National College of Ireland

Configuration Manual

MSc Research Project
Programme Name

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MSc Project Submission Sheet

School of Computing

Student Name:	Srikanth Konka
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Programme:	MSc Cloud Computing **Year:** 2024-25
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Lecturer:	Sean Heeney
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Configuration Manual

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1 Introduction

This project configuration manual contains instructions to help the user setup the research project infrastructure for the AWS-Ansible Code Smell Detection Framework. This framework is intended to detect and analyze code smells in ansible IaC scripts written for AWS-focused Ansible infrastructure as code (IaC) scripts. This work follows a combined approach involving program dependence graph (PDG) analysis and multi-layer perceptron (MLP) neural networks to locate the different types of code smells present in Ansible playbooks and propose remediation strategies accordingly.

2 System Requirements

2.1 Local Hardware Requirements

- Processor: Intel Quad-core Processor or better
- RAM: 8GB Minimum, Recommended 16GB
- Storage: SSD Preferred with 256GB or more

2.2 Software Requirements

- OS: Linux (Ubuntu 20.04 LTS or newer), macOS, or Windows 10/11
- Python: 3.8 or later
- Python package manager: pip3
- Git: for repository cloning

2.2 Ansible Control Node Specifications

- OS: Linux (Ubuntu 20.04 LTS or newer)
- EC2 Instances: t2.medium or higher
- RAM: 4GB Minimum
- Storage: 24 GB minimum

3 AWS Setup Instructions

3.1 AWS IAM User Permission

- Login using IAM in AWS Console and create programmatic access user with these policies:
    - - AmazonEC2FullAccess
    - - AmazonVPCFullAccess

- - AmazonRDSFullAccess
- - AmazonS3FullAccess

- Save the access key ID and secret access key

3.2 Ansible Control Node Setup

- SSH into control node: ssh -i ansible-key.pem ubuntu@<control-node-ip>
- Update and install required packages
  - `sudo apt update`
  - `sudo apt upgrade -y`
  - `sudo apt install -y python3-pip git`
- Install Ansible and required Python packages
  - `pip3 install ansible boto3 botocore`
  - `pip3 install ansible-lint yamllint`
- Install Python machine learning packages for deep learning component
  - `pip3 install pandas scikit-learn matplotlib seaborn tensorflow`

3.3 AWS Credentials Configuration

```
# Configure AWS credentials
mkdir -p ~/.aws
cat > ~/.aws/credentials << EOF
[default]
aws_access_key_id = YOUR_ACCESS_KEY_ID
aws_secret_access_key = YOUR_SECRET_ACCESS_KEY
EOF

cat > ~/.aws/config << EOF
[default]
region = eu-west-1
output = json
EOF
```

4 Project Structure

- create a main project directory structure pattern as below:

```
bash
>> mkdir -p code-smell-detector
>> cd code-smell-detector
```

code-smell-detector

- combined/ #combined MLP-PDG Detector Tool
  - combined_smell_detector.py
  - ml-analyzer.py
  - pdg-analyzer.py
- ml/ #ML Analyser

        - features.csv
        - labels.csv
        - ml_analyzer.py
    - models/ # Models directory after training
        - smell-detector-model.h5
        - best_model.h5
        - feature_scaler.joblib
        - model_metadata.json
    - pdg/ #PDG Analyser
        - pdg_analyzer.py
    - playbooks/ #Ansible Playbooks Directory
        - deploy_vulnerable_instances.yml
        - deploy_vulnerable_security_groups.yml
        - deploy_vulnerable_webapp.yml
        - synthetic_HP1_main.yml
        - synthetic_HP1_site.yml
        - synthetic_SEC_main.yml
        - synthetic_SEC_site.yml
        - synthetic_UO1_main.yml
        - synthetic_UO1_site.yml
        - synthetic_UR1_main.yml
        - synthetic_UR1_site.yml
    - reports.html
    - results/ #Result save directory
        - refactoring/
        - deploy_vulnerable_instances_refactoring.md
        - deploy_vulnerable_security_groups_refactoring.md
        - deploy_vulnerable_webapp_refactoring.md
        - deploy_vulnerable_instances_report.html
        - deploy_vulnerable_security_groups_report.html
        - deploy_vulnerable_webapp_report.html
        - deploy_vulnerable_instances_analysis.json
        - deploy_vulnerable_security_groups_analysis.json
        - deploy_vulnerable_webapp_analysis.json
    - scripts/
    - generate_labels.py
    - training_data/
        - ansible-examples/ #GitHub Ansible Playbooks
        - ansible-for-deveops/ #GitHub Ansible Playbooks
        - playbooks2/ - #Synthetically generated Ansible Playbooks for ML Training

5 Ansible Configuration

```
# Create Ansible configuration
cat > ansible.cfg << EOF
[defaults]
inventory = inventory
host_key_checking = False
roles_path = roles
```

```
retry_files_enabled = False
stdout_callback = yaml

[inventory]
enable_plugins = aws_ec2
EOF

cat > inventory/aws_ec2.yml << EOF
plugin: aws_ec2
regions:
  - eu-west-1
keyed_groups:
  - key: tags.Environment
    prefix: env
  - key: tags.Role
    prefix: role
compose:
  ansible_host: public_ip_address
EOF
```

6 Test Ansible Playbook – vulnerable_environment.yml

```
# vulnerable_environment.yml
---
- name: Create AWS Test Environment with Intentional Code Smells
  hosts: localhost
  connection: local
  gather_facts: false
  vars:
    # Setup variables
    region: "eu-west-1"
    # UR1: Unsafe reuse due to impure initializer
    # Using random in a template expression that will be reused
    environment_id: "testenv-{{ 999 | random }}"
    vpc_cidr: "10.0.0.0/16"
    project_name: "ansible-smell-test"

  tasks:
    # VPC Creation
    - name: Create VPC
      amazon.aws.ec2_vpc_net:
        name: "{{ project_name }}-vpc"
        cidr_block: "{{ vpc_cidr }}"
        region: "{{ region }}"
        tags:
          Name: "{{ project_name }}-vpc"
          Environment: "{{ environment_id }}"
      register: vpc
```

```
        # UO1: Unconditional override - Overriding the environment_id
unnecessarily
    - name: Override environment ID unconditionally
      set_fact:
        environment_id: "testenv-override"

    # Create Subnets
    - name: Create public subnet
      amazon.aws.ec2_vpc_subnet:
        vpc_id: "{{ vpc.vpc.id }}"
        cidr_block: "10.0.1.0/24"
        map_public: yes
        region: "{{ region }}"
        tags:
          Name: "{{ project_name }}-public-subnet"
          Environment: "{{ environment_id }}"
      register: public_subnet

    # Create Private Subnet
    - name: Create private subnet
      amazon.aws.ec2_vpc_subnet:
        vpc_id: "{{ vpc.vpc.id }}"
        cidr_block: "10.0.2.0/24"
        region: "{{ region }}"
        map_public: no
        tags:
          Name: "{{ project_name }}-private-subnet"
          Environment: "{{ environment_id }}"
      register: private_subnet

    # Internet Gateway
    - name: Create Internet Gateway
      amazon.aws.ec2_vpc_igw:
        vpc_id: "{{ vpc.vpc.id }}"
        region: "{{ region }}"
        tags:
          Name: "{{ project_name }}-igw"
          Environment: "{{ environment_id }}"
      register: igw

    # Route Tables
    - name: Create public route table
      amazon.aws.ec2_vpc_route_table:
        vpc_id: "{{ vpc.vpc.id }}"
        region: "{{ region }}"
        subnets:
          - "{{ public_subnet.subnet.id }}"
        routes:
          - dest: 0.0.0.0/0
            gateway_id: "{{ igw.gateway_id }}"
        tags:
          Name: "{{ project_name }}-public-route-table"
          Environment: "{{ environment_id }}"
```

```
    # UO2: Unused override - Using vars block that won't take effect
    - name: Create security group with unused override
      amazon.aws.ec2_security_group:
        name: "web-server-sg"
        description: "Web server security group"
        vpc_id: "{{ vpc.vpc.id }}"
        region: "{{ region }}"
        rules:
          - proto: tcp
            ports: 80
            cidr_ip: 0.0.0.0/0
          - proto: tcp
            ports: 443
            cidr_ip: 0.0.0.0/0
          - proto: tcp
            ports: 22
            cidr_ip: 0.0.0.0/0  # Security smell - unrestricted SSH access
        vars:
              region: "eu-central-1"   # UO2: This will be ignored due to
variable precedence
        tags:
          Name: "{{ project_name }}-web-sg"
          Environment: "{{ environment_id }}"
      register: web_sg
```

7 Project Run Commands

7.1 PDG Analyzer

```
>>python3 pdg/pdg_analyzer.py
playbooks/deploy_vulnerable_security_groups.yml --verbose --visualize
>>python3 pdg/pdg_analyzer.py playbooks/deploy_vulnerable_instances.yml
--verbose --visualize
>>python3 pdg/pdg_analyzer.py playbooks/deploy_vulnerable_webapp.yml
--verbose --visualize
```

7.2 ML Analyzer

```
>>python3 ml/ml_analyzer.py extract playbooks/ --output ml/features.csv
>>python3 ml/ml_analyzer.py train ml/featuresv3.csv ml/labelsv3.csv
--output models
>>python3 ml/ml_analyzer.py analyze
playbooks/deploy_vulnerable_instances.yml --model models/best_model.h5
--scaler models/feature_scaler.joblib --metadata models/model_metadata.json
--output reports
>>python3 ml/ml_analyzer.py analyze
playbooks/deploy_vulnerable_security_groups.yml --model
models/best_model.h5 --scaler models/feature_scaler.joblib --metadata
models/model_metadata.json --output reports
>>python3 ml/ml_analyzer.py analyze playbooks/deploy_vulnerable_webapp.yml
--model models/best_model.h5 --scaler models/feature_scaler.joblib
--metadata models/model_metadata.json --output reports
```

7.3 Combined PDG-MLP Analyzer

```
>>python3 combined/combined_smell_detector.py analyze
playbooks/deploy_vulnerable_security_groups.yml --model
models/best_model.h5 --scaler models/feature_scaler.joblib --metadata
models/model_metadata.json --output results
>>python3 combined/combined_smell_detector.py analyze
playbooks/deploy_vulnerable_instances.yml --model models/best_model.h5
--scaler models/feature_scaler.joblib --metadata models/model_metadata.json
--output results
>>python3 combined/combined_smell_detector.py analyze
playbooks/deploy_vulnerable_webapp.yml --model models/best_model.h5
--scaler models/feature_scaler.joblib --metadata models/model_metadata.json
--output results
```

8 Combined PDG-ML Detection Tool - Output

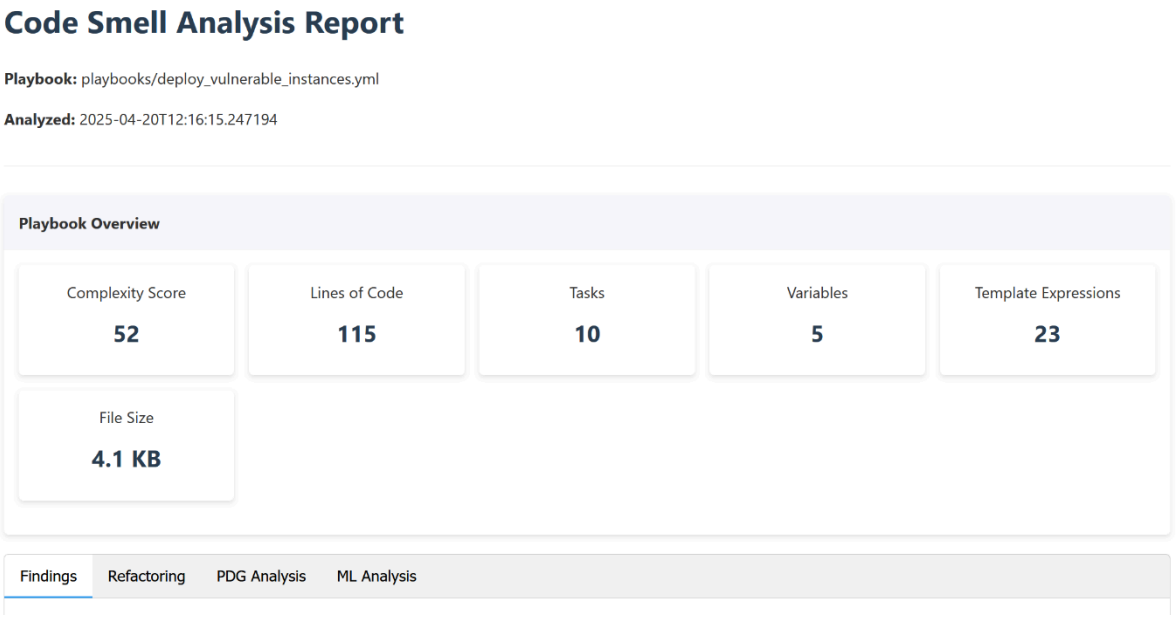


Figure 1. HTML Report – Dashboard

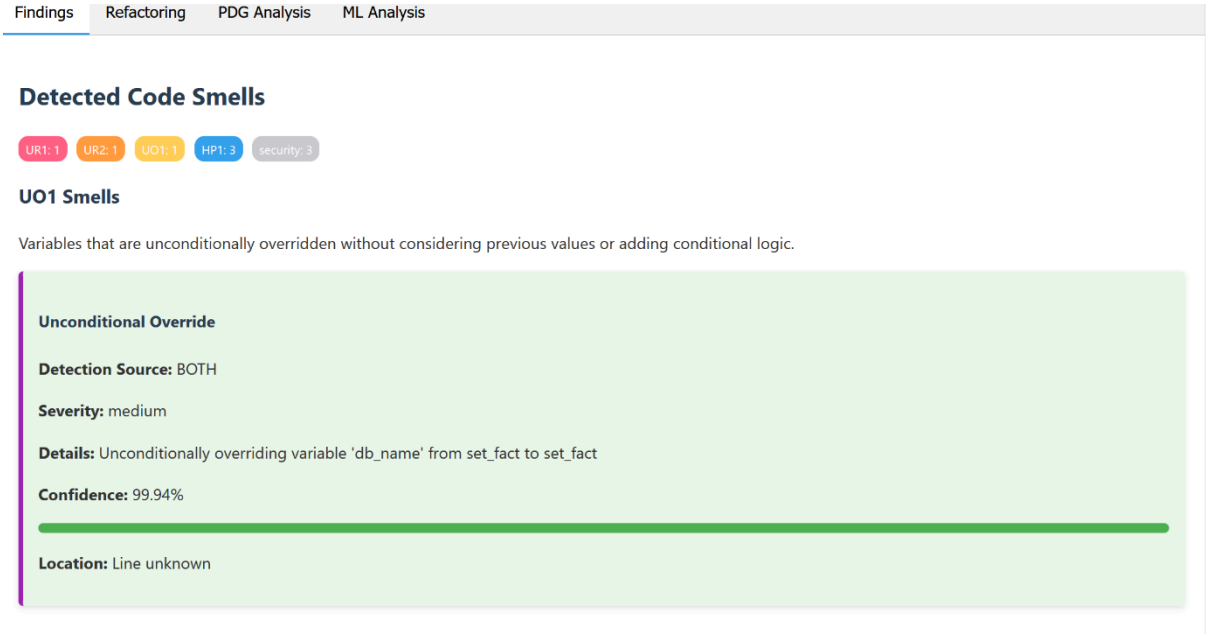
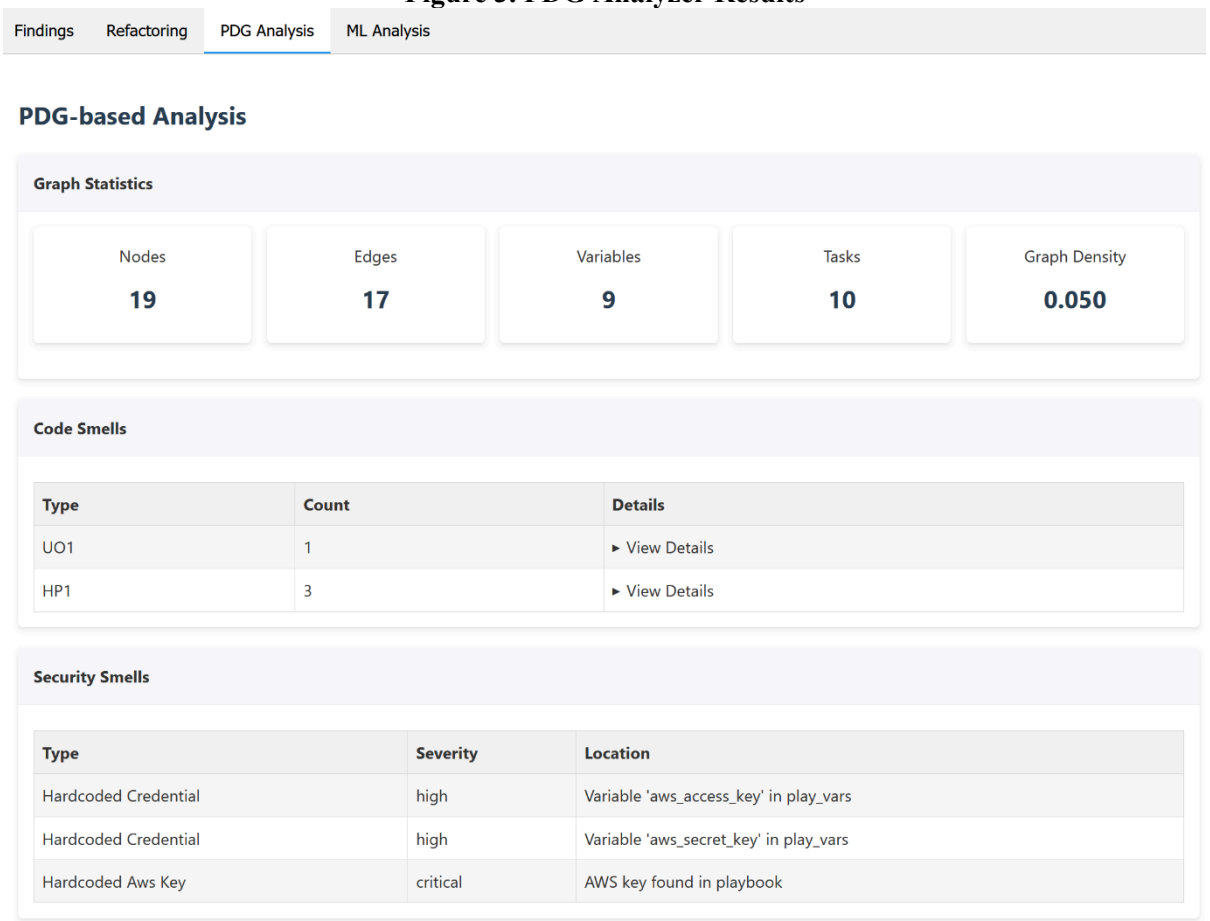


Figure 2. Detected Code Smells Window

Figure 3. PDG Analyzer Results



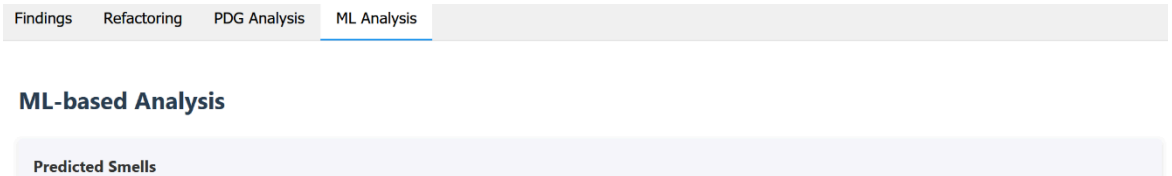


Figure 4. ML Analyzer Results

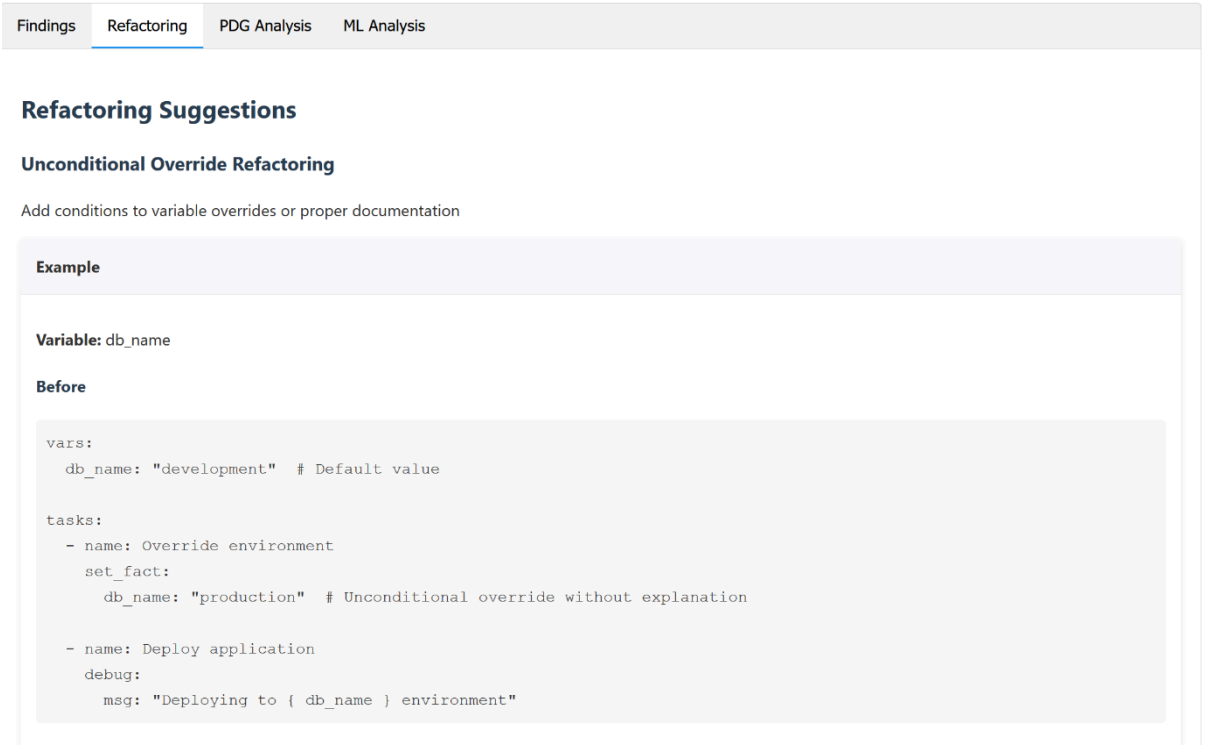


Figure 5. Refactoring Suggestions Window

References

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