Tworzenie aplikacji rozproszonych
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PS1

Zadanie: AWS – Zadanie (1pkt)

Treść zadania

AWS - Zadanie (1 pkt)
Badanie skalowania i równoważenia obciążenia aplikacji internetowych z użyciem usług AWS

W ramach zadania należy uruchomić skalowalną aplikację internetową na infrastrukturze AWS oraz przeprowadzić demonstrację skalowalności. Technologia wytworzenia aplikacji jest dowolna. Skalowalność ma polegać na możliwości uruchomienia aplikacji na dowolnej liczbie maszyn. Można to osiągnąć na kilka sposobów, m.in. poprzez aplikacje bezstanowe czy też korzystanie ze współdzielonej bazy danych.

Aby wykorzystać i wykazać możliwość skalowania aplikacji, należy ją uruchomić z użyciem 2 usług AWS:

Auto Scaling,
Elastic Load Balancing.

Demonstracja polegać ma na wysyłaniu żądań do aplikacji za pomocą narzędzia typu JMeter. Należy podczas tej symulacji zademonstrować efekt automatycznego skalowania aplikacji przez usługę EC2 Auto Scaling (lub AWS Auto Scaling).

Jako wynik zadania należy dołączyć:

plik z wynikami takiego badania (log z aplikacji typu JMeter),
wszelkie tekstowe pliki konfiguracyjne (JMeter, AWS CloudFormation jeśli było użyte),
wykres z serwisu AWS CloudWatch średniego obciążenia maszyn w użytej grupie skalowania.

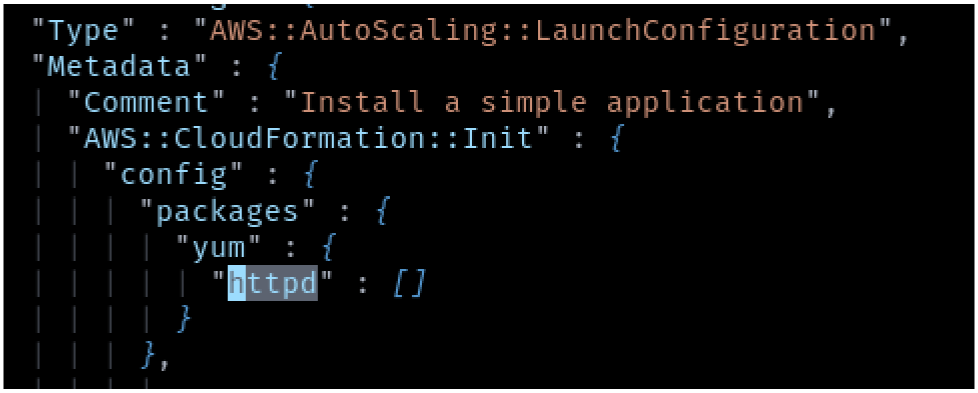
Nie jest wymagane dołączanie źródeł aplikacji internetowej.

Użycie usługi AWS Cloud Formation (stworzenie szablonu uruchamianej infrastruktury) podnosi punktację do 1,5 pkt.

Sprawozdanie

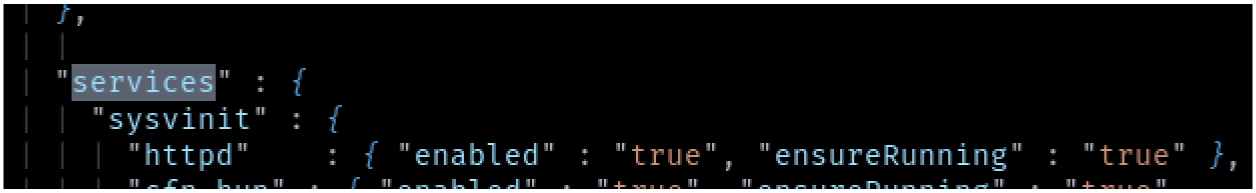
Aplikacja/Infrastruktura

Niniejsza sekcja opisuje aplikację, którą obciążano używając programu Jmeter. Jest to prosta statyczna strona udostępniona dzięki serwerowi HTTP Apache – httpd.



```
"Type" : "AWS::AutoScaling::LaunchConfiguration",
"Metadata" : {
  "Comment" : "Install a simple application",
  "AWS::CloudFormation::Init" : {
    "config" : {
      "packages" : {
        "yum" : {
          "httpd" : []
        }
      },
```

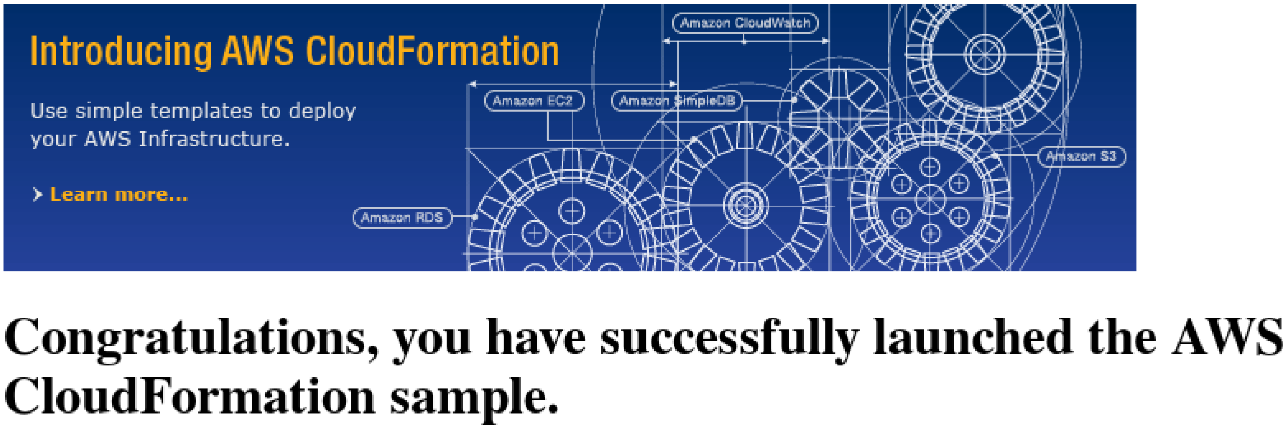
Ilustracja 1: Serwer Apache httpd w pliku JSON opisującym infrastrukturę tworzoną przez CloudFormation (AWS::AutoScaling::LaunchConfiguration)



```
    },

    "services" : {
      "sysvinit" : {
        "httpd"    : { "enabled" : "true", "ensureRunning" : "true" },
        "cfn-hup" : { "enabled" : "true", "ensureRunning" : "true"
```

Ilustracja 2: Włączenie usługi httpd (AWS::AutoScaling::LaunchConfiguration)



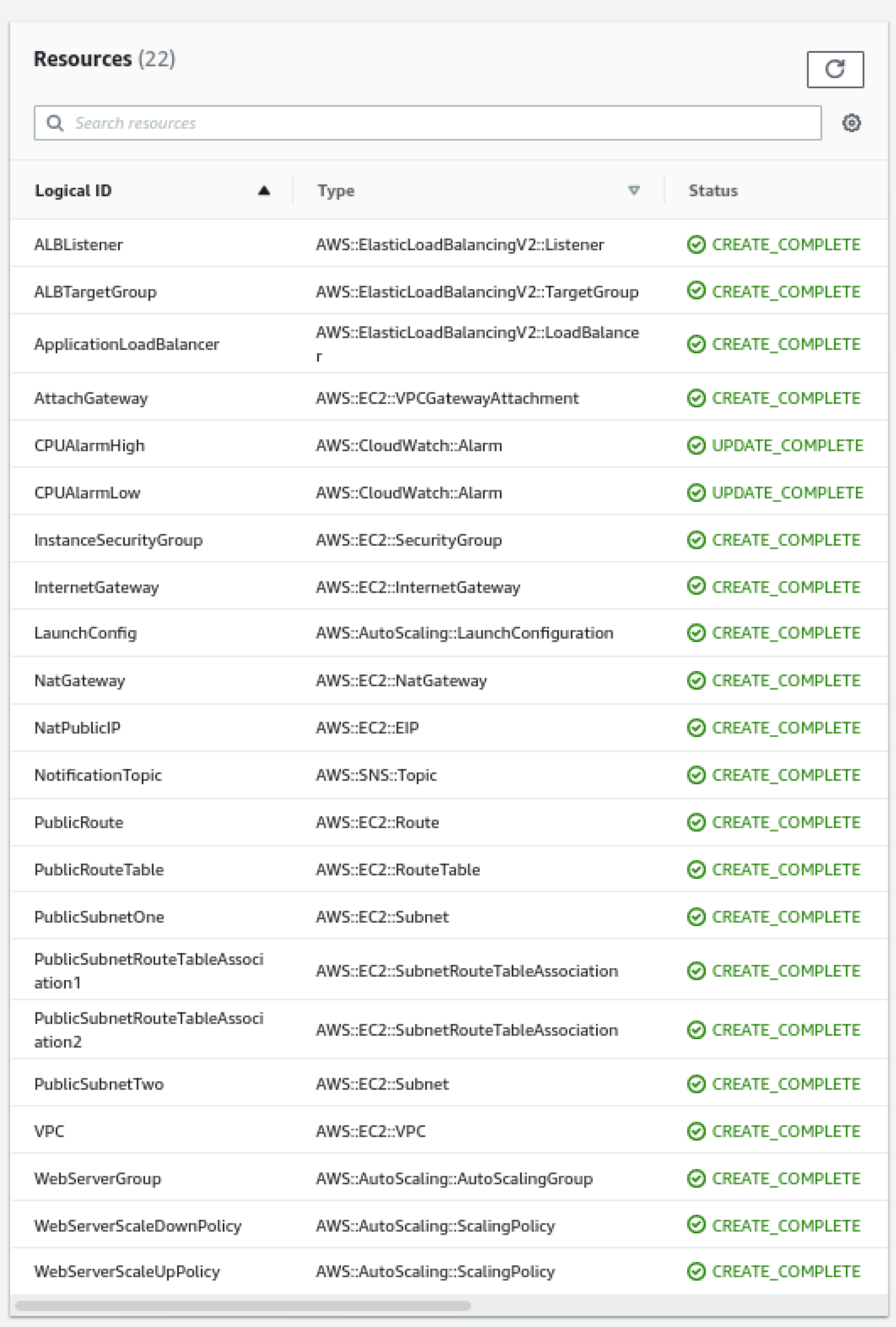
Introducing AWS CloudFormation
Use simple templates to deploy your AWS Infrastructure.
› Learn more...
Amazon CloudWatch
Amazon EC2
Amazon SimpleDB
Amazon S3
Amazon RDS

Congratulations, you have successfully launched the AWS CloudFormation sample.

Ilustracja 3: Wygląd pliku index.html wyrenderowanego przez przeglądarkę. index.html jest udostępniany przez httpd.

Jedynym plikiem hostowanym przez serwer jest index.html. Wkrótce okaże się, że przy tak lekkim pliku (zaledwie parę KB) odpowiednie obciążenie serwera tak, aby sprowokować Load Balancer do użycia dwóch instancji maszyn wirtualnych zamiast jednej jest wyzwaniem.

Zasoby użyte w CloudFormation prezentują się następująco:



Resources (22)

Search resources

Logical ID ▲	Type ▽	Status
ALBListener	AWS::ElasticLoadBalancingV2::Listener	CREATE_COMPLETE
ALBTargetGroup	AWS::ElasticLoadBalancingV2::TargetGroup	CREATE_COMPLETE
ApplicationLoadBalancer	AWS::ElasticLoadBalancingV2::LoadBalancer	CREATE_COMPLETE
AttachGateway	AWS::EC2::VPCGatewayAttachment	CREATE_COMPLETE
CPUAlarmHigh	AWS::CloudWatch::Alarm	UPDATE_COMPLETE
CPUAlarmLow	AWS::CloudWatch::Alarm	UPDATE_COMPLETE
InstanceSecurityGroup	AWS::EC2::SecurityGroup	CREATE_COMPLETE
InternetGateway	AWS::EC2::InternetGateway	CREATE_COMPLETE
LaunchConfig	AWS::AutoScaling::LaunchConfiguration	CREATE_COMPLETE
NatGateway	AWS::EC2::NatGateway	CREATE_COMPLETE
NatPublicIP	AWS::EC2::EIP	CREATE_COMPLETE
NotificationTopic	AWS::SNS::Topic	CREATE_COMPLETE
PublicRoute	AWS::EC2::Route	CREATE_COMPLETE
PublicRouteTable	AWS::EC2::RouteTable	CREATE_COMPLETE
PublicSubnetOne	AWS::EC2::Subnet	CREATE_COMPLETE
PublicSubnetRouteTableAssociation1	AWS::EC2::SubnetRouteTableAssociation	CREATE_COMPLETE
PublicSubnetRouteTableAssociation2	AWS::EC2::SubnetRouteTableAssociation	CREATE_COMPLETE
PublicSubnetTwo	AWS::EC2::Subnet	CREATE_COMPLETE
VPC	AWS::EC2::VPC	CREATE_COMPLETE
WebServerGroup	AWS::AutoScaling::AutoScalingGroup	CREATE_COMPLETE
WebServerScaleDownPolicy	AWS::AutoScaling::ScalingPolicy	CREATE_COMPLETE
WebServerScaleUpPolicy	AWS::AutoScaling::ScalingPolicy	CREATE_COMPLETE

Ilustracja 4: Zasoby użyte w "Stacku" CloudFormation

Aplikacja używa instancji EC2 t3.nano bo są najtańsze (chwilowo nie korzystamy z AWS Educate). Też najłatwiej je obciążyć, posiadają tylko jedno vCPU.

Tworzenie powyższej infrastruktury odbywa się poprzez AWS CLI oraz poniższą komendę (definicje usług CloudFormation znajdują się w pliku stack.cf.json):

```
CLI_PROFILE=default
STACK_NAME=rownolegle
REGION=eu-central-1
EC2_INSTANCE_TYPE=t3.nano #cheapest i think
OPERATOR_EMAIL=jakisemail@example.com #prawdziwy email ukryto
KEY_NAME=rownolegle
echo -e "\n==Deploying stack.cf.json===\n"
aws cloudformation deploy \
  --region $REGION \
  --profile $CLI_PROFILE \
  --stack-name $STACK_NAME \
  --template-file stack.cf.json \
  --no-fail-on-empty-changeset \
  --capabilities CAPABILITY_NAMED_IAM \
  --parameter-overrides \
    InstanceType=$EC2_INSTANCE_TYPE \
    OperatorEMail=$OPERATOR_EMAIL \
    KeyName=$KEY_NAME \
```

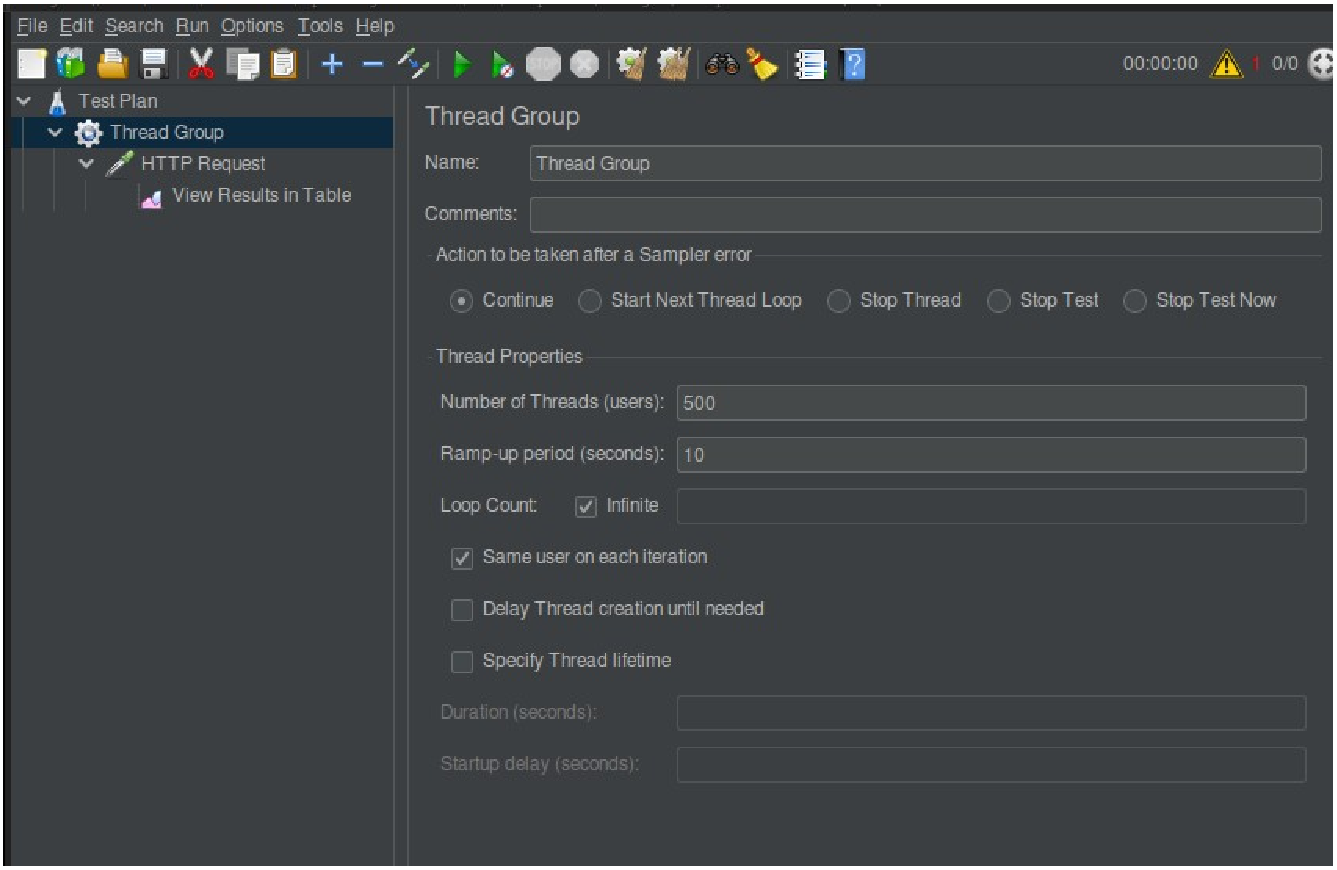
Komenda jest bardzo podobna do tej prezentowanej w książce “The Good Parts of AWS” autorstwa Daniela Vassallo oraz Josha Pschorra (zakupionej do użytku prywatnego przez jednego z członków zespołu tworzącego to sprawozdanie).

Plik stack.cf.json w dużej mierze opiera się na samouczku do tworzenia infrastruktury z Load Balancerem udostępnionym przez AWS. Znajduje się on pod odnośnikiem: https://docs.aws.amazon.com/AWSCloudFormation/latest/UserGuide/example-templates-autoscaling.html#example-templates-autoscaling-description

Alerty CloudWatch są ustawione tak, aby Load Balancer tworzył nową instancję EC2 gdy przez 60 sekund zużycie jednej z dotychczas istniejącej instacji EC2 przekracza 50%. Instancje są usuwane gdy średnie zużycie procesora na instancjach spadnie poniżej 20% na 60 sekund.

Konfiguracja Jmeter

Aby odpowiednio obciążyć load balancer, użyto Apache Jmeter.Stworzono bardzo prosty test plan:



Thread Group

Name: Thread Group

Comments:

Action to be taken after a Sampler error

● Continue ○ Start Next Thread Loop ○ Stop Thread ○ Stop Test ○ Stop Test Now

Thread Properties

Number of Threads (users): 500

Ramp-up period (seconds): 10

Loop Count: ☑ Infinite

☑ Same user on each iteration

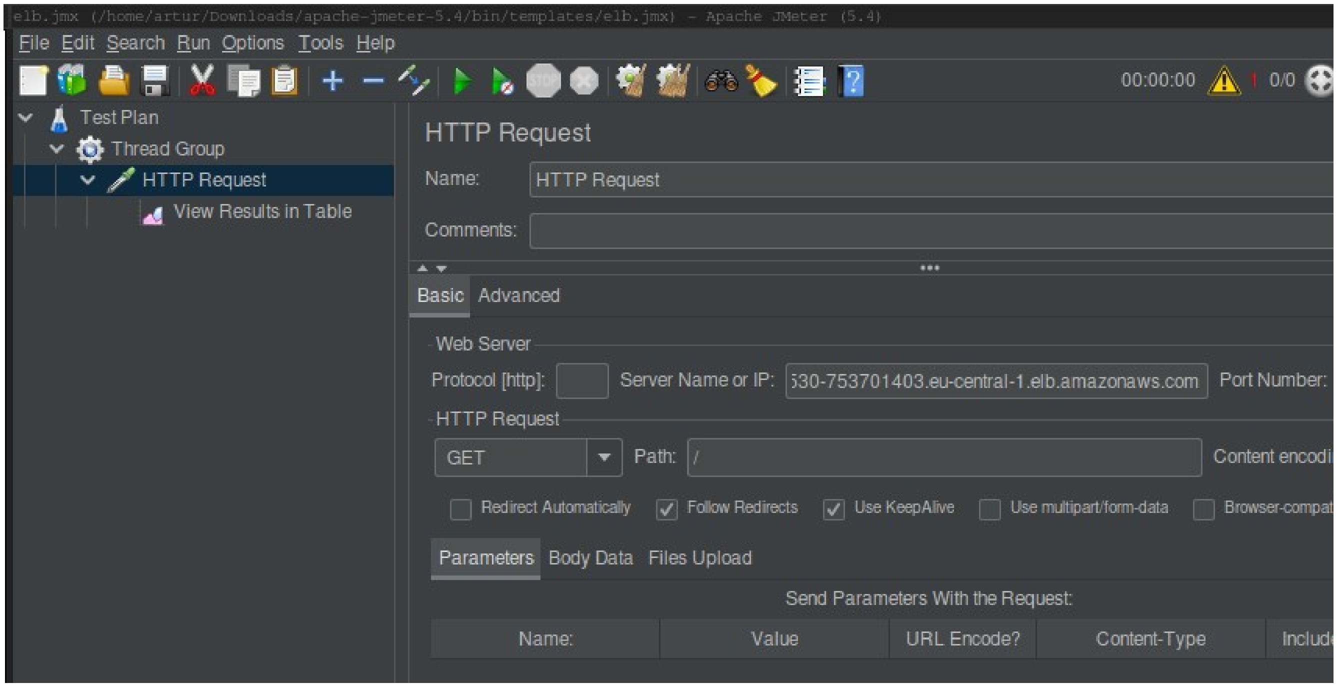
□ Delay Thread creation until needed

□ Specify Thread lifetime

Duration (seconds):

Startup delay (seconds):

Ilustracja 5: Konfiguracja thread group - najważniejszym ustawieniem jest oczywiście "Number of threads" – 500. Test plan działa w nieskończoność (Loop count = Infinite)



elb.jmx (/home/artur/Downloads/apache-jmeter-5.4/bin/templates/elb.jmx) - Apache JMeter (5.4)

Name: HTTP Request

Comments:

Protocol [http]:

Server Name or IP: 530-753701403.eu-central-1.elb.amazonaws.com

Port Number:

GET

Path: /

Content encodi

☐ Redirect Automatically ☑ Follow Redirects ☑ Use KeepAlive ☐ Use multipart/form-data ☐ Browser-compat

Name:	Value	URL Encode?	Content-Type	Includ

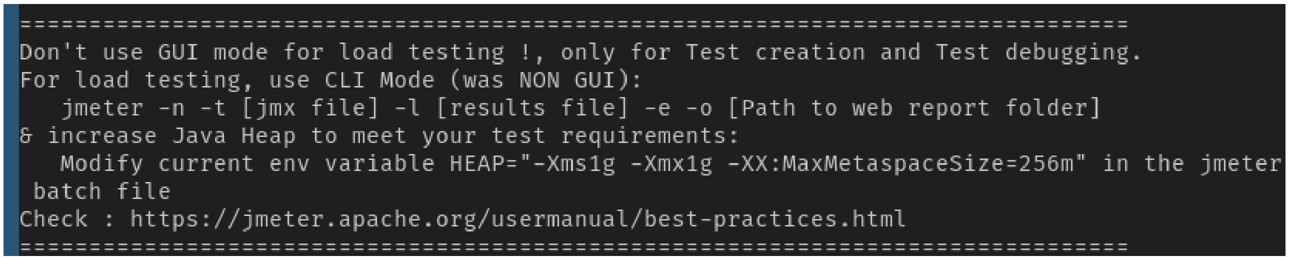
Ilustracja 6: Sampler do wykonywania żądań HTTP. W polu "Server Name or IP" dodano adres DNS instancji Load Balancera.

Początkowo podjęto próby obciążenia load balancera używając 5 oraz 50 wątków. Niestety taka konfiguracja wykonywała jedynie ok. 10 (5 wątków w trybie GUI JMeter) lub 100 (50 wątków w trybie GUI JMeter) żądań do serwera na sekundę. Zużycie procesora na jednej maszynie wirtualnej przy tej nieskutecznej konfiguracji wynosiło od 0 do 20 procent.

Oczywiście możliwe byłoby zmodyfikowanie alertów CloudWatch aby Load Balancer dodawał kolejną maszynę wirtualną zaledwie przy 20% zużycia procesora, jednak nie symulowałoby to prawdziwej sytuacji w środowisku produkcyjnym, gdzie klient raczej nie jest skłonny płacić za marnotractwo zasobów.

Kluczowe okazało się m.in:

- **Uruchomienie Jmeter w trybie CLI**



```
================================================================================
Don't use GUI mode for load testing !, only for Test creation and Test debugging.
For load testing, use CLI Mode (was NON GUI):
   jmeter -n -t [jmx file] -l [results file] -e -o [Path to web report folder]
& increase Java Heap to meet your test requirements:
   Modify current env variable HEAP="-Xms1g -Xmx1g -XX:MaxMetaspaceSize=256m" in the jmeter
 batch file
Check : https://jmeter.apache.org/usermanual/best-practices.html
================================================================================
```

Ilustracja 7: Komunikat rekomendujący użycie JMeter w trybie CLI. Pojawia się, gdy uruchomimy JMeter w trybie GUI z terminala (apache-jmeter/bin/jmeter)

Idąc za radą komunikatu pojawiającego się przy otwarciu Jmeter, użyto trybu CLI do obciążania Load Balancera. Wymaga to wcześniejszego stworzenia test planu w trybie GUI I zapisania go do pliku w formacie .jmx. W naszym przypadku ścieżka do pliku .jmx to: apache-jmeter/bin/templates/elb.jmx

Po stworzeniu test planu użyto niniejszej komendy:

```
./jmeter -n -t ./templates/elb.jmx -l results.log -e -o reports
```

Komenda co pewien czas wyświetla raport o wykonanych żądaniach, na przykład:

```
summary + 342923 in 00:00:30 = 11430.4/s Avg:    43 Min:    31 Max:  1739 Err:     0 (0.00%)
Active: 500 Started: 500 Finished: 0
summary = 7773089 in 00:12:05 = 10728.1/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
```

prezentujący ile żądań wykonano w ostatniej iteracji (w ciągu ostatnich parudziesięciu sekund – summary +), oraz ile żądań wykonano ogółem dotychczas (summary = …). Powyższy przykład pochodzi z faktycznego testu na naszej infrastrukturze, gdzie wykonano 7 mln żądan.

- **Podwyższenie liczby wątków do 500**
  To znacznie powiększyło ilość żądań wykonywanych do serwera. Pozwoliło to w końcu wywołać zużycie procesora na poziome 87% na instancji EC2 typu t3.nano oraz sprowokowanie Load Balancera do stworzenia drugiej instancji t3.nano w celu rozłożenia nakładu żądań.

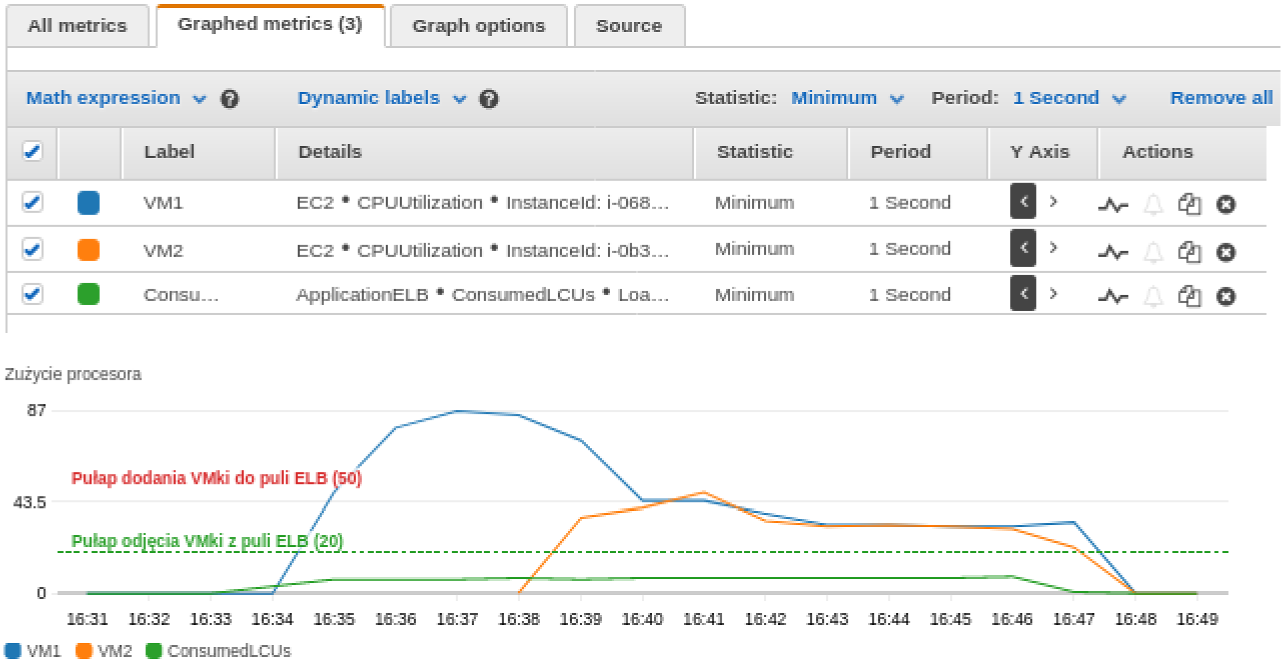
Sprawdzanie działania Load Balancera (obciążanie aplikacji)

1. Utworzono infrastrukturę używając komendy **aws cloudformation deploy**
2. Skopiowano adres DNS Load balancera: **rowno-Appli-5S4OE6PTK530-753701403.eu-central-1.elb.amazonaws.com**
3. Wklejono URL Load balancera do test planu Jmeter.
4. Uruchomiono Jmeter w trybie CLI: **./jmeter -n -t ./templates/elb.jmx -l results.log -e -o reports**

Rezultatem tego było wykonanie 8 mln żądan w przeciągu 12 min:
summary = 8126098 in 00:12:35 = 10769.4/s Avg: 45 Min: 31 Max: 3659 Err: 0 (0.00%)

Wykresy CloudWatch

Jak widać VM2 została stworzona o 16:38 dzięki czemu obniżyła zużycie procesora VM1 do ok 43%.



☑		Label	Details	Statistic	Period	Y Axis	Actions
☑	🟦	VM1	EC2 • CPUUtilization • InstanceId: i-068...	Minimum	1 Second	‹ ›	
☑	🟧	VM2	EC2 • CPUUtilization • InstanceId: i-0b3...	Minimum	1 Second	‹ ›	
☑	🟩	Consu...	ApplicationELB • ConsumedLCUs • Loa...	Minimum	1 Second	‹ ›	

Log Jmeter (skrócony)

Skrócony log (z Jmeter w trybie CLI):

```
t430 :: Downloads/apache-jmeter-5.4/bin % ./jmeter -n -t ./templates/elb.jmx -l results.log -e -o reports                    130 ↲
Creating summariser <summary>
Created the tree successfully using ./templates/elb.jmx
Starting standalone test @ Thu May 06 18:34:24 CEST 2021 (1620318864966)
Waiting for possible Shutdown/StopTestNow/HeapDump/ThreadDump message on port 4445
Warning: Nashorn engine is planned to be removed from a future JDK release
summary +  11336 in 00:00:05 = 2488.1/s Avg:    43 Min:    33 Max:   259 Err:     0 (0.00%) Active: 226 Started: 226 Finished: 0
summary + 298958 in 00:00:30 = 9965.3/s Avg:    47 Min:    31 Max:  3104 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 310294 in 00:00:35 = 8979.5/s Avg:    47 Min:    31 Max:  3104 Err:     0 (0.00%)
summary + 326945 in 00:00:30 = 10898.2/s Avg:    45 Min:    32 Max:  1279 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 637239 in 00:01:05 = 9871.1/s Avg:    46 Min:    31 Max:  3104 Err:     0 (0.00%)
summary + 291937 in 00:00:30 = 9731.2/s Avg:    51 Min:    33 Max:  3355 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 929176 in 00:01:35 = 9826.7/s Avg:    47 Min:    31 Max:  3355 Err:     0 (0.00%)
summary + 297731 in 00:00:30 = 9924.4/s Avg:    50 Min:    32 Max:  3370 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 1226907 in 00:02:05 = 9850.2/s Avg:    48 Min:    31 Max:  3370 Err:     0 (0.00%)
summary + 304765 in 00:00:30 = 10158.8/s Avg:    49 Min:    32 Max:  2743 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 1531672 in 00:02:35 = 9910.1/s Avg:    48 Min:    31 Max:  3370 Err:     0 (0.00%)
summary + 311899 in 00:00:30 = 10396.6/s Avg:    48 Min:    32 Max:  3088 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 1843571 in 00:03:05 = 9989.2/s Avg:    48 Min:    31 Max:  3370 Err:     0 (0.00%)
summary + 311739 in 00:00:30 = 10391.3/s Avg:    47 Min:    32 Max:  1286 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 2155310 in 00:03:35 = 10045.4/s Avg:    48 Min:    31 Max:  3370 Err:     0 (0.00%)
summary + 321906 in 00:00:30 = 10730.2/s Avg:    46 Min:    33 Max:  3068 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 2477216 in 00:04:05 = 10129.4/s Avg:    48 Min:    31 Max:  3370 Err:     0 (0.00%)
summary + 331700 in 00:00:30 = 11056.7/s Avg:    45 Min:    31 Max:  3089 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 2808916 in 00:04:35 = 10230.8/s Avg:    47 Min:    31 Max:  3370 Err:     0 (0.00%)
summary + 305100 in 00:00:30 = 10170.0/s Avg:    49 Min:    32 Max:  3659 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 3114016 in 00:05:05 = 10224.8/s Avg:    47 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 311178 in 00:00:30 = 10372.6/s Avg:    48 Min:    32 Max:  3093 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 3425194 in 00:05:35 = 10238.0/s Avg:    47 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 324937 in 00:00:30 = 10831.2/s Avg:    46 Min:    31 Max:  3066 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 3750131 in 00:06:05 = 10286.8/s Avg:    47 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 340515 in 00:00:30 = 11350.5/s Avg:    43 Min:    31 Max:  3087 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 4090646 in 00:06:35 = 10367.7/s Avg:    47 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 319387 in 00:00:30 = 10646.2/s Avg:    46 Min:    31 Max:  3381 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 4410033 in 00:07:05 = 10387.4/s Avg:    47 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 336860 in 00:00:30 = 11228.7/s Avg:    44 Min:    31 Max:  3066 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 4746893 in 00:07:35 = 10442.9/s Avg:    47 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 346286 in 00:00:30 = 11542.9/s Avg:    43 Min:    32 Max:  1084 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 5093179 in 00:08:05 = 10511.0/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 327603 in 00:00:30 = 10920.1/s Avg:    45 Min:    31 Max:  3076 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 5420782 in 00:08:35 = 10534.9/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 336181 in 00:00:30 = 11206.0/s Avg:    44 Min:    31 Max:  1368 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 5756963 in 00:09:05 = 10571.8/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 347995 in 00:00:30 = 11599.8/s Avg:    42 Min:    31 Max:  3084 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 6104958 in 00:09:35 = 10625.5/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 334309 in 00:00:30 = 11142.1/s Avg:    44 Min:    31 Max:  1110 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 6439267 in 00:10:05 = 10651.2/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 328495 in 00:00:30 = 10950.9/s Avg:    45 Min:    31 Max:  3094 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 6767762 in 00:10:35 = 10665.3/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 342388 in 00:00:30 = 11413.3/s Avg:    43 Min:    31 Max:  3088 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 7110150 in 00:11:05 = 10699.1/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 320016 in 00:00:30 = 10667.2/s Avg:    46 Min:    31 Max:  3091 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 7430166 in 00:11:35 = 10697.7/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 342923 in 00:00:30 = 11430.4/s Avg:    43 Min:    31 Max:  1739 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 7773089 in 00:12:05 = 10728.1/s Avg:    46 Min:    31 Max:  3659 Err:     0 (0.00%)
summary + 353009 in 00:00:30 = 11767.4/s Avg:    42 Min:    31 Max:  1078 Err:     0 (0.00%) Active: 500 Started: 500 Finished: 0
summary = 8126098 in 00:12:35 = 10769.4/s Avg:    45 Min:    31 Max:  3659 Err:     0 (0.00%)
```

Log Jmeter (z pliku results.log)

Faktyczny plik ma rozmiar 1.3 GB więc poniższy log zawiera jedynie żądania których ID to wielokrotność to 100,000 (stu tysięcy)

```
1620318879267,44,HTTP Request,200,OK,Thread Group 1-357,text,true,,507,168,500,500,http://rowno-Appli-5S4OE6PTK530-753701403.eu-central-1.elb.amazonaws.com/,44,0,0
1620318888653,37,HTTP Request,200,OK,Thread Group 1-460,text,true,,507,168,500,500,http://rowno-Appli-5S4OE6PTK530-753701403.eu-central-1.elb.amazonaws.com/,37,0,0
1620318899003,39,HTTP Request,200,OK,Thread Group 1-299,text,true,,507,168,500,500,http://rowno-Appli-5S4OE6PTK530-753701403.eu-central-1.elb.amazonaws.com/,39,0,0
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Test plan Jmeter (elb.jmx)

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      <boolProp name="TestPlan.functional_mode">false</boolProp>
      <boolProp name="TestPlan.tearDown_on_shutdown">true</boolProp>
      <boolProp name="TestPlan.serialize_threadgroups">false</boolProp>
      <elementProp name="TestPlan.user_defined_variables" elementType="Arguments" guiclass="ArgumentsPanel"
testclass="Arguments" testname="User Defined Variables" enabled="true">
        <collectionProp name="Arguments.arguments"/>
      </elementProp>
      <stringProp name="TestPlan.user_define_classpath"></stringProp>
    </TestPlan>
    <hashTree>
      <ThreadGroup guiclass="ThreadGroupGui" testclass="ThreadGroup" testname="Thread Group" enabled="true">
        <stringProp name="ThreadGroup.on_sample_error">continue</stringProp>
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testclass="LoopController" testname="Loop Controller" enabled="true">
          <boolProp name="LoopController.continue_forever">false</boolProp>
          <intProp name="LoopController.loops">-1</intProp>
        </elementProp>
        <stringProp name="ThreadGroup.num_threads">500</stringProp>
        <stringProp name="ThreadGroup.ramp_time">10</stringProp>
        <boolProp name="ThreadGroup.scheduler">false</boolProp>
        <stringProp name="ThreadGroup.duration"></stringProp>
        <stringProp name="ThreadGroup.delay"></stringProp>
        <boolProp name="ThreadGroup.same_user_on_next_iteration">true</boolProp>
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          <elementProp name="HTTPsampler.Arguments" elementType="Arguments" guiclass="HTTPArgumentsPanel"
testclass="Arguments" testname="User Defined Variables" enabled="true">
            <collectionProp name="Arguments.arguments"/>
          </elementProp>
          <stringProp name="HTTPSampler.domain">rowno-Appli-5S4OE6PTK530-753701403.eu-central-1.elb.amazonaws.com</
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          <stringProp name="HTTPSampler.protocol"></stringProp>
          <stringProp name="HTTPSampler.contentEncoding"></stringProp>
          <stringProp name="HTTPSampler.path">/</stringProp>
          <stringProp name="HTTPSampler.method">GET</stringProp>
          <boolProp name="HTTPSampler.follow_redirects">true</boolProp>
          <boolProp name="HTTPSampler.auto_redirects">false</boolProp>
          <boolProp name="HTTPSampler.use_keepalive">true</boolProp>
          <boolProp name="HTTPSampler.DO_MULTIPART_POST">false</boolProp>
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          <stringProp name="HTTPSampler.connect_timeout"></stringProp>
          <stringProp name="HTTPSampler.response_timeout"></stringProp>
        </HTTPSamplerProxy>
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            <objProp>
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                <samplerData>false</samplerData>
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                <responseHeaders>false</responseHeaders>
                <requestHeaders>false</requestHeaders>
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                <assertionsResultsToSave>0</assertionsResultsToSave>
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                <connectTime>true</connectTime>
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          </ResultCollector>
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              </hashTree>
            </hashTree>
          </hashTree>
</jmeterTestPlan>
```

Plik CloudFormation opisujący infrastrukturę (JSON) – używany w komendzie aws cloudformation deploy:

```
{
  "AWSTemplateFormatVersion" : "2010-09-09",

  "Description" : "AWS CloudFormation Sample Template AutoScalingMultiAZWithNotifications: Create a multi-az, load balanced and
Auto Scaled sample web site running on an Apache Web Serever. The application is configured to span all Availability Zones in the region
and is Auto-Scaled based on the CPU utilization of the web servers. Notifications will be sent to the operator email address on scaling
events. The instances are load balanced with a simple health check against the default web page. **WARNING** This template creates
one or more Amazon EC2 instances and an Application Load Balancer. You will be billed for the AWS resources used if you create a stack
from this template.",

  "Parameters" : {
    "InstanceType" : {
      "Description" : "WebServer EC2 instance type",
      "Type" : "String",
      "Default" : "t2.small",
      "AllowedValues" : [ "t1.micro", "t2.nano", "t3.nano", "t2.micro", "t2.small", "t2.medium", "t2.large", "m1.small", "m1.medium",
"m1.large", "m1.xlarge", "m2.xlarge", "m2.2xlarge", "m2.4xlarge", "m3.medium", "m3.large", "m3.xlarge", "m3.2xlarge", "m4.large",
"m4.xlarge", "m4.2xlarge", "m4.4xlarge", "m4.10xlarge", "c1.medium", "c1.xlarge", "c3.large", "c3.xlarge", "c3.2xlarge", "c3.4xlarge",
"c3.8xlarge", "c4.large", "c4.xlarge", "c4.2xlarge", "c4.4xlarge", "c4.8xlarge", "g2.2xlarge", "g2.8xlarge", "r3.large", "r3.xlarge",
"r3.2xlarge", "r3.4xlarge", "r3.8xlarge", "i2.xlarge", "i2.2xlarge", "i2.4xlarge", "i2.8xlarge", "d2.xlarge", "d2.2xlarge", "d2.4xlarge",
"d2.8xlarge", "hi1.4xlarge", "hs1.8xlarge", "cr1.8xlarge", "cc2.8xlarge", "cg1.4xlarge"]
,
      "ConstraintDescription" : "must be a valid EC2 instance type."
    },

    "OperatorEMail": {
      "Description": "EMail address to notify if there are any scaling operations",
      "Type": "String",
      "AllowedPattern": "([a-zA-Z0-9_\\-\\.]+)@((\\[[0-9]{1,3}\\.[0-9]{1,3}\\.[0-9]{1,3}\\.)|(([a-zA-Z0-9\\-]+\\.)+))([a-zA-Z]{2,4}|[0-9]
{1,3})(\\]?)",
      "ConstraintDescription": "must be a valid email address."
    },

    "KeyName" : {
      "Description" : "The EC2 Key Pair to allow SSH access to the instances",
      "Type" : "AWS::EC2::KeyPair::KeyName",
      "ConstraintDescription" : "must be the name of an existing EC2 KeyPair."
    },

    "SSHLocation" : {
      "Description" : "The IP address range that can be used to SSH to the EC2 instances",
      "Type": "String",
      "MinLength": "9",
      "MaxLength": "18",
      "Default": "0.0.0.0/0",
      "AllowedPattern": "(\\d{1,3})\\.(\\d{1,3})\\.(\\d{1,3})\\.(\\d{1,3})/(\\d{1,2})",
      "ConstraintDescription": "must be a valid IP CIDR range of the form x.x.x.x/x."
    }
  },

  "Mappings" : {
    "Region2Examples" : {
      "ap-east-1"      : { "Examples" : "https://s3-ap-east-1.amazonaws.com/cloudformation-examples-ap-east-1" },
      "ap-northeast-1" : { "Examples" : "https://s3-ap-northeast-1.amazonaws.com/cloudformation-examples-ap-northeast-1" },
      "ap-northeast-2" : { "Examples" : "https://s3-ap-northeast-2.amazonaws.com/cloudformation-examples-ap-northeast-2" },
      "ap-northeast-3" : { "Examples" : "https://s3-ap-northeast-3.amazonaws.com/cloudformation-examples-ap-northeast-3" },
      "ap-south-1"     : { "Examples" : "https://s3-ap-south-1.amazonaws.com/cloudformation-examples-ap-south-1" },
      "ap-southeast-1" : { "Examples" : "https://s3-ap-southeast-1.amazonaws.com/cloudformation-examples-ap-southeast-1" },
      "ap-southeast-2" : { "Examples" : "https://s3-ap-southeast-2.amazonaws.com/cloudformation-examples-ap-southeast-2" },
      "ca-central-1"   : { "Examples" : "https://s3-ca-central-1.amazonaws.com/cloudformation-examples-ca-central-1" },
      "cn-north-1"     : { "Examples" : "https://s3.cn-north-1.amazonaws.com.cn/cloudformation-examples-cn-north-1" },
      "cn-northwest-1" : { "Examples" : "https://s3.cn-northwest-1.amazonaws.com.cn/cloudformation-examples-cn-northwest-1" },
      "eu-central-1"   : { "Examples" : "https://s3-eu-central-1.amazonaws.com/cloudformation-examples-eu-central-1" },
      "eu-north-1"     : { "Examples" : "https://s3-eu-north-1.amazonaws.com/cloudformation-examples-eu-north-1" },
      "eu-west-1"      : { "Examples" : "https://s3-eu-west-1.amazonaws.com/cloudformation-examples-eu-west-1" },
      "eu-west-2"      : { "Examples" : "https://s3-eu-west-2.amazonaws.com/cloudformation-examples-eu-west-2" },
      "eu-west-3"      : { "Examples" : "https://s3-eu-west-3.amazonaws.com/cloudformation-examples-eu-west-3" },
      "me-south-1"     : { "Examples" : "https://s3-me-south-1.amazonaws.com/cloudformation-examples-me-south-1" },
      "sa-east-1"      : { "Examples" : "https://s3-sa-east-1.amazonaws.com/cloudformation-examples-sa-east-1" },
      "us-east-1"      : { "Examples" : "https://s3.amazonaws.com/cloudformation-examples-us-east-1" },
      "us-east-2"      : { "Examples" : "https://s3-us-east-2.amazonaws.com/cloudformation-examples-us-east-2" },
      "us-west-1"      : { "Examples" : "https://s3-us-west-1.amazonaws.com/cloudformation-examples-us-west-1" },
      "us-west-2"      : { "Examples" : "https://s3-us-west-2.amazonaws.com/cloudformation-examples-us-west-2" }
    }
,
    "AWSInstanceType2Arch" : {
      "t1.micro"    : { "Arch" : "HVM64"  },
      "t2.nano"     : { "Arch" : "HVM64"  },
      "t3.nano"     : { "Arch" : "HVM64"  },
      "t2.micro"    : { "Arch" : "HVM64"  },
      "t2.small"    : { "Arch" : "HVM64"  },
      "t2.medium"   : { "Arch" : "HVM64"  },
      "t2.large"    : { "Arch" : "HVM64"  },
      "m1.small"    : { "Arch" : "HVM64"  },
      "m1.medium"   : { "Arch" : "HVM64"  },
      "m1.large"    : { "Arch" : "HVM64"  },
      "m1.xlarge"   : { "Arch" : "HVM64"  },
      "m2.xlarge"   : { "Arch" : "HVM64"  },
      "m2.2xlarge"  : { "Arch" : "HVM64"  },
      "m2.4xlarge"  : { "Arch" : "HVM64"  },
      "m3.medium"   : { "Arch" : "HVM64"  },
      "m3.large"    : { "Arch" : "HVM64"  },
      "m3.xlarge"   : { "Arch" : "HVM64"  },
      "m3.2xlarge"  : { "Arch" : "HVM64"  },
      "m4.large"    : { "Arch" : "HVM64"  },
      "m4.xlarge"   : { "Arch" : "HVM64"  },
      "m4.2xlarge"  : { "Arch" : "HVM64"  },
      "m4.4xlarge"  : { "Arch" : "HVM64"  },
      "m4.10xlarge" : { "Arch" : "HVM64"  },
      "c1.medium"   : { "Arch" : "HVM64"  },
      "c1.xlarge"   : { "Arch" : "HVM64"  },
      "c3.large"    : { "Arch" : "HVM64"  },
  "c3.xlarge"   : { "Arch" : "HVM64"  },
  "c3.2xlarge"  : { "Arch" : "HVM64"  },
  "c3.4xlarge"  : { "Arch" : "HVM64"  },
  "c3.8xlarge"  : { "Arch" : "HVM64"  },
  "c4.large"    : { "Arch" : "HVM64"  },
  "c4.xlarge"   : { "Arch" : "HVM64"  },
  "c4.2xlarge"  : { "Arch" : "HVM64"  },
  "c4.4xlarge"  : { "Arch" : "HVM64"  },
  "c4.8xlarge"  : { "Arch" : "HVM64"  },
  "g2.2xlarge"  : { "Arch" : "HVMG2"  },
  "g2.8xlarge"  : { "Arch" : "HVMG2"  },
  "r3.large"    : { "Arch" : "HVM64"  },
  "r3.xlarge"   : { "Arch" : "HVM64"  },
  "r3.2xlarge"  : { "Arch" : "HVM64"  },
  "r3.4xlarge"  : { "Arch" : "HVM64"  },
  "r3.8xlarge"  : { "Arch" : "HVM64"  },
  "i2.xlarge"   : { "Arch" : "HVM64"  },
  "i2.2xlarge"  : { "Arch" : "HVM64"  },
  "i2.4xlarge"  : { "Arch" : "HVM64"  },
  "i2.8xlarge"  : { "Arch" : "HVM64"  },
  "d2.xlarge"   : { "Arch" : "HVM64"  },
  "d2.2xlarge"  : { "Arch" : "HVM64"  },
  "d2.4xlarge"  : { "Arch" : "HVM64"  },
  "d2.8xlarge"  : { "Arch" : "HVM64"  },
  "hi1.4xlarge" : { "Arch" : "HVM64"  },
  "hs1.8xlarge" : { "Arch" : "HVM64"  },
  "cr1.8xlarge" : { "Arch" : "HVM64"  },
  "cc2.8xlarge" : { "Arch" : "HVM64"  }
},

"AWSInstanceType2NATArch" : {
  "t1.micro"    : { "Arch" : "NATHVM64"  },
  "t2.nano"     : { "Arch" : "NATHVM64"  },
  "t2.micro"    : { "Arch" : "NATHVM64"  },
  "t2.small"    : { "Arch" : "NATHVM64"  },
  "t2.medium"   : { "Arch" : "NATHVM64"  },
  "t2.large"    : { "Arch" : "NATHVM64"  },
  "m1.small"    : { "Arch" : "NATHVM64"  },
  "m1.medium"   : { "Arch" : "NATHVM64"  },
  "m1.large"    : { "Arch" : "NATHVM64"  },
  "m1.xlarge"   : { "Arch" : "NATHVM64"  },
  "m2.xlarge"   : { "Arch" : "NATHVM64"  },
  "m2.2xlarge"  : { "Arch" : "NATHVM64"  },
  "m2.4xlarge"  : { "Arch" : "NATHVM64"  },
  "m3.medium"   : { "Arch" : "NATHVM64"  },
  "m3.large"    : { "Arch" : "NATHVM64"  },
  "m3.xlarge"   : { "Arch" : "NATHVM64"  },
  "m3.2xlarge"  : { "Arch" : "NATHVM64"  },
  "m4.large"    : { "Arch" : "NATHVM64"  },
  "m4.xlarge"   : { "Arch" : "NATHVM64"  },
  "m4.2xlarge"  : { "Arch" : "NATHVM64"  },
  "m4.4xlarge"  : { "Arch" : "NATHVM64"  },
  "m4.10xlarge" : { "Arch" : "NATHVM64"  },
  "c1.medium"   : { "Arch" : "NATHVM64"  },
  "c1.xlarge"   : { "Arch" : "NATHVM64"  },
  "c3.large"    : { "Arch" : "NATHVM64"  },
  "c3.xlarge"   : { "Arch" : "NATHVM64"  },
  "c3.2xlarge"  : { "Arch" : "NATHVM64"  },
  "c3.4xlarge"  : { "Arch" : "NATHVM64"  },
  "c3.8xlarge"  : { "Arch" : "NATHVM64"  },
  "c4.large"    : { "Arch" : "NATHVM64"  },
  "c4.xlarge"   : { "Arch" : "NATHVM64"  },
  "c4.2xlarge"  : { "Arch" : "NATHVM64"  },
  "c4.4xlarge"  : { "Arch" : "NATHVM64"  },
  "c4.8xlarge"  : { "Arch" : "NATHVM64"  },
      "g2.2xlarge"  : { "Arch" : "NATHVMG2"  },
      "g2.8xlarge"  : { "Arch" : "NATHVMG2"  },
      "r3.large"    : { "Arch" : "NATHVM64"  },
      "r3.xlarge"   : { "Arch" : "NATHVM64"  },
      "r3.2xlarge"  : { "Arch" : "NATHVM64"  },
      "r3.4xlarge"  : { "Arch" : "NATHVM64"  },
      "r3.8xlarge"  : { "Arch" : "NATHVM64"  },
      "i2.xlarge"   : { "Arch" : "NATHVM64"  },
      "i2.2xlarge"  : { "Arch" : "NATHVM64"  },
      "i2.4xlarge"  : { "Arch" : "NATHVM64"  },
      "i2.8xlarge"  : { "Arch" : "NATHVM64"  },
      "d2.xlarge"   : { "Arch" : "NATHVM64"  },
      "d2.2xlarge"  : { "Arch" : "NATHVM64"  },
      "d2.4xlarge"  : { "Arch" : "NATHVM64"  },
      "d2.8xlarge"  : { "Arch" : "NATHVM64"  },
      "hi1.4xlarge" : { "Arch" : "NATHVM64"  },
      "hs1.8xlarge" : { "Arch" : "NATHVM64"  },
      "cr1.8xlarge" : { "Arch" : "NATHVM64"  },
      "cc2.8xlarge" : { "Arch" : "NATHVM64"  }
    }
,
    "AWSRegionArch2AMI" : {
      "af-south-1"       : {"HVM64" : "ami-064cc455f8a1ef504", "HVMG2" : "NOT_SUPPORTED"},
      "ap-east-1"        : {"HVM64" : "ami-f85b1989", "HVMG2" : "NOT_SUPPORTED"},
      "ap-northeast-1"   : {"HVM64" : "ami-0b2c2a754d5b4da22", "HVMG2" : "ami-09d0e0e099ecabba2"},
      "ap-northeast-2"   : {"HVM64" : "ami-0493ab99920f410fc", "HVMG2" : "NOT_SUPPORTED"},
      "ap-northeast-3"   : {"HVM64" : "ami-01344f6f63a4decc1", "HVMG2" : "NOT_SUPPORTED"},
      "ap-south-1"       : {"HVM64" : "ami-03cfb5e1fb4fac428", "HVMG2" : "ami-0244c1d42815af84a"},
      "ap-southeast-1"   : {"HVM64" : "ami-0ba35dc9caf73d1c7", "HVMG2" : "ami-0e46ce0d6a87dc979"},
      "ap-southeast-2"   : {"HVM64" : "ami-0ae99b503e8694028", "HVMG2" : "ami-0c0ab057a101d8ff2"},
      "ca-central-1"     : {"HVM64" : "ami-0803e21a2ec22f953", "HVMG2" : "NOT_SUPPORTED"},
      "cn-north-1"       : {"HVM64" : "ami-07a3f215cc90c889c", "HVMG2" : "NOT_SUPPORTED"},
      "cn-northwest-1"   : {"HVM64" : "ami-0a3b3b10f714a0ff4", "HVMG2" : "NOT_SUPPORTED"},
      "eu-central-1"     : {"HVM64" : "ami-0474863011a7d1541", "HVMG2" : "ami-0aa1822e3eb913a11"},
      "eu-north-1"       : {"HVM64" : "ami-0de4b8910494dba0f", "HVMG2" : "ami-32d55b4c"},
      "eu-south-1"       : {"HVM64" : "ami-08427144fe9ebdef6", "HVMG2" : "NOT_SUPPORTED"},
      "eu-west-1"        : {"HVM64" : "ami-015232c01a82b847b", "HVMG2" : "ami-0d5299b1c6112c3c7"},
      "eu-west-2"        : {"HVM64" : "ami-0765d48d7e15beb93", "HVMG2" : "NOT_SUPPORTED"},
      "eu-west-3"        : {"HVM64" : "ami-0caf07637eda19d9c", "HVMG2" : "NOT_SUPPORTED"},
      "me-south-1"       : {"HVM64" : "ami-0744743d80915b497", "HVMG2" : "NOT_SUPPORTED"},
      "sa-east-1"        : {"HVM64" : "ami-0a52e8a6018e92bb0", "HVMG2" : "NOT_SUPPORTED"},
      "us-east-1"        : {"HVM64" : "ami-032930428bf1abbff", "HVMG2" : "ami-0aeb704d503081ea6"},
      "us-east-2"        : {"HVM64" : "ami-027cab9a7bf0155df", "HVMG2" : "NOT_SUPPORTED"},
      "us-west-1"        : {"HVM64" : "ami-088c153f74339f34c", "HVMG2" : "ami-0a7fc72dc0e51aa77"},
      "us-west-2"        : {"HVM64" : "ami-01fee56b22f308154", "HVMG2" : "ami-0fe84a5b4563d8f27"}
    }

  },

  "Resources" : {
    "VPC": {
      "Type": "AWS::EC2::VPC",
      "Properties": {
        "CidrBlock": "10.0.0.0/16",
        "EnableDnsHostnames": true
      }
    },
    "InternetGateway": {
      "Type": "AWS::EC2::InternetGateway"
    },
    "AttachGateway": {
      "Type": "AWS::EC2::VPCGatewayAttachment",
      "Properties": {
        "VpcId": { "Ref": "VPC" },
        "InternetGatewayId": { "Ref": "InternetGateway" }
      }
    },
    "PublicSubnetOne": {
      "Type": "AWS::EC2::Subnet",
      "Properties": {
        "VpcId": {"Ref": "VPC"},
        "CidrBlock": "10.0.0.0/24",
        "AvailabilityZone": {
          "Fn::Select": ["0", {"Fn::GetAZs": ""}]
        },
        "MapPublicIpOnLaunch": true
      }
    },
    "PublicSubnetTwo": {
      "Type": "AWS::EC2::Subnet",
      "Properties": {
        "VpcId": {"Ref": "VPC"},
        "CidrBlock": "10.0.1.0/24",
        "AvailabilityZone": {
          "Fn::Select": ["1", {"Fn::GetAZs": ""}]
        },
        "MapPublicIpOnLaunch": true
      }
    },
    "PublicRouteTable": {
      "Type": "AWS::EC2::RouteTable",
      "Properties": {
        "VpcId": {"Ref": "VPC"}
      }
    },
    "PublicRoute": {
      "Type": "AWS::EC2::Route",
      "Properties": {
        "RouteTableId": {"Ref":"PublicRouteTable"},
        "DestinationCidrBlock": "0.0.0.0/0",
        "GatewayId": {"Ref": "InternetGateway"}
      }
    },
    "PublicSubnetRouteTableAssociation1":{
      "Type": "AWS::EC2::SubnetRouteTableAssociation",
      "Properties": {
        "SubnetId": {"Ref": "PublicSubnetOne"},
        "RouteTableId": {"Ref": "PublicRouteTable"}
      }
    },
    "PublicSubnetRouteTableAssociation2":{
      "Type": "AWS::EC2::SubnetRouteTableAssociation",
      "Properties": {
        "SubnetId": {"Ref": "PublicSubnetTwo"},
        "RouteTableId": {"Ref": "PublicRouteTable"}
      }
    },
    "NatGateway": {
      "Type": "AWS::EC2::NatGateway",
      "DependsOn": "NatPublicIP",
      "Properties": {
        "SubnetId": {"Ref": "PublicSubnetOne"},
        "AllocationId": {"Fn::GetAtt": ["NatPublicIP", "AllocationId"]}
      }
    },
    "NatPublicIP": {
      "Type": "AWS::EC2::EIP",
      "DependsOn": "VPC",
      "Properties": {
        "Domain": "vpc"
      }
    },
    "NotificationTopic": {
      "Type": "AWS::SNS::Topic",
      "Properties": {
        "Subscription": [ { "Endpoint": { "Ref": "OperatorEMail" }, "Protocol": "email" } ]
      }
    },

    "WebServerGroup" : {
      "Type" : "AWS::AutoScaling::AutoScalingGroup",
      "Properties" : {
        "VPCZoneIdentifier" : [{"Ref": "PublicSubnetOne"}, {"Ref": "PublicSubnetTwo"}],
        "LaunchConfigurationName" : { "Ref" : "LaunchConfig" },
        "MinSize" : "1",
        "MaxSize" : "3",
        "TargetGroupARNs" : [ { "Ref" : "ALBTargetGroup" } ],
        "NotificationConfiguration" : {
          "TopicARN" : { "Ref" : "NotificationTopic" },
          "NotificationTypes" : [ "autoscaling:EC2_INSTANCE_LAUNCH",
                                  "autoscaling:EC2_INSTANCE_LAUNCH_ERROR",
                                  "autoscaling:EC2_INSTANCE_TERMINATE",
                                  "autoscaling:EC2_INSTANCE_TERMINATE_ERROR"]
        }
      },
      "CreationPolicy" : {
        "ResourceSignal" : {
          "Timeout" : "PT15M",
          "Count"   : "1"
        }
      },
      "UpdatePolicy": {
        "AutoScalingRollingUpdate": {
          "MinInstancesInService": "1",
          "MaxBatchSize": "1",
          "PauseTime" : "PT15M",
          "WaitOnResourceSignals": "true"
        }
      }
    },
    "LaunchConfig" : {
      "Type" : "AWS::AutoScaling::LaunchConfiguration",
      "Metadata" : {
        "Comment" : "Install a simple application",
        "AWS::CloudFormation::Init" : {
          "config" : {
            "packages" : {
              "yum" : {
                "httpd" : []
              }
            },

            "files" : {
              "/var/www/html/index.html" : {
                "content" : { "Fn::Join" : ["\n", [
                  "<img src=\"", {"Fn::FindInMap" : ["Region2Examples", {"Ref" : "AWS::Region"}, "Examples"]},
"/cloudformation_graphic.png\" alt=\"AWS CloudFormation Logo\"/>",
                  "<h1>Congratulations, you have successfully launched the AWS CloudFormation sample.</h1>"
                ]]},
                "mode"    : "000644",
                "owner"   : "root",
                "group"   : "root"
              },

              "/etc/cfn/cfn-hup.conf" : {
                "content" : { "Fn::Join" : ["", [
                  "[main]\n",
                  "stack=", { "Ref" : "AWS::StackId" }, "\n",
                  "region=", { "Ref" : "AWS::Region" }, "\n"
                ]]},
                "mode"    : "000400",
                "owner"   : "root",
                "group"   : "root"
              },

              "/etc/cfn/hooks.d/cfn-auto-reloader.conf" : {
                "content": { "Fn::Join" : ["", [
                  "[cfn-auto-reloader-hook]\n",
                  "triggers=post.update\n",
                  "path=Resources.LaunchConfig.Metadata.AWS::CloudFormation::Init\n",
                  "action=/opt/aws/bin/cfn-init -v ",
                  "         --stack ", { "Ref" : "AWS::StackName" },
                  "         --resource LaunchConfig ",
                  "         --region ", { "Ref" : "AWS::Region" }, "\n",
                  "runas=root\n"
                ]]},
                                "mode"    : "000400",
                                "owner"   : "root",
                "group"   : "root"
              }
            },

            "services" : {
              "sysvinit" : {
                "httpd"    : { "enabled" : "true", "ensureRunning" : "true" },
                "cfn-hup" : { "enabled" : "true", "ensureRunning" : "true",
                               "files" : ["/etc/cfn/cfn-hup.conf", "/etc/cfn/hooks.d/cfn-auto-reloader.conf"]}
              }
            }
          }
        }
      },
      "Properties" : {
        "KeyName" : { "Ref" : "KeyName" },
        "ImageId" : { "Fn::FindInMap" : [ "AWSRegionArch2AMI", { "Ref" : "AWS::Region" },
                                           { "Fn::FindInMap" : [ "AWSInstanceType2Arch", { "Ref" : "InstanceType" }, "Arch" ] } ] },
        "SecurityGroups" : [ { "Ref" : "InstanceSecurityGroup" } ],
        "InstanceType" : { "Ref" : "InstanceType" },
        "UserData"       : { "Fn::Base64" : { "Fn::Join" : ["", [
             "#!/bin/bash -xe\n",
             "yum update -y aws-cfn-bootstrap\n",

             "yum update -y aws-cli\n",

             "/opt/aws/bin/cfn-init -v ",
             "         --stack ", { "Ref" : "AWS::StackName" },
             "         --resource LaunchConfig ",
             "         --region ", { "Ref" : "AWS::Region" }, "\n",

             "/opt/aws/bin/cfn-signal -e $? ",
             "         --stack ", { "Ref" : "AWS::StackName" },
             "         --resource WebServerGroup ",
             "         --region ", { "Ref" : "AWS::Region" }, "\n"
        ]]}}
      }
    },

    "WebServerScaleUpPolicy" : {
      "Type" : "AWS::AutoScaling::ScalingPolicy",
      "Properties" : {
```

```
      "AdjustmentType" : "ChangeInCapacity",
      "AutoScalingGroupName" : { "Ref" : "WebServerGroup" },
      "Cooldown" : "60",
      "ScalingAdjustment" : "1"
    }
  },
  "WebServerScaleDownPolicy" : {
    "Type" : "AWS::AutoScaling::ScalingPolicy",
    "Properties" : {
      "AdjustmentType" : "ChangeInCapacity",
      "AutoScalingGroupName" : { "Ref" : "WebServerGroup" },
      "Cooldown" : "60",
      "ScalingAdjustment" : "-1"
    }
  },

  "CPUAlarmHigh": {
   "Type": "AWS::CloudWatch::Alarm",
   "Properties": {
      "AlarmDescription": "Scale-up if CPU > 90% for 10 minutes",
      "MetricName": "CPUUtilization",
      "Namespace": "AWS/EC2",
      "Statistic": "Average",
      "Period": "60",
      "EvaluationPeriods": "1",
      "Threshold": "50",
      "AlarmActions": [ { "Ref": "WebServerScaleUpPolicy" } ],
      "Dimensions": [
        {
          "Name": "AutoScalingGroupName",
          "Value": { "Ref": "WebServerGroup" }
        }
      ],
      "ComparisonOperator": "GreaterThanThreshold"
    }
  },
  "CPUAlarmLow": {
   "Type": "AWS::CloudWatch::Alarm",
   "Properties": {
      "AlarmDescription": "Scale-down if CPU < 70% for 10 minutes",
      "MetricName": "CPUUtilization",
      "Namespace": "AWS/EC2",
      "Statistic": "Average",
      "Period": "60",
      "EvaluationPeriods": "1",
      "Threshold": "20",
      "AlarmActions": [ { "Ref": "WebServerScaleDownPolicy" } ],
      "Dimensions": [
        {
          "Name": "AutoScalingGroupName",
          "Value": { "Ref": "WebServerGroup" }
        }
      ],
      "ComparisonOperator": "LessThanThreshold"
    }
  },

  "ApplicationLoadBalancer" : {
    "Type" : "AWS::ElasticLoadBalancingV2::LoadBalancer",
    "Properties" : {
      "Subnets" : [{"Ref": "PublicSubnetOne"}, {"Ref": "PublicSubnetTwo"}],
      "SecurityGroups": [{"Ref": "InstanceSecurityGroup"}]
    }
  },
  "ALBListener" : {
   "Type" : "AWS::ElasticLoadBalancingV2::Listener",
   "Properties" : {
    "DefaultActions" : [{
     "Type" : "forward",
     "TargetGroupArn" : { "Ref" : "ALBTargetGroup" }
    }],
    "LoadBalancerArn" : { "Ref" : "ApplicationLoadBalancer" },
    "Port" : "80",
    "Protocol" : "HTTP"
   }
  },

  "ALBTargetGroup" : {
   "Type" : "AWS::ElasticLoadBalancingV2::TargetGroup",
   "Properties" : {
    "HealthCheckIntervalSeconds" : 30,
    "HealthCheckTimeoutSeconds" : 5,
    "HealthyThresholdCount" : 3,
    "Port" : 80,
    "Protocol" : "HTTP",
    "UnhealthyThresholdCount" : 5,
    "VpcId" : {"Ref" : "VPC"}
   }
  },

  "InstanceSecurityGroup" : {
   "Type" : "AWS::EC2::SecurityGroup",
   "Properties" : {
    "GroupDescription" : "Enable SSH access and HTTP from the load balancer only",
    "SecurityGroupIngress" : [ {
     "IpProtocol" : "tcp",
     "FromPort" : "22",
     "ToPort" : "22",
     "CidrIp" : { "Ref" : "SSHLocation"}
    },
    {
     "IpProtocol" : "tcp",
     "FromPort" : "80",
     "ToPort" : "80",
     "CidrIp" : { "Ref" : "SSHLocation"}
    } ],
    "VpcId" : { "Ref" : "VPC" }
   }
  }
 },

 "Outputs" : {
  "URL" : {
   "Description" : "The URL of the website",
   "Value" :  { "Fn::Join" : [ "", [ "http://", { "Fn::GetAtt" : [
     "ApplicationLoadBalancer", "DNSName" ]}]]}
  }
 }
}
```

Skrypt ułatwiający wdrożenie (deploy-stack.cf.json)

```
#!/bin/bash

CLI_PROFILE=default
```

```
STACK_NAME=rownolegle
REGION=eu-central-1
EC2_INSTANCE_TYPE=t3.nano #cheapest i think
OPERATOR_EMAIL=atagisow@protonmail.com
KEY_NAME=rownolegle

echo -e "\n==Deploying stack.cf.json===\n"
aws cloudformation deploy \
  --region $REGION \
  --profile $CLI_PROFILE \
  --stack-name $STACK_NAME \
  --template-file stack.cf.json \
  --no-fail-on-empty-changeset \
  --capabilities CAPABILITY_NAMED_IAM \
  --parameter-overrides \
    InstanceType=$EC2_INSTANCE_TYPE \
    OperatorEMail=$OPERATOR_EMAIL \
    KeyName=$KEY_NAME
```