University of Warsaw
Faculty of Mathematics, Informatics and Mechanics

Piotr Styczyński
Student no. 386038

Michał Balcerzak
Student no. 385130

Michał Ołtarzewski
Student no. 382783

Gor Safaryan
Student no. 381501

AWS Cost Optimization Tool

Bachelor's thesis
in COMPUTER SCIENCE

Supervisor:
dr Janina Mincer-Daszkiewicz
Instytut Informatyki

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Supervisor's statement

Hereby I confirm that the presented thesis was prepared under my supervision and that it fulfils the requirements for the degree of Bachelor of Computer Science.

Date Supervisor's signature

Authors' statements

Hereby I declare that the presented thesis was prepared by me and none of its contents was obtained by means that are against the law.

The thesis has never before been a subject of any procedure of obtaining an academic degree.

Moreover, I declare that the present version of the thesis is identical to the attached electronic version.

Date Authors' signatures

Abstract

Authors describe the design and implementation process, in-depth system and code architecture as well as used communication protocols, storing methods and other internals of the AWS Cost Optimization System.

Keywords

AWS, Amazon Web Services, cloud computing, cost optimization, cost management

Thesis domain (Socrates-Erasmus subject area codes)

11.3 Informatics, Computer Science

Subject classification

D. Software

Tytuł pracy w języku polskim

Narzędzie do optymalizacji kosztów na platformie AWS

Contents

Chapter 1

Introduction

1.1. Overview

Cloud computing has become recently one of the most important paradigm shifts in the area of real world software engineering. It has reshaped the whole process of how applications are developed and reduced the amount of upfront investment required to start an internet business. While commercial cloud computing services were first offered in 2006 by Amazon Inc, the original idea and preliminary implementation traces back to Multics OS developed by MIT, GE and Bell Labs. However the idea of time-sharing systems that was the ancestor of a cloud concept was widespread in 60ies [**Markus**].

The term "Cloud computing" can refer to every layer of application stack: hardware, hosting platform, software and even to a single function. Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide these services. The services themselves have long been referred to as Software as a Service (SaaS) [**Armbrust**]. Generally speaking cloud can be perceived as a shared pool of computer resources such as computing capacity, transient and persistent memory, which can be acquired or released on demand. The undisputed power of cloud computing constitutes in its elasticity and granularity: it allows users to ask for hundreds of computers for only 5 minute usage which are shipped during several minutes. Such services are usually offered over remote network connection and users are billed for the portion of the resources they have used. Depending on the cloud infrastructure type the payment models can be different [**Laatikainen**], but the common spendings are associated with data storage, data transfer, and computing timeshare.

Nowadays the industry increasingly relies on cloud technologies. More and more companies start or move their products to cloud environment. Unfortunately it comes with additional financial costs imposed by cloud providers. In order to make business profitable, companies try to reduce amont of money they are supposed to pay to the minimum. Despite different solutions, like employing specific cloud cost optimization team, more and more firms decide to benefit from dedicated software, which is supposed to help manage and optimize their cloud usage. It is not easy to choose the right tool having that many choices.

There are some notable solutions of AWS cloud optimization problem – *AWS Cost Explorer* and *AWS Cost Management*, *Cloudability*, *Apptio* and others widely used nowadays. In spite of that fact there is still place for new tools targeting omitted types of clients or wrapping and bundling the greatest features from exisiting ones.

1.2. Aim of the thesis

The primary objective of the thesis is to create a tool complementing existing solutions used in cloud cost optimisation. We focus on Amazon Web Services platform maintained by Amazon as it is one of the most commonly used. In our tool, called *Omigost*, we will try to target small/middle sized companies creating simple and easy to use software with flexible configuration options.

1.3. Structure of the thesis

The thesis is structured as follows. In Chapter 2 we describe the problem of cloud cost optimization with additional description of selected existing solutions. In Chapter 3 we write about our development process – the tools and techniques we used to efficiently communicate and coordinate with people involved in the project and successfully deliver the product. Then, in Chapter 4 we present our solution in detail. We mention, among others, whole system architecture, API and configuration. Finally, in Chapter 5 we sum up the whole thesis. In Appendix A we describe how to introduce our solution in a company.

1.4. Contribution of each author

It is important to mention that each author worked to some extent on every part of the thesis. However authors contributed mainly to the following parts:

- Michał Ołtarzewski
  - Software development process management
  - Design of backend architecture
  - Implementation of Slack API connection
  - Backend part implementation
- Michał Balcerzak
  - Research of existing solutions
  - Design of backend architecture
  - Implementation of budget overflow notifications
  - Backend part implementation
- Piotr Styczyński
  - Design and prototype of a visual part of the tool
  - Localstack integration
  - AWS deployment automation
  - Frontend part implementation
- Gor Safaryan
  - Research of AWS APIs and SDKs
  - Design of backend architecture
  - Implementation of machine termination flow
  - Backend part implementation

Chapter 2

Problem statement

2.1. Motivation

As there are plenty of various billing models for cloud services [**Laatikainen**], the effective management of them became a tough problem. The ease of resource allocation led to situation when tracking tiniest details of billings is an unaffordable challenge.

However, according to our client, some businesses they are in contact with (as well as theirs) reported a demand for a tool that would provide budgeting management and basic machine termination automation. Such tool may not cover as many use cases as the tools available on the market, but it would allow for huge savings while also being simple in implementation and maintenance. The tooling that exists is targetting wideworld-scale companies that are able to require expensive licenses and hire cost-optimization teams.

This is a demand in the small-to-medium business market that our solution, *Omigost*, attempts to cover. Having one versatile tool removes the need for using few detached pieces of software. The most important aspects of our tool are intuitive interface and different types of user notifications, which highly increase spendings clarity and help in decisions related to costs cutting. We hope it will allow companies to focus more on providing value to their clients and having significantly lower costs in the same time without having to spend resources on extensive toolkit for cost optimization. This should be possible to achieve with budget and machine termination solutions that are very simple in concept and implementation, but provide great savings.

During the designing process of Omigost, we decided to dedicate our focus on providing a solution with the following features:

- Free and Open Source
- Easy cloud management without complex knowledge
- Intuitive interface for individual workers to request resources
- Notifications for cost surpassing and redundant resources
- Proper notification management – only significant alerts
- Integration with communication via Slack

2.2. Overview of exisiting solutions

Businesses that rely upon cloud services often reach a point where resources they are using up gradually become less and less manageable. As the problem is well known to the cloud market, both Amazon and other third-party companies made attempts to fulfill these needs by creating custom software implementing various AWS expense optimization approaches that include:

1. Budget limit configuration, alerting users when those are exceeded
2. Instance alerting management
3. Cost analytics

Some of the most prominent tools currently available on the market that improve resource management experience for AWS cloud are described in the following sections. Every description is supposed to show key features crucial for cost optimization.

2.2.1. AWS Budgets

AWS Budgets [**AWSDocs**] is a part of Amazon Web Services that allows to limit how many resources of a certain type are used on AWS throughout a selected period of time (i.e. every month). AWS enables their users to specify the scope of such a budget in detail. For example, one may make a budget only consider costs of those machines that are either tagged in a specific way or are owned by a certain group of accounts.

When a limit is either exceeded, close to be exceeded or is forecasted to exceed the configured threshold before the end of that period, a preconfigured action takes place. For such an occasion, the administrator can either choose to have email notifications sent out to a list of addresses or have Amazon's Simple Notification System (SNS) triggered. SNS provides the AWS users a way to implement custom notification flows.

Types of resources one can put this kind of a budget on include:

1. Money spent in total or on a certain type of machines
2. Utilisation of selected services
3. Utilisation or coverage of reserved instances

2.2.2. AWS Cost Explorer and AWS Cost Management

AWS Cost Explorer [**CostExplorer**] enables access to all budget data. User can define and generate custom reports in a form of a data chart spanning a selected time interval with chosen time granularity of the samples. AWS Cost Explorer is also a basis for AWS Cost Management, which is basically a set of predefined reports that form an easily accessible dashboard.

2.2.3. Cloudability

Atlassian's Cloudability [**Cloudability**] delivers a budget system functionality analogous to AWS Budgets along with tools for predicting future spendings and presenting the real cost of AWS resources in utilisation. In comparison to Amazon's native tools, Cloudability also allows management of multiple accounts in the same time. It saves effort of having to set up budgets separately in every owned account.

2.2.4. Apptio

Apptio [**Apptio**] provides a set of tools that mainly focuses on analysis of expenses and their forecasts, managing them collaboratively and planning future ones. They expose features that make it easier to discover underutilized resource, compare spendings with a database of similar benchmarks, organize resources into groups to make reports even clearer, and offer other useful management utilities.

2.2.5. Stax.io

Stax.io's [**Stax.io**] main focus is to provide insight about cost, wastage, compliance and cloud quality. It can analyse how cloud resources are used, measure quality of the way cloud is utilized, set up checks for business-compliance of a cloud with several standards and give customized advice on what could be optimized to reduce wastage, while also allowing for creation of custom views of data. Basic tools for budgeting instances, accounts, tags and more, monthly or annually, and configuring overspend alerts are also available there.

2.2.6. SnowSoftware

SnowSoftware's toolset, alongside fulfilling some of the more specific usecases like optimizing usage of software from SAP Software Solutions or optimizing and managing software licenses, also has tools that are dedicated to optimizing cloud costs.

Snow for SaaS attempts to give a holistic view about application usage including, among others, how SaaS applications are used on cloud and whether there are zombie virtual machines [**SnowSaaS**].

Snow Automation Platform suggests approach based on automated and preconfigured provision of resources. By pre-giving those resources a decommission date one can avoid issue of zombie instances. It is also possible to preconfigure budgets and schedule machine starts and stops to further optimize costs [**SnowBlog**].

2.3. Conclusions

After a lecture and research of those resources publicly available on the Internet that describe above-mentioned AWS optimization solutions, we concluded that many of the competing tools available on the market don't target simpler usecases that could cover needs of multiple small-to-medium businesses that rely on AWS cloud, but often rather focus on delivering multifaceted and highly configurable systems. These tools also often require costly subscriptions and time spent on maintaining the configuration.

Our research failed to find a tool that would fill this demand. Many of them fail to provide both instance budgeting and machine termination automation. A number of them also put most of their emphasis on analysing usage data rather than helping with instance management.

According to our research, from tools listed in section 2.2, Snow Automation Platform is the only system that features both budgeting and automating machine termination and stopping. However, it's approach is not to straightforwardly manage already existing machines, but rather to automate their provisioning.

Cloudability [**CloudabilityAlerts**] offers simple alerts, but they lack Slack (team collaboration toolkit, communication service) support and beforementioned propagation abilities.

In some cases the software, as it is in case of Cloudability, is too complex for an average user and does not provide an easy way to incorporate custom business flows into the tool.

Amazon, as one of the leading cloud providers, offers different tools for exploration of expenses. Most commonly used options are either their public APIs [**AWSCostManagement**] or specific SDKs supporting lots of languages. Unfortuantely those tools are rather simple and do not satisfy all of the needs of potential clients.

2.4. Our solution

Omigost is an app that focuses on two main features:

1. easily manageable AWS Budgets
2. automatic machine termination

as well as uses Slack integration as a convenient and not overly intrusive mean of providing employees a simplified way of saving company's money in their day-to-day work.

TODO a little more of the overview of the app and its business cases

TODO idea - how about moving this to beginning of Chapter 4 (new section), then swapping Chapters 3 and 4?

Chapter 3

Project development

In this section we describe the way we developed the application – management and organization of work along with supporting tools.

3.1. Version control

During development as our version control system we use Git and whole code repository is hosted on GitHub. We have chosen this particular service because of a few reasons.

First of all GitHub [**GitHub**] is one of the most popular Git hosting services and also has one of the largest open source communities. This is quite important, especially when considering a possibility of future development of the tool after finishing this thesis.

The second reason is integration with lots of useful applications. It is easy to use it with different services that improve the development process like TravisCI [**TravisCI**] and Slack [**Slack**].

Last but not least, GitHub has a built in issue tracker. It can be highly customised and makes project management easier. We created dashboard divided into a few sections, which separate tasks in different stages of development. Everything is automated – depending on actions performed by users like merging Pull Requests (PRs), issues are moved between sections. In order to help prioritize tasks we employed GitHub's issue tagging system.

3.2. Continuous Integration

For Continuous Integration we use hosted service – TravisCI. It allows us to make sure new changes we introduce are compliant with the rest of our codebase. There are two reasons we have chosen this service: it is easy to configure using only one YAML file inside repository and it is free for open source projects. After every code submission, at the beginning TravisCI performs Smoke Tests trying to build the project and check whether it runs or not. Successful build is followed by both backend and frontend tests.

3.3. Communication

All of the communication happens via Slack. It is a convenient collaboration platform allowing team members to communicate efficiently. Everybody can create their own instance of a Slack workspace and then invite other members to join and use it. Various channels can be created there, with persistent message history both public and private. There is also possibility to

reach out to any member directly whenever needed. Today Slack is one of the most popular options for groups of any kind to coordinate their teamwork on a daily basis. We use Slack because it is free, it integrates easily with GitHub and it allows us to test Omigost integration with Slack.

3.4. Organization of work

We work in iterations that last around one month. At the beginning we define and create new issues. During the iteration everyone chooses desirable task, completes it and makes corresponding Pull Request in GitHub. At the end we discuss our overall progress and plan next steps.

In order to let a new feature become part of the repository it has to be accepted. It means that Pull Request has to pass Continuous Integration system build and be approved by one of the reviewers. Every issue is solved in a separate branch and every PR is merged directly to the master branch, which allows us to group all commits that are part of one feature or issue.

3.5. Contact with the client company – Sumo Logic

The whole project and the thesis are developed under Sumo Logic mentorship. There is one particular person designated to act as mentor – Jacek Migdał. He makes sure we are provided with every resource we need to work on the project without unnecessary breaks. Also our mentor helps revolve any ambiguity and gives technical advice.

Day to day communication with mentor takes place via Slack. Additionally approximately twice a month our team meets in Sumo Logic office to review current progress and overcome major difficulties. Every new feature is discussed beforehand with the company.

Chapter 4

Tool for AWS cost optimization

In this chapter we will describe the whole application – *Omigost*.

4.1. Use cases

In this section you can find descriptions of the most common use cases grouped by actors. Every use case assumes company is already preconfigured in AWS Organizations.

4.1.1. Actor – AWS cost optimization admin

Admin is a person designed to have an access to AWS Cost Optimization platform. Most of the interactions happen throught application website.

First of all admin can configure users inside the application. There are following possible actions using configuration tab:

1. Adding employee
2. Adding contact to employee (currently only Slack)
3. Linking account to specific employee
4. Defining timeframe for machines termination suggestions

It is important to mention that most of the similar actions like editing and deleting are possible.

Despite configuration admin can have insight into AWS costs looking at dashboards with charts. It is also possible to customize charts to show only subset of costs.

4.1.2. Actor – Employee

An ordinary employee does not have access to the platform itself. Most of the interactions happen through Slack. There are a few situations when a user can receive Slack message from an application bot:

1. Surpassing a budget
2. Budget is forecasted to being surpassed
3. Machine on AWS works in specific timeframe

If any of the budgets linked to the employee's accounts are surpassed, the employee will receive notification. Additionally, if a budget has a machine tag filter configured, account owners of those machines that surpass that budget will be notified.

Messages sent by the bot are rather simple. They consist of the title, a button and description that includes information about a triggered budget. Clicking the button redirects to a dedicated form website on our frontend which allows the employee to request more money from the manager.

We can imagine example scenario:

1. A budget is being surpassed
2. The employee receives message from the bot on Slack
3. The employee analyzes the description
4. The employee decides to request more money and clicks the button
5. The employee is redirected to the request form website
6. The employee completes and submits the request form

The situation with machine termination is very similar. If a machine linked to the account owned by the employee is found to be running in defined timeframe, a notification will be triggered. The message body contains machine description, a stop button and a termination button. By clicking one of those buttons the user can conveniently stop or terminate the corresponding machine without having to enter AWS' dedicated interface for that purpose.

4.2. Overall architecture

Our solution is based on an architecture that is visualized on Figure 4.1

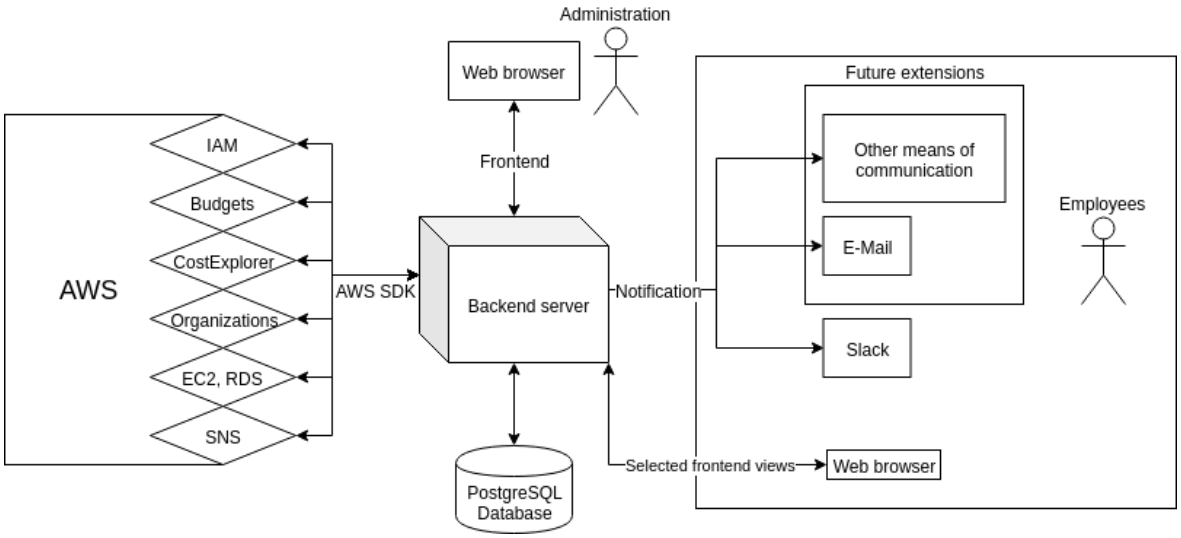

Figure 4.1: Draft diagram of the tool architecture

The architecture of our tool can be described as a traditional client-server architecture. Actors make requests over the HTTP protocol to the system with a web browser using the

frontend client application served by the Omigost server or, alternatively, from any kind of a storage service like, for example, Amazon's S3. Those requests are then handled by a backend application running on a central server machine. During the handling process our application uses both a local instance of a PostgreSQL relational database and a connection with selected Amazon Web Services via a SDK library. Additionally, end users are notified about budget or instance events related to their cloud activity through Slack.

4.2.1. Role of AWS cloud services

Connecting with Amazon's cloud services not only allows the application to access machines and spending data, but many of them also solve many of the problems we would otherwise have to solve ourselves – resulting in time saved and a codebase that is more concise and easier to maintain.

Services that are used in the project and their respective roles in it are as follows:

- Identity and Access Management (IAM) – provision of the main Amazon account ID that is used in other services
- Organizations – insight into structure of the Organization used by the company, including listing accounts
- Budgets – service keeping eye on spendings that triggers a SNS notification whenever a budget limit is or is going to be exceeded
- SNS – alert notifications for backend that let it know about spendings events
- Cost Explorer – data for graph visualizing spendings in frontend
- EC2/RDS – information about state of instances running on the account

TODO at the end of the project – check if any other "sublibraries" were used and/or if any other use cases emerged

4.2.2. Backend

Backend is the main agent of our application's functionalities. It is responsible for fetching or receiving data from either of other connected resources, parsing it and taking appropriate actions. Some of its more important tasks include:

- receiving SNS budget alert notifications and notifying appropriate users via Slack,
  - providing single use tokens and links for non-admin users to be able to request budget limit increases,
- fetching and providing raw data for the frontend so it can be displayed to the user,
- receiving configuration or data modification requests and adjusting the application environment components to fulfill them,
- checking machine state on preconfigured times and notifying users about possible instance optimizations.

4.2.3. Frontend

Frontend is a web application that allows the user to see and alter the state of the application using a graphical user interface (GUI). Its main roles are to:

- request and parse raw data from backend into visual representations of it,
- provide an interface for the user,
- translate the interface clicks to appropriate backend requests and display the results of these requests.

4.3. Technology stack

4.3.1. Frontend

Frontend was written in Typescript [**Typescript**] using React [**React**] framework. Typescript offers both great flexibility and type safety compared to vanilla Javascript. It is the most common alternative to Javascript, supported by large bussiness insitutions like Microsoft. We decided that other alternatives, i.e Reason (or other functional languages compiled to Javascript) or Dart are useful, but still need development and their interoperability is sometimes very limiting factor. All the codebase is lintend using *tslinter*.

Typescript code is transpiled using *tsc* and bundled by *webpack*. We do not use any other build tools like *Grunt* or *Gulp* as the backend has its own tooling, i.e Gradle. It would just unnecessarly compilicate building process without any gains. Frontend build is coordinated by npm plugin for Gradle.

Frontend codebase is split between universal, reusable components and concrete implementation of user views. That design decision was an effect of following general good programming guidelines. It enables future application contributors and users to effectively implement customizations or modification in existing code without unnecessarly big work efforts. The views are split between various *modules*. A module is a standalone entity that provides its own button in the sidemenu of application. For increased customizability and modularity each of them can be separately disabled or modified. To synchronize the data between separate modules we decided to use *Redux* with its Flux architecture. That allows us to easily persist the application state in the local storage of the browser or elsewhere. Redux store is a central storage for information about current modules settings but also serves views routing data, states of dialogs and notifications.

We also provided *Jest* test suites as well as documentation generated by *tsdoc*. We also decided to utilize *Storybook* to easily design and visually test frontend components, which for users stands for a complement rather than an alternative for Jest and the documentation.

4.3.2. Backend

Core of the backend is *Java 8*. We have selected this programming language because most of us were familiar with it. Also this language has huge community and lots of useful libraries and frameworks.

For creation of the whole backend service we have chosen Spring [**Spring**] framework. It is currently one of the most common choices. Spring allows to build web applications imposing usage of design patterns like Model-View-Controller and Dependency Injection. It helps to keep code easily testable and well organized. Additionally it provides various features out of the box, which speeds up development process.

Gradle [**Gradle**] is responsible for build and dependencies management. It is easy to use with various IDEs and has flexible configuration. The main competitor of Gradle is Maven so obviously we considered both. Gradle turned out to be better in terms of performance and usage convenience.

For data persistence we have chosen PostgreSQL database. Relational database enforces having strictly defined data model with validation. Performance is not an important aspect for us so there was no need for other types of databases. PostgreSQL is a great open source database with strong data integrity and fault-tolerance guaranties. Furthermore, AWS allows setting up PostgreSQL instance with just a few clicks with parameters automatically configured for optimal performance.

In our application we use the following libraries:

1. Spring Core, Spring Boot, Spring Data, Spring Web,
2. Project Lombok,
3. JUnit,
4. AWS SDKs.

4.3.3. Deployment

The whole tool is bundled up by Docker. Following a straightforward instruction everyone is able to create their own Docker image of the application. Moreover, all of the configuration is present in one file making it easy to adapt it your way.

A preferable method of deployment is to use AWS Elastic Beanstalk with Docker image. In such a way AWS will be responsible for almost everything including capacity provisioning, load balancing and auto-scaling.

4.4. Communication integration

The application is designed for two groups of users: the employees and the administrators. While the frontend interface we describe in chapter 4.3.1 is created mainly for the usage of administrators, interaction between the system and the employees is mostly taken care via Slack.

Slack apps offer many customization and extension options, but to cover needs of Omigost users we mainly relied on a bot feature.

4.4.1. Setup and configuration

Basically, to be able to use Omigost with Slack, first of all the administrator has to install an Omigost Slack app, choosing from a range of other apps available on Slack's app page. Alternatively, it is possible to set up the app on one's own in a Slack collaboration workspace. As a result an Omigost bot capable of messaging users is added to the workspace. The administrator is then also provided with an API token that can be entered in the main Omigost server configuration for it to be able to connect with that bot. The administrator should then provide Slack usernames in attached workspace for each user in a dedicated configuration panel. He also configures who among those users should be considered an administrator so the system can also notify him.

4.4.2. Messaging details

The integration itself is made possible thanks to the REST API that Slack exposes for each instance of our Slack app. Every time our app needs to message a user, it issues HTTP calls that specify the message content, potential attachments and destination.

To allow interactions with the system, messages issued by Omigost can contain either links or actions. We use links to route users to forms that they can fulfill to provide additional info to the system. The forms use short-lived, single-use generated tokens for identifying correlation between form payload and an event that this payload responds to.

4.4.3. Slack message use cases

The Slack bot sends notification to the users when they cross a predefined budget or leave instances running after the business hours.

Budget notification flow is as follows: on an event of the system detecting either forecasting or detecting a budget overflow, the system collects a list of users responsible for machines that are related to that budget. To each of those users we send a message that contains actual or potential budget overflow details as well as a button link to a form where that user can request an increase to the budget limit. Responding via such a form results in the system notifying administrators about a new limit increase request so they can then decide whether to comply with the request, and then act accordingly.

Machine termination is suggested to users with messages when bussiness hours of a day are nearing to an end. The messages tell the user how many machines are running at the moment and provides a set of actions that enable the user to conveniently stop or terminate them. After a successful teardown the user is also notified with a "Done!" message.

The implementation of the machine termination communication has certain subtleties. Comparing to budget messages, the application doesn't keep track of messages related to machine termination, but only tracks the timestamps of the last time a person was notified via any channel. This allows us to limit the number of notifications and not spam the user.

As the communication is asynchronous between application and the end user, we do not rely on immediate response. Instead, we bundle the message with the encrypted user AWS id and the timestamp of the notification. We also keep the encryption keys in the databases for the other instances of the application to be able to handle any request. The key-timestamp pairs help us identify the user, implement action timeout and make sure that nobody from outside can stop the application on behalf of the users. Such architecture helps us keep the application stateless and increases the overall security of the system.

4.5. Service termination architecture

While developing the application, we kept a certain model of organization of resources in mind, which the enterprise user might have in the AWS cloud. A common way of keeping an organization in AWS cloud is via service called "AWS Organizations" [**AWSOrganizations**]. The service allows to allocate AWS accounts with the predefined roles and permissions for every member of organization. Such structure also isolates resources from each other and lowers the granular control that the root account has on user allocated resources.

For our application to be able to tweak and monitor every machine created by the organization members, every employee of the organization needs to create a certain predefined role which should have the same name across all accounts. The role should have access to

all resources that the user wants to be monitored. This can be done by a simple script every time a new member joins to the organization.

Secondly the account, from which the application will be deployed, needs to create an AWS IAM user [**AWSIAM**], which will be used by the application to assume the roles created by other members of the organization. To enable the functionality, the administrator needs to give "AssumeRole" permission to the newly created IAM user.

We recommended to take the following steps to grant the above mentioned permission.

1. Create an IAM group called "AssumesRolesGroup".
2. Go to the permissions section of the group.
3. Create a custom group policy.
4. Add the following "JSON" to the policy document.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "sts:AssumeRole"
      ],
      "Resource": "*"
    }
  ]
}
```

5. Add the IAM user to the "AssumesRoleGroup" group.

After taking all those steps, you just need to copy the AWS keys of that IAM user account to the application configuration file and you are good to go.

Chapter 5

Summary

The purpose of the project was to implement a solution for optimizing cloud costs in a typical medium-sized company according to needs reported by Sumologic. From two approaches that were suggested by the ordering party, we chose one that was more software-focused rather than analytic.

Development spanned a period of about a half of a year and planning and preparations took us a few more months. We developed our application in irregular iterations that each of us adjusted to their schedule. Additionally, we held meetings with our supervisor roughly every 2-3 weeks as well as with the contractor when we needed to consult development and requirement details. The company expressed a huge interest in the implementation of the project as well as further development of it.

(<TODO>)In the late stage of the development phase our system was tested by a sample group of employees at Sumologic, who provided us with an additional feedback that allowed us to further improve the product.(</TODO>)

In the end we built a system focusing on simplifying AWS Budgets management and machine termination automation, both of which benefit heavily from a Slack integration.

The product is a web application consisting of Java Spring server and Typescript browser frontend. The solution is deployed along a Postgres relational database with a Docker container on a Beanstalk instance. The project is fully open-source, released under MIT license and available on GitHub.

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