

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 l'envoyer sur l'adresse mail de l'enseignant encadrant votre séance de TP.

 **LISEZ-BIEN TOUT LE TP** 

Prérequis

- ✓ Accès au proxy IUT
- ✓ Votre VM utilisé au TP02 avec docker/kind/kubectl installés
- ✓ Cluster kind avec 1 controle-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
```

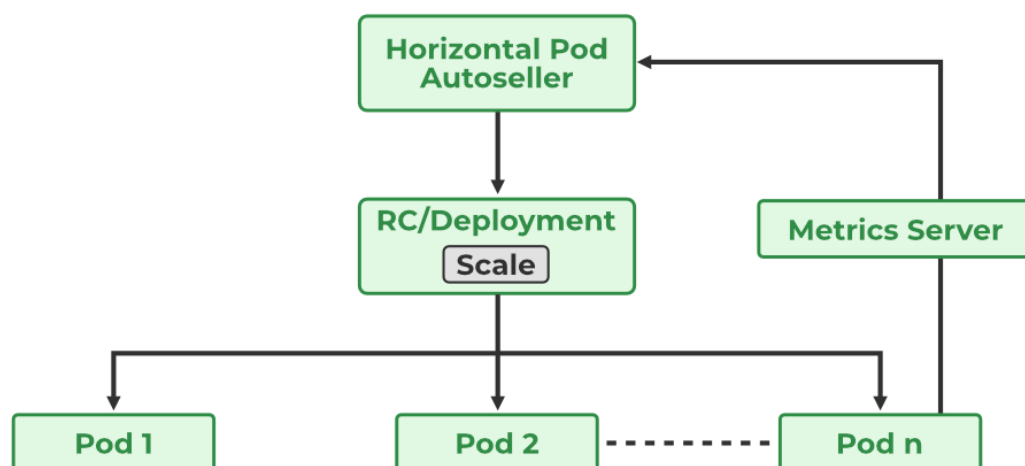
```
1 kubectl wait --namespace ingress-nginx \  
2 --for=condition=ready pod \  
3 --selector=app.kubernetes.io/component=controller \  
4 --timeout=90s
```

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 ressources CPU et/ou RAM allouées au pod
Noeuds	Ajoute ou retire des noeuds	Modifie les ressources CPU et/ou RAM allouées au nœud

- Horizontal Scaling signifie modifier les ressources de calcul d'un cluster existant, par exemple en y ajoutant de nouveaux nœuds ou en ajoutant de nouveaux pods en augmentant le nombre de réplicas 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 difference 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"} ] '
```

Vérifier 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 ?*
- *Expliquer simplement le résultat de cette commande ?*

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/-/
17 accepts-1.3.7.tgz",
18      "integrity": "sha512-I180Qs2WjY1JIBNzNkK6KYq1VMTbZLXgHx2oT0pU/
19 fjRHyEp+PEfEPY0R3WCwAGV0tauxh1h0xNgIf5bv7dQpA==",
20      "dependencies": {
21        "mime-types": "~2.1.24",
22        "negotiator": "0.6.2"
23      },
24      "engines": {
25        "node": ">= 0.6"
26      }
27    },
28    "node_modules/array-flatten": {
29      "version": "1.1.1",
30      "resolved": "https://registry.npmjs.org/array-flatten/-/array-
31 flatten-1.1.1.tgz",
32      "integrity": "sha1-m19pkFGx5wczKPKgCJaLZ0opVdI="
33    },
34    "node_modules/body-parser": {
35      "version": "1.19.0",
36      "resolved": "https://registry.npmjs.org/body-parser/-/body-
37 parser-1.19.0.tgz",
```

```
38     "integrity": "sha512-
39 dhEPs72UPbDnAQJ9ZKMNTp6ptJaionhP5cBb541nXP1W60Jepo9RV/
40 a4fX4XWW9CuFNK22krhrj1+rgzifNCsw==",
41     "dependencies": {
42       "bytes": "3.1.0",
43       "content-type": "~1.0.4",
44       "debug": "2.6.9",
45       "depd": "~1.1.2",
46       "http-errors": "1.7.2",
47       "iconv-lite": "0.4.24",
48       "on-finished": "~2.3.0",
49       "qs": "6.7.0",
50       "raw-body": "2.4.0",
51       "type-is": "~1.6.17"
52     },
53     "engines": {
54       "node": ">= 0.8"
55     }
56   },
57   "node_modules/bytes": {
58     "version": "3.1.0",
59     "resolved": "https://registry.npmjs.org/bytes/-/bytes-3.1.0.tgz",
60     "integrity": "sha512-
61 zauLjrfCG+xvoyaQLoV8bLVXXNGC4JqlxFCutSDWA6fJrTo2ZuvLYTqZ7aHBLZSMOopbzwv8f+w
62     "engines": {
63       "node": ">= 0.8"
64     }
65   },
66   "node_modules/content-disposition": {
67     "version": "0.5.3",
68     "resolved": "https://registry.npmjs.org/content-disposition/-/
69 content-disposition-0.5.3.tgz",
70     "integrity": "sha512-
71 Ex00774ikE0bIAEV9kDo50o+79VCUdEB6n61zKgGwupcVerlhrj3qGAfwq8G6uBJjqLrhT0qEY
72     "dependencies": {
73       "safe-buffer": "5.1.2"
74     },
75     "engines": {
76       "node": ">= 0.6"
77     }
78   },
79   "node_modules/content-type": {
80     "version": "1.0.4",
81     "resolved": "https://registry.npmjs.org/content-type/-/content-
82 type-1.0.4.tgz",
83     "integrity": "sha512-
84 hIP3EePs8tB9AT1L+NUqtw0Aps4mk2Zob89MWMHjHWg9milF/j4osnnQLXBCFBk/tvIG/
85 tUc9m0UJiPBhPXA==",
86     "engines": {
87       "node": ">= 0.6"
88     }
89   },
90   "node_modules/cookie": {
91     "version": "0.4.0",
92     "resolved": "https://registry.npmjs.org/cookie/-/
93 cookie-0.4.0.tgz",
94     "integrity": "sha512-
```

```
95 +Hp8fLp57wnUSt0tY0tHEXh4voZRDnoIrZPqlo3DPiI4y9lwj/jqx+10m94/  
96 W6ZaPD0Ubnj0t/99w66zk+11Xg==",  
97   "engines": {  
98     "node": ">= 0.6"  
99   }  
100 },  
101   "node_modules/cookie-signature": {  
102     "version": "1.0.6",  
103     "resolved": "https://registry.npmjs.org/cookie-signature/-/cookie-  
104 signature-1.0.6.tgz",  
105     "integrity": "sha1-4w0ogrNCzD7oylE6eZmXNNqzriw="  
106   },  
107   "node_modules/debug": {  
108     "version": "2.6.9",  
109     "resolved": "https://registry.npmjs.org/debug/-/debug-2.6.9.tgz",  
110     "integrity": "sha512-bc7E1rdJaJnPbAP+1EotYvqZsb3ec15wi6Bfi6BJTUcNowp6cvspg0jXznRTKDjm/  
111 E7AdgFBVeAPVMNcKGsHMA==",  
112     "dependencies": {  
113       "ms": "2.0.0"  
114     }  
115   },  
116 },  
117   "node_modules/depd": {  
118     "version": "1.1.2",  
119     "resolved": "https://registry.npmjs.org/depd/-/depd-1.1.2.tgz",  
120     "integrity": "sha1-m81S4UwJd2PnSbJ0xDRu0uVgtak=",  
121     "engines": {  
122       "node": ">= 0.6"  
123     }  
124   },  
125   "node_modules/destroy": {  
126     "version": "1.0.4",  
127     "resolved": "https://registry.npmjs.org/destroy/-/  
128 destroy-1.0.4.tgz",  
129     "integrity": "sha1-l4hXRCxEJ5CBmE+N5RiBYJqvYA="  
130   },  
131   "node_modules/ee-first": {  
132     "version": "1.1.1",  
133     "resolved": "https://registry.npmjs.org/ee-first/-/ee-  
134 first-1.1.1.tgz",  
135     "integrity": "sha1-WQxhFWsk4vTwJVcyoViyZrxWsh0="  
136   },  
137   "node_modules/encodeurl": {  
138     "version": "1.0.2",  
139     "resolved": "https://registry.npmjs.org/encodeurl/-/  
140 encodeurl-1.0.2.tgz",  
141     "integrity": "sha1-rT/0yG7C0CkyL1oCw6mmBs1bP1k=",  
142     "engines": {  
143       "node": ">= 0.8"  
144     }  
145   },  
146   "node_modules/escape-html": {  
147     "version": "1.0.3",  
148     "resolved": "https://registry.npmjs.org/escape-html/-/escape-  
149 html-1.0.3.tgz",  
150     "integrity": "sha1-Aljq5NPQwJdN4cFpGI7wBR0dGYg="  
151   },
```

```
152     "node_modules/etag": {
153       "version": "1.8.1",
154       "resolved": "https://registry.npmjs.org/etag/-/etag-1.8.1.tgz",
155       "integrity": "sha1-Qa4u62XvpiJorr/qg6x9eSmbCIc=",
156       "engines": {
157         "node": ">= 0.6"
158       }
159     },
160     "node_modules/express": {
161       "version": "4.17.1",
162       "resolved": "https://registry.npmjs.org/express/-/
163 express-4.17.1.tgz",
164       "integrity": "sha512-mHJ9079RqIuphRrcw2X/
165 GTh3k9tVv8YcoyY4Kkh4WDMUYKRZUq0h1o0w2rrrxBqM7VoeUVqgb27x1EMXTnYt4g==",
166       "dependencies": {
167         "accepts": "~1.3.7",
168         "array-flatten": "1.1.1",
169         "body-parser": "1.19.0",
170         "content-disposition": "0.5.3",
171         "content-type": "~1.0.4",
172         "cookie": "0.4.0",
173         "cookie-signature": "1.0.6",
174         "debug": "2.6.9",
175         "depd": "~1.1.2",
176         "encodeurl": "~1.0.2",
177         "escape-html": "~1.0.3",
178         "etag": "~1.8.1",
179         "finalhandler": "~1.1.2",
180         "fresh": "0.5.2",
181         "merge-descriptors": "1.0.1",
182         "methods": "~1.1.2",
183         "on-finished": "~2.3.0",
184         "parseurl": "~1.3.3",
185         "path-to-regexp": "0.1.7",
186         "proxy-addr": "~2.0.5",
187         "qs": "6.7.0",
188         "range-parser": "~1.2.1",
189         "safe-buffer": "5.1.2",
190         "send": "0.17.1",
191         "serve-static": "1.14.1",
192         "setprototypeof": "1.1.1",
193         "statuses": "~1.5.0",
194         "type-is": "~1.6.18",
195         "utils-merge": "1.0.1",
196         "vary": "~1.1.2"
197       },
198       "engines": {
199         "node": ">= 0.10.0"
200       }
201     },
202     "node_modules/finalhandler": {
203       "version": "1.1.2",
204       "resolved": "https://registry.npmjs.org/finalhandler/-/
205 finalhandler-1.1.2.tgz",
206       "integrity": "sha512-
207 aAWcW57uxVNrQQzqFXjITpW3sIUQMhGG3qSb9mUah9MgMC4NeWhN01NjXEYq3HjRAvL6arUviZGG
208       "dependencies": {
```



```
209     "debug": "2.6.9",
210     "encodeurl": "~1.0.2",
211     "escape-html": "~1.0.3",
212     "on-finished": "~2.3.0",
213     "parseurl": "~1.3.3",
214     "statuses": "~1.5.0",
215     "unpipe": "~1.0.0"
216   },
217   "engines": {
218     "node": ">= 0.8"
219   }
220 },
221 "node_modules/forwarded": {
222   "version": "0.2.0",
223   "resolved": "https://registry.npmjs.org/forwarded/-/
224 forwarded-0.2.0.tgz",
225   "integrity": "sha512-
226 buRG0fpBtRHSTCOASe6hD258tEubFoRLb4ZNA6NxMVHNw2g0cwHo9wyablzMz0A5z9xA9L1KNjk
227 Nt6MT9aYow==",
228   "engines": {
229     "node": ">= 0.6"
230   }
231 },
232 "node_modules/fresh": {
233   "version": "0.5.2",
234   "resolved": "https://registry.npmjs.org/fresh/-/fresh-0.5.2.tgz",
235   "integrity": "sha1-PYyt2Q2XZWn6g1qx+0Sy0hBWBac=",
236   "engines": {
237     "node": ">= 0.6"
238   }
239 },
240 "node_modules/http-errors": {
241   "version": "1.7.2",
242   "resolved": "https://registry.npmjs.org/http-errors/-/http-
243 errors-1.7.2.tgz",
244   "integrity": "sha512-uUQBt3H/cSIVfch6i1EuPNy/
245 YsRSOUBXTVfZ+yR7Zjez3qjBz6i9+i4zjNaoqcoFVI4lQJ5p1g63TvGfRSDCRg==",
246   "dependencies": {
247     "depd": "~1.1.2",
248     "inherits": "2.0.3",
249     "setprototypeof": "1.1.1",
250     "statuses": ">= 1.5.0 < 2",
251     "toidentifier": "1.0.0"
252   },
253   "engines": {
254     "node": ">= 0.6"
255   }
256 },
257 "node_modules/iconv-lite": {
258   "version": "0.4.24",
259   "resolved": "https://registry.npmjs.org/iconv-lite/-/iconv-
260 lite-0.4.24.tgz",
261   "integrity": "sha512-
262 v3MXnZAcvnywkTUEZomIActle7RXXeedOR31wwl7VlYoX04Qi9arvSenNQWne1TcRwhCL1HwLI2
263 rA==",
264   "dependencies": {
265     "safer-buffer": ">= 2.1.2 < 3"
```

```
266     },
267     "engines": {
268       "node": ">=0.10.0"
269     }
270   },
271   "node_modules/inherits": {
272     "version": "2.0.3",
273     "resolved": "https://registry.npmjs.org/inherits/-/
274 inherits-2.0.3.tgz",
275     "integrity": "sha1-Yzwsg+PaQqUC9SRmAiSA9CCCYd4="
276   },
277   "node_modules/ipaddr.js": {
278     "version": "1.9.1",
279     "resolved": "https://registry.npmjs.org/ipaddr.js/-/
280 ipaddr.js-1.9.1.tgz",
281     "integrity": "sha512-0KI/607xoxSToH7GjN1FfSbLoU0+btTicjsQSWQlh/
282 hZyK8KpmMf7uYwPW3R+akZ6R/w18ZlXSHBYXiYUP03g=",
283     "engines": {
284       "node": ">= 0.10"
285     }
286   },
287   "node_modules/media-typer": {
288     "version": "0.3.0",
289     "resolved": "https://registry.npmjs.org/media-typer/-/media-
290 typer-0.3.0.tgz",
291     "integrity": "sha1-hxDXrwqmJvj/+hzgAWhUUmMlV0g=",
292     "engines": {
293       "node": ">= 0.6"
294     }
295   },
296   "node_modules/merge-descriptors": {
297     "version": "1.0.1",
298     "resolved": "https://registry.npmjs.org/merge-descriptors/-/merge-
299 descriptors-1.0.1.tgz",
300     "integrity": "sha1-sAqQVW3YtEVoFQ7J0b1T8/kMu2E="
301   },
302   "node_modules/methods": {
303     "version": "1.1.2",
304     "resolved": "https://registry.npmjs.org/methods/-/
305 methods-1.1.2.tgz",
306     "integrity": "sha1-VSmk1nZUE07cxSZmVoNbD4Ua/04=",
307     "engines": {
308       "node": ">= 0.6"
309     }
310   },
311   "node_modules/mime": {
312     "version": "1.6.0",
313     "resolved": "https://registry.npmjs.org/mime/-/mime-1.6.0.tgz",
314     "integrity": "sha512-x0Vn8spI+uwJ106S7gnbaQg8Pxh4NNHb7KSINmEWKiPE4RK0plvijN+NkmYmmRgP68mc70j2Ebe
315 x0Vn8spI+uwJ106S7gnbaQg8Pxh4NNHb7KSINmEWKiPE4RK0plvijN+NkmYmmRgP68mc70j2Ebe
316     "bin": {
317       "mime": "cli.js"
318     },
319     "engines": {
320       "node": ">=4"
321     }
322   },

```

```
323     "node_modules/mime-db": {
324       "version": "1.48.0",
325       "resolved": "https://registry.npmjs.org/mime-db/-/mime-
326 db-1.48.0.tgz",
327       "integrity": "sha512-
328 FM3QwxV+TnZYQ2aRqh1KBMHxk101TbMt3bBkMAp54ddrNeVSfcQY00KuGuy3Ddrm38I04If834f
329       "engines": {
330         "node": ">= 0.6"
331       }
332     },
333     "node_modules/mime-types": {
334       "version": "2.1.31",
335       "resolved": "https://registry.npmjs.org/mime-types/-/mime-
336 types-2.1.31.tgz",
337       "integrity": "sha512-
338 XGZnNzm3QvgKxa8dpzyhFTHmpP315YNusmne07VUOXxou9CqUqYa/HBy124RqtVh/
339 02pECas/M0csDgpilPOPg==",
340       "dependencies": {
341         "mime-db": "1.48.0"
342       },
343       "engines": {
344         "node": ">= 0.6"
345       }
346     },
347     "node_modules/ms": {
348       "version": "2.0.0",
349       "resolved": "https://registry.npmjs.org/ms/-/ms-2.0.0.tgz",
350       "integrity": "sha1-VgiurfwAvmwpAd9fmGF4jeDVl8g="
351     },
352     "node_modules/negotiator": {
353       "version": "0.6.2",
354       "resolved": "https://registry.npmjs.org/negotiator/-/
355 negotiator-0.6.2.tgz",
356       "integrity": "sha512-
357 hZXc7K2e+PgeI1eDBe/10Ard4ekbfrG8Ep+8Jmf4JID2bNg7NvCPOZN+kfF574pFQI7mum2AU
358       "engines": {
359         "node": ">= 0.6"
360       }
361     },
362     "node_modules/on-finished": {
363       "version": "2.3.0",
364       "resolved": "https://registry.npmjs.org/on-finished/-/on-
365 finished-2.3.0.tgz",
366       "integrity": "sha1-IPEzZIGwg811M3mSoWlxqi2QaUc=",
367       "dependencies": {
368         "ee-first": "1.1.1"
369       },
370       "engines": {
371         "node": ">= 0.8"
372       }
373     },
374     "node_modules/parseurl": {
375       "version": "1.3.3",
376       "resolved": "https://registry.npmjs.org/parseurl/-/
377 parseurl-1.3.3.tgz",
378       "integrity": "sha512-
379 JZyN5m0z9PfXw4SCBJ6Sygz1Dp10wqjlhDEGGBP1GnsUVEL0p63hoG1fcj3fHynXi9NY04nWOL+
```

```

380     "engines": {
381       "node": ">= 0.8"
382     },
383   },
384   "node_modules/path-to-regexp": {
385     "version": "0.1.7",
386     "resolved": "https://registry.npmjs.org/path-to-regexp/-/path-to-
387 regexp-0.1.7.tgz",
388     "integrity": "sha1-32BBEABfUi8V60SQ5yR6G/qmf4w=",
389   },
390   "node_modules/proxy-addr": {
391     "version": "2.0.7",
392     "resolved": "https://registry.npmjs.org/proxy-addr/-/proxy-
393 addr-2.0.7.tgz",
394     "integrity": "sha512-11QsMLSUDUPT44jdrU/
395 037qlnifitDP+ZwrmmZcoSKyLKvtZxpyV0n2/bD/N4tBAAZ/gJEdZU7KMraoK1+XYAg==",
396     "dependencies": {
397       "forwarded": "0.2.0",
398       "ipaddr.js": "1.9.1"
399     },
400     "engines": {
401       "node": ">= 0.10"
402     }
403   },
404   "node_modules/qs": {
405     "version": "6.7.0",
406     "resolved": "https://registry.npmjs.org/qs/-/qs-6.7.0.tgz",
407     "integrity": "sha512-VCdBRNFTX1fyE7Nb6FYoURo/
408 SPe62QCaAyzJvUjwRaIsc+NePBEEniHlvxFmmX56+HZphIGtV0XeCirBtpDrTyQ==",
409     "engines": {
410       "node": ">=0.6"
411     }
412   },
413   "node_modules/range-parser": {
414     "version": "1.2.1",
415     "resolved": "https://registry.npmjs.org/range-parser/-/range-
416 parser-1.2.1.tgz",
417     "integrity": "sha512-
418 Hrgsx+orqoygnmhFbKaHE6c296J+HTAQXoxEF6gNupR0mmGJRozfG3ccAveqCBwr/2yxQ5BVd
419 GT15ag0wSg==",
420     "engines": {
421       "node": ">= 0.6"
422     }
423   },
424   "node_modules/raw-body": {
425     "version": "2.4.0",
426     "resolved": "https://registry.npmjs.org/raw-body/-/raw-
427 body-2.4.0.tgz",
428     "integrity": "sha512-
429 iJIi4005cGV1wnYP5hvZP8ZN0T+jjNkL0QepXs+EsQ9XJ8ipEDoiH70ySUJP3Q==",
430     "dependencies": {
431       "bytes": "3.1.0",
432       "http-errors": "1.7.2",
433       "iconv-lite": "0.4.24",
434       "unpipe": "1.0.0"
435     },
436     "engines": {

```

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437       "node": ">= 0.8"
438     }
439   },
440   "node_modules/safe-buffer": {
441     "version": "5.1.2",
442     "resolved": "https://registry.npmjs.org/safe-buffer/-/safe-
443 buffer-5.1.2.tgz",
444     "integrity": "sha512-Gd2UZBJDkXlY7GbJxfsE8/
445 nvKkUEU1G38c1siN6QP6a9PT9MmHB8GnpScSmMJSofF8L0Irt8ud/wPtojys4G6+g=="
446   },
447   "node_modules/safer-buffer": {
448     "version": "2.1.2",
449     "resolved": "https://registry.npmjs.org/safer-buffer/-/safer-
450 buffer-2.1.2.tgz",
451     "integrity": "sha512-
452 YZo3K82SD7Riyi0E1EQPojLz7kpepnSQI9IyPbHHg1XXXevb5dJI7tpyN2ADxGcQbHG7vcyRHk0
453   },
454   "node_modules/send": {
455     "version": "0.17.1",
456     "resolved": "https://registry.npmjs.org/send/-/send-0.17.1.tgz",
457     "integrity": "sha512-
458 BsVKsiGcQMFwT8UxypobUKyv7irCNRHk1T0G680vk88yf6LBBYGcZJ0TJCrTP2xVN6yI+XjPJcN
459     "dependencies": {
460       "debug": "2.6.9",
461       "depd": "~1.1.2",
462       "destroy": "~1.0.4",
463       "encodeurl": "~1.0.2",
464       "escape-html": "~1.0.3",
465       "etag": "~1.8.1",
466       "fresh": "0.5.2",
467       "http-errors": "~1.7.2",
468       "mime": "1.6.0",
469       "ms": "2.1.1",
470       "on-finished": "~2.3.0",
471       "range-parser": "~1.2.1",
472       "statuses": "~1.5.0"
473     },
474     "engines": {
475       "node": ">= 0.8.0"
476     }
477   },
478   "node_modules/send/node_modules/ms": {
479     "version": "2.1.1",
480     "resolved": "https://registry.npmjs.org/ms/-/ms-2.1.1.tgz",
481     "integrity": "sha512-
482 EfhwI4gl1Hwq8B/GmY/0oXZ6nF8hDVesS/FpnYaD/k0WhYQvyg=="
483   },
484   "node_modules/serve-static": {
485     "version": "1.14.1",
486     "resolved": "https://registry.npmjs.org/serve-static/-/serve-
487 static-1.14.1.tgz",
488     "integrity": "sha512-
489 JMrVUwE54emCYWlTI+hGrGv5I8dEwmco/00EvkzIIIsR7MqrHonbD9p02M0fFnpFnt17ecpZs+3m
490     "dependencies": {
491       "encodeurl": "~1.0.2",
492       "escape-html": "~1.0.3",
493       "parseurl": "~1.3.3",
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494     "send": "0.17.1"
495   },
496   "engines": {
497     "node": ">= 0.8.0"
498   }
499 },
500 "node_modules/setprototypeof": {
501   "version": "1.1.1",
502   "resolved": "https://registry.npmjs.org/setprototypeof/-/
503 setprototypeof-1.1.1.tgz",
504   "integrity": "sha512-
505 JvdAWfbXeIGaZ9cILp38HntZSFSO3mWg6xGcJJsd+d4aRM0qauag1C63dJfDw70aMYwEbHMOxEZ
506 },
507 "node_modules/statuses": {
508   "version": "1.5.0",
509   "resolved": "https://registry.npmjs.org/statuses/-/
510 statuses-1.5.0.tgz",
511   "integrity": "sha1-Fhx9rBd2Wf2YefQ3cfqZ0BR4Yow=",
512   "engines": {
513     "node": ">= 0.6"
514   }
515 },
516 "node_modules/toidentifier": {
517   "version": "1.0.0",
518   "resolved": "https://registry.npmjs.org/toidentifier/-/
519 toidentifier-1.0.0.tgz",
520   "integrity": "sha512-ya0H/Pk/
521 VEhBWWTlhI+qXxDFXlejDGcQipMlyxda9nthulaxLZUNcUqFxokp0vcYnvteJln5FNQDRrxj3Yc
522   "engines": {
523     "node": ">=0.6"
524   }
525 },
526 "node_modules/type-is": {
527   "version": "1.6.18",
528   "resolved": "https://registry.npmjs.org/type-is/-/type-
529 is-1.6.18.tgz",
530   "integrity": "sha512-
531 TkRkr9sUTxEH8MdfuCSP7VizJyzRNMjj2J2do2Jr3Kym598JVdEksuzPQCn1FPW4ky9Q+iA+ma9
532   "dependencies": {
533     "media-typer": "0.3.0",
534     "mime-types": "~2.1.24"
535   },
536   "engines": {
537     "node": ">= 0.6"
538   }
539 },
540 "node_modules/unpipe": {
541   "version": "1.0.0",
542   "resolved": "https://registry.npmjs.org/unpipe/-/
543 unpipe-1.0.0.tgz",
544   "integrity": "sha1-sr906FFKrMFltIF4KdIbLvSZB0w=",
545   "engines": {
546     "node": ">= 0.8"
547   }
548 },
549 "node_modules/utils-merge": {
550   "version": "1.0.1",
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551     "resolved": "https://registry.npmjs.org/utils-merge/-/utils-
552 merge-1.0.1.tgz",
553     "integrity": "sha1-n5VxD1CiZ5R7LMwSR0HBAoQn5xM=",
554     "engines": {
555       "node": ">= 0.4.0"
556     }
557   },
558   "node_modules/vary": {
559     "version": "1.1.2",
560     "resolved": "https://registry.npmjs.org/vary/-/vary-1.1.2.tgz",
561     "integrity": "sha1-IpnwLG3tMNS1lhsLn3RSShj2NPw=",
562     "engines": {
563       "node": ">= 0.8"
564     }
565   },
566 },
567 "dependencies": {
568   "accepts": {
569     "version": "1.3.7",
570     "resolved": "https://registry.npmjs.org/accepts/-/
571 accepts-1.3.7.tgz",
572     "integrity": "sha512-I180Qs2WjY1JIBNzNkK6KYq1VMTbZLXgHx2oT0pU/
573 fjRHyEp+PEfEPY0R3WCwAGV0tauxh1h0xNgIf5bv7dQpA==",
574     "requires": {
575       "mime-types": "~2.1.24",
576       "negotiator": "0.6.2"
577     }
578   },
579   "array-flatten": {
580     "version": "1.1.1",
581     "resolved": "https://registry.npmjs.org/array-flatten/-/array-
582 flatten-1.1.1.tgz",
583     "integrity": "sha1-m19pkFGx5wczKPKgCJaLZ0opVdI="
584   },
585   "body-parser": {
586     "version": "1.19.0",
587     "resolved": "https://registry.npmjs.org/body-parser/-/body-
588 parser-1.19.0.tgz",
589     "integrity": "sha512-dhEPs72UPbDnAQJ9ZKMNTp6ptJaionhP5cBb541nXPlW60Jepo9RV/
590 a4fX4XWW9CuFNK22krhrj1+rgzifNCsw==",
591     "requires": {
592       "bytes": "3.1.0",
593       "content-type": "~1.0.4",
594       "debug": "2.6.9",
595       "depd": "~1.1.2",
596       "http-errors": "1.7.2",
597       "iconv-lite": "0.4.24",
598       "on-finished": "~2.3.0",
599       "qs": "6.7.0",
600       "raw-body": "2.4.0",
601       "type-is": "~1.6.17"
602     }
603   },
604 },
605 "bytes": {
606   "version": "3.1.0",
607   "resolved": "https://registry.npmjs.org/bytes/-/bytes-3.1.0.tgz",
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608     "integrity": "sha512-
609 zauLjrfCG+xvoyaQLoV8bLVXXNGC4JqlxFCutSDWA6fJrTo2ZuvLYTqZ7aHBLZSM0opbwv8f+w
610   },
611   "content-disposition": {
612     "version": "0.5.3",
613     "resolved": "https://registry.npmjs.org/content-disposition/-/
614 content-disposition-0.5.3.tgz",
615     "integrity": "sha512-
616 Ex00774ikE0bIAEV9kDo50o+79VCUdEB6n6lzKgGwupcVerlhrj3qGAfwq8G6uBJjkqLrhT0qEY
617     "requires": {
618       "safe-buffer": "5.1.2"
619   }
620 },
621 "content-type": {
622   "version": "1.0.4",
623   "resolved": "https://registry.npmjs.org/content-type/-/content-
624 type-1.0.4.tgz",
625   "integrity": "sha512-
626 hIP3EEPs8tB9AT1L+NUqtW0Aps4mk2Zob89MWMHjHWg9milF/j4osnnQLXBCFBk/tvIG/
627 tUc9m0UJiPBhPXA=="
628 },
629 "cookie": {
630   "version": "0.4.0",
631   "resolved": "https://registry.npmjs.org/cookie/-/
632 cookie-0.4.0.tgz",
633   "integrity": "sha512-
634 +Hp8fLp57wnUSt0tY0tHEXh4voZRDnoIrZPqlo3DPiI4y9lwq/jqx+10m94/
635 W6ZaPD0Ubnj0t/99w66zk+l1Xg=="
636 },
637 "cookie-signature": {
638   "version": "1.0.6",
639   "resolved": "https://registry.npmjs.org/cookie-signature/-/cookie-
640 signature-1.0.6.tgz",
641   "integrity": "sha1-4wOogrNCzD7oylE6eZmXNNqzriw="
642 },
643 "debug": {
644   "version": "2.6.9",
645   "resolved": "https://registry.npmjs.org/debug/-/debug-2.6.9.tgz",
646   "integrity": "sha512-
647 bC7E1rdJaJnPbAP+1EotYvqZsb3ec15wi6Bfi6BJTUcNowp6cvspg0jXznRTKDjm/
648 E7AdgFBVeAPVMNcKGsHMA=="
649   "requires": {
650     "ms": "2.0.0"
651   }
652 },
653 "depd": {
654   "version": "1.1.2",
655   "resolved": "https://registry.npmjs.org/depd/-/depd-1.1.2.tgz",
656   "integrity": "sha1-m81S4UwJd2PnSbJ0xDRu0uVgtak="
657 },
658 "destroy": {
659   "version": "1.0.4",
660   "resolved": "https://registry.npmjs.org/destroy/-/
661 destroy-1.0.4.tgz",
662   "integrity": "sha1-14hXRCxEJ5CBmE+N5RiBYJqvYA="
663 },
664 "ee-first": {
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665     "version": "1.1.1",
666     "resolved": "https://registry.npmjs.org/ee-first/-/ee-
667 first-1.1.1.tgz",
668     "integrity": "sha1-WQxhFWsK4vTwJVcyoViyZrxWsh0="
669   },
670   "encodeurl": {
671     "version": "1.0.2",
672     "resolved": "https://registry.npmjs.org/encodeurl/-/
673 encodeurl-1.0.2.tgz",
674     "integrity": "sha1-rT/0yG7C0CkyL1oCw6mmBs1bP1k="
675   },
676   "escape-html": {
677     "version": "1.0.3",
678     "resolved": "https://registry.npmjs.org/escape-html/-/escape-
679 html-1.0.3.tgz",
680     "integrity": "sha1-Aljq5NPQwJdN4cFpGI7wBR0dGYg="
681   },
682   "etag": {
683     "version": "1.8.1",
684     "resolved": "https://registry.npmjs.org/etag/-/etag-1.8.1.tgz",
685     "integrity": "sha1-Qa4u62XvpiJorr/qg6x9eSmbCIc="
686   },
687   "express": {
688     "version": "4.17.1",
689     "resolved": "https://registry.npmjs.org/express/-/
690 express-4.17.1.tgz",
691     "integrity": "sha512-mHJ9079Rq1uphRrcw2X/
692 GTh3k9tVv8YcoyY4Kkh4WDMUYKRZUq0h1o0w2rrxBqM7VoeUVqgb27xlEMXTnYt4g==",
693     "requires": {
694       "accepts": "~1.3.7",
695       "array-flatten": "1.1.1",
696       "body-parser": "1.19.0",
697       "content-disposition": "0.5.3",
698       "content-type": "~1.0.4",
699       "cookie": "0.4.0",
700       "cookie-signature": "1.0.6",
701       "debug": "2.6.9",
702       "depd": "~1.1.2",
703       "encodeurl": "~1.0.2",
704       "escape-html": "~1.0.3",
705       "etag": "~1.8.1",
706       "finalhandler": "~1.1.2",
707       "fresh": "0.5.2",
708       "merge-descriptors": "1.0.1",
709       "methods": "~1.1.2",
710       "on-finished": "~2.3.0",
711       "parseurl": "~1.3.3",
712       "path-to-regexp": "0.1.7",
713       "proxy-addr": "~2.0.5",
714       "qs": "6.7.0",
715       "range-parser": "~1.2.1",
716       "safe-buffer": "5.1.2",
717       "send": "0.17.1",
718       "serve-static": "1.14.1",
719       "setprototypeof": "1.1.1",
720       "statuses": "~1.5.0",
721       "type-is": "~1.6.18",
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722     "utils-merge": "1.0.1",
723     "vary": "~1.1.2"
724   }
725 },
726   "finalhandler": {
727     "version": "1.1.2",
728     "resolved": "https://registry.npmjs.org/finalhandler/-/
729 finalhandler-1.1.2.tgz",
730     "integrity": "sha512-
731 aAwcW57uxVNrQZqFXjITpW3sIUQmHGG3qSb9mUah9MgMC4NeWhN01NjXEYq3HjRAvL6arUviZGG
732     "requires": {
733       "debug": "2.6.9",
734       "encodeurl": "~1.0.2",
735       "escape-html": "~1.0.3",
736       "on-finished": "~2.3.0",
737       "parseurl": "~1.3.3",
738       "statuses": "~1.5.0",
739       "unpipe": "~1.0.0"
740     }
741   },
742   "forwarded": {
743     "version": "0.2.0",
744     "resolved": "https://registry.npmjs.org/forwarded/-/
745 forwarded-0.2.0.tgz",
746     "integrity": "sha512-
747 buRG0fpBtRHSTCOASe6hD258tEubFoRLb4ZNA6NxMVHNw2g0cwHo9wyablzMz0A5z9xA9L1KNjk
748 Nt6MT9aYow=="
749   },
750   "fresh": {
751     "version": "0.5.2",
752     "resolved": "https://registry.npmjs.org/fresh/-/fresh-0.5.2.tgz",
753     "integrity": "sha1-PYyt2Q2XZWn6g1qx+0Sy0hBWBac="
754   },
755   "http-errors": {
756     "version": "1.7.2",
757     "resolved": "https://registry.npmjs.org/http-errors/-/http-
758 errors-1.7.2.tgz",
759     "integrity": "sha512-uUQBt3H/cSIVfch6i1EuPNy/
760 YsRSOUBXTVfZ+yR7Zjz3qjBz6i9+i4zjNaoqcoFVI4lQJ5p1g63TvGfRSDCRg==",
761     "requires": {
762       "depd": "~1.1.2",
763       "inherits": "2.0.3",
764       "setprototypeof": "1.1.1",
765       "statuses": ">= 1.5.0 < 2",
766       "toidentifier": "1.0.0"
767     }
768   },
769   "iconv-lite": {
770     "version": "0.4.24",
771     "resolved": "https://registry.npmjs.org/iconv-lite/-/iconv-
772 lite-0.4.24.tgz",
773     "integrity": "sha512-
774 v3MXnZAcvnywkTUEZomIActle7RXXeedOR31wwl7VlYoX04Qi9arvSenNQWne1TcRwhCL1HwLI2
775 rA==",
776     "requires": {
777       "safer-buffer": ">= 2.1.2 < 3"
778     }
779   }
```

```
779     },
780     "inherits": {
781       "version": "2.0.3",
782       "resolved": "https://registry.npmjs.org/inherits/-/
783 inherits-2.0.3.tgz",
784       "integrity": "sha1-Yzwsg+PaQqUC9SRmAiSA9CCCYd4="
785     },
786     "ipaddr.js": {
787       "version": "1.9.1",
788       "resolved": "https://registry.npmjs.org/ipaddr.js/-/
789 ipaddr.js-1.9.1.tgz",
790       "integrity": "sha512-0KI/607xoxSToH7GjN1FfSbLoU0+btTicjsQSWQlh/
791 hZykN8KpmMf7uYwPW3R+akZ6R/w18ZlXSHBYXiYUP03g==",
792     },
793     "media-typer": {
794       "version": "0.3.0",
795       "resolved": "https://registry.npmjs.org/media-typer/-/media-
796 typer-0.3.0.tgz",
797       "integrity": "sha1-hxDXrwqmJvj/+hzgAWhUUmMlV0g="
798     },
799     "merge-descriptors": {
800       "version": "1.0.1",
801       "resolved": "https://registry.npmjs.org/merge-descriptors/-/merge-
802 descriptors-1.0.1.tgz",
803       "integrity": "sha1-sAqQVW3YtEVofQ7J0b1T8/kMu2E="
804     },
805     "methods": {
806       "version": "1.1.2",
807       "resolved": "https://registry.npmjs.org/methods/-/
808 methods-1.1.2.tgz",
809       "integrity": "sha1-VSmk1nZUE07cxSZmVoNbD4Ua/04="
810     },
811     "mime": {
812       "version": "1.6.0",
813       "resolved": "https://registry.npmjs.org/mime/-/mime-1.6.0.tgz",
814       "integrity": "sha512-x0Vn8spI+uwJ106S7gnbaQg8Pxh4NNHb7KSINmEWKiPE4RK0plvij+NmYmmRgP68mc70j2Ebe
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816     },
817     "mime-db": {
818       "version": "1.48.0",
819       "resolved": "https://registry.npmjs.org/mime-db/-/mime-
820 db-1.48.0.tgz",
821       "integrity": "sha512-FM3QwxV+TnZYQ2aRqh1KBMHxk101TbMt3bBkMAP54ddrNeVSfcQY00KuGuy3Ddrm38I04If834f
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823     },
824     "mime-types": {
825       "version": "2.1.31",
826       "resolved": "https://registry.npmjs.org/mime-types/-/mime-
827 types-2.1.31.tgz",
828       "integrity": "sha512-XGZnNzm3QvgKxa8dpzyhFTHmpP315YNusmne07VUOXxou9CqUqYa/HBy124RqtVh/
829 XGZnNzm3QvgKxa8dpzyhFTHmpP315YNusmne07VUOXxou9CqUqYa/HBy124RqtVh/
830 02pECas/M0csDgpilPOPg==",
831       "requires": {
832         "mime-db": "1.48.0"
833       }
834     },
835     "ms": {
```

```

836     "version": "2.0.0",
837     "resolved": "https://registry.npmjs.org/ms/-/ms-2.0.0.tgz",
838     "integrity": "sha1-VgiurfwAvmwpAd9fmGF4jeDVl8g="
839   },
840   "negotiator": {
841     "version": "0.6.2",
842     "resolved": "https://registry.npmjs.org/negotiator/-/
843 negotiator-0.6.2.tgz",
844     "integrity": "sha512-
845 hZxc7K2e+PgeI1eDBe/10Ard4ekbfrrqG8Ep+8Jmf4JID2bNg7NvCP0ZN+kff574pFQI7mum2AU
846   },
847   "on-finished": {
848     "version": "2.3.0",
849     "resolved": "https://registry.npmjs.org/on-finished/-/on-
850 finished-2.3.0.tgz",
851     "integrity": "sha1-IPEzZIGwg811M3mSoWlxi2QaUc=",
852     "requires": {
853       "ee-first": "1.1.1"
854     }
855   },
856   "parseurl": {
857     "version": "1.3.3",
858     "resolved": "https://registry.npmjs.org/parseurl/-/
859 parseurl-1.3.3.tgz",
860     "integrity": "sha512-
861 JZyN5m0z9PfxW4SCBJ6Syzg1Dp10wqjlhDEGGBP1GnsUVEL0p63hoG1fcj3fHynXi9NY04nWOL+
862   },
863   "path-to-regexp": {
864     "version": "0.1.7",
865     "resolved": "https://registry.npmjs.org/path-to-regexp/-/path-to-
866 regexp-0.1.7.tgz",
867     "integrity": "sha1-32BBEABfUi8V60SQ5yR6G/qmf4w="
868   },
869   "proxy-addr": {
870     "version": "2.0.7",
871     "resolved": "https://registry.npmjs.org/proxy-addr/-/proxy-
872 addr-2.0.7.tgz",
873     "integrity": "sha512-
874 037qlnifitDP+ZwrmmZcoSKyLKvtZxpyV0n2/bD/N4tBAAZ/gJEdZU7KMraoK1+XYAg==",
875     "requires": {
876       "forwarded": "0.2.0",
877       "ipaddr.js": "1.9.1"
878     }
879   },
880   "qs": {
881     "version": "6.7.0",
882     "resolved": "https://registry.npmjs.org/qs/-/qs-6.7.0.tgz",
883     "integrity": "sha512-
884 SPe62QCaAyzJvUjwRaIsc+NePBEhiHlvxFmmX56+HZphIGtV0XeCirBtpDrTyQ=="
885   },
886   "range-parser": {
887     "version": "1.2.1",
888     "resolved": "https://registry.npmjs.org/range-parser/-/range-
889 parser-1.2.1.tgz",
890     "integrity": "sha512-
891 Hrgsx+orqoygnmhFbKaHE6c296J+HTAQXoxEF6gNupR0mmGJRozzfG3ccAveqCBwr/2yxQ5BVd
892 GT15ag0wSg=="

```

```

    },
    "raw-body": {
      "version": "2.4.0",
      "resolved": "https://registry.npmjs.org/raw-body/-/raw-body-2.4.0.tgz",
      "integrity": "sha512-40z8DUIwdvoad5qMJelxipzi/iJI4005cGV1wNYp5hvZP8ZN0T+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-Gd2UZBJDkXl1Y7GbJxfsE8/nvKkUEU1G38c1siN6QP6a9PT9MmHB8GnpscSmMJSoF8L0Irt8ud/wPtoajys4G6+g==",
    },
    "safer-buffer": {
      "version": "2.1.2",
      "resolved": "https://registry.npmjs.org/safer-buffer/-/safer-buffer-2.1.2.tgz",
      "integrity": "sha512-YZo3K82SD7Riyi0E1EQPojLz7kpepnSQI9IyPbHHg1XXXevb5dJI7tpyN2ADxGcQbHG7vcyRHk0",
    },
    "send": {
      "version": "0.17.1",
      "resolved": "https://registry.npmjs.org/send/-/send-0.17.1.tgz",
      "integrity": "sha512-BsVKsiGcQMFwT8UxypobUKyv7irCNRHk1T0G680vk88yf6LBBYGcZJ0TJCrTP2xVN6yI+XjPJcN",
      "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",
        "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+3m
      "requires": {
        "encodeurl": "~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-
JvdAWfbXeIGaZ9cILp38HntZSFS03mWg6xGcJJsd+d4aRM0quag1C63dJfDw70aMYwEbHMOxEZ
    },
    "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-
VEhBWWTlhI+qXxDFXlejDGcQipMlyxda9nthulaxLZUNcUqFxokp0vcYnvteJln5FNQDRrxj3Yc
    },
    "type-is": {
      "version": "1.6.18",
      "resolved": "https://registry.npmjs.org/type-is/-/type-
is-1.6.18.tgz",
      "integrity": "sha512-
TkRkr9sUTxEH8MdfuCSP7VizJyzRNMjj2J2do2Jr3Kym598JVdEksuzPQCn1FPW4ky9Q+iA+ma9
      "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-sr906FFKrmltIF4KdIbLvSZB0w="
    },
    "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-IpnwLG3tMNS1lhsLn3RSShj2NPw="
  }
}
}

```

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": "Etyy",
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 a 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 terminaux 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 basez sur des metriques qui ne sont pas cpu/memoire. Comment faites-vous ?

Pour les plus rapides

Deployer un serveur minecraft dans votre Cluster.

Merci de votre attention

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