

docker container kubernetes tp03 autoscaling

# TP03 | K8s - Autoscaling

## Déroulement du TP

L'objectif du TP est de voir comment l'Autoscaling Horizontal fonctionne dans un cluster Kubernetes.

Il y a des questions lors de ce TP affichées par le symbole

Vous **DEVEZ** faire un compte-rendu et me l'envoyer sur l'adresse email :  
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**LISEZ-BIEN TOUT LE TP**

## Prérequis

- Accès au proxy IUT
- Votre VM utilisé au TP02 avec docker/kind/kubectl installés
- Cluster kind avec 1 control-plane + 2 workers avec la configuration suivante :

```
1 kind: Cluster
2 apiVersion: kind.x-k8s.io/v1alpha4
3 nodes:
4 - role: control-plane
5   kubeadmConfigPatches:
6   - |
7     kind: InitConfiguration
8     nodeRegistration:
9       kubeletExtraArgs:
10         node-labels: "ingress-ready=true"
11   extraPortMappings:
12   - containerPort: 80
13     hostPort: 80
14     protocol: TCP
15   - containerPort: 443
16     hostPort: 443
17     protocol: TCP
18   - role: worker
19   - role: worker
```

### Installation de l'ingress nginx

#### Tip

```
1 echo 'export {https_proxy,http_proxy,HTTP_PROXY,HTTPS_PROXY}="http://c3-
2 user:mdp@192.168.0.2:3128"' >> ~/.bashrc
  echo 'export {no_proxy,NO_PROXY}="localhost,127.0.0.1/8,mon-app.local"' >>
~/.bashrc
```

#### ⚠️ Puis reload votre shell ⚠️

```
1 kubectl apply -f https://raw.githubusercontent.com/kubernetes/ingress-nginx/
main/deploy/static/provider/kind/deploy.yaml
```

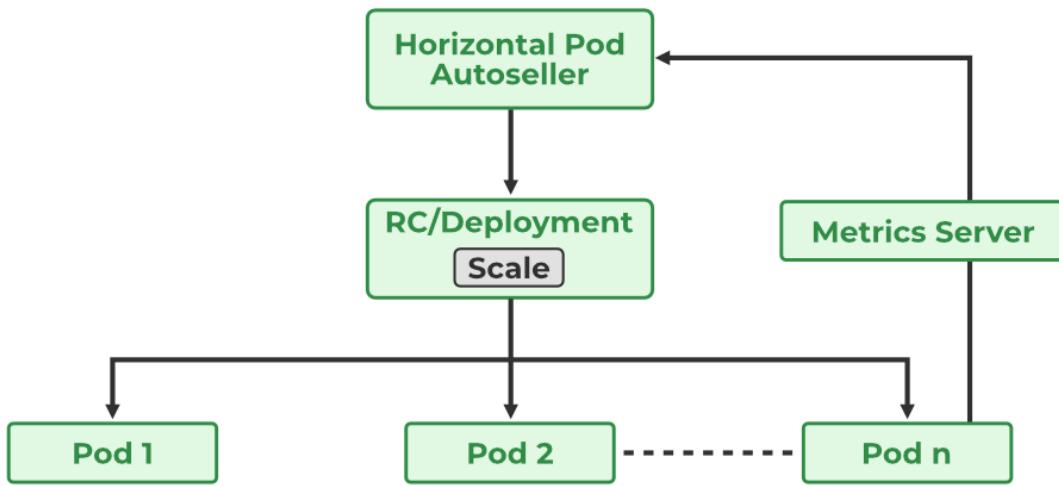
```
1 kubectl wait --namespace ingress-nginx \
2   --for=condition=ready pod \
3   --selector=app.kubernetes.io/component=controller \
4   --timeout=90s
```

## Focus sur Horizontal Pod Autoscaling

Dans Kubernetes, un `HorizontalPodAutoscaler` met automatiquement à jour une ressource de charge de travail (telle qu'un `Deployment` ou un `StatefulSet`), dans le but d'adapter automatiquement la charge de travail à la demande. La mise à l'échelle horizontale signifie que la réponse à l'augmentation de la charge consiste à déployer davantage de Pods. Si la charge diminue et que le nombre de Pods est supérieur au minimum configuré, le

`HorizontalPodAutoscaler` demande à la ressource de charge de travail (`Deployment`, `StatefulSet` ou autre ressource similaire) de réduire son échelle. L'autoscaling horizontal des pods ne s'applique pas aux objets qui ne peuvent pas être mis à l'échelle (par exemple, un `DaemonSet`).

### Comment fonctionne un `HorizontalPodAutoscaler` ?



Kubernetes implémente l'autoscaling horizontal des pods comme une boucle de contrôle qui s'exécute par intermittence. L'intervalle est défini par le paramètre `--horizontal-pod-autoscaler-sync-period` du `kube-controller-manager` (l'intervalle par défaut est de 15 secondes).

Dans la plupart des cas, ces mesures sont l'utilisation du CPU et de la RAM, mais il est également possible de spécifier vos mesures personnalisées (trafic ou autres). L'HPA vérifie en permanence les mesures de CPU et de mémoire générées par le `metrics-server` installé sur le cluster Kubernetes.

## Horizontal vs Vertical Scaling

Ressources	Horizontal	Vertical
Pod	Ajoute ou retire des pods	Modifie les resources CPU et/ou RAM allouées au pod
Noeuds	Ajoute ou retire des noeuds	Modifie les resources CPU et/ou RAM allouées au noeud

- Horizontal Scaling signifie modifier les ressources de calcul d'un cluster existant, par exemple en y ajoutant de nouveaux noeuds ou en ajoutant de nouveaux pods en augmentant le nombre de replicas de pods (Horizontal Pod Autoscaler).

- Vertical Scaling signifie modifier les ressources attribuées (comme CPU ou RAM) de chaque nœud du cluster. Dans la plupart des cas, cela signifie créer un pool de nœuds entièrement nouveau à l'aide de machines ayant des configurations matérielles différentes. La mise à l'échelle verticale sur les pods signifie l'ajustement dynamique des demandes de ressources et des limites en fonction des exigences actuelles de l'application (Vertical Pod Autoscaler).

Dans ce TP nous aborderons le scaling horizontal.

#### ✓ Questions

- *Quelle est la différence entre un scaling horizontal et vertical ?*
- *Quels objets Kubernetes peut-on scale avec le HPA ?*
- *Pourquoi scale une application ?*

## Scaling Horizontal d'une application

Pour suivre ce TP, vous devez également utiliser un cluster dans lequel un Metrics Server a été déployé et configuré. Le serveur de métriques Kubernetes collecte des métriques de ressources auprès des `kubelets` de votre cluster et expose ces métriques via l'API Kubernetes, en utilisant un `APIService` pour ajouter de nouveaux types de ressources qui représentent des lectures de métriques.

### Installation de metrics-server

```
1 kubectl apply -f https://github.com/kubernetes-sigs/metrics-server/releases/latest/download/components.yaml
```

Pour faire fonctionner `metrics server` dans notre cluster il faut modifier le déploiement :

```
1 kubectl patch -n kube-system deployment metrics-server --type=json \
2   -p '[{"op":"add","path":"/spec/template/spec/containers/0/
args/-","value":"--kubelet-insecure-tls"}]'
```

Verifier le bon fonctionnement de metrics server :

```
1 sudo apt install jq -y
2 kubectl get --raw "/apis/metrics.k8s.io/v1beta1/nodes" | jq .
```

#### ✓ Questions

- Quel est le résultat de la commande `curl` ?
- Expliquer simplement le résultat de cette commande `curl` ?

## Build d'une application en docker

Avant de tester l'autoscaling dans Kubernetes il faut créer un déploiement d'une application. Pour ce faire créer un dossier `express` avec comme fichiers :

### Dockerfile

```
1 FROM node:16-alpine3.11
2
3 WORKDIR /usr/src/app
4
5 COPY package*.json ./
6
7 RUN npm ci --only=production
8
9 COPY server.js .
10
11 CMD [ "node", "server.js" ]
```

### package-lock.json

```
1 {
2   "name": "express",
3   "version": "1.0.0",
4   "lockfileVersion": 2,
5   "requires": true,
6   "packages": {
7     "": {
8       "version": "1.0.0",
9       "license": "ISC",
10      "dependencies": {
11        "express": "^4.17.1"
12      }
13    },
14    "node_modules/accepts": {
15      "version": "1.3.7",
16      "resolved": "https://registry.npmjs.org/accepts/-/accepts-1.3.7.tgz",
17      "integrity": "sha512-I180Qs2WjYlJIBNzNkK6KYqlVMTbZLXgHx2oT0pU/fjRHyp+PEFEPY0R3WCwAGV0tauxh1h0xNgIf5bv7dQpA==",
18      "dependencies": {
19        "mime-types": "~2.1.24",
20        "negotiator": "0.6.2"
21      },
22      "engines": {
23        "node": ">= 0.6"
24      }
25    }
26  }
27}
```

```
25      }
26  },
27  "node_modules/array-flatten": {
28    "version": "1.1.1",
29    "resolved": "https://registry.npmjs.org/array-flatten/-/array-
30 flatten-1.1.1.tgz",
31    "integrity": "sha1-m19pkFGx5wczKPKgCJaLZ0opVdI="
32  },
33  "node_modules/body-parser": {
34    "version": "1.19.0",
35    "resolved": "https://registry.npmjs.org/body-parser/-/body-
36 parser-1.19.0.tgz",
37    "integrity": "sha512-
38 dhEPs72UPbDnAQJ9ZKMNTP6ptJaionhP5cBb541nXPlW60Jepo9RV/
39 a4fX4XWW9CuFNK22krhrj1+rgzifNCsw==",
40    "dependencies": {
41      "bytes": "3.1.0",
42      "content-type": "~1.0.4",
43      "debug": "2.6.9",
44      "depd": "~1.1.2",
45      "http-errors": "1.7.2",
46      "iconv-lite": "0.4.24",
47      "on-finished": "~2.3.0",
48      "qs": "6.7.0",
49      "raw-body": "2.4.0",
50      "type-is": "~1.6.17"
51    },
52    "engines": {
53      "node": ">= 0.8"
54    }
55  },
56  "node_modules/bytes": {
57    "version": "3.1.0",
58    "resolved": "https://registry.npmjs.org/bytes/-/bytes-3.1.0.tgz",
59    "integrity": "sha512-
60 zauLjrfCG+xvoyaqlLoV8bLVXXNGC4JqlxFCutSDWA6fJrTo2ZuvLYTqZ7aHBLZSM0opbzv8f+wZcV
61    "engines": {
62      "node": ">= 0.8"
63    }
64  },
65  "node_modules/content-disposition": {
66    "version": "0.5.3",
67    "resolved": "https://registry.npmjs.org/content-disposition/-/
68 content-disposition-0.5.3.tgz",
69    "integrity": "sha512-
70 Ex00774ikE0bIAEV9kDo50o+79VCUDEB6n6lzKgGwupcVeRlhrj3qGAfwq8G6uBJjkqLrhT0qEYFcW
71    "dependencies": {
72      "safe-buffer": "5.1.2"
73    },
74    "engines": {
75      "node": ">= 0.6"
76    }
77  },
```

```
78      "node_modules/content-type": {
79        "version": "1.0.4",
80        "resolved": "https://registry.npmjs.org/content-type/-/content-
81        type-1.0.4.tgz",
82        "integrity": "sha512-
83 hIP3EEPs8tB9AT1L+NUqtw0Aps4mk2Zob89MWXMHjHWg9milF/j4osnnQLXCBFBk/tvIG/
84 tUc9m0UJiPBhPXAA==",
85        "engines": {
86          "node": ">= 0.6"
87        }
88      },
89      "node_modules/cookie": {
90        "version": "0.4.0",
91        "resolved": "https://registry.npmjs.org/cookie/-/cookie-0.4.0.tgz",
92        "integrity": "sha512-
93 +Hp8fLp57wnUSt0tY0tHEXh4voZRDnoIrZPqlo3DPiI4y9lwg/jqx+10m94/
94 W6ZaPD0Ubnej0t/99w66zk+l1Xg==",
95        "engines": {
96          "node": ">= 0.6"
97        }
98      },
99      "node_modules/cookie-signature": {
100        "version": "1.0.6",
101        "resolved": "https://registry.npmjs.org/cookie-signature/-/cookie-
102        signature-1.0.6.tgz",
103        "integrity": "sha1-4w0ogrNCzD7oylE6eZmXNNqzriw="
104      },
105      "node_modules/debug": {
106        "version": "2.6.9",
107        "resolved": "https://registry.npmjs.org/debug/-/debug-2.6.9.tgz",
108        "integrity": "sha512-
109 bC7ElrdJaJnPbAP+1EotYvqZsb3ec15wi6Bfi6BJTUcNowp6cvspg0jXznRTKDjm/
110 E7AdgFBVeAPVMNcKGsHMA==",
111        "dependencies": {
112          "ms": "2.0.0"
113        }
114      },
115      "node_modules/depd": {
116        "version": "1.1.2",
117        "resolved": "https://registry.npmjs.org/depd/-/depd-1.1.2.tgz",
118        "integrity": "sha1-m81S4UwJd2PnSbJ0xDRu0uVgtak=",
119        "engines": {
120          "node": ">= 0.6"
121        }
122      },
123      "node_modules/destroy": {
124        "version": "1.0.4",
125        "resolved": "https://registry.npmjs.org/destroy/-/destroy-1.0.4.tgz",
126        "integrity": "sha1-14hXRCxEJ5CBmE+N5RiBYJqvYA="
127      },
128      "node_modules/ee-first": {
129        "version": "1.1.1",
130        "resolved": "https://registry.npmjs.org/ee-first/-/ee-
```

```
131  first-1.1.1.tgz",
132    "integrity": "sha1-WQxhFWsK4vTwJVcyoViyZrxWsh0="
133  },
134  "node_modules/encodeurl": {
135    "version": "1.0.2",
136    "resolved": "https://registry.npmjs.org/encodeurl/-/
137 encodeurl-1.0.2.tgz",
138    "integrity": "sha1-rT/0yG7C0CkyL1oCw6mmBslbP1k=",
139    "engines": {
140      "node": ">= 0.8"
141    }
142  },
143  "node_modules/escape-html": {
144    "version": "1.0.3",
145    "resolved": "https://registry.npmjs.org/escape-html/-/escape-
146 html-1.0.3.tgz",
147    "integrity": "sha1-Aljq5NPQwJdN4cFpGI7wBR0dGYg="
148  },
149  "node_modules/etag": {
150    "version": "1.8.1",
151    "resolved": "https://registry.npmjs.org/etag/-/etag-1.8.1.tgz",
152    "integrity": "sha1-Qa4u62XvpiJorr/qg6x9eSmbCIc=",
153    "engines": {
154      "node": ">= 0.6"
155    }
156  },
157  "node_modules/express": {
158    "version": "4.17.1",
159    "resolved": "https://registry.npmjs.org/express/-/
160 express-4.17.1.tgz",
161    "integrity": "sha512-mHJ9079RqluphRrcw2X/
162 GTh3k9tVv8YcoY4Kkh4WDMUYKRZUq0h1o0w2rrrxBqM7VoeUVqgb27x1EMXTnYt4g==",
163    "dependencies": {
164      "accepts": "~1.3.7",
165      "array-flatten": "1.1.1",
166      "body-parser": "1.19.0",
167      "content-disposition": "0.5.3",
168      "content-type": "~1.0.4",
169      "cookie": "0.4.0",
170      "cookie-signature": "1.0.6",
171      "debug": "2.6.9",
172      "depd": "~1.1.2",
173      "encodeurl": "~1.0.2",
174      "escape-html": "~1.0.3",
175      "etag": "~1.8.1",
176      "finalhandler": "~1.1.2",
177      "fresh": "0.5.2",
178      "merge-descriptors": "1.0.1",
179      "methods": "~1.1.2",
180      "on-finished": "~2.3.0",
181      "parseurl": "~1.3.3",
182      "path-to-regexp": "0.1.7",
183      "proxy-addr": "~2.0.5",
```

```
184     "qs": "6.7.0",
185     "range-parser": "~1.2.1",
186     "safe-buffer": "5.1.2",
187     "send": "0.17.1",
188     "serve-static": "1.14.1",
189     "setprototypeof": "1.1.1",
190     "statuses": "~1.5.0",
191     "type-is": "~1.6.18",
192     "utils-merge": "1.0.1",
193     "vary": "~1.1.2"
194   },
195   "engines": {
196     "node": ">= 0.10.0"
197   }
198 },
199 "node_modules/finalhandler": {
200   "version": "1.1.2",
201   "resolved": "https://registry.npmjs.org/finalhandler/-/finalhandler-1.1.2.tgz",
202   "integrity": "sha512-aAWcW57uxVNrQZqFXjITpW3sIUQmHGG3qSb9mUah9MgMC4NeWhN0lNjXEYq3HjRAvL6arUviZGGJsB
203   "dependencies": {
204     "debug": "2.6.9",
205     "encodeurl": "~1.0.2",
206     "escape-html": "~1.0.3",
207     "on-finished": "~2.3.0",
208     "parseurl": "~1.3.3",
209     "statuses": "~1.5.0",
210     "unpipe": "~1.0.0"
211   },
212   "engines": {
213     "node": ">= 0.8"
214   }
215 },
216 "node_modules/forwarded": {
217   "version": "0.2.0",
218   "resolved": "https://registry.npmjs.org/forwarded/-/forwarded-0.2.0.tgz",
219   "integrity": "sha512-buRG0fpBtrHSTCOASE6hD258tEubFoRLb4ZNA6NxMVHNw2gOcwHo9wyablzMzOA5z9xA9L1KNjk/
220 Nt6MT9aYow==",
221   "dependencies": {
222     "node": ">= 0.6"
223   }
224 },
225 "node_modules/fresh": {
226   "version": "0.5.2",
227   "resolved": "https://registry.npmjs.org/fresh/-/fresh-0.5.2.tgz",
228   "integrity": "sha1-PYyt2Q2XZWn6g1qx+0Sy0hBWbac=",
229   "engines": {
230     "node": ">= 0.6"
231   }
232 }
```

```
237      "node_modules/http-errors": {
238        "version": "1.7.2",
239        "resolved": "https://registry.npmjs.org/http-errors/-/http-
240 errors-1.7.2.tgz",
241        "integrity": "sha512-uUQBt3H/cSIVfch6i1EuPNy/
242 YsRSOUBXTVfZ+yR7Zjez3qjBz6i9+i4zjNaoqcoFVI4lQJ5plg63TvGfRSDCRg==",
243        "dependencies": {
244          "depd": "~1.1.2",
245          "inherits": "2.0.3",
246          "setprototypeof": "1.1.1",
247          "statuses": ">= 1.5.0 < 2",
248          "toidentifier": "1.0.0"
249        },
250        "engines": {
251          "node": ">= 0.6"
252        }
253      },
254      "node_modules/iconv-lite": {
255        "version": "0.4.24",
256        "resolved": "https://registry.npmjs.org/iconv-lite/-/iconv-
257 lite-0.4.24.tgz",
258        "integrity": "sha512-
259 v3MXnZAcvnywkTUEZomIActle7RXxeed0R31wwl7VlyoX04Qi9arvSenNQWne1TcRwhCL1HwLI21bE
260 rA==",
261        "dependencies": {
262          "safer-buffer": ">= 2.1.2 < 3"
263        },
264        "engines": {
265          "node": ">=0.10.0"
266        }
267      },
268      "node_modules/inherits": {
269        "version": "2.0.3",
270        "resolved": "https://registry.npmjs.org/inherits/-/
271 inherits-2.0.3.tgz",
272        "integrity": "sha1-Yzwsg+PaQqUC9SRmAiSA9CCYd4="
273      },
274      "node_modules/ipaddr.js": {
275        "version": "1.9.1",
276        "resolved": "https://registry.npmjs.org/ipaddr.js/-/
277 ipaddr.js-1.9.1.tgz",
278        "integrity": "sha512-0KI/607xoxSToH7GjN1FfSbLoU0+btTicjsQSWSQlh/
279 hZykN8KpmMf7uYwPW3R+akZ6R/w18Z1XSHBYXiYUP03g==",
280        "engines": {
281          "node": ">= 0.10"
282        }
283      },
284      "node_modules/media-typer": {
285        "version": "0.3.0",
286        "resolved": "https://registry.npmjs.org/media-typer/-/media-
287 typer-0.3.0.tgz",
288        "integrity": "sha1-hxDXrwqmJvj/+hzgAWhUUmM1V0g=",
289        "engines": {
```

```
290         "node" : ">= 0.6"
291     }
292 },
293 "node_modules/merge-descriptors": {
294     "version": "1.0.1",
295     "resolved": "https://registry.npmjs.org/merge-descriptors/-/merge-
296 descriptors-1.0.1.tgz",
297     "integrity": "sha1-sAqqVW3YtEVoFQ7J0b1T8/kMu2E="
298 },
299 "node_modules/methods": {
300     "version": "1.1.2",
301     "resolved": "https://registry.npmjs.org/methods/-/methods-1.1.2.tgz",
302     "integrity": "sha1-VSmk1nZUE07cxSZmVoNbD4Ua/04=",
303     "engines": {
304         "node": ">= 0.6"
305     }
306 },
307 "node_modules/mime": {
308     "version": "1.6.0",
309     "resolved": "https://registry.npmjs.org/mime/-/mime-1.6.0.tgz",
310     "integrity": "sha512-
311 x0Vn8spI+wuJ106S7gnbaQg8Pxh4NNHb7KSINmEWKiPE4RK0plvijn+NkmYmmRgP68mc70j2EbeTFR
312     "bin": {
313         "mime": "cli.js"
314     },
315     "engines": {
316         "node": ">=4"
317     }
318 },
319 "node_modules/mime-db": {
320     "version": "1.48.0",
321     "resolved": "https://registry.npmjs.org/mime-db/-/mime-
322 db-1.48.0.tgz",
323     "integrity": "sha512-
324 FM3QwxV+TnZYQ2aRqh1KBMHxk101TbMt3bBkMAp54ddrNeVSfcQY00KuGuy3Ddrm38I04If834f0US
325     "engines": {
326         "node": ">= 0.6"
327     }
328 },
329 "node_modules/mime-types": {
330     "version": "2.1.31",
331     "resolved": "https://registry.npmjs.org/mime-types/-/mime-
332 types-2.1.31.tgz",
333     "integrity": "sha512-
334 XGZnNzm3QvgKxa8dpzyhFTmpP315YNusmne07VU0Xou9CqUqYa/HBy124RqtVh/02pECas/
335 M0csDgpilPOPg==",
336     "dependencies": {
337         "mime-db": "1.48.0"
338     },
339     "engines": {
340         "node": ">= 0.6"
341     }
342 },
```

```
343     "node_modules/ms": {
344         "version": "2.0.0",
345         "resolved": "https://registry.npmjs.org/ms/-/ms-2.0.0.tgz",
346         "integrity": "sha1-VgiurfwAvmwpAd9fmGF4jeDVL8g="
347     },
348     "node_modules/negotiator": {
349         "version": "0.6.2",
350         "resolved": "https://registry.npmjs.org/negotiator/-/
351 negotiator-0.6.2.tgz",
352         "integrity": "sha512-
hZXc7K2e+PgeI1eDBe/10Ard4ekbfrrqG8Ep+8Jmf4JID2bNg7NvCP0ZN+kff574pFQI7mum2AUqDi
353         "engines": {
354             "node": ">= 0.6"
355         }
356     },
357     "node_modules/on-finished": {
358         "version": "2.3.0",
359         "resolved": "https://registry.npmjs.org/on-finished/-/on-
360 finished-2.3.0.tgz",
361         "integrity": "sha1-IPEzZIGwg811M3mSoWlxqi2QaUc=",
362         "dependencies": {
363             "ee-first": "1.1.1"
364         },
365         "engines": {
366             "node": ">= 0.8"
367         }
368     },
369     "node_modules/parseurl": {
370         "version": "1.3.3",
371         "resolved": "https://registry.npmjs.org/parseurl/-/
372 parseurl-1.3.3.tgz",
373         "integrity": "sha512-Ciye0xFT/
374 JZyN5m0z9Pfxw4SCBJ6Sygz1Dpl0wqj1hDEGGP1GnsUVEL0p63hoG1fcj3fHynXi9NY04nWOL+qQ=
375         "engines": {
376             "node": ">= 0.8"
377         }
378     },
379     "node_modules/path-to-regexp": {
380         "version": "0.1.7",
381         "resolved": "https://registry.npmjs.org/path-to-regexp/-/path-to-
382 regexp-0.1.7.tgz",
383         "integrity": "sha1-32BBeABfUi8V60SQ5yR6G/qmf4w="
384     },
385     "node_modules/proxy-addr": {
386         "version": "2.0.7",
387         "resolved": "https://registry.npmjs.org/proxy-addr/-/proxy-
388 addr-2.0.7.tgz",
389         "integrity": "sha512-llQsMLSUDUPT44jdrU/
390 037qlnifitDP+ZwrmmZcoSKyLKvtZxpyV0n2/bD/N4tBAAZ/gJEdZU7KMraoK1+XYAg==",
391         "dependencies": {
392             "forwarded": "0.2.0",
393             "ipaddr.js": "1.9.1"
394         }
395     }
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396     "engines": {
397         "node": ">= 0.10"
398     },
399 },
400 "node_modules/qs": {
401     "version": "6.7.0",
402     "resolved": "https://registry.npmjs.org/qs/-/qs-6.7.0.tgz",
403     "integrity": "sha512-VCdBRNFTX1fyE7Nb6FYoURo/SPe62QCaAyzJvUjwRaIsc+NePBEniHlVxFmmX56+HzphIGtV0XeCirBtpDrTyQ==",
404     "engines": {
405         "node": ">=0.6"
406     },
407 },
408 },
409 "node_modules/range-parser": {
410     "version": "1.2.1",
411     "resolved": "https://registry.npmjs.org/range-parser/-/range-
412 parser-1.2.1.tgz",
413     "integrity": "sha512-Hrgsx+orgoygnmhFbKaHE6c296J+HTAQXoxEF6gNupR0mmGJRozfG3ccAveqCBrrwr/2yxQ5BVd/GT15ag0wSg==",
414     "engines": {
415         "node": ">= 0.6"
416     },
417 },
418 },
419 },
420 "node_modules/raw-body": {
421     "version": "2.4.0",
422     "resolved": "https://registry.npmjs.org/raw-body/-/raw-
423 body-2.4.0.tgz",
424     "integrity": "sha512-40z8DUIwdvoa5qMJelxipzi/iJIi4005cGV1wNYp5hvZP8ZN0T+jiNkL0QepXs+EsQ9XJ8ipEDoiH70ySUJP3Q==",
425     "dependencies": {
426         "bytes": "3.1.0",
427         "http-errors": "1.7.2",
428         "iconv-lite": "0.4.24",
429         "unpipe": "1.0.0"
430     },
431     "engines": {
432         "node": ">= 0.8"
433     }
434 },
435 },
436 "node_modules/safe-buffer": {
437     "version": "5.1.2",
438     "resolved": "https://registry.npmjs.org/safe-buffer/-/safe-
439 buffer-5.1.2.tgz",
440     "integrity": "sha512-Gd2UZBJDkX1Y7GbJxfsE8/nvKkUEU1G38c1siN6QP6a9PT9MmHB8GnpscSmJSof8L0Irt8ud/wPtojys4G6+g=="
441     },
442     "node_modules/safer-buffer": {
443         "version": "2.1.2",
444         "resolved": "https://registry.npmjs.org/safer-buffer/-/safer-
445 buffer-2.1.2.tgz",
446         "integrity": "sha512-Yzo3K82SD7Riyi0E1EQPojLz7kpepnSQI9IyPbHHg1XXXevb5dJI7tpyN2ADxGcQbHG7vcyRHk0cbw
```

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449 },
450 "node_modules/send": {
451   "version": "0.17.1",
452   "resolved": "https://registry.npmjs.org/send/-/send-0.17.1.tgz",
453   "integrity": "sha512-  
454 BsVKsiGcQMFWt8UxypobUKyv7irCNRhk1T0G680vk88yf6LBBYGcZJ0TJCrTP2xVN6yI+XjPJcNuE3  
455   "dependencies": {
456     "debug": "2.6.9",
457     "depd": "~1.1.2",
458     "destroy": "~1.0.4",
459     "encodeurl": "~1.0.2",
460     "escape-html": "~1.0.3",
461     "etag": "~1.8.1",
462     "fresh": "0.5.2",
463     "http-errors": "~1.7.2",
464     "mime": "1.6.0",
465     "ms": "2.1.1",
466     "on-finished": "~2.3.0",
467     "range-parser": "~1.2.1",
468     "statuses": "~1.5.0"
469   },
470   "engines": {
471     "node": ">= 0.8.0"
472   }
473 },
474 "node_modules/send/node_modules/ms": {
475   "version": "2.1.1",
476   "resolved": "https://registry.npmjs.org/ms/-/ms-2.1.1.tgz",
477   "integrity": "sha512-tgp+dl5cGk28utYktBsrFqa7HKgrhgPsg6Z/  
478 EfhwI4gl1Hwq8B/GmY/0oXZ6nF8hDVesS/FpnYaD/k0WhYQvyg=="
479 },
480 "node_modules/serve-static": {
481   "version": "1.14.1",
482   "resolved": "https://registry.npmjs.org/serve-static/-/serve-
483 static-1.14.1.tgz",
484   "integrity": "sha512-  
485 JMrvUwE54emCYW1TI+hGrGv5I8dEwmco/00EvkzIIIsR7MqrHonbD9p02M0fFnpFntl7ecpZs+3mW+X
486   "dependencies": {
487     "encodeurl": "~1.0.2",
488     "escape-html": "~1.0.3",
489     "parseurl": "~1.3.3",
490     "send": "0.17.1"
491   },
492   "engines": {
493     "node": ">= 0.8.0"
494   }
495 },
496 "node_modules/setprototypeof": {
497   "version": "1.1.1",
498   "resolved": "https://registry.npmjs.org/setprototypeof/-/
499 setprototypeof-1.1.1.tgz",
500   "integrity": "sha512-  
501 JvdAWfbXeIGaZ9cILp38HntZSFSo3mWg6xGcJJsd+d4aRM0qauag1C63dJfDw70aMYwEbHM0xEZ1lq
```

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502 },
503   "node_modules/statuses": {
504     "version": "1.5.0",
505     "resolved": "https://registry.npmjs.org/statuses/-/status
506     es-1.5.0.tgz",
507       "integrity": "sha1-Fhx9rBd2Wf2YEfQ3cfqZ0BR4Yow=",
508       "engines": {
509         "node": ">= 0.6"
510       }
511     },
512   "node_modules/toidentifier": {
513     "version": "1.0.0",
514     "resolved": "https://registry.npmjs.org/toidentifier/-/
515     toidentifier-1.0.0.tgz",
516       "integrity": "sha512-yaOH/Pk/
517 VEhBWWT1hI+qXxDXFlejDGcQipMlyxda9nthulaxLZUNcUqFxokp0vcYnvteJln5FNQDRrxj3YcbVw
518       "engines": {
519         "node": ">=0.6"
520       }
521     },
522   "node_modules/type-is": {
523     "version": "1.6.18",
524     "resolved": "https://registry.npmjs.org/type-is/-/type-
525     is-1.6.18.tgz",
526       "integrity": "sha512-
527 TkRKr9sUTxEH8MdFuCSP7VizJyzRNMjj2J2do2Jr3Kym598JVdEksuzPQCn1FPW4ky9Q+iA+ma9BGm
528       "dependencies": {
529         "media-typer": "0.3.0",
530         "mime-types": "~2.1.24"
531       },
532       "engines": {
533         "node": ">= 0.6"
534       }
535     },
536   "node_modules/unpipe": {
537     "version": "1.0.0",
538     "resolved": "https://registry.npmjs.org/unpipe/-/unpipe-1.0.0.tgz",
539       "integrity": "sha1-sr906FFKrmFltIF4KdIbLvSZB0w=",
540       "engines": {
541         "node": ">= 0.8"
542       }
543     },
544   "node_modules/utils-merge": {
545     "version": "1.0.1",
546     "resolved": "https://registry.npmjs.org/utils-merge/-/utils-
547     merge-1.0.1.tgz",
548       "integrity": "sha1-n5VxD1CiZ5R7LMwSR0HBAoQn5xM=",
549       "engines": {
550         "node": ">= 0.4.0"
551       }
552     },
553   "node_modules/vary": {
554     "version": "1.1.2",
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555     "resolved": "https://registry.npmjs.org/vary/-/vary-1.1.2.tgz",
556     "integrity": "sha1-IpnwLG3tMNSllhsLn3RSShj2NPw=",
557     "engines": {
558       "node": ">= 0.8"
559     }
560   },
561 },
562 "dependencies": {
563   "accepts": {
564     "version": "1.3.7",
565     "resolved": "https://registry.npmjs.org/accepts/-/accepts-1.3.7.tgz",
566     "integrity": "sha512-I180Qs2WjYlJIBNzNkK6KYqlVMTbZLXgHx2oT0pU/fjRHyp+PEfEPY0R3WCwAGVOtauxh1h0xNgIf5bv7dQpA==",
567     "requires": {
568       "mime-types": "~2.1.24",
569       "negotiator": "0.6.2"
570     }
571   },
572   "array-flatten": {
573     "version": "1.1.1",
574     "resolved": "https://registry.npmjs.org/array-flatten/-/array-
575 flatten-1.1.1.tgz",
576     "integrity": "sha1-m19pkFGx5wcZKPKgCJaLZ0opVdI="
577   },
578   "body-parser": {
579     "version": "1.19.0",
580     "resolved": "https://registry.npmjs.org/body-parser/-/body-
581 parser-1.19.0.tgz",
582     "integrity": "sha512-
583 dhEPs72UPbDnAQJ9ZKMNTP6ptJaionhP5cBb541nXP1W60Jepo9RV/
584 a4fx4XWW9CuFNK22krhrj1+rgzifNCsw==",
585     "requires": {
586       "bytes": "3.1.0",
587       "content-type": "~1.0.4",
588       "debug": "2.6.9",
589       "depd": "~1.1.2",
590       "http-errors": "1.7.2",
591       "iconv-lite": "0.4.24",
592       "on-finished": "~2.3.0",
593       "qs": "6.7.0",
594       "raw-body": "2.4.0",
595       "type-is": "~1.6.17"
596     }
597   },
598   "bytes": {
599     "version": "3.1.0",
600     "resolved": "https://registry.npmjs.org/bytes/-/bytes-3.1.0.tgz",
601     "integrity": "sha512-
602 zauLjrfCG+xvoyaqLoV8bLVXXNGC4JqlxFCutSDWA6fJrTo2ZuvLYTqZ7aHBLZSM0opbwv8f+wZcV
603   },
604   "content-disposition": {
605     "version": "0.5.3",
606     "resolved": "https://registry.npmjs.org/content-disposition/-/
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608 "content-disposition-0.5.3.tgz",
609   "integrity": "sha512-
610 Ex00774ikE0bIAEV9kDo50o+79VCUdEB6n6lzKgGwpcVeRlhrj3qGAfwq8G6uBJjkqLrhT0qEYFcW
611   "requires": {
612     "safe-buffer": "5.1.2"
613   },
614 },
615 "content-type": {
616   "version": "1.0.4",
617   "resolved": "https://registry.npmjs.org/content-type/-/content-
618 type-1.0.4.tgz",
619   "integrity": "sha512-
620 hIP3EEPs8tB9AT1L+NUqtwOAp4mk2Zob89MWXMHjHWg9milF/j4osnnQLXBCFBk/tvIG/
621 tUc9mOUJiPBhPXA=="
622 },
623 "cookie": {
624   "version": "0.4.0",
625   "resolved": "https://registry.npmjs.org/cookie/-/cookie-0.4.0.tgz",
626   "integrity": "sha512-
627 +Hp8fLp57wnUSt0tY0tHEXh4voZRDnoIrZPqlo3DPiI4y9lwg/jqx+10m94/
628 W6ZaPDQUBnj0t/99w66zk+l1Xg=="
629 },
630 "cookie-signature": {
631   "version": "1.0.6",
632   "resolved": "https://registry.npmjs.org/cookie-signature/-/cookie-
633 signature-1.0.6.tgz",
634   "integrity": "sha1-4w0ogrNCzD7oylE6eZmXNNqzriw="
635 },
636 "debug": {
637   "version": "2.6.9",
638   "resolved": "https://registry.npmjs.org/debug/-/debug-2.6.9.tgz",
639   "integrity": "sha512-
640 bC7ElrdJaJnPbAP+1EotYvqZsb3ec15wi6Bfi6BJTUcNowp6cvspg0jXznRTKDjm/
641 E7AdgFBVeAPVMNcKGsHMA==",
642   "requires": {
643     "ms": "2.0.0"
644   },
645 },
646 "depd": {
647   "version": "1.1.2",
648   "resolved": "https://registry.npmjs.org/depd/-/depd-1.1.2.tgz",
649   "integrity": "sha1-m81S4UwJd2PnSbJ0xDRu0uVgtak="
650 },
651 "destroy": {
652   "version": "1.0.4",
653   "resolved": "https://registry.npmjs.org/destroy/-/destroy-1.0.4.tgz",
654   "integrity": "sha1-14hXRCxEJ5CBmE+N5RiBYJqvYA="
655 },
656 "ee-first": {
657   "version": "1.1.1",
658   "resolved": "https://registry.npmjs.org/ee-first/-/ee-
659 first-1.1.1.tgz",
660   "integrity": "sha1-WQxhFWsK4vTwJVcyoViyZrxWsh0="
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661      },
662      "encodeurl": {
663        "version": "1.0.2",
664        "resolved": "https://registry.npmjs.org/encodeurl/-/encodeurl-1.0.2.tgz",
665        "integrity": "sha1-rT/0yG7C0CkyL1oCw6mmBslbP1k="
666      },
667      "escape-html": {
668        "version": "1.0.3",
669        "resolved": "https://registry.npmjs.org/escape-html/-/escape-
670        html-1.0.3.tgz",
671        "integrity": "sha1-Aljq5NPQwJdN4cFpGI7wBR0dGYg="
672      },
673      "etag": {
674        "version": "1.8.1",
675        "resolved": "https://registry.npmjs.org/etag/-/etag-1.8.1.tgz",
676        "integrity": "sha1-Qa4u62XvpiJorr/qg6x9eSmbCIc="
677      },
678      "express": {
679        "version": "4.17.1",
680        "resolved": "https://registry.npmjs.org/express/-/
681        express-4.17.1.tgz",
682        "integrity": "sha512-mHJ9079RqluphRrcw2X/
683        GTh3k9tVv8YcoY4Kkh4WDMUYKRZUq0h1o0w2rrxBqM7VoeUVqgb27x1EMXTnYt4g==",
684        "requires": {
685          "accepts": "~1.3.7",
686          "array-flatten": "1.1.1",
687          "body-parser": "1.19.0",
688          "content-disposition": "0.5.3",
689          "content-type": "~1.0.4",
690          "cookie": "0.4.0",
691          "cookie-signature": "1.0.6",
692          "debug": "2.6.9",
693          "depd": "~1.1.2",
694          "encodeurl": "~1.0.2",
695          "escape-html": "~1.0.3",
696          "etag": "~1.8.1",
697          "finalhandler": "~1.1.2",
698          "fresh": "0.5.2",
699          "merge-descriptors": "1.0.1",
700          "methods": "~1.1.2",
701          "on-finished": "~2.3.0",
702          "parseurl": "~1.3.3",
703          "path-to-regexp": "0.1.7",
704          "proxy-addr": "~2.0.5",
705          "qs": "6.7.0",
706          "range-parser": "~1.2.1",
707          "safe-buffer": "5.1.2",
708          "send": "0.17.1",
709          "serve-static": "1.14.1",
710          "setprototypeof": "1.1.1",
711          "statuses": "~1.5.0",
712          "type-is": "~1.6.18",
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714         "utils-merge": "1.0.1",
715         "vary": "~1.1.2"
716     },
717 },
718 "finalhandler": {
719     "version": "1.1.2",
720     "resolved": "https://registry.npmjs.org/finalhandler/-/
721 finalhandler-1.1.2.tgz",
722     "integrity": "sha512-
723 aAWcW57uxVNrQZqFXjITpW3sIUQmHGG3qSb9mUah9MgMC4NeWhN0lNjXEYq3HjRAvL6arUviZGGJsB
724     "requires": {
725         "debug": "2.6.9",
726         "encodeurl": "~1.0.2",
727         "escape-html": "~1.0.3",
728         "on-finished": "~2.3.0",
729         "parseurl": "~1.3.3",
730         "statuses": "~1.5.0",
731         "unpipe": "~1.0.0"
732     }
733 },
734 "forwarded": {
735     "version": "0.2.0",
736     "resolved": "https://registry.npmjs.org/forwarded/-/
737 forwarded-0.2.0.tgz",
738     "integrity": "sha512-
739 buRG0fpBTRHSTCOASe6hD258tEubFoRLb4ZNA6NxMVHNw2g0cwHo9wyablzMzOA5z9xA9L1KNjk/
740 Nt6MT9aYow=="
741     },
742     "fresh": {
743         "version": "0.5.2",
744         "resolved": "https://registry.npmjs.org/fresh/-/fresh-0.5.2.tgz",
745         "integrity": "sha1-PYyt2Q2XZWn6g1qx+OSy0hBWbac="
746     },
747     "http-errors": {
748         "version": "1.7.2",
749         "resolved": "https://registry.npmjs.org/http-errors/-/http-
750 errors-1.7.2.tgz",
751         "integrity": "sha512-uUQBt3H/cSIVfch6i1EuPNy/
752 YsRS0UBXTVfZ+yR7Zjez3qjBz6i9+i4zjNaoqcoFVI4lQJ5plg63TvGfRSDCRg==",
753         "requires": {
754             "depd": "~1.1.2",
755             "inherits": "2.0.3",
756             "setprototypeof": "1.1.1",
757             "statuses": ">= 1.5.0 < 2",
758             "toidentifier": "1.0.0"
759         }
760     },
761     "iconv-lite": {
762         "version": "0.4.24",
763         "resolved": "https://registry.npmjs.org/iconv-lite/-/iconv-
764 lite-0.4.24.tgz",
765         "integrity": "sha512-
766 v3MXnZAcvnywkTUEZomIActle7RXeed0R31wwl7VlyoX04Qi9arvSenNQWne1TcRwhCL1HwLI21bE
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767     rA==",
768     "requires": {
769       "safer-buffer": ">= 2.1.2 < 3"
770     }
771   },
772   "inherits": {
773     "version": "2.0.3",
774     "resolved": "https://registry.npmjs.org/inherits/-/
775 inherits-2.0.3.tgz",
776     "integrity": "sha1-Yzwsg+PaQqUC9SRmAiSA9CCCYd4="
777   },
778   "ipaddr.js": {
779     "version": "1.9.1",
780     "resolved": "https://registry.npmjs.org/ipaddr.js/-/
781 ipaddr.js-1.9.1.tgz",
782     "integrity": "sha512-0KI/607xoxSToH7GjN1FfSbLoU0+btTicjsQSWQ1h/
783 hZykN8KpmMf7uYwPW3R+akZ6R/w18Z1XSHBYXiYUP03g=="
784   },
785   "media-typer": {
786     "version": "0.3.0",
787     "resolved": "https://registry.npmjs.org/media-typer/-/
788 media-
789 typer-0.3.0.tgz",
790     "integrity": "sha1-hxDXrwqmJvj/+hzgAWhUUmM1V0g="
791   },
792   "merge-descriptors": {
793     "version": "1.0.1",
794     "resolved": "https://registry.npmjs.org/merge-descriptors/-/
795 merge-
796 descriptors-1.0.1.tgz",
797     "integrity": "sha1-sAqqVW3YtEVoFQ7J0b1T8/kMu2E="
798   },
799   "methods": {
800     "version": "1.1.2",
801     "resolved": "https://registry.npmjs.org/methods/-/
802 methods-1.1.2.tgz",
803     "integrity": "sha1-VSmk1nZUE07cxSZmVoNbD4Ua/04="
804   },
805   "mime": {
806     "version": "1.6.0",
807     "resolved": "https://registry.npmjs.org/mime/-/
808 mime-1.6.0.tgz",
809     "integrity": "sha512-
810 x0Vn8spI+wuJ106S7gnbaQg8Pxh4NNHb7KSINmEWKiPE4RK0plvijn+NkmYmmRgP68mc70j2EbeTFR
811   },
812   "mime-db": {
813     "version": "1.48.0",
814     "resolved": "https://registry.npmjs.org/mime-db/-/
815 mime-
816 db-1.48.0.tgz",
817     "integrity": "sha512-
818 FM3QwxV+TnZYQ2aRqh1KBMHxk101TbMt3bBkMAp54ddrNeVSfcQY00KuGuy3Ddrm38I04If834fOUS
819   },
820   "mime-types": {
821     "version": "2.1.31",
822     "resolved": "https://registry.npmjs.org/mime-types/-/
823 mime-
824 types-2.1.31.tgz",
825     "integrity": "sha512-
```

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820 XGZnNzm3QvgKxa8dpzyhFTHmpP315YNusmne07VU0Xou9CqUqYa/HBy124RqtVh/02pECas/
821 M0csDgpilPOPg==",
822     "requires": {
823         "mime-db": "1.48.0"
824     }
825 },
826     "ms": {
827         "version": "2.0.0",
828         "resolved": "https://registry.npmjs.org/ms/-/ms-2.0.0.tgz",
829         "integrity": "sha1-VgiurfwAvmwpAd9fmGF4jeDVl8g="
830     },
831     "negotiator": {
832         "version": "0.6.2",
833         "resolved": "https://registry.npmjs.org/negotiator/-/
834 negotiator-0.6.2.tgz",
835         "integrity": "sha512-
836 hZXc7K2e+PgeI1eDBe/10Ard4ekbfrrqG8Ep+8Jmf4JID2bNg7NvCP0ZN+kfF574pFQI7mum2AUqDi
837     },
838     "on-finished": {
839         "version": "2.3.0",
840         "resolved": "https://registry.npmjs.org/on-finished/-/on-
841 finished-2.3.0.tgz",
842         "integrity": "sha1-IPEzZIGwg811M3mSoWlxqi2QaUc=",
843         "requires": {
844             "ee-first": "1.1.1"
845         }
846     },
847     "parseurl": {
848         "version": "1.3.3",
849         "resolved": "https://registry.npmjs.org/parseurl/-/
850 parseurl-1.3.3.tgz",
851         "integrity": "sha512-Ciye0xFT/
852 JZyN5m0z9PfXw4SCBJ6Sygz1Dpl0wqj1hDEGGBP1GnsUVEL0p63hoG1fcj3fHynXi9NY04nWOL+qQ=
853     },
854     "path-to-regexp": {
855         "version": "0.1.7",
856         "resolved": "https://registry.npmjs.org/path-to-regexp/-/path-to-
857 regexp-0.1.7.tgz",
858         "integrity": "sha1-32BBeABfUi8V60SQ5yR6G/qmf4w="
859     },
860     "proxy-addr": {
861         "version": "2.0.7",
862         "resolved": "https://registry.npmjs.org/proxy-addr/-/proxy-
863 addr-2.0.7.tgz",
864         "integrity": "sha512-llQsMLSUDUPT44jdrU/
865 037qlnifitDP+ZwrmmZcoSKyLKvtZxpyV0n2/bD/N4tBAAZ/gJEdZU7KMraoK1+XYAg==",
866         "requires": {
867             "forwarded": "0.2.0",
868             "ipaddr.js": "1.9.1"
869         }
870     },
871     "qs": {
872         "version": "6.7.0",
```

```
        "resolved": "https://registry.npmjs.org/qs/-/qs-6.7.0.tgz",
        "integrity": "sha512-VCdBRNFTX1fyE7Nb6FYoURo/
SPe62QCaAyzJvUjwRaIsc+NePBEniHlVxFmmX56+HzphIGtV0XeCirBtpDrTyQ=="
    },
    "range-parser": {
        "version": "1.2.1",
        "resolved": "https://registry.npmjs.org/range-parser/-/range-
parser-1.2.1.tgz",
        "integrity": "sha512-
Hrgsx+orqoygnmhFbKaHE6c296J+HTAQXoxEF6gNupR0mmGJRozfG3ccAveqCBrrr/2yxQ5BVd/
GTl5ag0wSg=="
    },
    "raw-body": {
        "version": "2.4.0",
        "resolved": "https://registry.npmjs.org/raw-body/-/raw-
body-2.4.0.tgz",
        "integrity": "sha512-40z8DUIwdvoa5qMJelxipzi/
iJIi4005cGV1wNYp5hvZP8ZN0T+jiNkL0QepXs+EsQ9XJ8ipEDoiH70ySUJP3Q==",
        "requires": {
            "bytes": "3.1.0",
            "http-errors": "1.7.2",
            "iconv-lite": "0.4.24",
            "unpipe": "1.0.0"
        }
    },
    "safe-buffer": {
        "version": "5.1.2",
        "resolved": "https://registry.npmjs.org/safe-buffer/-/safe-
buffer-5.1.2.tgz",
        "integrity": "sha512-Gd2UZBJDkX1Y7GbJxfsE8/
nvKkUEU1G38c1siN6QP6a9PT9MmHB8GnpscSmJSof8L0Irt8ud/wPtojys4G6+g=="
    },
    "safer-buffer": {
        "version": "2.1.2",
        "resolved": "https://registry.npmjs.org/safer-buffer/-/safer-
buffer-2.1.2.tgz",
        "integrity": "sha512-
YZo3K82SD7Riyi0E1EQPojLz7kpepnSQI9IyPbHHg1XXXevb5dJI7tpyN2ADxGcQbHG7vcyRHk0cbw
    },
    "send": {
        "version": "0.17.1",
        "resolved": "https://registry.npmjs.org/send/-/send-0.17.1.tgz",
        "integrity": "sha512-
BsVKsiGcQMFWt8UxypobUKyv7irCNRhk1T0G680vk88yf6LBByGcZJ0TJCrTP2xVN6yI+XjPJcNuE3
        "requires": {
            "debug": "2.6.9",
            "depd": "~1.1.2",
            "destroy": "~1.0.4",
            "encodeurl": "~1.0.2",
            "escape-html": "~1.0.3",
            "etag": "~1.8.1",
            "fresh": "0.5.2",
            "http-errors": "~1.7.2",
            "on-finished": "2.3.0"
        }
    }
}
```

```
        "mime": "1.6.0",
        "ms": "2.1.1",
        "on-finished": "~2.3.0",
        "range-parser": "~1.2.1",
        "statuses": "~1.5.0"
    },
    "dependencies": {
        "ms": {
            "version": "2.1.1",
            "resolved": "https://registry.npmjs.org/ms/-/ms-2.1.1.tgz",
            "integrity": "sha512-tgp+dl5cGk28utYktBsrFqA7HKgrhgPsg6Z/EfhWI4gl1Hwq8B/GmY/0oXZ6nf8hDVesS/FpnYaD/k0WhYQvyg=="
        }
    },
    "serve-static": {
        "version": "1.14.1",
        "resolved": "https://registry.npmjs.org/serve-static/-/serve-static-1.14.1.tgz",
        "integrity": "sha512-JMrvUwE54emCYWlTI+hGrGv5I8dEwmco/00EvkzIIIsR7MqrHonbD9p02M0fFnpFnt17ecpZs+3mW+X"
    },
    "requires": {
        "urlencode": "~1.0.2",
        "escape-html": "~1.0.3",
        "parseurl": "~1.3.3",
        "send": "0.17.1"
    },
    "setprototypeof": {
        "version": "1.1.1",
        "resolved": "https://registry.npmjs.org/setprototypeof/-/setprototypeof-1.1.1.tgz",
        "integrity": "sha512-JvdAWfbXeIGaZ9cILp38HntZFSO3mWg6xGcJJsd+d4aRM0qauag1C63dJfDw70aMYwEbHM0xEZ1lq"
    },
    "statuses": {
        "version": "1.5.0",
        "resolved": "https://registry.npmjs.org/statuses/-/statuses-1.5.0.tgz",
        "integrity": "sha1-Fhx9rBd2Wf2YEfQ3cfqZ0BR4Yow="
    },
    "toidentifier": {
        "version": "1.0.0",
        "resolved": "https://registry.npmjs.org/toidentifier/-/toidentifier-1.0.0.tgz",
        "integrity": "sha512-yaOH/Pk/VEHBWWTlhI+qXxDfxlejDGcQipMlyxda9nthulaxLZUNcUqFxokp0vcYnvteJln5FNQDRrxj3YcbVw"
    },
    "type-is": {
        "version": "1.6.18",
        "resolved": "https://registry.npmjs.org/type-is/-/type-is-1.6.18.tgz",
        "integrity": "sha512-
```

```
TkRKr9sUTxEH8MdfuCSP7VizJyzRNMjj2J2do2Jr3Kym598JVdEksuzPQCn1FPW4ky9Q+iA+ma9BGm
  "requires": {
    "media-typer": "0.3.0",
    "mime-types": "~2.1.24"
  },
  "unpipe": {
    "version": "1.0.0",
    "resolved": "https://registry.npmjs.org/unpipe/-/unpipe-1.0.0.tgz",
    "integrity": "sha1-sr906FFKrmFltIF4KdIbLvSZB0w="
  },
  "utils-merge": {
    "version": "1.0.1",
    "resolved": "https://registry.npmjs.org/utils-merge/-/utils-merge-1.0.1.tgz",
    "integrity": "sha1-n5VxD1CiZ5R7LMwSR0HBAoQn5xM="
  },
  "vary": {
    "version": "1.1.2",
    "resolved": "https://registry.npmjs.org/vary/-/vary-1.1.2.tgz",
    "integrity": "sha1-IpnwLG3tMNSllhsLn3RSShj2NPw="
  }
}
```

### package.json

```
1  {
2    "name": "express",
3    "version": "1.0.0",
4    "description": "",
5    "main": "server.js",
6    "scripts": {
7      "test": "echo \\"Error: no test specified\\" && exit 1"
8    },
9    "repository": {
10      "type": "git",
11      "url": "git+https://gitlab.com/etyy/support-cours-iut.git"
12    },
13    "author": "Etty",
14    "license": "ISC",
15    "bugs": {
16      "url": "https://gitlab.com/etyy/support-cours-iut/-/issues"
17    },
18    "homepage": "https://cours.loutsch.me/",
19    "dependencies": {
20      "express": "^4.17.1"
21    }
22 }
```

**server.js**

```
1 const express = require('express');
2 const app = express();
3 const PORT = 8080;
4 const HOST = '0.0.0.0';
5
6 // Calcul Fibonacci => Calcul intense
7 const fibonacci = (num) => {
8     if (num <= 1) return 1;
9     return fibonacci(num - 1) + fibonacci(num - 2);
10 }
11
12 app.get('/cpu', (req, res) => {
13     fibonacci(42);
14     res.send('Fibonacci Sequence');
15 })
16 // Generate lot of ram usage
17 app.get('/memory', (req, res) => {
18     var arr = new Array(20000000).fill(0);
19     res.send('Array is created');
20 })
21
22 app.listen(PORT, HOST, () => {
23     console.log(`Server listening at http://${HOST}:${PORT}`);
24 })
```

**Note**

- /cpu → Générer une charge CPU
- /memory → Générer une charge memoire

✓ Builder votre image docker avec le nom `mon-app` et le tag `v0.1`

- Quelle est la commande docker pour créer son image ?

**Tip**

Build avec le proxy `--build-arg http_proxy=` `--build-arg https_proxy=`

## Création du déploiement Kubernetes

Maintenant il faut créer votre déploiement dans Kubernetes de votre application. Pour ce faire créer un dossier `hpa` et dedans appliquer ces manifests :

**mon-app.yml**

```
1  ---
2  apiVersion: apps/v1
3  kind: Deployment
4  metadata:
5    name: express
6    namespace: default
7  spec:
8    selector:
9      matchLabels:
10     app: express
11   template:
12     metadata:
13       labels:
14         app: express
15   spec:
16     containers:
17       - name: express
18         imagePullPolicy: Never
19         image: docker.io/library/mon-app:v0.1
20         ports:
21           - containerPort: 8080
22         resources:
23           limits:
24             cpu: 500m
25             memory: 256Mi
26           requests:
27             cpu: 200m
28             memory: 128Mi
29   ---
30  apiVersion: v1
31  kind: Service
32  metadata:
33    name: express
34    labels:
35      app: express
36  spec:
37    ports:
38      - protocol: TCP
39        port: 8080
40        targetPort: 8080
41    selector:
42      app: express
43   ---
44  apiVersion: networking.k8s.io/v1
45  kind: Ingress
46  metadata:
47    name: express
48    labels:
49      app: express
50    annotations:
```

```
51      kubernetes.io/ingress.class: nginx
52  spec:
53    rules:
54      - host: "mon-app.local"
55        http:
56          paths:
57            - path: /
58              pathType: Prefix
59            backend:
60              service:
61                name: express
62                port:
63                  number: 8080
```

Ensuite il faut load l'image docker dans kind :

```
1 kind load docker-image mon-app:v0.1
```

#### Questions

- Que déploie ce manifest kubernetes ?
- Pourquoi mettre un ingress dans ce contexte ?

## Création d'un HPA

Vous allez déployer, toujours dans le répertoire `hpa`, ce manifest. Cela va permettre de définir le comportement du contrôleur **HPA**.

#### hpa.yml

```
1  ---
2  apiVersion: autoscaling/v2
3  kind: HorizontalPodAutoscaler
4  metadata:
5    name: express
6    namespace: default
7  spec:
8    scaleTargetRef:
9      apiVersion: apps/v1
10     kind: Deployment
11     name: express
12   minReplicas: 1
13   maxReplicas: 10
14   behavior:
15     scaleUp:
16       policies:
17         - type: Pods
18           value: 1
```

```
19      periodSeconds: 60
20      scaleDown:
21          policies:
22              - type: Percent
23                  value: 10
24                  periodSeconds: 60
25      metrics:
26          - type: Resource
27              resource:
28                  name: cpu
29                  target:
30                      type: Utilization
31                      averageUtilization: 80
32          - type: Resource
33              resource:
34                  name: memory
35                  target:
36                      type: Utilization
37                      averageUtilization: 70
```

- Comment afficher la liste des HPA ?
- Donner la liste des HPA présent sur le cluster ?

### Focus sur la ressources hpa

Ici nous avons une politique de mise à l'échelle, il permet à 1 réplique au maximum d'être mise à l'échelle en une minute.

```
1      scaleUp:
2          policies:
3              - type: Pods
4                  value: 1
5                  periodSeconds: 60
```

Le second est une politique de réduction qui permet de réduire au maximum 10 % des répliques actuelles en une minute.

```
1      scaleDown:
2          policies:
3              - type: Percent
4                  value: 10
5                  periodSeconds: 60
```

Avec cette métrique, le contrôleur HPA va scale quand l'utilisation du CPU dépasse 80% de moyenne.

```
1      - type: Resource
```

```
2     resource:
3       name: cpu
4       target:
5         type: Utilization
6         averageUtilization: 80
```

De même pour celle-ci sauf que le contrôleur cible la mémoire à 70%.

```
1   - type: Resource
2     resource:
3       name: memory
4       target:
5         type: Utilization
6         averageUtilization: 70
```

## Tests du HPA

Maintenant, vous allez tester l'autoscaling. Pour ce faire

- ✓ Ouvrir 3 terminals avec, respectivement, comme commandes :

- `watch -n 1 -t kubectl get pods`
- `watch -n 1 -t -w kubectl get hpa`
- `curl mon-app.local/cpu` **Lancer une fois cette commande !**
- *Que remarquez-vous dans les 2 premiers shells, expliquer pourquoi ?*
- *Combien de temps le HPA met-il à scale-up un nouveau pod ?*
- *Combien de temps le HPA met-il à scale-down un pod ?*

Faites le `curl` sur l'API `/memory`

- *Que remarquez-vous dans les 2 premiers shells, expliquer pourquoi ?*
- *Combien de temps le HPA met-il à scale-up un nouveau pod ?*
- *Combien de temps le HPA met-il à scale-down un pod ?*

Question Bonus :

Vous devez scale une application web, mais vous devez vous baser sur des métriques qui ne sont pas CPU/mémoire. Comment faites-vous ?

Pour les plus rapides

Deployer un serveur minecraft dans votre Cluster.

*Merci de votre attention*

---

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