Project and Testing Report

Cloud Management System

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1. Project Overview

The Cloud Management System is a virtualization management tool developed in Python. It serves as a centralized dashboard that allows users to create and manage Virtual Machines (VMs) using QEMU/KVM and Containerized Applications using the Docker Engine. The system was developed on a Windows Subsystem for Linux (WSL2) environment to leverage native Linux kernel features while running on a Windows host.

2. Design Choices

To meet the project requirements, the following design decisions were made:

- **Programming Language:** Python 3 was chosen for its strong support for system automation and library ecosystem.
- **Libraries Used:**
    - `subprocess`: Used to execute complex QEMU shell commands directly from the script.
    - `docker`: The official Python SDK was used to interact with the Docker daemon programmatically, which is cleaner and more robust than running shell commands.
    - `json`: Used to parse configuration files, allowing for reproducible VM setups.
- **Architecture:** The code is modularized into three separate files (`main.py`, `vm_manager.py`, `docker_manager.py`) to separate concerns. The `main.py` acts as the controller (UI), while the other modules handle the logic.

3. Challenges Faced & Solutions

During the development process, several technical hurdles were encountered:

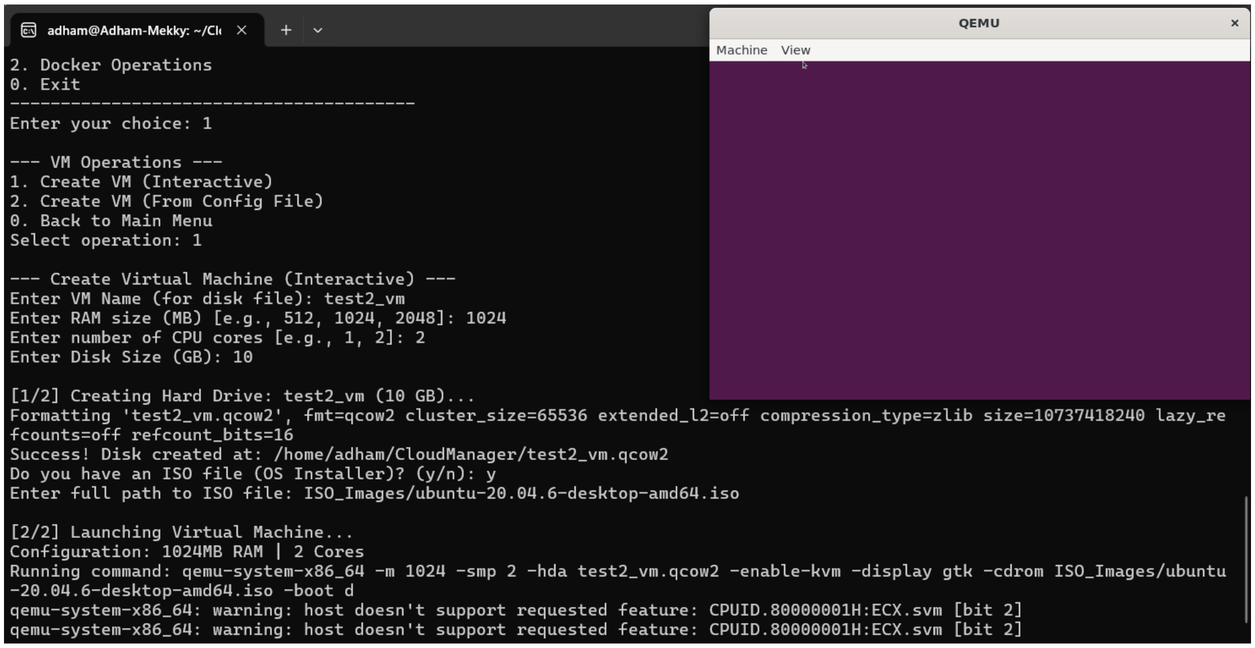
- **Challenge 1: Docker Socket Permissions**
    - *Issue:* The application initially failed with a "Permission Denied" error when trying to talk to the Docker Daemon.
    - *Solution:* We modified the user privileges by adding the current user to the `docker` group (`sudo usermod -aG docker $USER`) and restarting the session.
- **Challenge 2: KVM/QEMU Access in WSL**
    - *Issue:* QEMU failed to launch with a "Could not access KVM kernel module" error. This is a known issue in WSL where permissions reset after reboot.
    - *Solution:* We implemented a manual override by changing the permissions of the accelerator device (`sudo chmod 666 /dev/kvm`) before launching the application.
- **Challenge 3: Handling User Input**
    - *Issue:* Users could crash the program by typing text when numbers were expected (e.g., for RAM size).
    - *Solution:* We implemented `try-except` blocks to catch `ValueError` and prompt the user to try again, preventing the system from crashing.

4. Testing & Evaluation

The system was tested thoroughly to ensure all functional requirements were met. Below are the test cases and evidence of success.

Test Case 1: Virtual Machine Creation

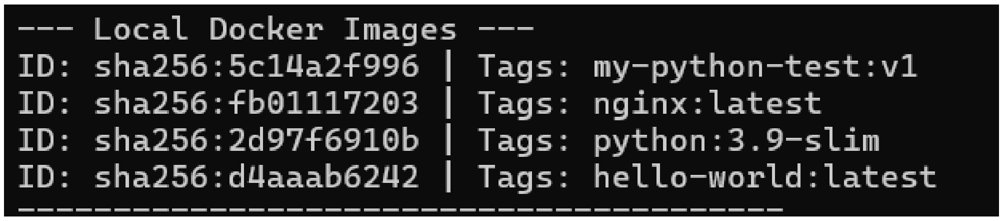
- **Objective:** Create a VM with 512MB RAM and 1 CPU core using the interactive menu.
- **Result:** The QEMU window launched successfully. The "No bootable device" screen confirms the virtual hardware was initialized correctly.



```
2. Docker Operations
0. Exit
----------------------------------------
Enter your choice: 1

--- VM Operations ---
1. Create VM (Interactive)
2. Create VM (From Config File)
0. Back to Main Menu
Select operation: 1

--- Create Virtual Machine (Interactive) ---
Enter VM Name (for disk file): test2_vm
Enter RAM size (MB) [e.g., 512, 1024, 2048]: 1024
Enter number of CPU cores [e.g., 1, 2]: 2
Enter Disk Size (GB): 10

[1/2] Creating Hard Drive: test2_vm (10 GB)...
Formatting 'test2_vm.qcow2', fmt=qcow2 cluster_size=65536 extended_l2=off compression_type=zlib size=10737418240 lazy_re
fcounts=off refcount_bits=16
Success! Disk created at: /home/adham/CloudManager/test2_vm.qcow2
Do you have an ISO file (OS Installer)? (y/n): y
Enter full path to ISO file: ISO_Images/ubuntu-20.04.6-desktop-amd64.iso

[2/2] Launching Virtual Machine...
Configuration: 1024MB RAM | 2 Cores
Running command: qemu-system-x86_64 -m 1024 -smp 2 -hda test2_vm.qcow2 -enable-kvm -display gtk -cdrom ISO_Images/ubuntu
-20.04.6-desktop-amd64.iso -boot d
qemu-system-x86_64: warning: host doesn't support requested feature: CPUID.80000001H:ECX.svm [bit 2]
qemu-system-x86_64: warning: host doesn't support requested feature: CPUID.80000001H:ECX.svm [bit 2]
```

Test Case 2: Docker Image Management

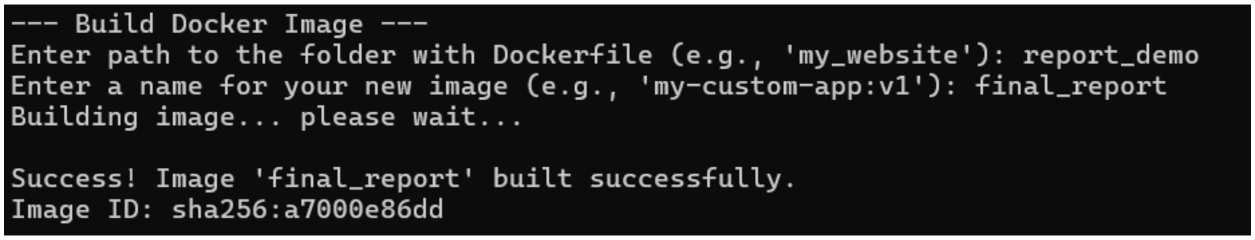
- **Objective:** Pull an image (`nginx`) and list it to verify persistence.
- **Result:** The system successfully connected to DockerHub, downloaded the layers, and displayed the image ID in the list.



```
--- Local Docker Images ---
ID: sha256:5c14a2f996 | Tags: my-python-test:v1
ID: sha256:fb01117203 | Tags: nginx:latest
ID: sha256:2d97f6910b | Tags: python:3.9-slim
ID: sha256:d4aaab6242 | Tags: hello-world:latest
----------------------------------------
```

Test Case 3: Custom Dockerfile Build

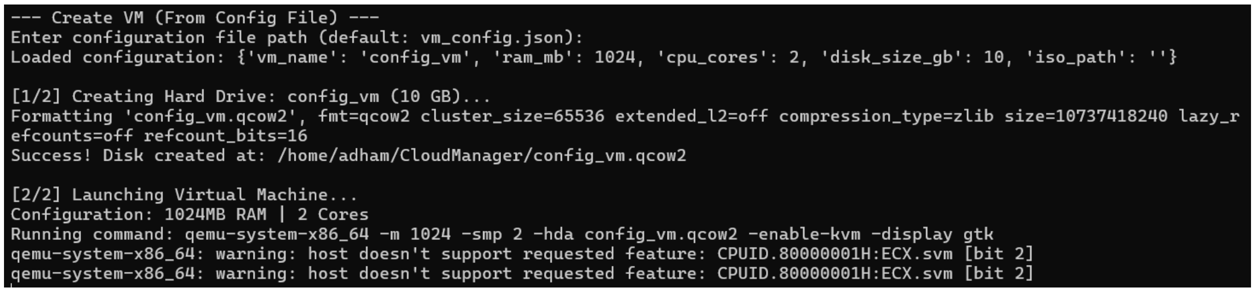
- **Objective:** Create a custom Dockerfile and build a new image from it.
- **Result:** The application generated the file structure and the Docker Engine successfully built the image tagged `my-python-test`.



```
--- Build Docker Image ---
Enter path to the folder with Dockerfile (e.g., 'my_website'): report_demo
Enter a name for your new image (e.g., 'my-custom-app:v1'): final_report
Building image... please wait...

Success! Image 'final_report' built successfully.
Image ID: sha256:a7000e86dd
```

Test Case 4: Configuration File Loading

- **Objective:** Load VM settings from `vm_config.json`.
- **Result:** The system correctly parsed the JSON file and launched the VM with the specific parameters defined in the file.



```
--- Create VM (From Config File) ---
Enter configuration file path (default: vm_config.json):
Loaded configuration: {'vm_name': 'config_vm', 'ram_mb': 1024, 'cpu_cores': 2, 'disk_size_gb': 10, 'iso_path': ''}

[1/2] Creating Hard Drive: config_vm (10 GB)...
Formatting 'config_vm.qcow2', fmt=qcow2 cluster_size=65536 extended_l2=off compression_type=zlib size=10737418240 lazy_r
efcounts=off refcount_bits=16
Success! Disk created at: /home/adham/CloudManager/config_vm.qcow2

[2/2] Launching Virtual Machine...
Configuration: 1024MB RAM | 2 Cores
Running command: qemu-system-x86_64 -m 1024 -smp 2 -hda config_vm.qcow2 -enable-kvm -display gtk
qemu-system-x86_64: warning: host doesn't support requested feature: CPUID.80000001H:ECX.svm [bit 2]
qemu-system-x86_64: warning: host doesn't support requested feature: CPUID.80000001H:ECX.svm [bit 2]
```

5. Conclusion

The project successfully meets all outlined objectives. By leveraging Python's automation capabilities, we created a tool that simplifies the complex syntax of QEMU and Docker into a user-friendly menu. The system handles errors gracefully and provides a robust foundation for cloud resource management.