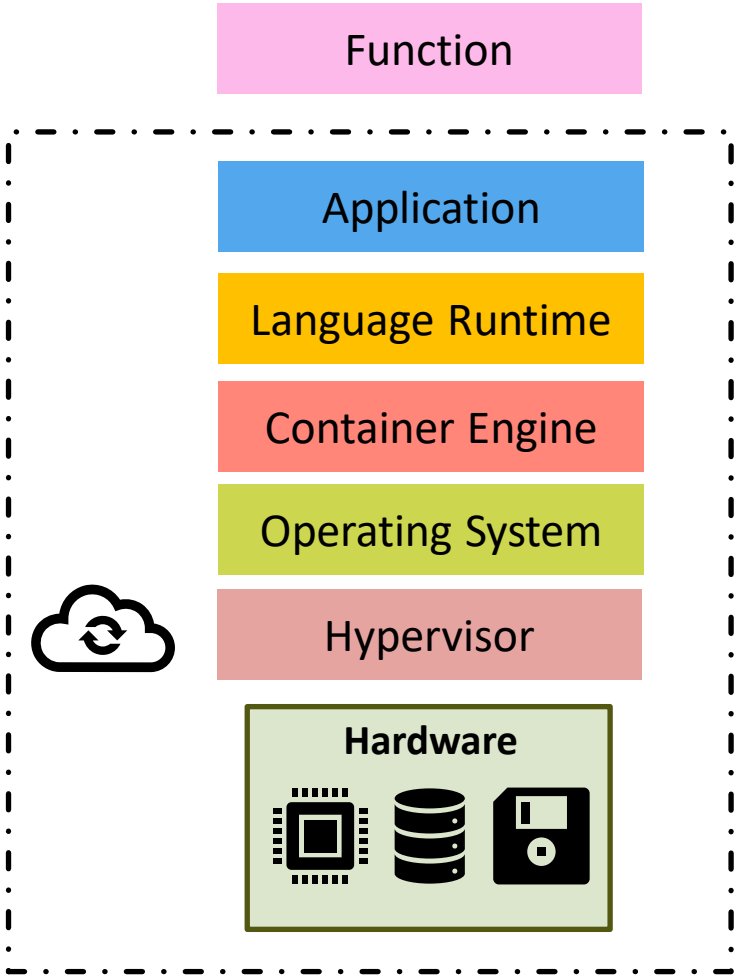
LUKAS MÖLLER, MARCIN COPIK, ALEXANDRU CALOTOIU, TORSTEN HOEFLER

Cppless: Productive and Performant Serverless Programming in C++

Cloud and Serverless

Cloud and Serverless



Functions

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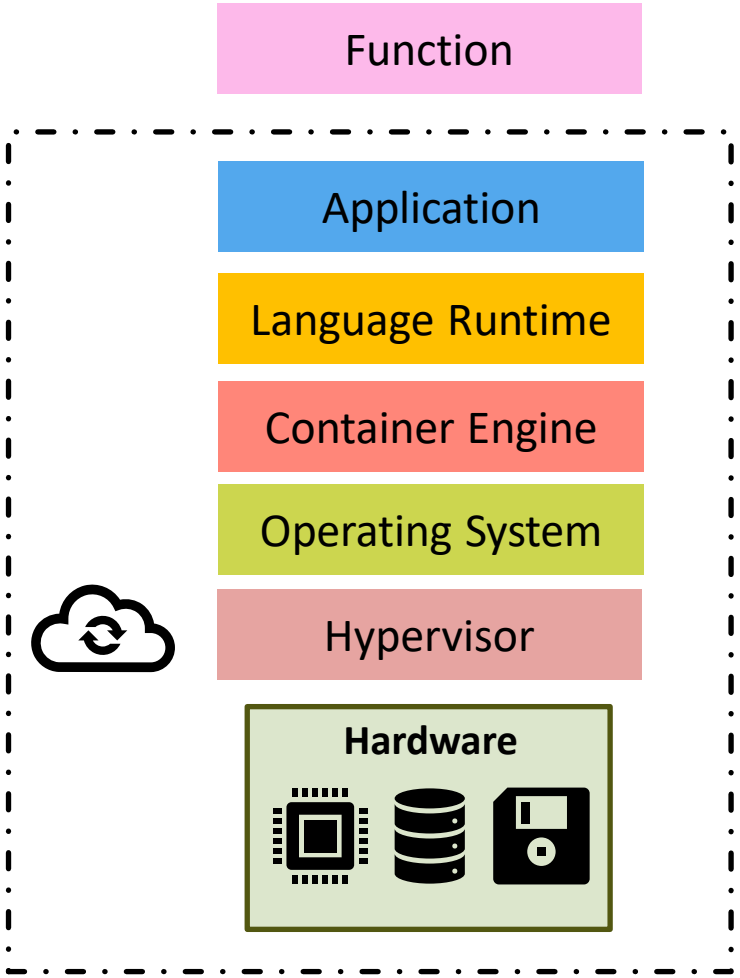

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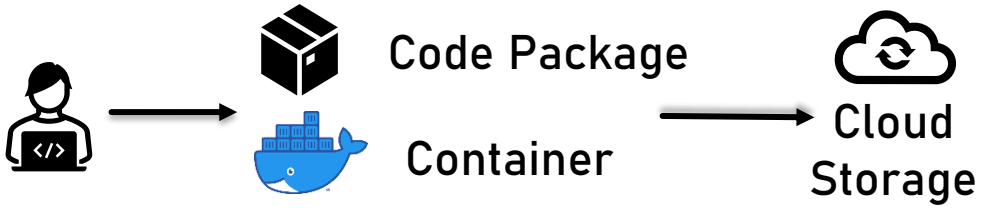

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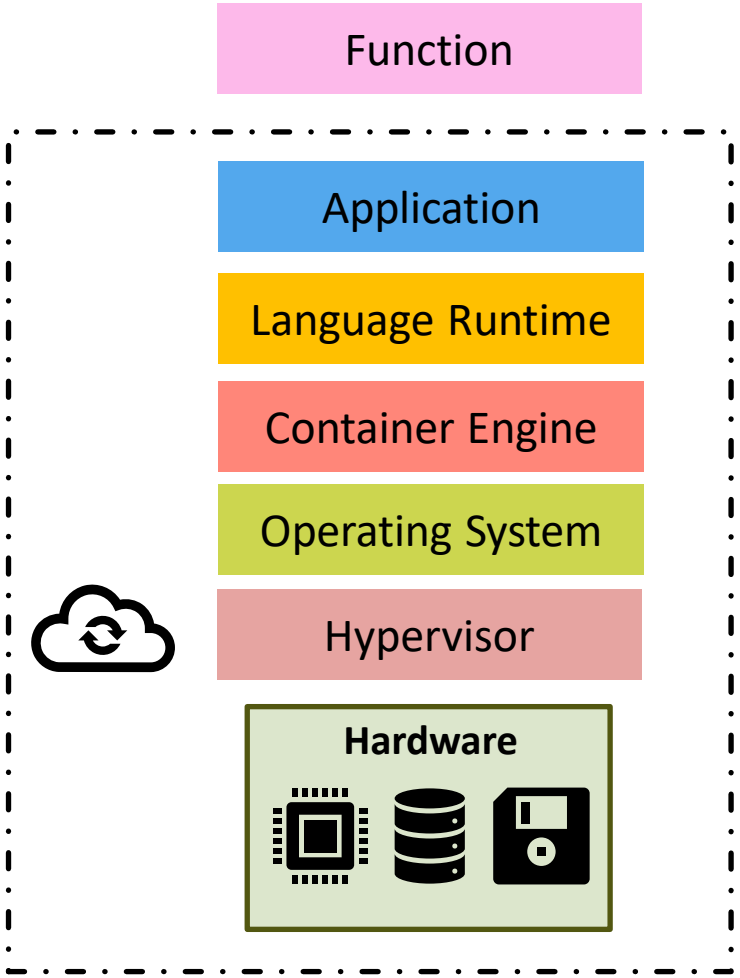

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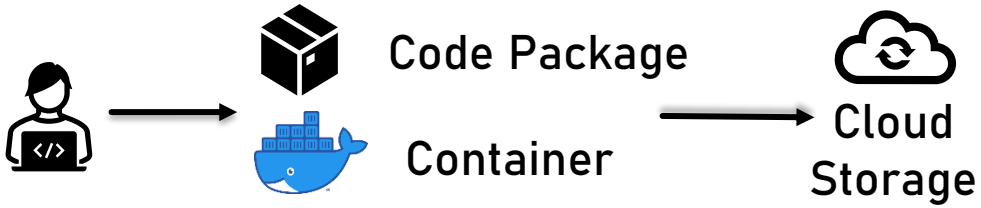
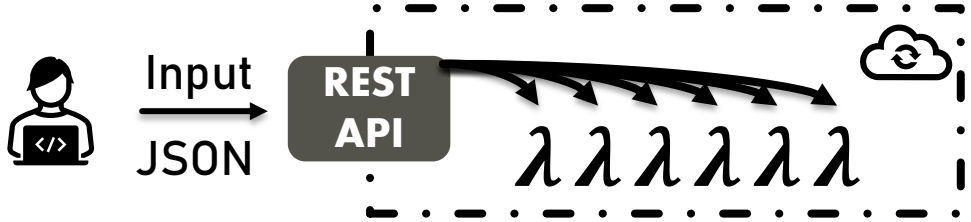


Runtime: invoking existing functions.



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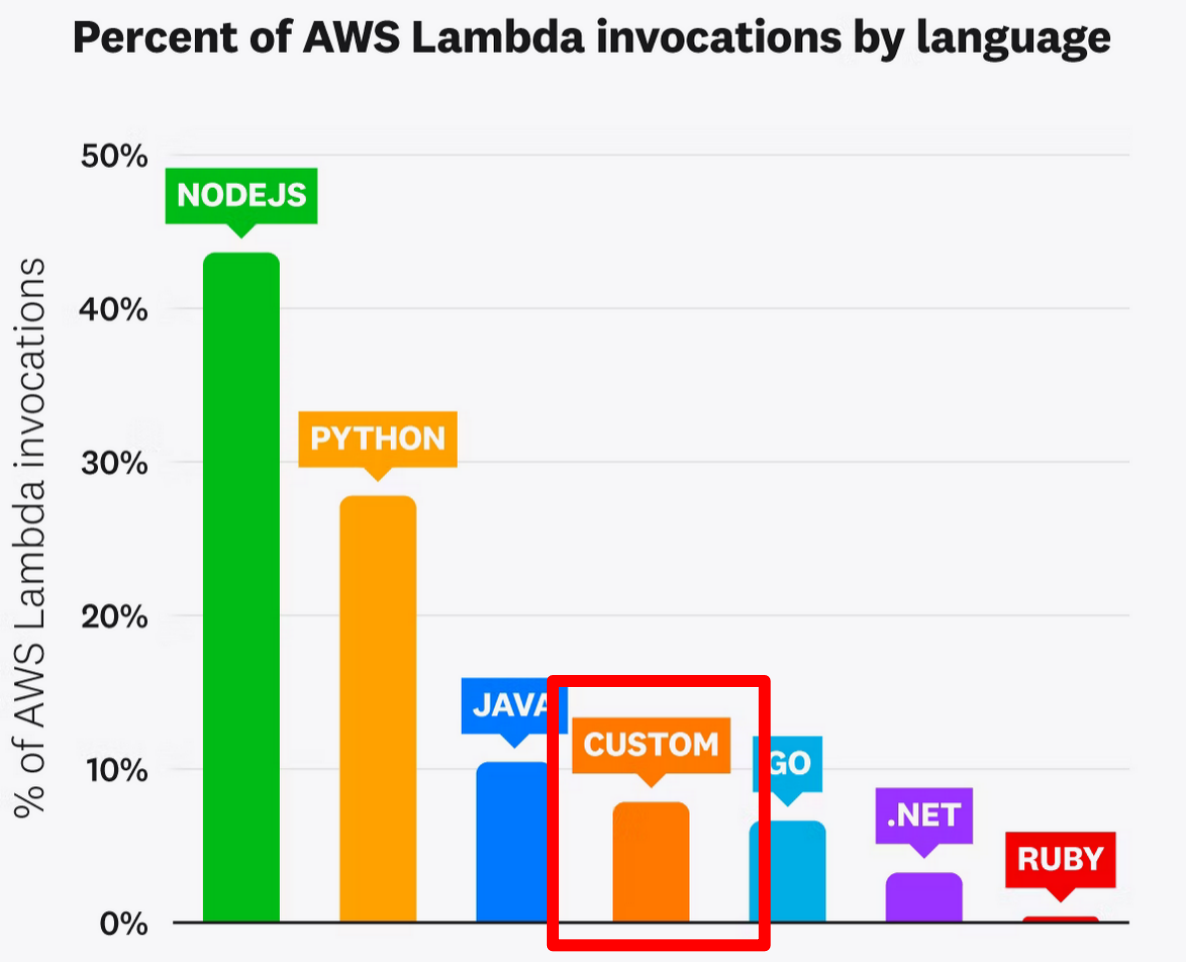

Source: DataDog, “State of Serverless 2023”, https://www.datadoghq.com/state-of-serverless/

AWS Lambda with C++ - Function

```
#include <aws/lambda-runtime/runtime.h>
#include <aws/core/utils/json/JsonSerializer.h>
#include <aws/core/utils/memory/stl/SimpleStringStream.h>

using namespace aws::lambda_runtime;

invocation_response my_handler(invocation_request const& request)
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invocation_response my_handler(invocation_request const& request)
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  using namespace Aws::Utils::Json;
  JsonValue json(request.payload);
  if (!json.WasParseSuccessful()) {
    return invocation_response::failure(
      "Failed to parse input JSON", "InvalidJSON"
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  }





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Link with custom runtime.

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Link with custom runtime.

Upload to cloud with all dependencies.

AWS Lambda with C++ - Function

```
bool InvokeFunction(
  const Aws::String& functionName,
  std::shared_ptr<Aws::Lambda::LambdaClient> client,
  int invocations, int &result
)
{
  Aws::Lambda::Model::InvokeRequest invokeRequest;
  invokeRequest.SetFunctionName(functionName);
  invokeRequest.SetInvocationType(
  Aws:::Lambda::Model::InvocationType::RequestResponse);

  std::shared_ptr<Aws::IOStream> payload
        = Aws::MakeShared<Aws::StringStream>();
  Aws::Utils::Json::JsonValue jsonPayload;
  jsonPayload.WithInt64("iterations", iterations);
  *payload <<< jsonPayload.View().WriteReadable();
  invokeRequest.SetBody(payload);
  invokeRequest.SetContentType("application/json");

  …

}
```

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AWS Lambda with C++ - Function

```
bool InvokeFunction(
)
{
  {
    …

    auto outcome = client->-Invoke(invokeRequest);

    if (outcome.IsSuccess()) {
      auto &result = outcome.GetResult();
      Aws::IOStream &payload = result.GetPayload();
      Aws::String functionResult;
      std::getline(payload, functionResult);
      result = std::stoi(functionResult);
      return true;
    } else {
      return false;
    }

  }
  …
}
```

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AWS Lambda with C++ - Function

```
Aws::SDKOptions options;
Aws::InitAPI(options);
Aws::Client::ClientConfiguration clientConfig;
auto m_client = Aws::MakeShared<Aws::Lambda::LambdaClient>(
  ALLOCATION_TAG,
  clientConfig
);

int n = 10000;
int np = 10;
std::vector<int> results(np);
std::vector<std::thread> threads;
for (int i = 0; i < np; i++) {
  threads.emplace_back([&, i]() {
    InvokeFunction("pi-mc-worker", n / np, results[i]);
  });
}

for (auto &thread : threads) {
  thread.join();
}
auto pi = std:::reduce(results.begin(), results.end()) / np;
```

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Challenges

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Complex, multi-source project setup

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#pragma omp but in serverless
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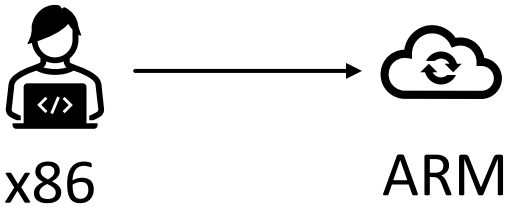

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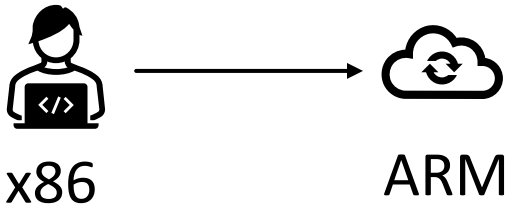

Lack of static typing

Manual verification?
JSON Schema?

Cppless: single-source C++ compiler for serverless

```
double pi_mc(int n);

double pi_estimate()
{
  const int n = 100000000;
  const int np = 128;

  cppless::aws_dispatcher dispatcher;
  auto aws = dispatcher.create_instance();

  std:::vector<double> results(np);
  auto fn = [=] { return pi_mc(n / np); };

  for (auto& result : results)
        cppless:::dispatch(aws, fn, result);
  cppless:::wait(aws, np);

  auto pi = std:::reduce(
    results.begin(), results.end()
  ) / np;

  return pi;
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  Automatically compiled to a cloud function.

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  Avoids the vendor lock-in and simplifies invocations.
- **Serverless function as C++ lambda expression.**
  Automatically compiled to a cloud function.
- **Integrated invocation of the function.**
  Automatic serialization and type checking.

How it works?

Compile Time

Runtime

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Compile Time

Source code

int foo(int x)

int bar(int x)

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task baz

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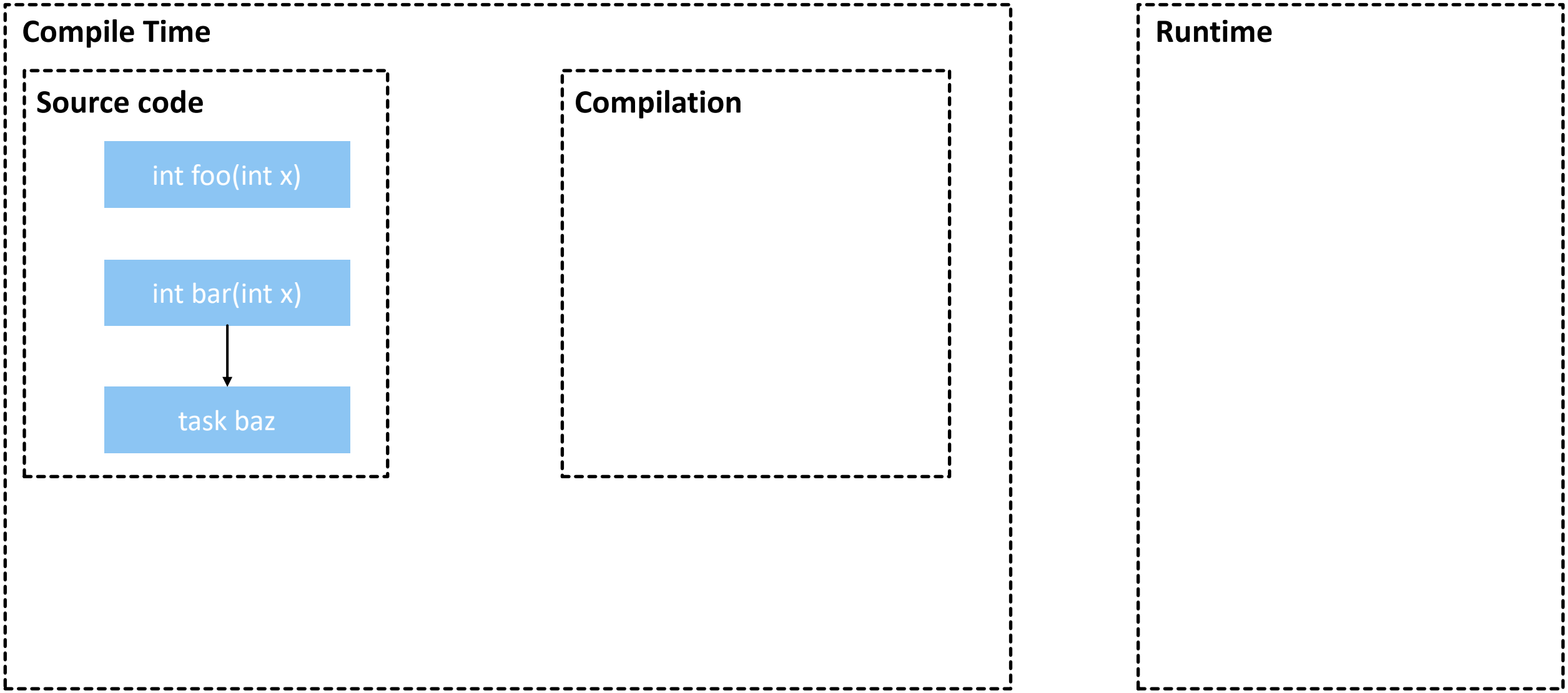
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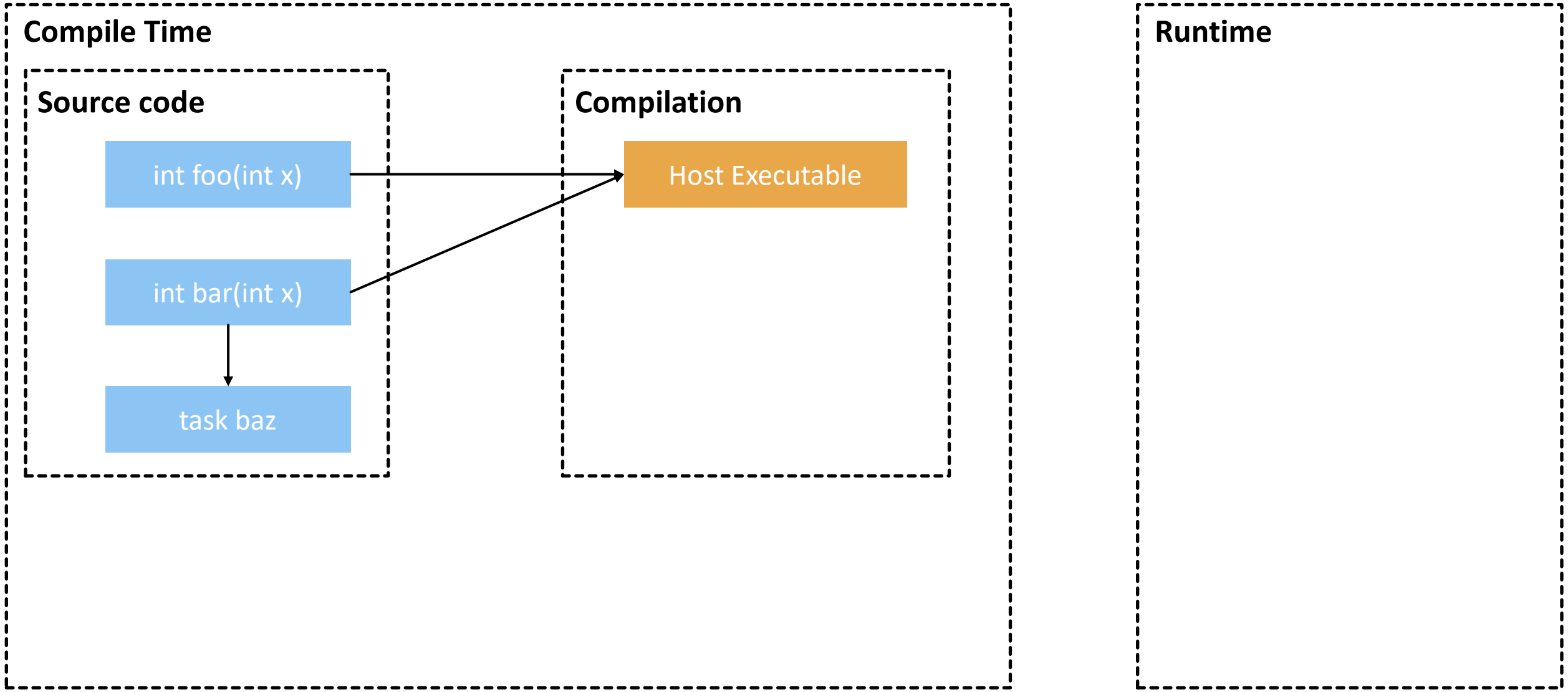
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Compilation
Host Executable
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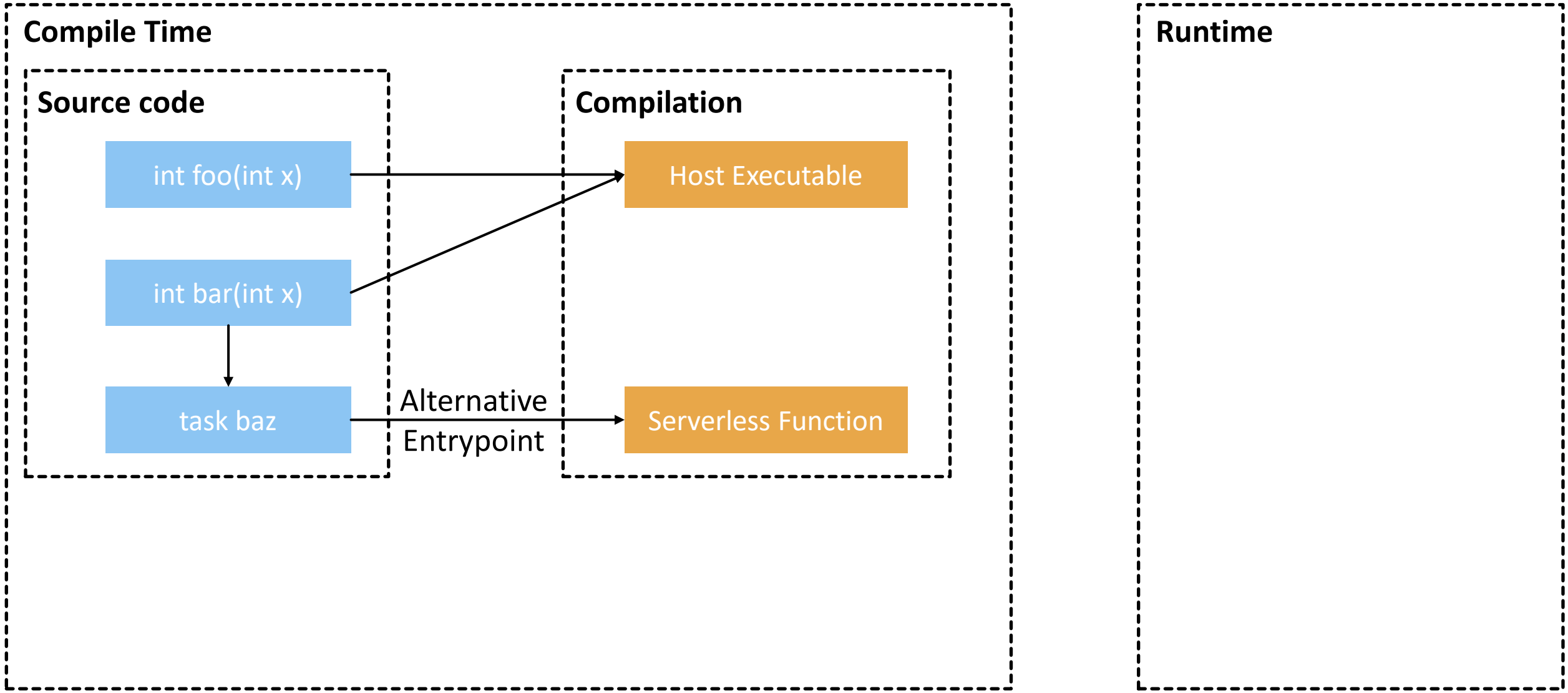
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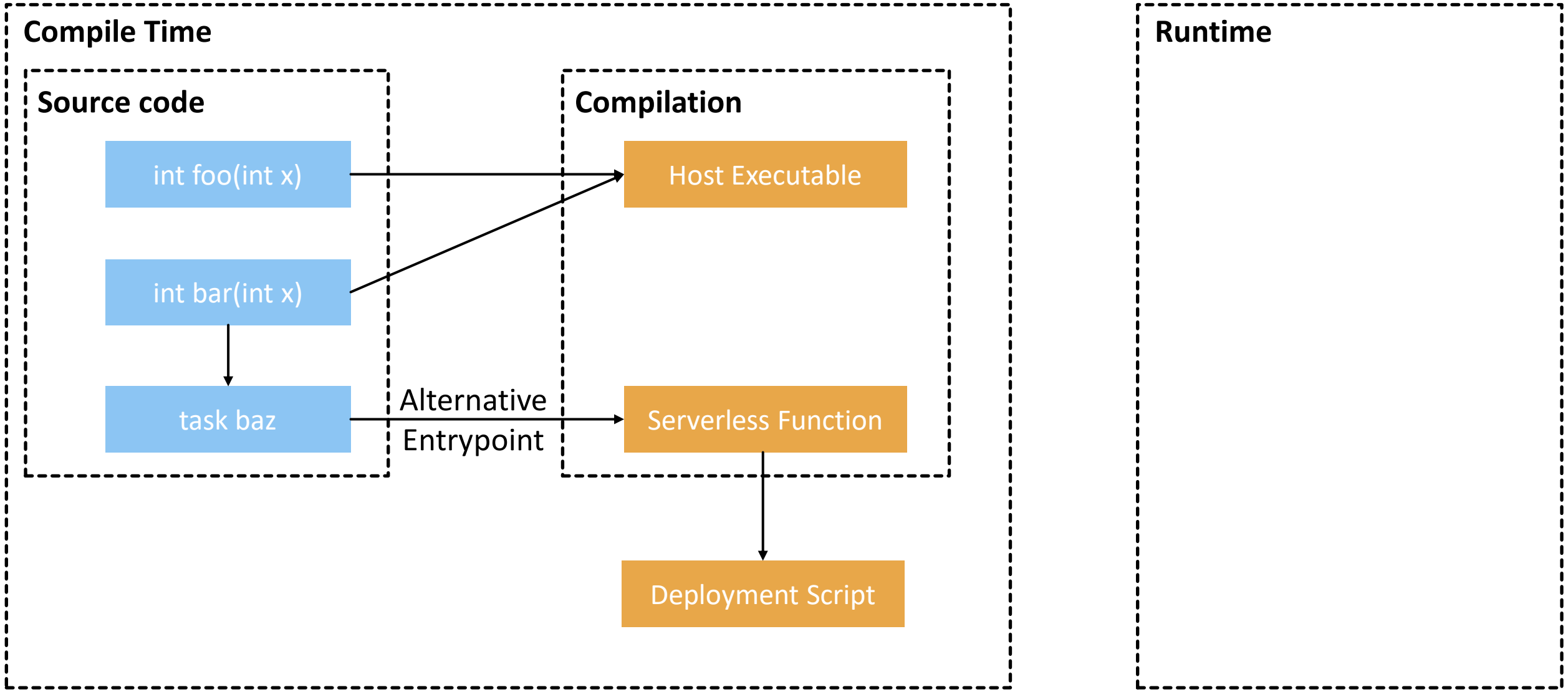
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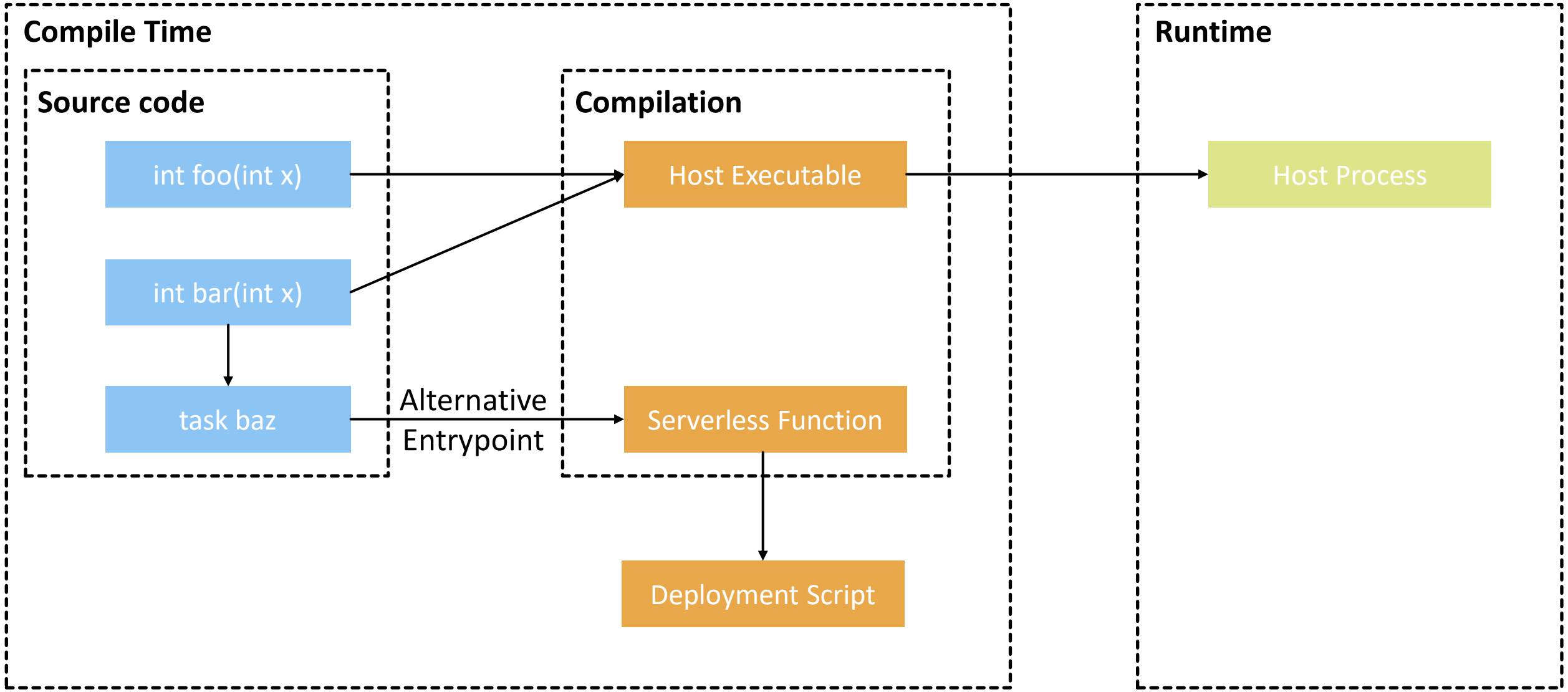
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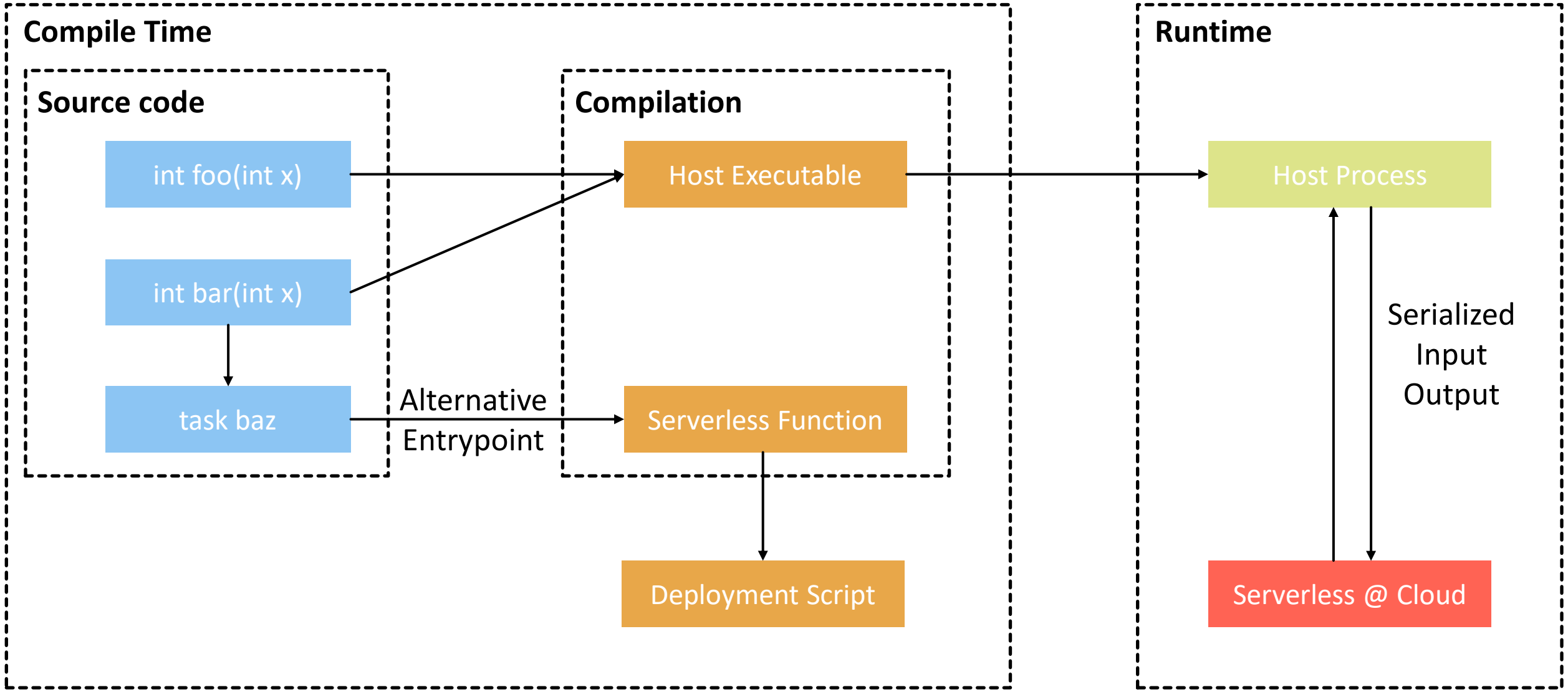
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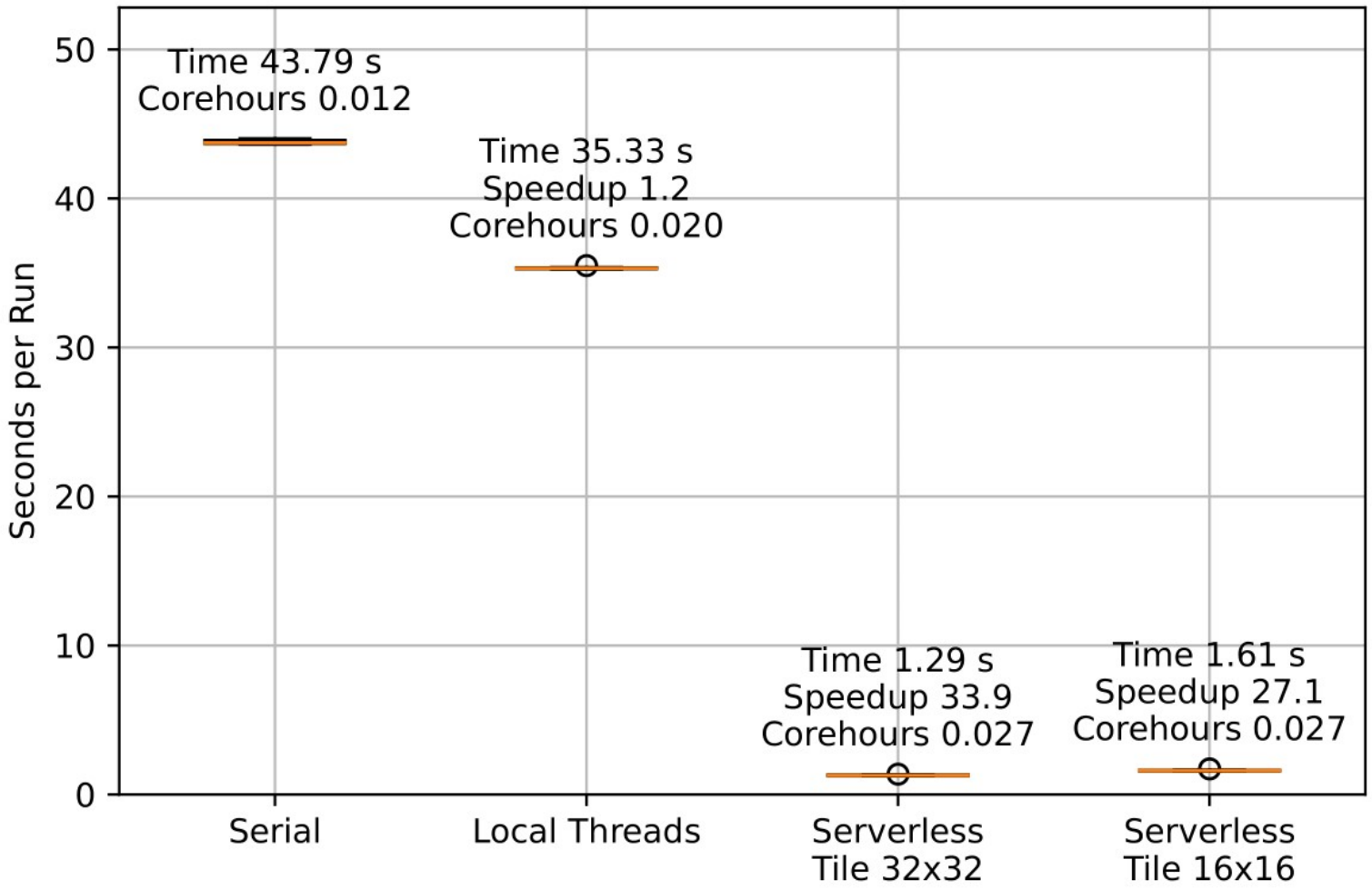
Serialized
Input
Output
Serverless @ Cloud

Serverless ray tracing: from small VM to many functions



Conclusions

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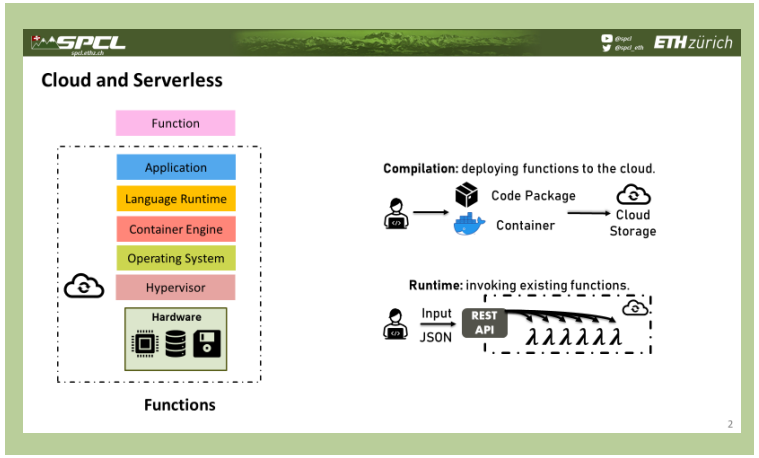

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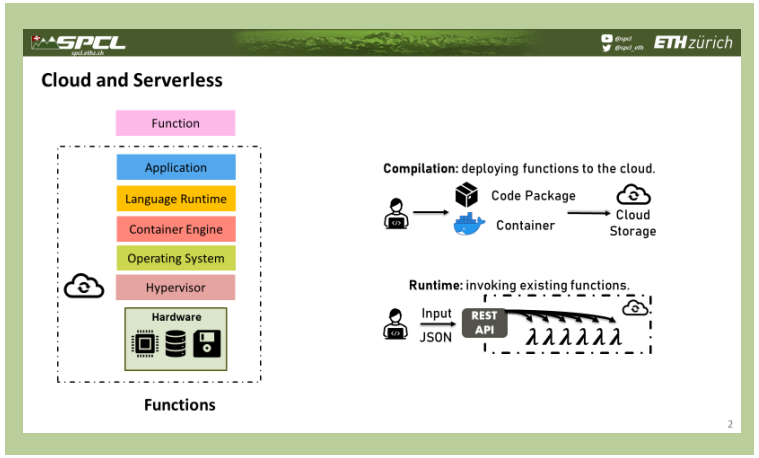

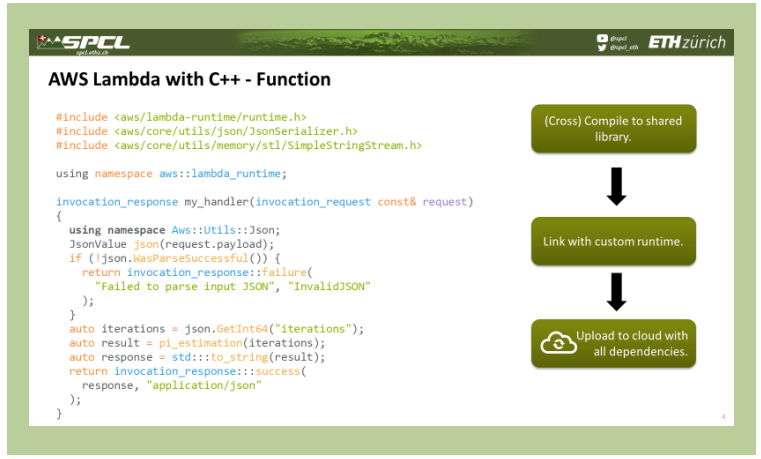

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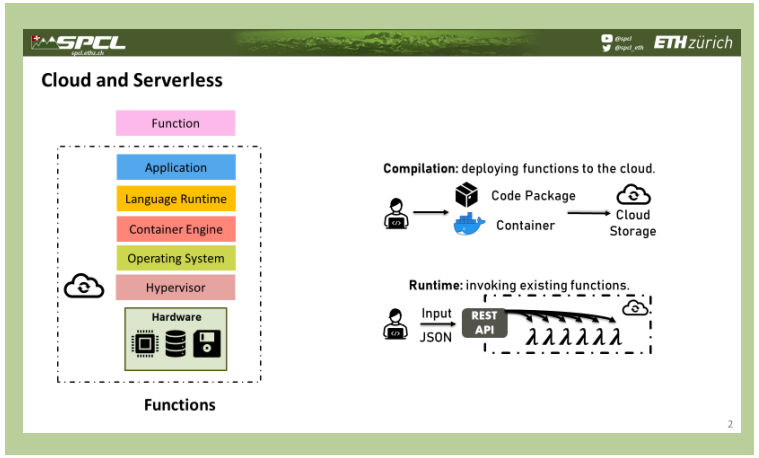

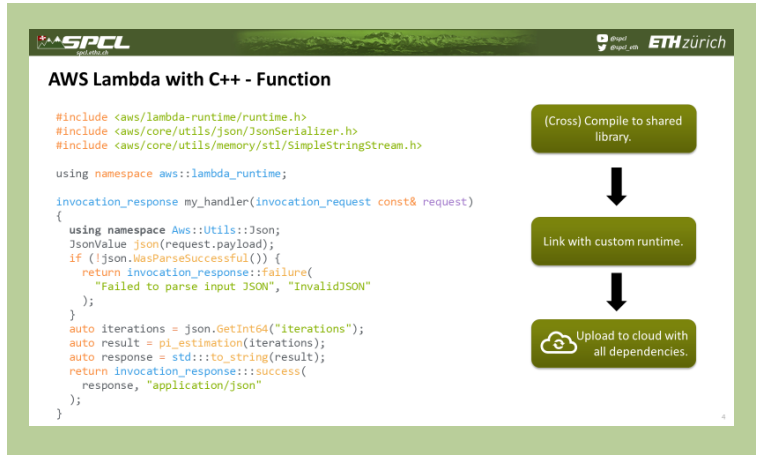

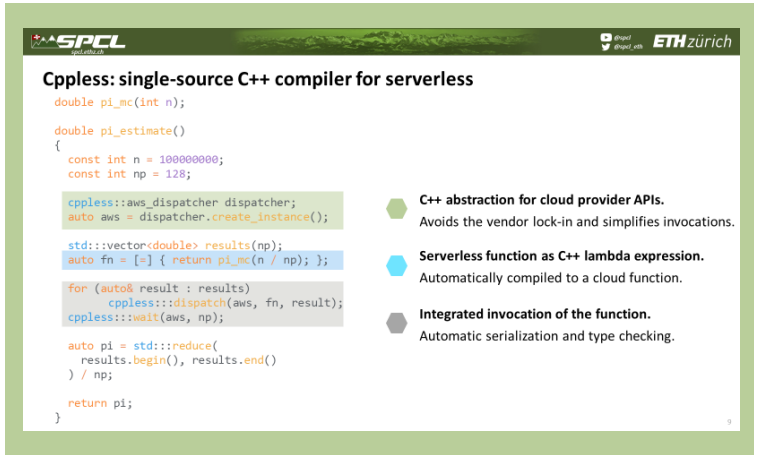

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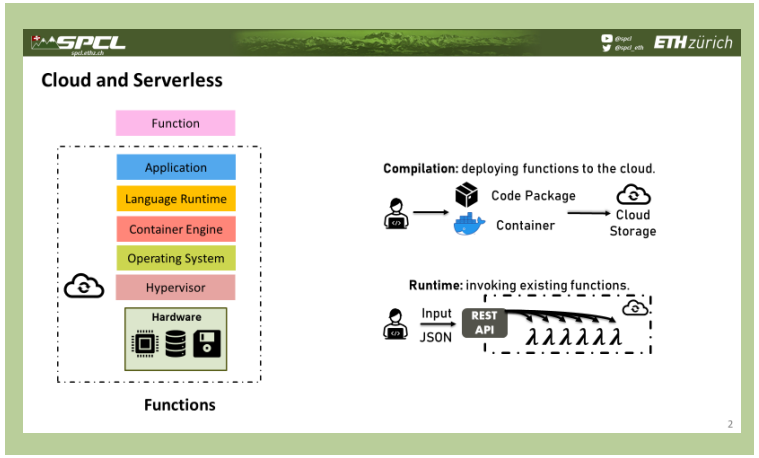

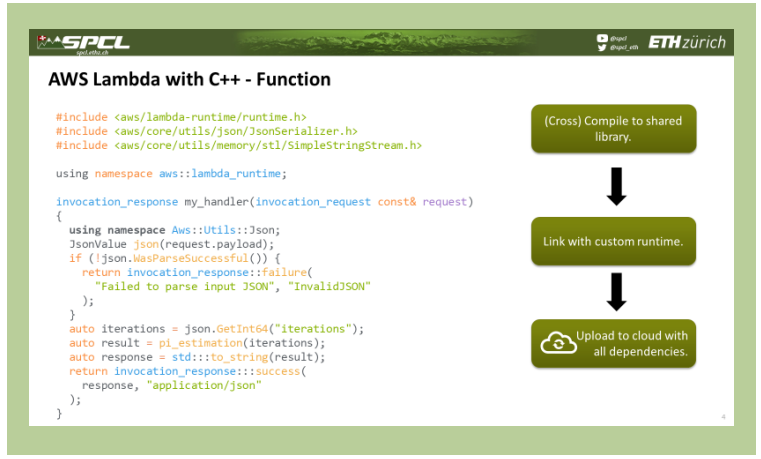

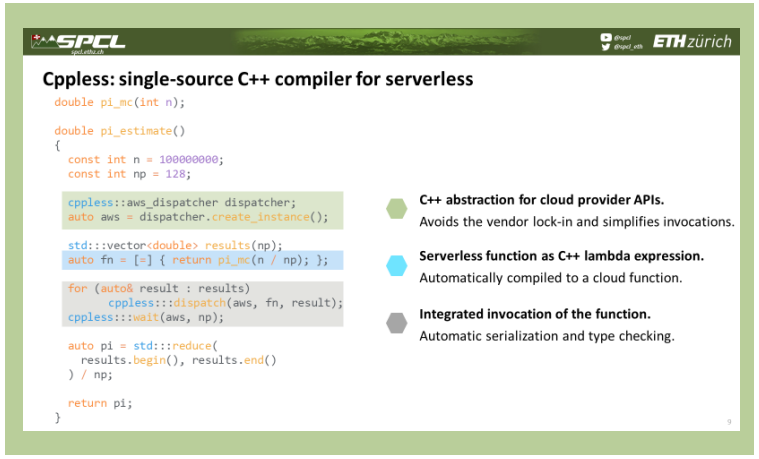

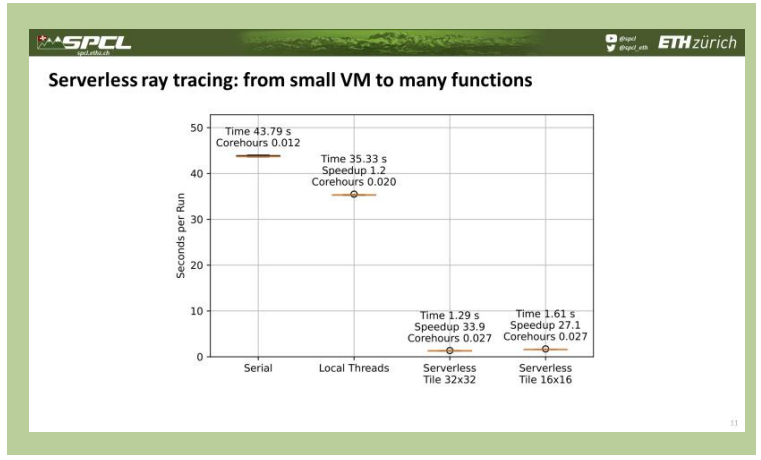

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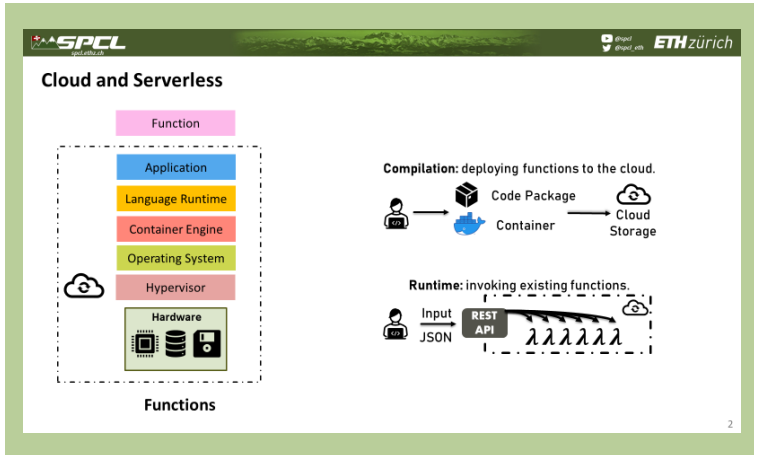

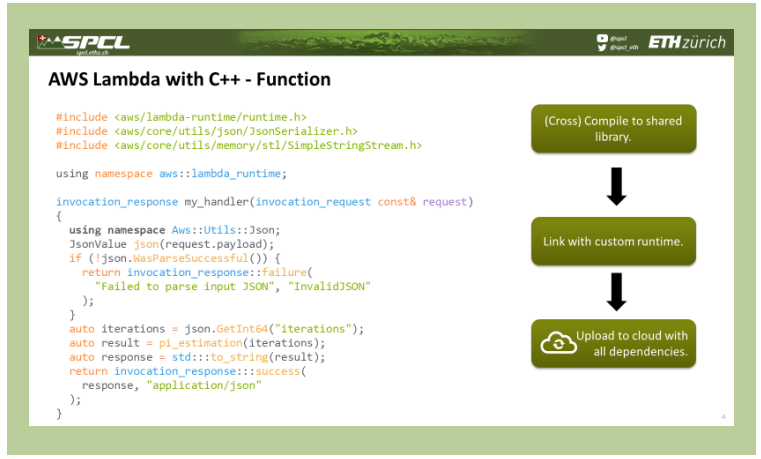

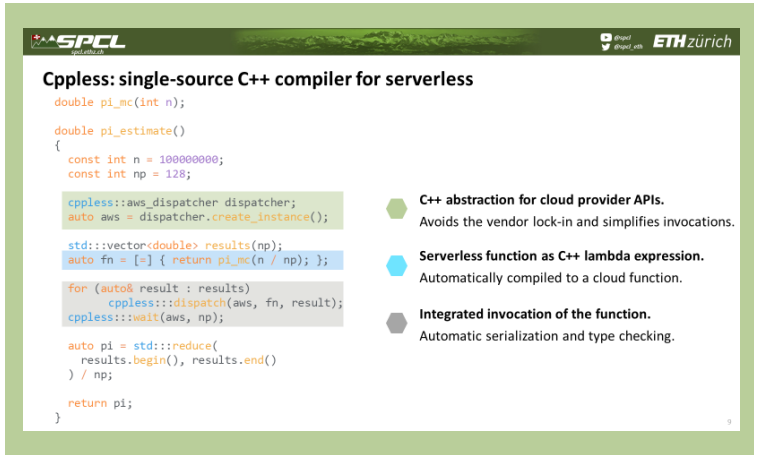

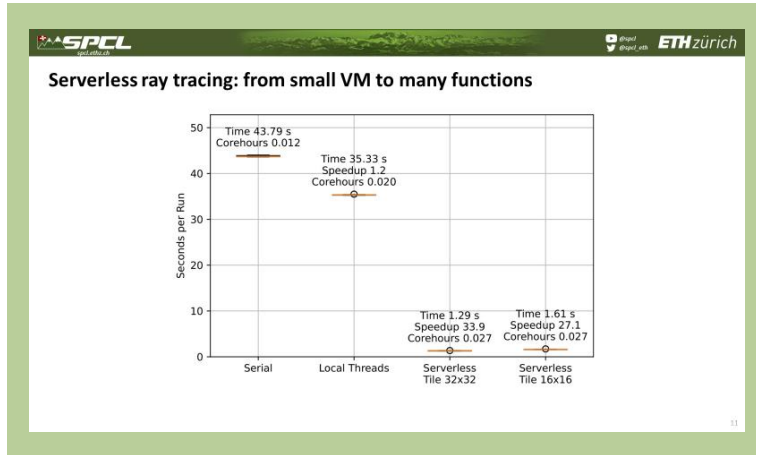

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