National College of Ireland

Configuration Manual

MSc Research Project
Cloud Computing

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MSc Project Submission Sheet

School of Computing

Student Name: …Keshav Nandkishor Singh….
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Programme: … ……MSC in Cloud Computing **Year:** ……2024……..
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Module: MSc Research Project……..……

Lecturer: …Sai Emani……..……

Submission Due Date: ……16-09-2024……..……

Project Title: … Enhancing Virtual Machine Migration through the utilization of Reinforcement Learning and Apache Kafka Messaging Services……..…
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Date: ……16-09-2024
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Configuration Manual

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1 System Requirements

Before proceeding to implementation make sure the systems meet the following requirements.

Operating System	Windows, macOS, Linux
Processor	Multi-core
RAM	16 GB
Storage	At least 10GB of free disk space
Python version	3.7 or higher
Java version	8 or higher
Apache Kafka	Latest compatible version

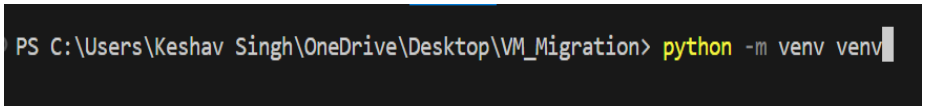
Table 1. System Requirements

2 Software Requirements

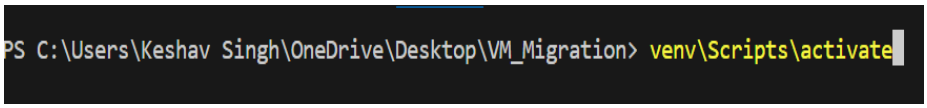
2.1 Python and Virtual Environment

1. Download and install Python
2. Create virtual environment
    - Navigate to project directory

    - Create a virtual environment



    - Activate



3. Install the required libraries
    - pip install tensorflow gym kafka-python

2.2 Java (Prerequisite for Apache Kafka)

2.3 Apache Kafka

1. Download and extract Kafka

2. **Setup Kafka**
    - Navigate to the directory
      cd C:\kafka_2.13-3.7.1\bin\windows
    - Start Zookeeper
      > zookeeper-server-start.bat ..\..\config\zookeeper.properties
    - In new terminal start Kafka broker
      kafka-server-start.bat ..\..\config\server.properties

3 Kafka configuration

3.1 Create Kafka Topic

1. **Create Topic for the VM Metrics**

kafka-topics.bat --create --topic vm-metrics --bootstrap-server localhost:9092 --replication-factor 1 --partitions 1

3.2 Start Kafka Producer and Consumer

1. **Kafka Producer**
    - Kafka Producer will generate and send VM metrics to the kafka topic i.e. vm metrics topic
    - Create python script for producer named kafka_producer.py

```python
import time
import json
import random
from kafka import KafkaProducer

producer = KafkaProducer(bootstrap_servers='localhost:9092',
                         value_serializer=lambda v: json.dumps(v).encode('utf-8'))

iterations = 5000  # Number of iterations before stopping

for _ in range(iterations):
    vm_metrics = {
        'vm_id': random.randint(1, 10),
        'cpu_usage': random.uniform(0, 100),
        'memory_usage': random.uniform(0, 100),
        'network_usage': random.uniform(0, 100)
    }
    producer.send('vm-metrics', vm_metrics)
    print(f"Sent: {vm_metrics}")
    #time.sleep(1)
```

Fig 1. Kafka Producer script

    - Run the script

      python kafka_producer.py

2. Kafka consumer and RL Agent

- Create python script named rl_agent.py

```python
class RLAgent:
    def __init__(self, state_size, action_size):
        self.state_size = state_size
        self.action_size = action_size
        self.model = self.build_model()

    def build_model(self):
        model = tf.keras.models.Sequential([
            tf.keras.layers.Input(shape=(self.state_size,)),
            tf.keras.layers.Dense(24, activation='relu'),
            tf.keras.layers.Dense(24, activation='relu'),
            tf.keras.layers.Dense(self.action_size, activation='linear')
        ])
        model.compile(loss='mse', optimizer=tf.keras.optimizers.Adam(learning_rate=0.001))
        return model

    def train(self, env, episodes, batch_size=32):
        for e in range(episodes):
            state = env.reset()
            state = np.reshape(state, [1, self.state_size])
            for time in range(500):
                action = np.argmax(self.model.predict(state)[0])
                next_state, reward, done, _ = env.step(action)
                next_state = np.reshape(next_state, [1, self.state_size])
                self.model.fit(state, np.array([action]), epochs=1, verbose=0)
                state = next_state
                if done:
                    print(f"episode: {e}/{episodes}, score: {time}")
                    break
```

```python
# Initialize Kafka consumer
consumer = KafkaConsumer('vm-metrics', bootstrap_servers='localhost:9092',
                         value_deserializer=lambda m: json.loads(m.decode('utf-8')),
                         auto_offset_reset='earliest',  # Ensure we consume from the beginning if no off
                         enable_auto_commit=True,        # Commit offsets automatically
                         group_id='vm-migration-group')  # Group ID for consumer group
print("Consumer initialized. Waiting for messages...")
env = VMEnvironment()
agent = RLAgent(state_size=env.observation_space.shape[0], action_size=env.action_space.n)
max_messages = 10
messages_processed = 0

for message in consumer:
    if messages_processed >= max_messages:
        break

    print(f"Received message: {message.value}")  # Debugging statement to print the received message
    vm_metrics = message.value
    state = np.array([vm_metrics['cpu_usage'], vm_metrics['memory_usage'], vm_metrics['network_usage']])
    state = np.reshape(state, [1, env.observation_space.shape[0]])
    env.state = state[0]  # Ensure the environment state is properly set
    action = np.argmax(agent.model.predict(state)[0])
    next_state, reward, done, _ = env.step(action)
    next_state = np.reshape(next_state, [1, env.observation_space.shape[0]])
    agent.model.fit(state, np.array([action]), epochs=1, verbose=0)
    print(f"Processed message. Action: {action}, Reward: {reward}")  # Debugging statement to confirm pr
    messages_processed += 1
    if done:
        state = env.reset()
    time.sleep(1)

print("Finished processing messages.")
```

Run the RL agent script

- python rl_agent.py

4 Run complete implementation

1. Start Zookeeper and Kafka Broker
2. Run Kafka Producer – this script will start sending vm metrics to the kafka topic
3. Run RL Agent – this script will start processing vm metrics and make migration decisions
4. Monitor Outputs – kafka producer script will print the vm metrics and rl_agent script will print received metrics, action and rewards.

5 Stopping services

```bash
deactivate
```