An Analysis of Risk in Open-Source Project Dependencies

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Introduction

- Popularity of Open Source Software has shown a steady increase over time
  - 3.6 million repos depend on the top 50 open-source projects
- The use comes with the risk of software vulnerabilities
  - Attackers can exploit these
- Prediction of risk is important for this
  - Software metrics
  - Project Activity
  - Vulnerability Data

Research Questions

Question 1:

Are there feature combinations that can be made from risk prediction methods that could provide developers with a more effective risk measure that allows them to minimise risk when choosing between multiple candidate open-source components?

Question 2:

Can a visual dependency tree be created for a project consisting of colour-coded nodes based on the predicted risks?

Background Research

Vulnerability Propagation

- Only 1.2% directly use vulnerable code
- Small packages can affect many packages in the Maven ecosystem
    - CVEs can affect a large number of projects
- The more dependencies the more complex it is to find vulnerabilities in dependencies

Project Metadata Analysis

- Project activity level is an indicator of survival
  - Number of commits, time-to-fix
  - Long-time Contributors
- Less than 50% of abandoned projects find new contributors
- Standard measurement for commits is:
  - Number of commits per month

Vulnerability CVE Data Analysis

- Predicting number of vulnerabilities per month is also important
- ARIMA is a very popular method of prediction
  - Seasonality not a factor
- Datasets from the NVD were used in every study we analysed
  - Prediction of CVEs
- Most models fall flat at the three month mark

Case Studies

Log4j Vulnerability

➔ Discovered in November 2021 in popular logging library
➔ Gateway to gain control of the machine
➔ Many projects unaware they were affected

Heartbleed Vulnerability

➔ Discovered in April 2014 in popular cryptography library
➔ Receive private information after crafting similar messages
➔ Many servers unaware they were affected

Methodology

Data & Dependencies Gathering

- Different GitHub projects to test the algorithm
- GitHub API for project activity
- NVD API for vulnerability Data

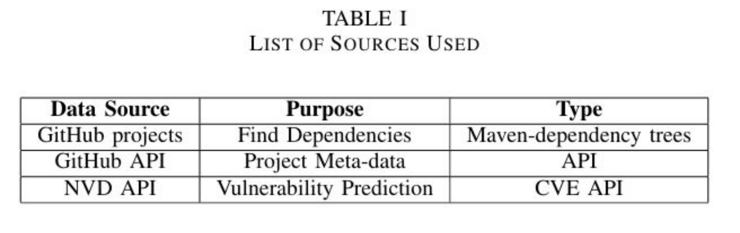


TABLE I
LIST OF SOURCES USED

Data Source	Purpose	Type
GitHub projects	Find Dependencies	Maven-dependency trees
GitHub API	Project Meta-data	API
NVD API	Vulnerability Prediction	CVE API

Predictions

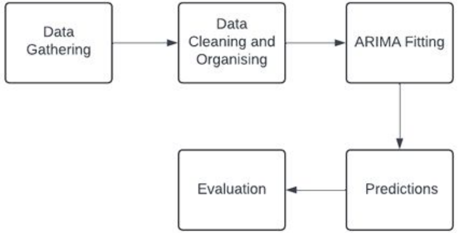
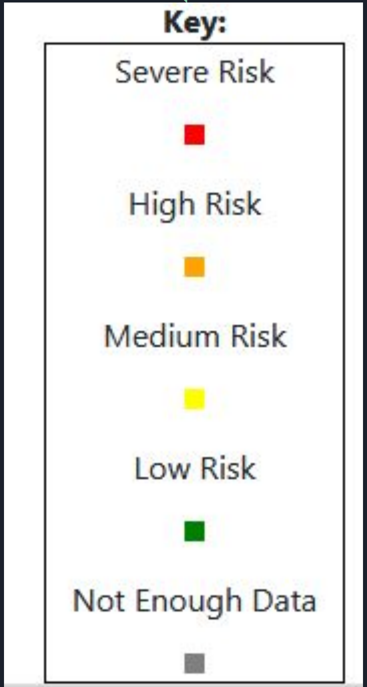


Fig. 1. The Time Series Pipeline.

Risk Calculations

Results

Example Final Graph



Key:

Severe Risk

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High Risk

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Medium Risk

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Low Risk

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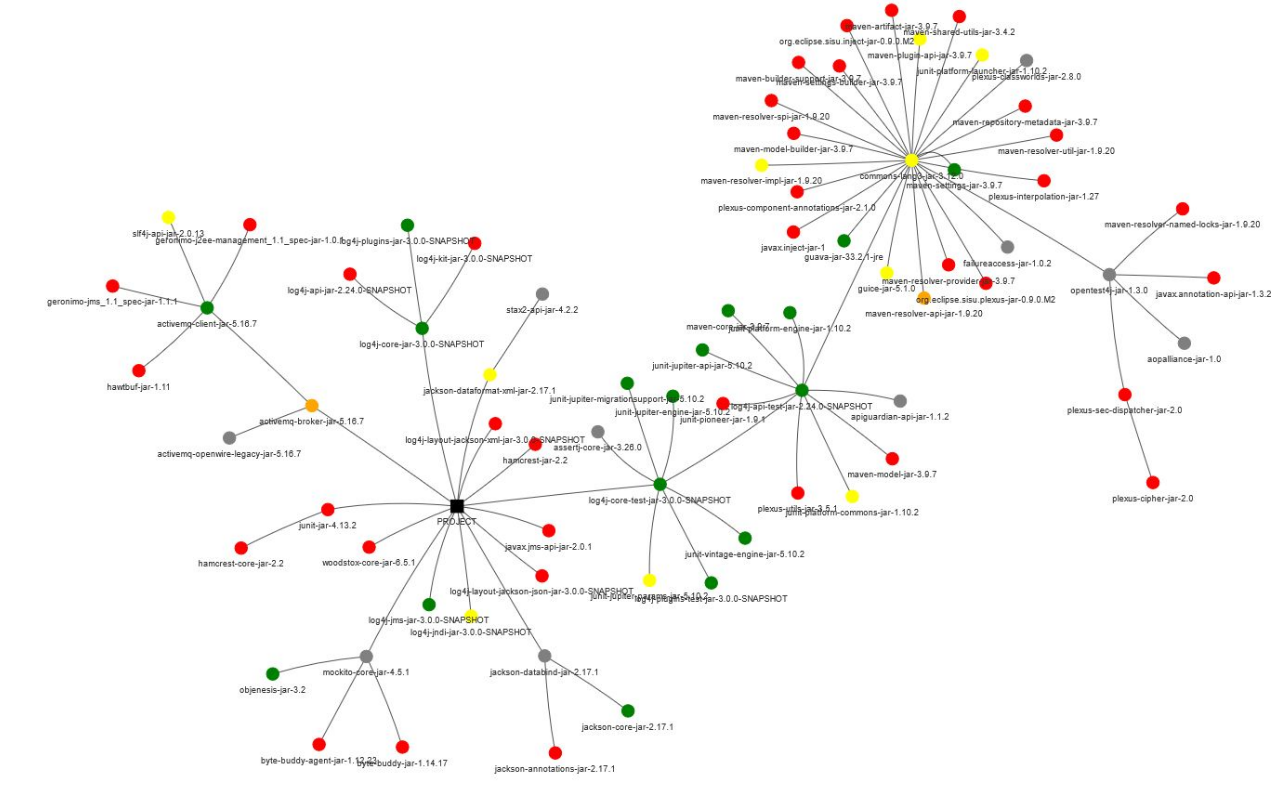
Not Enough Data

⬜



maven-artifact-jar-3.9.7
maven-shared-utils-jar-3.4.2
org.eclipse.sisu.inject-jar-0.9.0.M2
maven-plugin-api-jar-3.9.7
junit-platform-launcher-jar-1.10.2
plexus-classworlds-jar-2.8.0
maven-builder-support-jar-3.9.7
maven-settings-builder-jar-3.9.7
maven-resolver-spi-jar-1.9.20
maven-repository-metadata-jar-3.9.7
maven-model-builder-jar-3.9.7
maven-resolver-util-jar-1.9.20
maven-resolver-impl-jar-1.9.20
commons-lang3-jar-3.12.0
maven-settings-jar-3.9.7
plexus-interpolation-jar-1.27
plexus-component-annotations-jar-2.1.0
maven-resolver-named-locks-jar-1.9.20
javax.inject-jar-1
guava-jar-33.2.1-jre
failureaccess-jar-1.0.2
maven-resolver-provider-jar-3.9.7
guice-jar-5.1.0
opentest4j-jar-1.3.0
javax.annotation-api-jar-1.3.2
org.eclipse.sisu.plexus-jar-0.9.0.M2
maven-resolver-api-jar-1.9.20
aopalliance-jar-1.0
slf4j-api-jar-2.0.13
geronimo-j2ee-management_1.1_spec-jar-1.0.1
log4j-plugins-jar-3.0.0-SNAPSHOT
log4j-kit-jar-3.0.0-SNAPSHOT
log4j-api-jar-2.24.0-SNAPSHOT
geronimo-jms_1.1_spec-jar-1.1.1
activemq-client-jar-5.16.7
stax2-api-jar-4.2.2
log4j-core-jar-3.0.0-SNAPSHOT
maven-core-jar-3.9.7
junit-platform-engine-jar-1.10.2
hawtbuf-jar-1.11
junit-jupiter-api-jar-5.10.2
jackson-dataformat-xml-jar-2.17.1
junit-jupiter-migrationsupport-jar-5.10.2
log4j-api-test-jar-2.24.0-SNAPSHOT
junit-jupiter-engine-jar-5.10.2
apiguardian-api-jar-1.1.2
plexus-sec-dispatcher-jar-2.0
junit-pioneer-jar-1.9.1
activemq-broker-jar-5.16.7
log4j-layout-jackson-xml-jar-3.0.0-SNAPSHOT
assertj-core-jar-3.26.0
activemq-openwire-legacy-jar-5.16.7
hamcrest-jar-2.2
maven-model-jar-3.9.7
plexus-cipher-jar-2.0
log4j-core-test-jar-3.0.0-SNAPSHOT
plexus-utils-jar-3.5.1
junit-platform-commons-jar-1.10.2
junit-jar-4.13.2
PROJECT
hamcrest-core-jar-2.2
woodstox-core-jar-6.5.1
javax.jms-api-jar-2.0.1
junit-vintage-engine-jar-5.10.2
log4j-layout-jackson-json-jar-3.0.0-SNAPSHOT
junit-jupiter-params-jar-5.10.2
log4j-plugins-test-jar-3.0.0-SNAPSHOT
log4j-jms-jar-3.0.0-SNAPSHOT
log4j-jndi-jar-3.0.0-SNAPSHOT
mockito-core-jar-4.5.1
jackson-databind-jar-2.17.1
objenesis-jar-3.2
jackson-core-jar-2.17.1
byte-buddy-agent-jar-1.12.23
byte-buddy-jar-1.14.17
jackson-annotations-jar-2.17.1

Example Graph of Project Activity Risk Prediction

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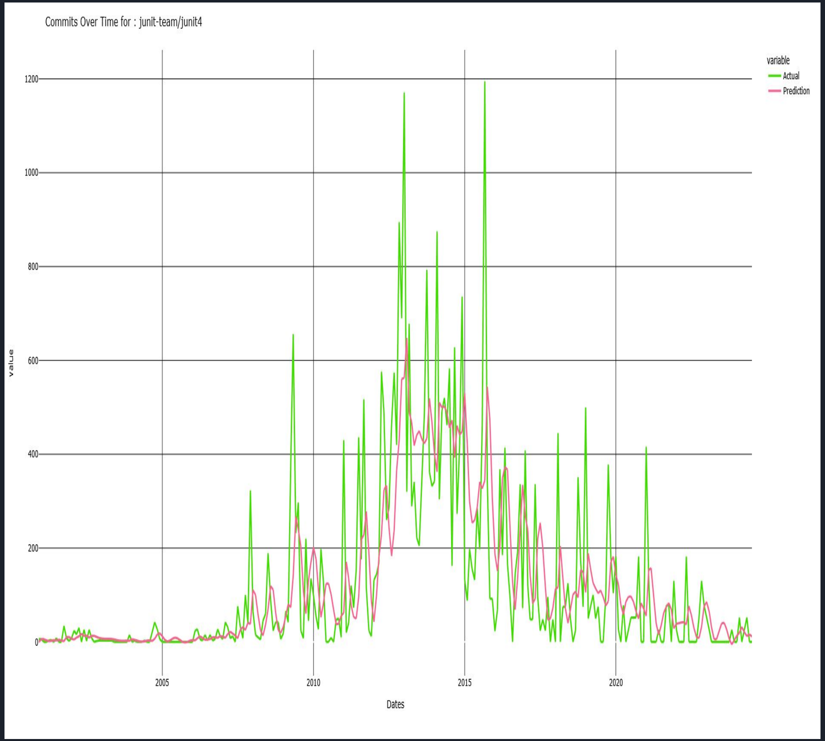

Example Graph of Vulnerability Risk Prediction

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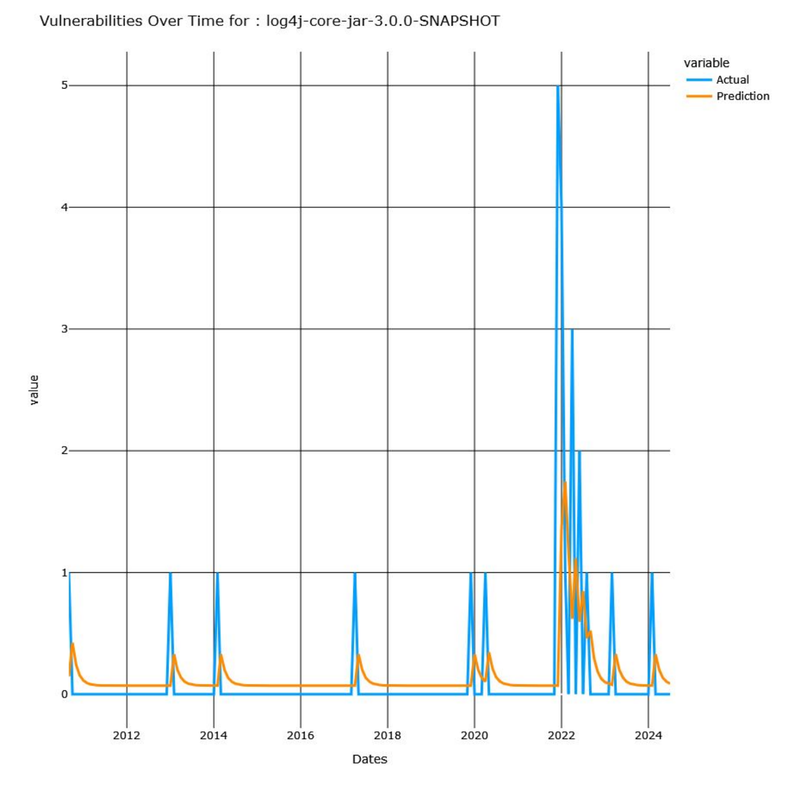

Technical Challenges

Student Contribution

Róisín Ní Bhriain

- Gitlab setup + Issues
- Literature Review
- Software
- Practicum Paper First + Second Draft

Sneha Dechamma Mallengada Suresh

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Conclusion

References

Thank You For Listening!