Towards Semantic Detection of Smells in Cloud Infrastructure Code

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Infrastructure as Code

“Infrastructure as code (IaC) is the process of managing and provisioning computer data centers through machine-readable definition files, rather than physical hardware configuration or interactive configuration tools.” ~ Wikipedia

Topology and Orchestration Specification for Cloud Applications

Infrastructure as Code: TOSCA

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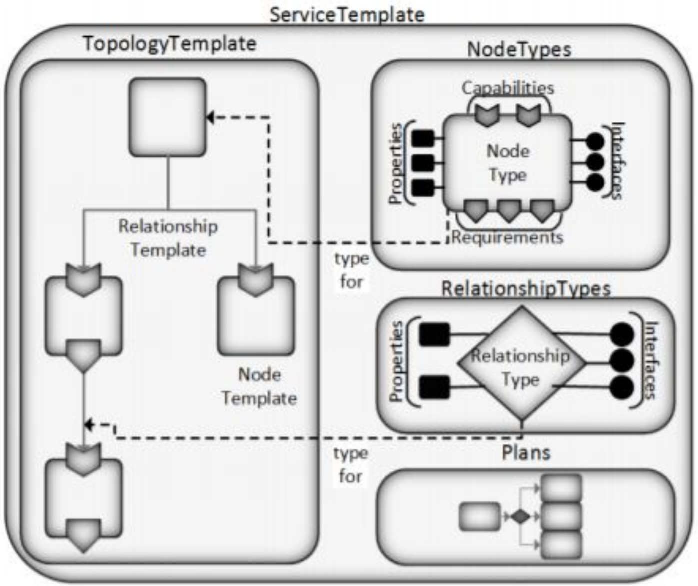

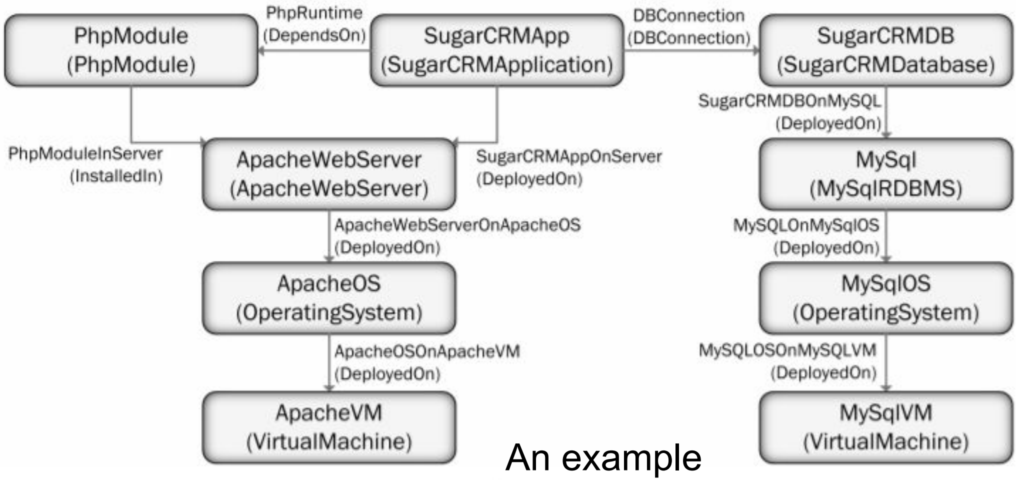

An example

TOSCA (open standard) is IaC technology agnostic, application domain agnostic, and infrastructure provider agnostic.

Problem: Smells in Infrastructure as Code

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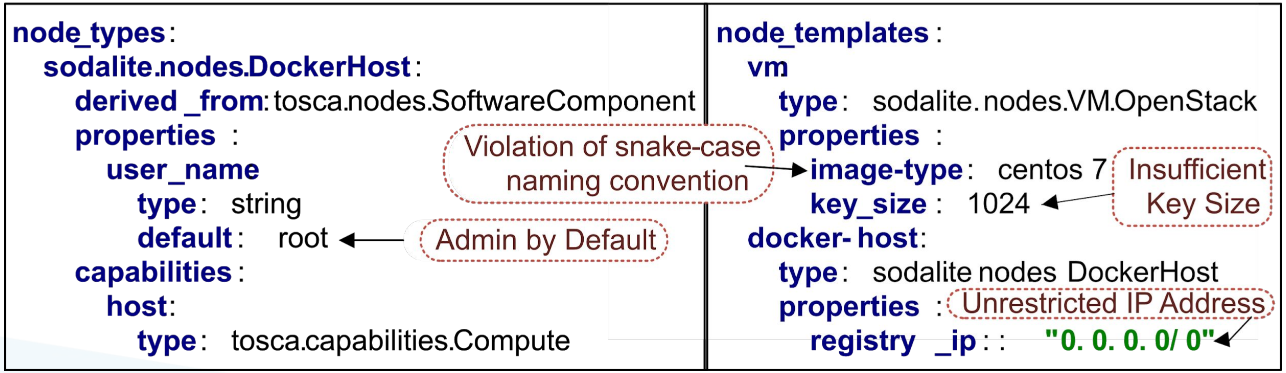
- A software smell is any characteristic in the artifacts of the software that possibly indicates a deeper problem or quality issue.



Our Approach to Detect Smells

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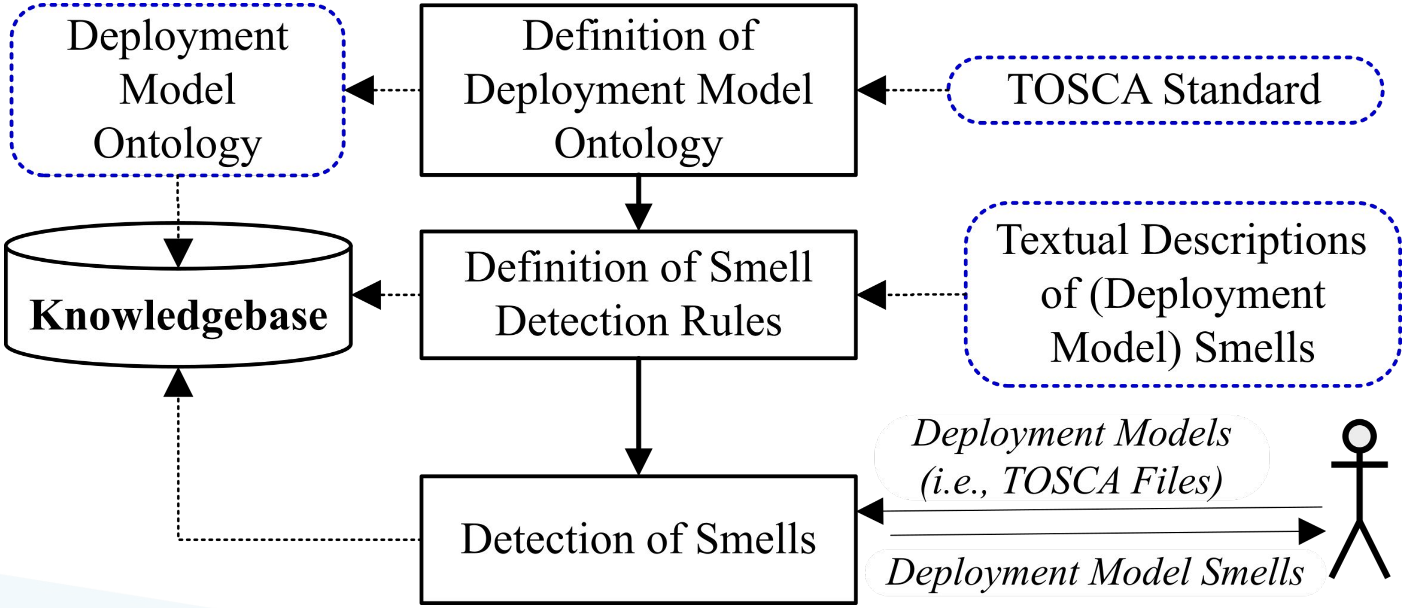

Deployment Model Ontology

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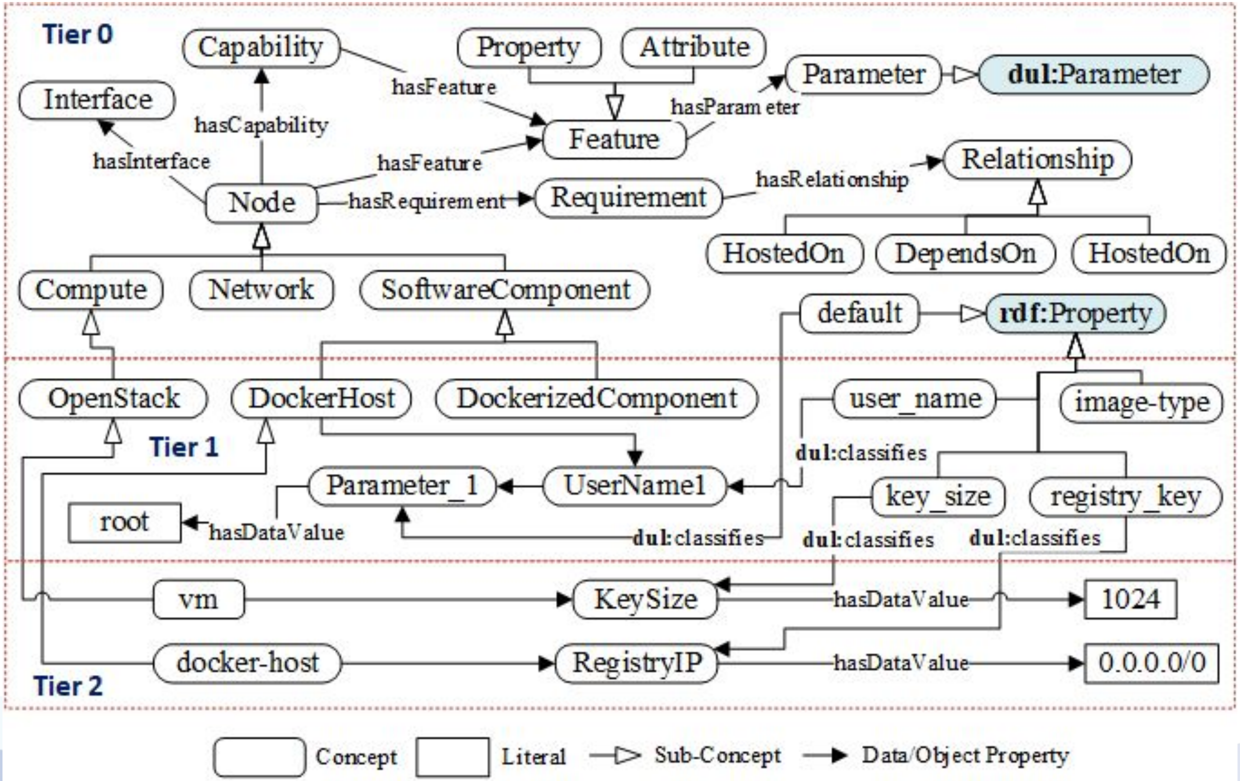
- Align with multi-level modeling of TOSCA
- Grounded on ontology design patterns

https://github.com/SODALITE-EU/semantic-models



Smell Detection Rules

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We primarily use SPARQL queries for specifying detection rules.

An Example: a rule for detecting admin by default.

```
select distinct ?property ?propertyDef
where {
    ?property DUL:classifies ?propertyDef.
    FILTER(regex(str(?propertyDef),"user(.+?)|(.+?)?user","i")).
    optional { # node type definitions - tier1
          ?property DUL:hasParameter ?p .
          ?p DUL:classifies tosca:default .
          ?p tosca:hasDataValue ?value.
       }.
    optional { # node template definitions - tier0
         ?property tosca:hasDataValue ?value.
       }.
    FILTER (bound(?value)).
    FILTER (str(?value) IN ('admin', 'root'))
}
```

All rules are at https://github.com/SODALITE-EU/defect-prediction

Smell Detection Rules (Cont'd)

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Smell	Smell Description	Abstract Detection Rule
Admin by default	Default users are administrative users.	isUser (x.name) $\wedge isAdmin(x.name)$
Empty password	A password as a zero-length string.	isPassword(x.name) $\wedge(isEmpty(x.value) \vee isEmpty(x.defaultValue))$
Hard-coded secret	Secrets such as usernames and passwords are hardcoded.	(isPassword(x.name) $\vee isUser(x.name) \vee isSecKey(x.name)) \wedge$ ((~isEmpty(x.value) ∧~isVariable(x.value)) ∨~isEmpty(x.defaultValue))
Suspicious comment	A comment includes the information indicating secrets and buggy implementations.	hasComment(x) $\wedge isSuspicious(x.comment)$
Unrestricted IP address	Using "0.0.0.0" or "::" as binding IP addresses of servers	isIP(x.name) $\wedge(isInvalidBind(x.value) \vee isInvalidBind(x.defaultValue))$
Insecure communication	Using insecure communication protocols, instead of their secure counterparts	(isURL(x.value) $\wedge isInsecure(x.value)) \vee$ (isURL(x.defaultValue) $\wedge isInsecure(x.defaultValue))$
Weak crypto. algo.	Use of weak cryptography algorithms such as MD5 and SHA1	hasWeakAlgo(x.value) $\vee hasWeakAlgo(x.defaultValue)$
Insufficient key Size	The size of a key used by an encryption algorithm is less than the recommended key size, e.g., 2048 bits for RSA.	isCryptoKeySize(x.name) $\wedge(hasInsufficientKeySize(x.value)$ $\vee hasInsufficientKeySize(x.defaultValue))$
Inconsistent naming convention	The conventions used for naming nodes, properties, attributes, etc., are inconsistent.	(case=='CamelCase' $\rightarrow isCamelCase(x.name)) \vee (case ==' SnakeCase'$ $\rightarrow isSnakeCase(x.name)) \vee (case ==' DashCase' \rightarrow isDashCase(x.name))$
Invalid port ranges	TCP port values are not within the range from 0 to 65535.	isPort(x.name) $\wedge(outOfRange(x.value) \vee outOfRange(x.defaultValue))$

All SPARQL rules are at
https://github.com/SODALITE-EU/defect-prediction

Prototype and Evaluation

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Validated with three industrial case studies of SODALITE H2020 project

1. In-silico clinical trials for spinal operations
2. Vehicle IoT Use Case
3. Water availability prediction with mountains images

Demo - https://www.youtube.com/watch?v=IThr5vlleTI

Conclusion and Future Work

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- We presented an approach that can formally model a cloud application deployment model with ontologies, and detect the smells in the model with ontological reasoning.
- Ongoing works
  - Extend the semantic models to specify smells, their causes, and their fixes.
  - Extend the rule-base to cover all smells identified by a systematic literature review on infrastructure code smells.

Conclusion and Future Work

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- Ongoing works
  - Build a unified framework to detect smells across heterogeneous deployment and infrastructure code specifications by utilizing semantic Web techniques such as ontology mapping, alignment, and query rewriting

Questions

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