Serverless Computing

Mathieu Bacou
`mathieu.bacou@telecom-sudparis.eu`
Télécom SudParis, IMT, IP Paris, Inria

Do we really want Containers?

- An **environment** is required
  - Overhead of building containers and pods
- A management layer is required
  - Overhead of configuring service availability (orchestrator)
- **Backends** are required
  - Overhead of management of support features
    - Database servers, monitoring…
  - Always-on servers
    - May scale down to 0, but then latency overhead on next request

Introducing: Serverless

- Real cloud-native applications: only provide **code** to implement business core features
  - A continuation from micro-services
- Management and execution service provided by the cloud platform
  - From execution environment to service availability
- Serverless = **Function-as-a-Service** + **Backend-as-a-Service**

Backend-as-a-Service (BaaS)

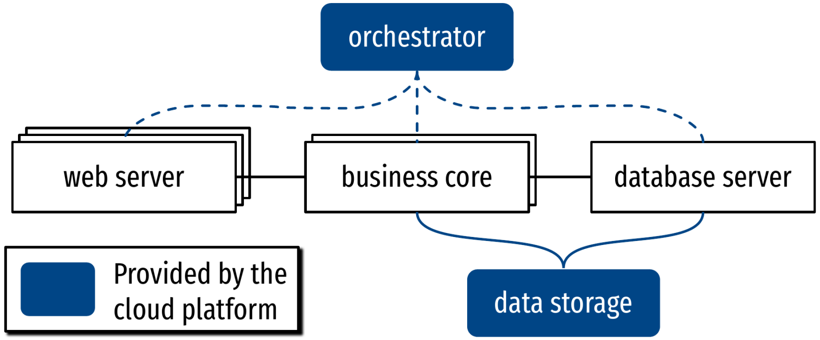
- **Common backend components** in applications architectures
  - Database servers, messages queues, (object) storage, Pub/Sub services…
- A good thing: better served by the cloud provider
  - Mutualized, no overhead for the user, always available
  - Provides an ecosystem of ready-to-use components
    - But beware of vendor lock-in!
- **Elasticty** requirements: scale in synchronization with the FaaS workload *(see next)*
  - dynamically
  - quickly
  - up and also down to zero

Function-as-a-Service (FaaS)

- Run application code without fixed long-lived servers
  - Execution runtimes are spawned on-demand
  - Fully managed by the cloud FaaS platform
- Unit of execution, and unit of application architecture: **a function**
  - I.e., a singular feature of the application
- Applications are (mostly) **event-driven**
  - Triggered by requests or events from BaaS sources
- Parallelism at the level of the cloud function, managed by the platform
  - *Technically, concurrency is possible inside the cloud function*
- Core feature of serverless

Comparison with micro-services

- API gateway: managed routing of HTTP REST requests to functions
- Triggers: HTTP request, message queue, event stream, complex orchestration, timer, storage, etc.



orchestrator

web server

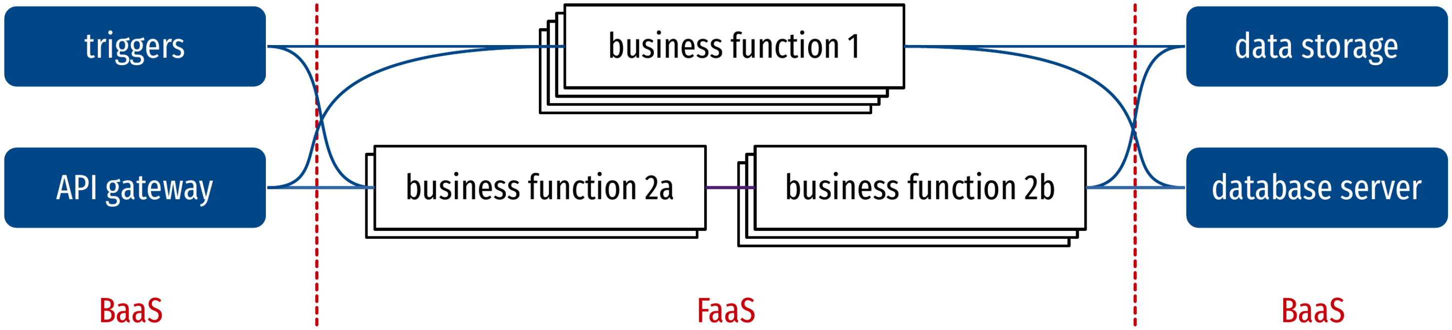
business core

database server

data storage

🟦 Provided by the cloud platform

Micro-services architecture.



triggers

API gateway

business function 1

business function 2a

business function 2b

data storage

database server

BaaS

FaaS

BaaS

Serverless architecture.

Benefits of Function-as-a-Service

- **Elasticity**: granularity of the request handler allows more precise scaling
  - Quick scaling, each function can scale down to 0
- **Deployment**: just write code and upload it
  - Quick experimentation, quick update
- **Cost**: pay only the compute time you need
  - No request = no running function = no resource = no cost
  - Cost = Compute time × Reserved Memory (approximately)

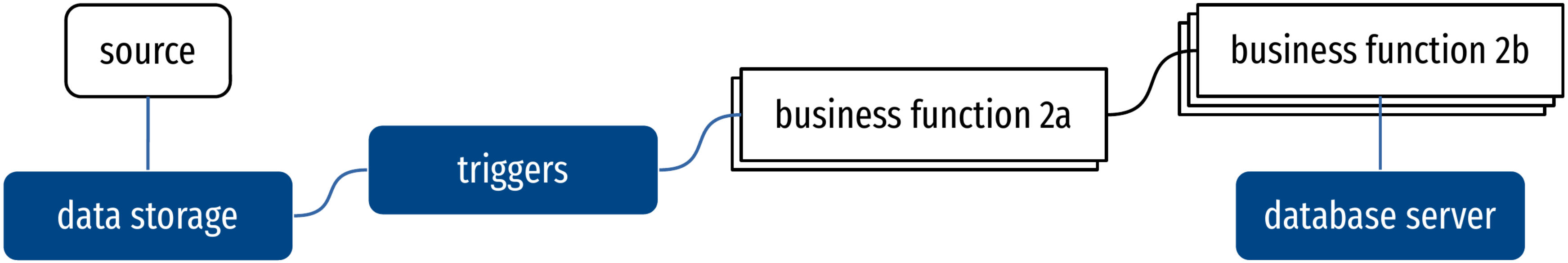
Demo: Apache OpenWhisk

1. Create a new function
2. Manually invoke a function
3. Use the API gateway to invoker a function as the backend to REST requests
4. Use triggers to integrate function invocation
5. Present warm and cold starts

Apache OpenWhisk logo.

Application architecture with Function-as-a-Service (1/2)

- Most often following the paradigm of **Extract – Transform – Load** (ETL)
    1. Get data
    2. Process data
    3. Output data
- Fit for event-driven processing
    - Execute when a request arrives or a trigger is fired
- **Stateless** functions: no single instance is tied to a request
    - Consecutive invocations may be served by any instance (including new ones)
    - FaaS uses BaaS to store business data
    - FaaS relies on the API gateway or on the client to keep transient state



Example of the Extract – Transform – Load paradigm in Serverless computing.

Application architecture with Function-as-a-Service (2/2)

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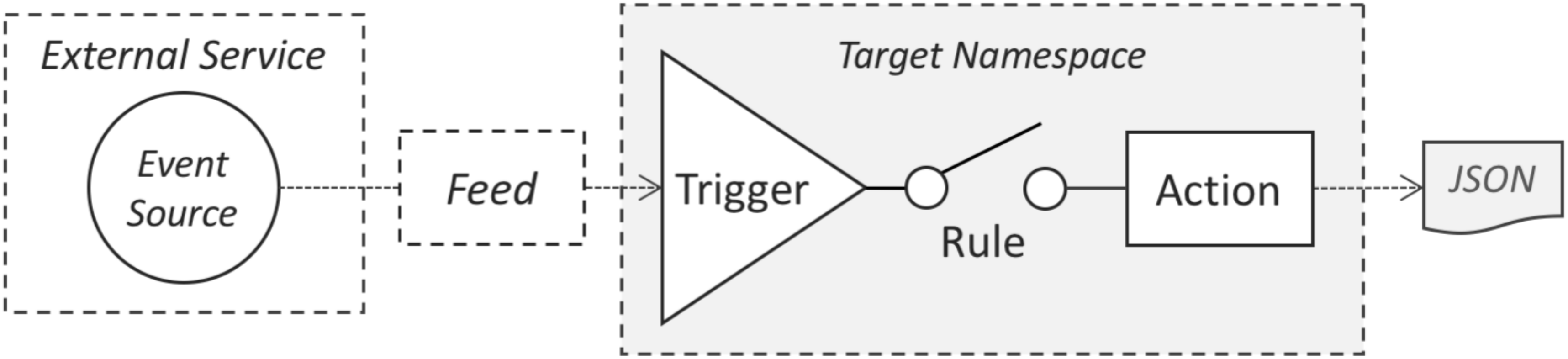
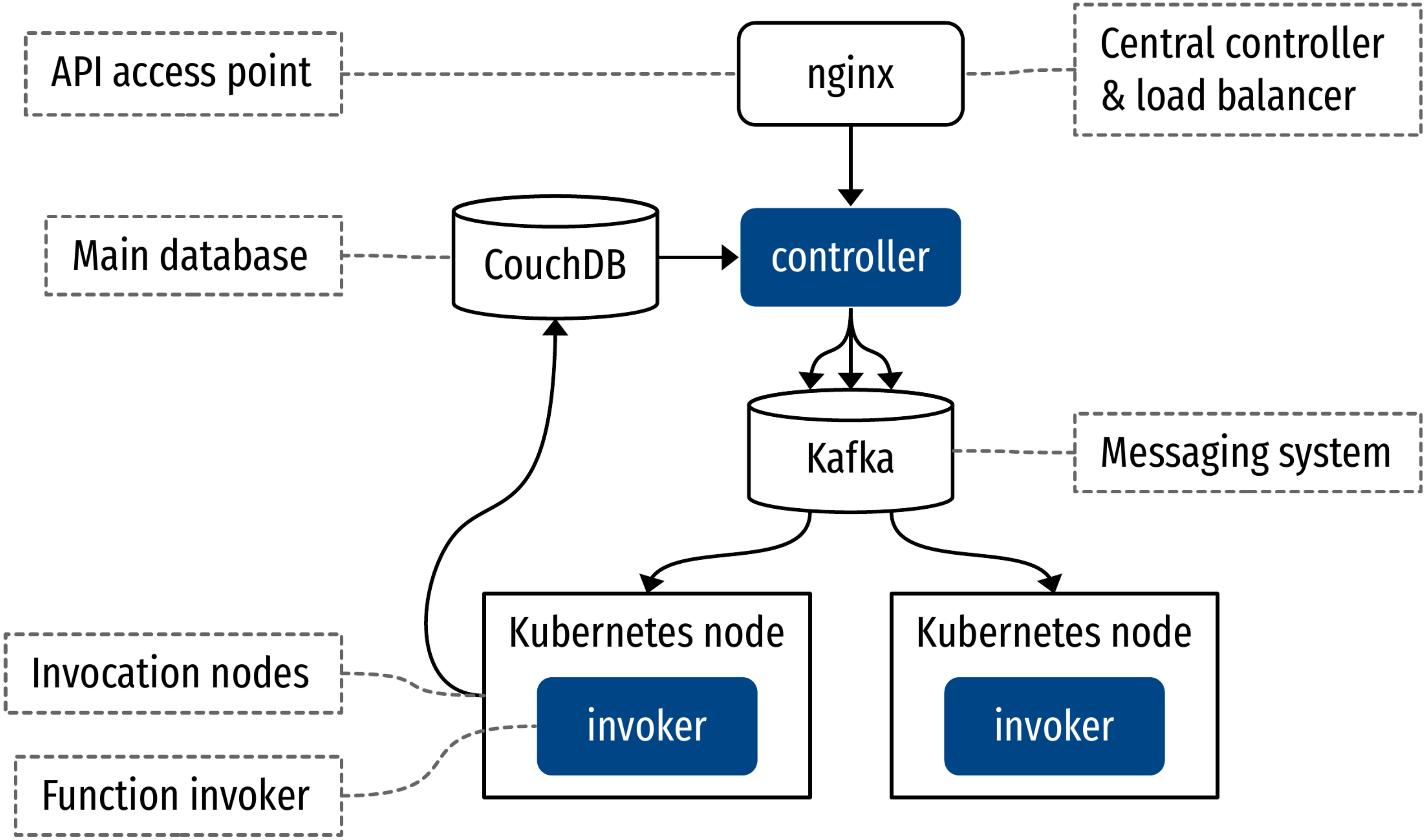


Programming model of Apache OpenWhisk.

What makes a FaaS application

- Naturally multi-process thanks to platform-level parallelism
- **Chains** and **graphs** of processing dependency between functions
    - Chain function calls to implement complex features with fine control granularity
    - Next level: handle a dependency graph (MapReduce pattern, etc.)
        - Some vendors integrate it, often must be done manually
- In practice: platform-level configuration + code pieces
- To execute functions:
    - Use provided environments: NodeJS, Python, Java…
    - Or provide a custom environment: Docker images, opaque binary executables

Internals of Apache OpenWhisk



Architecture of Apache OpenWhisk.

Invocation of a function

1. Control authentication, rights to invoke, housekeeping…
2. Spawn a new container with the function’s runtime
3. Inject the function’s code
4. Execute the function with the request’s parameters
5. Retrieve the function’s result
6. Destroy the container

- **Optimizations** for steps 2 and 6

Management of function runtime containers

- Creating a new runtime container is slow (compared to serving a request)
  - Hundreds of milliseconds vs. execution time of 100ms
- Solution: **reuse existing containers!**
  - Functions are stateless: all containers with a function’s runtime are equivalent
- **Cold starts** and **warm starts**
  - No runtime container available: cold start
  - Available runtime (ready and idle): warm start
- Cold starts are around **40 times slower!**
  - Depends on function runtime, language…
- Importance of managing the runtime container pool
- Concerns:
  - Maintain a pool of pre-warmed containers to speed up first requests
  - But balance between occupied resources and execution latency
    - Pre-warmed containers use resources that are not billed to the user!

Limits of serverless computing

- **Latency**:
  - cold starts
  - overhead of FaaS platform
- **Compatibility** with serverful applications
  - What about stateful applications?
    - No per-request local state
  - What about massively parallel applications?
    - Strong isolation between functions makes MPI hard
  - FaaS is not fit for long-running processing
    - Costs more, is less efficient
- Still a recent cloud paradigm!
  - Promising for easy cloud access and cloud-native applications

Serverless computing

- Function-as-a-Service for core business code and features
- Backend-as-a-Service to provide architectural services
- **Cloud-native paradigm**
  - Fine-grained, elastic, pay-as-you-go, no-management-overhead
- But not suited to all applications
  - Yet?