K8s Checkmate

Design Document

Team 58
Workiva
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Executive Summary

Development Standards & Practices Used

No hardware, purely software

Agile

Modular code

Clean code

Well documented code

Summary of Requirements

Runs in CLI

Parses Helm charts

Creates policies based on rules provided in templates

checks configs of helm charts and alerts if they fail

Applicable Courses from Iowa State University Curriculum

SE 309 - Working as a team with the Agile work process

SE 363 - Used Docker after the provided virtual machines were not working.

SE 311 - Working with data structures and developing the most efficient algorithms

As far as for the tools that we are using for this project, there are no classes that are teaching Go or Docker skills. For the classes that we did use these tools in, it was only because we were interested in learning and the learning was self guided.

New Skills/Knowledge acquired that was not taught in courses

Configuration with Kubernetes

Parsing Files with Security Checks

Experience with Go Programming Language

Communicating to an Advisor of our group’s progress

Communicating to an Advisor with team management

Manipulation of Helm Charts

Knowledge of Python in General

Helm configuration

Docker usage

Table of Contents

List of figures/tables/symbols/definitions (This should be similar to the project plan)

1 Introduction

1.1 Acknowledgment

Julie Rursch - Group Advisor

Eric Anders - Workiva

Thank you for your contributions!

1.2 Problem and Project Statement

There does not exist a tool that checks the configuration of helm charts nor the configurations produced by them. Linters and syntax checkers exist, however, they only check that the helm charts are formatted correctly. They do not check that clusters comply with predefined rule sets.

By creating an extensible framework we hope to provide a well documented, highly extensible, useful tool that prevents a lot of security issues that can exist when using kubernetes. Often the setup of these services is done without enough thought put into the security of the company. Our project will allow companies to be more confident about the security and the correct initialization of their clustered computing setups.

There is nothing out there that exists on what we are trying to accomplish. Our drive is not only to give the open-source community this tool but also be the first people to craft a tool like this. Since this project will be open source it will also service its users better because of the potential for future community development.

1.3 Operational Environment

The end product will run in a Command Line Interface, and will not be exposed to unusually hazardous conditions. This is solely software-based, so there will be no expectations physically for the product. However, we do expect the end product to be able to run on Linux and MacOS.

1.4 Requirements

Functional requirements

- System should parse and check Kubernetes configuration files
- System should parse and check helm charts
- Command-line interface should allow for easy interaction with the system
- System should alert the user of potential security vulnerabilities
- System should suggest how to fix potential security vulnerabilities

Economic requirements

Since the project is almost entirely software, there are very few economic requirements. There is no hardware that needs to be purchased or licenses that need to be paid for since the project will be entirely open-source.

Environmental requirements

Again, since the project is almost entirely software-bound, the physical environment has no effect on it. There is no hardware that could be exposed to the elements or poor weather. In terms of the computer architecture environment, the project should be able to run on macOS and *NIX systems.

UI requirements

To keep the program lightweight and portable, the UI will not consist of a GUI, but rather a command-line interface. This is plenty sufficient for usability and fulfilling the intended use cases.

1.5 Intended Users and Uses

The intended user is the person conducting a security review for a Kubernetes project.

The intended use is to streamline and reduce user error in the process of checking security configurations against a defined ruleset.

1.6 Assumptions and Limitations

Assumptions

We assume that the user will have a basic knowledge of Kubernetes security configurations.

We assume that the user will have a basic knowledge of security with files in general

These assumptions are made because the intended user is for someone who wants to perform security checks with Kubernetes. Someone who doesn't have this previous knowledge probably wouldn't be using this then.

Limitations

The end product will be lightweight and run in a CLI.

We expect the end product to be able to run Linux and macOS.

We expect the end product to be able to effectively perform a security review.

It will not add functionality to kubernetes, but to the initialization and setup.

The product will need to be sought after in order to be found as it is not a commercial product.

1.7 Expected End Product and Deliverables

The end product and deliverables for our senior design project are as follows.

- A lightweight and portable CLI program that can check, verify, and alert users about potentially insecure and vulnerable Kubernetes configurations and helm charts. Lightweight means that it must be a small program that can be downloaded quickly from any internet connection. Portable means that it is not system-dependent and can run on a multitude of Operating Systems.
- Extensive documentation on the installation and use of the program so that anyone will be able to understand and use this. This documentation will include readme markdown documentation for outside users intending to use the program. Additionally, this will include a well-commented code for the open-source community intending to clone and contribute to the repository.
- Open-source code for continual improvement by the open-source community. It is proven that open-source code is more cost-effective, quicker to develop, much more secure/transparent, and more extensible in the future by anyone. We are making our program open-sourced for the aforementioned reasons

The delivery dates for these deliverables is T.B.D due to the nature of the senior design program. We can estimate that the above will be ready sometime around May of 2020.

2. Specifications and Analysis

2.1 Proposed Design

We have a proof-of-concept program capable of parsing configuration YAML files.

The application will parse and analyze Helm and Kubernetes security configuration files, and compare the results against a defined set of rules.

The application will run in CLI.

The application will accept templates of rule sets to compare to.

The application will be rigorously tested to sufficiently ensure correctness.

2.2 Design Analysis

Our group has been communicating with both our advisor and each other about team roles and planning for our code development. We have mostly been communicating through online messaging with our entire team. Although our team has also met in person as well. So far our meetings, whether that be face-to-face or online, have been very successful. Each one of us is able to understand what is expected and we are able to hold each other accountable for tasks that need to get done.

Our strengths are communication and expectations. Everyone in our team is okay with sharing their thoughts and ideas. Expectations are clearly understood and set as well. Our biggest weakness is availability. All of our members are extremely busy so finding times to meet in person is a challenge.

Observations and thoughts on our team style so far are mostly positive. We all are communicating effectively and getting tasks done on time.

Finally, our team members have been learning the GO language. This is the language that we will be developing our code in.

2.3 Development Process

We are using an Agile development process because our requirements are well-defined but we are meeting with our team of couple of weeks to make adjustments if needed.

We are developing one part at a time, testing it with our tests, showing our advisors what we have how it works now, and testing it in the environment it will be used, and making any necessary changes.

2.4 Design Plan

We are developing our code one feature at a time. This ensures our code is modular. Each feature can run on its own and is imported into the main package. The high degree of modularity makes the code more extensible so that others can modify it for their purposes.

The GUIs are going to be written as local client/servers. This model reduces the overhead and allows them to be run from the terminal, regardless of the desktop environment. This also reduces the number of dependencies needed for the application.

As of now we do not know all of the dependencies and modules we will be using. We anticipate that we will only need modules and dependencies we will have will be from the standard library.

3. Statement of Work

3.1 Previous Work And Literature

One product that has some similarities to our product is Amazon's "Inspector". This program automatically improves the security of applications on AWS. Then it will show the user where the threats are and explain to the user how serious each threat is. The difference is that "Inspector" only deals with applications on AWS and it doesn't relate to Helm at all.

Source: See *Link 1*

Aqua works with Kubernetes and performs security checks daily. After the check, Aqua will make a report based on their findings. This is similar to our project because this analyzes security flaws with Kubernetes. Although this differs from our project because our project is focusing more heavily on Helm charts.

See Link 2

3.2 Technology Considerations

Our project is entirely software so technology considerations will only be in the computer area. As for the language that we are going to use, we are going to code in GO.

Some of the strengths of using GO are that it's compiled based, has memory safety, and has a garbage collection.

Weakness: Most of our team hasn't used GO before so we had to learn the language

3.3 Task Decomposition

The main tasks that we will need to do for this are to break the helm chart/kubernetes down before and after running in order to parse them to check for inaccuracies. Once this is done we will be able to create a user interface for the project. This user interface is important because it is what is going to allow us to add the extras after aside from the parsing, we will need to finish that before we go on to making a template generator. Aside from that it is just the linter that will need to be added and whatever else we want to add if we find that we want more.

3.4 Possible Risks And Risk Management

Lack of experience in the area is a risk we are actively combating through studying GoLang and Kubernetes.

Loss of one or more team members is a possible severe risk, we are mitigating this risk by ensuring our documentation is routinely up-to-date such that a team change would not result in a catastrophic loss of progress or information.

Risks such as the obsolescence of Kubernetes are insignificantly likely, though even in the event such things come to pass we could transfer the skills we learn here to whatever may replace it.

3.5 Project Proposed Milestones and Evaluation Criteria

Key milestones would consist of the following: Parsing of helmcharts/kubernetes files, parse templates and store values after configuration, check values of parsed info to make sure it has finished correctly, create alerts based off of the incorrect info, make a user interface for the application, setup a template generator, add a linter to the system. Each of these milestones are designed so that they are able to be tested task-wise. When we give reach these milestones we will know because all of these are provable/tangible parts of our project. In fact, these are basically where the same times that we need to do major testing on each portion. The tests for each of these milestones will be dependent on what is being tested. Most of the important testing will be to make sure our parsed information is correct and we will need to spend a lot of time on this because the entire project is reliant on this being correct.

3.6 Project Tracking Procedures

First off we spoke with our advisor and we set milestones on what we want to accomplish. We are going to track ourselves with when we hit those milestones and whether it was before or after our "due date". Also, we will be tracking our progress through completed issues on Github. Based on how many issues get done per person, we will determine the difficulty of every task and determine how much work they have done. So if a GitHub issue is harder than normal, then when that task is completed then that person will have done more work compared to an average Github issue. We are following the agile style of development so we will also make note of when someone gets their smaller tasks done on time.

3.7 Expected Results and Validation

The desired outcome of the project is a lightweight application running on the command line, parsing Kubernetes configurations and alerting the user on incorrect configurations. The application should be able to be configured for various templates.

We will confirm that our solutions work at a high level through rigorous testing and use in Kubernetes environments.

4. Project Timeline, Estimated Resources, and Challenges

4.1 Project Timeline

February 2020 - Phase 3 done

Dec 30 2019 Phase 1

- Project design planning
- Requirements gathering

- Regular team meetings to plan and schedule
- Familiarization with framework and languages
- Design document drafting
- Initial implementation of the parser

Jan 15 2020 phase 2

- Ability to parse templates AND store proper configuration values

Feb 10 phase 3

- Alert/Gracefully handle misconfigured values

Feb 20 phase 4

- Make a GUI for easy interaction with the program
- GUI is either standalone or integrated with a tool like Rancher

March 1 phase 5

- Provide template generation - making it easier to user and less error prone
- Possibly make a GUI for template generation
- Like phase 4, could integrate with a tool like Rancher

March 12 phase 6:

- Implement functionality to alert on CVEs found in the stack running the containers

March 22 phase 7:

- Add a linter for security policy templates
- Add additional features as we see fit
- Optimize for speed and size

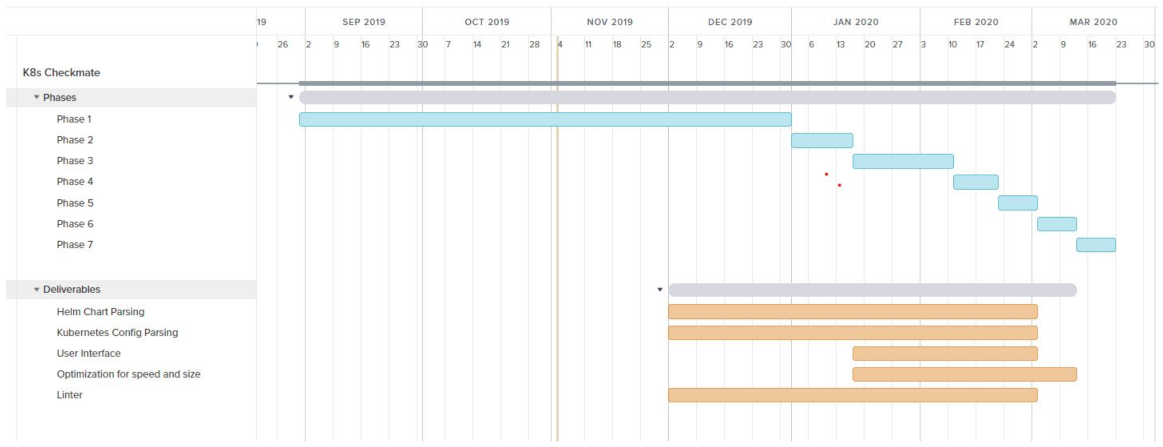


Figure 1: Gantt Chart

4.2 Feasibility Assessment

Realistically, the project will sufficiently fill our requirements, though it is unlikely to fulfill some of our unofficial open-ended nonfunctional requirements. Examples of challenges we have foreseen are that GoLang does not support the data structures we initially planned to use, requiring us to reconfigure our plans, and that because only superficially similar applications exist we cannot take significantly useful inspiration from those.

4.3 Personnel Effort Requirements

Table 1: Effort requirements with explanation

Task	Text reference/explanation	Estimate of effort
Parsing of helm charts/kubernetes files	This will be the first milestone that we will need to accomplish and will allow a base to check against	This is going to be the medium difficulty because it is important that this is robust and holds up with many test cases.
Parse templates and store values after configuration	This will likely be mainly be similar to the previous one but a bit more difficult because they will be checked off of configured setups.	This will be similar to above but with an added layer of difficulty as we are needing to check the already run templates to verify that the setups have run correctly and store that info.
Check values of parsed info to make sure it has finished correctly	This will be the core of our product and will be important to get correct, as well as important to test.	Assuming we are able to get our information setup side by side with the before an after, this will just be a check to make sure the values are the same
Create alerts based off of the incorrect info	This is going to the first part of the user portion of the program	This is going to be triggered by the above check, and should not be
Make a user interface for the application	This will make the application easy to use	This will be difficult because we will need to make sure it is simple to use and difficult to break. Also making this robust for our use will be important so that it eases the use for the customer.

Setup a template generator	This is an addition and not a core feature but will be important	This will, as above help with the robustness for user ease. It will not be difficult, but will require us to be very knowledgeable on the relationships between different settings on the helm charts.
Add a linter to the system	This is another feature that will add robustness to our application	The linter is something that already exists, but since we would like our project to be powerful it is important to have it. Since it does exist, it will not be too hard, and we will be able to take inspiration from other open source examples.

4.4 Other Resource Requirements

No additional resources will be required to conduct the project.

4.5 Financial Requirements

No additional financial resources will be required to conduct the project.

5. Testing and Implementation

5.1 Interface Specifications

Our project will not be dealing with hardware and software interfacing with each other and our project will be able to be run on both Unix and Windows systems since it will be written using Go. Because of this, the effects of hardware interfacing will not be important.

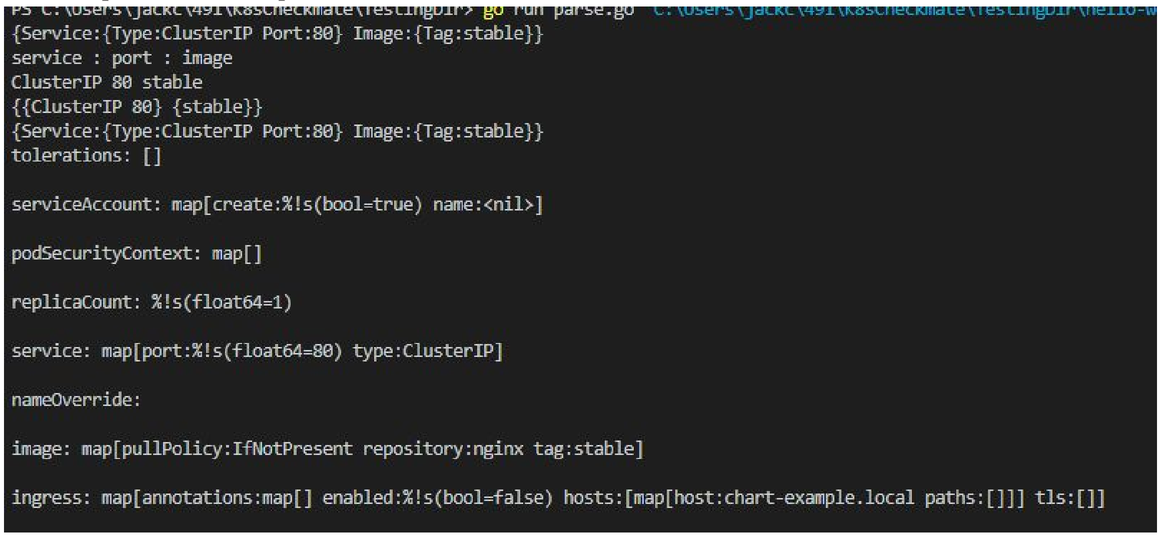
5.2 Hardware and software

We do not require any hardware specifications due to our project being a lightweight software program. We are currently testing in visual studio code with simple test cases and simple yaml files in to validate our proof of concept.

5.3 Functional Testing

Our group has been doing unit testing. Currently we are parsing through yaml files to determine the validity of our input.

An example of a valid input file:

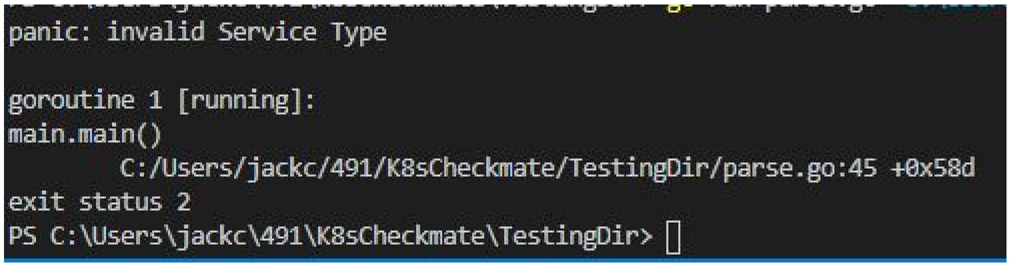


```
PS C:\Users\jackc\491\K8sCheckmate\TestingDir> go run parse.go  C:\Users\jackc\491\K8sCheckmate\TestingDir\hello-w
{Service:{Type:ClusterIP Port:80} Image:{Tag:stable}}
service : port : image
ClusterIP 80 stable
{{ClusterIP 80} {stable}}
{Service:{Type:ClusterIP Port:80} Image:{Tag:stable}}
tolerations: []

serviceAccount: map[create:%!s(bool=true) name:<nil>]

podSecurityContext: map[]

replicaCount: %!s(float64=1)

service: map[port:%!s(float64=80) type:ClusterIP]

nameOverride:

image: map[pullPolicy:IfNotPresent repository:nginx tag:stable]

ingress: map[annotations:map[] enabled:%!s(bool=false) hosts:[map[host:chart-example.local paths:[]]] tls:[]]
```

Photo 1: valid input

Everything we are looking for a valid yaml file was provided. We then are currently printing out the results.

An example of an invalid file:



```
panic: invalid Service Type

goroutine 1 [running]:
main.main()
        C:/Users/jackc/491/K8sCheckmate/TestingDir/parse.go:45 +0x58d
exit status 2
PS C:\Users\jackc\491\K8sCheckmate\TestingDir> 
```

Photo 2: invalid input

Right now our current validity checks are simple, but this proves we will be able to set our own check against files to our specifications.

5.4 Non-Functional Testing

So far we have not done any testing for performance, security, usability, or compatibility. This is currently because our project is mainly behind the scenes checks of configurations, which does not require early implementation of these functions. We have dedicated our time to functional testing.

5.5 Process

We mocked a simple input/result test. We gave test files that we expected to pass and then we gave test files that we expected to fail. Then if the desired result was not met, we would make changes to our code.

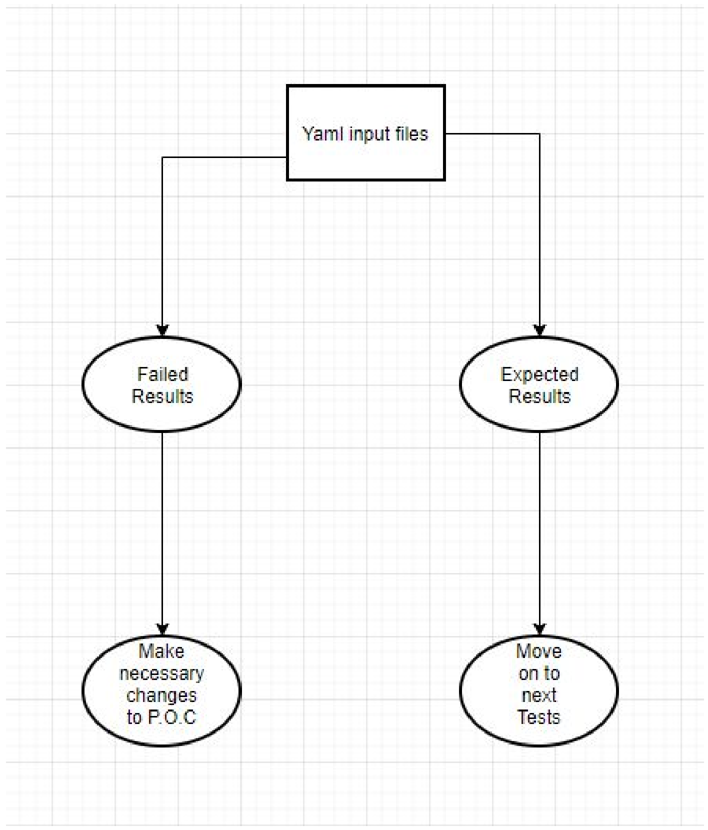


Photo 3: process mockup

5.6 Results

Failures:

We tried to use a parsing technique by utilizing the built in ioutil file reader. This lead to some complications because we had no way in checking the config files' contents.

Successes:

We implemented our own parsing function that lets us control the logic of checking the file contents of yaml files which lead to more success in testing

Learned:

Overall we learned that we do have a lot of work to do, but we were able to prove that it is possible to check yaml file's contents.

6. Closing Material

6.1 Conclusion

Thus far we have primarily been learning and familiarizing ourselves with the language and systems we are using to accomplish our goals, and while doing so have worked to manufacture a definitive design for our product. We have also put together a working proof-of-concept program to prove that our designs are sound and can perform according to our goals.

Our goal is a lightweight program running in a command line interface that can parse Kubernetes and Helm charts for valid values. Should incorrect values be found, the user will be alerted. The code will be open-source, and have extensive documentation on the use of the program.

The best solution to achieve our goals is to continue with our proof-of-concept, refining and iterating on it in an agile manner until we have developed a product that fulfills our specifications. This is the optimal solution because only superficially similar products already exist, and they cannot be used for our purposes. All in all, we are well on our way to arriving at our goal.

6.2 References

Lafeldt, M. and Hamburg, G. (2019). *Decoding YAML in Go*. [online] The Sharp End. Available at: https://sharpend.io/blog/decoding-yaml-in-go/ [Accessed 9 Dec. 2019].

Kubernetes.io. (2019). *Production-Grade Container Orchestration*. [online] Available at: https://kubernetes.io/ [Accessed 9 Dec. 2019].

Helm.sh. (2019). *Helm*. [online] Available at: https://helm.sh/ [Accessed 9 Dec. 2019].

6.3 Appendices

We currently do not have any additional information that needs to be added.