Implications of Alternative Serverless Application Control Flow Methods

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https://www.serverlesscomputing.org/wosc7/papers/p3

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Problem

Serverless Application Control Flow (Orchestration)

- **Distributed applications require orchestration**
- **Different methods of orchestration are available**
- **The cost and performance implications of different orchestration patterns are not apparent**

Definitions

- **Amazon Web Services (AWS)**
  - **Lambda - Function-as-a-Service platform**
    - **Allows users to configure the memory allocated to a function affecting performance and cost**
  - **Aurora - Serverless Relational Database**
    - **Implementation based on MySQL 5.6**
  - **S3 - Object storage service**
  - **EC2 - Compute service (e.g. VMs -as-a-service)**
- **Serverless Application Analytics Framework (SAAF)**
  - **Supports profiling workload performance, resource utilization (e.g. CPU, memory, disk, network I/O), and infrastructure**
  - **Developed by UW Tacoma Cloud and Distributed Systems Research Group**

Use Case

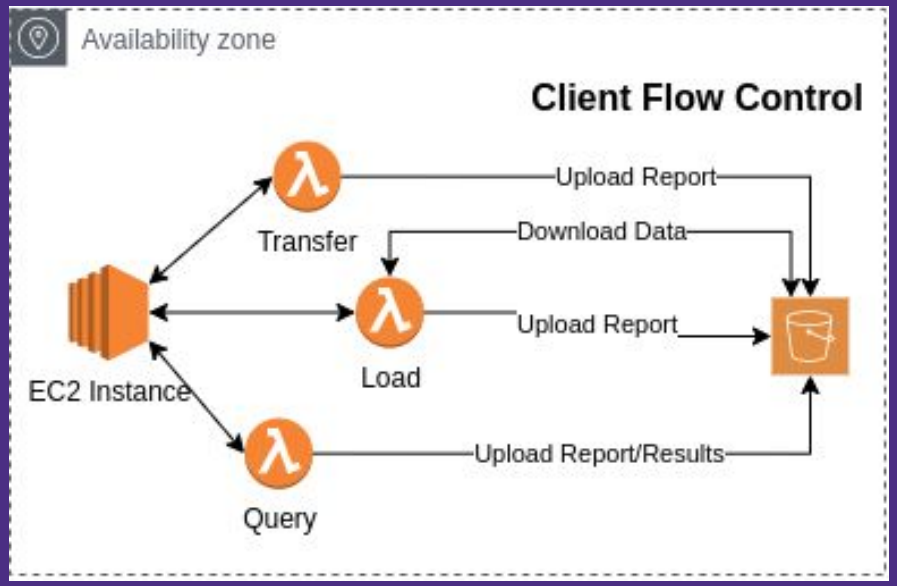
Serverless Data Processing Pipeline

- Transform Load Query
  - Step 1: Transform (T)
    - Downloads CSV file from Amazon S3
    - Removes duplicate rows, adds order processing and gross margin columns
    - Uploads transformation result (new CSV file) to S3
  - Step 2: Load (L)
    - Loads CSV to Amazon Aurora in batches of 1,000 rows
  - Step 3: Query (Q)
    - Performs 5 separate aggregation queries using UNION
    - Saves results to S3
    - Performs SELECT * query

Control Flow Methods

VM-Client

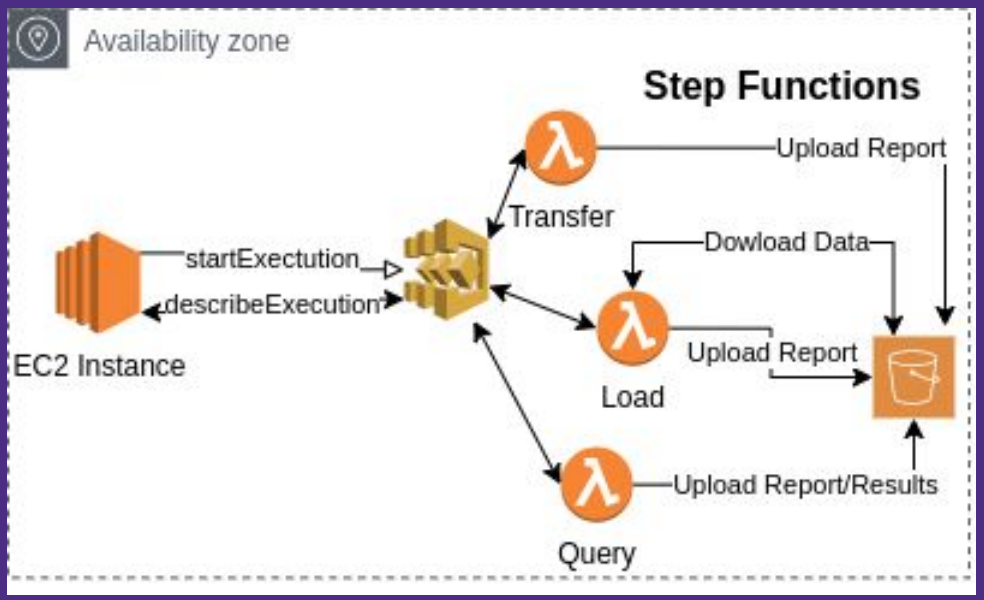
- Orchestrate function calls from client
- Client could be any computer



Control Flow Methods - 2

State-Machine

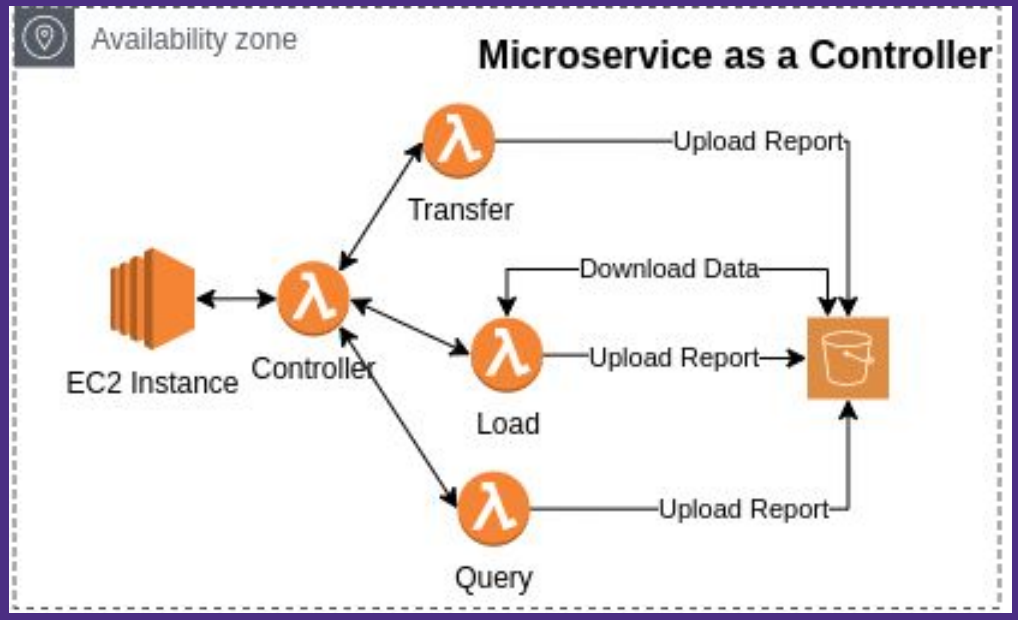
- AWS Step Functions
- AWS manages transitions and data passing
- Billed per transition
- Asynchronous
- Poll for completion



Control Flow Methods - 3

Microservice Controller

- Orchestrate with controller function
- Suffers from "double billing"[1]
- Controller can be run at low memory

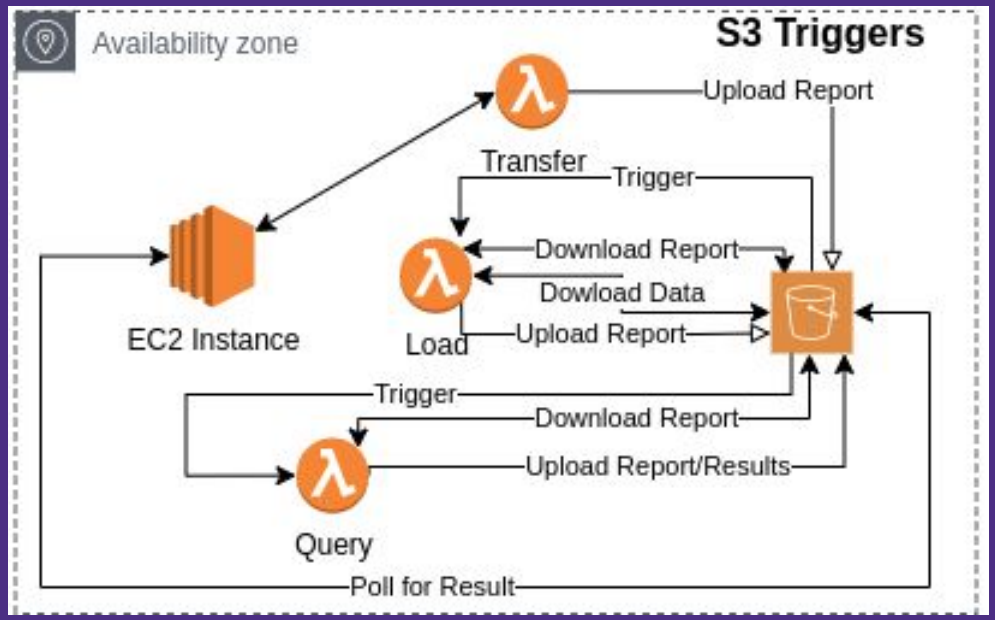


[1]Baldini, I., Cheng, P., Fink, S.J., Mitchell, N., Muthusamy, V., Rabbah, R., Suter, P. and Tardieu, O., The serverless trilemma: Function composition for serverless computing. In *Proceedings of the ACM SIGPLAN International Symposium on New Ideas, New Paradigms, and Reflections on Programming and Software (Onward! 2017)*, Oct 2017, pp. 89-103.

Control Flow Methods - 4

Event-Based-Triggers

- Initial function triggered by client
- S3 Event triggers next step
- Asynchronous
- Poll for completion



Metrics

- **Function runtime: Sum of runtime of T, L, and Q functions collected by SAAF**
- **Pipeline runtime: Elapsed time from the start of T, to the end of Q**
- **Latency: pipeline runtime - function runtime**
  - **captures transition time of T → L, and L →Q**

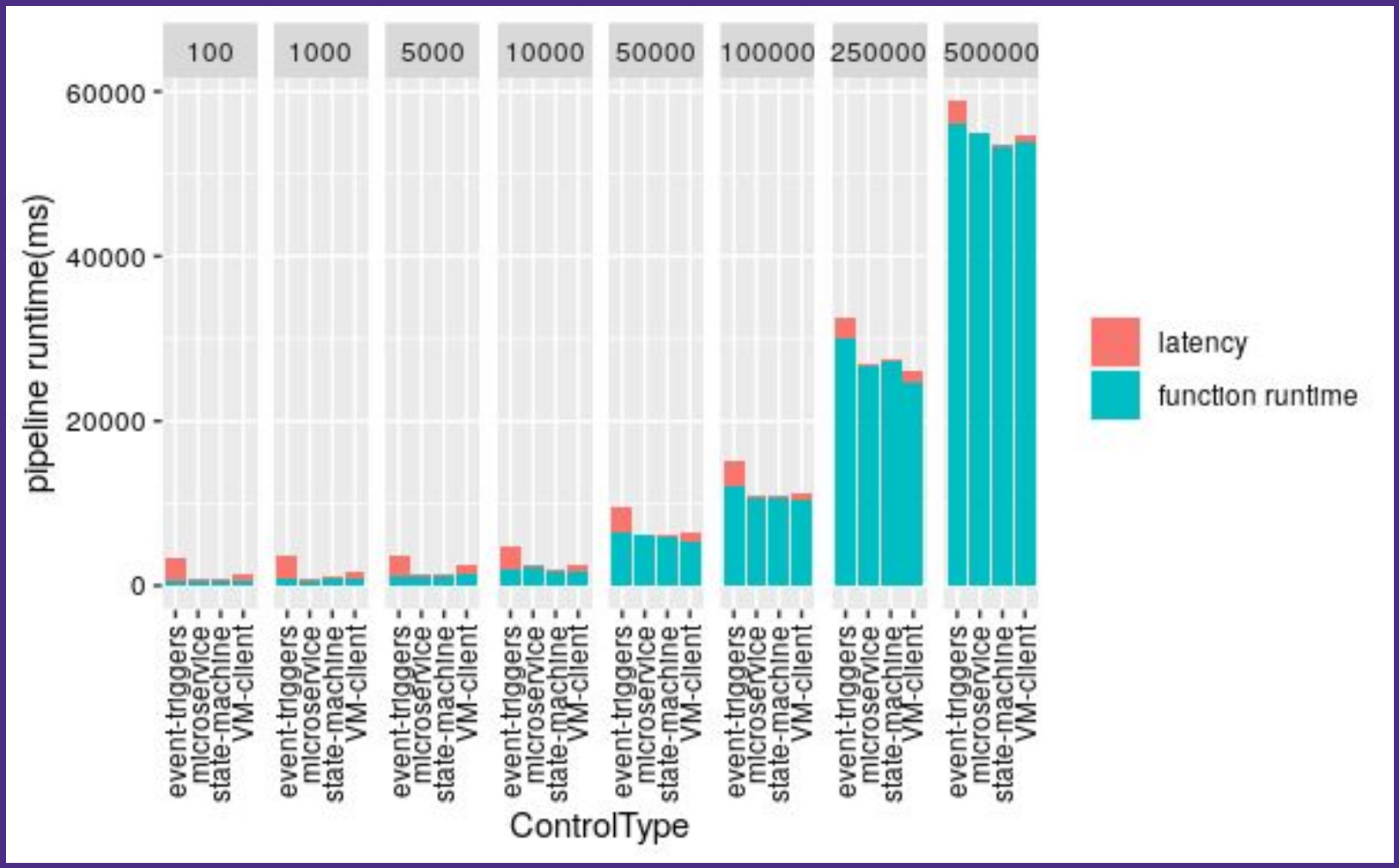
Performance Implications

Experiment: 10 runs of the TLQ pipeline using each control flow method, for 100, 1,000, 5,000, 10,000, 50000, 100,000, and 500,000 row datasets

Considerations:

- Event-Based-Triggers incurs additional function runtime to retrieve previous function output JSON
- Event-Based-Triggers and State-Machines are asynchronous
- Microservice Controller and VM-Client are synchronous

RQ-1: Performance Implications

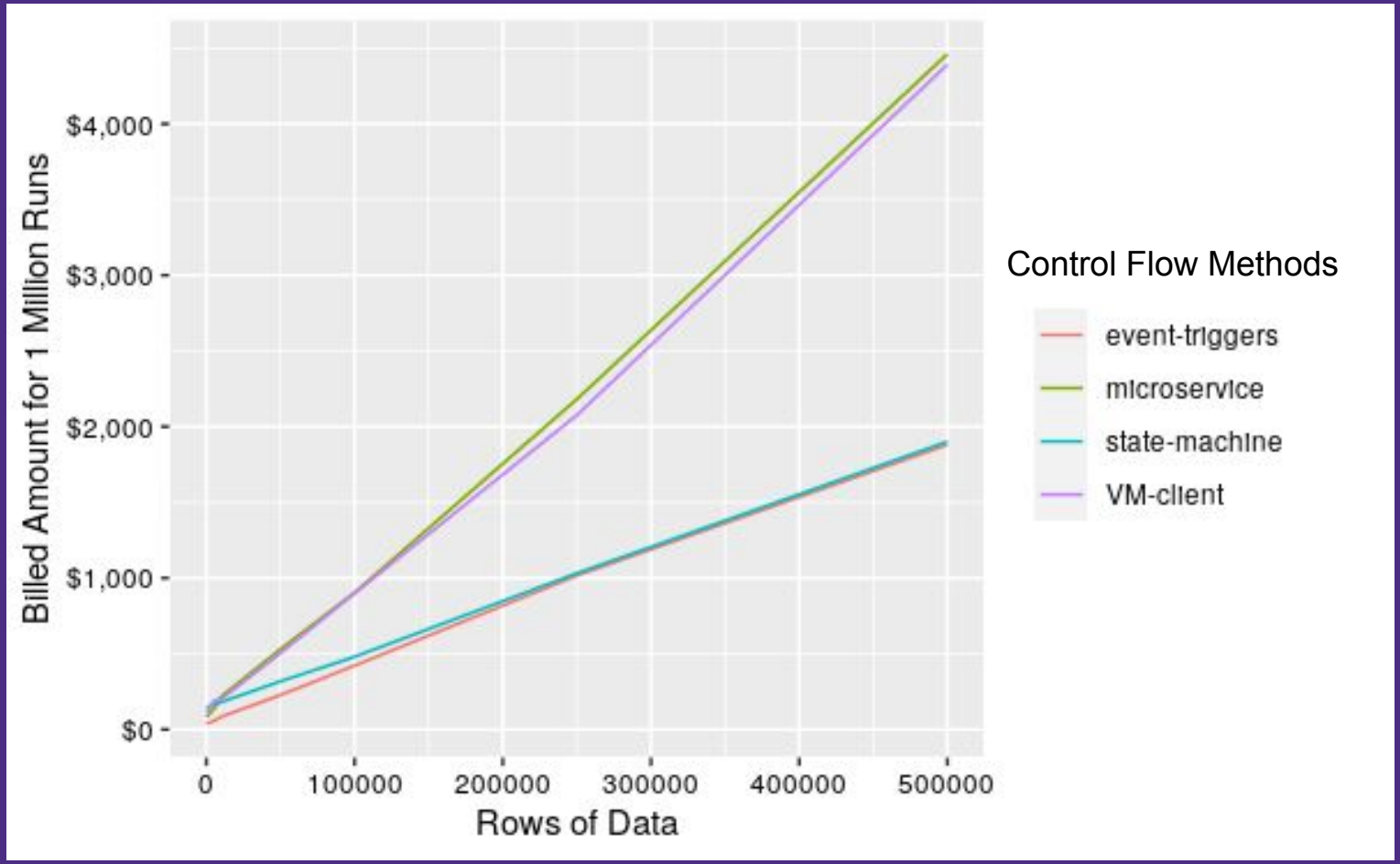


Cost Implications

Considerations:

- **Additional runtime for Event-Based-Triggers results in additional cost**
- **Asynchronous methods (Event-Based-Triggers and State-Machines) have constant transition cost**
- **Synchronous methods (Microservice Controller and VM-Client) transition cost scales with pipeline runtime**

RQ-2: Overall Cost Comparison



Best Control Flow Method ?

Step Functions
The best combination of developer experience, performance, and price

Event Based
Performance and development penalties

Client
Client control flow appropriate for smaller use cases

Microservice controller
Serverless synchronous control flow is expensive

Questions?