Google

Introduction to Service Weaver

A Framework for Writing Distributed Applications

https://serviceweaver.dev

Distributed Programming Today

In Our Experience:

Trend

- Split the application into many microservices
- A team owns multiple microservices
- Add new microservices frequently
- Use an internal framework to manage them

Microservices

A piece of code that exports an RPC service.

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Why Split

- Scalability, fault tolerance
- Improved agility, maintainability:
  - Multiple languages? But *a vast majority of the teams use only one language.*
  - Different rollout schedules? But *a significant fraction of the teams have only one rollout schedule.*
  - Frequent rollouts? But *only a tiny fraction of the microservices are released very often.*

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  - Different rollout schedules? But *a significant fraction of the teams have only one rollout schedule.*
  - Frequent rollouts? But *only a tiny fraction of the microservices are released very often.*

But splitting into microservices has drawbacks:

- Versioned upgrades
- Configuration complexity multiplied
- Added IDL and protocol complexity
- API hardening
- E2E and local testing

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Bad:

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- Harder to deploy
- Harder to maintain

Distributed Programming Today

Monolith

Single binary

Single config

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Bridges the gap between the two:

- Programming model of a modular binary
- Flexibility of microservices

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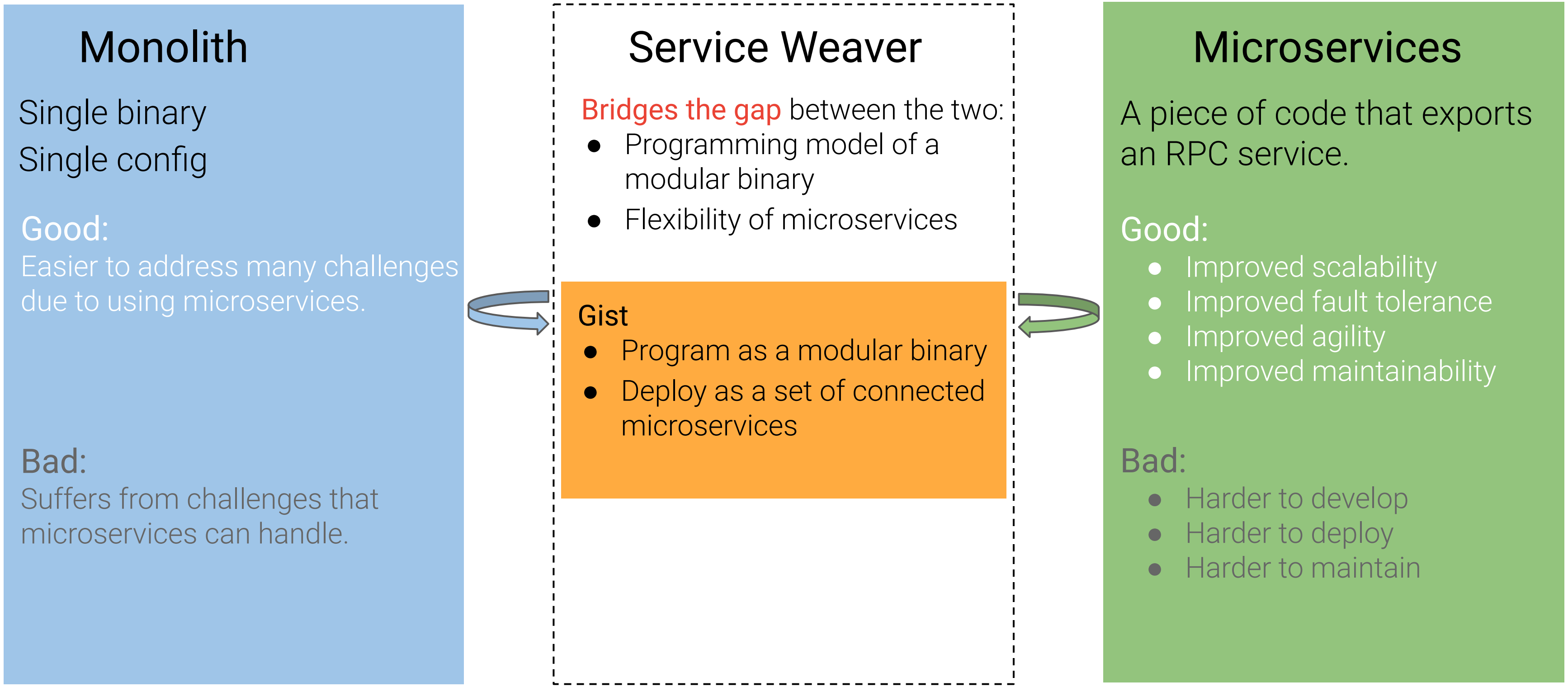

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Gist

- Program as a modular binary
- Deploy as a set of connected microservices

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Enables high-performance applications

Enables portability (multi-cloud, multi-language)

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Service Weaver at a Glance

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Development

- Using native language constructs
- Organized around native language interfaces
- No code versioning concerns
- Embedded fields to weavify the app

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- Run as a set of microservices at the same code version
- Multiple deployers (local, GKE, SSH)
- Safe rollouts (blue/green deployments)

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Telemetry and Testing

- Integrated logging, metrics, and tracing
- Easy local testing
- Quick local iteration over application changes via `go run`

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Performance

- Efficient serialization and transport
- Colocation
- Routing

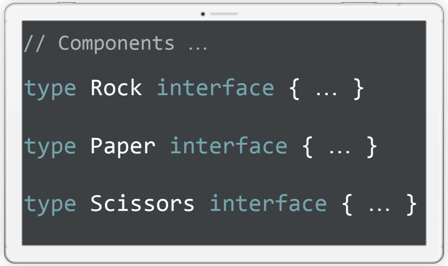
Development

Application

A set of `components` that call each other.

Under the hood: a code generator to weavify the application (e.g., generate encoding, stubs, etc.)

Write as a modular binary



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// Components ...
type Rock interface { … }
type Paper interface { … }
type Scissors interface { … }
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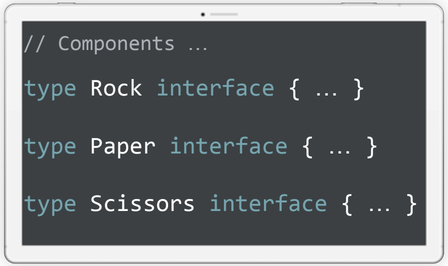

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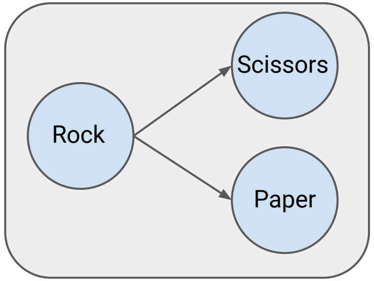
Run Locally



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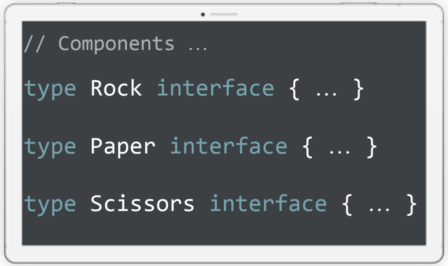

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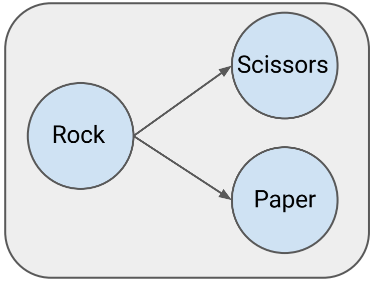
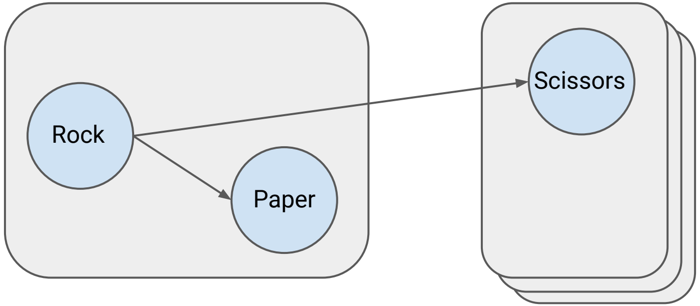


Run Distributed



Application

How to define a `component`?

- Represented as a Go interface
- Args/results must be serializable

```
// Cache component definition.
type Cache interface {
  Put(ctx context.Context, key, value string) error
  ...
}
```

Application

How to define a `component`?

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How to implement a `component`?

- As a Go struct
- The implementation should embed `weaver.Implements[T]`

```go
// Cache component definition.
type Cache interface {
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}



// Cache component implementation.
type cache struct {
  weaver.Implements[Cache] // to weavify the component
  data map[string]string
}

func (c *cache) Put(_ context.Context, key, value string) error {
  c.data[key] = value
  return nil
}
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Application

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- The implementation should embed `weaver.Implements[T]`

How to instantiate a `component`?

- `weaver.Init`(...) to initialize the application
- `weaver.Get[T]`returns a handle to the `component`

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// Cache component definition.
type Cache interface {
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// Cache component implementation.
type cache struct {
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func (c *cache) Put(_ context.Context, key, value string) error {
  c.data[key] = value
  return nil
}



func main() {
  ctx := context.Background()
  root := weaver.Init(ctx) // Initialize the app.
  cache, err := weaver.Get[Cache](root)
}
```

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How to interact with a `component`?

- Simple method calls

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func main() {
  ctx := context.Background()
  root := weaver.Init(ctx) // Initialize the app.
  cache, err := weaver.Get[Cache](root)
  …
  err = cache.Put(ctx, “mykey”, “myvalue”)
  …
}
```

Deployment

How to deploy?

Release a single binary

Single Config

- Tiny

```
// Rock Paper Scissors app config.
[serviceweaver]
binary = "./game"
colocate = [  // optional
  ["Rock", "Paper"], ["Scissors"]
]
rollout = "1m" // optional
```

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```
$ go run .                             # Run in a single process.
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```
$ go run .                         # Run in a single process.
$ weaver multi deploy weaver.toml  # Run in multiple processes.
```

How to deploy?

Release a single binary

Single Config

- Tiny
- Per deployment

Deployment commands for

- Local
- Multiple machines
- Cloud

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// Deployments config.
[ssh]
locations_file = "./ssh_locations.txt"
```

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$ go run .                           # Run in a single process.
$ weaver multi deploy weaver.toml    # Run in multiple processes.
$ weaver ssh deploy weaver.toml      # Run in the cluster.
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// Deployments config.
[ssh]
locations_file = "./ssh_locations.txt"

[gke]
regions = ["us-west1"]
public_listener = [
  {name = "game", hostname = "game.example.com"},
]
```

```
$ go run .                             # Run in a single process.
$ weaver multi deploy weaver.toml      # Run in multiple processes.
$ weaver ssh deploy weaver.toml        # Run in the cluster.
$ weaver gke deploy weaver.toml        # Run in the cloud.
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How is it deployed?

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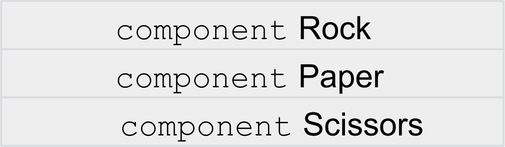
Modular binary



`component` Rock

`component` Paper

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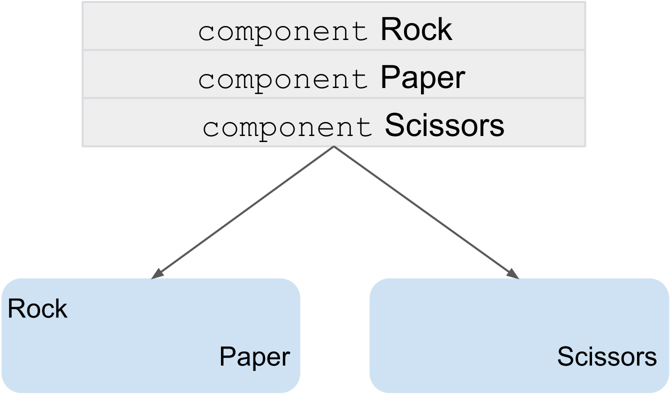

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Processes
`(aka microservices)`

Rock

Paper

Scissors

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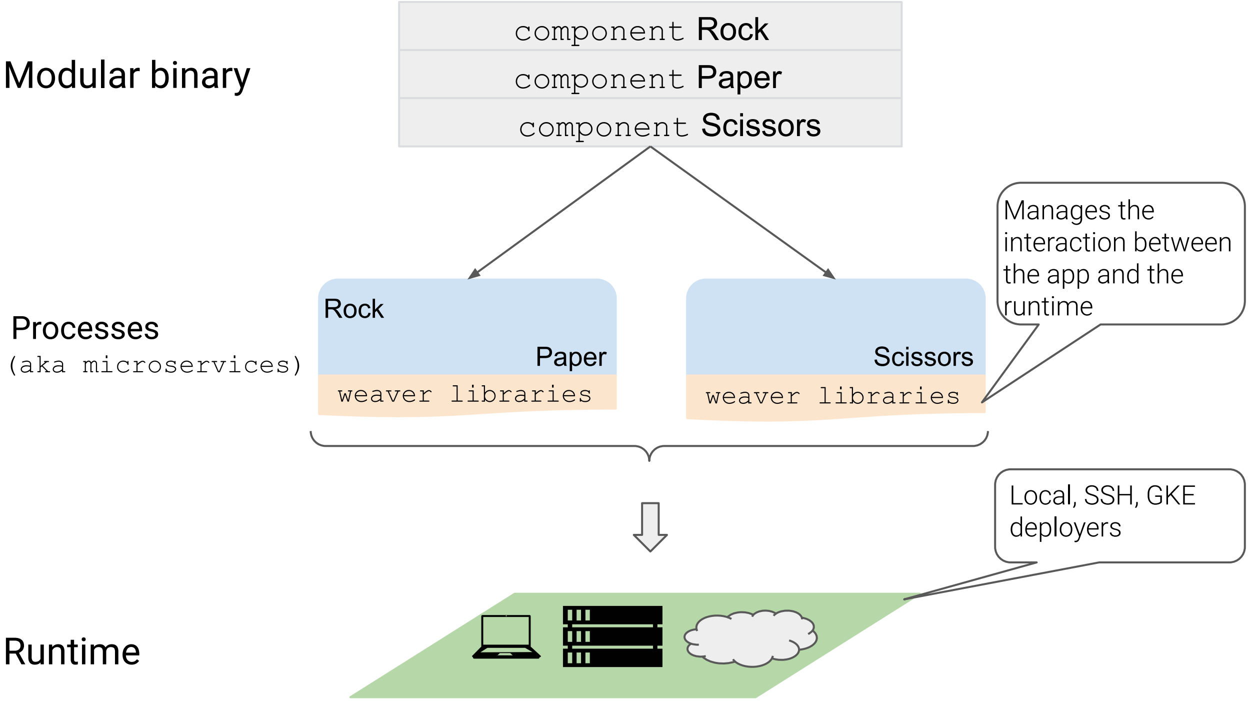

Modular binary

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Rock

Paper

`weaver libraries`

Scissors

`weaver libraries`

Manages the interaction between the app and the runtime

Runtime

Local, SSH, GKE deployers

Telemetry and Testing

Instrumentation

Logging

- Each `component` has an associated logger
- Structured logging: cat, tail, search, filter logs

```
...
func (c *cache) Put(_ context.Context, key, value string) error {
  c.Logger().Info(“Add”, “key”, key, “value”, value)
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$ weaver gke logs --follow  # Follow all the logs.
$ weaver gke logs ‘app==“cache” && level==”info” # Only info logs.
$ …
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Metrics

- Counters, gauges, and histograms
- Includes framework metrics

```
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var putCount = weaver.NewCounter(“put_count”, “Number of Put ops.”)
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Tracing

- Relies on OpenTelemetry
- Once enabled, all HTTP requests and `component` method calls are automatically traced

```
func main() {
  …
  // Create an otel handler to enable tracing.
  otelHandler := otelhttp.NewHandler(http.DefaultServeMux, “http”)
  http.Serve(lis, otelHandler)
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Profiling

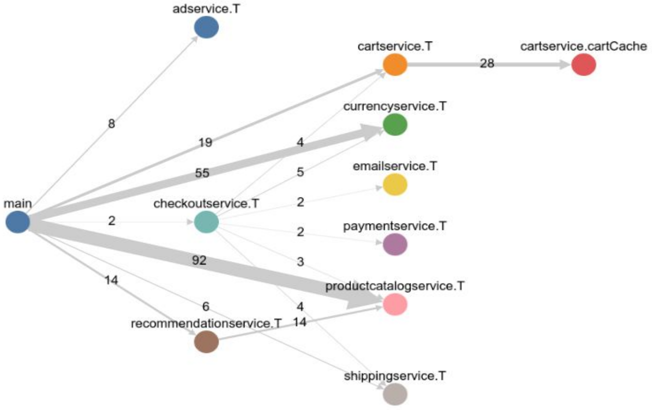
- Profile each individual process and aggregates into a single profile
- Captures the performance of the app as a whole

```
$ weaver gke profile cache             # CPU profile.
$ weaver gke profile --type=heap cache # Heap profile.
$ …
```

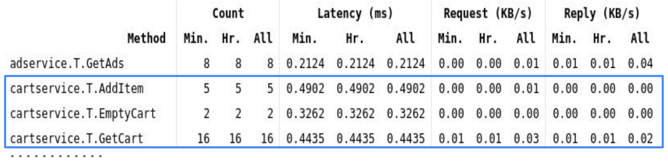
Monitoring

Dashboards

Bird’s eye view



Per component



	Count			Latency (ms)			Request (KB/s)			Reply (KB/s)		
Method	Min.	Hr.	All	Min.	Hr.	All	Min.	Hr.	All	Min.	Hr.	All
adservice.T.GetAds	8	8	8	0.2124	0.2124	0.2124	0.00	0.00	0.01	0.01	0.01	0.04
cartservice.T.AddItem	5	5	5	0.4902	0.4902	0.4902	0.00	0.00	0.01	0.00	0.00	0.00
cartservice.T.EmptyCart	2	2	2	0.3262	0.3262	0.3262	0.00	0.00	0.00	0.00	0.00	0.00
cartservice.T.GetCart	16	16	16	0.4435	0.4435	0.4435	0.01	0.01	0.03	0.01	0.01	0.02

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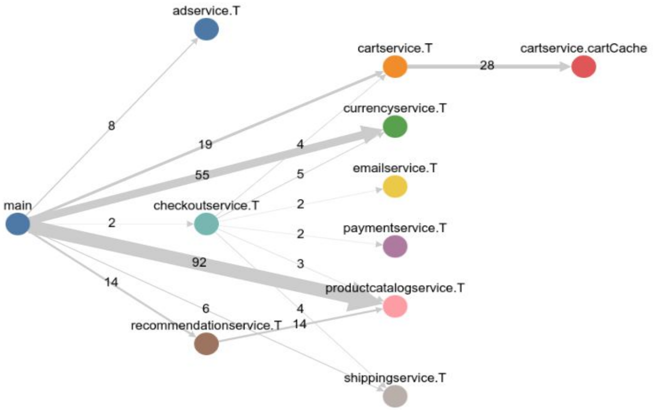

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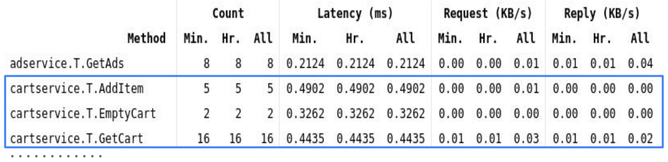

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cartservice.T.EmptyCart	2	2	2	0.3262	0.3262	0.3262	0.00	0.00	0.00	0.00	0.00	0.00
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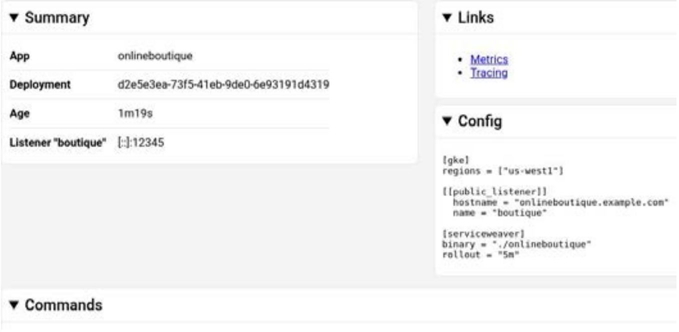
....												

Integration with Monitoring Frameworks



▼ Summary

App	onlineboutique
Deployment	d2e5e3ea-73f5-41eb-9de0-6e93191d4319
Age	1m19s
Listener "boutique"	[::]:12345

▼ Links

- Metrics
- Tracing

▼ Config

```
[gke]
regions = ["us-west1"]

[[public_listener]]
  hostname = "onlineboutique.example.com"
  name = "boutique"

[serviceweaver]
binary = "./onlineboutique"
rollout = "5m"
```

▼ Commands

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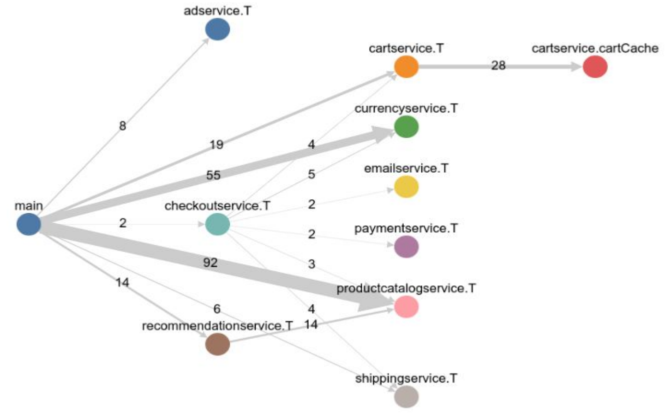

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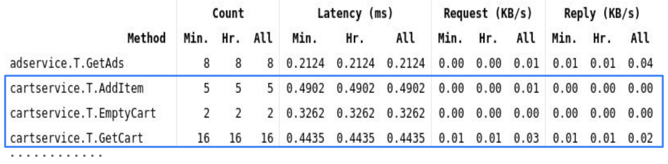

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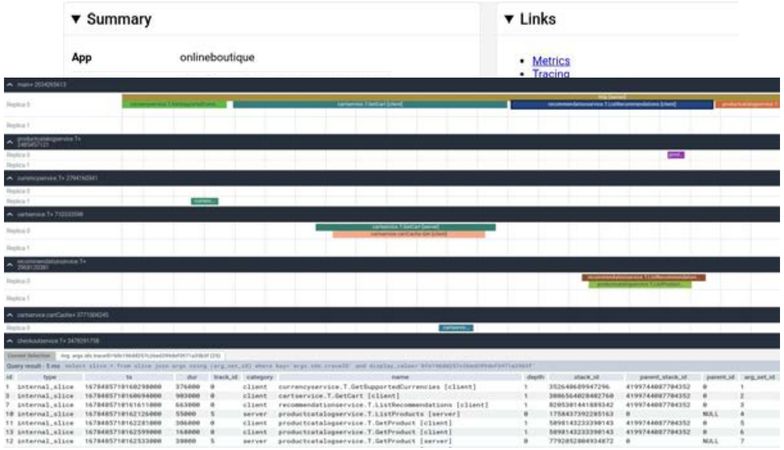
....

Integration with Monitoring Frameworks



▼ Summary

App onlineboutique

▼ Links

- Metrics
- Tracing

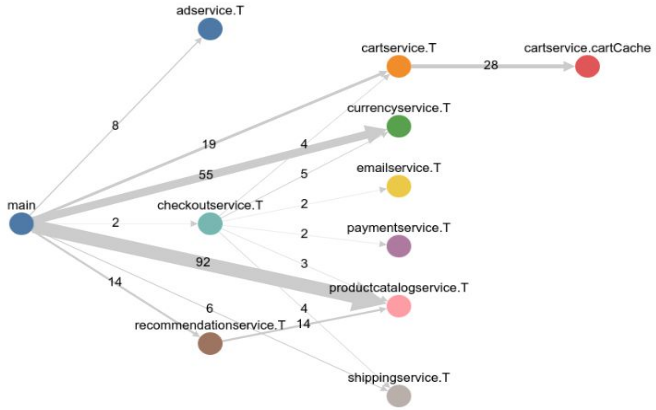
Query result - 5 ms select slice.* from slice join args using (arg_set_id) where key='args.ids.traceID' and display_value='[illegible]'

id	type	ts	dur	track_id	category	name	depth	stack_id	parent_stack_id	parent_id	arg_set_id
1	internal_slice	1678485718160298000	376000	0	client	currencyservice.T.GetSupportedCurrencies [client]	1	3526486089947296	4199744087704352	0	1
3	internal_slice	1678485718160694000	903000	0	client	cartservice.T.GetCart [client]	1	3086564028402768	4199744087704352	0	2
7	internal_slice	1678485718161611000	663000	0	client	recommendationservice.T.ListRecommendations [client]	1	8205301441889342	4199744087704352	0	3
10	internal_slice	1678485718162126000	55000	5	server	productcatalogservice.T.ListProducts [server]	0	1758437392285163	0	NULL	4
11	internal_slice	1678485718162281000	306000	0	client	productcatalogservice.T.GetProduct [client]	1	5098143233390143	4199744087704352	0	5
13	internal_slice	1678485718162599000	168000	0	client	productcatalogservice.T.GetProduct [client]	1	5098143233390143	4199744087704352	0	6
12	internal_slice	1678485718162533000	38000	5	server	productcatalogservice.T.GetProduct [server]	0	7792852004934872	0	NULL	7

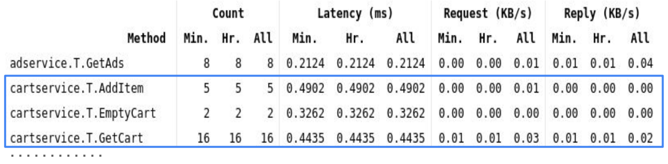
Monitoring

Dashboards

Bird's eye view



Per component



	Count			Latency (ms)			Request (KB/s)			Reply (KB/s)		
Method	Min.	Hr.	All	Min.	Hr.	All	Min.	Hr.	All	Min.	Hr.	All
adservice.T.GetAds	8	8	8	0.2124	0.2124	0.2124	0.00	0.00	0.01	0.01	0.01	0.04
cartservice.T.AddItem	5	5	5	0.4902	0.4902	0.4902	0.00	0.00	0.01	0.00	0.00	0.00
cartservice.T.EmptyCart	2	2	2	0.3262	0.3262	0.3262	0.00	0.00	0.00	0.00	0.00	0.00
cartservice.T.GetCart	16	16	16	0.4435	0.4435	0.4435	0.01	0.01	0.03	0.01	0.01	0.02

....

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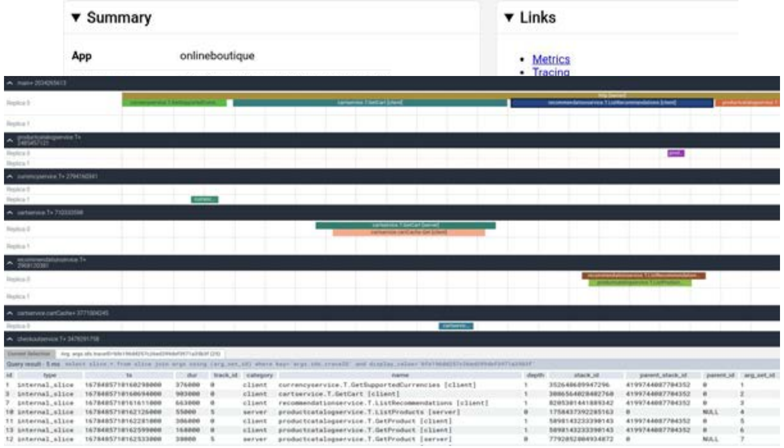

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Tracing:

- Perfetto
- Google Cloud Trace

Metrics:

- Prometheus
- Metrics Explorer

Logs:

- Logs Explorer

Testing

Unit testing

- Use `weavertest` package
- Run tests in single/multi process mode

```
func main() {
  ctx := context.Background()
  root := weaver.Init(ctx) // Initialize the app.
  cache, err := weaver.Get[Cache](root)
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  err = cache.Put(ctx, “mykey”, “myvalue”)
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E2E testing

- Use status commands
- Check logs, metrics, traces, dashboards
- Profiles

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(1)

```
# Run in a single process.
~/cache $ go run .
```

- Test whether the app still runs properly

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```go
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(2)

```
# Run in multiple processes.
~/cache $ weaver multi deploy weaver.toml
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- Test whether the app is making any assumptions that don’t hold in a distributed setting

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(3)

```
# Emulate GKE runs.
~/cache $ weaver gke-local deploy weaver.toml
```

- Test whether the app still works in the presence of multiple app versions running

Performance

Highly-Performant Runtime

Efficient encoding/decoding

- Argument/result types known at the sender/receiver
- No versioning overheads

Efficient transport

- Built on top of TCP
- Custom load-balancing

Colocation

- Flexibility to colocate some `components` in the same OS process

Routing

- Increased likelihood to route requests with the same key to the same `component` replica
- Increases cache hit ratio

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Benchmarking

- OnlineBoutique Application
- 11 microservices
- E2-Medium VMs (1 core each), GKE, us-west1, 670 qps load
- Non-Weaver vs. Weaver (split) vs. Weaver (merged)

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Go code	2647 lines	2117 lines	2117 lines	up to 1.25x

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Go code	2647 lines	2117 lines	2117 lines	up to 1.25x
Config code	1507 lines	9 lines	12 lines	∞
Autoscaled to	21 VMs	10 VMs	5 VMs	up to 4x

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Config code	1507 lines	9 lines	12 lines	∞
Autoscaled to	21 VMs	10 VMs	5 VMs	up to 4x
Median latency	40 ms	12 ms	6 ms	up to 7x
99p latency	520 ms	130 ms	14 ms	up to 37x

FAQ

Do’s

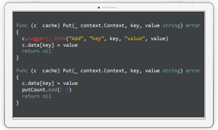
- Write a single modularized binary
- Decide on how to split into microservices only when you deploy
- Don't worry about the underlying network transports (e.g., HTTP, gRPC) and serialization (e.g., JSON, Protocol Buffers)
- Allows cross-component calls within the same process to be optimized down to local method calls

Don’ts

- Hide the network - the method calls should be treated as remote by default
- Organize the application code and low level interactions through an IDL
- Worry about code versioning issues and rollouts

Service Weaver

A Framework for Writing Distributed Applications



```
func (c *cache) Put(_ context.Context, key, value string) error
{
  c.Logger().Info("Add", "key", key, "value", value)
  c.data[key] = value
  return nil
}

func (c *cache) Put(_ context.Context, key, value string) error
{
  c.data[key] = value
  putCount.Add(1.0)
  return nil
}
```

Easy to Develop

Split into `Components`

Interact through method calls

Single binary

Easy to Deploy

Tiny Config

Deployed as microservices

Local, SSH, GKE deployers

Easy to Monitor

Embedded telemetry

Integration with Monitoring Frameworks

High-Performance

Efficient encoding

Efficient transport

Component Colocation

http://serviceweaver.dev

Try it out!

Contribute!

Give Feedback!

Google