Developing Cloud Serverless Components in Python

Domain-Driven Design Perspective

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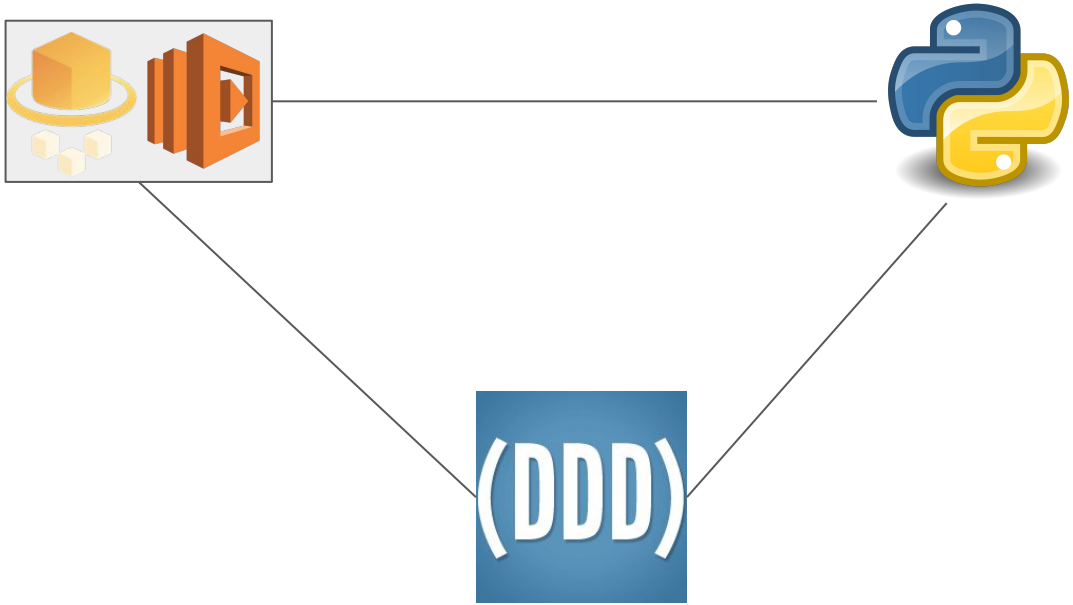
About Myself

- Software technologist/architect
- VP Engineering @ BST
- Previously CTO @ IRKI, DE @ Cisco, VP Technologies @ NDS
- Cross-discipline approach (connecting the dots):
  - (Strategic) Domain-Driven Design
  - Serverless Architecture
  - Cynefin
  - Wardley Maps
  - Lean Startup
  - Promise Theory
  - ...

- Articles on Medium
- Presentations on Slideshare
- @asterkin on Twitter
- Source code for this talk on GitHub

Connecting the Dots



What is Serverless Architecture?

- No servers to manage
- Highly available
- Flexible scaling
- Two flavors:
  - AWS Lambda - no pay for idle
  - AWS Fargate - log running fully managed containers
- More details
- Serverless computing is a tectonic shift in the software industry
  - S. Wardley “Why the fuss about serverless?”

“New Platform Capabilities Lead to New Architectural Style and New Operational Practices

S. Wardley (liberal quoting of mine)

Serverless-native Architecture is yet to Emerge

Some exploration and “safe-to-fail” experimentation are required

Cloud VM-native architecture

Cloud Container-native architecture

Cloud Serverless-native architecture

Tools have strong influence on thinking

Python is a Superb Tool for Exploration and Experimentation

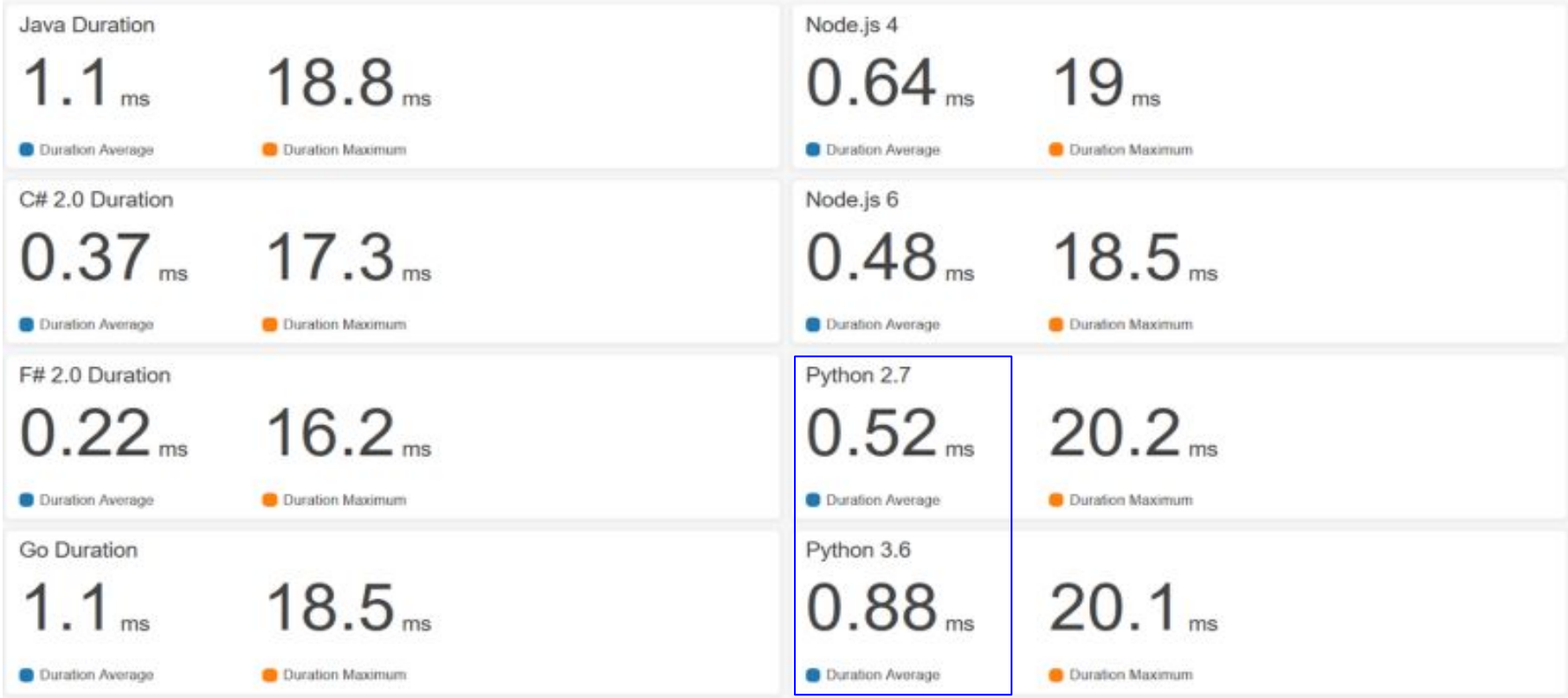
Outcomes of this research will be easy to port to other languages

AWS Lambda Function in Python

```
print('Loading function') #executed at cold start


def lambda_handler(event, context): # executed at every invocation
    print("value1 = " + event['key1']) # input data usually comes as a dict
    print("value2 = " + event['key2'])
    print("value3 = " + event['key3'])
    return event['key1']  # Return something if invoked synchronously
    #raise Exception('Something went wrong')
```

AWS Lambda Performance

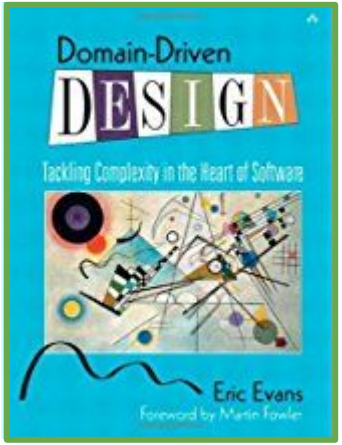


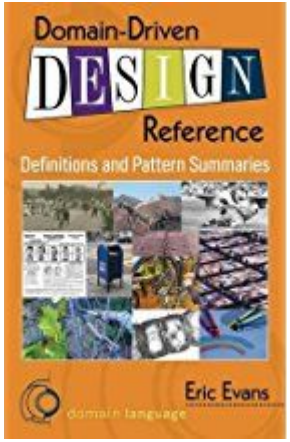
Source: Yun Zhi Lin, [“Comparing AWS Lambda performance of Node.js, Python, Java, C# and Go”]

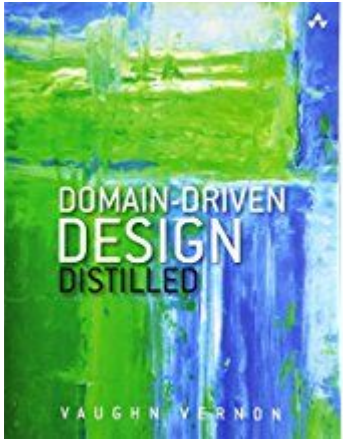
Serverless Architecture Needs Some Organizing Principles

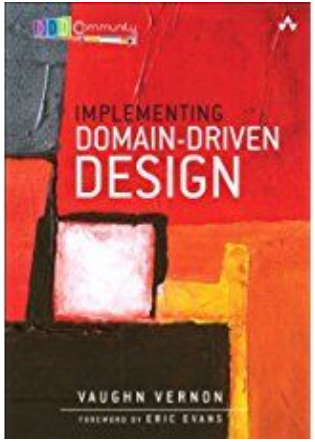
To prevent creation of a distributed monolith

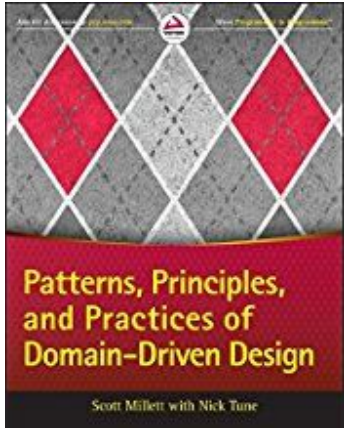
Domain-Driven Design

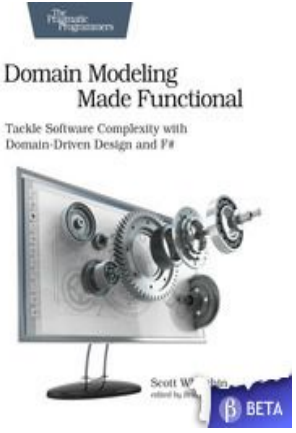


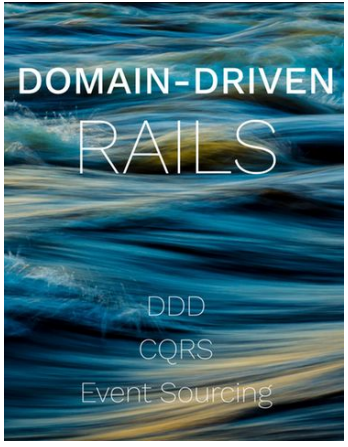


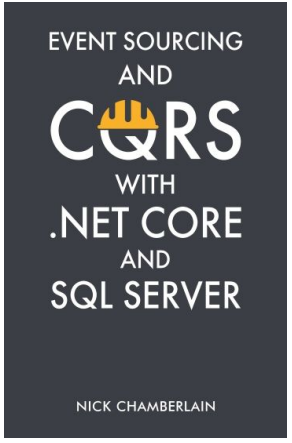












Domain-Driven Design at a Glance

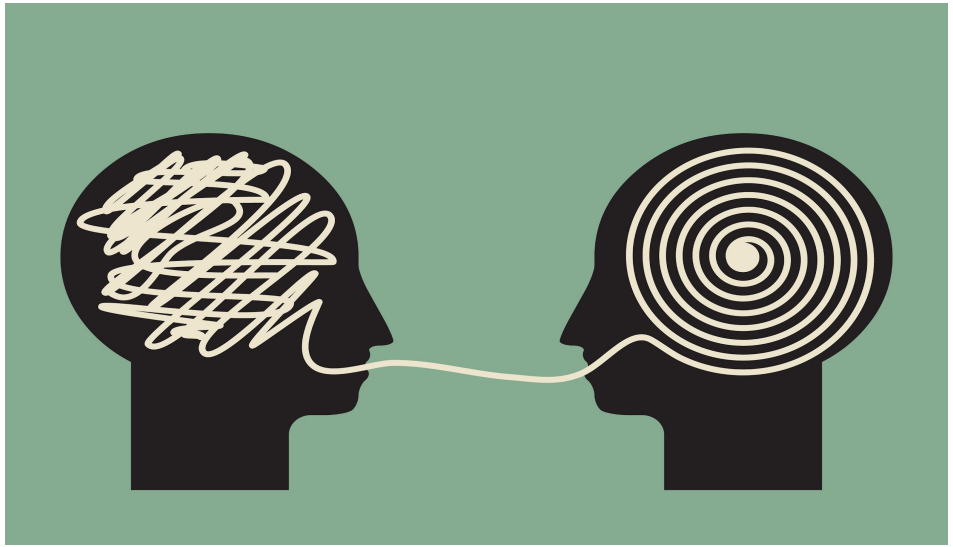
Language

Model

Boundaries

Nesting

Language



- Common (ubiquitous) language for domain and software experts
- Vocabulary reflected *directly* in software
- Normally a subset of domain-specific jargon

DDD is essentially a *linguistic* process

Boundaries

- “One size fits all” models are impractical
- G-d like models result in Big Ball of Mud
- DDD insists on identifying multiple models:
  - Coherent within their own boundaries
  - Mapped onto others where appropriate

DDD is about maintaining boundaries for- and mappings between- models

Subdomains (my interpretation)

Core

What justifies developing software in the first place

Supporting Services

From the same area of activity, but not specific enough

Generic Services

Completely generic, applicable to any domain



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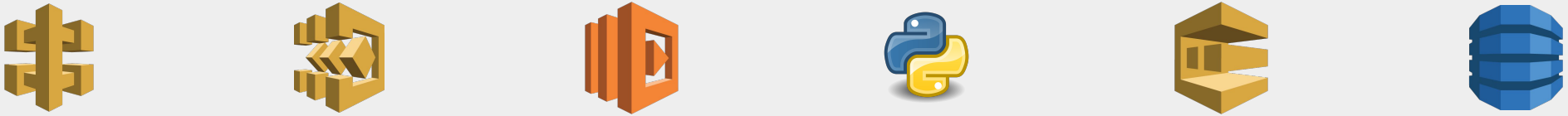
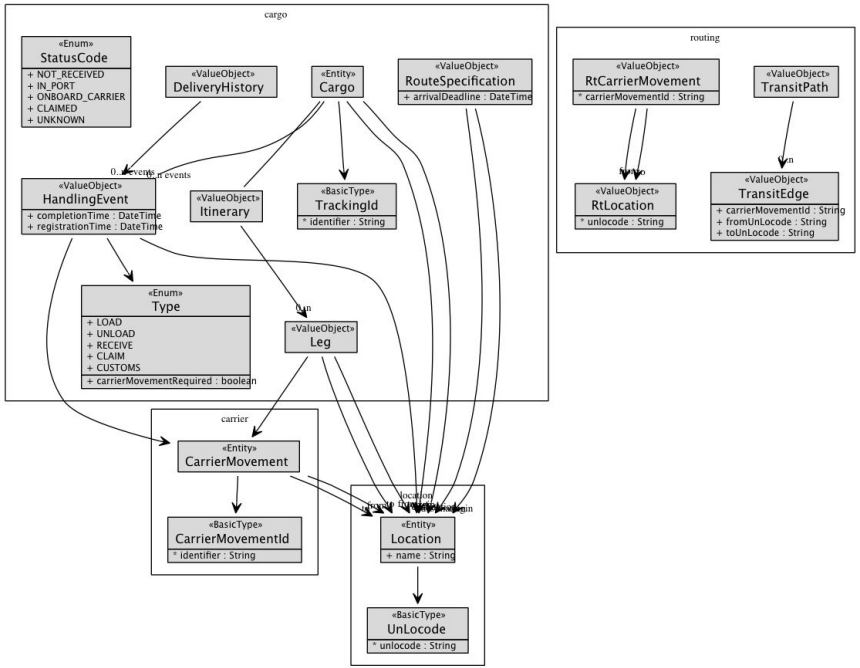


Evaluation Criteria

- Is domain language reflected directly in the code?
- Is core logic clearly separated from supporting, and generic subdomains?
- Is there an appropriate model underneath?

DDD Sample Application: Cargo Tracking System



Questions I wanted to address

- What would be an objective reason to prefer Python over JavaScript?
- What is involved in implementing DDD cargo Sample in Serverless Python?
- What is missing in the Serverless Python infrastructure, if any?

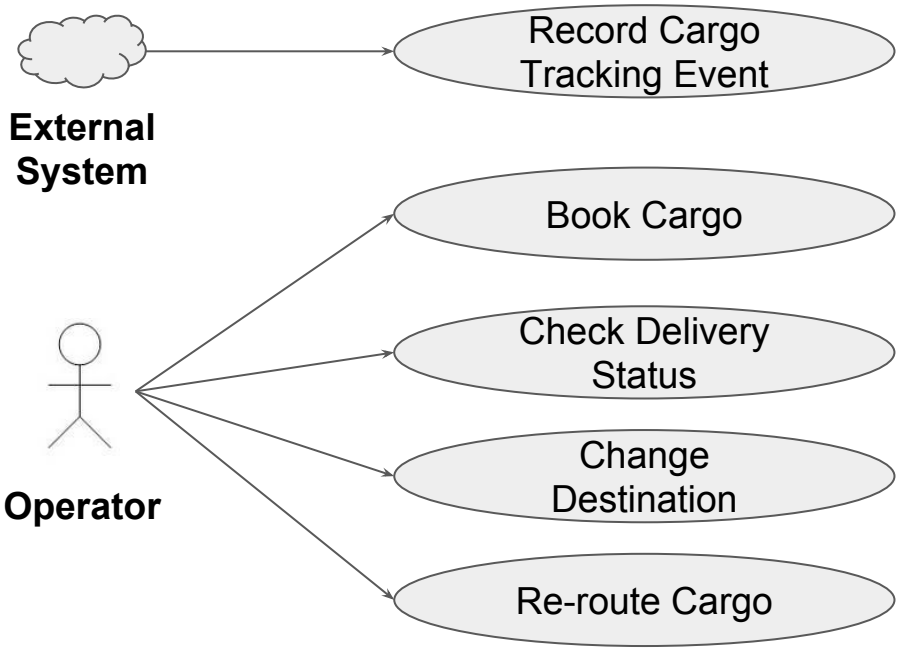
I was Very Surprised with the Answers

Let’s see why

You Always Start with a Use Case Model, Don’t You

In fact nobody does, and it’s a big problem

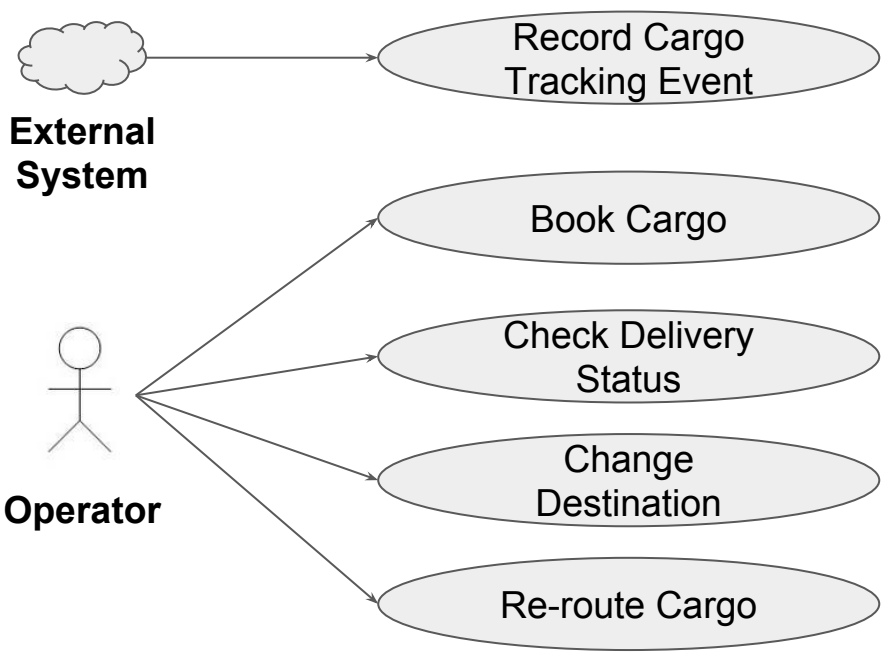
Cargo Tracking Use Cases

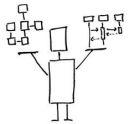


You Start with Architecturally Essential Use Case(s)

It’s far from trivial - you need an architect

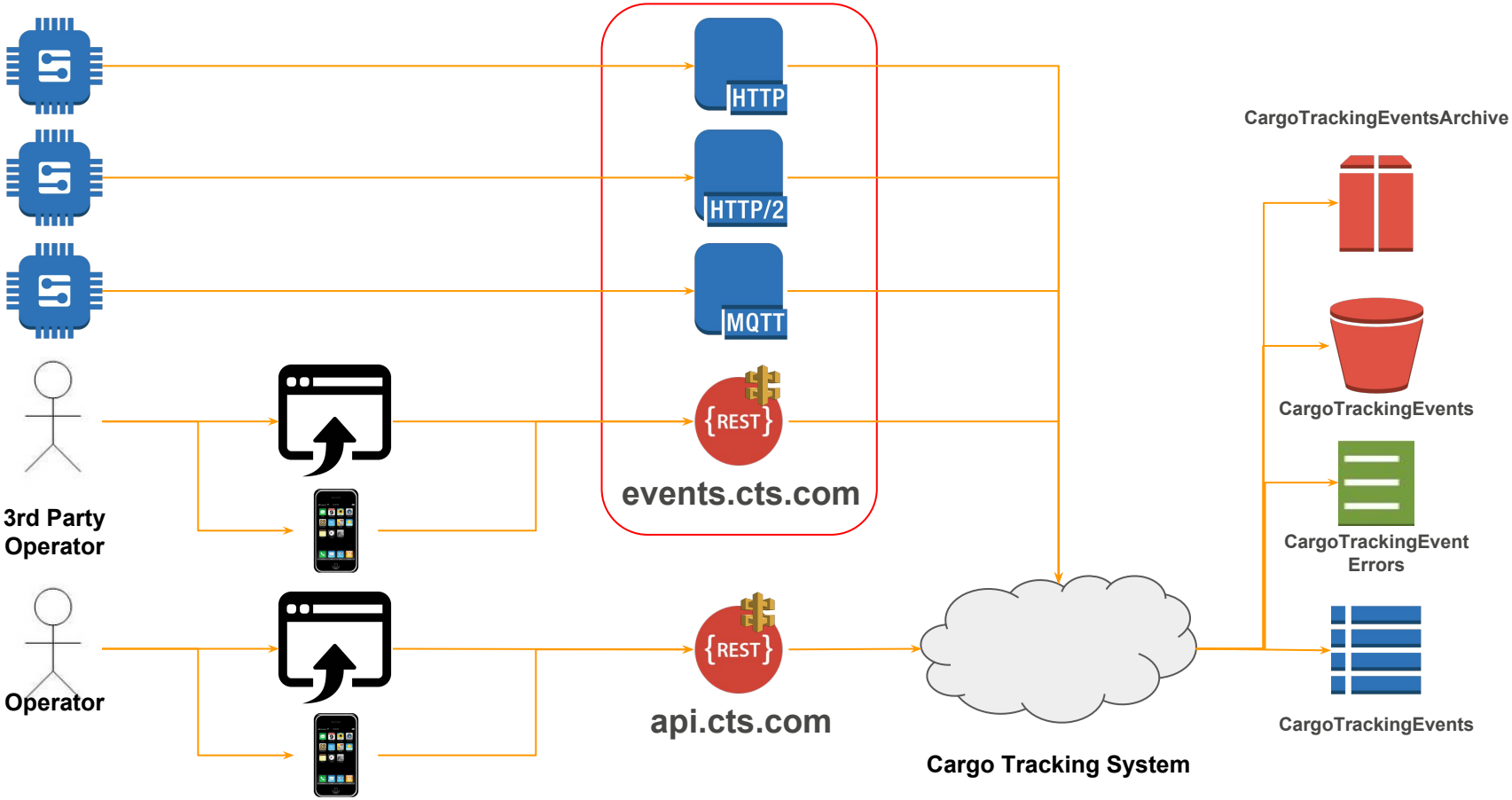
Cargo Tracking Use Cases



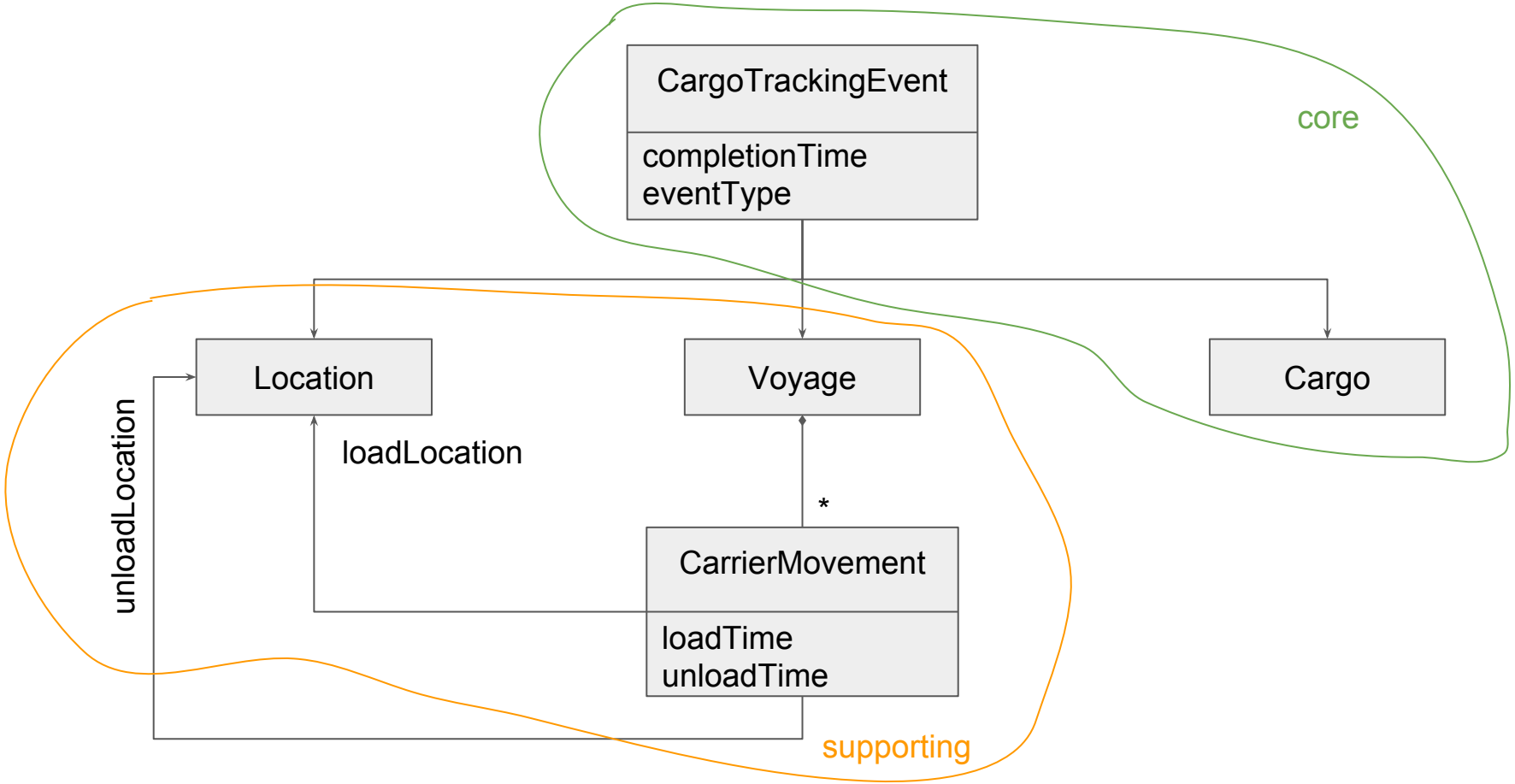


- Interfacing with external systems
- High volume
- High velocity
- Security concerns

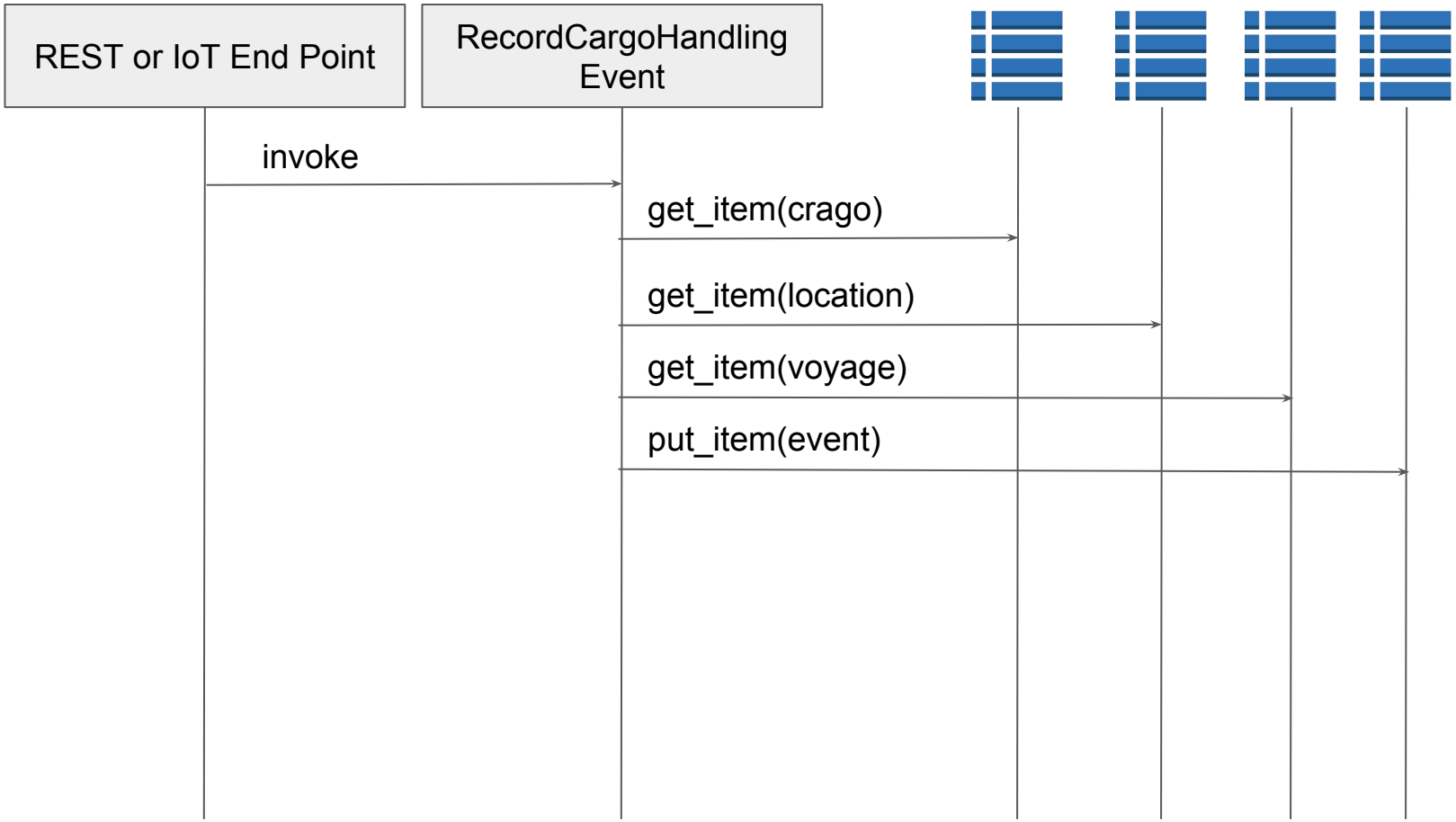
Diving One Inch Deeper



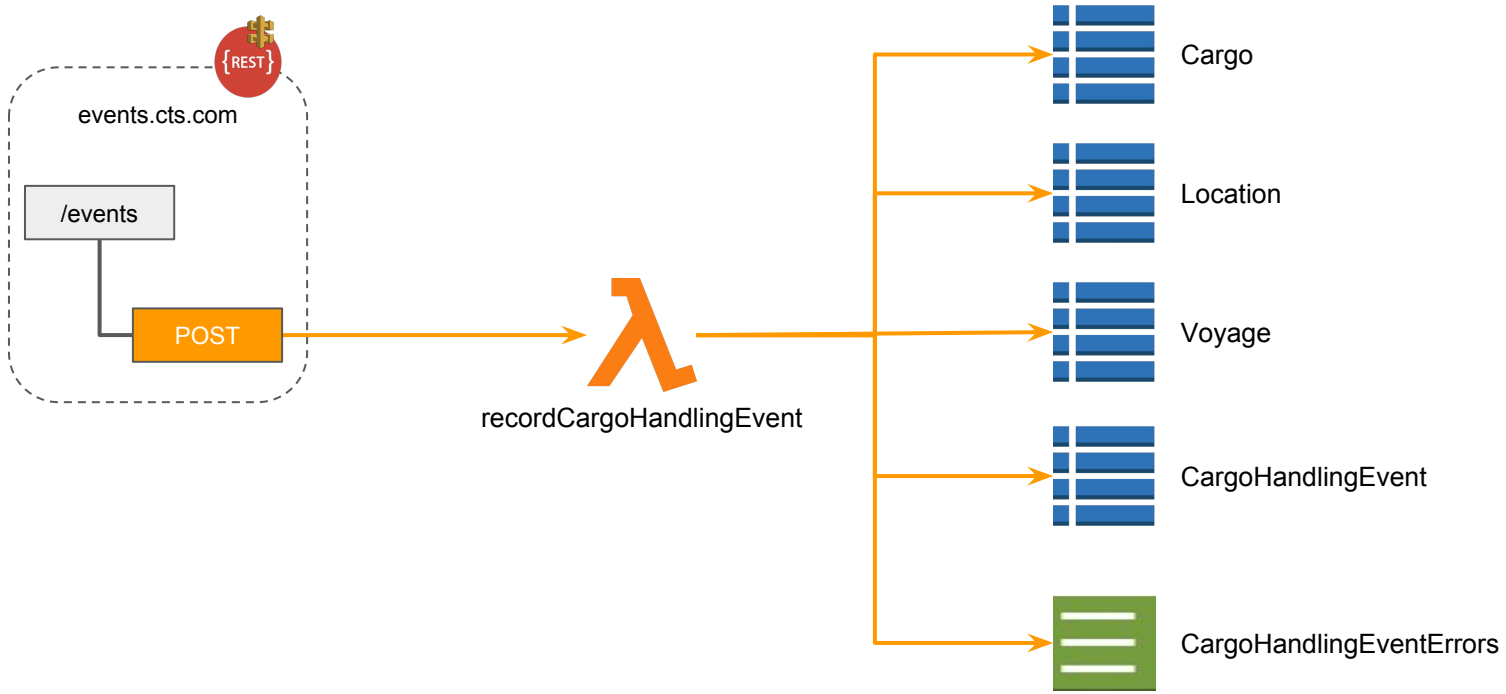
Cargo Handling Event



Record Cargo Tracking Event: First Cut



Record Cargo Handling Event: Architecture



Can we program this in half-an-hour?

```
import boto3
import os

dynamodb = boto3.resource('dynamodb')

def checkItem(table, key, event, value):
    if value in event:
        if 'Item' in table.get_item(Key={key:event[value]},ProjectionExpression=key):
            return []
        else:
            return ['%s not found' % value]
    else:
        return ['%s is missing' % value]

def flatten(status):
    return [e for es in status for e in es]
```

```
cargoTable = dynamodb.Table(os.getenv('CARGO_TABLE'))
def checkCargo(event):
    return checkItem(cargoTable, 'trackingId', event, 'cargo')

locationTable = dynamodb.Table(os.getenv('LOCATION_TABLE'))
def checkLocation(event):
    return checkItem(locationTable, 'unLocationCode', event, 'location')

VOYAGE_REQUIRED = {'LOAD', 'UNLOAD'}

voyageTable = dynamodb.Table(os.getenv('VOYAGE_TABLE'))
def checkVoyage(event):
    if not 'eventType' in event: return ['eventType is missing']
    if event['eventType'] in VOYAGE_REQUIRED:
        return checkItem(voyageTable, 'id', event, 'voyage')
    else:
        return ['unexpected voyageId'] if 'voyage' in event else []
```

```
from botocore.exceptions import ClientError
import time
eventTable = dynamodb.Table(os.getenv('EVENT_TABLE'))
def recordEvent(event):
    try:
        eventTable.put_item(
            Item= {
                'cargoTrackingId': event['cargo'],
                'completionTime': event['completionTime'],
                'registrationTime': int(time.time()*1000),
                'voyageId' : event['voyage'],
                'eventType' : event['eventType'],
                'location': event['location']
            },
            ConditionExpression = 'attribute_not_exists(cargoTrackingId) AND attribute_not_exists(completionTime)'
        )
        return 'OK'
    except ClientError as e:
        if e.response['Error']['Code'] == 'ConditionalCheckFailedException':
            return 'DUPLICATE'
        raise
```

```
import json

def reportError(event, error):
    print(json.dumps({'event': event, 'error': error}))

def lambda_handler(event, context):
    inputStatus = flatten([checkCargo(event), checkLocation(event), checkVoyage(event)])

    if len(inputStatus) > 0 :
        reportError(event, inputStatus)
    else :
        recordingStatus = recordEvent(event)
        if recordingStatus != 'OK' : reportError(event, recordingStatus)
```

Evaluation Criteria

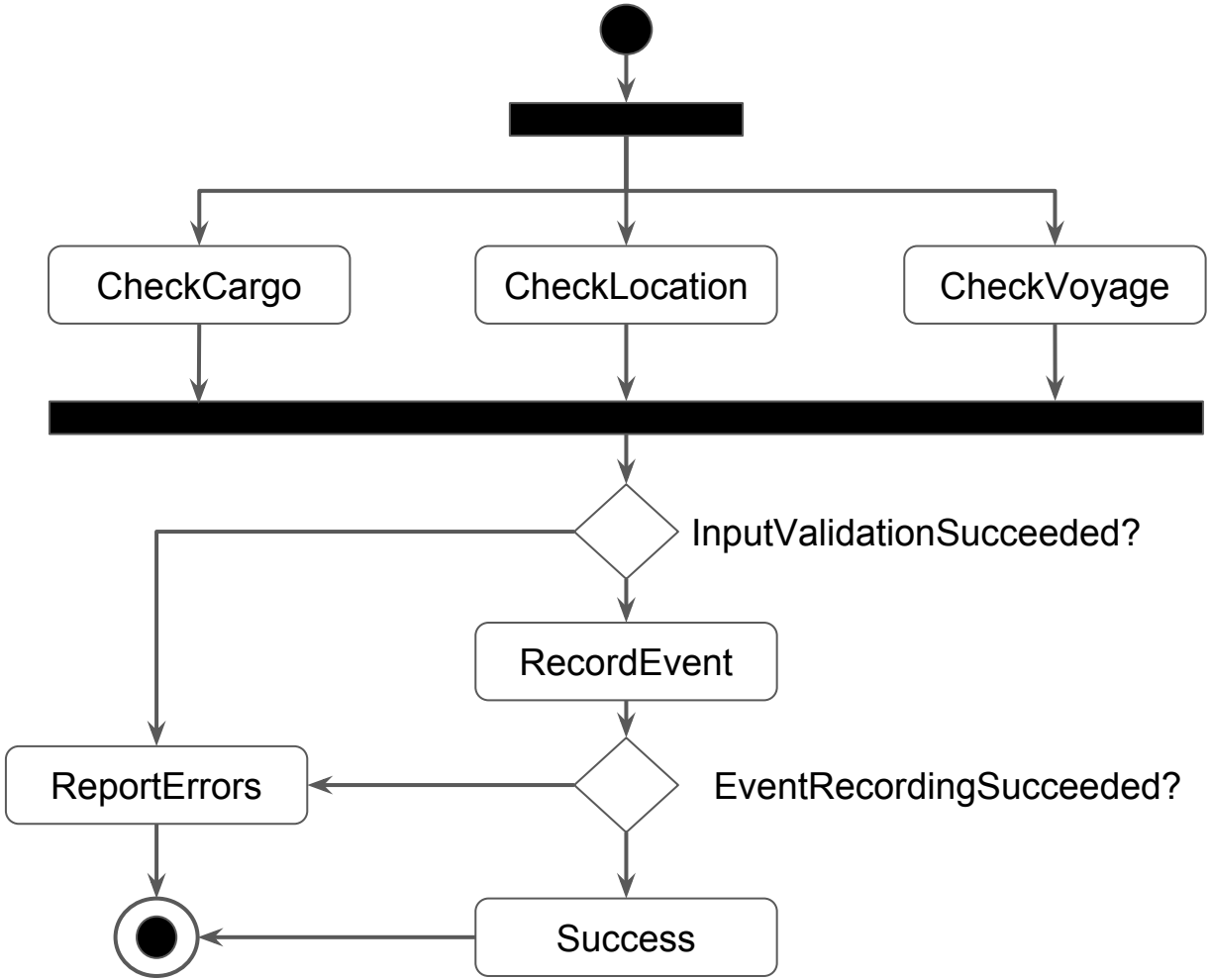
- Is domain language reflected directly in the code?
- Is core logic clearly separated from supporting, and generic subdomains?
- Is there an appropriate model underneath?

What would be an alternative?

Without alternatives it’s an ideology, not engineering

What if we used inappropriate tool for modelling the system logic?

Always a good question to ask

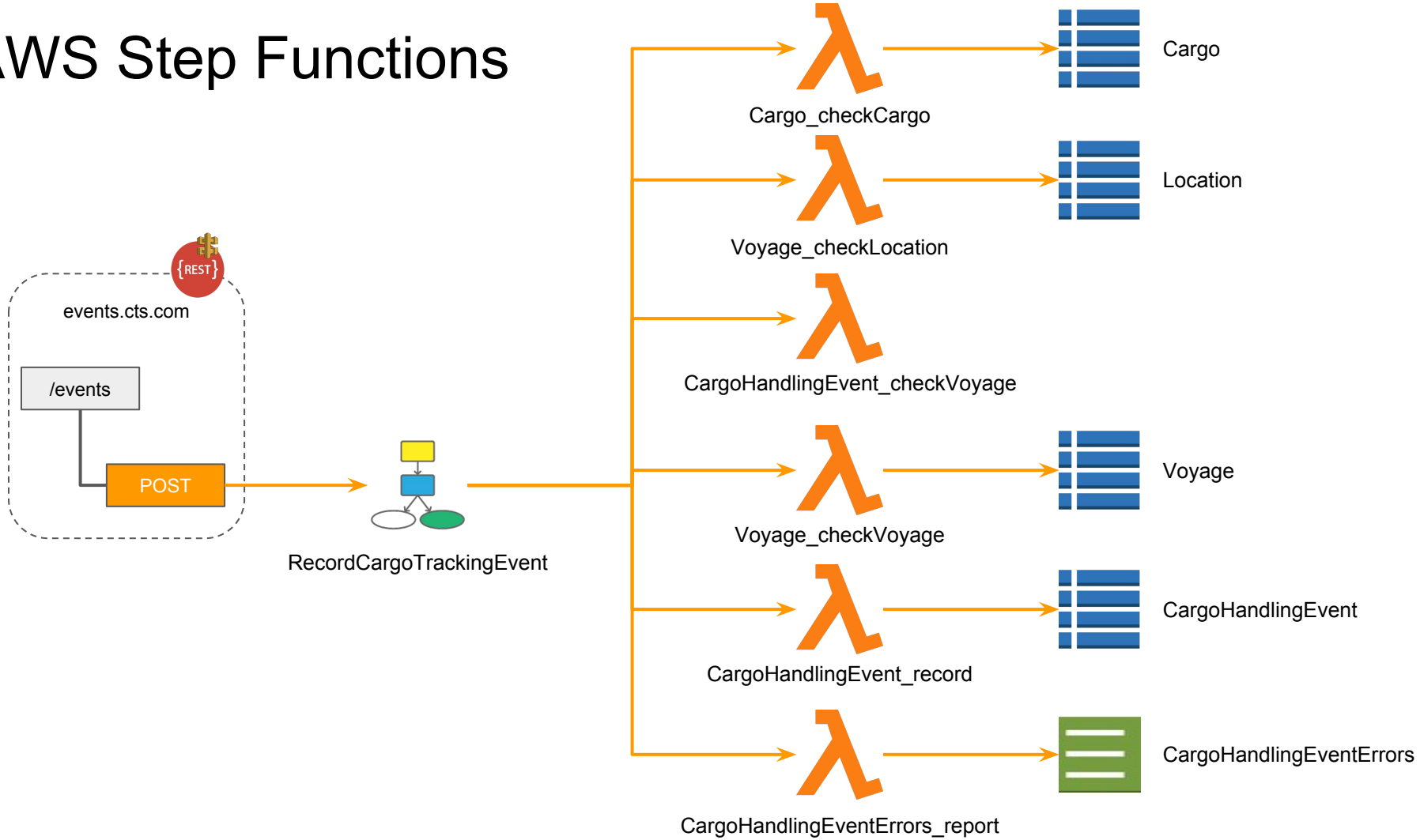


Input validations could be performed in parallel

How could we implement such logic?

- Use Python asyncio?
- Switch to JavaScript?
- Any other option?

AWS Step Functions



Look, Ma!

There is (almost) no code here!

Cargo.py

```
"""Encapsulates Cargo Repository and all relevant computations."""
import matte

CARGO = 'cargo'
CARGO_KEY = {CARGO : str}

Cargoes = matte.repository('Cargoes', hashKey = CARGO_KEY)
Specifications = matte.repository('Specifications', hashKey = CARGO_KEY)
Itineraries = matte.repository('Itineraries', hashKey = CARGO_KEY)
```

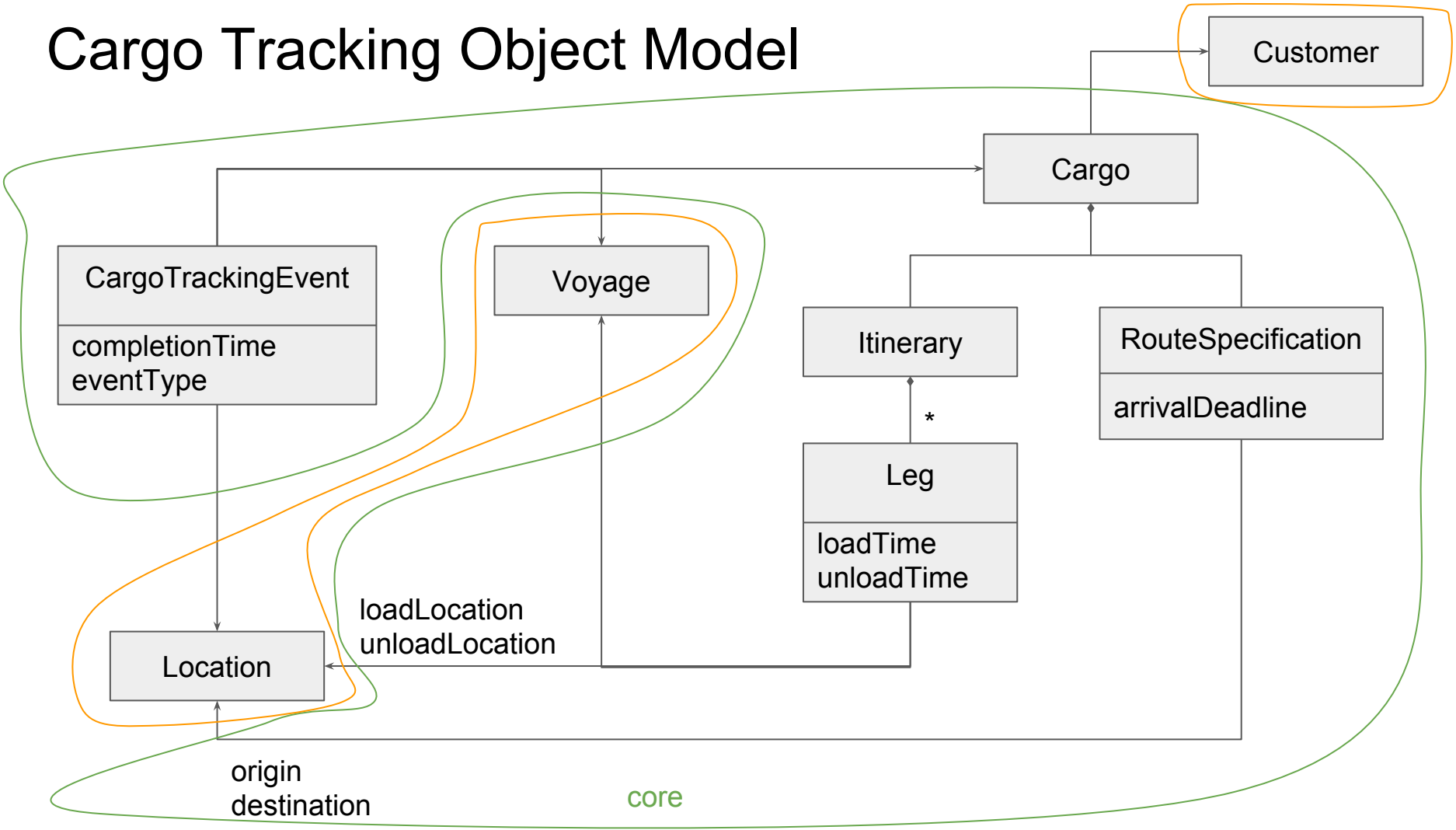
check_cargo.py

```
""" Check whether cargo reference is correct."""
from Cargo import Cargoes

cargoes = Cargoes.get_client()

def check_cargo(cargo):
   return cargoes.has_item(cargo)
```

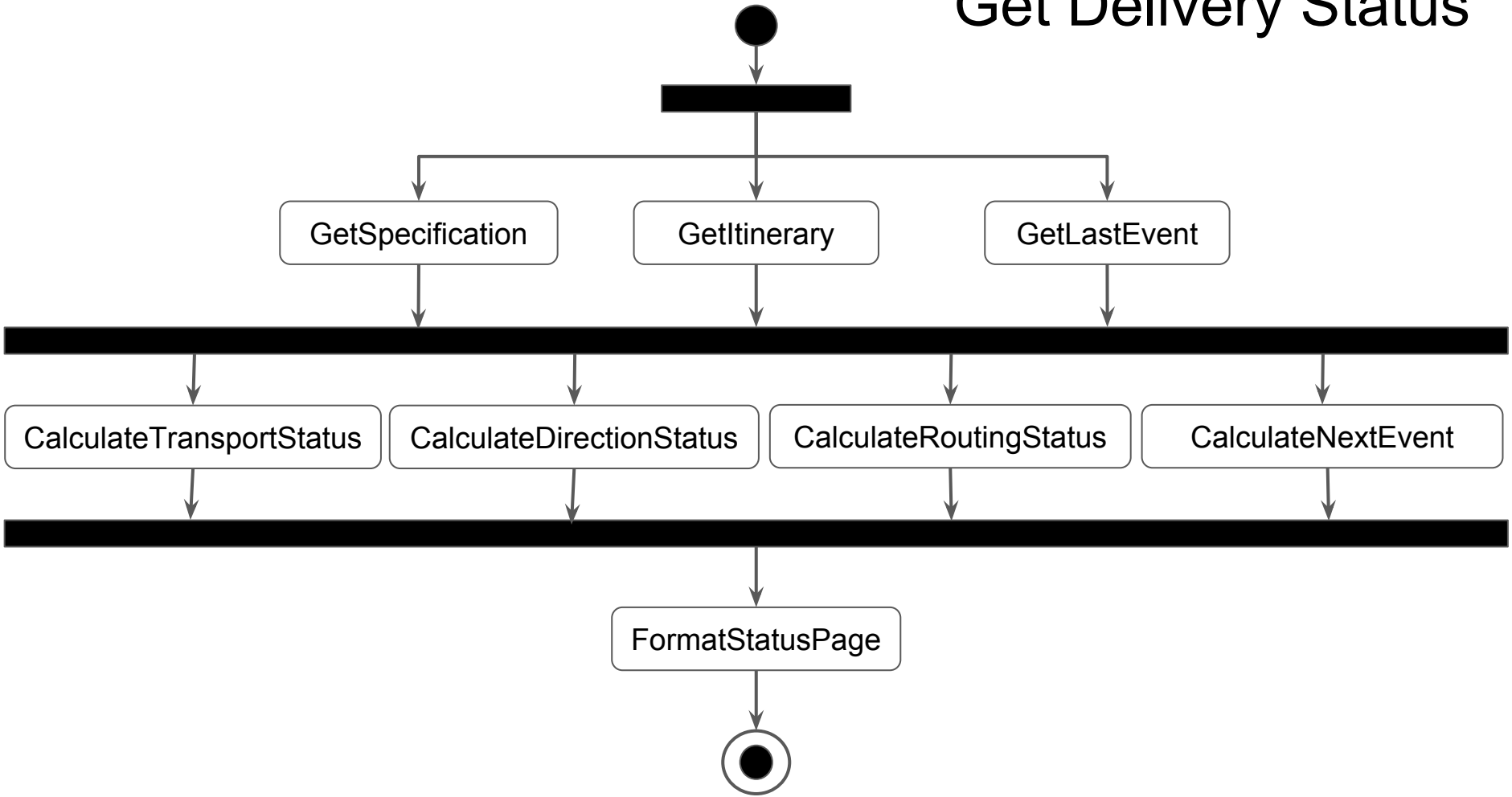
What About Other Use Cases?

Could we apply the same approach?

Cargo Tracking Object Model



Get Delivery Status



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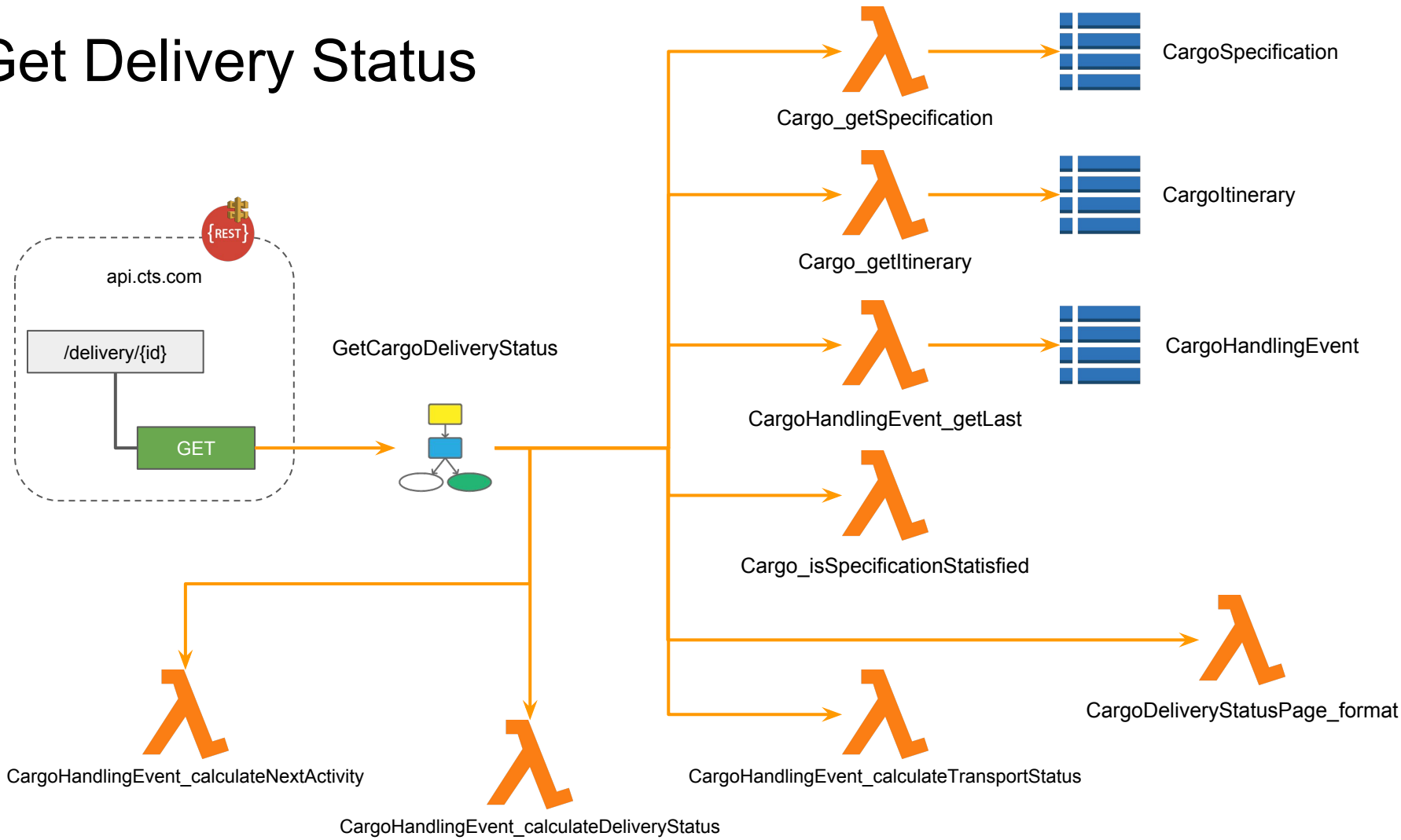


Now, We Speak Domain Language in the Code

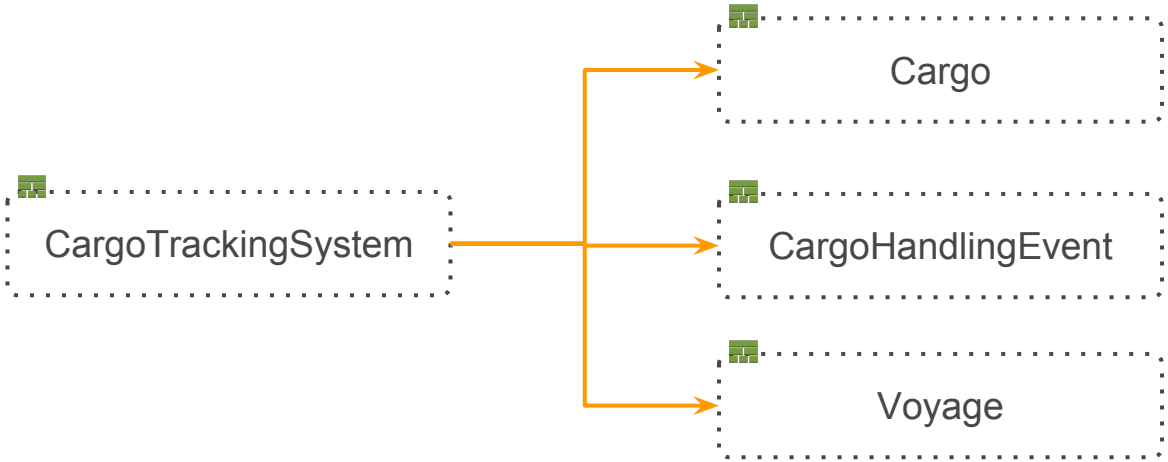
As we are supposed to

calculate_delivery_status.py

```python
"""Calculate cargo delivery status based on itinerary and the most recent event."""

from lib.Itinerary import Itinerary
import CargoHandlingEvent

def expected_at_interim_leg(last_event, itinerary):
    leg = itinerary.find(last_event)
    return (True, leg.is_on_schedule(last_event)) if leg else (False, '')

def expected_at_edge(last_event, leg):
    expected = leg.is_expected(last_event)
    return (expected, leg.is_on_schedule(last_event) if expected else '')

def expected_at_first_leg(last_event, itinerary):
    return expected_at_edge(last_event, itinerary.first())

def expected_at_final_leg(last_event, itinerary):
    return expected_at_edge(last_event, itinerary.last())

def default(last_event, itinerary):
    return (False, '')

def expect(last_event, itinerary):
    return {
        CargoHandlingEvent.RECEIVE: expected_at_first_leg,
        CargoHandlingEvent.LOAD:    expected_at_interim_leg,
        CargoHandlingEvent.UNLOAD:  expected_at_interim_leg,
        CargoHandlingEvent.CUSTOMS: expected_at_final_leg,
        CargoHandlingEvent.CLAIM:   expected_at_final_leg
    }.get(last_event.event_type, default)(last_event, itinerary)

def calculate_delivery_status(last_event, itinerary):
    if not itinerary: return 'UNKNOWN'
    (expected, on_schedule) = expect(last_event, Itinerary(itinerary))
    return on_schedule if expected else 'MISDIRECTED'

```

Polymorphism over Event Type

Cargo Tracking System (Micro?) Services



Missing Infrastructure Elements

- Conversion to/from JavaScript-style objects
- find() with predicate function
- Dropping None values from dict
- High-level encapsulation of managed services
- Automatic generation of SAM templates
- Automatic generation of Step Functions

Introducing Matte (Staff in Hebrew)

Staff of Moses that, upon command, was transformed to a snake, forth and back

Matte

Experimental Pyhton3 infrastructure toolkit to remove as much boilerplate from Serverless DDD code as possible

jso	lazy dict -> object conversion
find	list lookup with predicate
drop_nulls	remove None values from dict
make_handler	Automatic code generator of lambda_handler
make_sam_template	SAM template builder
Repository	DynamoDB resource descriptor
RepositoryClient	DynamoDB client with permissions
DecimalEncoder	Proper handling of Numeric fields
...	More to follow

Cargo Tracking System Subdomains

Core

Cargo, Specification, Itinerary, CargoHandlingEvent

Supporting Services

Voyage, Location

Generic Services

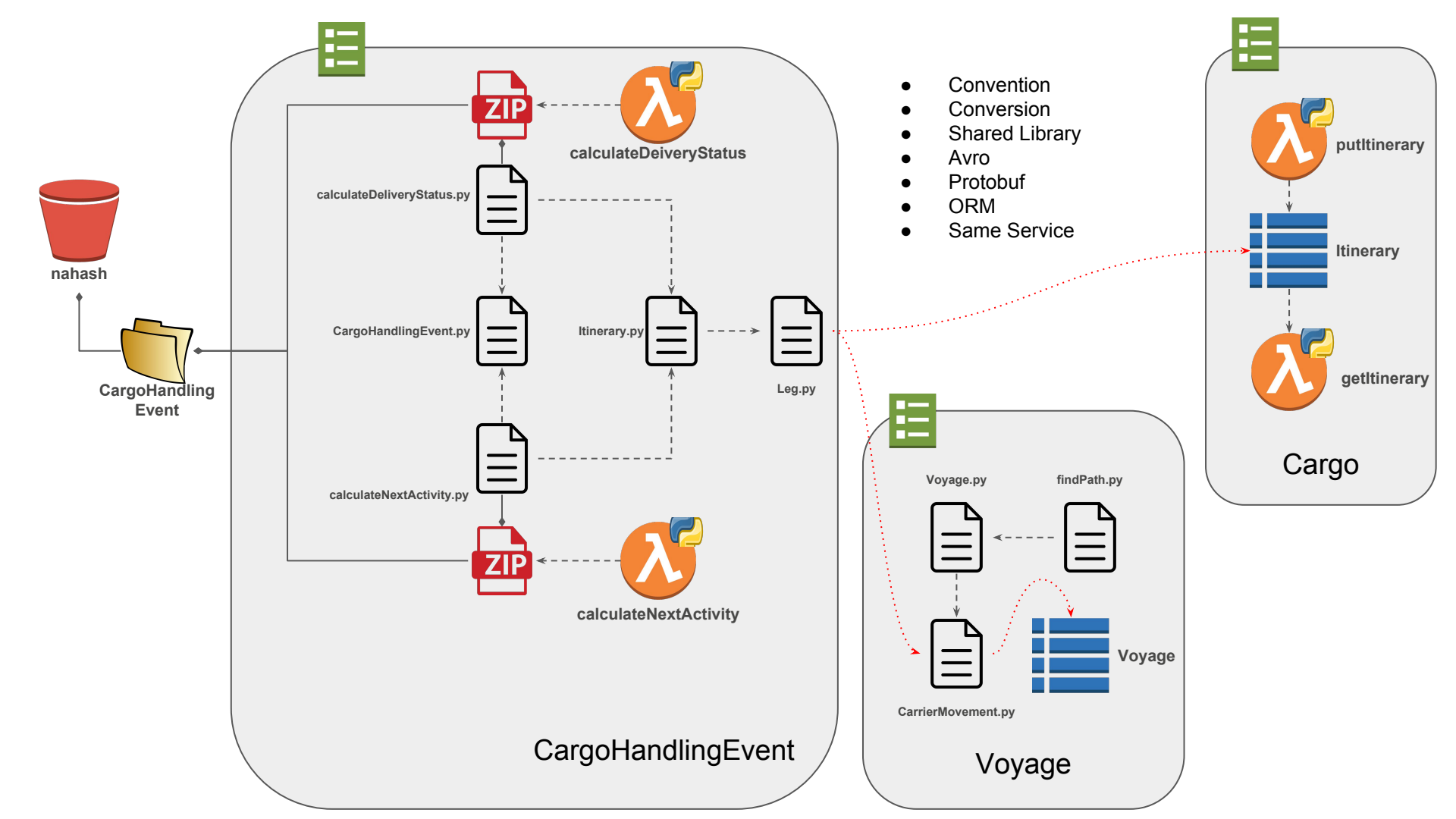
Matte

Software Architecture is a Context Mapping Process

From Use Cases to Core, to Supportive, to Generic sub-domains

Beware of Coupling

And always make it explicit


nahash
CargoHandling Event
ZIP
calculateDeiveryStatus
calculateDeliveryStatus.py
CargoHandlingEvent.py
Itinerary.py
Leg.py
calculateNextActivity.py
ZIP
calculateNextActivity
CargoHandlingEvent
Convention
Conversion
Shared Library
Avro
Protobuf
ORM
Same Service
putItinerary
Itinerary
getItinerary
Cargo
Voyage.py
findPath.py
Voyage
CarrierMovement.py
Voyage

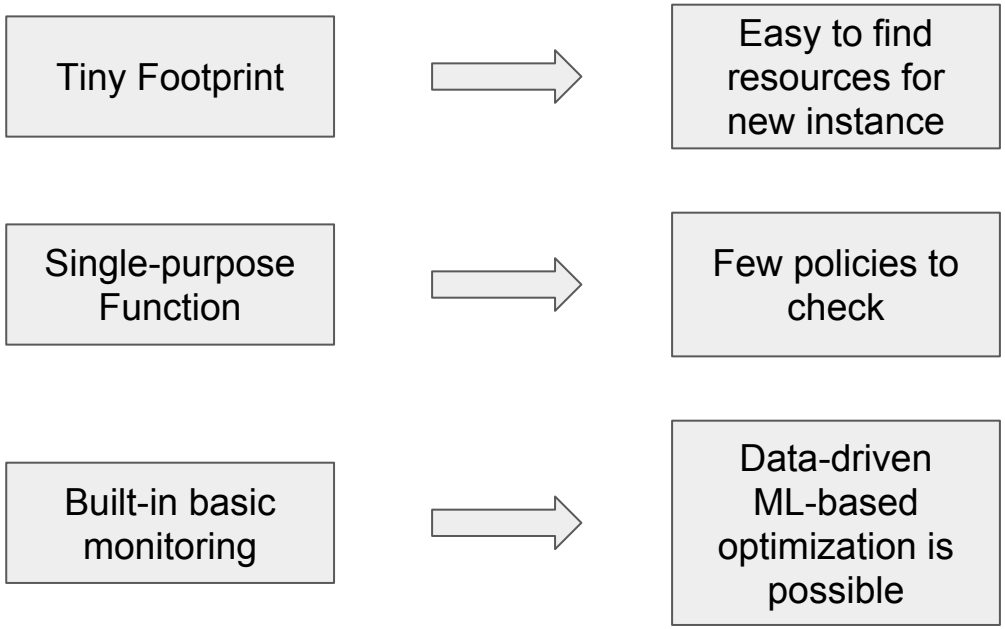
But isn’t this approach terribly inefficient?

Too many forth and backs between Step Function and Lambda

You never know until you measure

It might actually scale better than we think

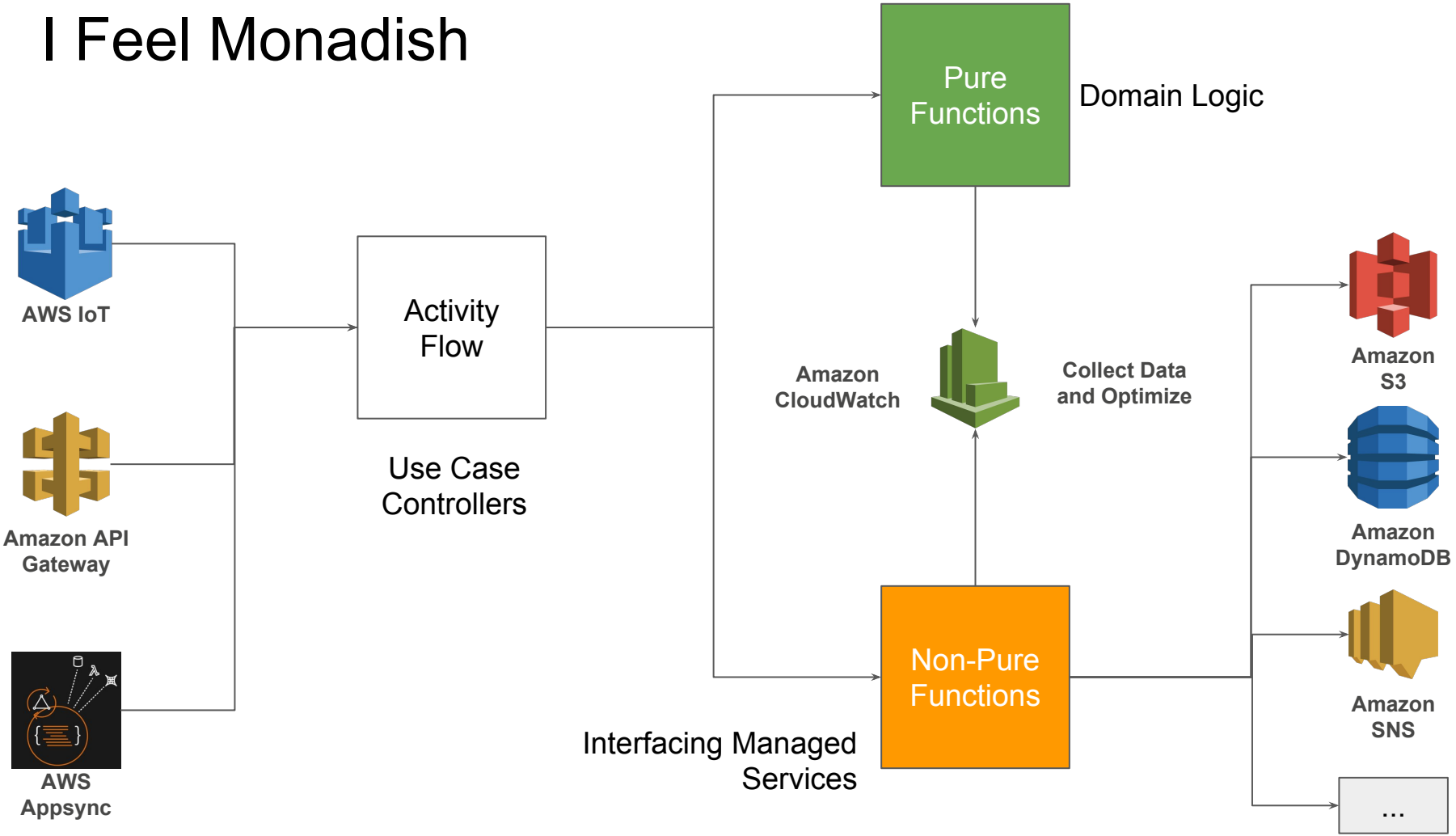
Why it might scale better?



What Comes After Serverless?

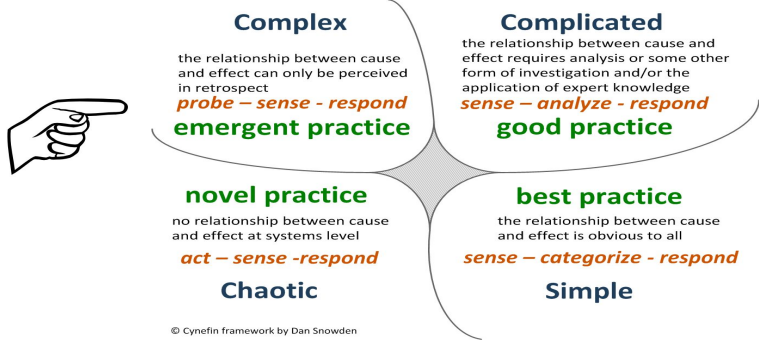
Some Wild Ideas, Inspired by this Research

I Feel Monadish



Maybe We Should Call it Threadless Architecture?

Who knows? Time will Tell.



Please, Disagree with Me

"Consensus is poisonous for innovation"

D. Snowden