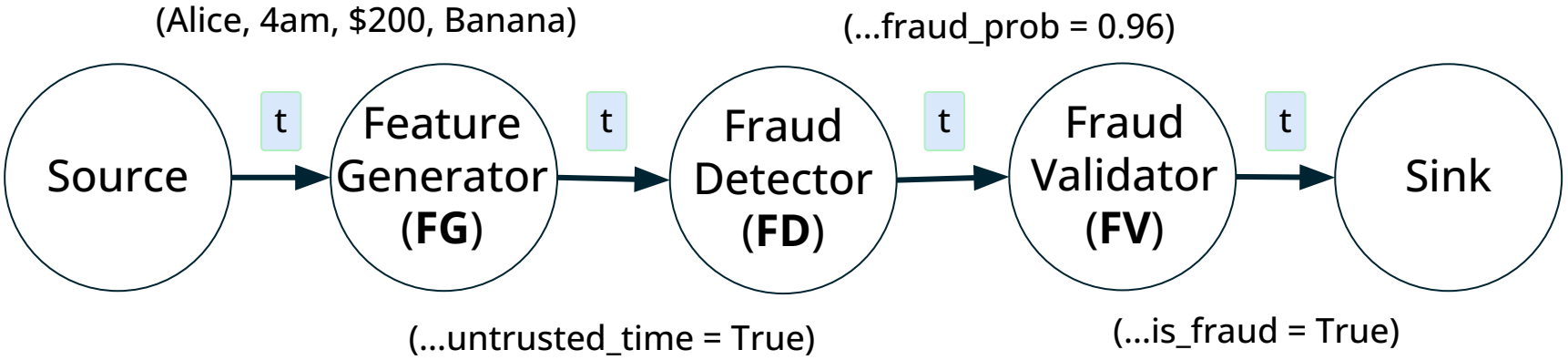
Data

Long running workflow

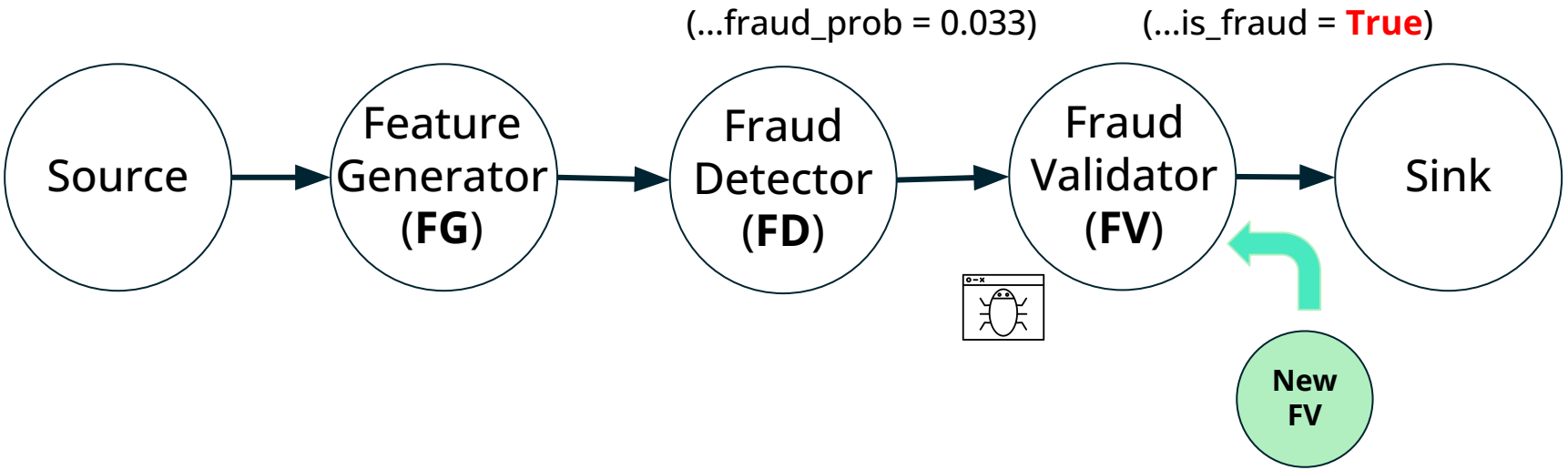
Motivation: Updating Logic in Big Data Workflows



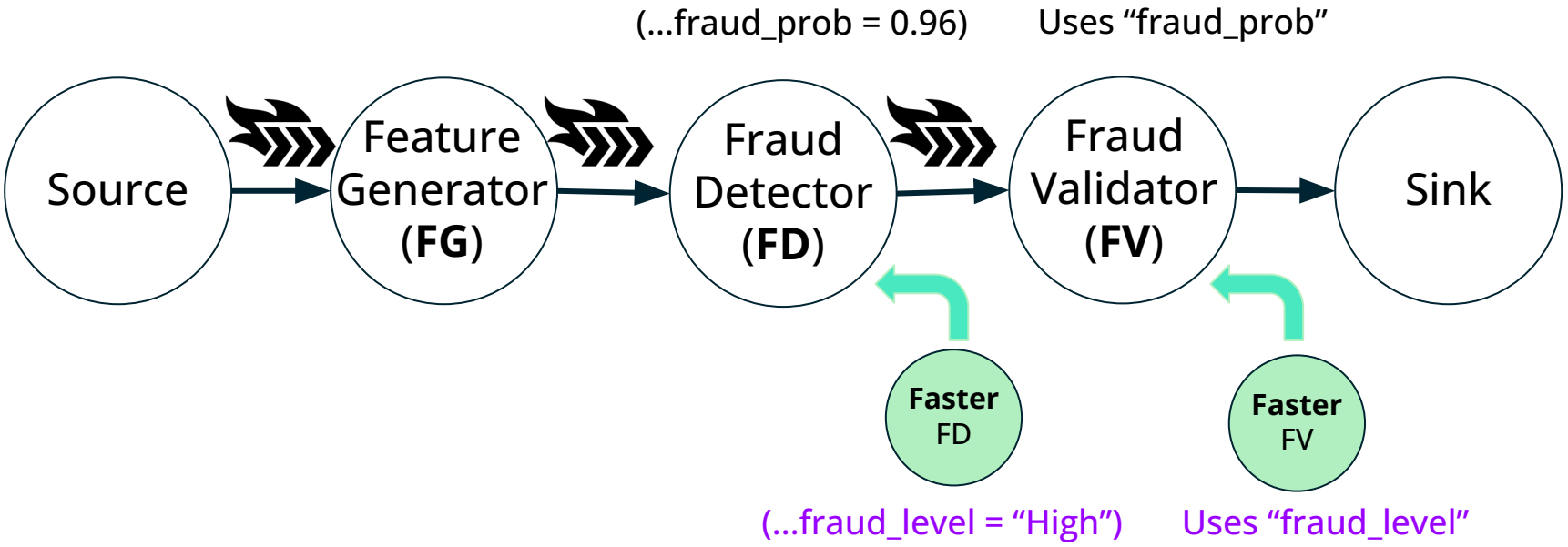
Example Workflow



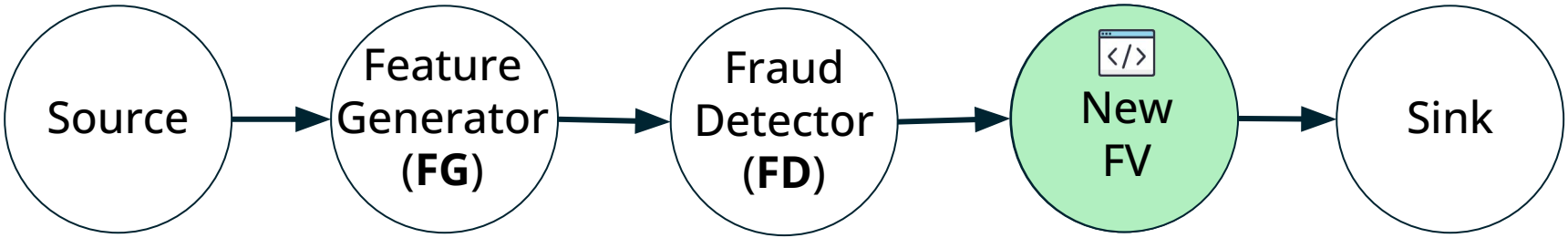
Update Logic Case 1: Fixing runtime bugs



Update Logic Case 2: Mitigating surge of input data



Reconfiguration: Updating operator code



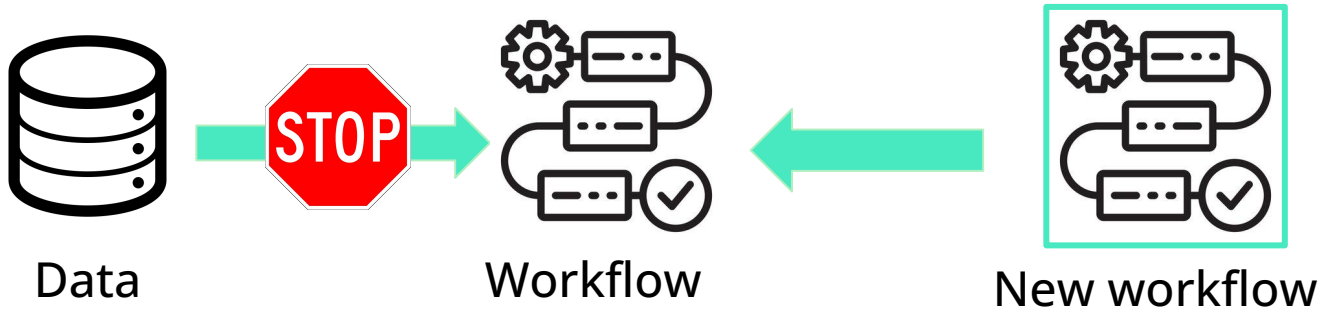
How to do reconfigurations?

Baseline 1: Stop and Restart

Pause Data Ingestion.

Wait for workflow to finish current tuples.

Replace the workflow.



Baseline 1: Stop and Restart

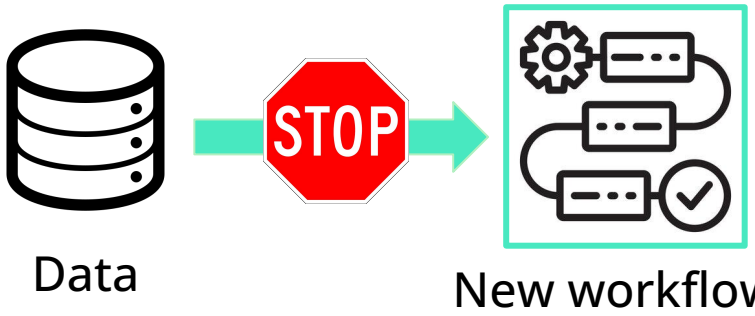
Pause Data Ingestion.

Wait for workflow to finish current tuples.

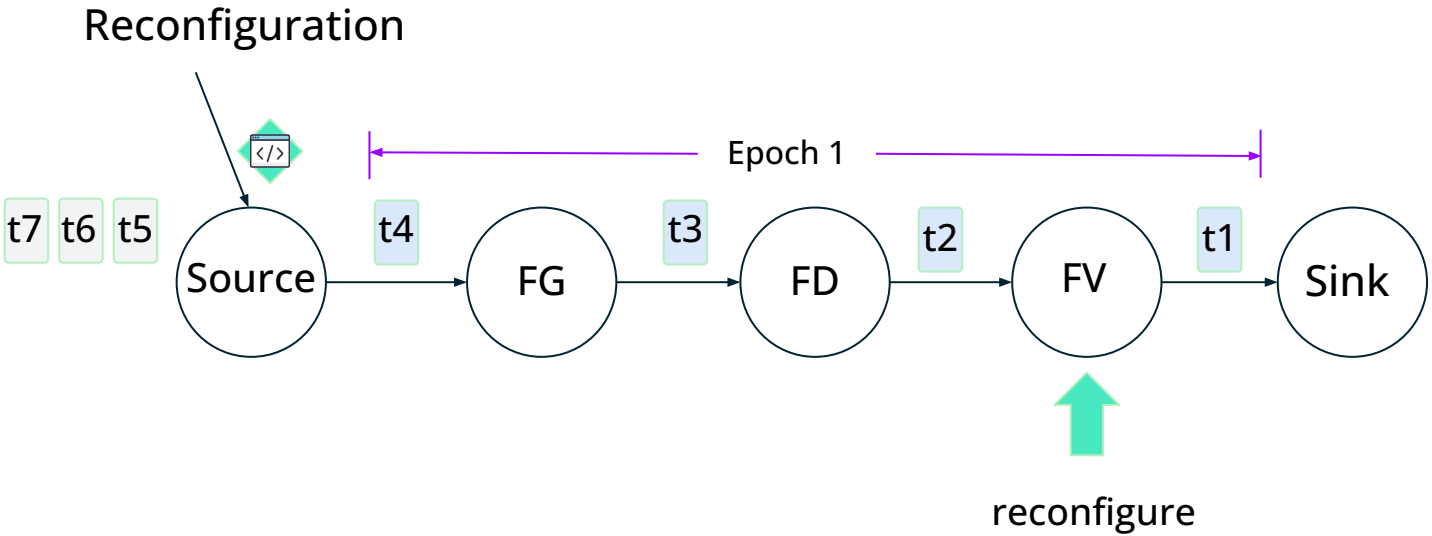
Replace the workflow.

Resume data ingestion.

Disruptive!



Baseline 2: Reconfiguring between epochs



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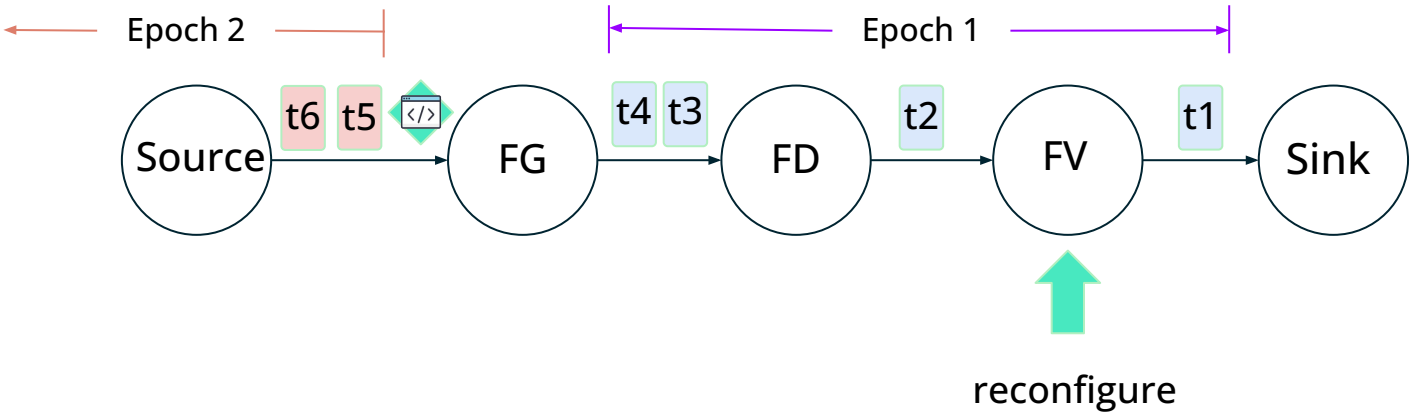

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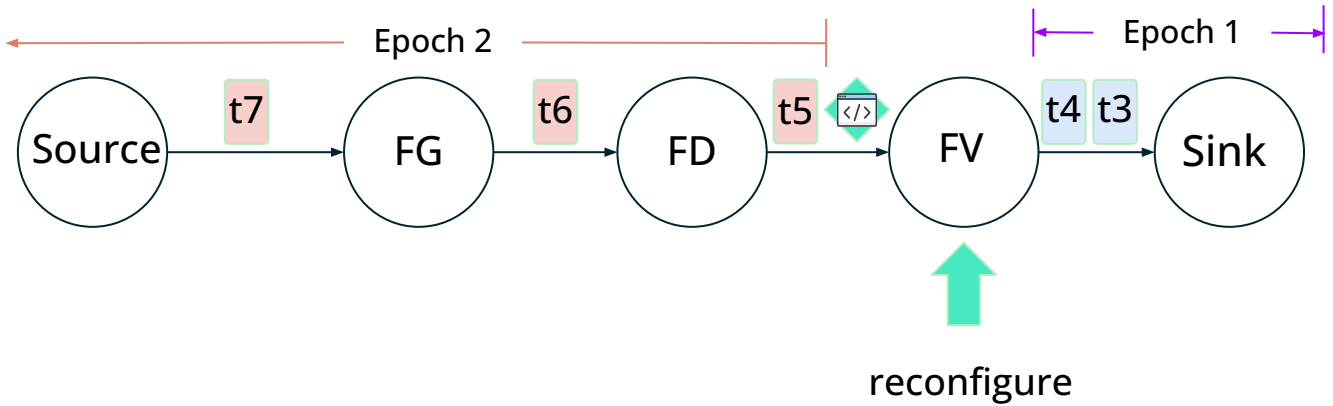

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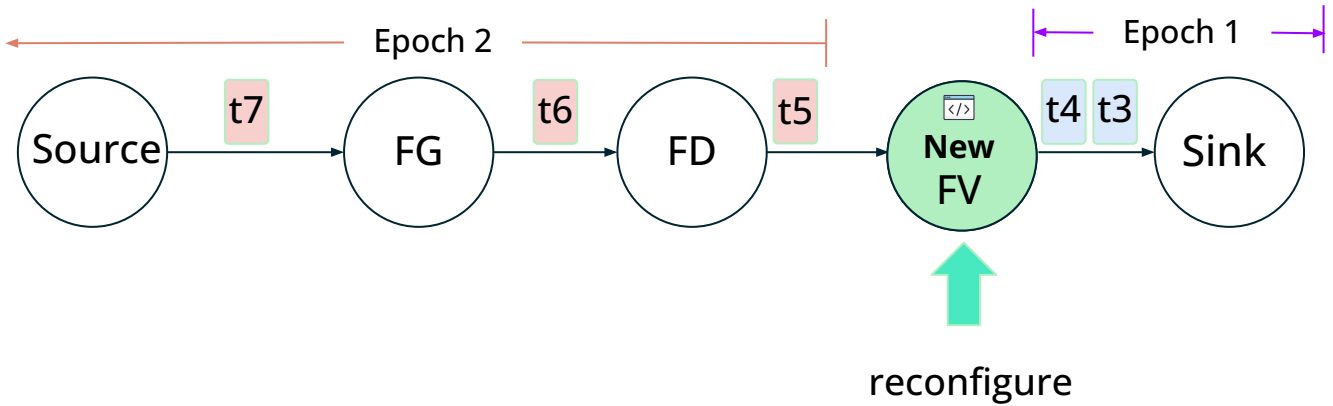
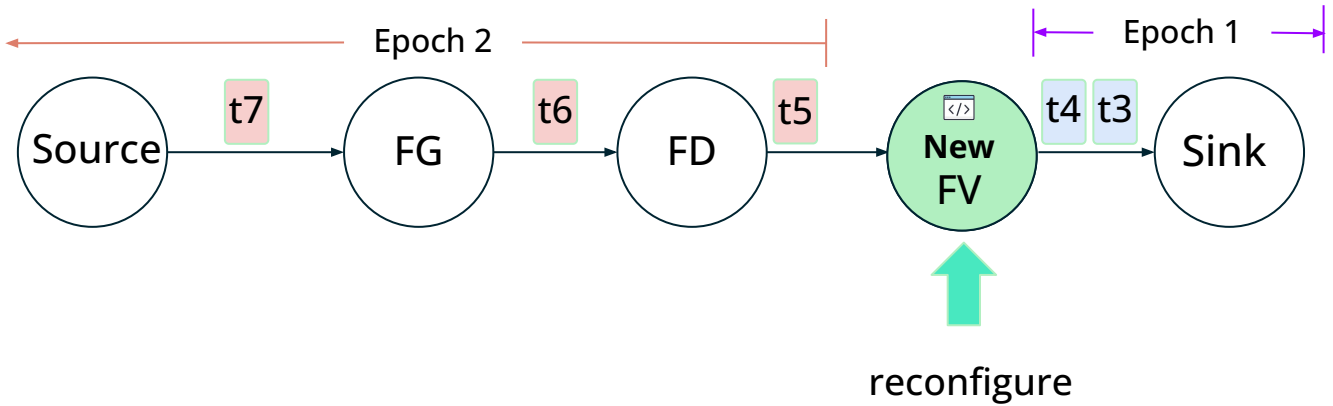


Baseline 2: Reconfiguring between epochs



Wait for processing of **all data in Epoch 1** ***slow!***

Challenges

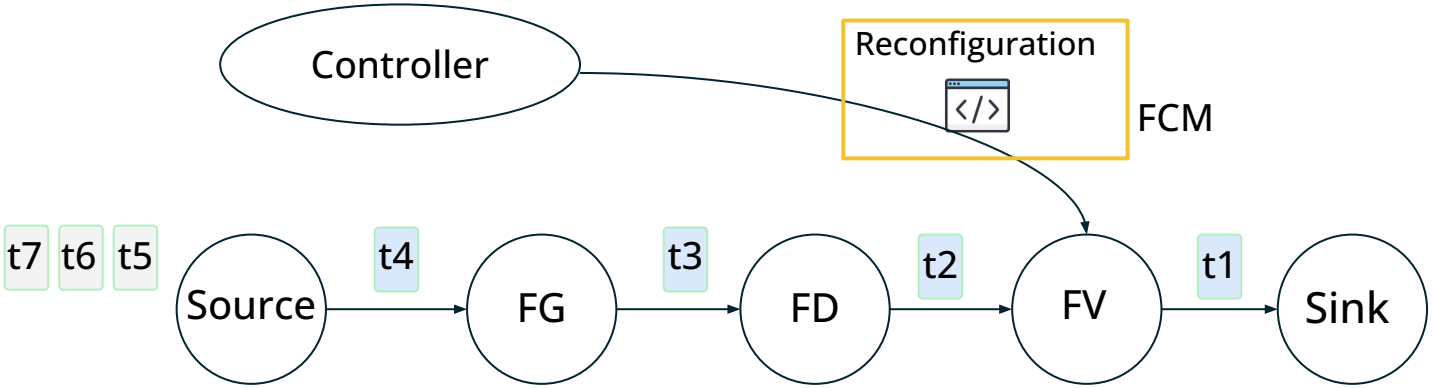
1. How to do it **fast**?
2. How to guarantee **consistency**?

Fries: a technique to answer those questions!

Challenges

1. How to do it **fast**?
2. How to guarantee **consistency**?

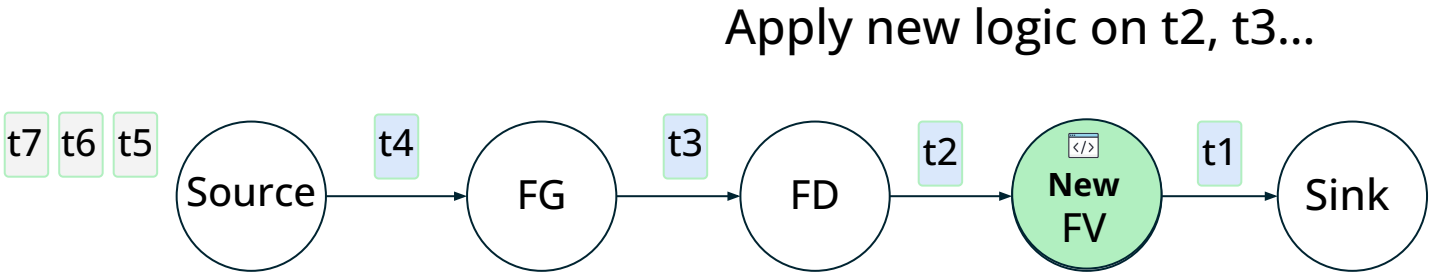
Using Fast Control Message (FCM)



Data does not block FCMs.

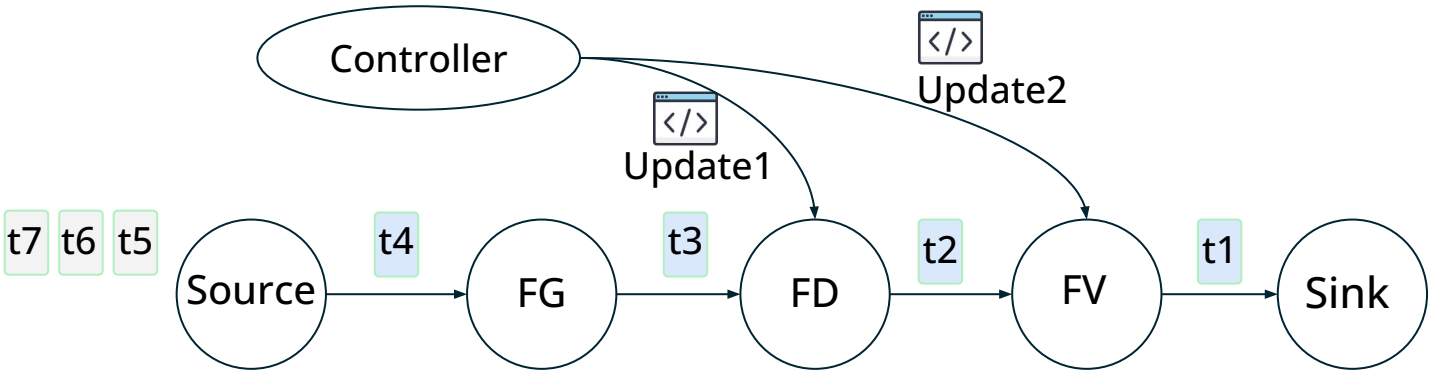
Fast!

Using Fast Control Message (FCM)



For multiple operators?

Using Fast Control Message (FCM)



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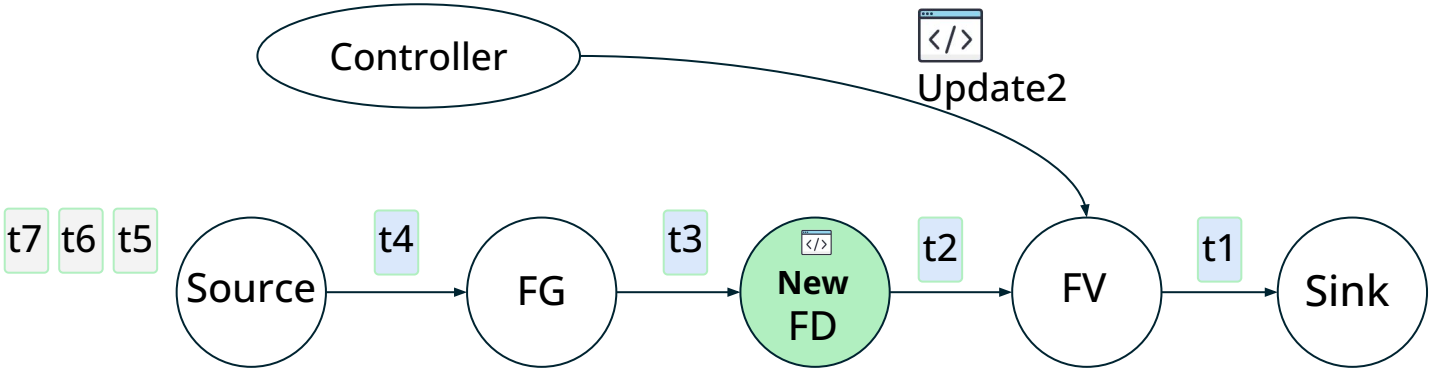

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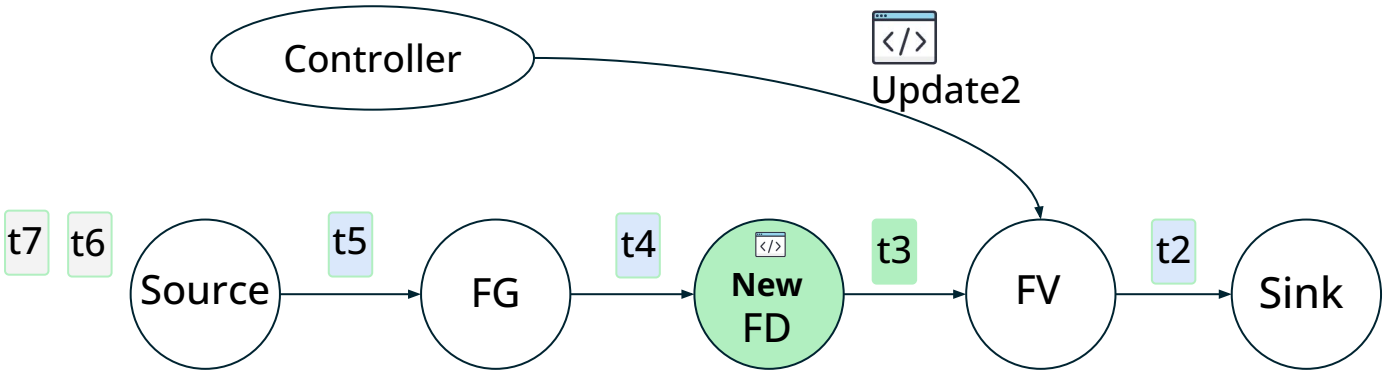
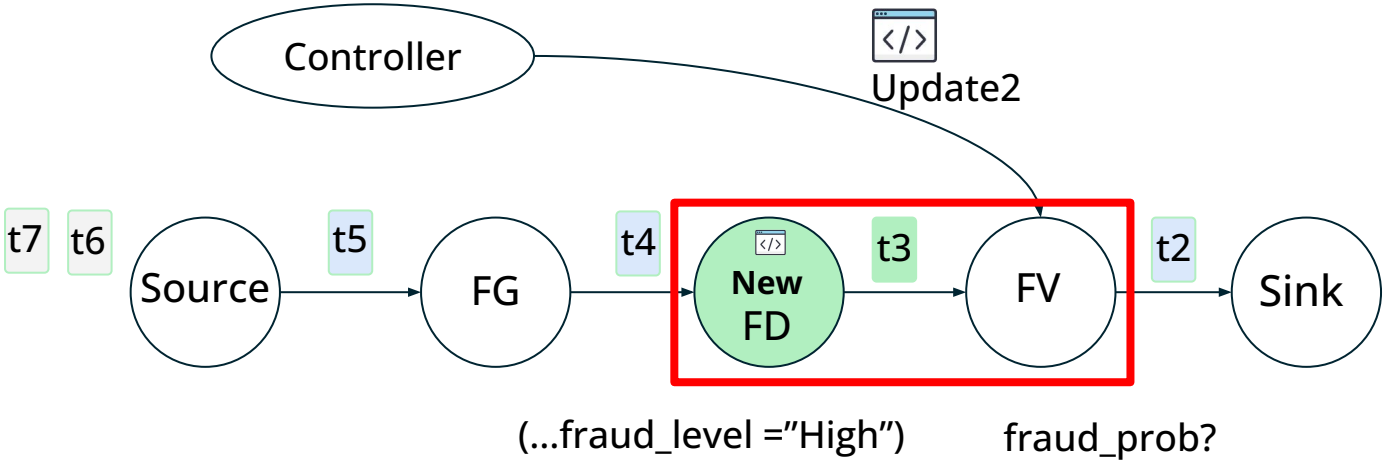


Using Fast Control Message (FCM)



Old FV cannot accept data from new FD.
E.g., schema mismatch.

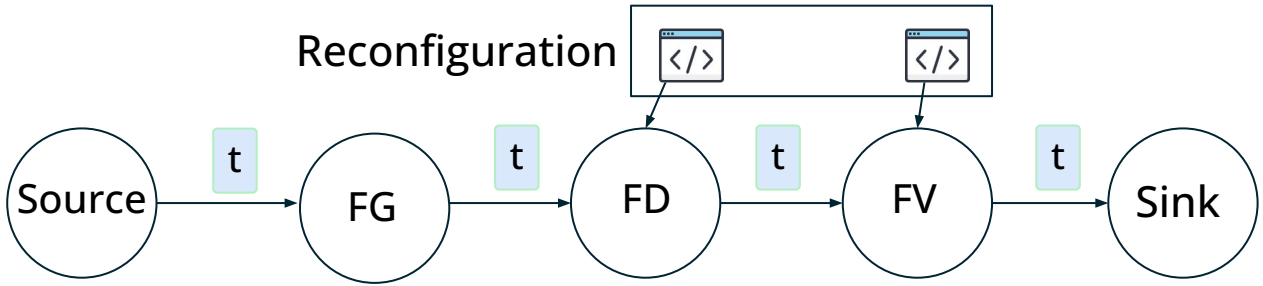
Inconsistent!

Challenges

1. How to do it **fast**?
2. How to guarantee **consistency**?

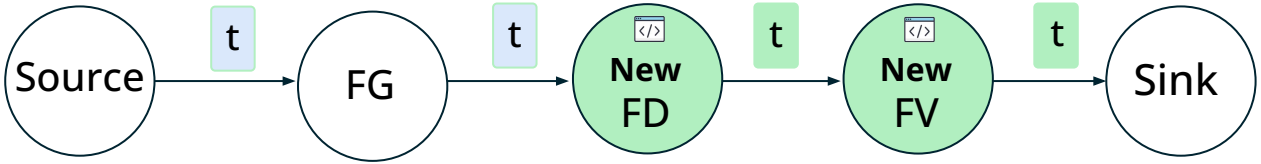
Reconfiguration Consistency

A tuple should be processed by the **same** version.

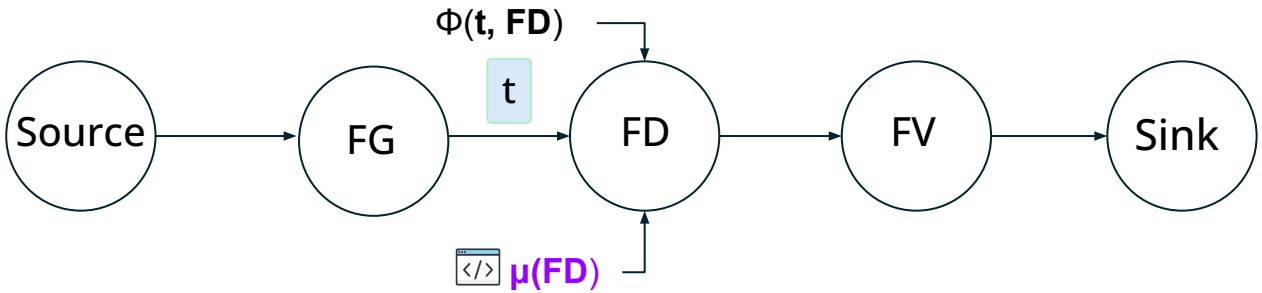


Reconfiguration Consistency

A tuple should be processed by the **same** version.



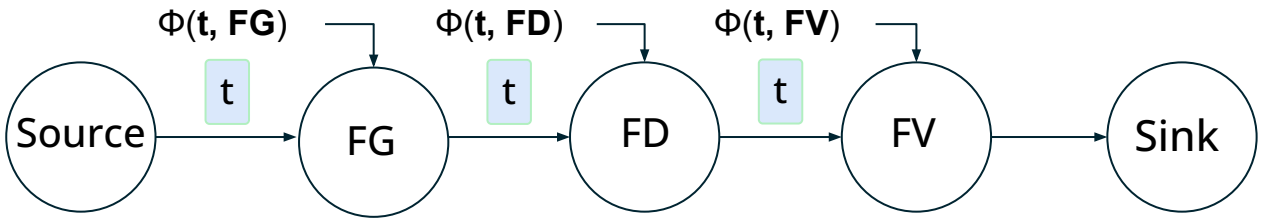
Reconfiguration Consistency



Data operation: Φ(**tuple, operator**)

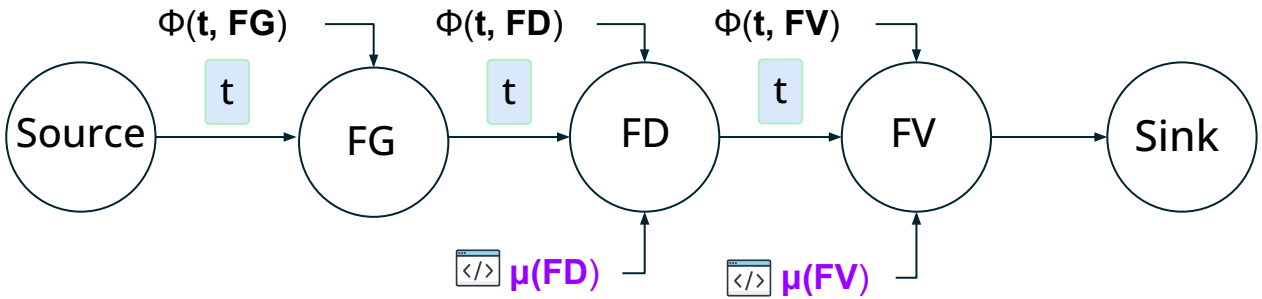
Function-update operation: μ(**operator**)

Reconfiguration Consistency



Data Transaction **T1** = [Φ(t, FG), Φ(t, FD), Φ(t, FV)]

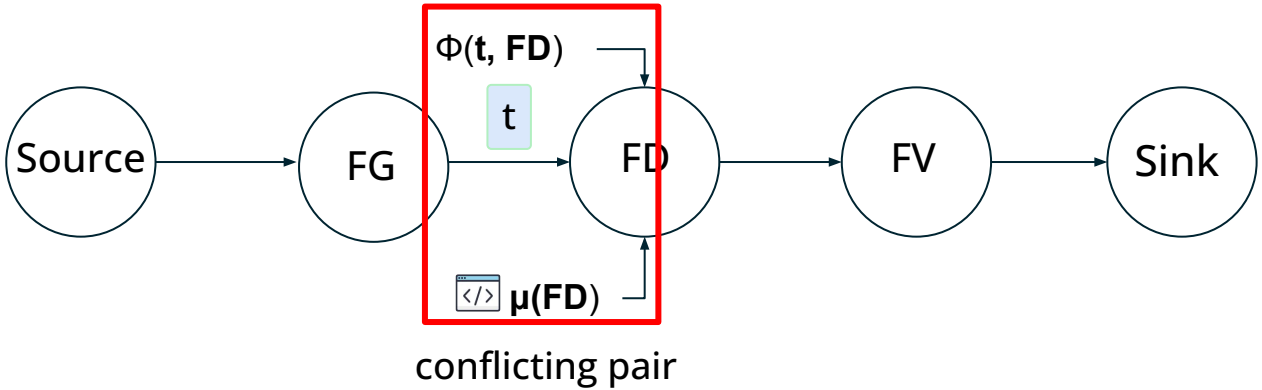
Reconfiguration Consistency



Data Transaction **T1** = [Φ(t, FG), Φ(t, FD), Φ(t, FV)]

Function-update Transaction **T2** = {μ(FD), μ(FV)}

Reconfiguration Consistency

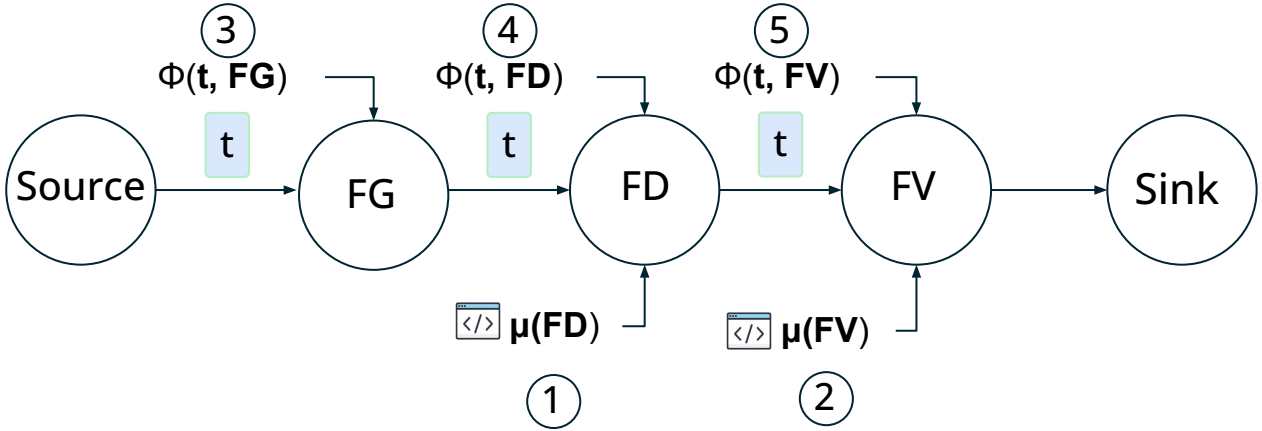


Data Transaction **T1** = [Φ(t, FG), Φ(t, FD), Φ(t, FV)]

Function-update Transaction **T2** = {μ(FD), μ(FV)}

How to resolve conflicts?

Reconfiguration Consistency

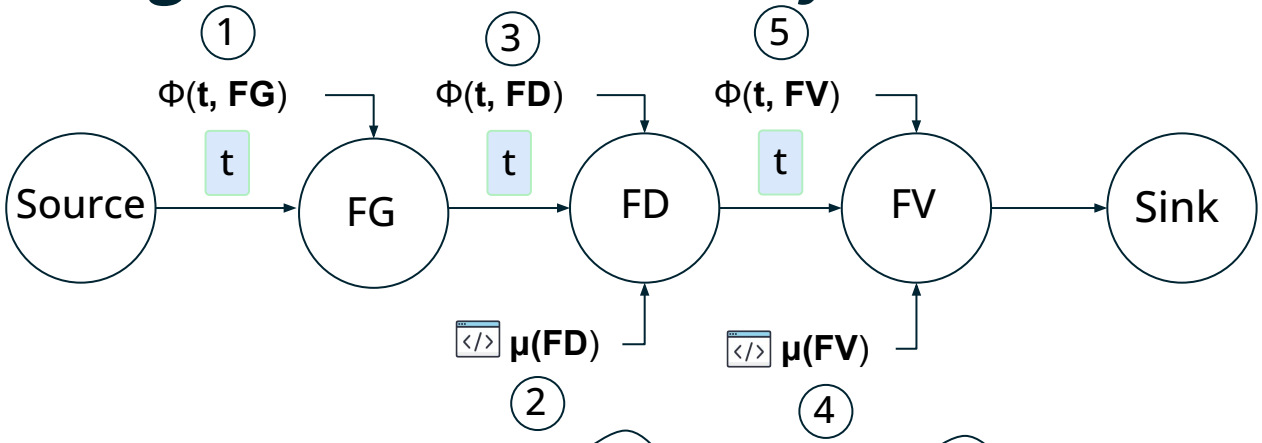


Serial Schedule S1 = [μ(FD) , μ(FV), Φ(t, FG), Φ(t, FD), Φ(t, FV)]

Using new logic

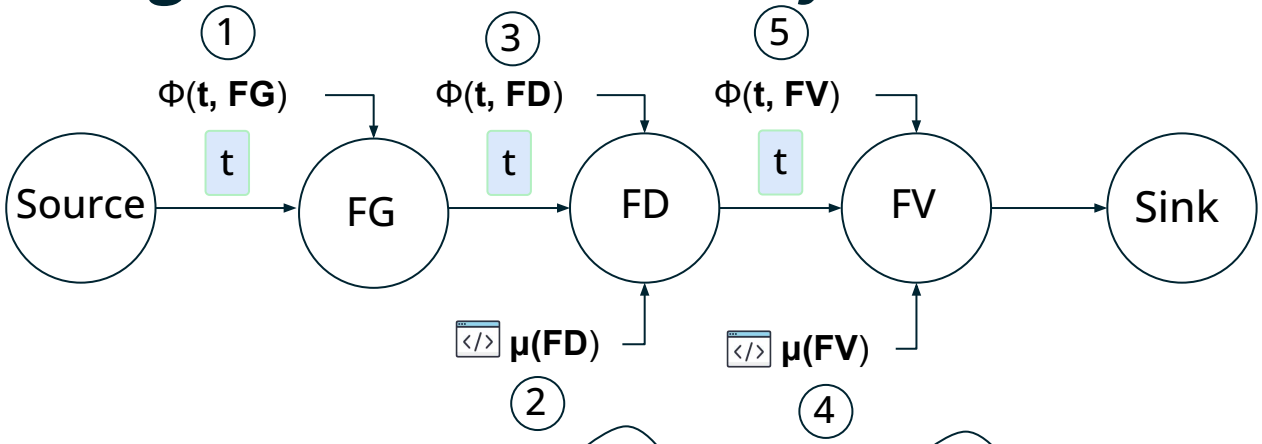
Guarantees same version!

Reconfiguration Consistency



Schedule S2 = [Φ(t, FG), μ(FD), Φ(t, FD), μ(FV), Φ(t, FV)]

Reconfiguration Consistency



Schedule S2 = [Φ(t, FG), μ(FD), Φ(t, FD), μ(FV), Φ(t, FV)]

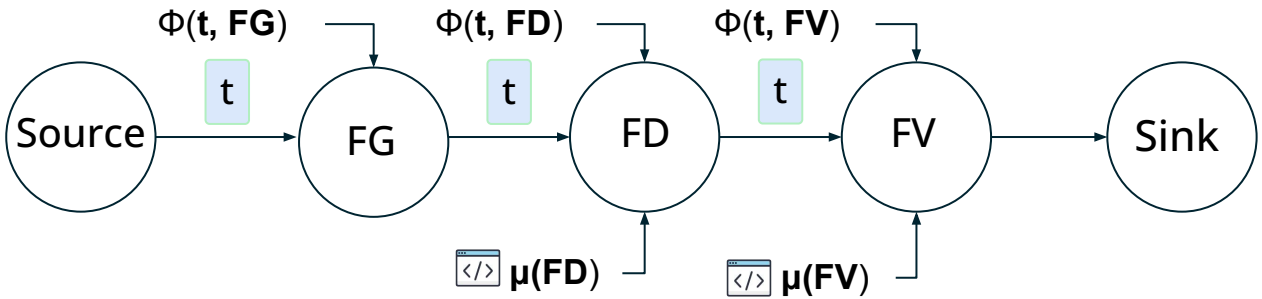
Conflict-Equivalent

Same version!

Serial Schedule S1 = [μ(FD), μ(FV), Φ(t, FG), Φ(t, FD), Φ(t, FV)]

Using new logic

How to generate consistent schedules?



For a schedule S:

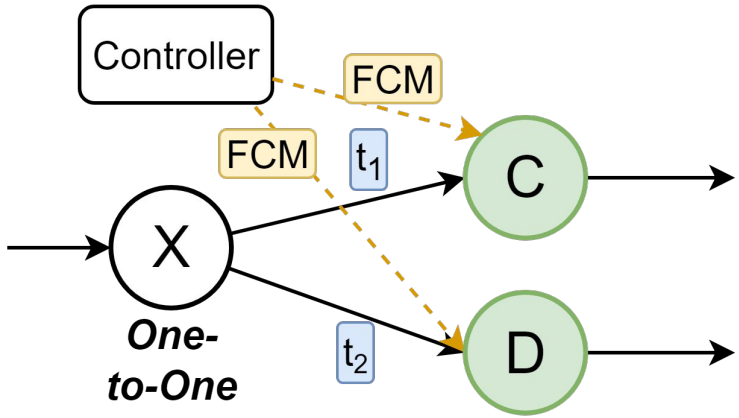
If Φ(t, FD) is before μ(FD),

Then Φ(t, FV) should be before μ(FV).

Requires synchronization!

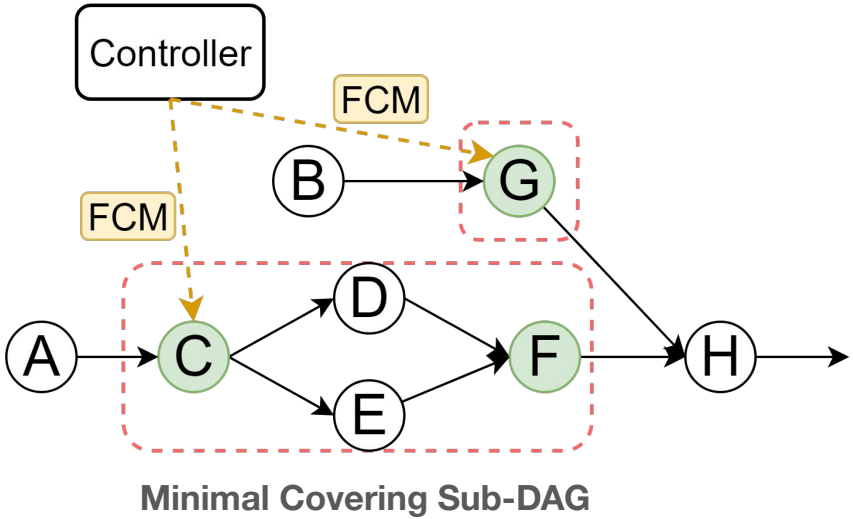
Guarantee Reconfiguration Consistency

Each output tuple goes to **either** C **or** D



No synchronization needed!

Fries Scheduler

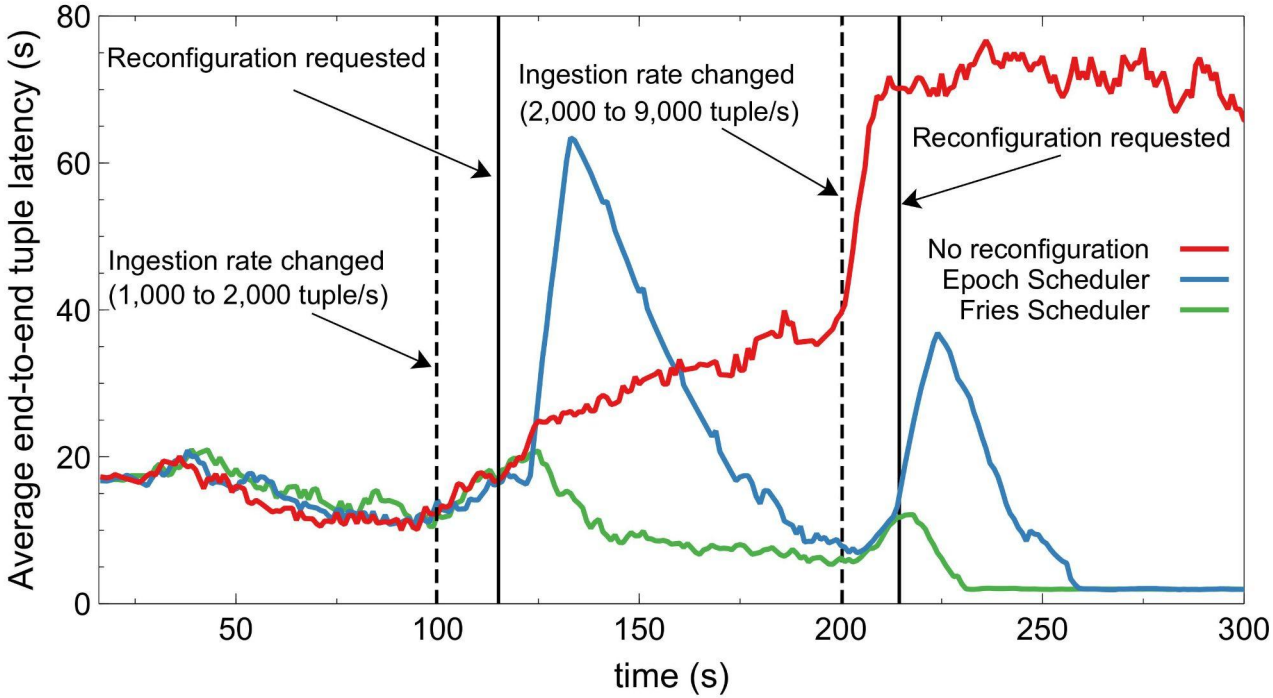


Finding the minimal scope for synchronization!

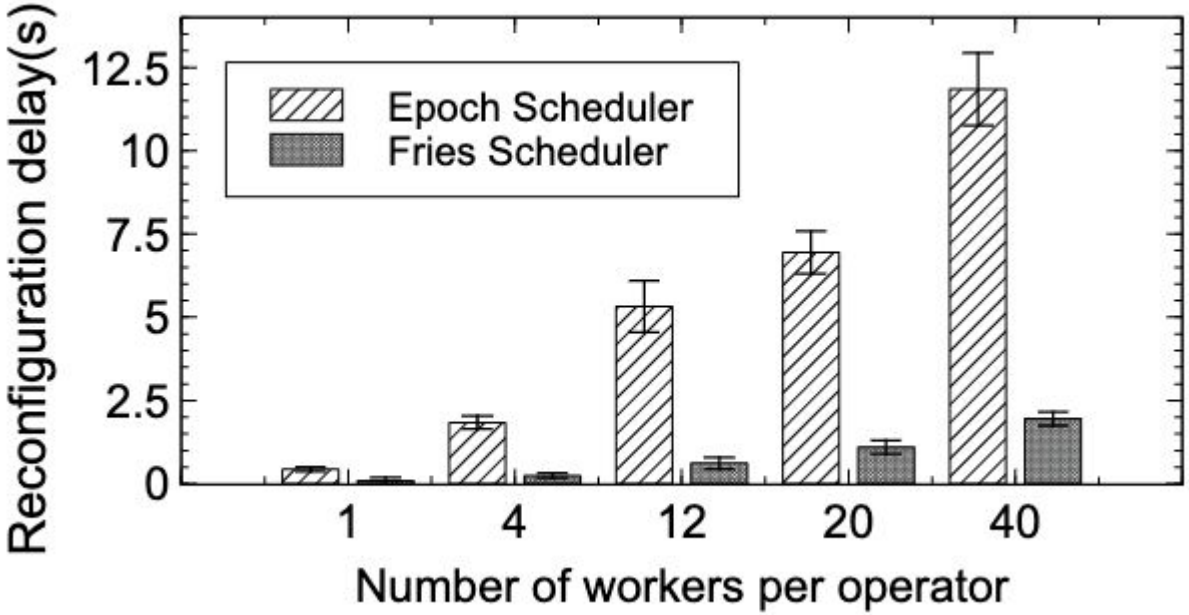
Experiments

1. Implemented on both Flink and Texera.
2. Fraud Detection, TPC-DS workflows.
3. 10 VMs on Google Cloud.

Benefits of Fast Reconfigurations



Scale out


Reconfiguration delay(s)
12.5
10
7.5
5
2.5
0
Epoch Scheduler
Fries Scheduler
1
4
12
20
40
Number of workers per operator

Our contributions

- Formally defined consistency in reconfiguration.
- Fries: Achieved both **Fast** and **Consistent** reconfigurations.
- Parallel execution, One-to-many operator…

Thank you!

Zuozhi Wang

Shengquan Ni

Avinash Kumar

Chen Li

UCI University of California, Irvine

Acknowledgements: We thank Sadeem Alsudais, Yicong Huang and the whole Texera team for their participation in discussions.