Databases and Serverless are Made for Each Other

Qian Li
Peter Kraft
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DBOS

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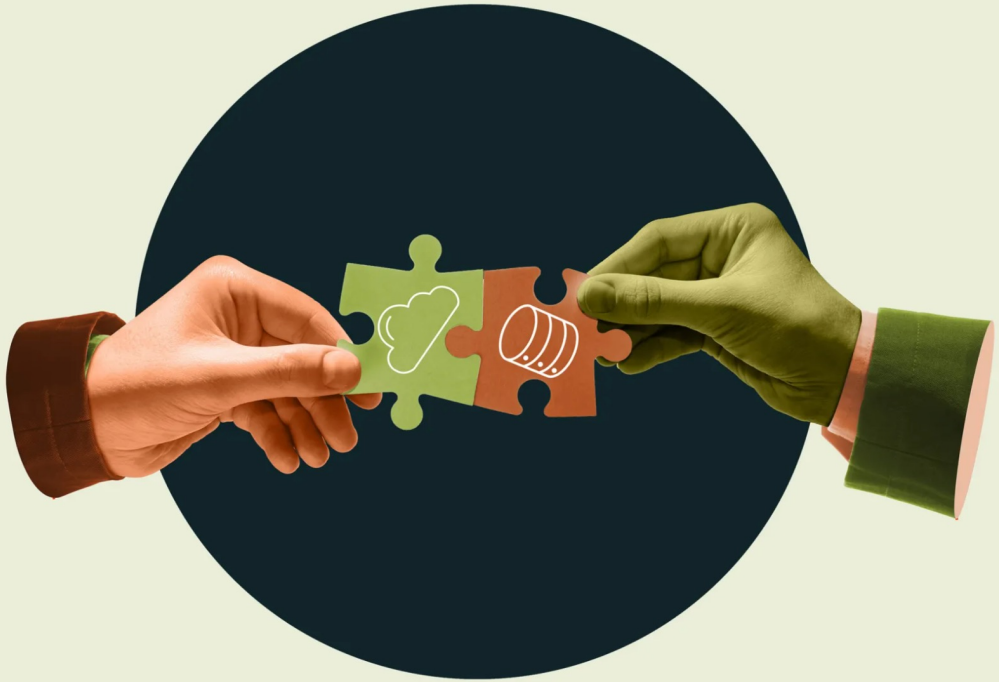

Practice Nov 20 2024

Transactions and Serverless are Made for Each Other

Serverless cloud platforms should be used to deploy stateful applications.

Qian Li and Peter Kraft

Architecture and Hardware

Feedback

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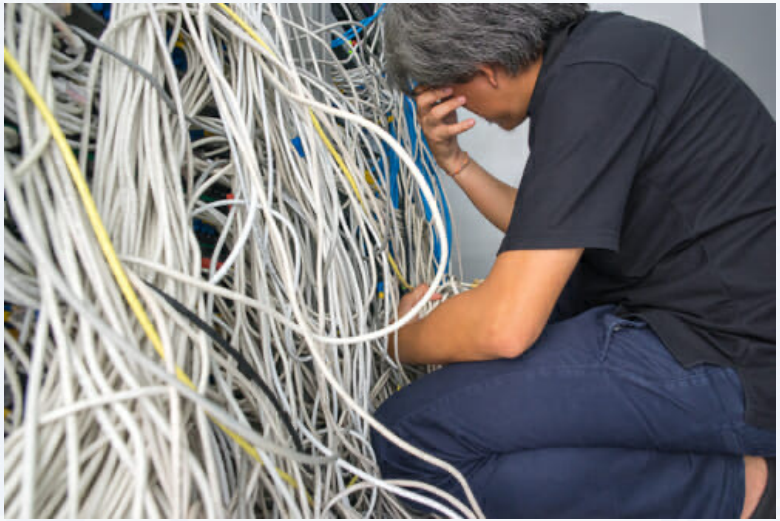
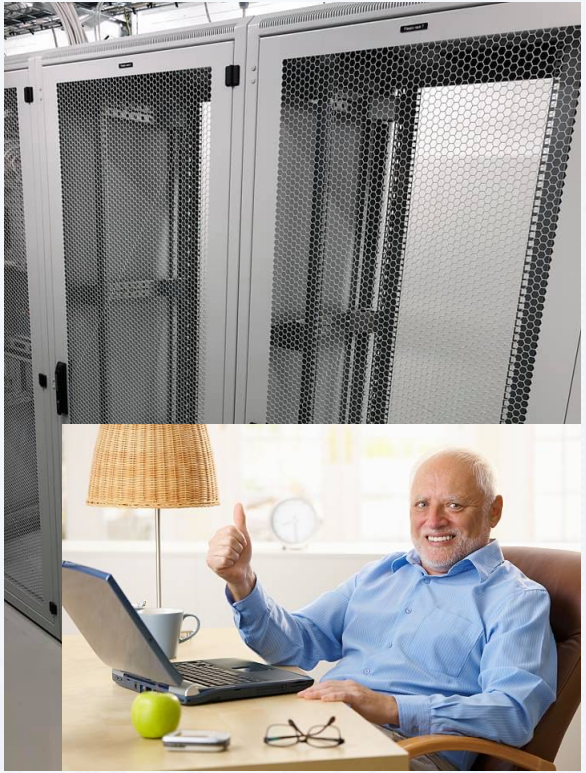
Serverless Simplifies Infra Management

- Autoscaling
- Pay-as-you-go





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But Serverless Is Usually *Stateless*

Mismatch for stateful apps: long-running with real-world interactions

- Payment processing
- Cron jobs
- Data pipelines
- Event processing (e.g., Kafka consumer)
- AI agents 🤖
- ...many more!

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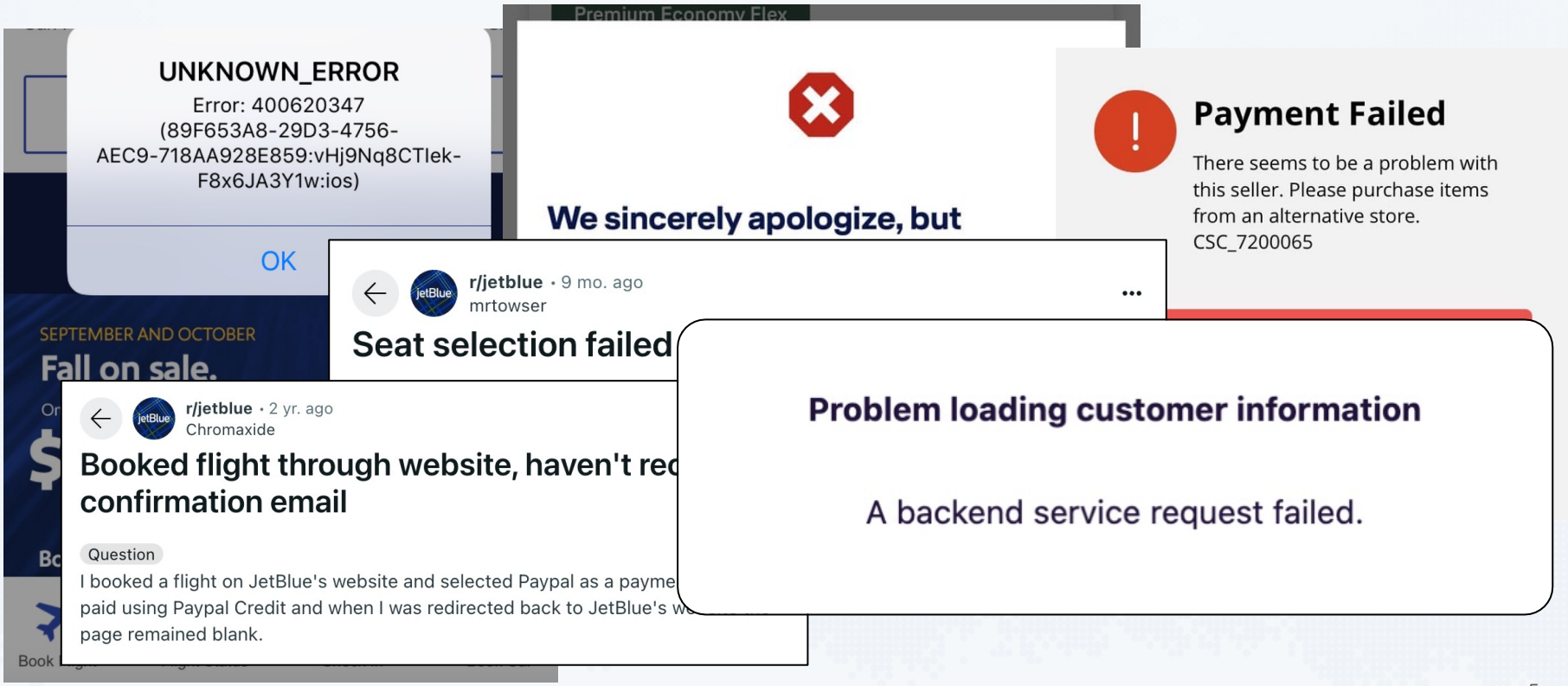
Building Stateful Apps is Hard



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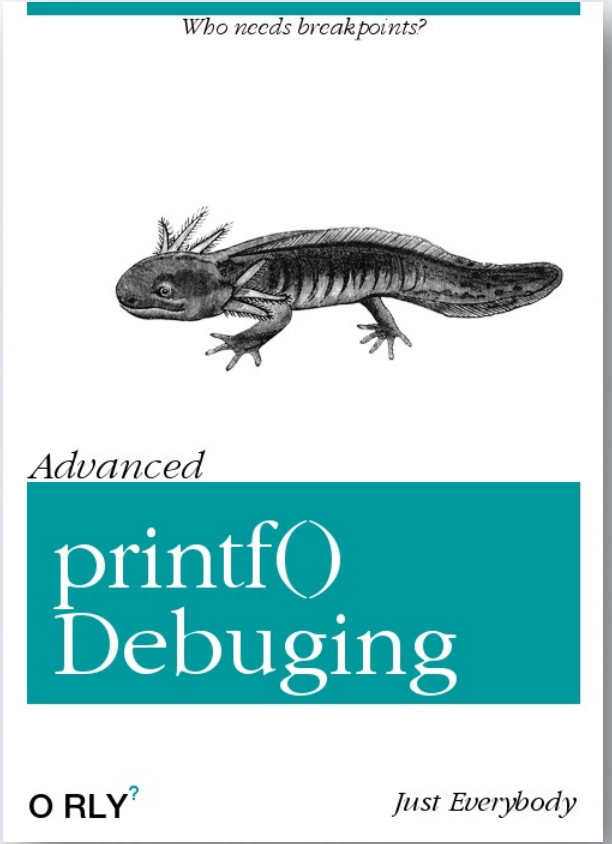
Serverless Makes It Harder

- Timeouts
- Fault tolerance (e.g., retries)
- No interactivity
- Observability



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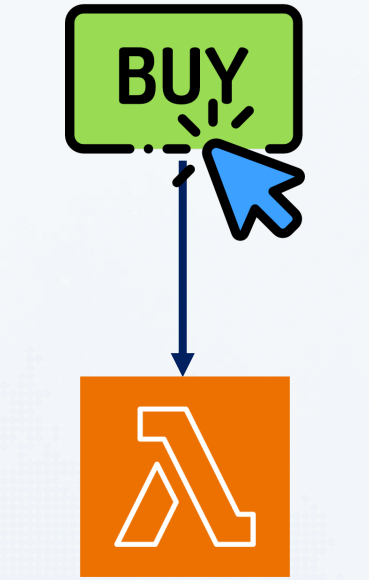
Example: Serverless E-Commerce



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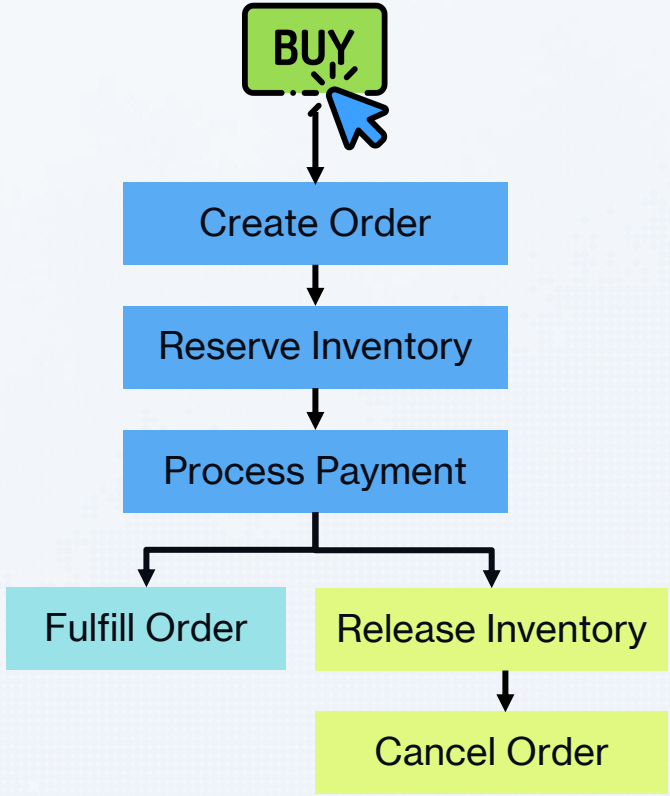
I Want to Just Write Code

widget_store.py

```python
def checkout(items):
    order = create_order()
    reserve_inventory(order, items)
    payment_status = process_payment(order, items)
    if payment_status == 'paid':
        fulfill_order(order)
    else:
        undo_reserve_inventory(order, items)
        cancel_order(order)
```



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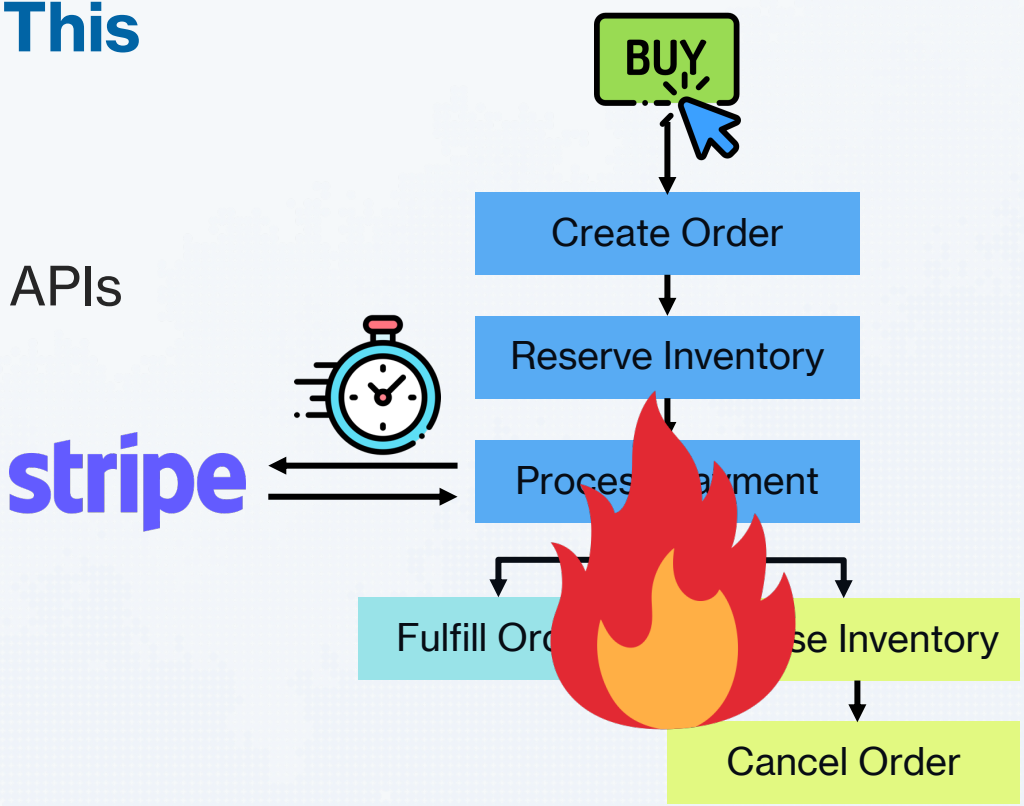
But Serverless Can't Do This

- Timeouts
- Can't invoke async external APIs
- Fault tolerance



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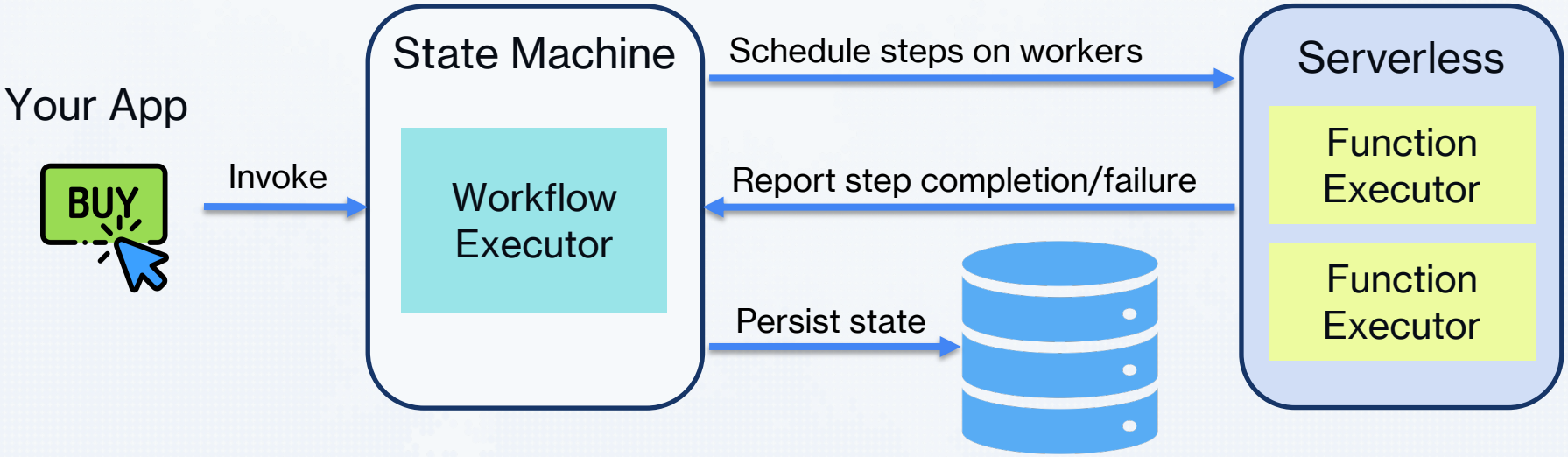
Solution: External Durable Execution Engine



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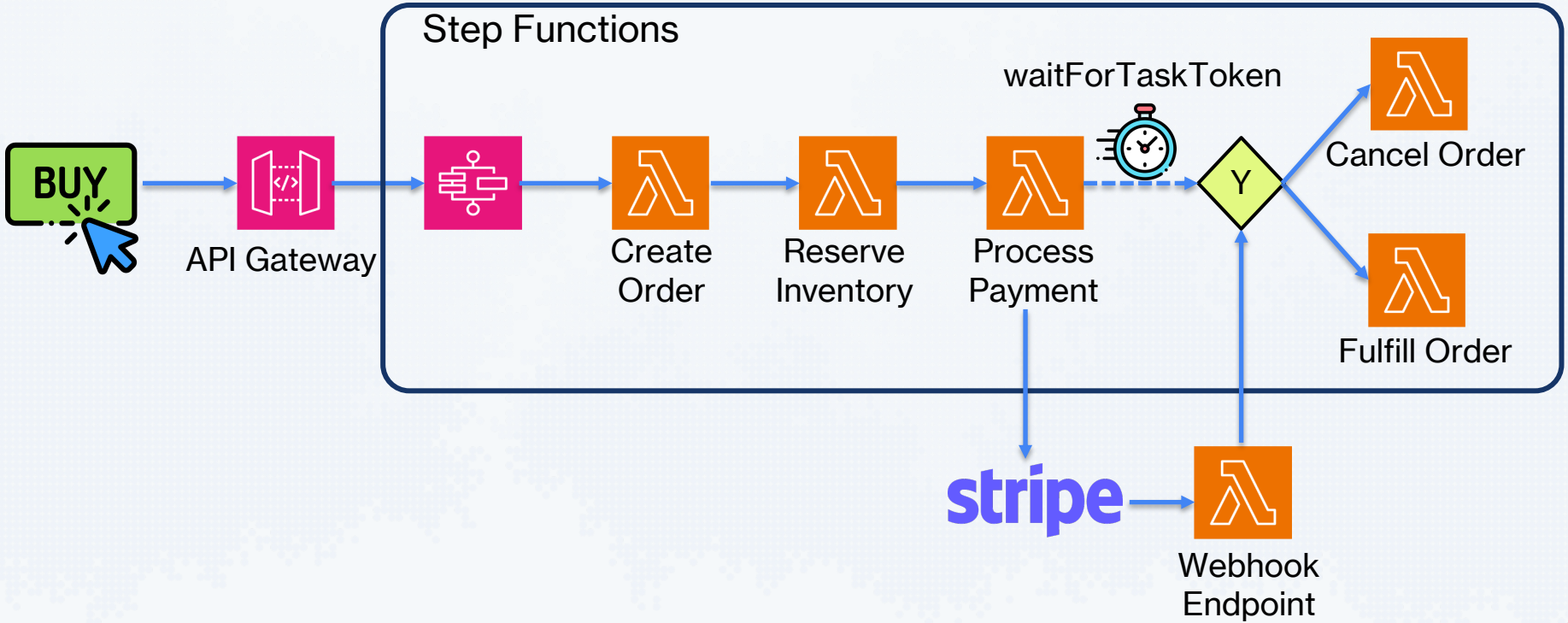
I Have to Make Things Complicated



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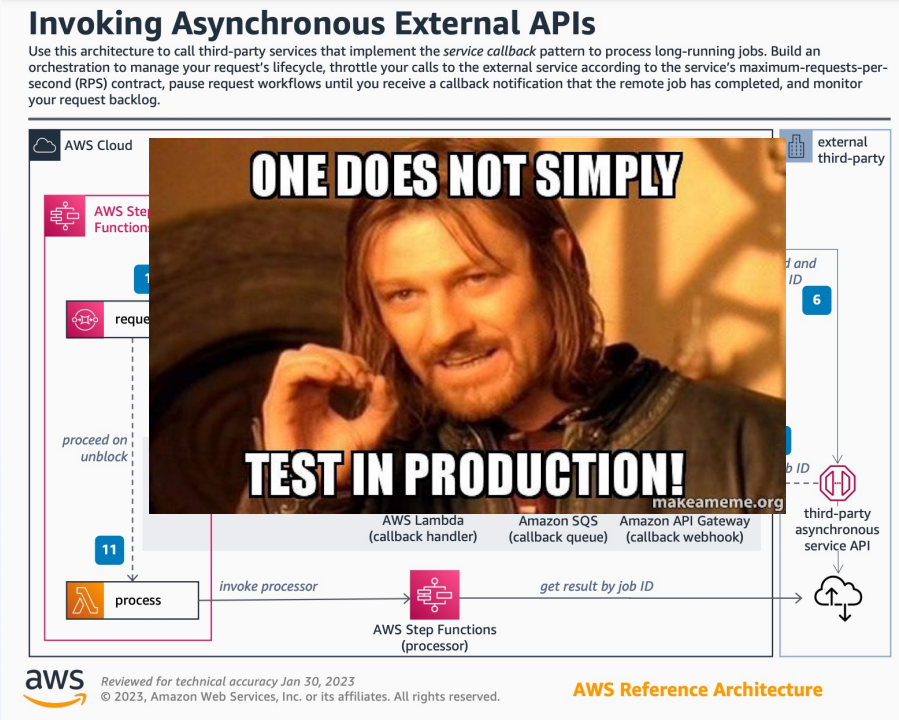
It Works! But Heavyweight

- Complicated Dev **and** Ops
- Hard to maintain/test
- Bad performance
- Expensive $$$



[1] https://d1.awsstatic.com/architecture-diagrams/ArchitectureDiagrams/invoking-asynchronous-external-apis-ra.pdf

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How to make serverless work for stateful apps?

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... Databases!

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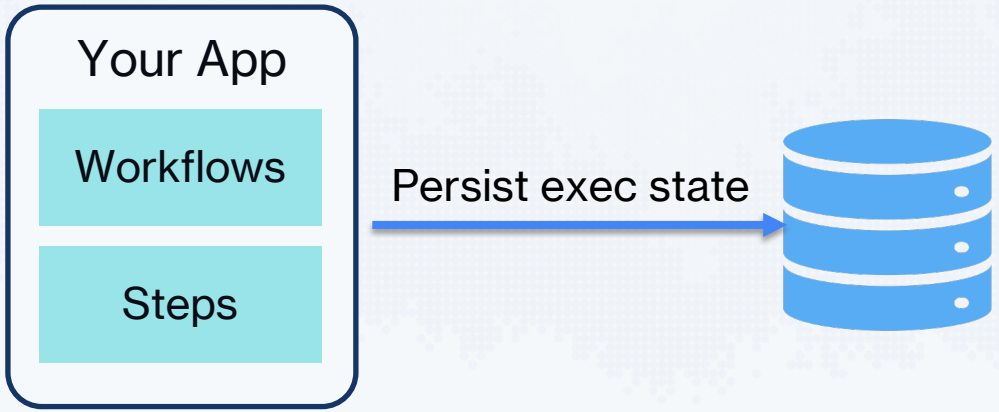
A New Serverless Architecture



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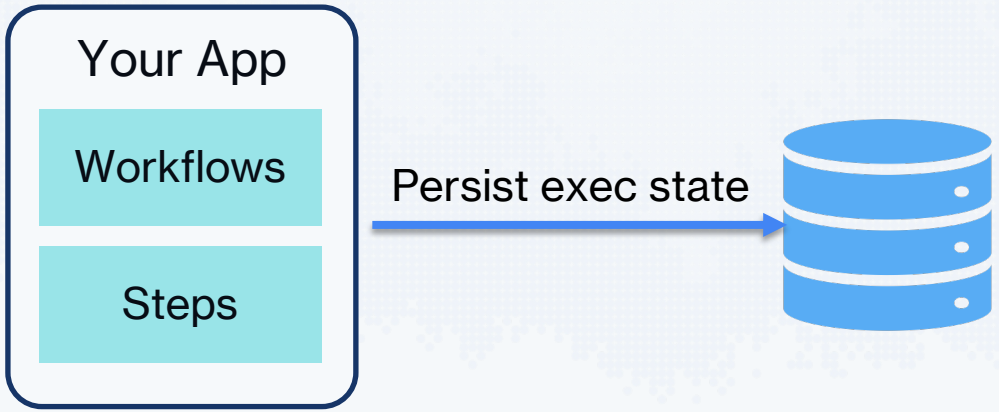
Key Insight

- To make a stateful app serverless, persist its execution state in a database
- Then you can safely execute it in ephemeral environments

- How to implement it?



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Implementing Durable Execution as a Library

widget_store.py

```python
def create_order():
  ...


def checkout(items):
   order = create_order()
   reserve_inventory(order, items)
   payment_status = process_payment(order, items)
   if payment_status == 'paid':
       fulfill_order(order)
   else:
       undo_reserve_inventory(order, items)
       cancel_order(order)
```

- Write normal functions

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Implementing Durable Execution as a Library

widget_store.py

```python
@DBOS.step()
def create_order():
  ...

@DBOS.workflow()
def checkout(items):
    order = create_order()
    reserve_inventory(order, items)
    payment_status = process_payment(order, items)
    if payment_status == 'paid':
        fulfill_order(order)
    else:
        undo_reserve_inventory(order, items)
        cancel_order(order)
```

- Write normal functions
- Annotate code with decorators
  - `@DBOS.workflow()`
  - `@DBOS.step()`
  - `@DBOS.transaction()`

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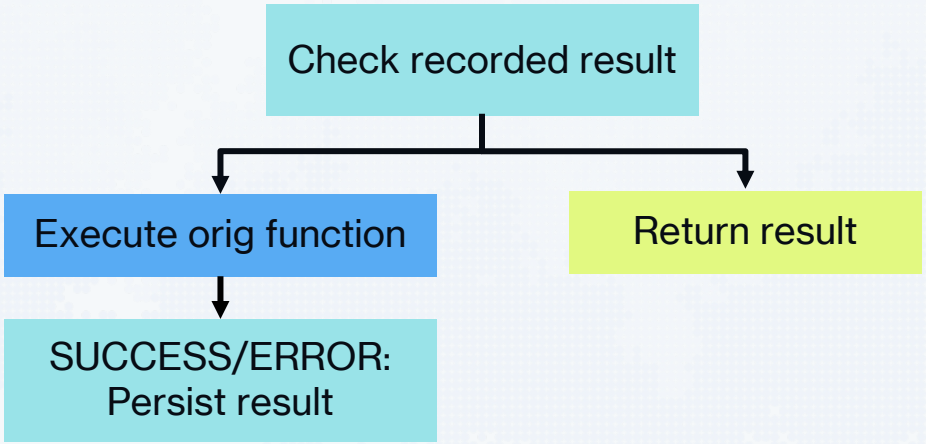
@step

- Wrap functions with durable execution logic
- Never re-execute a step after completion



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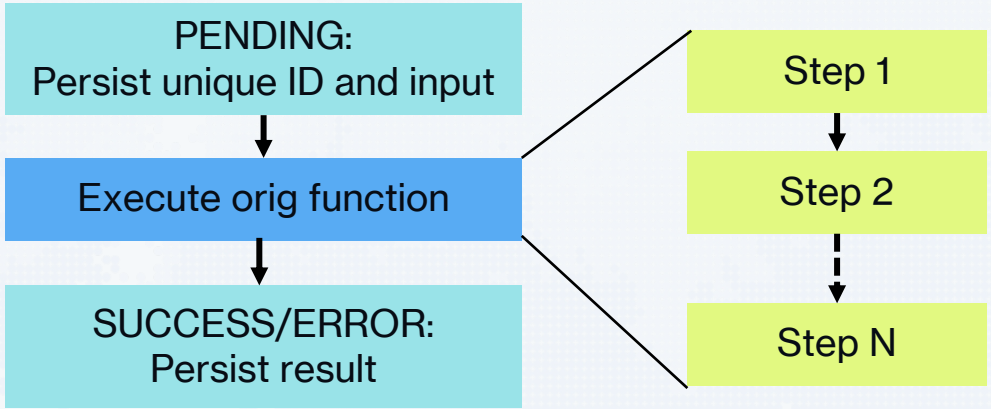
@workflow

- Must be deterministic (e.g., the order of steps)
- Restart on recovery, run to completion



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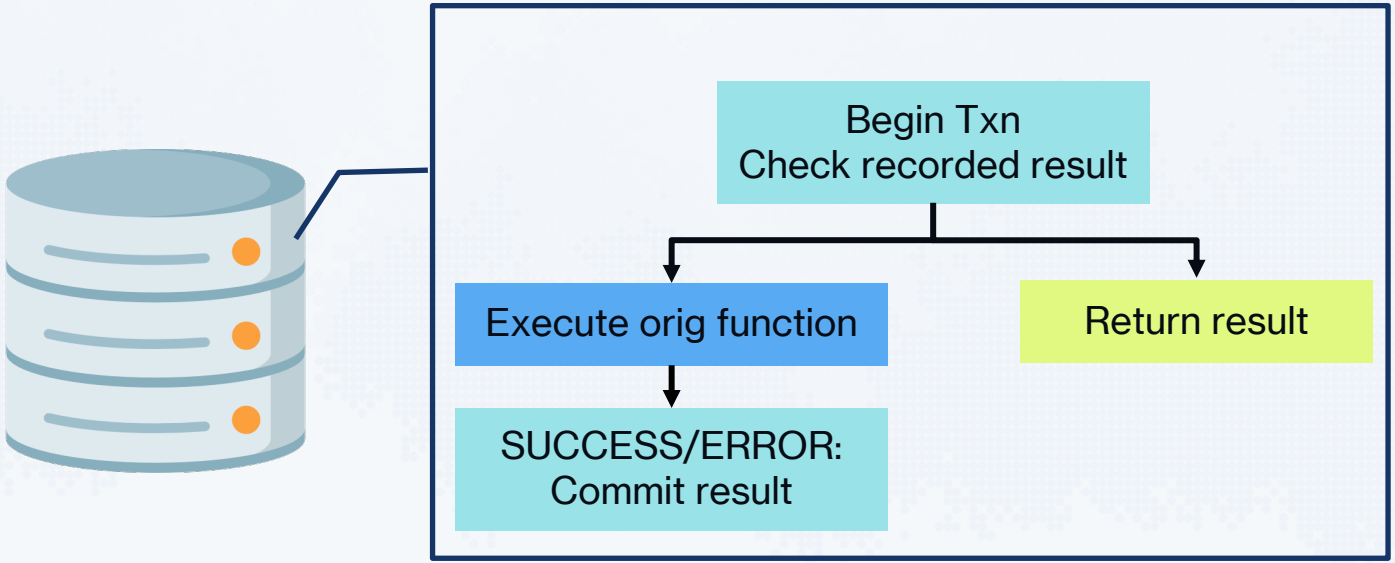
`@transaction`

- A special case to `@step`, guaranteeing **exactly once**
- Record the output in the same DB transaction



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Other Primitives Built On Top of the Database

- Queues
- Send/Recv (notifications)
- Cron jobs
- Durable sleep

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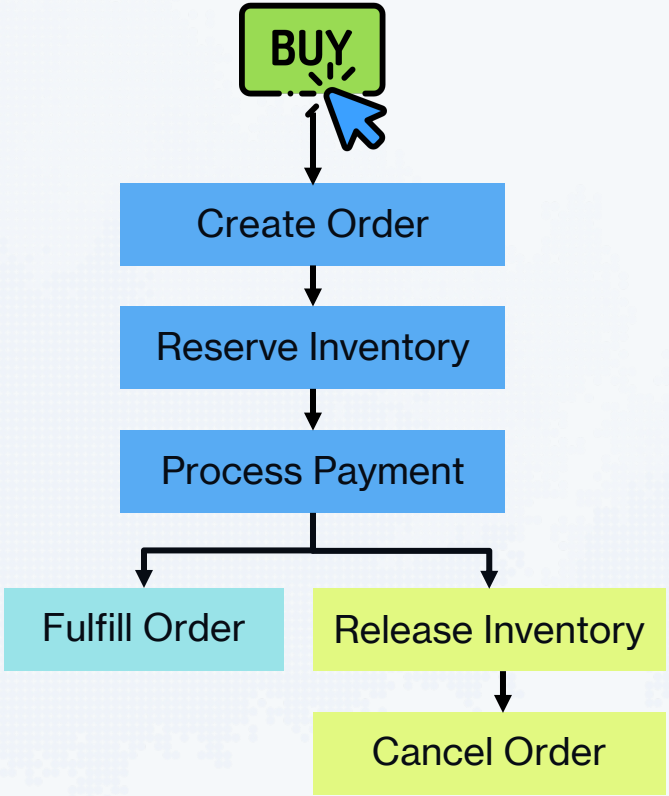
How DBOS Works:



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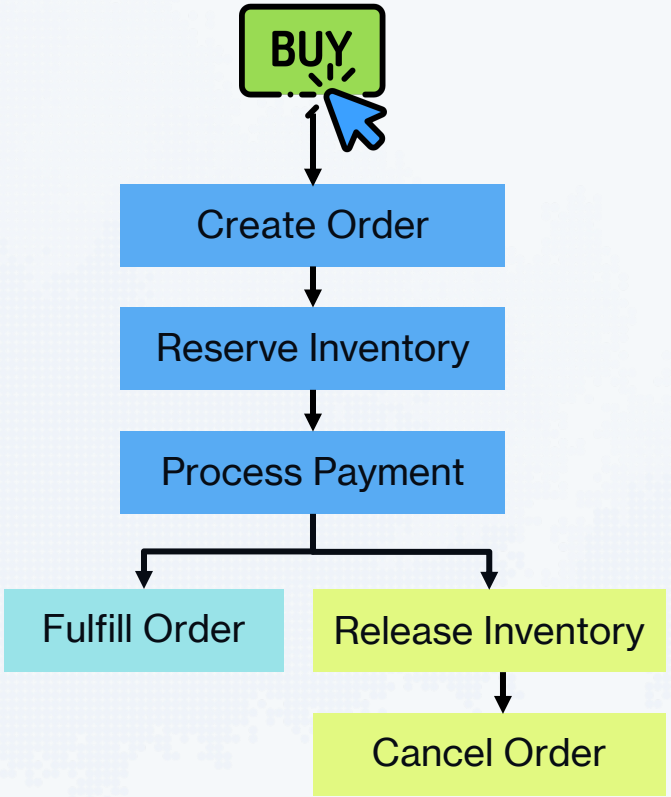
Record the Workflow Start




```
ID: hg4ttg2
Status: PENDING
```

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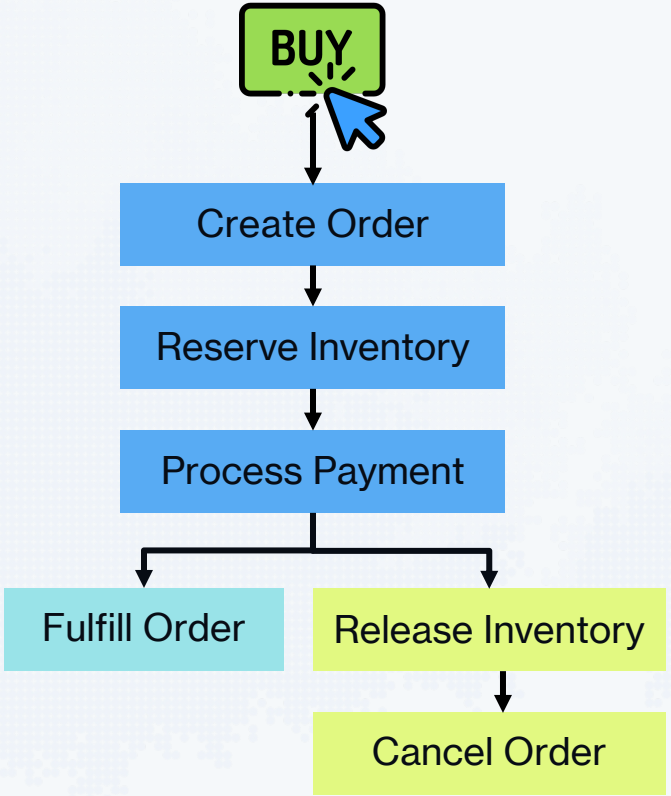
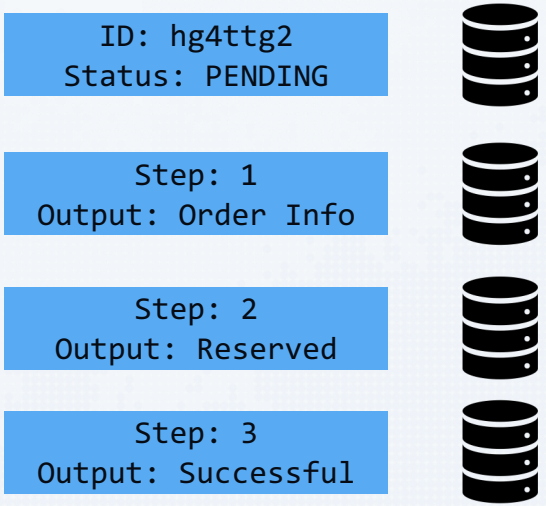
Record Each Step's Output





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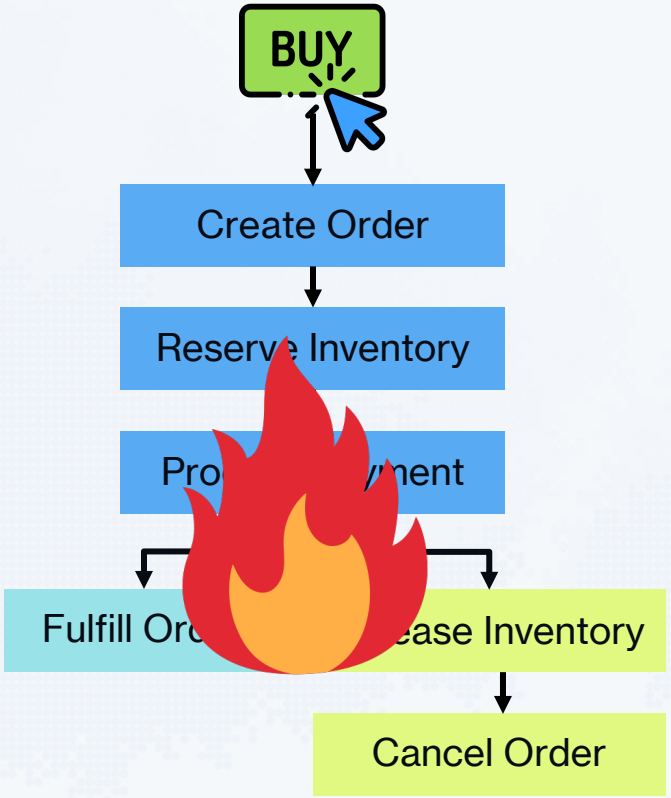
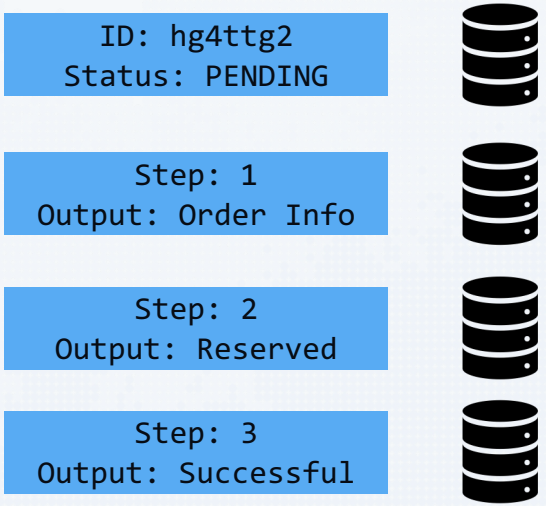
What If It Crashes?





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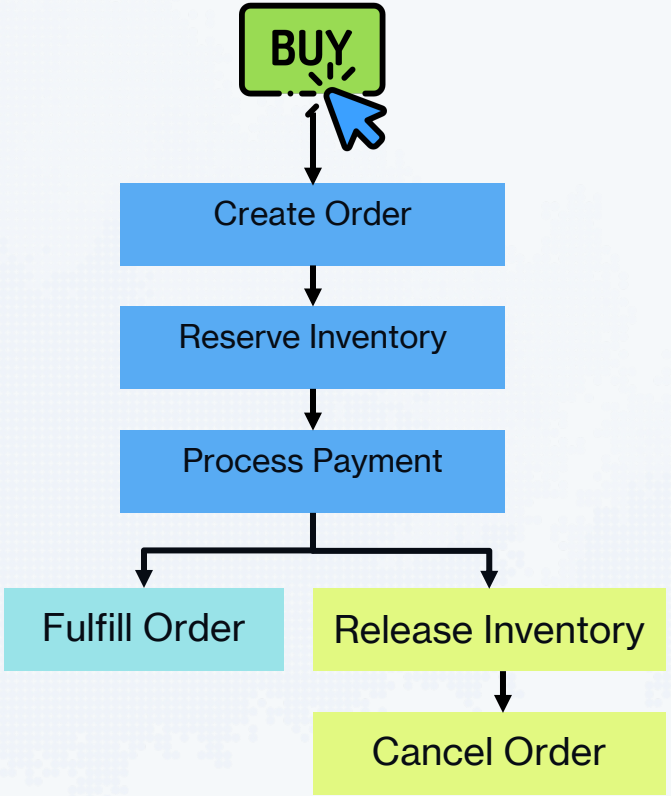
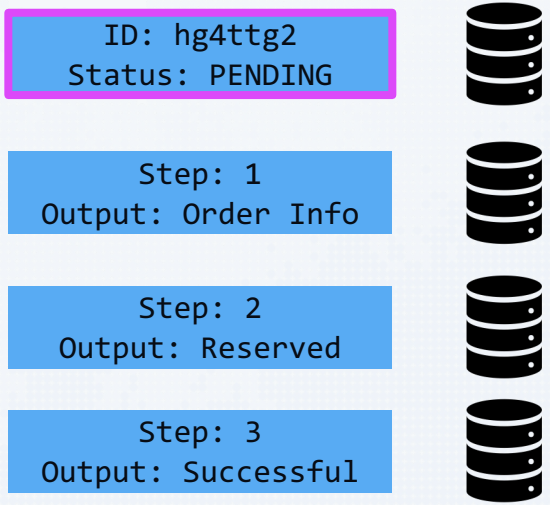
Restart and Check Recorded Outputs





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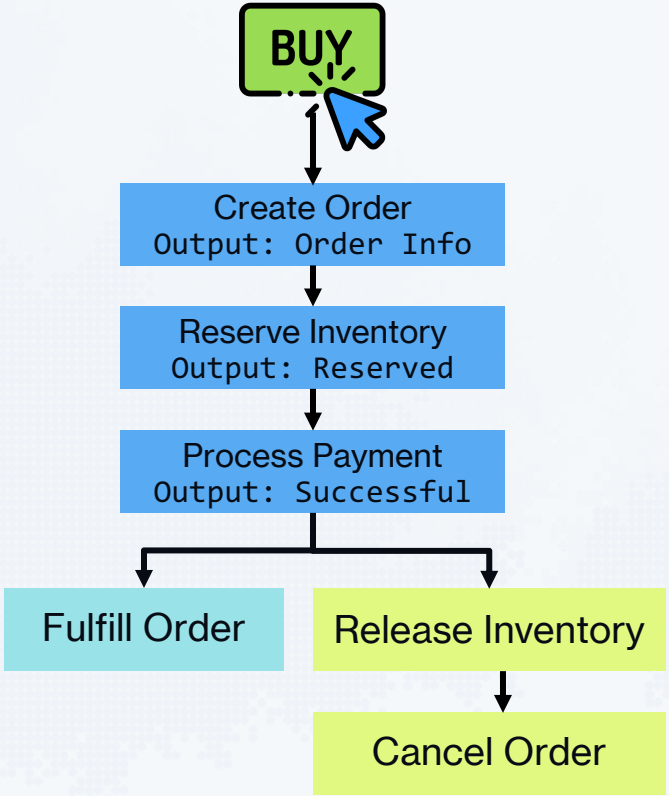

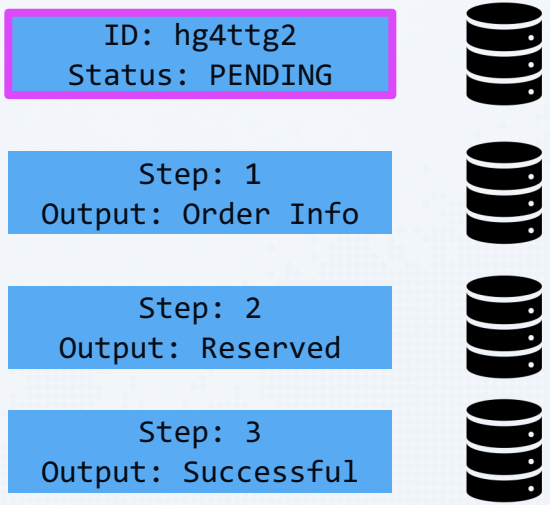

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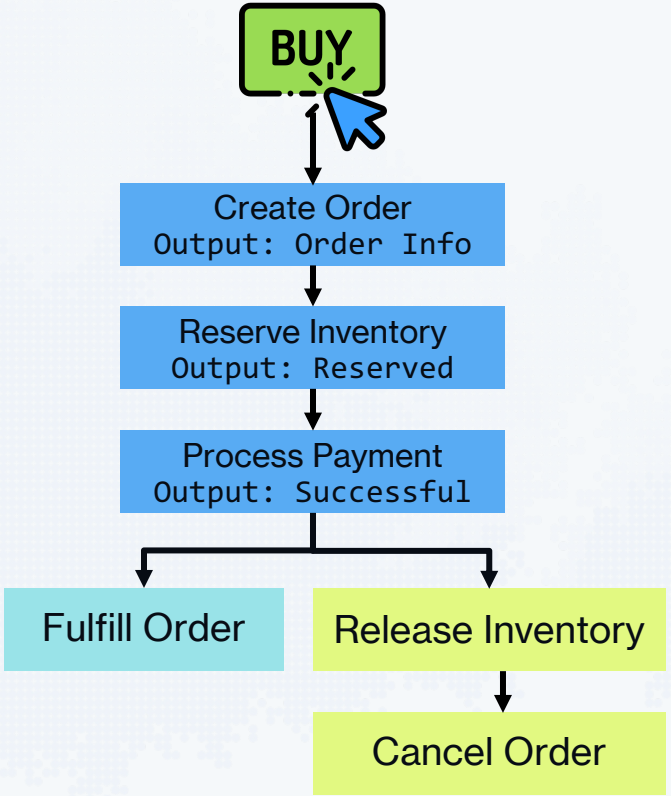
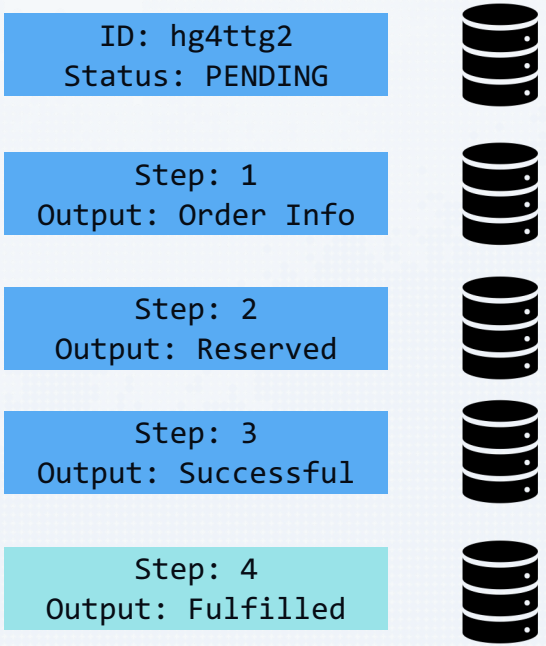
Resume From Where It Left Off





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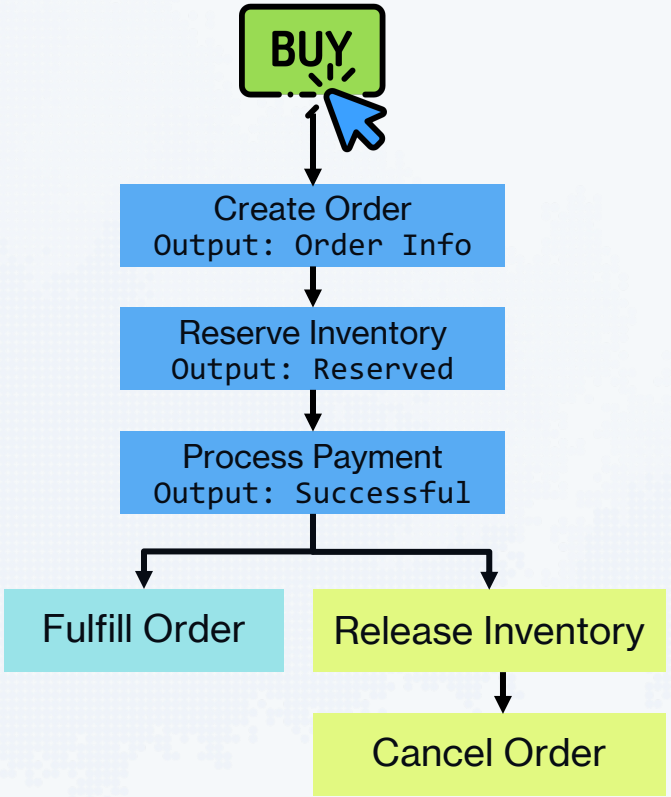
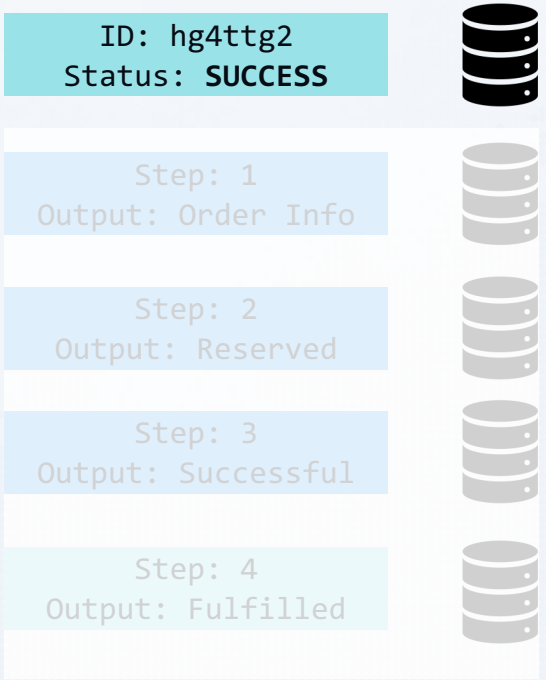
Run to Completion





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Widget Store Demo

- Live: https://demo-widget-store.cloud.dbos.dev/
- Tutorial: https://docs.dbos.dev/python/examples/widget-store

DBOS

Shop internals

Inventory

Restock

	Product	Available
	Premium Quality Widget	98

Orders

Order ID	Status	Progress until dispatch
913	CANCELLED	
912	CANCELLED	
911	DISPATCHED	

Widget Store

Premium Quality Widget — Only **98** left!

Enhance your productivity with our top-rated widgets!

Buy Now for $99.99

Server Tools

Crash the application at any time to simulate a server failure or service interruption. After crashing, the application will momentarily become inaccessible but then resume from exactly where it left off before the crash. Try it and see!

Crash the Application

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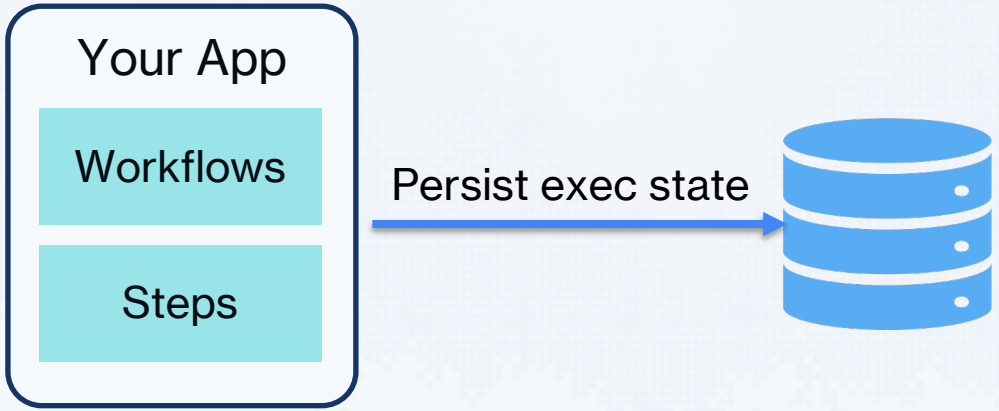
Takeaways

- Persist stateful functions' execution state in a database

  ➔ Simplify serverless architecture

- Databases 💙 Serverless



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Try it out & Talk to us!

https://dbos.dev

Open Source:

https://github.com/dbos-inc/dbos-transact-py

Qian Li

Peter Kraft

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