Overview of Serverless Computing

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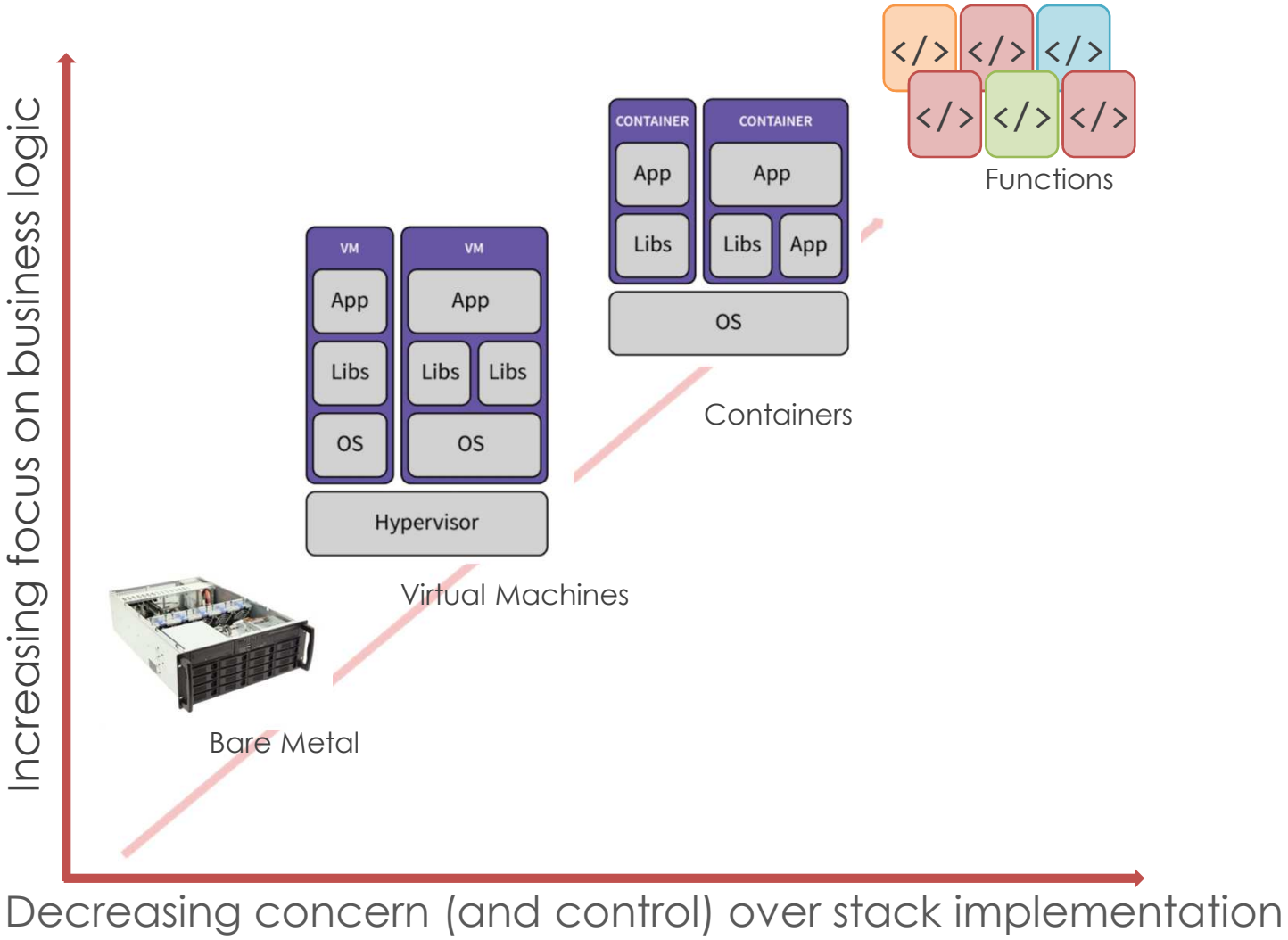
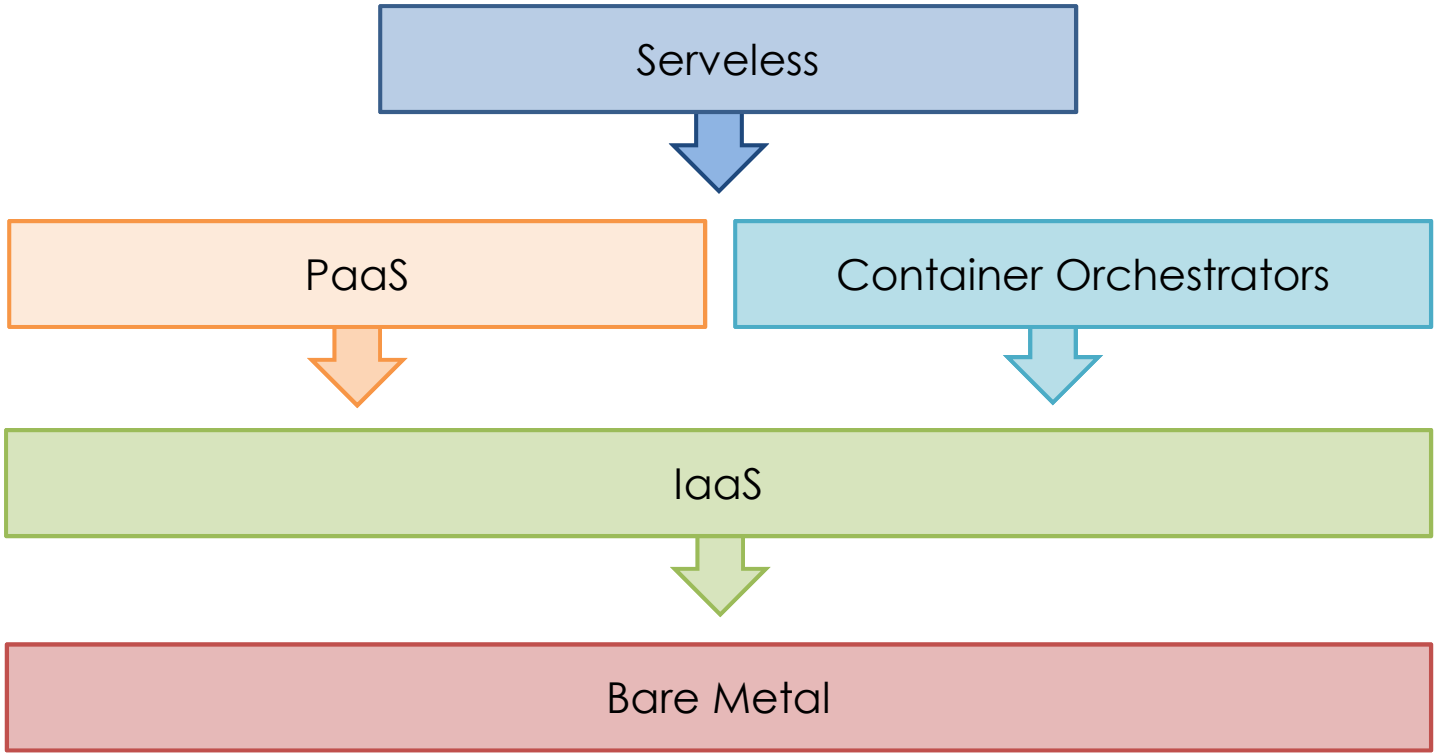
Table of Contents

- Cloud computing evolution
- What is serverless?
- Serverless patterns
- Serverless data analytics

Cloud Computing Evolution



Enter Serverless



Source: Paul Castro, Serverless Computing Tutorial for WoSC2.

What is Serverless?

As FAAS (Function-as-a-Service):

a cloud-native platform
FOR
short-running, stateless computation
AND
event- and (data-driven) applications
WHICH
scales up and down instantly and automatically
AND
charges for actual usage at a millisecond granularity

Source: Paul Castro, Serverless Computing Tutorial for WoSC2.

What is Serverless?

- Function ("Action")
  - Containerized custom-written application code
  - Should include bundled dependencies & binaries
  - Memory & execution time limits
- Triggers ("Events")
  - Causes function execution
  - Can be another function
  - Examples:
    - Upload of a video or image
    - Git commit to a repository
    - ...
- Resources
  - External BaaS/PaaS/FaaS services (object storage, queueing, elastic cache, etc.)

What is Serverless?

- Function example
  (pandas and numpy are dependencies)

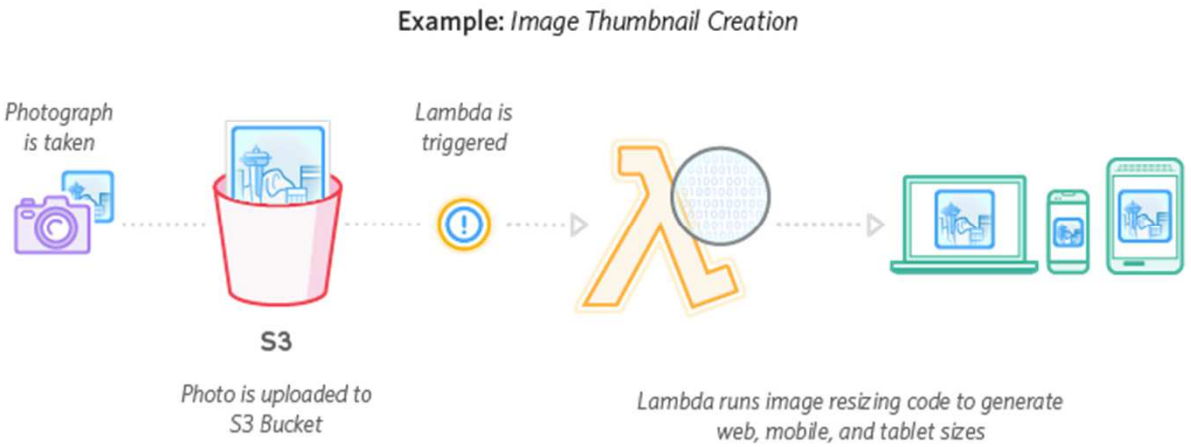
```
import pandas as pd
import numpy as np

def main(args):
    dates = pd.date_range('20130101', periods=2)
    df = pd.DataFrame(np.random.randn(2,2), index=dates,
columns=list('AB'))
    print(df)
    return df.to_dict('split')
```

```
In  [12]: df
Out[12]:
                   A        B
2013-01-01  0.468173  0.64710
2013-01-02 -0.297858 -0.07476
```

Serverless Pattern

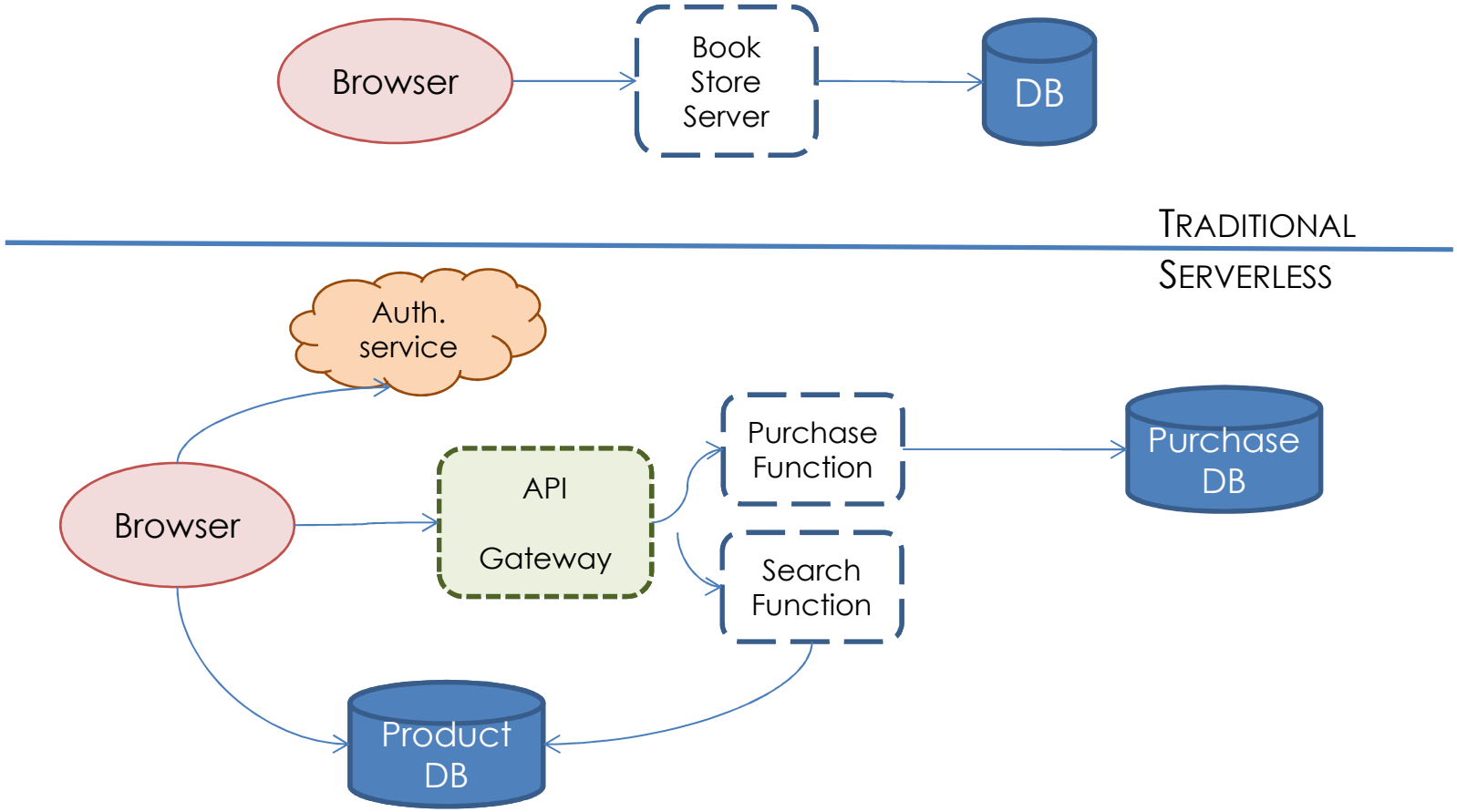
- An application is architected as a set of business logic functions, triggered by discrete events or requests



- Good for microservices, IoT, modest stream processing, ML inferencing, etc.

Serverless Pattern

- Another good example is a typical e-commerce app



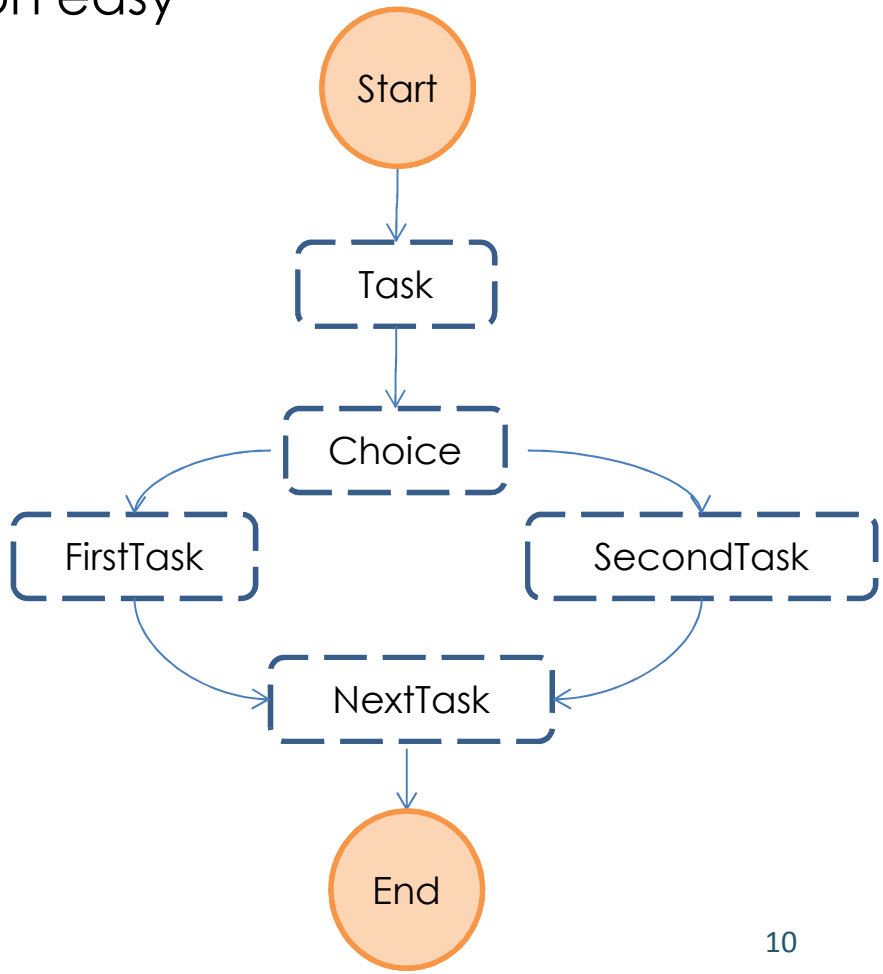
Example from https://martinfowler.com/articles/serverless.html

Serverless Pattern

- Also, there is tools such as AWS Step Functions that make function and workflow orchestration easy

- State Example: Choice

```
"Choice": {
    "Type": "Choice",
    "Choices": [
        {
            "Variable": "$.foo",
            "NumericEquals": 1,
            "Next": "FirstTask"
        },
        {
            "Variable": "$.foo",
            "NumericEquals": 2,
            "Next": "SecondTask"
        }
    ]}
```



Why is Serverless (Un)attractive?

	On-premise	VMs	Containers	Serverless
Time to provision	Weeks-Months	Minutes	Seconds-minutes	Milliseconds
Utilization	Low	High	Higher	Highest
Charging granularity	CapEx	Hours	Minutes	Interval of milliseconds

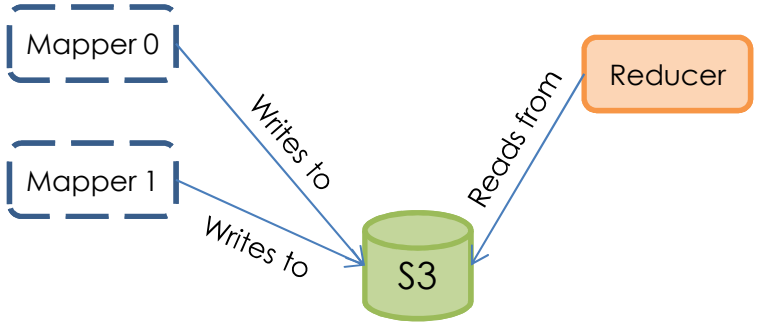
- The Good
  - Removal of the need for a traditional always-on servers
  - Making app development dramatically faster, cheaper, easier
  - Highly available and scalable apps with zero administration
- The Bad
  - No in-server state for serverless functions
  - Limited computation times and memory can entail app refactoring
  - Functions are not directly network-addressable

Table source: Jason McGee, IBM; Serverless Conference 2017.

SERVERLESS DATA ANALYTICS

Serverless Data Analytics?

- Abide by the functional programming paradigm:
  - Embarrassingly parallel functions
  - Immutable data through "slow" storage (e.g., S3)
  - PyWren† and ExCamera‡ research projects show that functions can perform a wider variety of such "map" functions
  - PyWren†'s word count job on 83M items is only 17% slower than PySpark running on dedicated servers



† Occupy the Cloud: Distributed Computing for the 99%. ACM SOCC 2017

‡ Encoding, Fast and Slow: Low-Latency Video Processing Using Thousands of Tiny Threads. USENIX NSDI 2017

Serverless Data Analytics?

- One can do a lot of things with a map(function, data)

```
def addone(x):
    return x + 1

wrenexec= pywren.default_executor()
data = range(1, 10)
futures = wrenexec.map(addone, data)

Output: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

- Functional, declarative programming models simplify consistency and fault tolerance
- Domain experts tend to write imperative programs
  - Java, Matlab, C++, R, Python, Fortran, ...
- Mismatch between experts' coding skills and analytics

Serverless Data Analytics?

- Imperative programming model with mutable data shall lower the barrier to large-scale (scientific) computation
  - existing, optimized, single-machine code running on the cloud

```
from cloudbutton import parallel, prange

@parallel
def summation(A):
    s = 0
    for i in prange(len(A)):
        s += A[i]
    return s
```

Shared variable (s)

Explicit parallel loop (prange)

Serverless Data Analytics?

- Large state won't fit into a single function
- How to manage large state with functions?
  - No direct communication between serverless functions
  - Fast access to remote shared state
  - Shared state should permit efficient fine-grained updates
- Pocket† research project has shown fast ephemeral data sharing in serverless analytics workloads is possible
  - Sub-millisecond latency
  - Yet, don't easily support all the use cases

† Pocket: Elastic Ephemeral Storage for Serverless Analytics. USENNIX OSDI 2018

THANK YOU!

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