How to handle Docker data?

Introduction

For our project we need to run multiple dockers that must import data as well as export data. Because the amount of data can become big quickly, we're going to explore multiple ways of doing this in this research and decide the way to go for our project.

Research questions

What is the most efficient and scalable approach for importing and exporting large amounts of data in and out of a Docker container?

1. What are the available approaches for importing and exporting data within and outside of a Docker container?
2. How can we measure the efficiency and scalability of the identified approaches?
3. What are the benefits and drawbacks of each approach in terms of efficiency and scalability?
4. What are the security implications of each approach?

What are the available approaches for importing and exporting data within and outside of a Docker container?

Dot methods

- Literature study
- Expert interview

1. **Docker volumes** are a mechanism that enables storing and managing data in a separate volume outside of a container. Volumes provide a persistent data storage solution for containers, which can be shared among multiple containers, allowing data to persist even when the container is deleted or recreated. To use Docker volumes, you can create a new volume and specify it when creating or running a container, which will mount the volume to the container's file system. You can also manage Docker volumes using the Docker CLI, allowing you to list, inspect, create, and remove volumes. Additionally, Docker volumes offer several benefits, such as improved performance, better data management, and more manageable backups and restores. To import data into a container, you can create a new volume and copy the data into it. To export data from a container, you can copy the data to a volume and then access it from the host machine. Overall, Docker volumes are a powerful feature that provide a flexible and efficient solution for data management in Docker containers.

2. **Docker bind mounts** are a mechanism that enables mounting a file or directory on the host machine into a container. Bind mounts provide a way to share files between the host and the container, allowing for easy access to files or directories that reside on the host machine. To use a bind mount, you can specify the source directory or file and the destination directory in the container when creating or running a container. Once the bind mount is set up, any changes made to the source directory or file on the host machine will also be reflected in the container, and vice versa. Docker bind mounts also offer several benefits, such as easy access to files, improved performance, and the ability to modify files outside of the container. However, bind mounts are not ideal for sharing data between containers or for persistent storage, as any changes made to the host machine could potentially break the container. To import data into a container, you can mount the directory containing the data into the container. To export data from a container, you can mount a directory from the container onto the host machine. Overall, Docker bind mounts are a useful feature for sharing files between the host and the container, but should be used with caution in production environments.

3. **The Docker copy command** allows you to copy files between a container and the host machine. To import data into a container, you can use the Docker copy command to copy the data from the host machine to the container. To export data from a container, you can use the Docker copy command to copy the data from the container to the host machine.

4. **The Docker export command** is a Docker CLI command that enables exporting a container's file system as a tar archive. This command can be used to save the state of a container's file system, including any changes made to the container's file system since it was created, as a single file that can be transferred and imported to other machines or environments. To use the Docker export command, you can specify the name or ID of the container and the path and filename of the output tar file. Once the tar file is created, it can be transferred to another machine or environment and imported using the Docker import command. However, it's important to note that the Docker export command does not include any metadata about the container, such as its networking or storage configuration, so it may not be suitable for all use cases. Additionally, exporting and importing containers can result in large tar files, which can be time-consuming to transfer and may require significant storage space. Overall, the Docker export command is a useful feature for exporting a container's file system as a tar archive, but should be used with caution and with a clear understanding of its limitations. To export data from a container, you can use the Docker export command to create a tar file containing the data. To import data into a container, you can use the Docker import command to create a new container from the tar file.

Expert interview

For the expert interview I talked to Henners from the Docker discord. We talked to him about the research we were doing for and let him read the sub question. He sad that the 4 approaches right now are a good start but there are so many more possibilities. To start with here is the list of 4 more approaches/possibilities.

1. Containers are able to use HTTPS
2. Containers can use databases and object store
3. NFS
4. Multi stage building

I think these are great options to look into and we will for sure do this within the group project. For now a big thank you to Henners for helping us out.

How can we measure the efficiency and scalability of the identified approaches?

To measure the efficiency and scalability of the identified approaches we need to determine what efficient and scalable means, given our context? We sat down with our Product Owner (PO) to discuss the requirements for the platform they can be found here: https://github.com/S-A-RB05/.github/blob/main/User%20stories.pdf

Dot methods

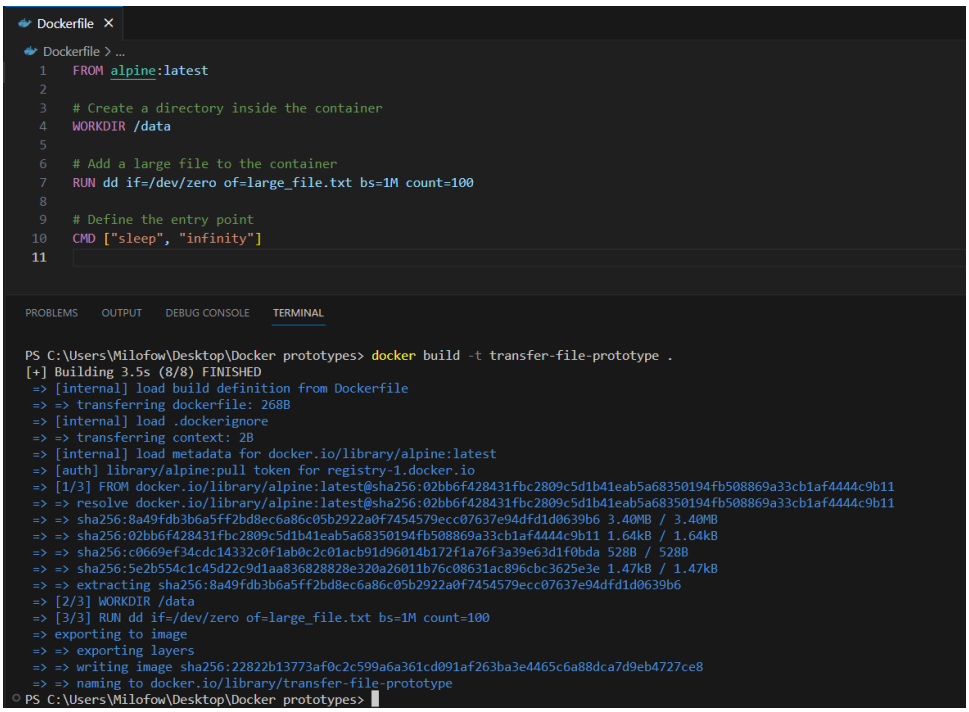
- Explore user requirements
- Prototyping (https://github.com/S-A-RB05/Research-docker-prototypes)
- Benchmark test

Efficiency

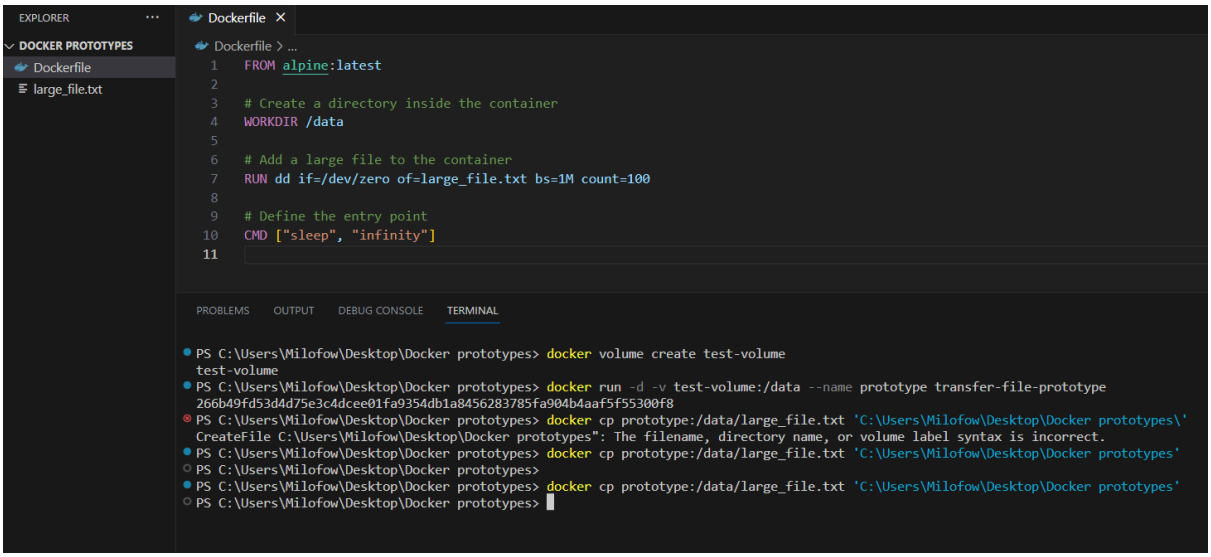
For our project the speed of importing and exporting is important, because this will be one of the main tasks when testing trading strategies on the platform and if the speed is low the latency will build up.

Besides being fast it should also be reliable meaning it should have a good percentage of succeeding and therefore should be a good practice rather than a special exceptional way of doing it.

To measure these two I will be building a test environment and will be timing how long a file transfer takes, I created a prototype docker image to work with. To test the reliability I tested it multiple times to ensure a constant result.

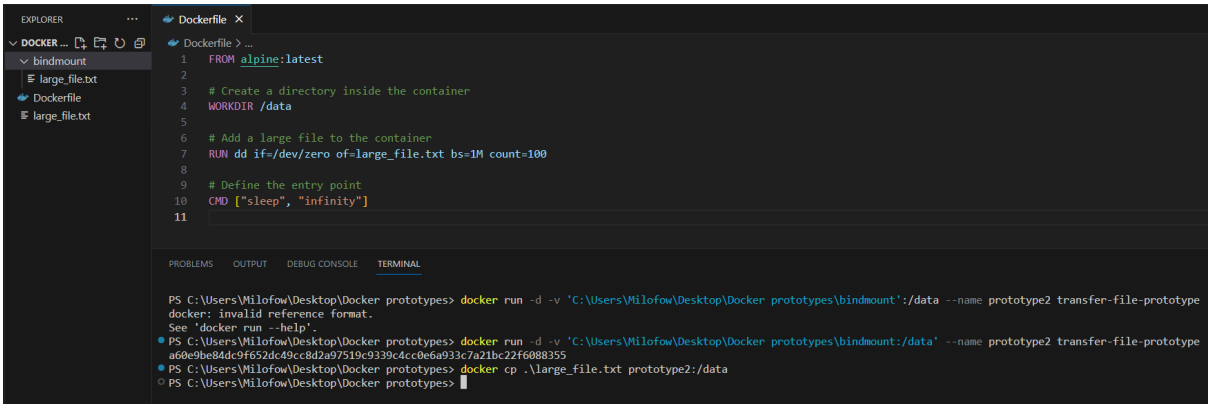


Volume



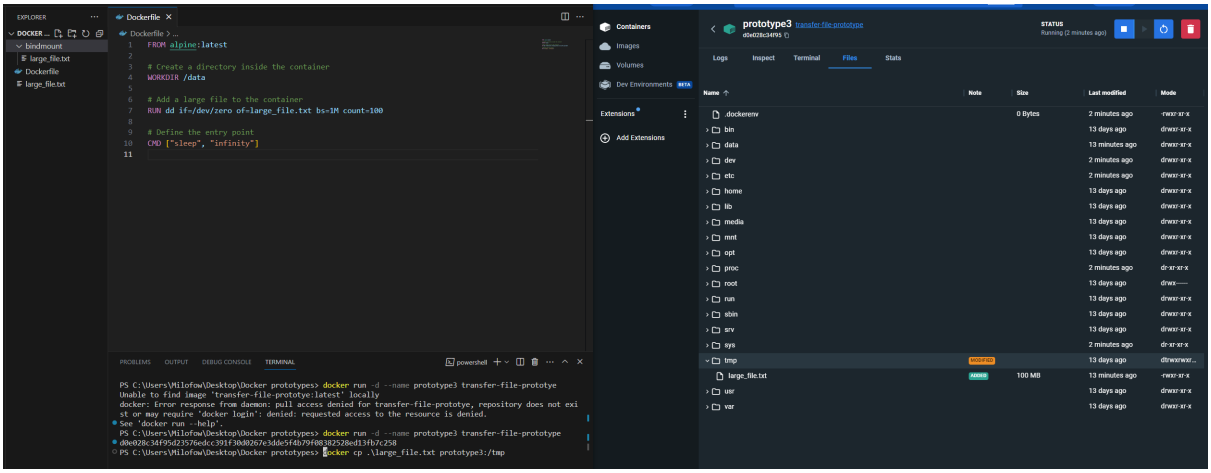
This took 0,96 seconds and didn't fail on multiple tries.

Bind mounts



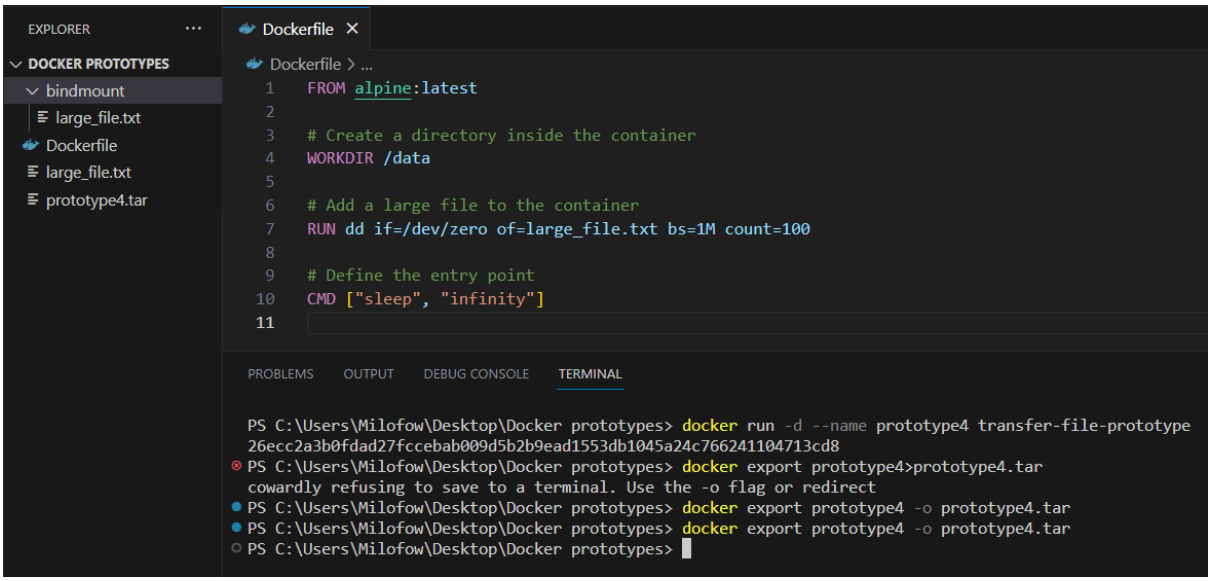
This took 1,01 seconds and didn't fail on multiple tries.

Docker copy

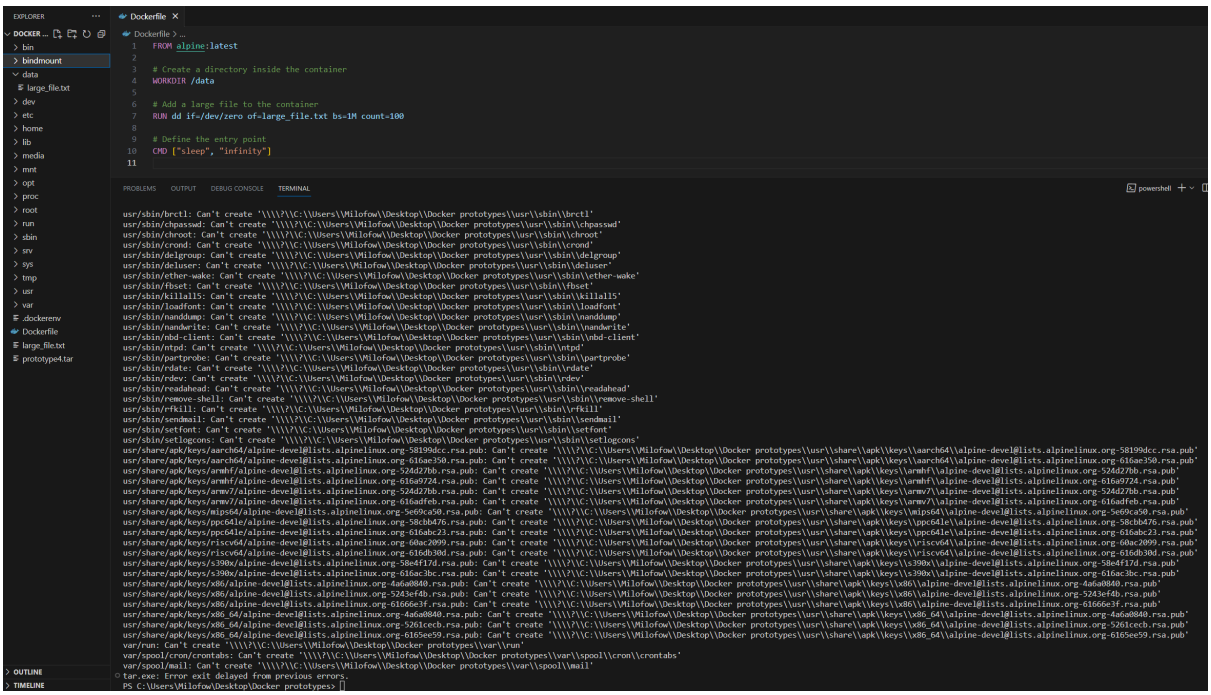


This took 1,08 seconds and didn't fail on multiple tries.

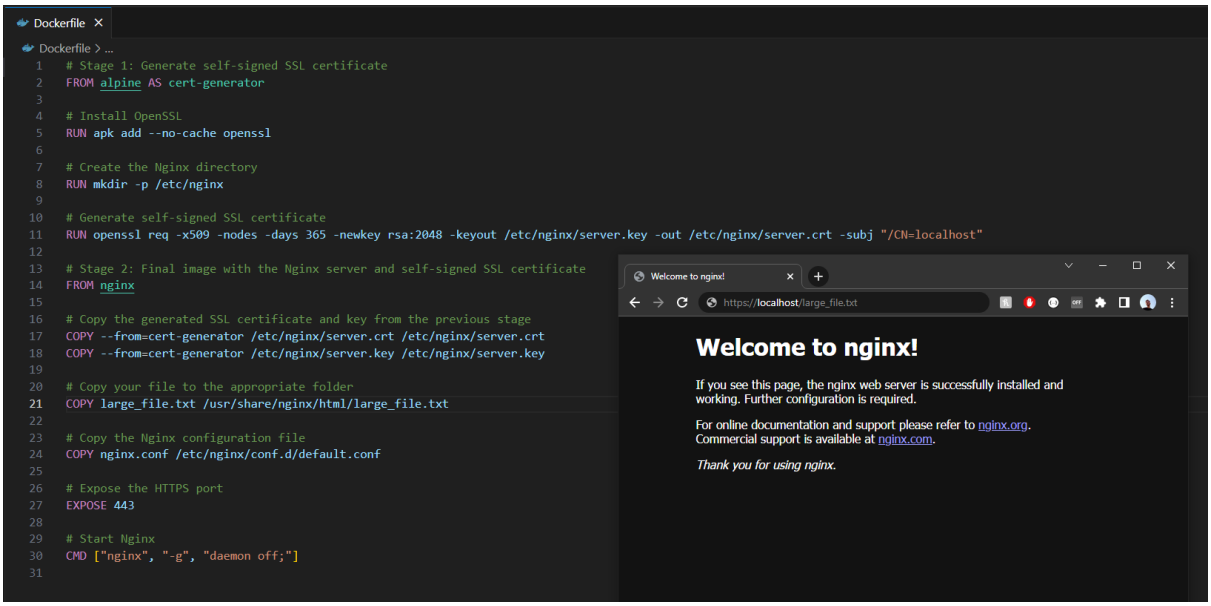
Docker export



This took 1,23 seconds and didn't fail on multiple tries, but you will also need to extract the .tar file which takes another 2,71 seconds.



HTTPS



This took 1,45 seconds and didn’t fail on multiple tries.

Databases/NFS

This will not be possible because directly accessing the database doesn’t fit into our architecture and this will also cause multiple points of failure if something goes wrong while connecting in multiple amounts of dockers

Multi stage building

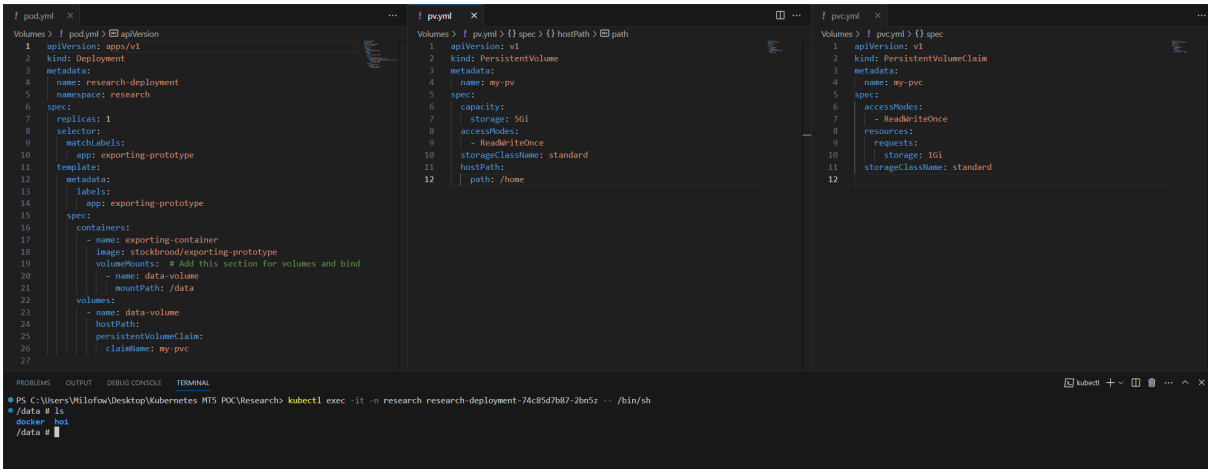
The multi stage building is not applicable in our situation because we don’t build every docker to reduce time, but just grab it from docker hub.

Scalability

While working on the group project we started working with Kubernetes and have suspicions that some of the identified ways of im-/exporting data will not work inside a cluster. Therefore the criteria is that it should work in a scalable environment. To test this I will try how easily I can deploy my prototypes to a Kubernetes cluster.

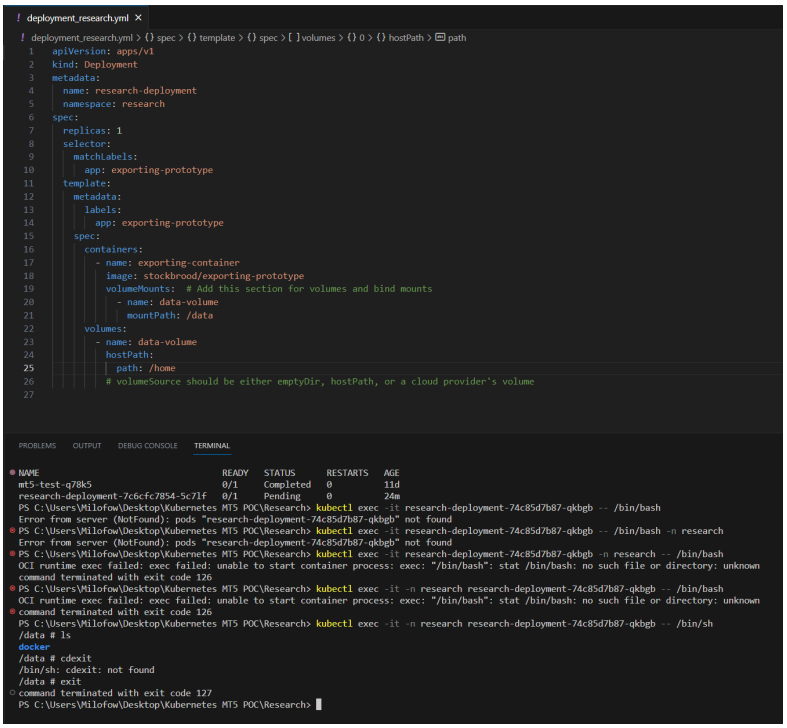
Docker volumes

To achieve this I used a Persistent volume claim (PVC) inside the Kubernetes cluster. Just like volumes are managed by Docker PVC are managed by Kubernetes. I created a new directory to test the PVC with called “hoi”.



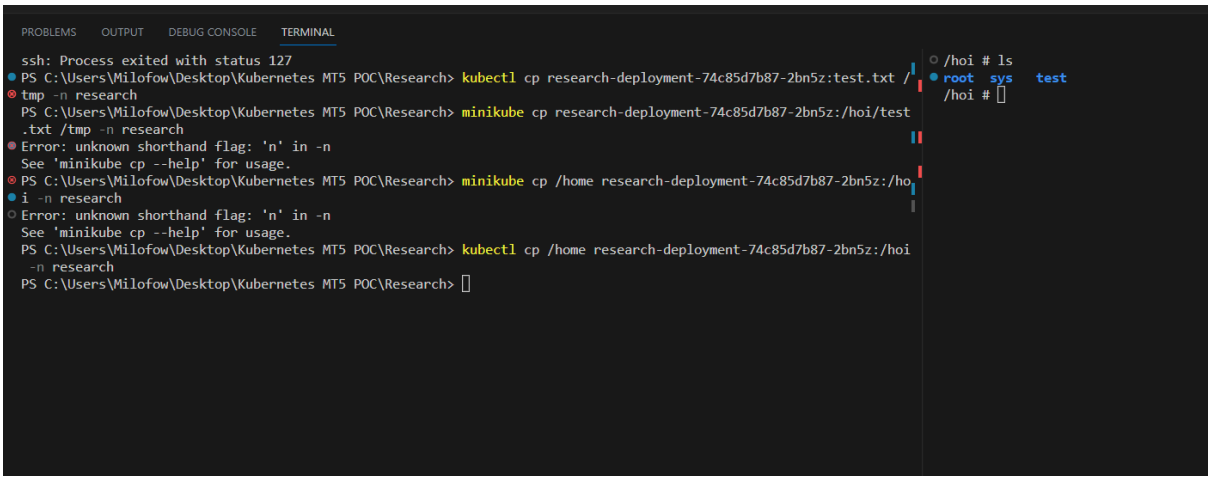
Bind mounts

Just like mounting a folder on the host to the docker you can do the same with this deployment in Kubernetes. In the terminal you can see that the home folder mount is visible inside the data folder inside the container.



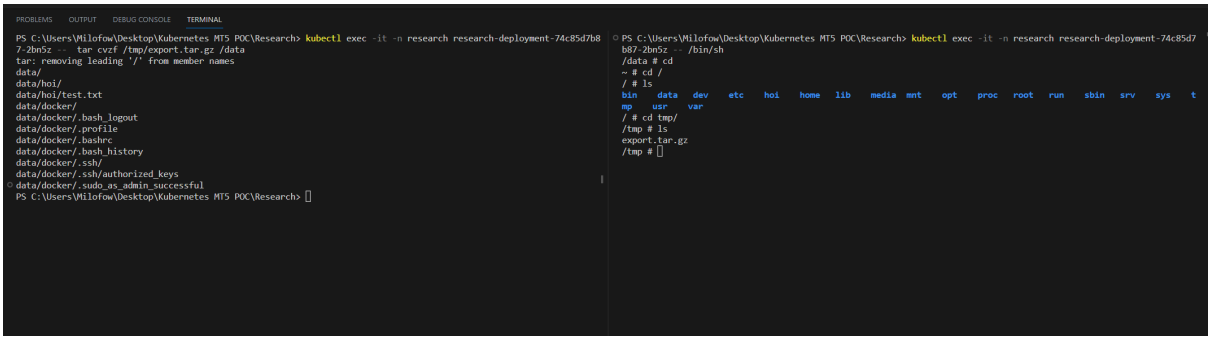
Docker copy

This works almost the same as the docker variant instead of docker copy you have the kubectl copy command. On the left you have the command and it copied a folder from the host to the pod.



Docker export

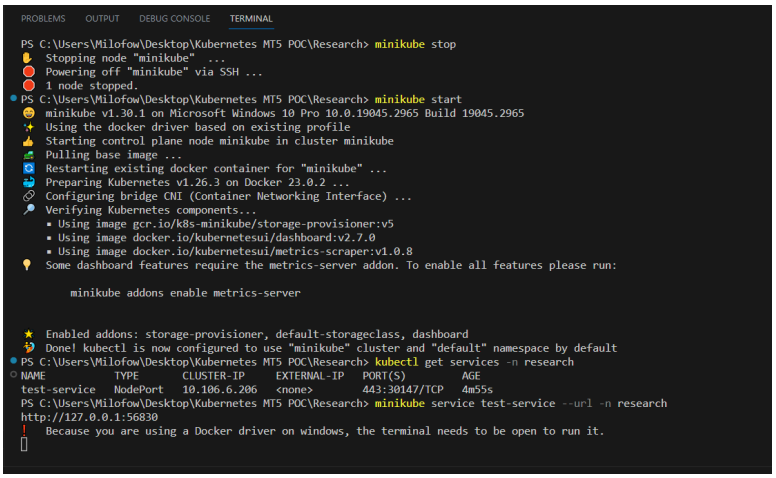
You can also execute the command inside the pod to export it to a .tar file. You can see here that it exports to the directory.



We can see from the speed results that exporting takes the most time and is also not efficient because it copies everything from that container and because our container is pretty big this is not useful.

HTTPS

I exposed the pod running the https web server with the file on it and can access It from my local machine through https.



What are the benefits and drawbacks of each approach in terms of efficiency and scalability?

Dot methods

- Literature study

1. **Docker volumes**

Benefits:

1. Improved efficiency: Docker volumes can improve the efficiency of containerized applications by reducing the overhead of copying and storing data in the container's file system. With volumes, data can be stored externally and accessed directly by the container, which can lead to faster read and write speeds.
2. Scalability: Docker volumes can improve scalability by allowing multiple containers to share the same data volume, which can reduce the amount of storage required and improve overall system performance.
3. Data persistence: Docker volumes provide a way to store data that persists beyond the life of a container. This means that containers can be easily recreated or moved between hosts without losing data.

Drawbacks:

1. Additional complexity: Using Docker volumes can add complexity to the management of a containerized application, especially when dealing with large or distributed data volumes.
2. Security risks: If not properly secured, Docker volumes can be a security risk, since data can be accessed by other containers or even outside the container environment.
3. Storage limitations: Docker volumes are limited by the storage capacity of the host machine, so you may need to manage multiple volumes or use external storage solutions for large datasets.
4. Compatibility issues: Some Docker images may not be compatible with Docker volumes, which can make it difficult to use them in some environments.

2. **Docker bind mounts**

Benefits:

1. Improved efficiency: Docker bind mounts can improve the efficiency of containerized applications by reducing the overhead of copying and storing data in the container's file system. With bind mounts, data can be stored externally and accessed directly by the container, which can lead to faster read and write speeds.
2. Flexibility: Docker bind mounts provide a flexible way to share data between the host machine and container, since the data can be updated outside of the container and the changes will be immediately visible inside the container.
3. No storage limitations: Docker bind mounts do not have storage limitations since they use the file system of the host machine. This can be advantageous for large data sets.

Drawbacks:

1. Security risks: If not properly secured, Docker bind mounts can be a security risk, since data can be accessed by other containers or even outside the container environment.
2. Compatibility issues: Bind mounts can be platform-specific and may not work across different operating systems or filesystems. This can lead to compatibility issues and make it difficult to use them in some environments.
3. Additional complexity: Using Docker bind mounts can add complexity to the management of a containerized application, especially when dealing with large or distributed data volumes.
4. Performance degradation: If the host file system is slow or the data being accessed is large, performance may be negatively impacted by using bind mounts.

3. **The Docker copy command**

Benefits:

1. Ease of use: The Docker copy command is easy to use and allows developers to quickly copy files and directories from the host machine to a Docker container.
2. Flexibility: Docker copy allows developers to copy specific files or directories to specific locations in the container, giving them flexibility in how they manage the files within the container.
3. No additional complexity: The Docker copy command does not add any additional complexity to the management of a containerized application since it simply copies files from the host machine to the container.

Drawbacks:

1. Performance degradation: The Docker copy command can be slow and inefficient, especially when copying large files or directories. This can result in longer build times and slower container startup times.
2. Limited scalability: The Docker copy command does not scale well when dealing with large or distributed data sets. In these cases, it may be more efficient to use Docker volumes or bind mounts to manage the data.
3. No data persistence: The Docker copy command does not provide any data persistence since the copied files exist only within the container.

4. **The Docker export command**

Benefits:

1. Portability: The Docker export command allows developers to easily move a container's file system to another machine or environment, making it highly portable.
2. Security: Exporting a container's file system as a tar archive can be useful for auditing or security purposes, as it allows developers to inspect the file system for any potential security issues.
3. No additional complexity: The Docker export command does not add any additional complexity to the management of a containerized application since it simply exports the container's file system as a tar archive.

Drawbacks:

1. Limited functionality: The Docker export command only exports the container's file system and does not include any metadata or information about the container itself. This can make it difficult to recreate the container exactly as it was on another machine.
2. No data persistence: The Docker export command does not provide any data persistence since the exported files exist only as a tar archive and must be re-imported into another container to be used.
3. Performance degradation: The Docker export command can be slow and inefficient, especially when exporting large file systems. This can result in longer export times and slower container startup times.

Conclusion

Dot-methods

- Multi-criteria decision making

While reading about the pros and cons of different approaches and working with it in our specific scenario. We came to the conclusion that all of the researched examples are possible and to keep into account that speed is a big criteria for us we want to say that using volumes or exporting could be an issue. HTTPS involves implementing extra services and another pod to run constantly, so that's not where our preference is going to. Because the implementation of the PVC was pretty straightforward and simple we want to go that way. Therefore we have a central point to collect results and from there we can use the copy command to get it to the back end for example. Maybe it's also possible to send it using RabbitMQ to ensure more reliability, but for now We know how we can import and export to and from a container In a scalable environment.