Monitoring

One of the most important decisions to make when setting up web application monitoring is deciding on the type of metrics you need to collect about your app. The metrics you choose simplifies troubleshooting when a problem occurs and also enables you to stay on top of the stability of your services and infrastructure.

The RED method follows on the principles outlined in the Four Golden Signals, which focuses on measuring things that end-users care about when using your web services. With the RED method, three key metrics are instrumented that monitor every microservice in your architecture:

- (Request) Rate - the number of requests, per second, your services are serving.
- (Request) Errors - the number of failed requests per second.
- (Request) Duration - The amount of time each request takes expressed as a time interval.

Rate, Errors and Duration attempt to cover the most obvious web service issues. These metrics also capture an error rate that is expressed as a proportion of request rate.

Of course, this is just a good starting point for metrics instrumentation. Generally, the more metrics we collect from an application the better.

> **Instrument first, ask questions later**
> During development you will never know what questions you need to ask later. Software needs good instrumentation, it’s not optional. Metrics are cheap. Use them generously. The First and the most important rule, if you have to remember only one thing remember this one. Instrument all the things!
>
> The Zen of Prometheus

Deploy the monitoring stack in Docker Compose

1). Start the monitoring stack:

```
cd b2m-nodejs-v2/lab-3
docker-compose build
docker-compose up -d
```

> Note, it may take a while for the first time, because it will download the monitoring stack images from DockerHub and build an image for our Node.js application.

2). While waiting for containers, review the configuration of our monitoring lab.

- `b2m-nodejs-v2/lab-3/docker-compose.yaml` - this is the main config file for docker-compose stack which specifies all options for all containers in the stack.
- `b2m-nodejs-v2/lab-3/app/server.js` - the source code of our sample Node.js application.
- `b2m-nodejs-v2/lab-3/app/Dockerfile` - this file is used to build your app docker image.

3). Verify that you can access the monitoring stack UIs:

- Prometheus: `http://<your-hostname>:9090`
- Grafana: `http://<your-hostname>:3000` (user/pw: admin/foobar)

4). Verify that your Node.js app works:

```
curl http://<your-hostname>:3003
```

Instrument application code with Node.js client library for Prometheus

Expose default Node.js runtime metrics

1). Go to the directory `b2m-nodejs-v2/lab-3/app` where the `server.js` file is located and add the following dependency to the `package.json`:

```
    "prom-client": "^11.2.1"
```

There are some default metrics recommended by Prometheus itself.

To collect these, call `collectDefaultMetrics`

> Some of the metrics, concerning File Descriptors and Memory, are only available on Linux.

In addition, some Node-specific metrics are included, such as event loop lag, active handles and Node.js version. See what metrics there are in https://github.com/siimon/prom-client/lib/metrics.

`collectDefaultMetrics` takes 1 options object with 3 entries, a timeout for how often the probe should be fired, an optional prefix for metric names and a registry to which metrics should be registered. By default probes are launched every 10 seconds, but this can be modified like this:

```
const client = require('prom-client');
const collectDefaultMetrics = client.collectDefaultMetrics;
// Probe every 5th second.
collectDefaultMetrics({ timeout: 5000 });
```

2). Edit `server.js` and *uncomment* the following lines to enable exposure of default set of Node.js metrics on standard Prometheus route `/metrics`

```
const Prometheus = require('prom-client')
const metricsInterval = Prometheus.collectDefaultMetrics()
```

and

```
 app.get('/metrics', (req, res) => {
   res.set('Content-Type', Prometheus.register.contentType)
   res.end(Prometheus.register.metrics())
 })
```

3). Rebuild you app container

```
cd ~/b2m-nodejs-v2/lab-3
docker-compose down
docker-compose build
docker-compose up -d
```

Run a couple of transactions by refreshing the URL: `http://<your-hostname>:3003/checkout`

Use browser or `curl` to access `http://<your-hostname>:3003/metrics` in order to verify exposed metrics. Output should be similar to:

```
# HELP process_cpu_user_seconds_total Total user CPU time spent in
seconds.
# TYPE process_cpu_user_seconds_total counter
process_cpu_user_seconds_total 0.028084 1546452963611

# HELP process_cpu_system_seconds_total Total system CPU time spent in
seconds.
# TYPE process_cpu_system_seconds_total counter
process_cpu_system_seconds_total 0.0038780000000000004 1546452963611

# HELP process_cpu_seconds_total Total user and system CPU time spent in
seconds.
# TYPE process_cpu_seconds_total counter
process_cpu_seconds_total 0.031962 1546452963611

# HELP process_start_time_seconds Start time of the process since unix
epoch in seconds.
# TYPE process_start_time_seconds gauge
process_start_time_seconds 1546452953

# HELP process_resident_memory_bytes Resident memory size in bytes.
# TYPE process_resident_memory_bytes gauge
process_resident_memory_bytes 29188096 1546452963611

# HELP nodejs_eventloop_lag_seconds Lag of event loop in seconds.
# TYPE nodejs_eventloop_lag_seconds gauge
nodejs_eventloop_lag_seconds 0.000393303 1546452963612

# HELP nodejs_active_handles_total Number of active handles.
# TYPE nodejs_active_handles_total gauge
nodejs_active_handles_total 3 1546452963611
```

```
# HELP nodejs_active_requests_total Number of active requests.
# TYPE nodejs_active_requests_total gauge
nodejs_active_requests_total 0 1546452963611

# HELP nodejs_heap_size_total_bytes Process heap size from node.js in
bytes.
# TYPE nodejs_heap_size_total_bytes gauge
nodejs_heap_size_total_bytes 20217856 1546452963611

# HELP nodejs_heap_size_used_bytes Process heap size used from node.js in
bytes.
# TYPE nodejs_heap_size_used_bytes gauge
nodejs_heap_size_used_bytes 8464704 1546452963611

# HELP nodejs_external_memory_bytes Nodejs external memory size in bytes.
# TYPE nodejs_external_memory_bytes gauge
nodejs_external_memory_bytes 24656 1546452963611

# HELP nodejs_heap_space_size_total_bytes Process heap space size total
from node.js in bytes.
# TYPE nodejs_heap_space_size_total_bytes gauge
nodejs_heap_space_size_total_bytes{space="read_only"} 0 1546452963612
nodejs_heap_space_size_total_bytes{space="new"} 8388608 1546452963612
nodejs_heap_space_size_total_bytes{space="old"} 8134656 1546452963612
nodejs_heap_space_size_total_bytes{space="code"} 1048576 1546452963612
nodejs_heap_space_size_total_bytes{space="map"} 1073152 1546452963612
nodejs_heap_space_size_total_bytes{space="large_object"} 1572864
1546452963612

# HELP nodejs_heap_space_size_used_bytes Process heap space size used from
node.js in bytes.
# TYPE nodejs_heap_space_size_used_bytes gauge
nodejs_heap_space_size_used_bytes{space="read_only"} 0 1546452963612
nodejs_heap_space_size_used_bytes{space="new"} 829768 1546452963612
nodejs_heap_space_size_used_bytes{space="old"} 6008448 1546452963612
nodejs_heap_space_size_used_bytes{space="code"} 847136 1546452963612
nodejs_heap_space_size_used_bytes{space="map"} 533016 1546452963612
nodejs_heap_space_size_used_bytes{space="large_object"} 249024
1546452963612

# HELP nodejs_heap_space_size_available_bytes Process heap space size
available from node.js in bytes.
# TYPE nodejs_heap_space_size_available_bytes gauge
nodejs_heap_space_size_available_bytes{space="read_only"} 0 1546452963612
nodejs_heap_space_size_available_bytes{space="new"} 3294904 1546452963612
nodejs_heap_space_size_available_bytes{space="old"} 1656536 1546452963612
nodejs_heap_space_size_available_bytes{space="code"} 0 1546452963612
nodejs_heap_space_size_available_bytes{space="map"} 80 1546452963612
nodejs_heap_space_size_available_bytes{space="large_object"} 1506500096
1546452963612

# HELP nodejs_version_info Node.js version info.
# TYPE nodejs_version_info gauge
nodejs_version_info{version="v10.7.0",major="10",minor="7",patch="0"} 1
```

Define custom metric

Node.js Prometheus client library allows to define various types of Prometheus metrics like histograms, summaries, gauges and counters. More detailed description of metric types can be found in Prometheus documentation.

In this lab we will define two custom metrics:

- counter `checkouts_total` which will store a total number of `checkout` requests
- histogram `http_request_duration_ms` which will store percentiles of application requests response time

Uncomment the rest of commented lines in `server.js`.

checkouts_total

Declaration of `checkouts_total` counter.

```
const checkoutsTotal = new Prometheus.Counter({
   name: 'checkouts_total',
   help: 'Total number of checkouts',
   labelNames: ['payment_method']
 })
```

This counter will be incremented for every `checkout` request

```
checkoutsTotal.inc({
     payment_method: paymentMethod
})
```

http_request_duration_ms

Declaration of `http_request_duration_ms` histogram:

```
const httpRequestDurationMicroseconds = new Prometheus.Histogram({
   name: 'http_request_duration_ms',
   help: 'Duration of HTTP requests in ms',
   labelNames: ['method', 'route', 'code'],
   buckets: [0.10, 5, 15, 50, 100, 200, 300, 400, 500]  // buckets for
response time from 0.1ms to 500ms
 })
```

The current time is recorded before each request:

```
app.use((req, res, next) => {
  res.locals.startEpoch = Date.now()
  next()
})
```

We record the current time also after each request and update our `http_request_duration_ms` histogram accordingly:

```
app.use((req, res, next) => {
  const responseTimeInMs = Date.now() - res.locals.startEpoch

  httpRequestDurationMicroseconds
    .labels(req.method, req.route.path, res.statusCode)
    .observe(responseTimeInMs)
  next()
})
```

After you complete code changes, rebuild your app container:

```
cd ~/b2m-nodejs-v2/lab-3
docker-compose down
docker-compose build
docker-compose up -d
```

Run a couple of transactions by refreshing the URL: `http://<your-hostname>:3003/checkout`

Use browser to access `http://<your-hostname>:3003/metrics` to verify exposed metrics. The output should be similar to:

```
(...)
# HELP checkouts_total Total number of checkouts
# TYPE checkouts_total counter
checkouts_total{payment_method="paypal"} 7
checkouts_total{payment_method="stripe"} 5

# HELP http_request_duration_ms Duration of HTTP requests in ms
# TYPE http_request_duration_ms histogram
http_request_duration_ms_bucket{le="0.1",code="304",route="/",method="GET"
} 0
http_request_duration_ms_bucket{le="5",code="304",route="/",method="GET"}
0
http_request_duration_ms_bucket{le="15",code="304",route="/",method="GET"}
0
http_request_duration_ms_bucket{le="50",code="304",route="/",method="GET"}
```

```
0
http_request_duration_ms_bucket{le="100",code="304",route="/",method="GET"
} 0
http_request_duration_ms_bucket{le="200",code="304",route="/",method="GET"
} 3
http_request_duration_ms_bucket{le="300",code="304",route="/",method="GET"
} 3
http_request_duration_ms_bucket{le="400",code="304",route="/",method="GET"
} 3
http_request_duration_ms_bucket{le="500",code="304",route="/",method="GET"
} 3
http_request_duration_ms_bucket{le="+Inf",code="304",route="/",method="GET
"} 3
http_request_duration_ms_sum{method="GET",route="/",code="304"} 415
http_request_duration_ms_count{method="GET",route="/",code="304"} 3
http_request_duration_ms_bucket{le="0.1",code="500",route="/bad",method="G
ET"} 0
http_request_duration_ms_bucket{le="5",code="500",route="/bad",method="GET
"} 1
http_request_duration_ms_bucket{le="15",code="500",route="/bad",method="GE
T"} 1
http_request_duration_ms_bucket{le="50",code="500",route="/bad",method="GE
T"} 1
http_request_duration_ms_bucket{le="100",code="500",route="/bad",method="G
ET"} 1
http_request_duration_ms_bucket{le="200",code="500",route="/bad",method="G
ET"} 1
http_request_duration_ms_bucket{le="300",code="500",route="/bad",method="G
ET"} 1
http_request_duration_ms_bucket{le="400",code="500",route="/bad",method="G
ET"} 1
http_request_duration_ms_bucket{le="500",code="500",route="/bad",method="G
ET"} 1
http_request_duration_ms_bucket{le="+Inf",code="500",route="/bad",method="
GET"} 1
http_request_duration_ms_sum{method="GET",route="/bad",code="500"} 1
http_request_duration_ms_count{method="GET",route="/bad",code="500"} 1
http_request_duration_ms_bucket{le="0.1",code="304",route="/checkout",meth
od="GET"} 8
http_request_duration_ms_bucket{le="5",code="304",route="/checkout",method
="GET"} 12
http_request_duration_ms_bucket{le="15",code="304",route="/checkout",metho
d="GET"} 12
http_request_duration_ms_bucket{le="50",code="304",route="/checkout",metho
d="GET"} 12
http_request_duration_ms_bucket{le="100",code="304",route="/checkout",meth
od="GET"} 12
http_request_duration_ms_bucket{le="200",code="304",route="/checkout",meth
od="GET"} 12
http_request_duration_ms_bucket{le="300",code="304",route="/checkout",meth
od="GET"} 12
http_request_duration_ms_bucket{le="400",code="304",route="/checkout",meth
od="GET"} 12
http_request_duration_ms_bucket{le="500",code="304",route="/checkout",meth
od="GET"} 12
http_request_duration_ms_bucket{le="+Inf",code="304",route="/checkout",met
hod="GET"} 12
http_request_duration_ms_sum{method="GET",route="/checkout",code="304"} 4
http_request_duration_ms_count{method="GET",route="/checkout",code="304"}
12
```

Besides the default set of metrics related to resource utilization by the application process, we can see the additional metrics:

- `checkouts_total`
- `http_request_duration_ms_bucket`

Metrics collection

Prometheus in this lab has been pre-configured to collect metrics from your Node.js app. Check the `b2m-nodejs/lab-3/prometheus/prometheus.yml` file for this config:

```
- job_name: 'b2m-nodejs'
  scrape_interval: 20s
  static_configs:
  - targets: ['b2m-nodejs:3003']
    labels:
      service: 'b2m-nodejs'
```

Verify that Prometheus server was started via: http://:9090
Check the status of scraping targets in Prometheus UI -> Status -> Targets

Run example PromQL queries

Generate some application load before running the queries:

```
for i in {1..10000}; do curl -w "\n" http://<your-hostname>:3003/checkout;
done
```

> If you run the lab locally, you can use the `localhost`

Run the following example PromQL queries using the Prometheus UI.

Throughput

Error rate

Range[0,1]: number of 5xx requests / total number of requests

```
sum(increase(http_request_duration_ms_count{code=~"^5..$"}[1m])) /
sum(increase(http_request_duration_ms_count[1m]))
```

Expected value `~0.2` because our application should return 500 for about 20% of transactions.

Request Per Minute

```
sum(rate(http_request_duration_ms_count[1m])) by (service, route, method,
code)  * 60
```

Check the graph.

Response Time

Apdex

Apdex score approximation: `100ms` target and `300ms` tolerated response time

```
(sum(rate(http_request_duration_ms_bucket{le="100"}[1m])) by (service) +
sum(rate(http_request_duration_ms_bucket{le="300"}[1m])) by (service)
) / 2 / sum(rate(http_request_duration_ms_count[1m])) by (service)
```

> Note that we divide the sum of both buckets. The reason is that the histogram buckets are cumulative. The le="100" bucket is also contained in the le="300" bucket; dividing it by 2 corrects for that. - Prometheus docs

95th Response Time

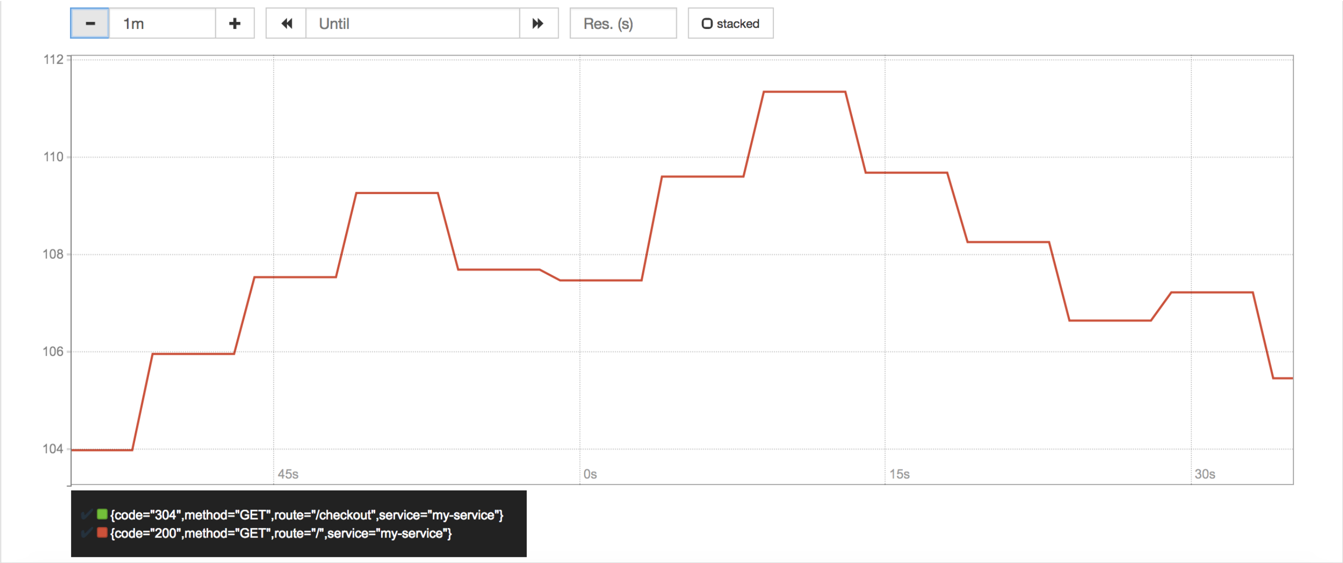
```
histogram_quantile(0.95, sum(rate(http_request_duration_ms_bucket[1m])) by
(le, service, route, method))
```

Median Response Time

```
histogram_quantile(0.5, sum(rate(http_request_duration_ms_bucket[1m])) by
(le, service, route, method))
```

Average Response Time

```
avg(rate(http_request_duration_ms_sum[1m]) /
rate(http_request_duration_ms_count[1m])) by (service, route, method,
code)
```



−
1m
+
◀◀
Until
▶▶
Res. (s)
○ stacked
112
110
108
106
104
45s
0s
15s
30s
🟩 {code="304",method="GET",route="/checkout",service="my-service"}
🟥 {code="200",method="GET",route="/",service="my-service"}

Memory Usage

Average Memory Usage

In Megabytes.

```
avg(nodejs_external_memory_bytes / 1024 ) by (service)
```

Configure Prometheus alert

Alerting rules allows to define alert conditions based on Prometheus expression language expressions and to send notifications about firing alerts to an external service. In this lab we will configure one alerting rule for median response time higher than 100ms.

Lab instruction:

Add the following alert rule to the `alert.rules` file. In the lab VM it is located in `/root/prometheus/prometheus/alert.rules`

```
  - alert: APIHighMedianResponseTime
    expr: histogram_quantile(0.5, sum by(le, service, route, method)
(rate(http_request_duration_ms_bucket[1m])))
      > 30
    for: 1m
    annotations:
      description: '{{ $labels.service }}, {{ $labels.method }} {{
$labels.route }}
        has a median response time above 100ms (current value: {{ $value
}}ms)'
      summary: High median response time on {{ $labels.service }} and {{
```

```
  $labels.method
          }} {{ $labels.route }}
```

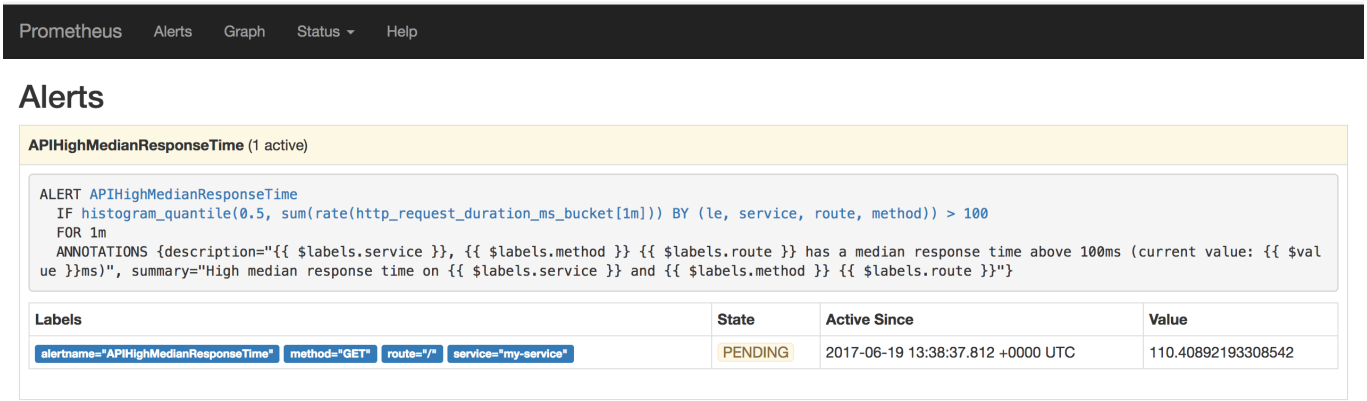
Restart the Prometheus stack:

```
cd ~/prometheus
docker-compose down
docker-compose up -d
```

Alerts can be listed via Prometheus UI: `http://<your-hostname>:9090/alerts`

States of active alerts:

- `pending`:



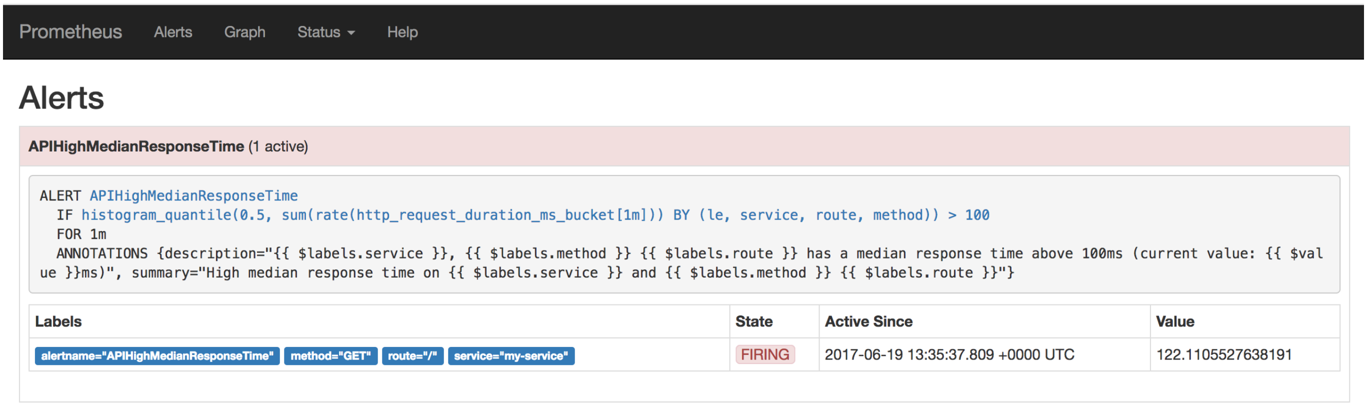
Alerts

APIHighMedianResponseTime (1 active)

```
ALERT APIHighMedianResponseTime
  IF histogram_quantile(0.5, sum(rate(http_request_duration_ms_bucket[1m])) BY (le, service, route, method)) > 100
  FOR 1m
  ANNOTATIONS {description="{{ $labels.service }}, {{ $labels.method }} {{ $labels.route }} has a median response time above 100ms (current value: {{ $val
ue }}ms)", summary="High median response time on {{ $labels.service }} and {{ $labels.method }} {{ $labels.route }}"}
```

Labels	State	Active Since	Value
alertname="APIHighMedianResponseTime" method="GET" route="/" service="my-service"	PENDING	2017-06-19 13:38:37.812 +0000 UTC	110.40892193308542

- `firing`:



Alerts

APIHighMedianResponseTime (1 active)

```
ALERT APIHighMedianResponseTime
  IF histogram_quantile(0.5, sum(rate(http_request_duration_ms_bucket[1m])) BY (le, service, route, method)) > 100
  FOR 1m
  ANNOTATIONS {description="{{ $labels.service }}, {{ $labels.method }} {{ $labels.route }} has a median response time above 100ms (current value: {{ $val
ue }}ms)", summary="High median response time on {{ $labels.service }} and {{ $labels.method }} {{ $labels.route }}"}
```

Labels	State	Active Since	Value
alertname="APIHighMedianResponseTime" method="GET" route="/" service="my-service"	FIRING	2017-06-19 13:35:37.809 +0000 UTC	122.1105527638191

Set the Prometheus datasource in Grafana

Logon to Grafana via `http://<your-hostname>:3000`

- user: admin
- password: foobar

Verify the prometheus datasource configuration in Grafana. If it was not already configured, create a Grafana datasource with these settings:

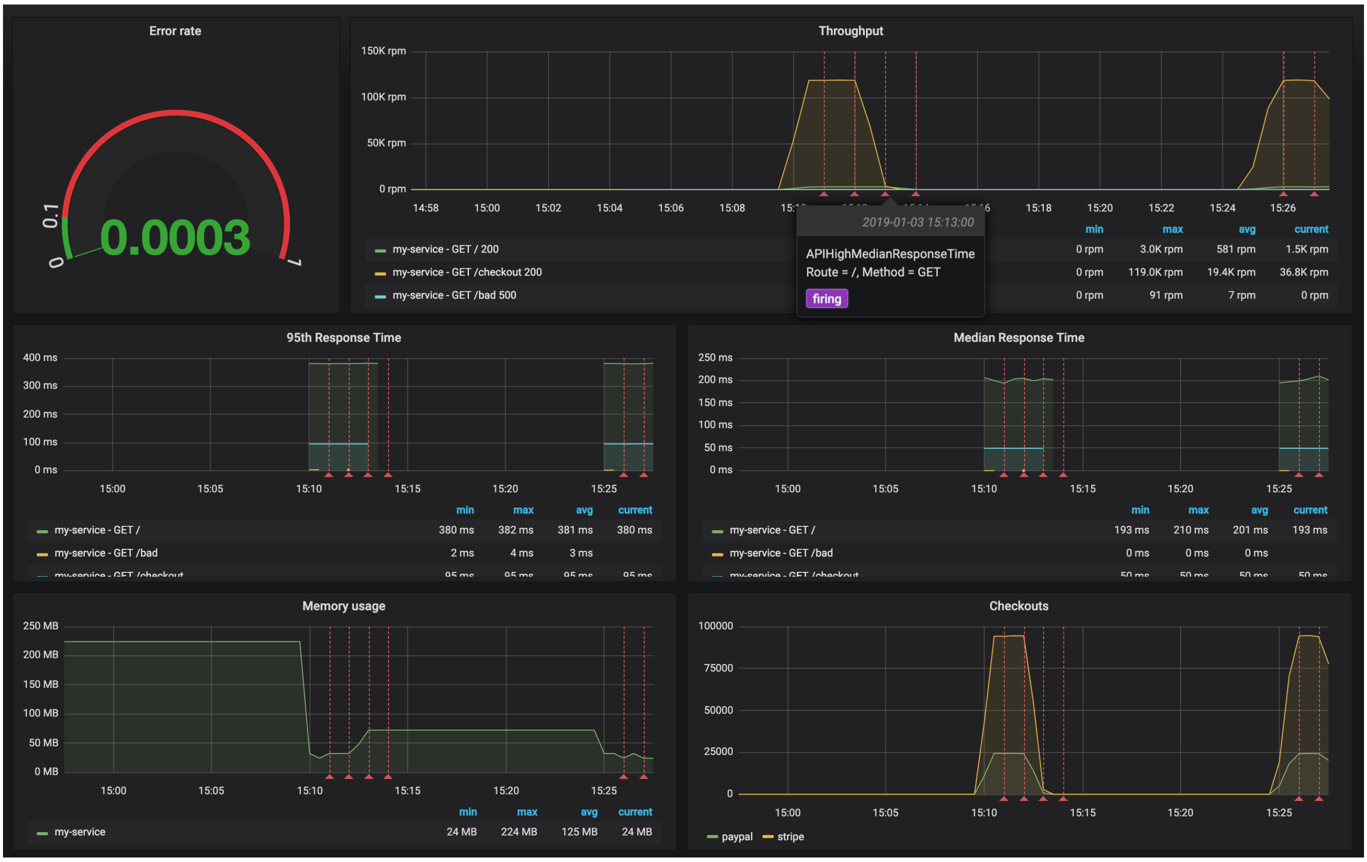
- name: Prometheus
- type: prometheus
- url: http://prometheus:9090
- Access: Server

Configure dashboard

Grafana Dashboard to import: `~/b2m-nodejs-v2/lab-3/btm-nodejs-grafana.json`

Monitoring dashboard was created according to the RED Method principles:

- Rate (`Thoughput` and `Checkouts` panels)
- Errors (`Error rate` panel)
- Duration (`95th Response Time` and `Median Response Time` panels)



2019-01-03 15:13:00

APIHighMedianResponseTime
Route = /, Method = GET

firing

Throughput

	min	max	avg	current
my-service - GET / 200	0 rpm	3.0K rpm	581 rpm	1.5K rpm
my-service - GET /checkout 200	0 rpm	119.0K rpm	19.4K rpm	36.8K rpm
my-service - GET /bad 500	0 rpm	91 rpm	7 rpm	0 rpm

95th Response Time

	min	max	avg	current
my-service - GET /	380 ms	382 ms	381 ms	380 ms
my-service - GET /bad	2 ms	4 ms	3 ms	
my-service - GET /checkout	95 ms	95 ms	95 ms	95 ms

Median Response Time

	min	max	avg	current
my-service - GET /	193 ms	210 ms	201 ms	193 ms
my-service - GET /bad	0 ms	0 ms	0 ms	
my-service - GET /checkout	50 ms	50 ms	50 ms	50 ms

Memory usage

	min	max	avg	current
my-service	24 MB	224 MB	125 MB	24 MB

Review the configuration of each dashboard panel. Check the annotation settings.

Define the Apdex score chart using the following query:

```
(sum(rate(http_request_duration_ms_bucket{le="100"}[1m])) by (service) +
sum(rate(http_request_duration_ms_bucket{le="300"}[1m])) by (service)
) / 2 / sum(rate(http_request_duration_ms_count[1m])) by (service)
```

You can add it to the existing dashboard:

- Click on the icon `Add panel` and select `Graph` panel type.
- Click on the panel title and select edit.
- Select `Prometheus` datasource in the `Metrics` tab of the panel query editor
- Copy PromQL to the free form field
- Verify the results on the panel preview
- Explore other Graph panel options