Software Architecture Reconstruction for Microservice Systems using Static Analysis via GraalVM Native Image

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March 13, 2024

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A holistic perspective is often **missing**.

- **Software Architecture Reconstruction (SAR)** for microservices generates high-level architectural views:

*https://www.iso.org/obp/ui/#iso:std:iso-iec-ieee:42010:ed-2:v1:en

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  - Views are common for describing software architecture*
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- Necessary precondition for detecting microservice smells:
  - wrong cuts
  - shared persistency
  - cyclic dependencies

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- Dynamic Analysis
  - Requires a runtime environment
- Static Analysis
  - Needs only the source code without execution
  - Traditional methods not suitable for SAR
  - Source code might not be available

Our Proposal

Perform **SAR** using static analysis on Java bytecode.

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- Does not need source code
  - Can analyze libraries, third-party dependencies, and legacy code

GraalVM Native Image

- Ahead-of-time (AOT) compiler for Java
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- Highly popular in the industry
  - Support from all major frameworks including Spring, Micronaut, Quarkus, and Helidon
- Industrial-grade static analysis
  - To detect reachable program elements
  - We can reuse the domain classes and tools

- Graal Intermediate Representation (Graal IR)
  - Well-documented
  - Visualization tool Ideal Graph Visualizer
    - Inspect the IR
    - Detect high-level patterns

SAR using GraalVM Native Image

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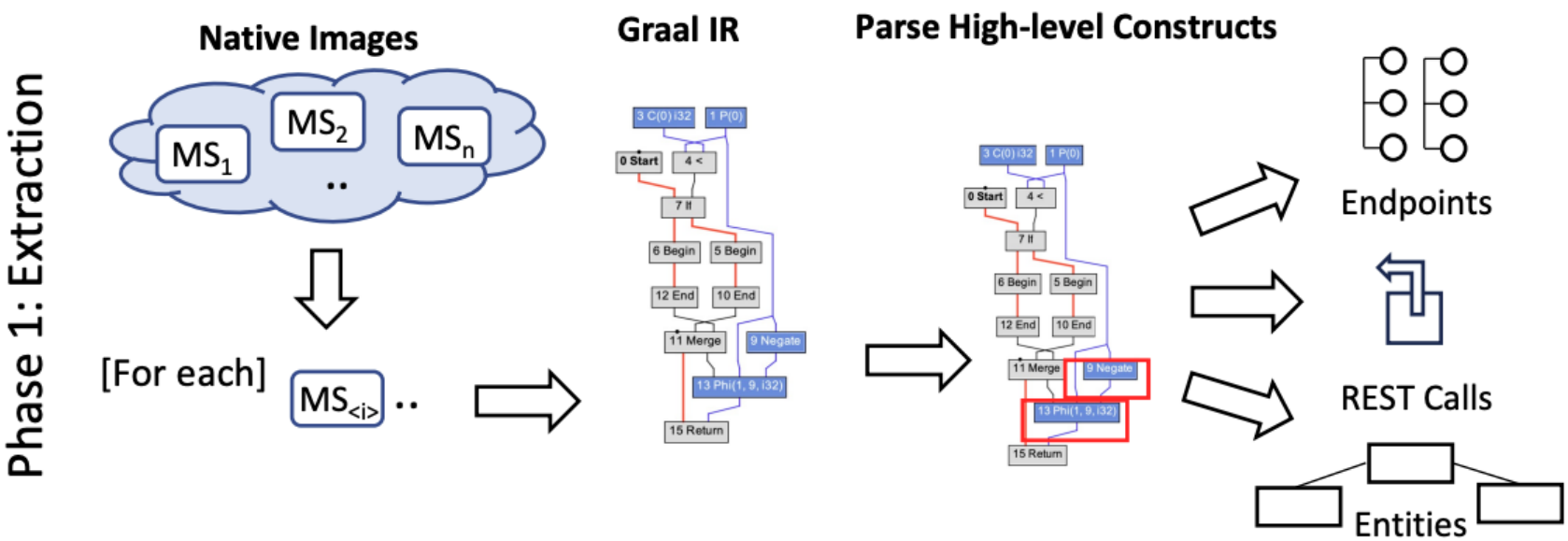
    - Inspect the IR
    - Detect high-level patterns
- Open-source
  - We can modify it easily

Phase 1: Extraction

First, we process each microservice using annotation scanning and pattern matching on the IR to extract:

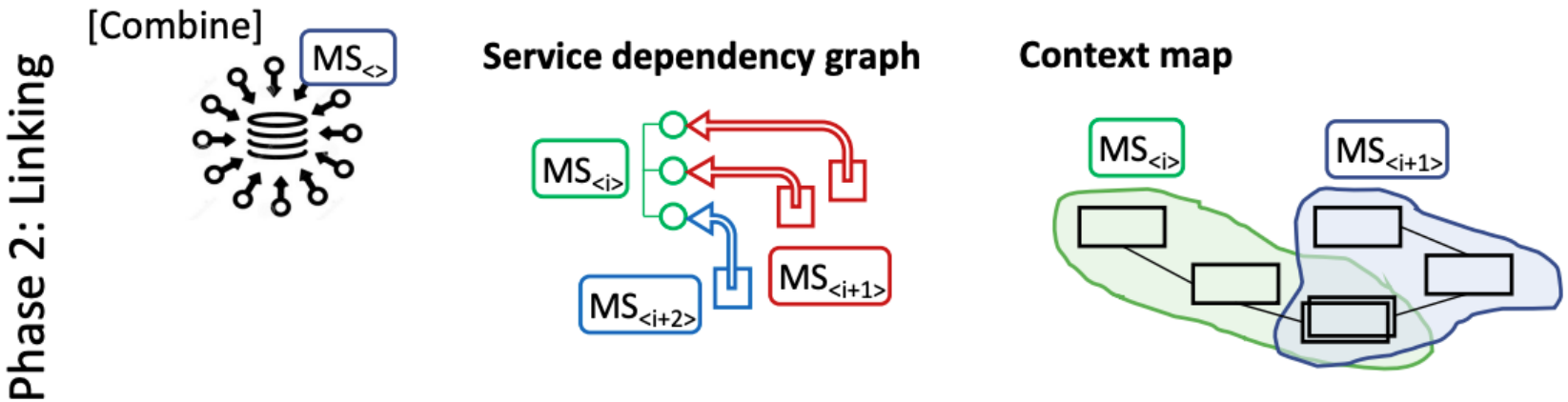
- Rest Endpoints
- Rest Calls
- Database Schema



Phase 2: Linking

Second, we combine the per-microservice domain data to generate SAR views:

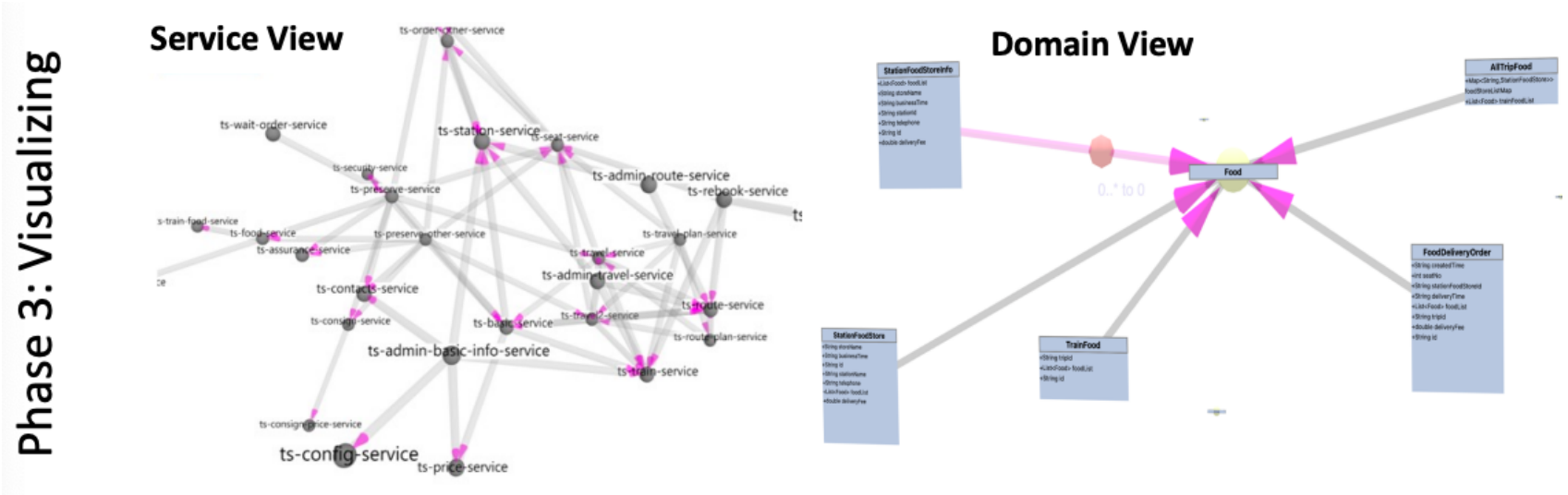
- Rest Calls linked with Rest Endpoints
- Database schemata merged based on equivalent entities between them



Phase 3: Visualization

Third, we visualize the obtained data to present a holistic view of the system:

- Service view – interaction among services
- Domain view – relations between database entities



Evaluation and Validation

We built a proof of concept - MicroGraal*:

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- Evaluation performed on 2018 MacBook Pro
  - Analysis Time **15s** per benchmark
  - Average Memory Consumption **850 MB**

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- Evaluation performed on 2018 MacBook Pro
  - Analysis Time **15s** per benchmark
  - Average Memory Consumption **850 MB**
- The analysis can be done locally

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Compared with:

- Manual analysis – taken as the ground truth
- Walker et al. 21* using static analysis of source code

Table: Service Dependency Graph Data Analysis

Numbers/Approaches	Manual	Source	Bytecode
REST Calls	146	146	146
Endpoints	261	261	261
Request Pairs in SDG	142	114	123
Links in SDG	90	82	82

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Table: TrainTicket: Context Map Data Analysis

Numbers/Approaches	Manual	Source	Bytecode
Entity Bounded Context	117	108	116
Relation Bounded Context	43	39	43
Entity Context Map	84	76	84
Relation Context Map	24	20	24

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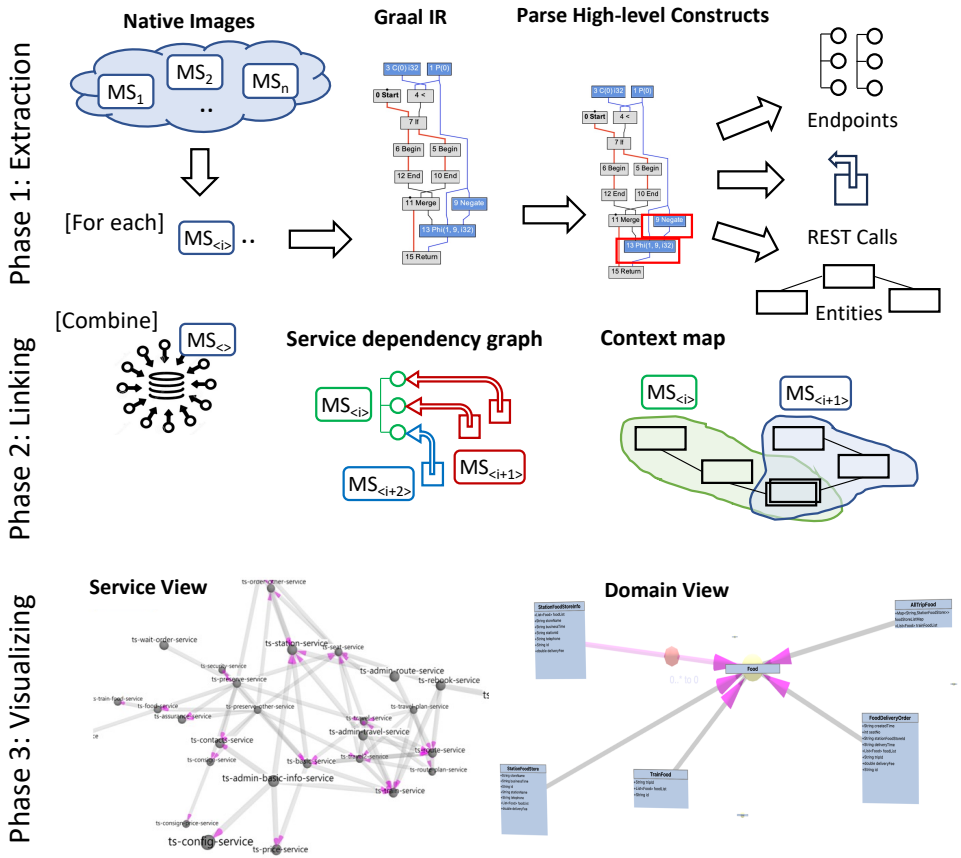

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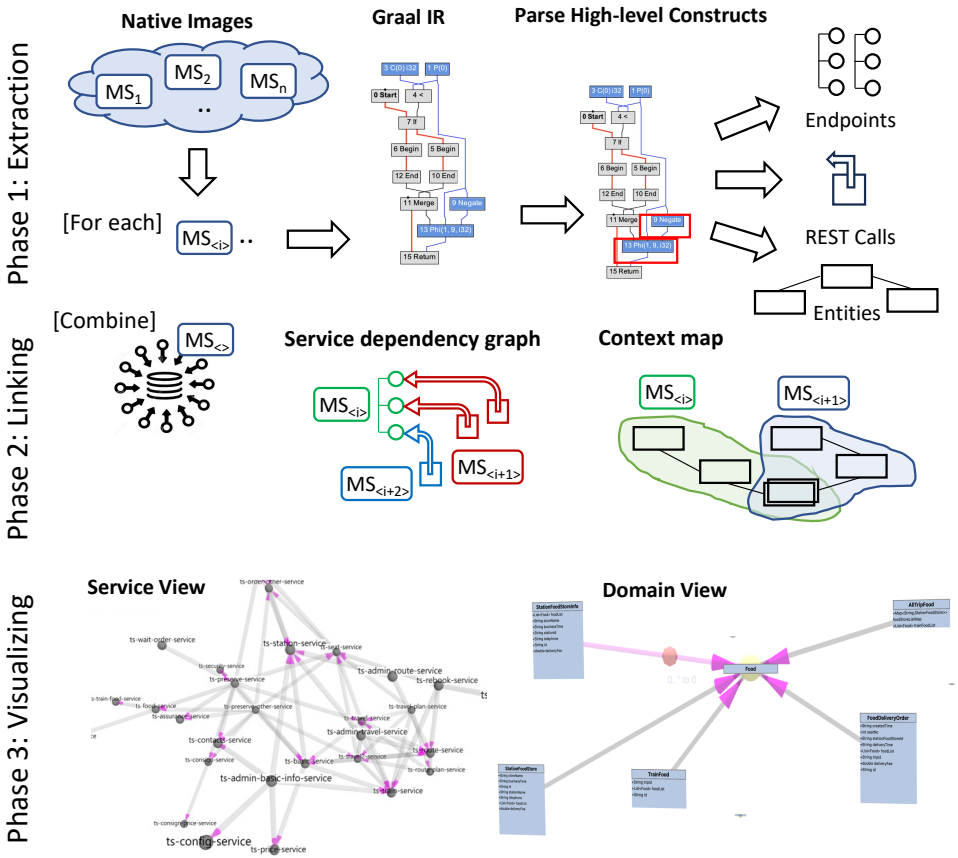

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- Future work:
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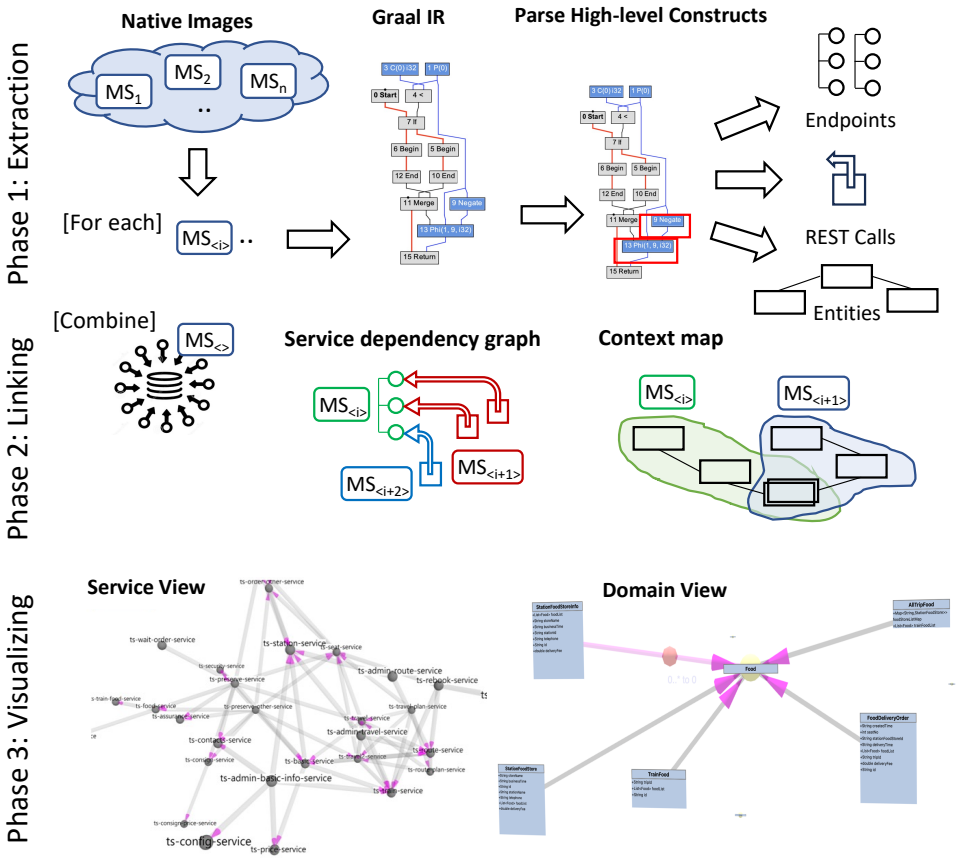

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