Serverless Computing

CS 4740: Cloud Computing

Fall 2024

Lecture 14

Yue Cheng

University of Virginia

Some material taken/derived from:

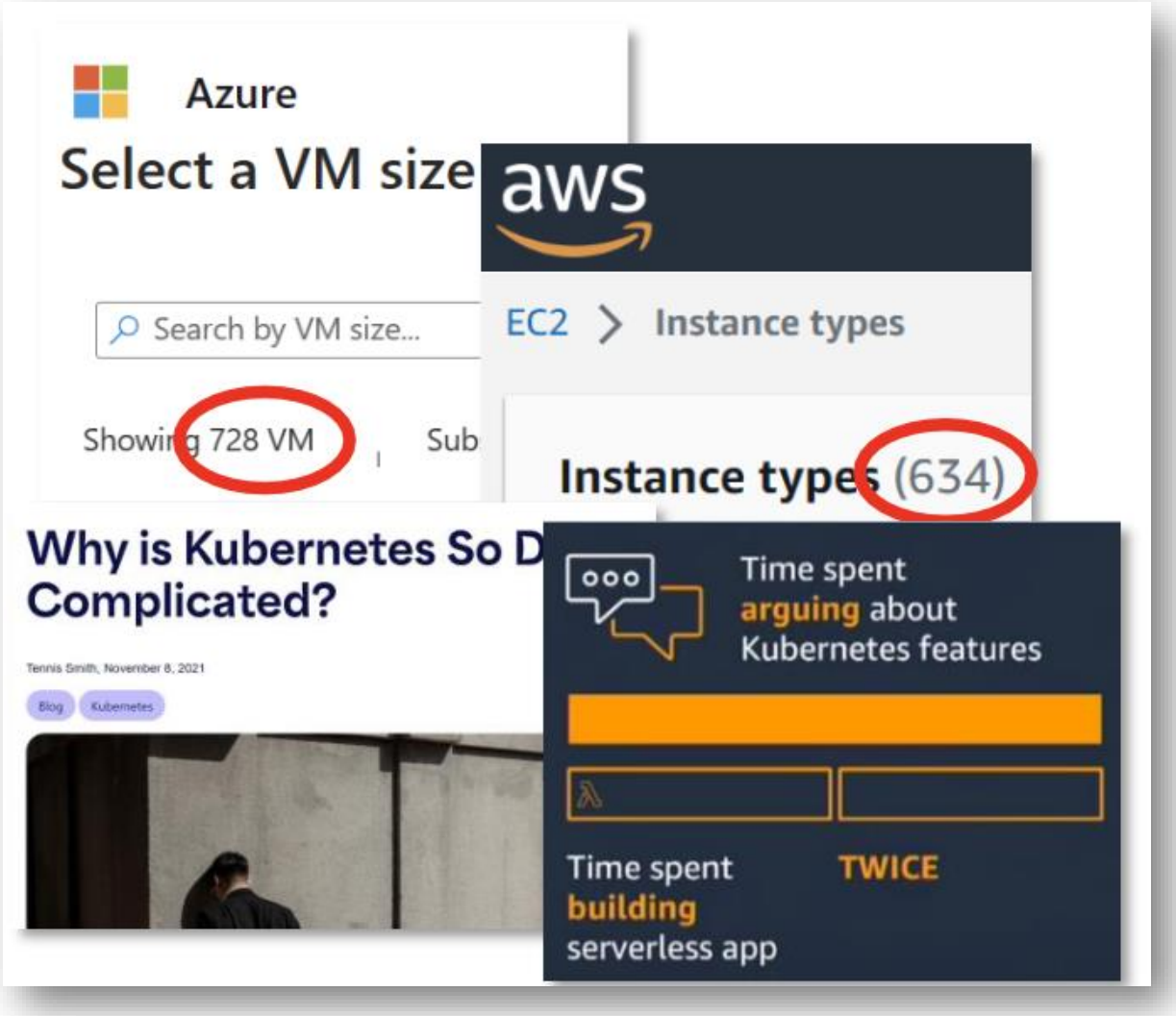
- Berkeley CS 262a (Spring '18) by Ali Ghodsi and Ion Stoica;
- Tyler Harter's HotCloud '18 OpenLambda talk;

Motivation

When to use the cloud?

- Data
  - Large amounts of data – can't store locally
  - Shared data across users
  - Long-term storage

- Compute
  - Need lots of CPUs for data processing
  - Varying computing demands (resources)
  - No admin (for managing your local hardware)


Azure
Select a VM size
Search by VM size...
Showing 728 VM
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Why is Kubernetes So D
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Kubernetes
Time spent
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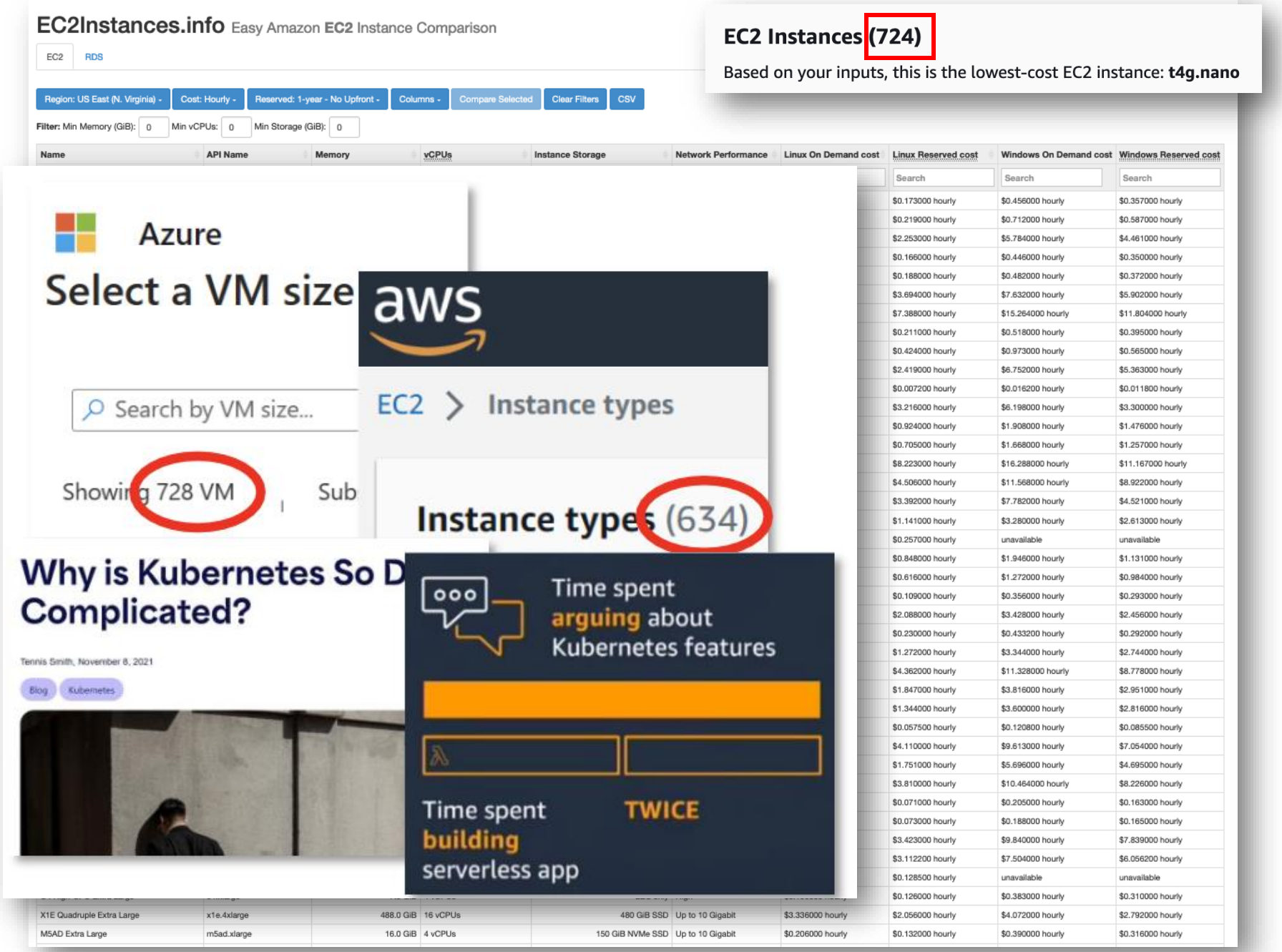
TWICE


EC2Instances.info Easy Amazon EC2 Instance Comparison
EC2
RDS
Region: US East (N. Virginia)
Cost: Hourly
Reserved: 1-year - No Upfront
Columns
Compare Selected
Clear Filters
CSV
Filter: Min Memory (GiB): 0 Min vCPUs: 0 Min Storage (GiB): 0
EC2 Instances (724)
Based on your inputs, this is the lowest-cost EC2 instance: t4g.nano
Name
API Name
Memory
vCPUs
Instance Storage
Network Performance
Linux On Demand cost
Linux Reserved cost
Windows On Demand cost
Windows Reserved cost
Search
Search
Search
$0.173000 hourly $0.456000 hourly $0.357000 hourly
$0.219000 hourly $0.712000 hourly $0.587000 hourly
$2.253000 hourly $5.784000 hourly $4.461000 hourly
$0.166000 hourly $0.446000 hourly $0.350000 hourly
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$3.694000 hourly $7.632000 hourly $5.902000 hourly
$7.388000 hourly $15.264000 hourly $11.804000 hourly
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$3.216000 hourly $6.198000 hourly $3.300000 hourly
$0.924000 hourly $1.908000 hourly $1.476000 hourly
$0.705000 hourly $1.668000 hourly $1.257000 hourly
$8.223000 hourly $16.288000 hourly $11.167000 hourly
$4.506000 hourly $11.568000 hourly $8.922000 hourly
$3.392000 hourly $7.782000 hourly $4.521000 hourly
$1.141000 hourly $3.280000 hourly $2.613000 hourly
$0.257000 hourly unavailable unavailable
$0.848000 hourly $1.946000 hourly $1.131000 hourly
$0.616000 hourly $1.272000 hourly $0.984000 hourly
$0.109000 hourly $0.356000 hourly $0.293000 hourly
$2.088000 hourly $3.428000 hourly $2.456000 hourly
$0.230000 hourly $0.433200 hourly $0.292000 hourly
$1.272000 hourly $3.344000 hourly $2.744000 hourly
$4.362000 hourly $11.328000 hourly $8.778000 hourly
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$0.073000 hourly $0.188000 hourly $0.165000 hourly
$3.423000 hourly $9.840000 hourly $7.839000 hourly
$3.112200 hourly $7.504000 hourly $6.056200 hourly
$0.128500 hourly unavailable unavailable
$0.126000 hourly $0.383000 hourly $0.310000 hourly
X1E Quadruple Extra Large x1e.4xlarge 488.0 GiB 16 vCPUs 480 GiB SSD Up to 10 Gigabit $3.336000 hourly $2.056000 hourly $4.072000 hourly $2.792000 hourly
M5AD Extra Large m5ad.xlarge 16.0 GiB 4 vCPUs 150 GiB NVMe SSD Up to 10 Gigabit $0.206000 hourly $0.132000 hourly $0.390000 hourly $0.316000 hourly
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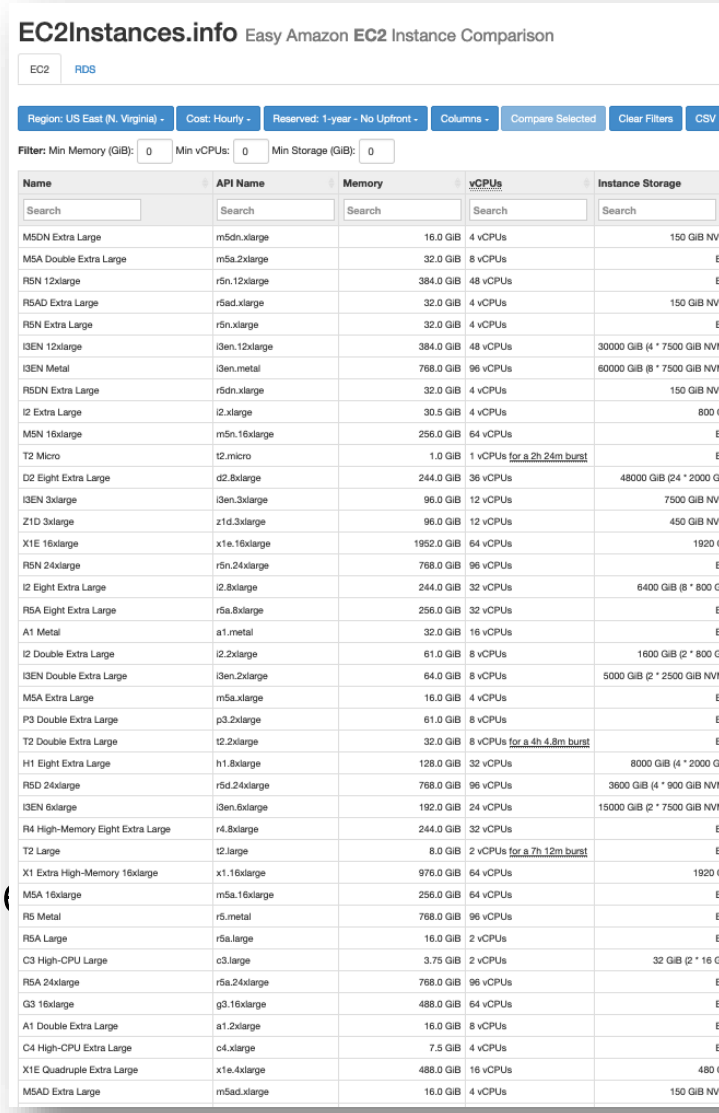
1. What type of instances?
2. How many to spin up?
3. What base image?
4. On-demand or spot?
5. What storage service to use?
6. And then wait to start…
7. Not the end of the horror story:
    1. When to scale out?
    2. When to scale in?
    3. When to switch to different instance types?
8. Go back to Step 1…



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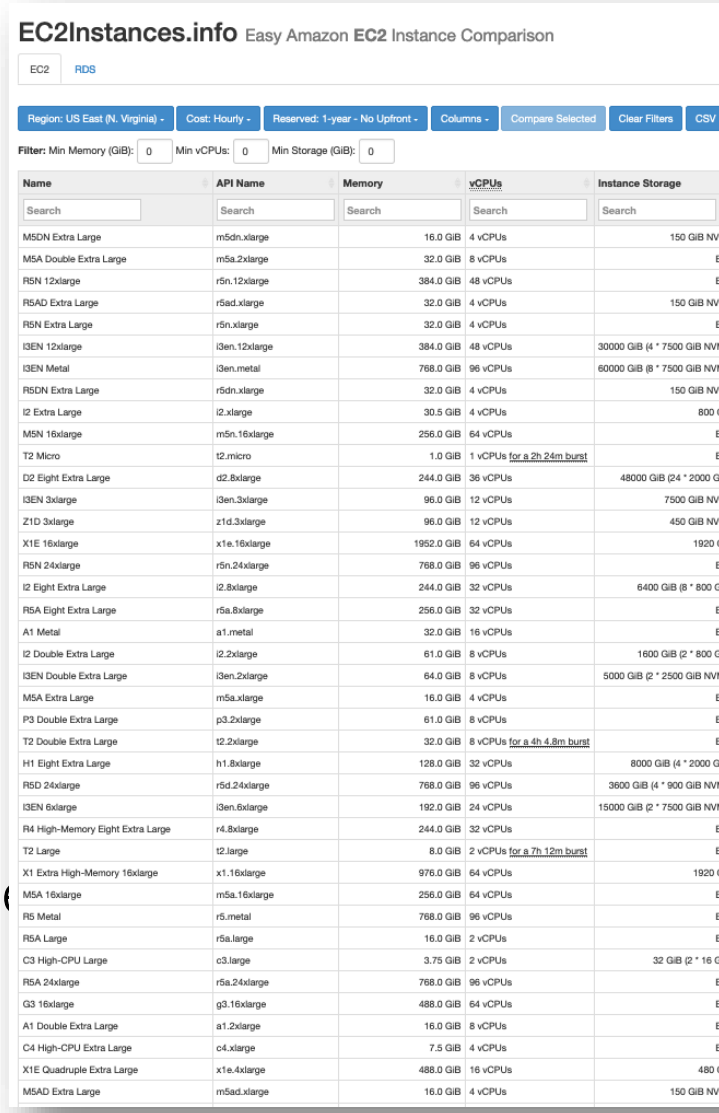

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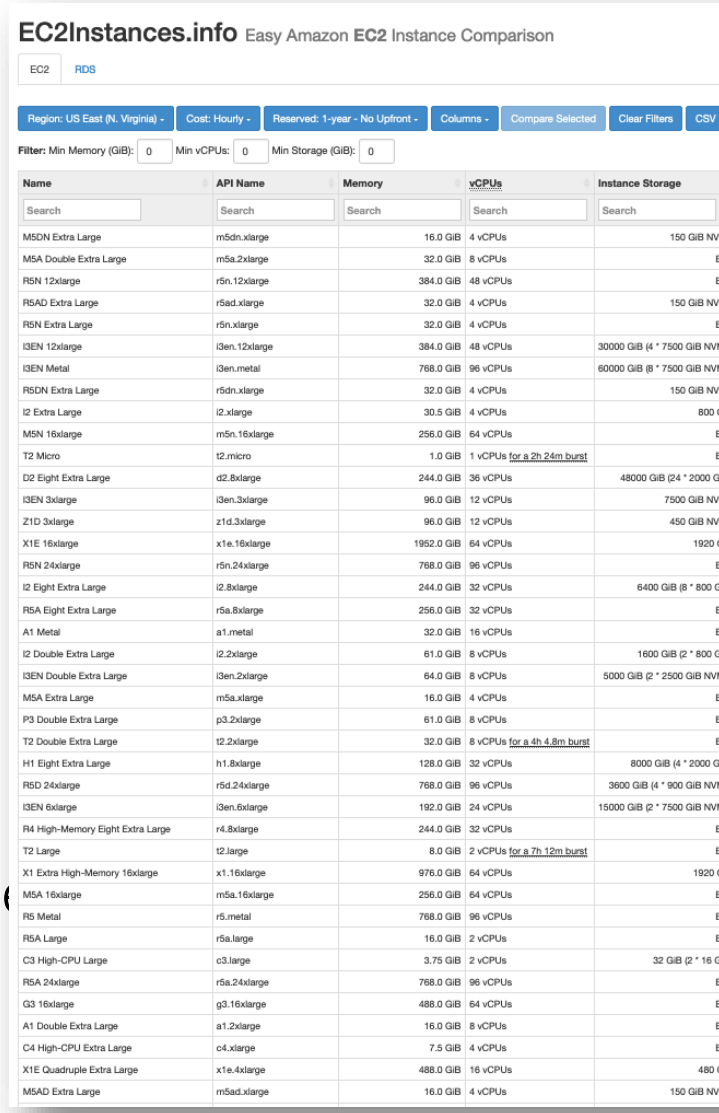

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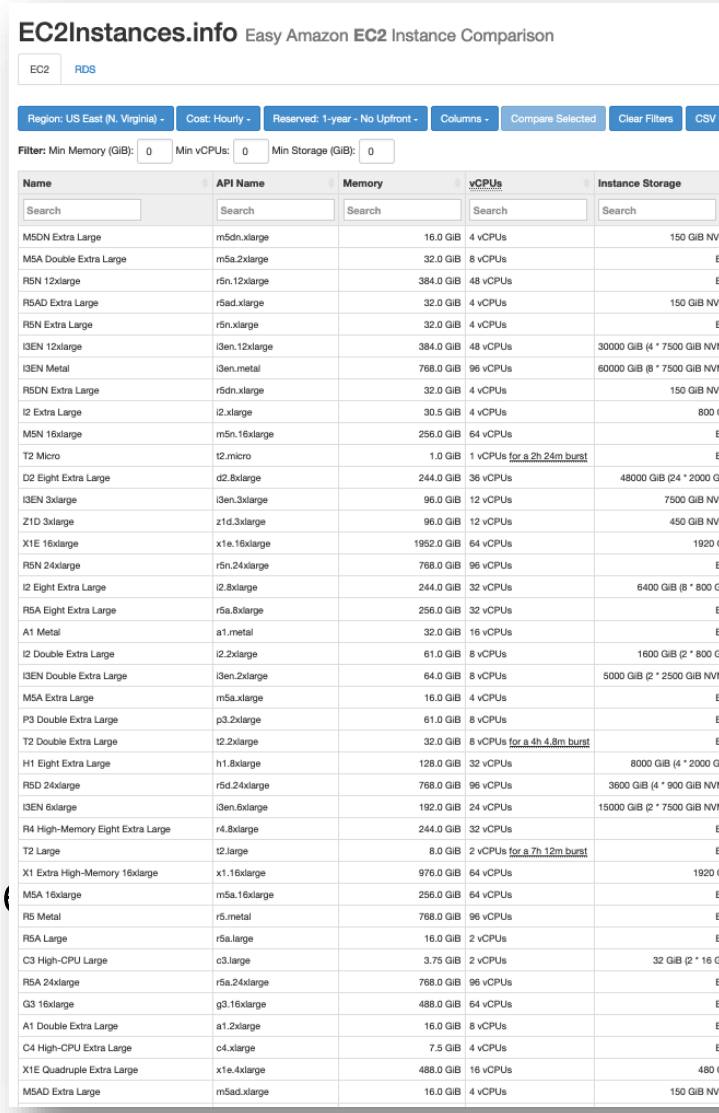

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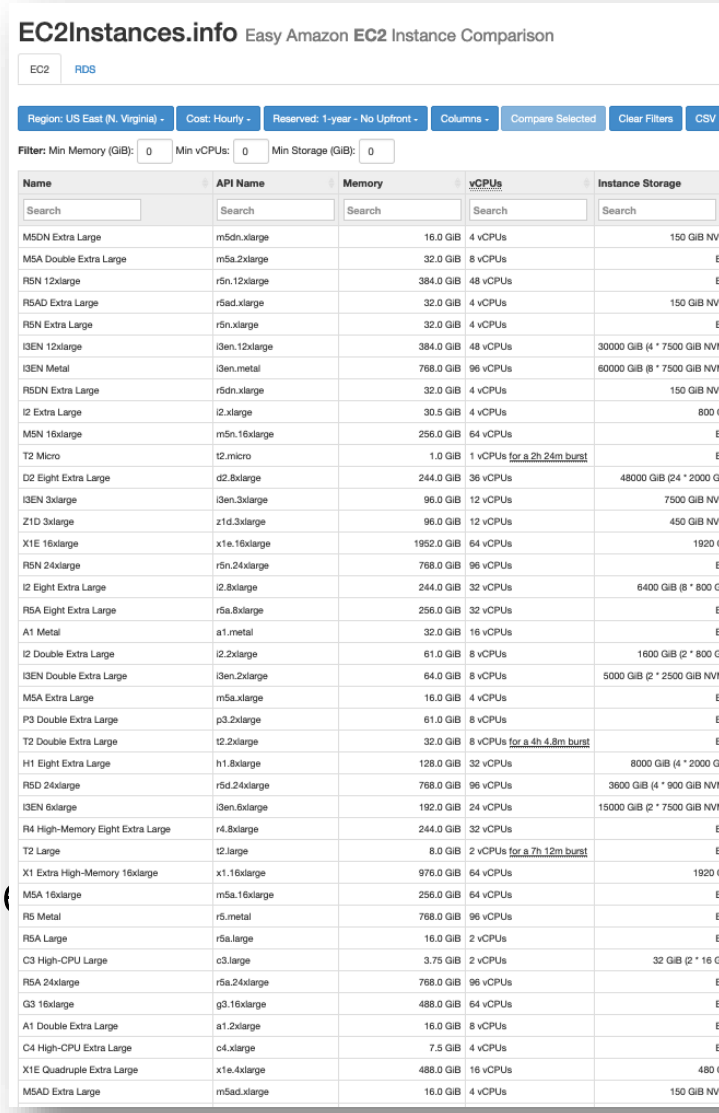

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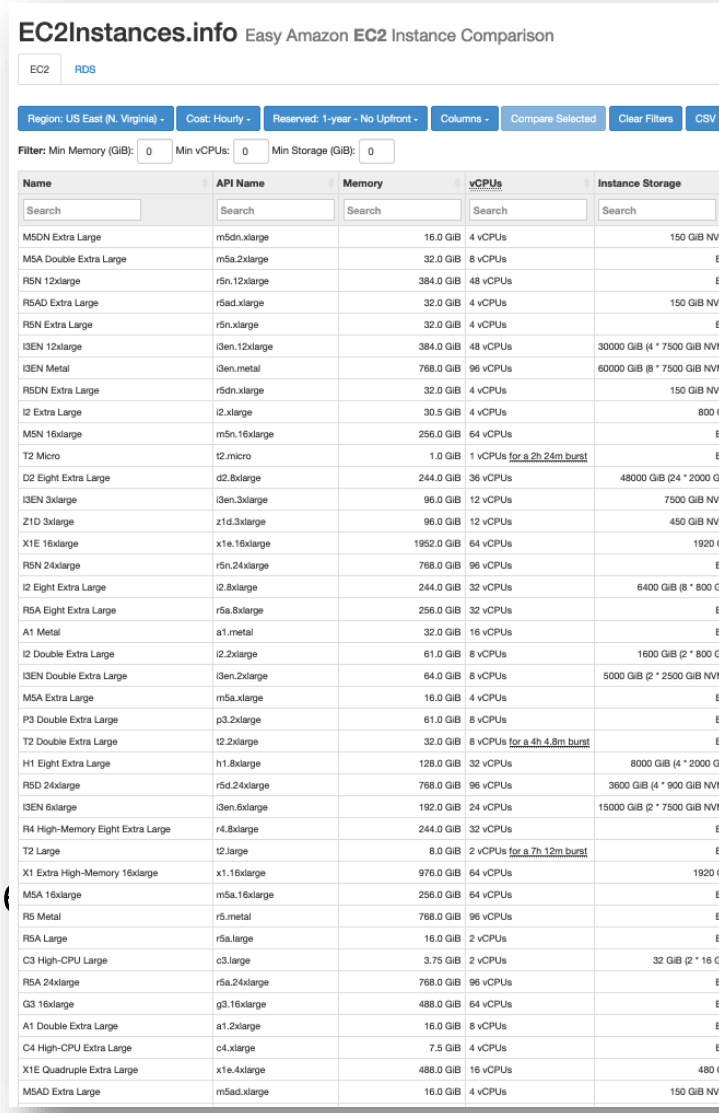

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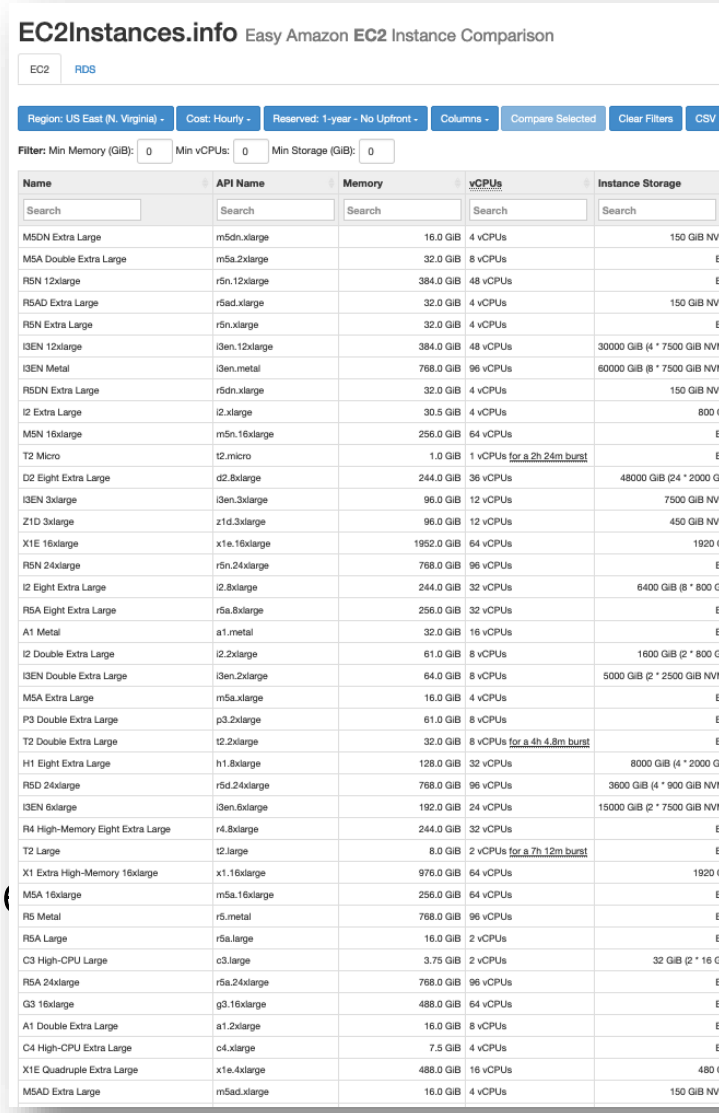

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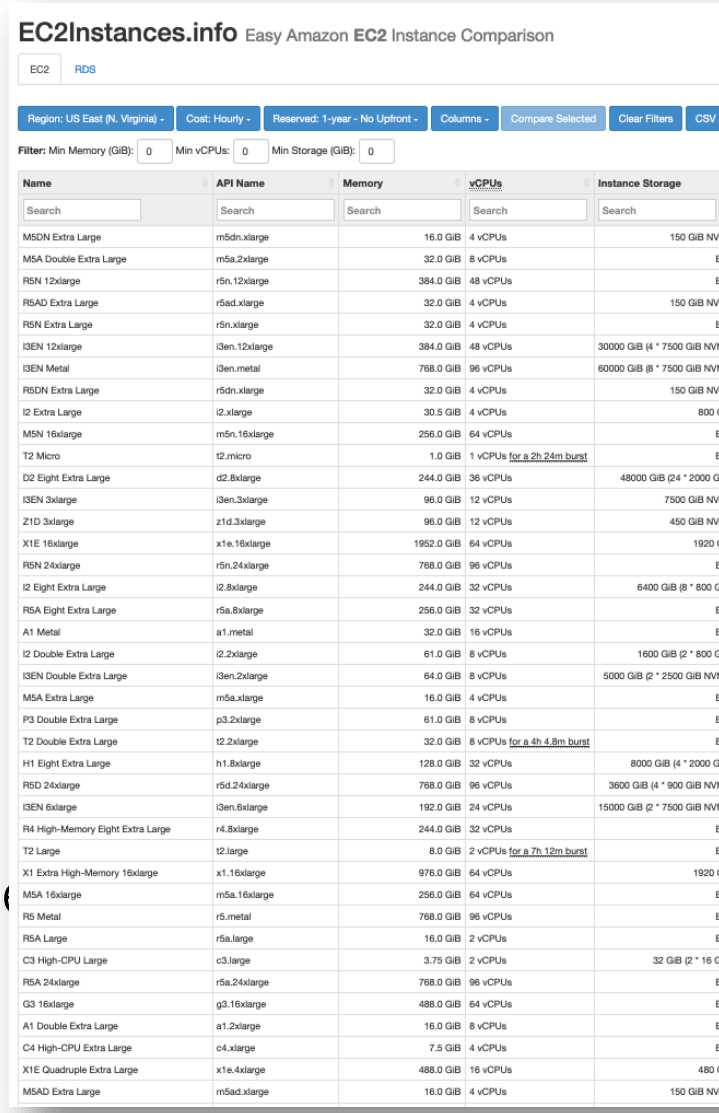

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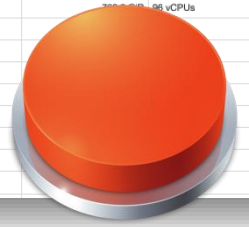
R5A Eight Extra Large	r5a.8xlarge	256.0 GiB	32 vCPUs	E
A1 Metal	a1.metal	32.0 GiB	16 vCPUs	E
I2 Double Extra Large	i2.2xlarge	61.0 GiB	8 vCPUs	1600 GiB (2 * 800 G
I3EN Double Extra Large	i3en.2xlarge	64.0 GiB	8 vCPUs	5000 GiB (2 * 2500 GiB NVI
M5A Extra Large	m5a.xlarge	16.0 GiB	4 vCPUs	E
P3 Double Extra Large	p3.2xlarge	61.0 GiB	8 vCPUs	E
T2 Double Extra Large	t2.2xlarge	32.0 GiB	8 vCPUs for a 4h 4.8m burst	E
H1 Eight Extra Large	h1.8xlarge	128.0 GiB	32 vCPUs	8000 GiB (4 * 2000 G
R5D 24xlarge	r5d.24xlarge	768.0 GiB	96 vCPUs	3600 GiB (4 * 900 GiB NVI
I3EN 6xlarge	i3en.6xlarge	192.0 GiB	24 vCPUs	15000 GiB (2 * 7500 GiB NVI
R4 High-Memory Eight Extra Large	r4.8xlarge	244.0 GiB	32 vCPUs	E
T2 Large	t2.large	8.0 GiB	2 vCPUs for a 7h 12m burst	E
X1 Extra High-Memory 16xlarge	x1.16xlarge	976.0 GiB	64 vCPUs	1920 G
M5A 16xlarge	m5a.16xlarge	256.0 GiB	64 vCPUs	E
R5 Metal	r5.metal		96 vCPUs	E
R5A Large	r5a.large			E
				32 GiB (2 * 16 G
				E
				E
				E
				E
				480 G
M5AD Extra Large	m5ad.xlarge			150 GiB NV



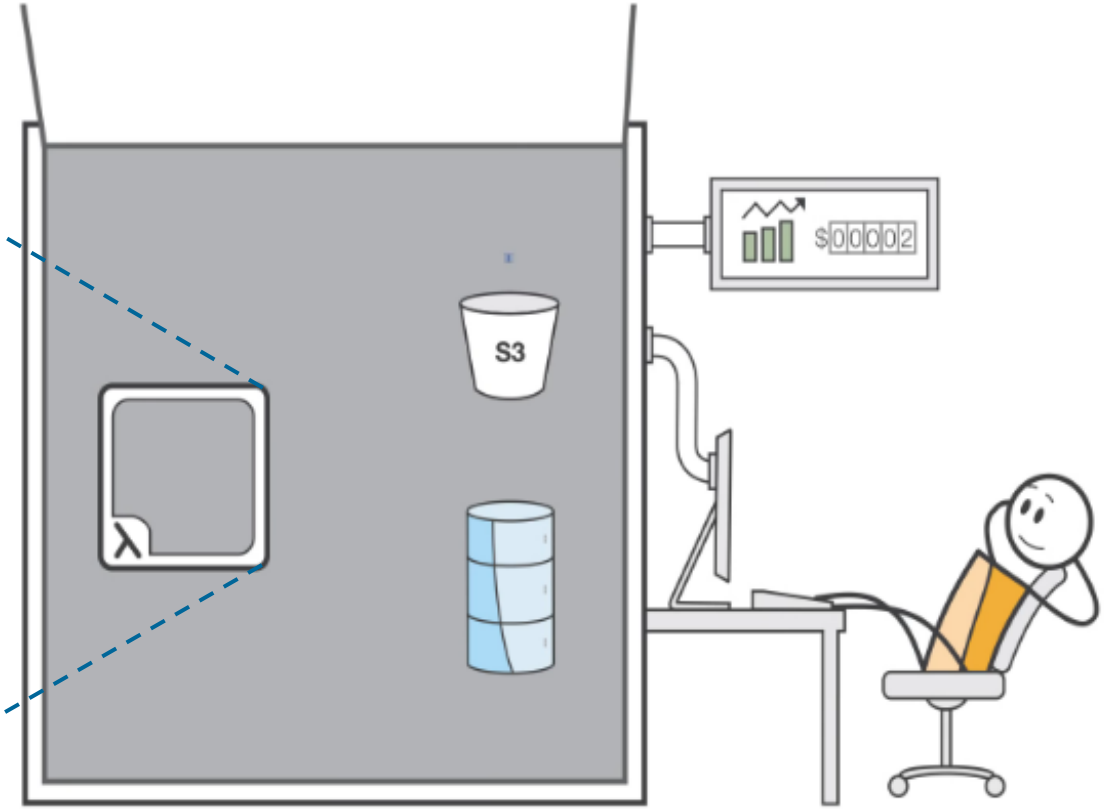
Why is there no “cloud button”?

~~Decision paralysis??~~
Go for Serverless!

Amazon
Lambda

Google Cloud Functions

Microsoft Azure Functions



What is serverless computing?

What is serverless computing?

Serverless computing (Function-as-a-Service, or FaaS) is a programming abstraction that enables users to upload programs, run them at (virtually) any scale, and pay only for the resources used

A car analogy

https://www.slideshare.net/loige/building-a-serverless-company-with-nodejs-react-and-the-serverless-framework-jsday-2017-verona

Concept of serverless is not new

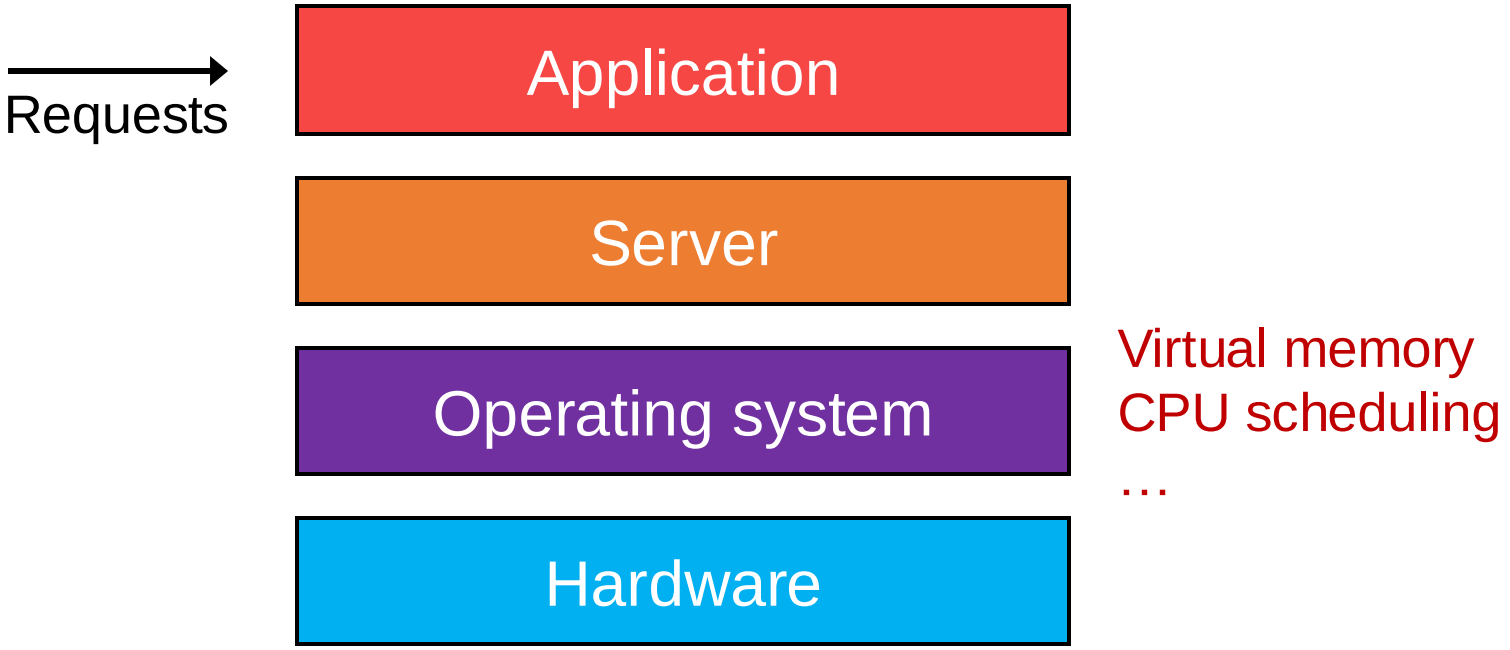
- Google App Engine
  - Fully managed platform as a service (PaaS) for developing and hosting web applications

- Google BigQuery
  - Fully managed data warehouse
  - “Arbitrarily” large data and queries
  - Pay per byte being processed
  - No concept of server or cluster

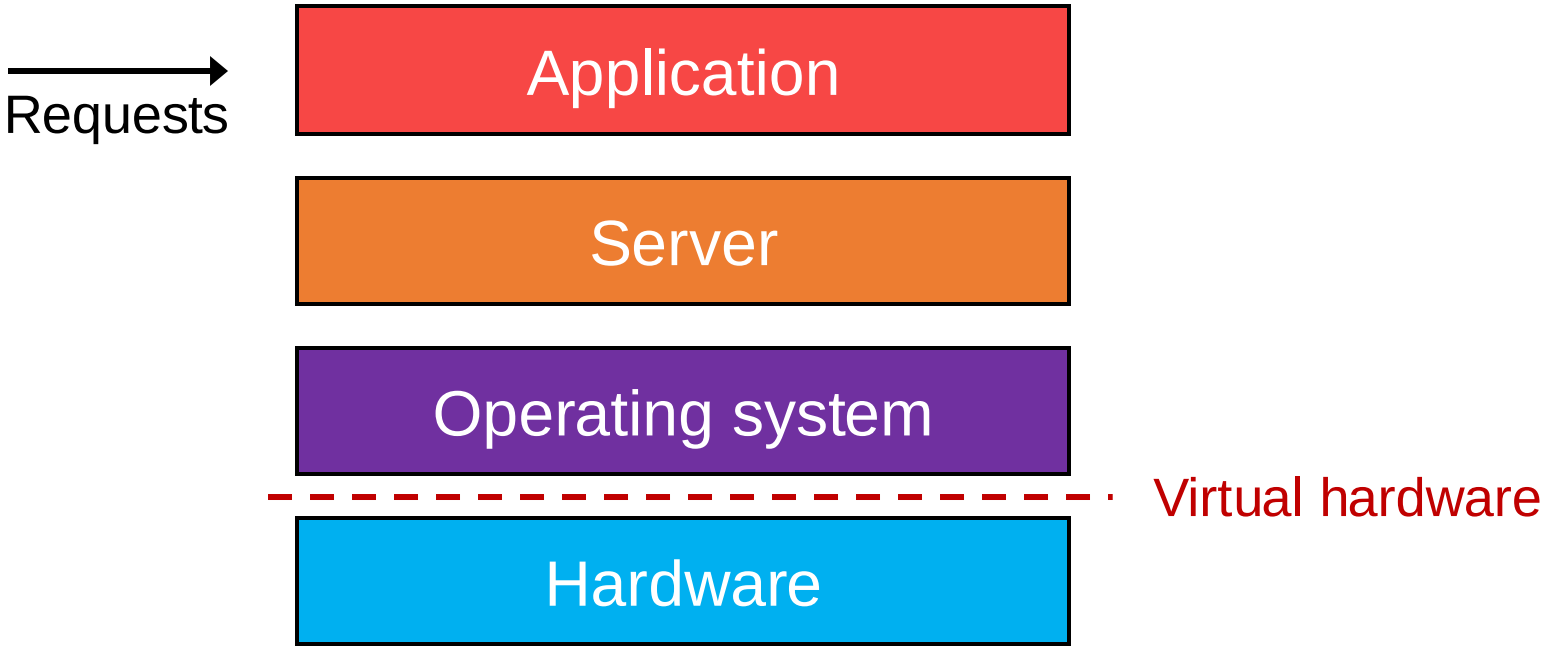
- AWS S3
  - Fully managed object storage service
  - Pay per byte being stored and written
  - No server maintenance or resource scaling

Recap: Cloud evolution history – A virtualization story

Classic cloud app stack



1st generation: virtual machine (VM)



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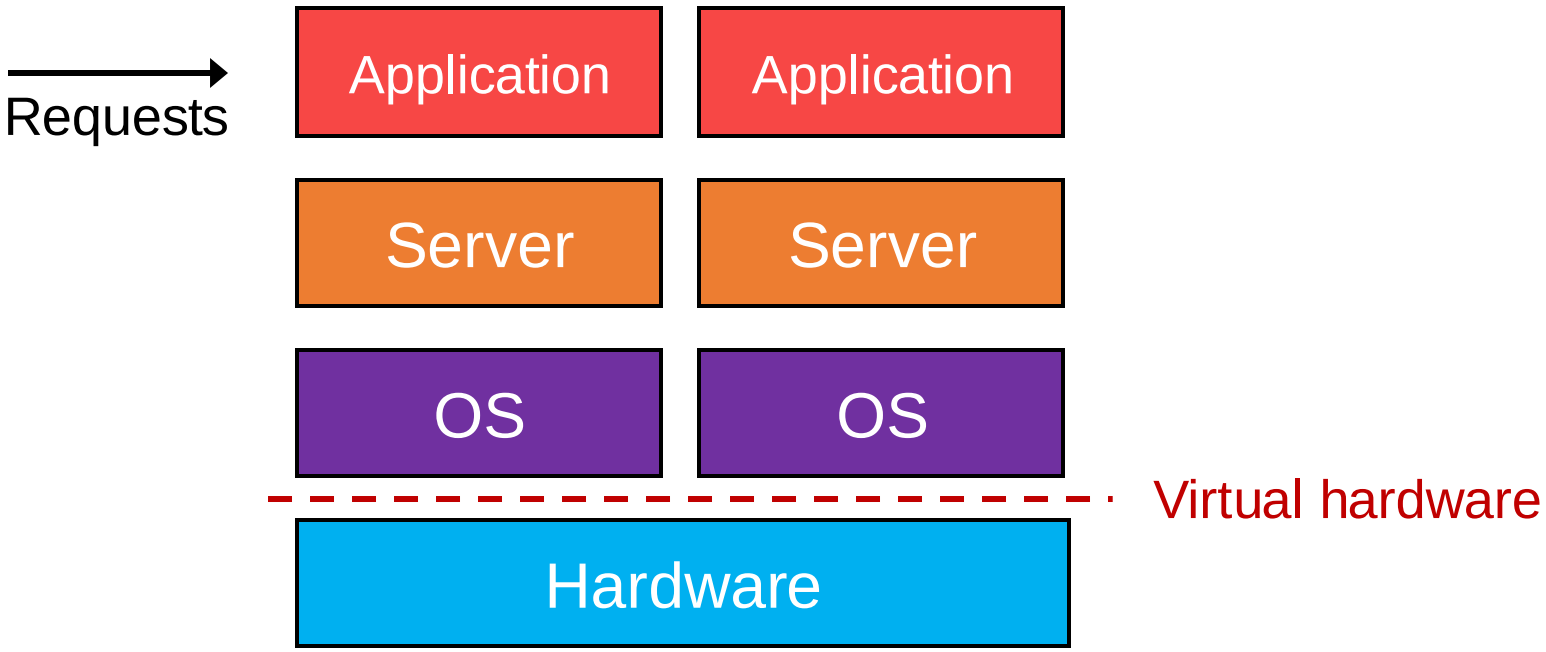
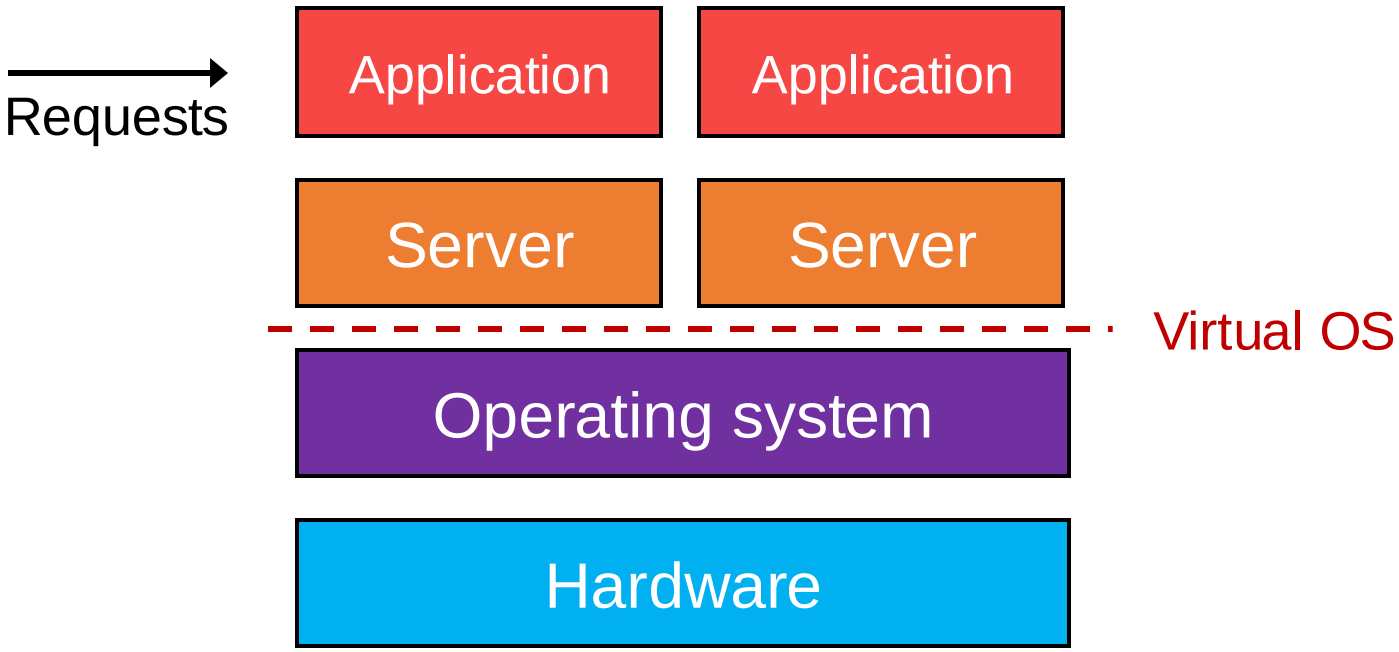
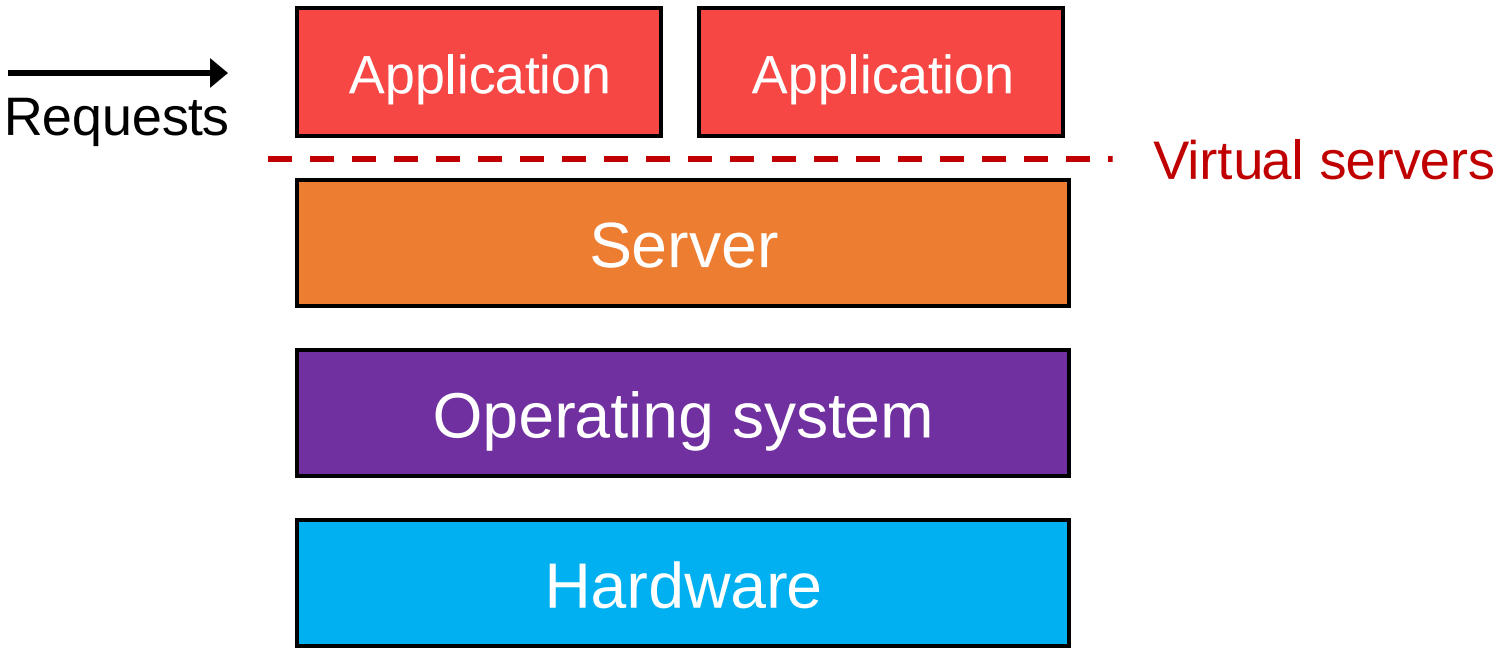


2nd generation: containers



3rd generation: serverless functions



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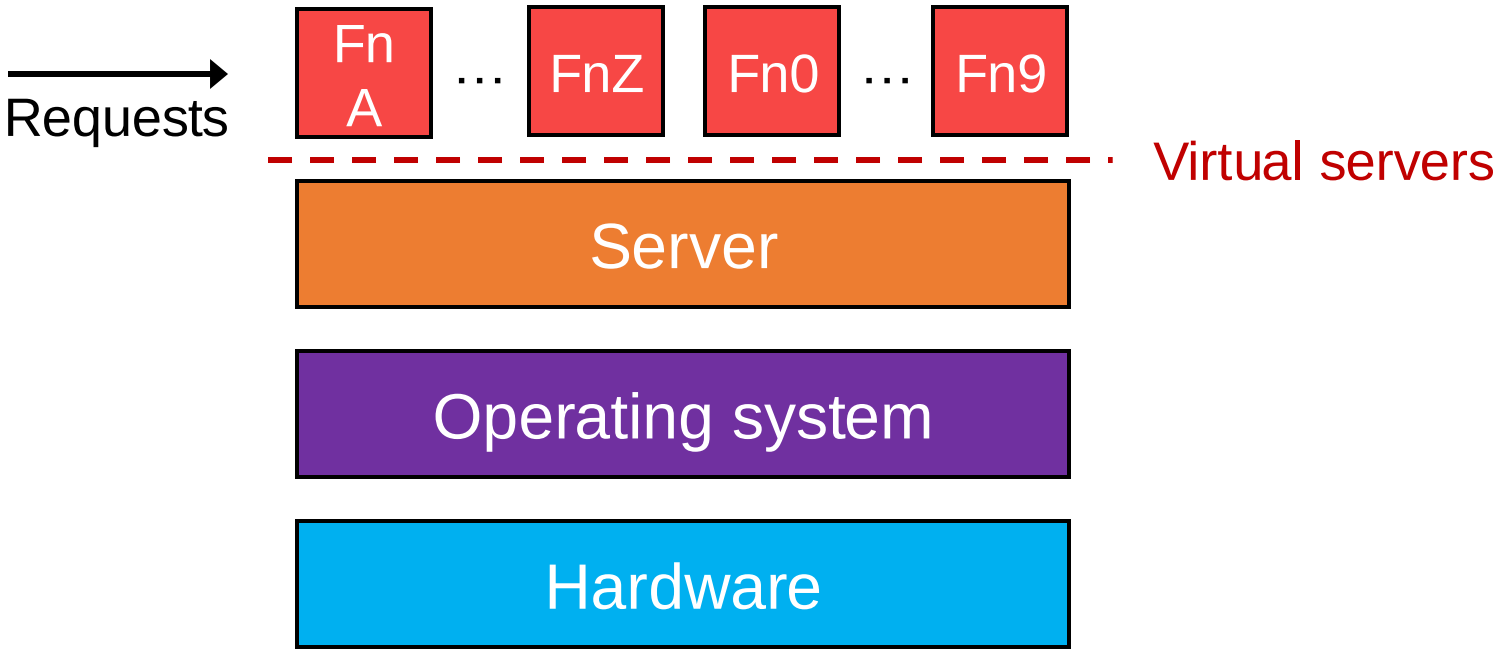

Tradeoff discussion

Serverless functions (AWS Lambdas)

Containers

VMs

Isolation?

Flexibility?

Overhead?

Above the surface: Core capability

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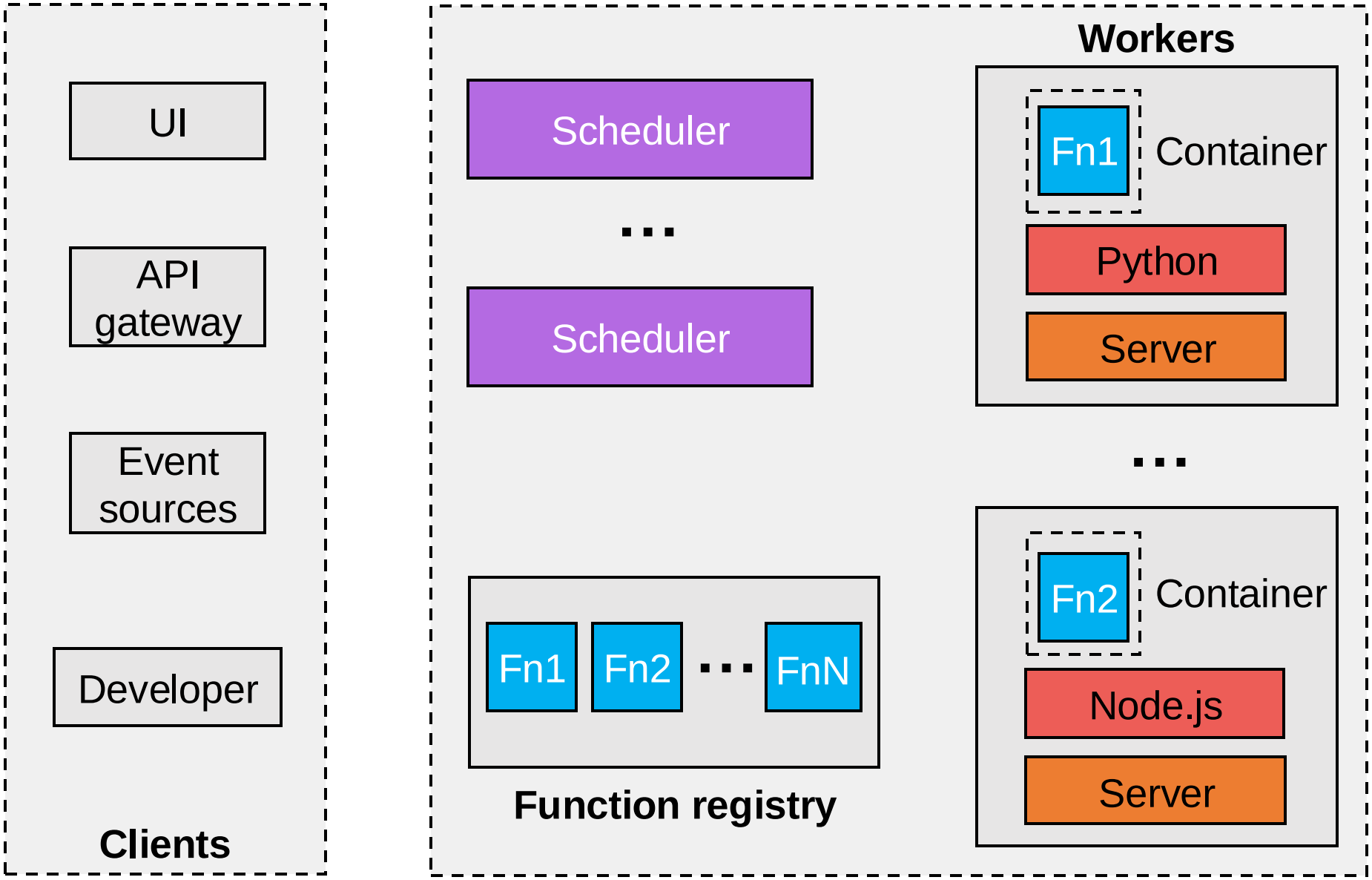
4. Find an existing instance of function or create a new one
5. Send the event to the function instance
6. Wait for a response
7. Gather execution logs
8. Make the response available to the user
9. Stop the function when the execution terminates

Under the hood: FaaS architecture



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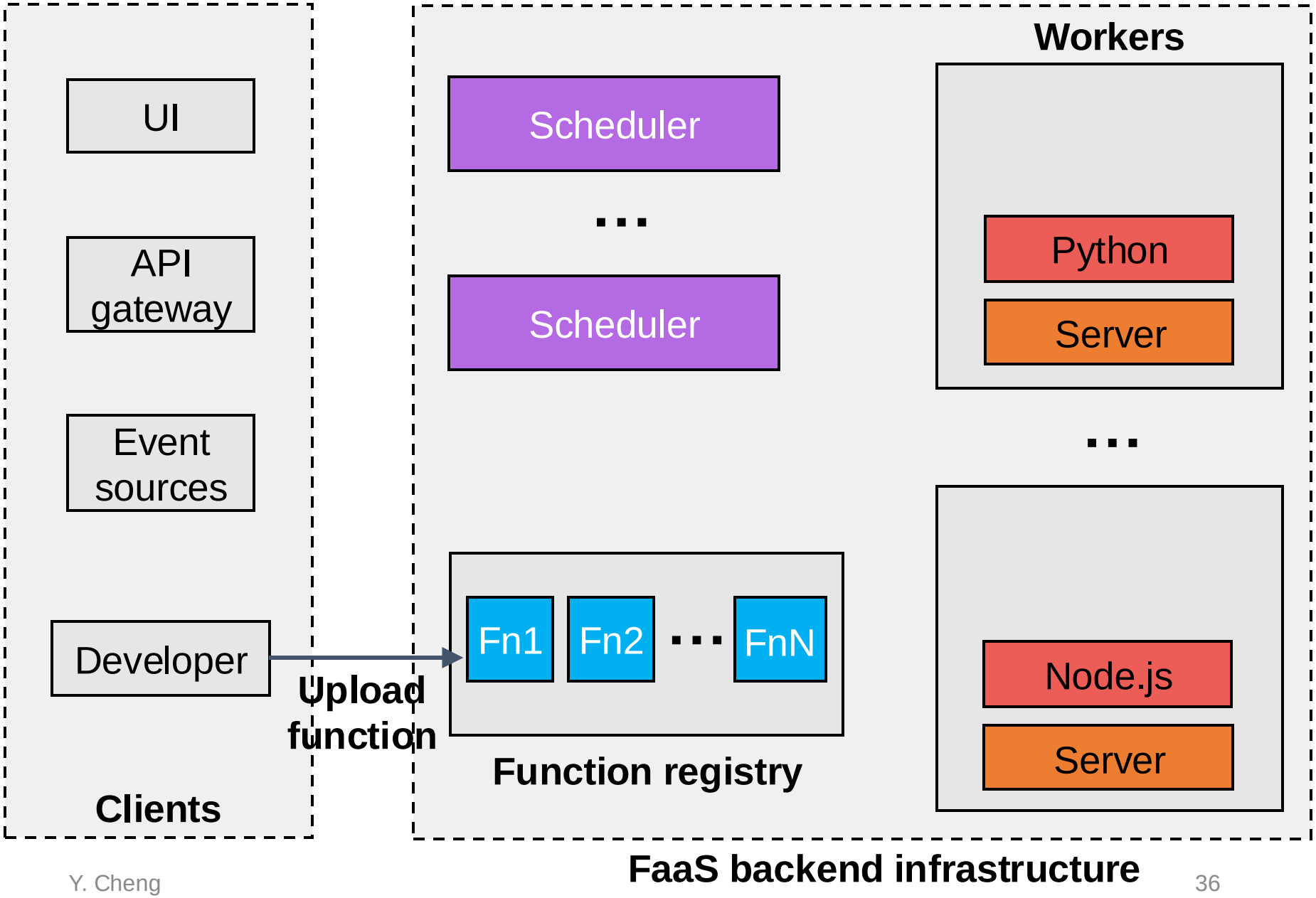

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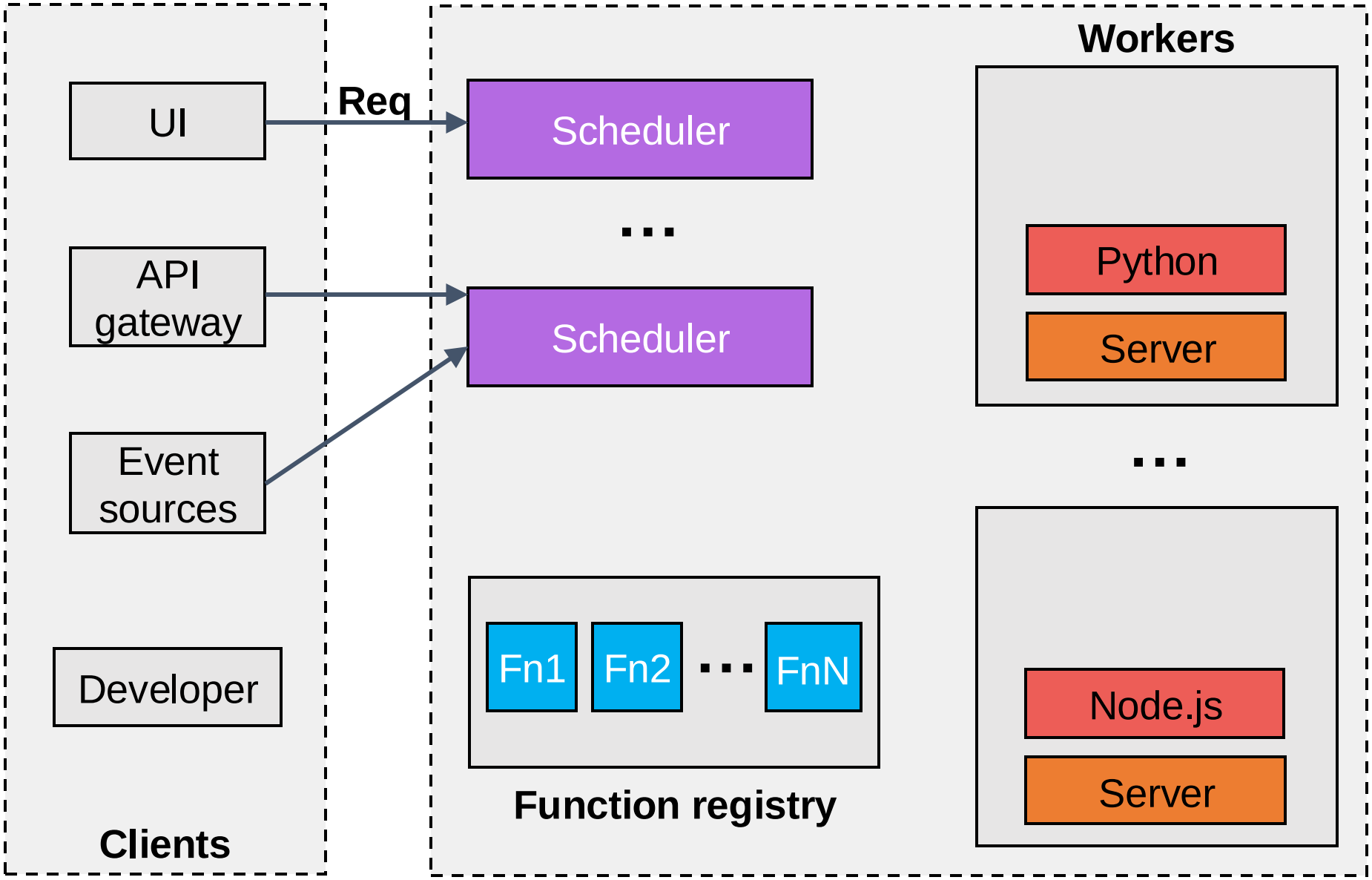

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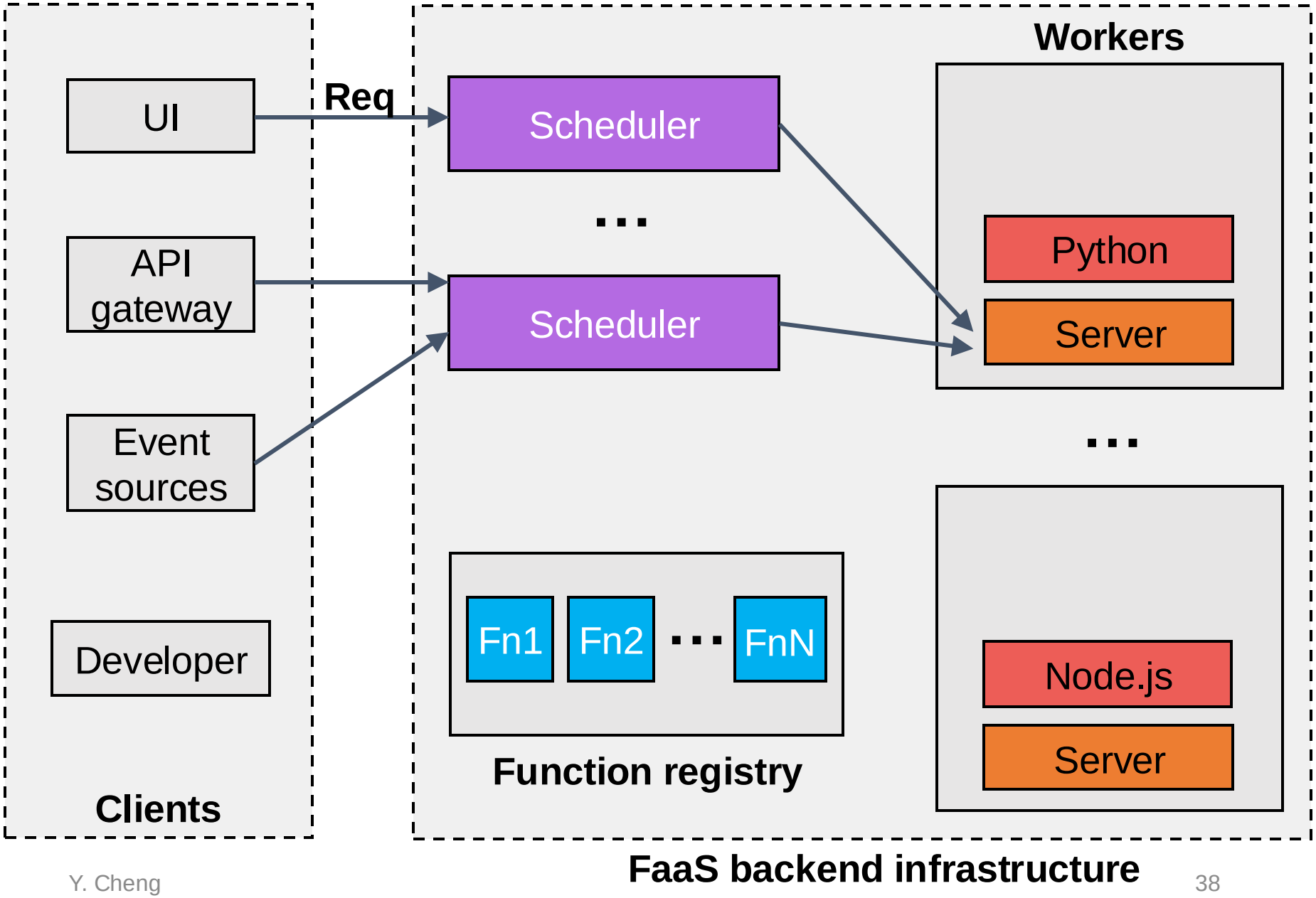

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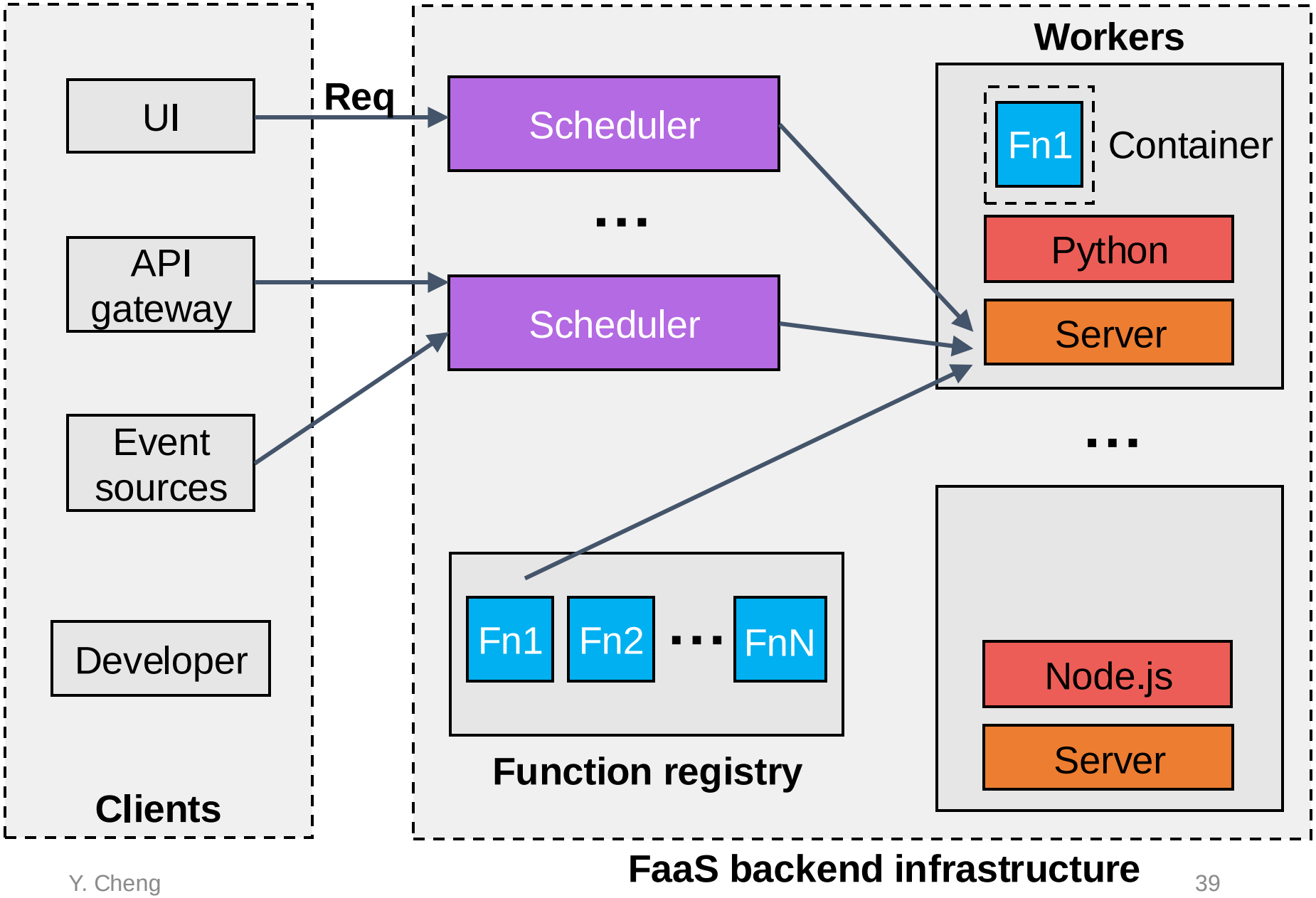

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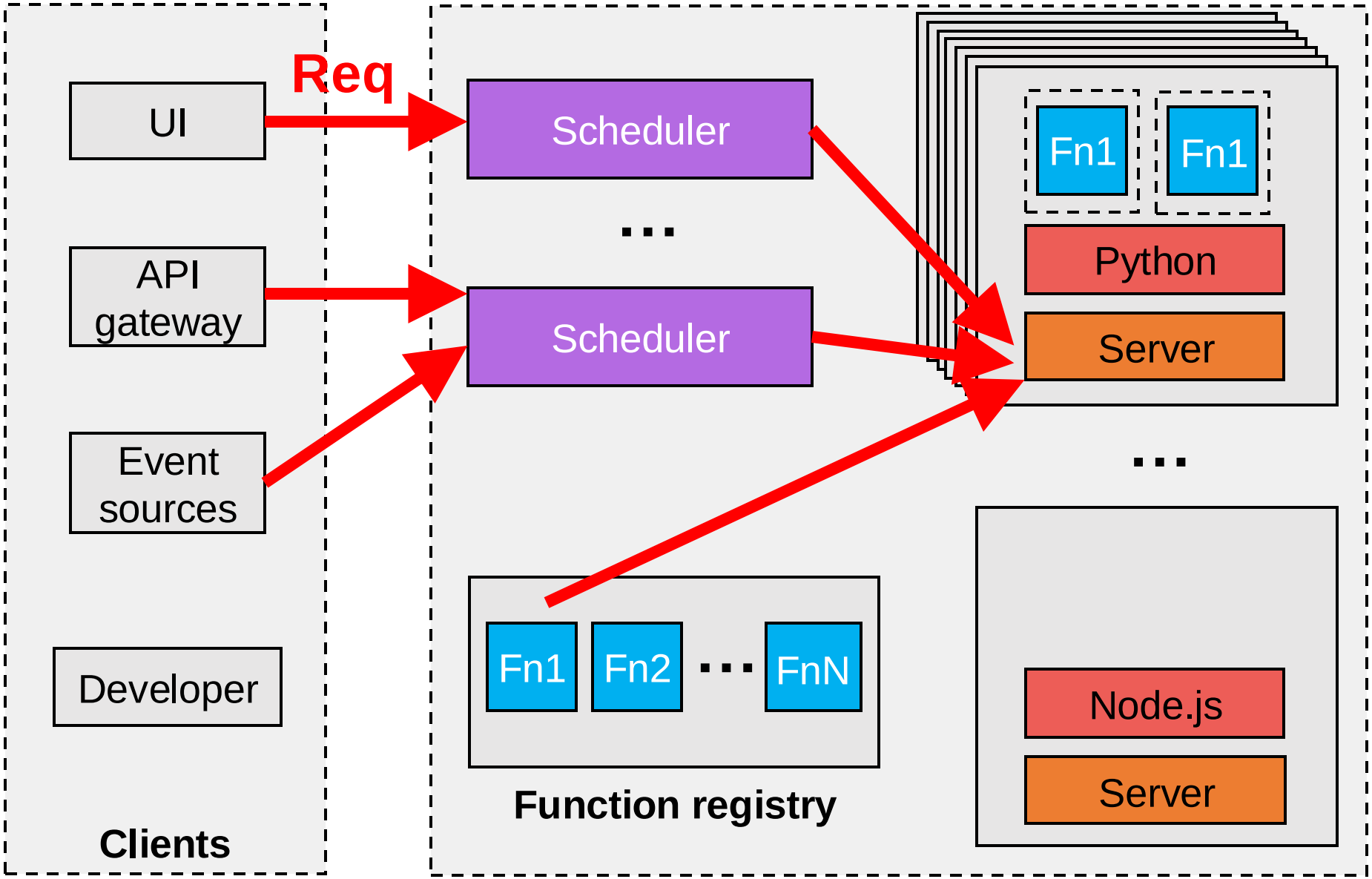

AWS Lambda

- Lambda capacity config keeps **evolving**:

1st gen:
- ~~300 seconds~~ 900 seconds (15 minutes)
- ~~single-core~~ ~~two-core~~ → up to 6 cores
- ~~1.5 GB~~ → 10 GB memory
- ~~512 MB~~ → up to 10GB of /tmp file system

Current offering

Python, Java, Node.js, Go, …

Pricing:

- Fine-grained billing: 1-millisecond billed duration
- $0.20 per 1M requests (invocations charge $)
- $0.0000166667 for every GB-second (compute time charges $$)
- 6,000 1 GB Lambda functions for one second: 10¢

Desirable properties

- (Near) zero administration overhead
  - “No-ops”: No need to handle server provisioning / infrastructure, failure, etc.
- Elastic auto-scaling
  - Spin up / tear down functions quickly based on load
- Pay-per-use
  - Only pay for the resources used (CPU-mem bundle)

Limitations

- **Banned** inbound network
- **No guaranteed** data availability
- Lambdas are **resource-constrained**
- Lambdas have **limited execution time**
- **High cold startup cost** and **invocation cost**