University of Stuttgart

Hochschule Reutlingen
Reutlingen University

Towards an
**Architecture-centric Methodology
for Migrating to Microservices**

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14.09.2022

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On the public forum, tech leaders proclaim: "Just move to the cloud, or you won't be competitive".
Then it turns out the migration process is shrouded in complexity as no realistic answers are easily available online.
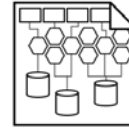
Marek Gajda
CTO, The Software House
https://tsh.io/blog/cloud-migration/

Application Modernization: Migrating to Microservices

New architectural pattern / paradigm for app. development
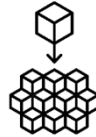
Companies struggle to migrate their existing applications

Research Topic
Application Modernization:
Refactoring to Microservices

Research Objective and Questions

Design, implement and evaluate
A practically applicable methodology
For migrating monolithic applications toward a Microservices architecture

RQ1: What are **intentions**, **strategies** and **challenges** in the context of migrating existing systems to Microservices?

RQ2: What **architectural refactoring techniques** are applicable in the context of decomposing a system into Microservices?
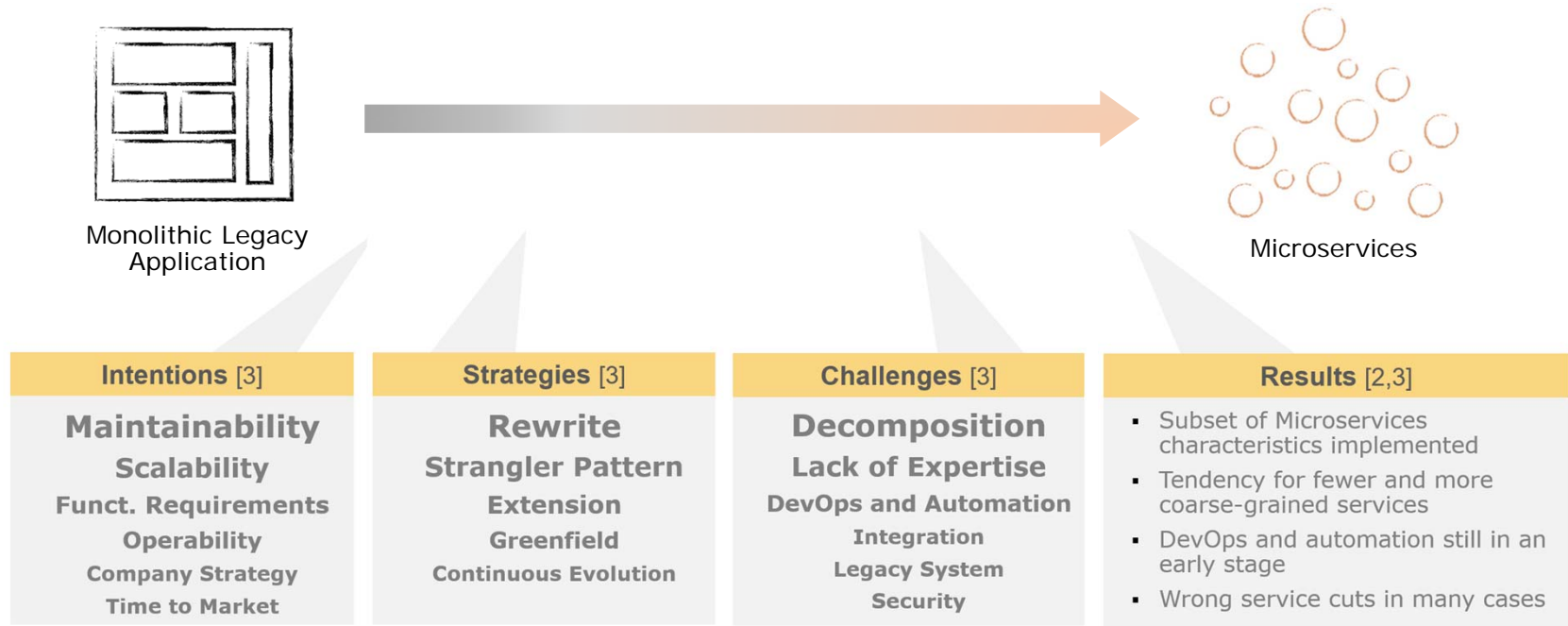
RQ3: What are relevant **quality attributes** and **metrics** for evaluating the appropriateness of service partitioning and service granularity?

RQ4: How can a practically applicable **migration methodology** guide architects?
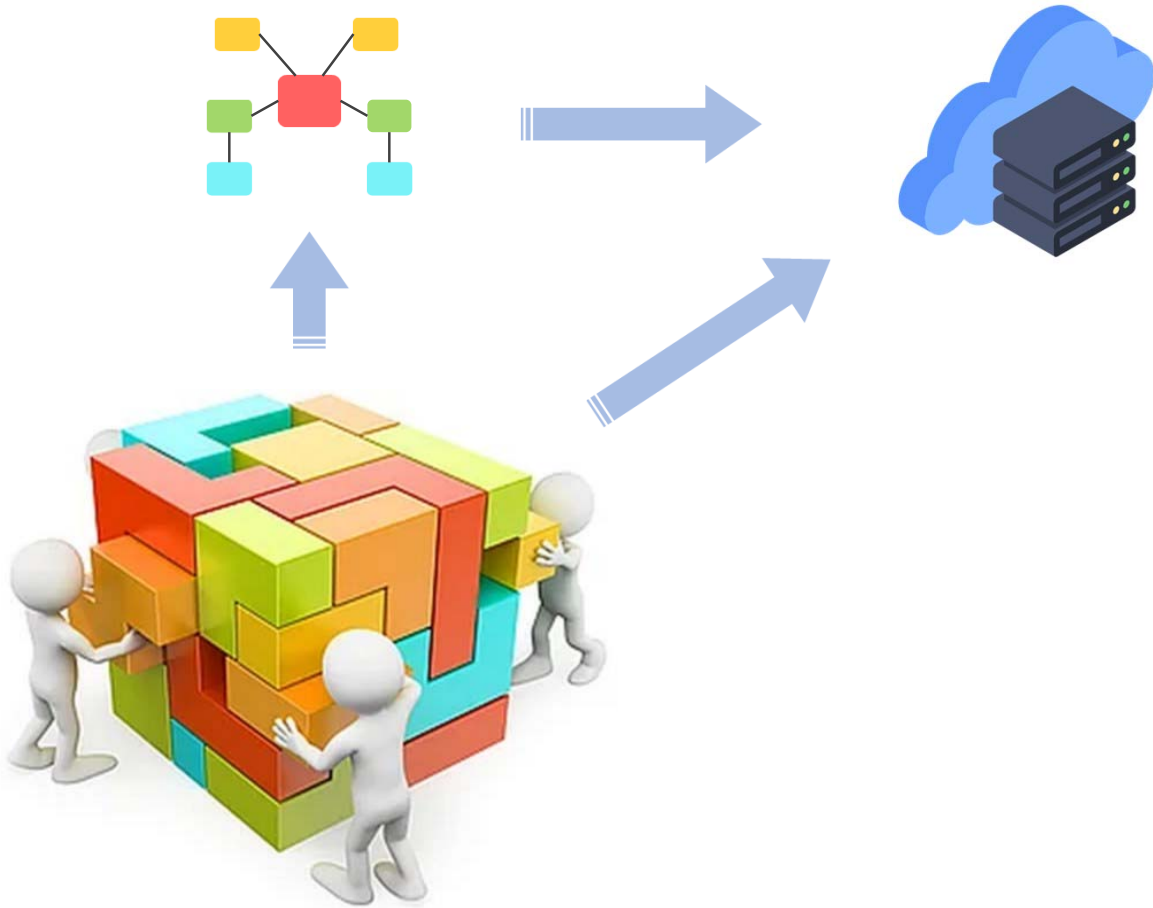
RQ1: Intentions, Strategies, Challenges:

Interview Study with 16 Practitioners from 10 German-based Companies, 14 Systems [2, 3]

Monolithic Legacy Application

Microservices

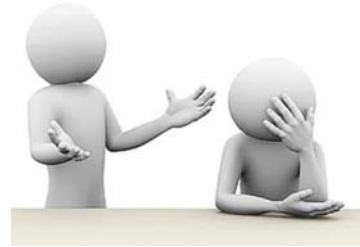| Intentions [3]	Strategies [3]	Challenges [3]	Results [2,3]
Maintainability	**Rewrite**	**Decomposition**	• Subset of Microservices characteristics implemented
Scalability	**Strangler Pattern**	**Lack of Expertise**	• Tendency for fewer and more coarse-grained services
Funct. Requirements	**Extension**	**DevOps and Automation**	• DevOps and automation still in an early stage
Operability	**Greenfield**	**Integration**	• Wrong service cuts in many cases
Company Strategy	**Continuous Evolution**	**Legacy System**	
Time to Market		**Security**	

[2] J. Bogner, J. Fritzsch, S. Wagner, A. Zimmermann, "Microservices in Industry: Insights into Technologies, Characteristics, and Software Quality.", in IEEE International Conference on Software Architecture Workshops (ICSA-W) IEEE Computer Society, Hamburg, Germany, **2019**
[3] J. Fritzsch, J. Bogner, S. Wagner, A. Zimmermann, "Microservices Migration in Industry: Intentions, Strategies, and Challenges", in 2019 IEEE International Conference on Software Maintenance and Evolution (ICSME), Cleveland (Ohio), USA, **2019**
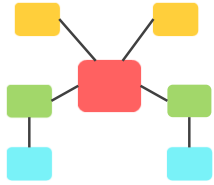
- Refactoring is a complex task

- Time- and resource-intensive

- Re-organization and process adaption

Scientific Studies

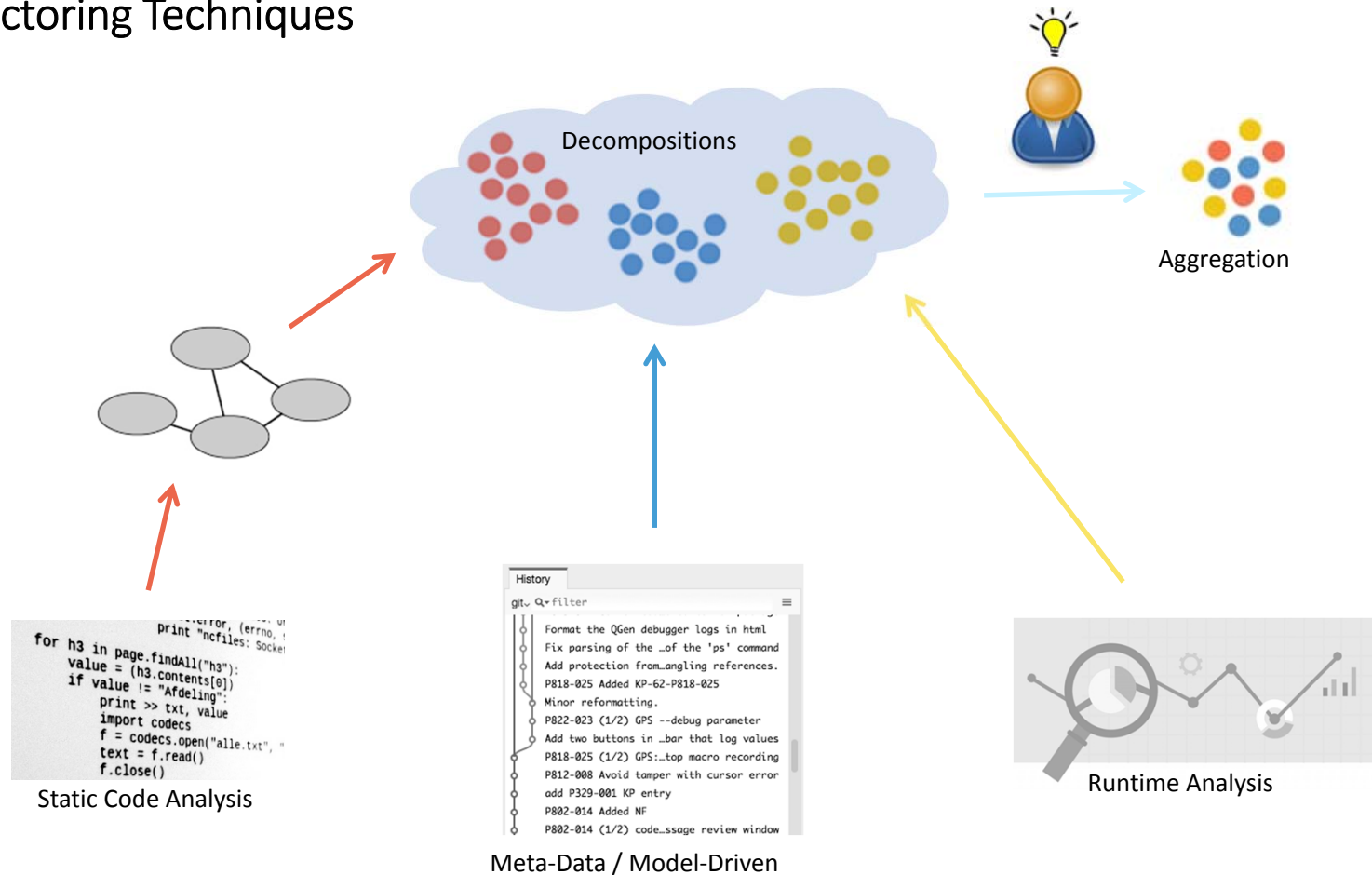|	
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An Automatic Extraction Approach - Transition to Microservices Architecture from Monolithic Application	SA
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Unsupervised learning approach for web application auto-decomposition into microservices	SA
Using Microservices for Legacy Software Modernization	MD+SA

RQ2: Refactoring Techniques

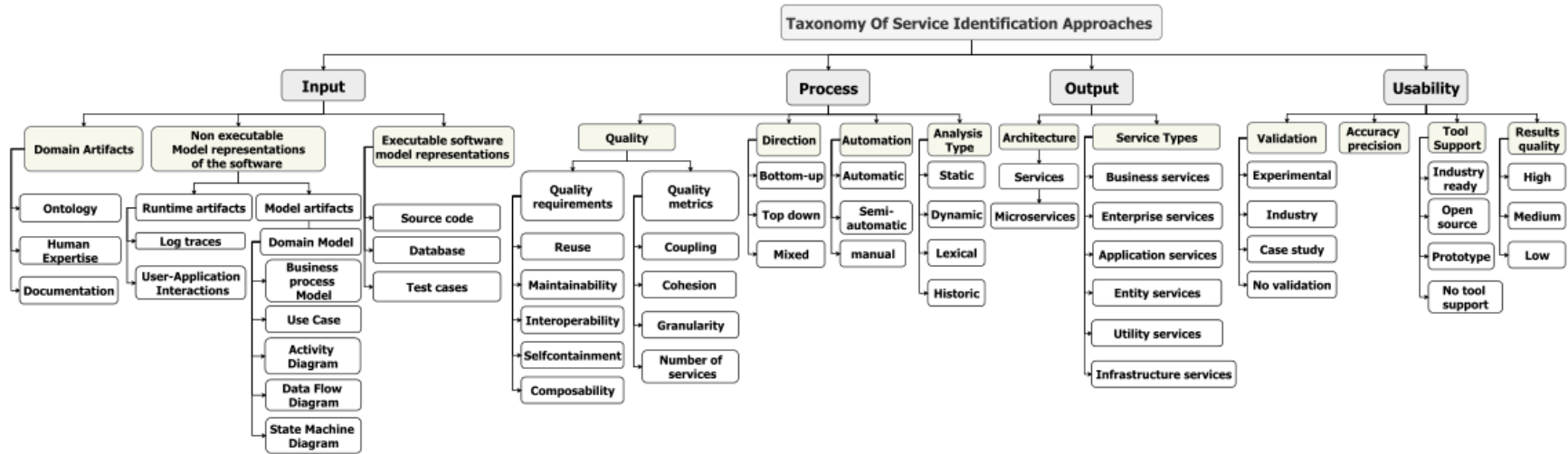Literature Review and Classification of **10** Refactoring Approaches [1]

#	Approach	Authors (Year)
1	Towards the understanding and evolution of monolithic applications as microservices	Escobar, et. al. (2016)
2	Towards a Technique for Extracting Microservices from Monolithic Enterprise Systems	Levcovitz, et. al. (2016)
3	Requirements reconciliation for scalable and secure microservice (de)composition	Ahmadvand, et. al. (2016)
4	Microservices Identification Through Interface Analysis	Baresi, et. al. (2017)
5	Service Cutter: A systematic approach to service decomposition	Gysel, et. al. (2016)
6	Extraction of Microservices from Monolithic Software Architectures	Mazlami, et. al. (2017)
7	GranMicro: A Black-Box Based Approach for Optimizing Microservices Based Applications	Mustafa, et. al. (2017)
8	Microservice Ambients: An Architectural Meta-Modelling Approach for Microservice Granularity	Hassan, et. al. (2017)
9	Workload-based Clustering of Coherent Feature Sets in Microservice Architectures	Klock, et. al. (2017)
10	Towards a MicroServices Architecture for Clouds	Procaccianti, et. al. (2016)

[1] J. Fritzsch, J. Bogner, A. Zimmermann, S. Wagner, "From Monolith to Microservices: A Classification of Refactoring Approaches", in Software Engineering Aspects of Continuous Development and New Paradigms of Software Production and Deployment. Cham: Springer International Publishing, **2019**, pp. 128–141.

Refactoring Techniques

Decompositions

Aggregation

Static Code Analysis

Meta-Data / Model-Driven

Runtime Analysis

A Taxonomy of Service Identification Approaches [4]

Taxonomy Of Service Identification Approaches

Input — Process — Output — Usability

[4]   M. Abdellatif *et al.*, "A taxonomy of service identification approaches for legacy software systems modernization," *J. Syst. Softw.*, vol. 173, p. 110868, Mar. 2021.

Limitations of Existing Migration/Refactoring Approaches

- 10 Refactoring/Migration Approaches reviewed in 2018 [1]

- 31 Refactoring/Migration Approaches reviewed in 2020

  ➢ focus on different requirements and quality attributes

  ➢ applicability limited to certain technologies, languages, architectures
     (e.g. MVC-Pattern, Java-based or web applications)

  ➢ based of different techniques (see classification in [1])

  ➢ no or only experimental tool support

  ➢ evaluation often insufficient

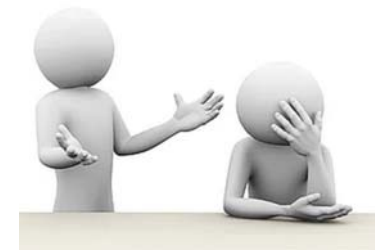 ➢ **not considered** by practitioners, or unknown to them [3]
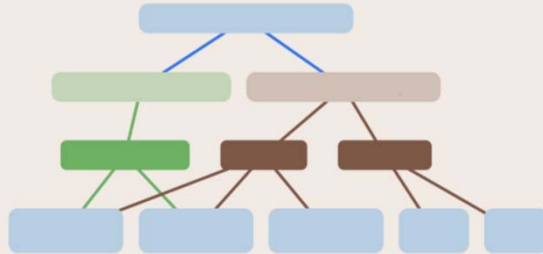
Scientific Studies

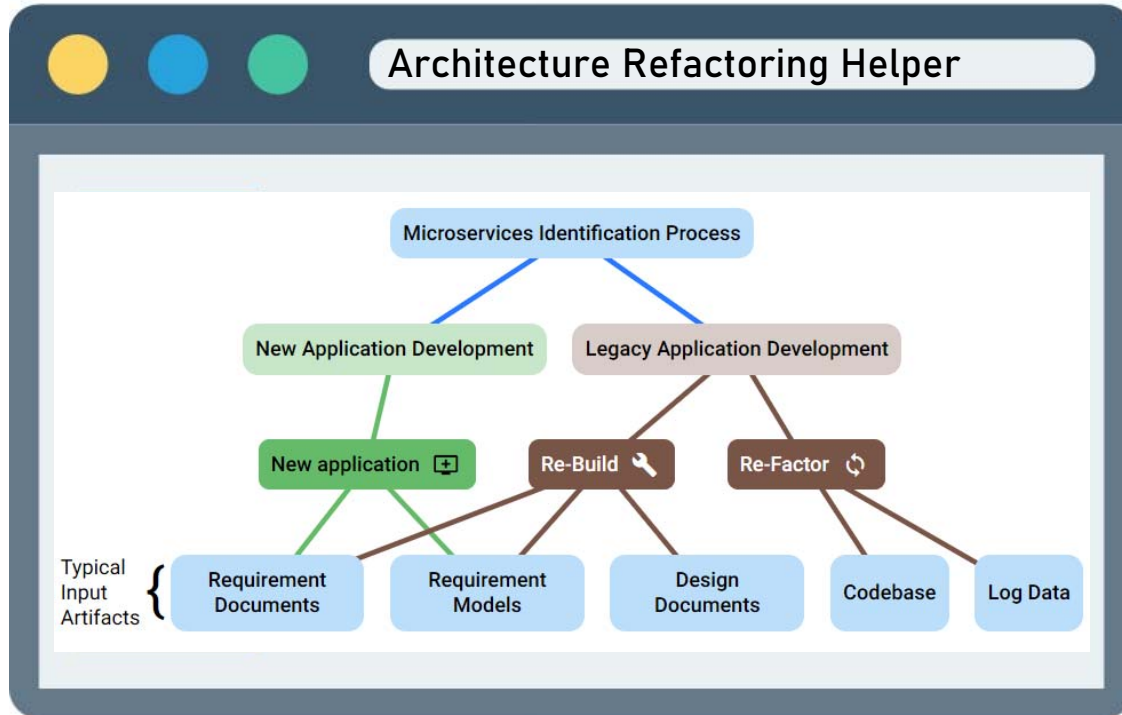|	
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Architecture Refactoring Helper

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Architecture Refactoring Helper

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100%	5	Reverse engineering relational databases to identify and specify basic Web services with respect to service oriented computing	Baghdadi, Youcef	👁 ∧
100%	9	Microservices Identification Through Interface Analysis	Baresi, Luciano; Garriga, Martin; Renzis, Alan	👁 ∧
100%	18	From a Monolith to a Microservices Architecture: An Approach Based on Transactional Contexts	Nunes, Luís; Santos, Nuno; Rito Silva, António	👁 ∧
80%	1	Functionality-oriented Microservice Extraction Based on Execution Trace Clustering	W. Jin, T. Liu, Q. Zheng, D. Cui and Y. Cai	👁 ∧
75%	13	Discovering Microservices in Enterprise Systems Using a Business Object Containment Heuristic	De Alwis, Adambarage Anuruddha Chathuranga; Barros, Alistair; Fidge, Colin; Polyvyanyy, Artem	👁 ∧
67%	16	From Monolithic Systems to Microservices: A Decomposition Framework based on Process Mining	Taibi, Davide; Systä, Kari	👁 ∧
50%	3	From objects to services: toward a stepwise migration approach for Java applications	Marchetto, Alessandro; Ricca, Filippo	👁 ∧
50%	7	A method to identify services using master data and artifact-centric modeling approach	Huergo, Rosane S.; Pires, Paulo F.; Delicato, Flavia C.	👁 ∧

Proposed Framework [5]

[5] J. Fritzsch, J. Bogner, M. Haug, S. Wagner, and A. Zimmermann, "Towards an Architecture-centric Methodology for Migrating to Microservices," Jul. 2022.
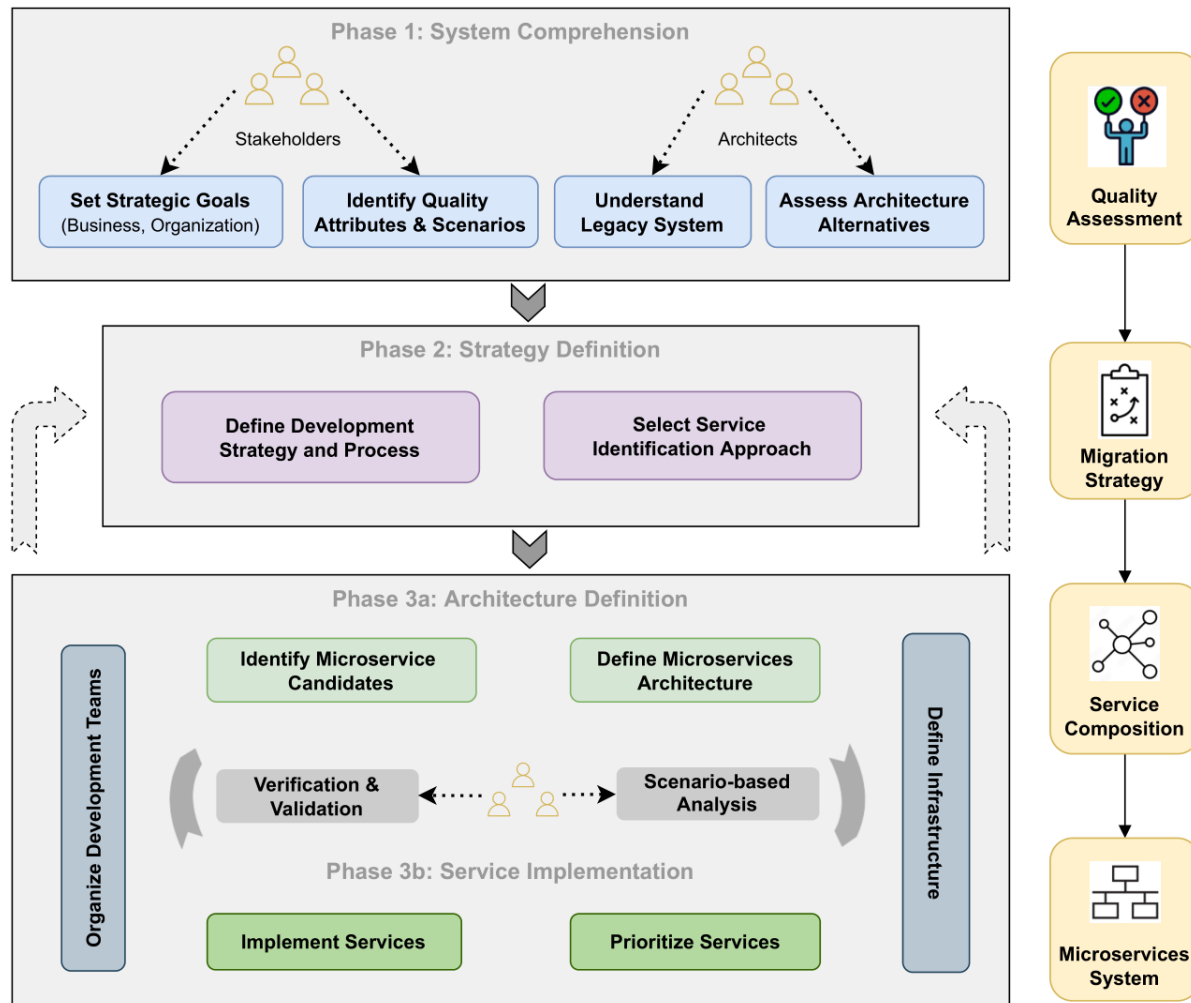
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Quality Model

Quality Model

System Properties

Granularity	Isolation
Coupling	Autonomy
Cohesion	Complexity
Technology Heterogeneity	

Monolith Architecture → *Impact Factors* → Migration Approach → Decomposition → *Impact Factors* → Architectural Pattern (Best Practice) → Microservice Architecture

MS MS MS MS MS

Quality Attributes

Reliability
- Availability
- Health Management (Fault Tolerance)
- Recoverability

Compatibility
- Interoperability
- Co-Existence

Security
- Confidentiality
- Accountability
- Authenticity
- Integrity

Performance
- Time Behavior
- Resource Utilisation
- Capability

Scalability

Portability
- Installability
- Replaceability
- Adaptability
- Agility
- Deployability

Maintainability
- Modifiability
- Testability
- Manageability
- Modularity
- Analysability
- Monitorability
- Reusability
- Understandability

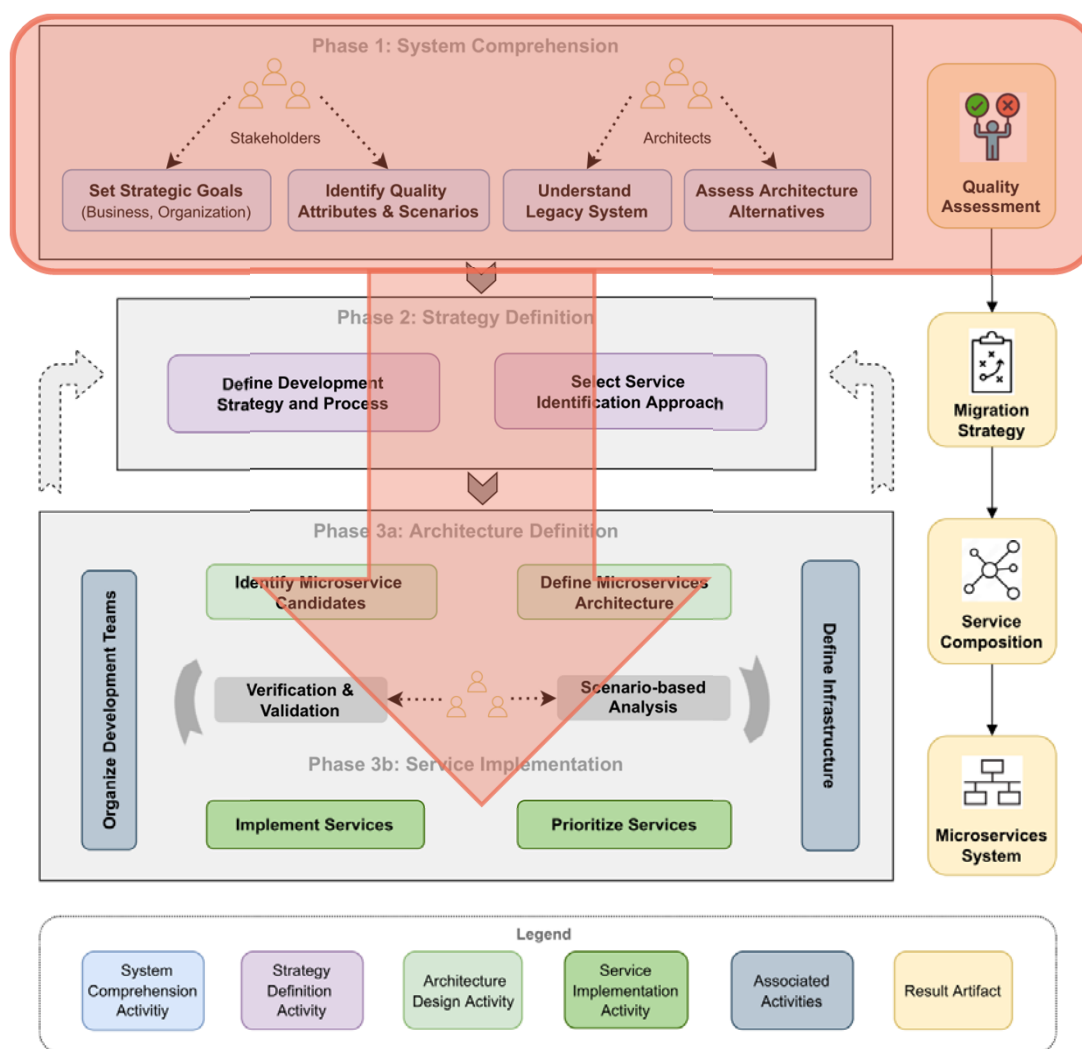**Business Attributes**
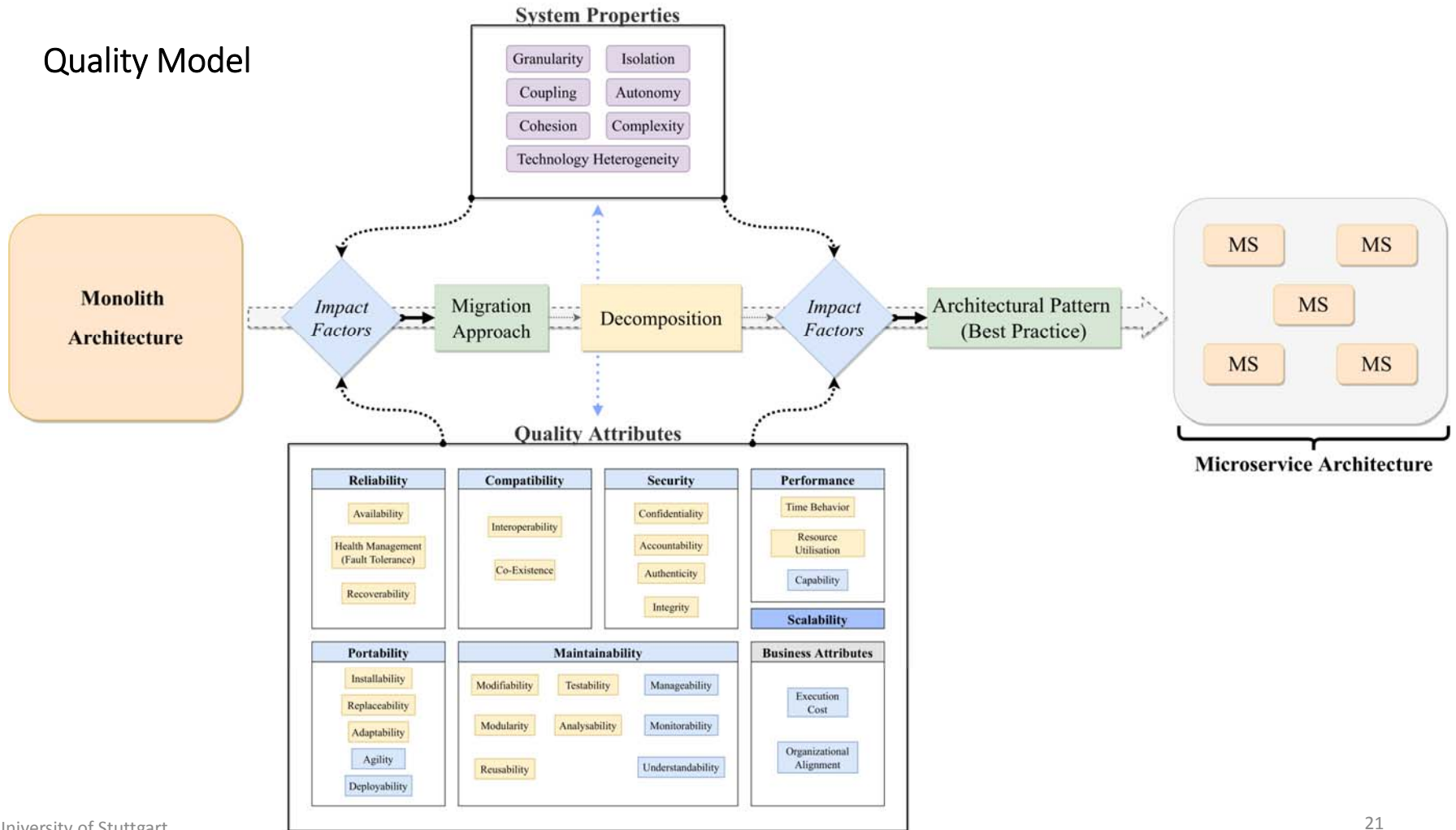- Execution Cost
- Organizational Alignment

Proposed Framework [5]

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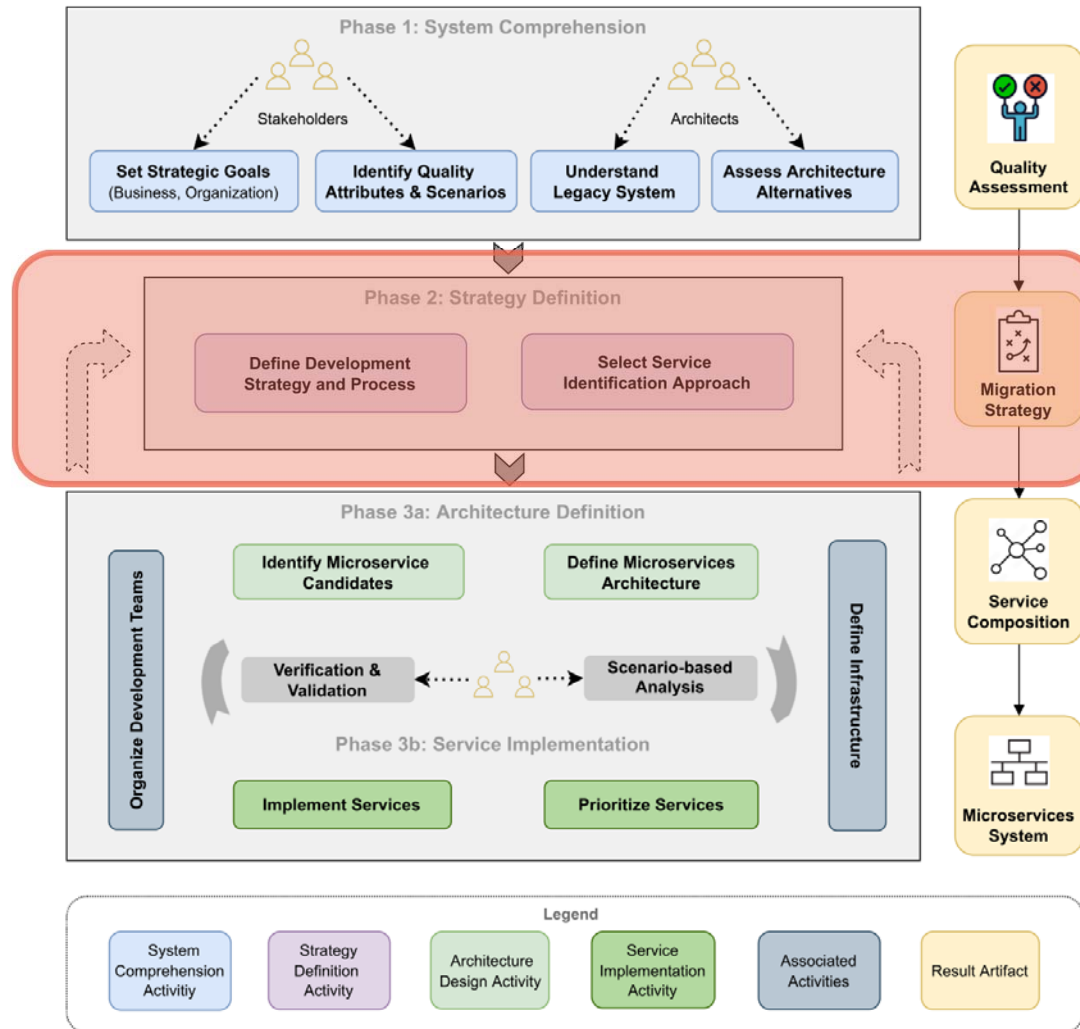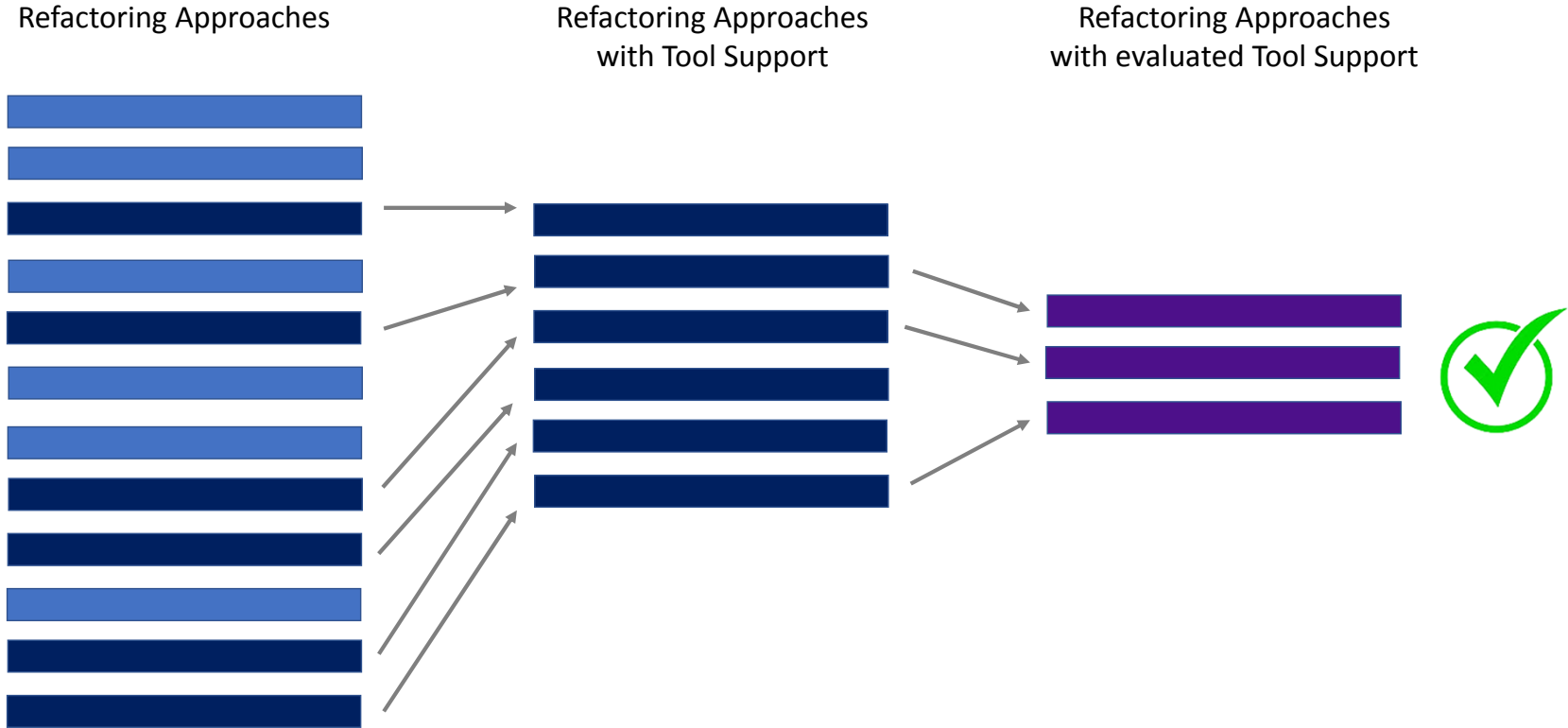
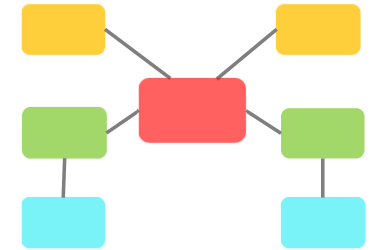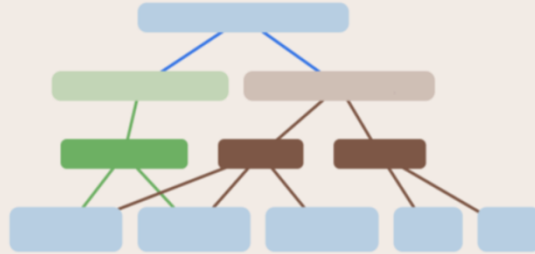

Evaluate Tool Support
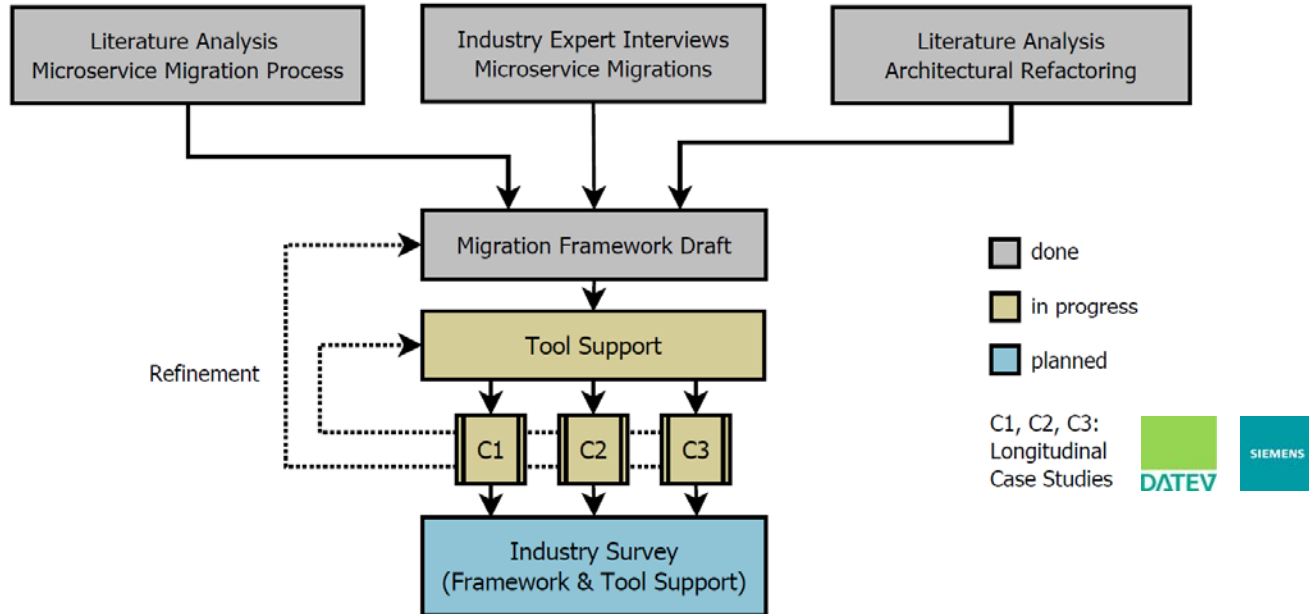
Focus: Approaches with Tool Support

Refactoring Approaches

Refactoring Approaches
with Tool Support

Refactoring Approaches
with evaluated Tool Support

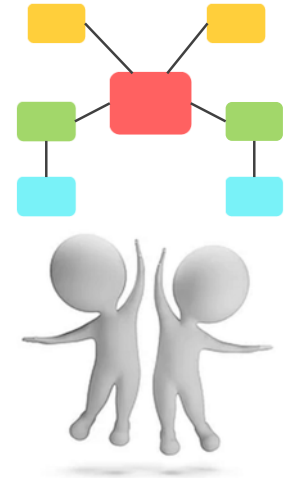Architecture Refactoring Helper

Research Progress

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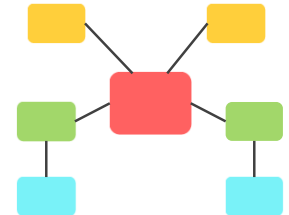Feedback

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Feedback

Thank you.

Jonas Fritzsch

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