Master Thesis: Final Talk

Investigating Quality Attributes and Best Practices of Microservices Architectures

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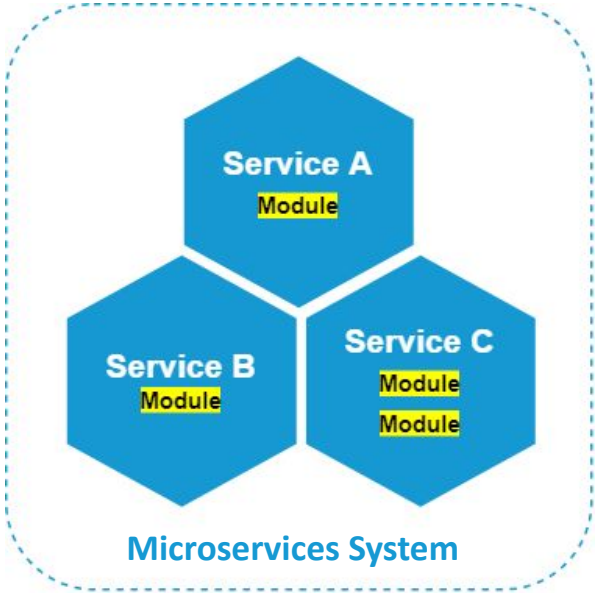
Outline

- Background
- Problem Statement
- Research Questions
- Research Approach
- Results
- Conclusion
- Future Work
- Summary

Background

- Microservice Architectures (MSA) present viable **solutions** to modern problems
- MSA offer increased **scalability**, low **coupling**, high **resilience**, independent **deployment**
- MSA pose **novel** challenges in essential software engineering activities



Background

- Tackling the high **complexity** in building software systems feasibly with the MSA pattern
  - *Design Guideline:* A fundamental **directive** which maintains certain rules and responsibilities, and impacts a **specified** scope of the system architecture

- Understanding how quality is **conceptualized** and **described** in MSA
  - *Quality Characteristic:* An **intrinsic** property of a service that gives it the ability to **satisfy** stakeholder requirements

Problem Statement

- **Unstructured** and unorganized information on **design guidelines** used to construct MSA
- Lack of information on how to **adopt** and exercise such guidelines
- Lack of **standardised** concepts that can enable targeted **quality** assurance of MSA
- Perceived lack of **depth** and **specificity** with respect to describing quality in MSA
- **Ambiguity** on how the design guidelines concretely **affect** quality in MSA

Research Questions

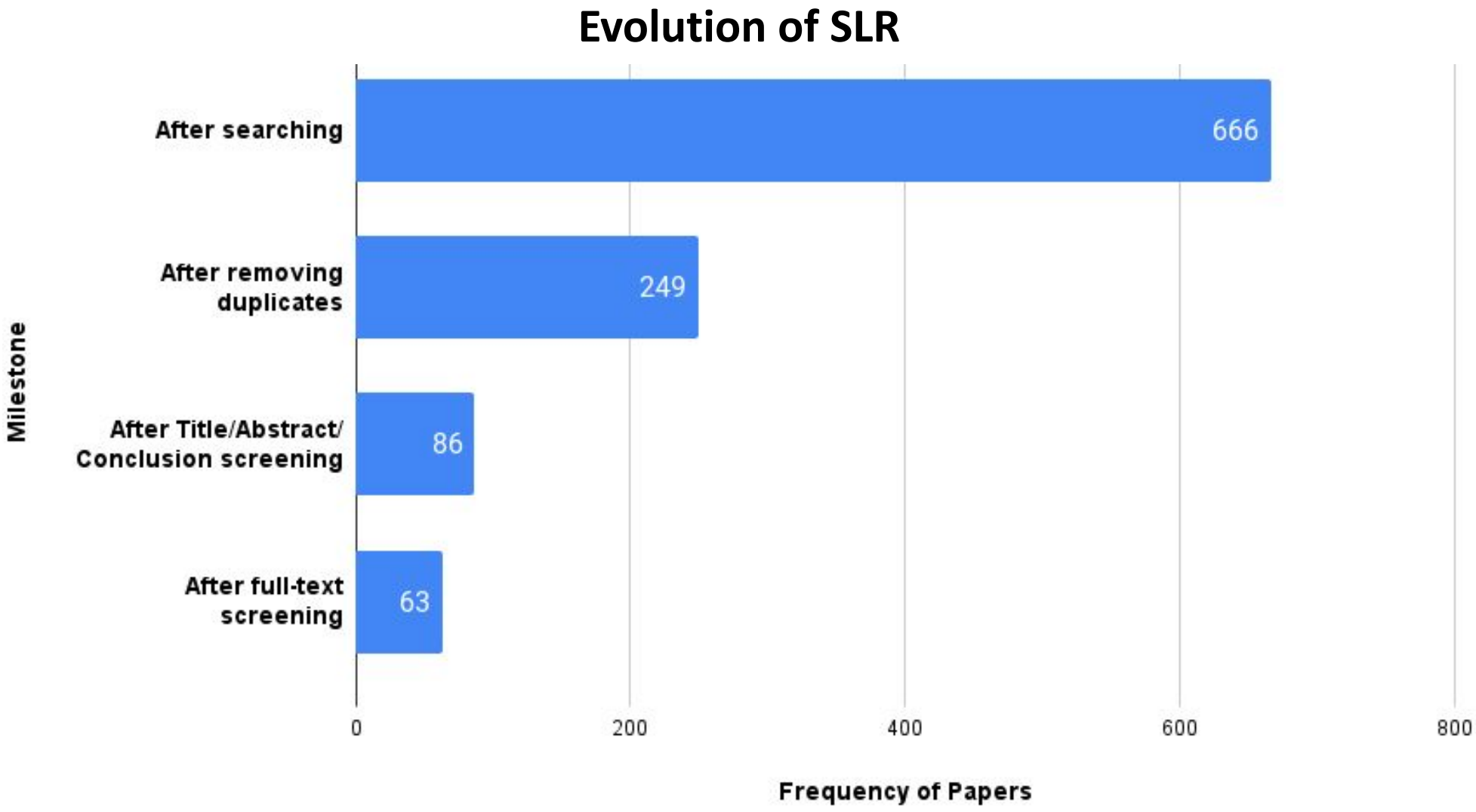
- **RQ1**: Which **design guidelines** exist for **constructing** meaningful MSA? 
- **RQ2*:*** Which **quality characteristics** adequately describe the quality of MSA and how can they be meaningfully represented in the form of a **Quality Model**? 
- **RQ3*:*** Which quality characteristics are **affected** by the existing design guidelines of MSA? 

Research Approach: RQ1

- **RQ1***:* Which **design guidelines** exist for **constructing** meaningful MSA? 

- **Approach:** 
  - **Performed** a *Systematic Literature Review (SLR)* to gather existing **design** guidelines associated with constructing meaningful MSA
  - **Employed** the *Grounded Theory Methodology (GTM)* to categorise and structure the collected information into a **catalogue**

Research Approach: RQ1 - SLR

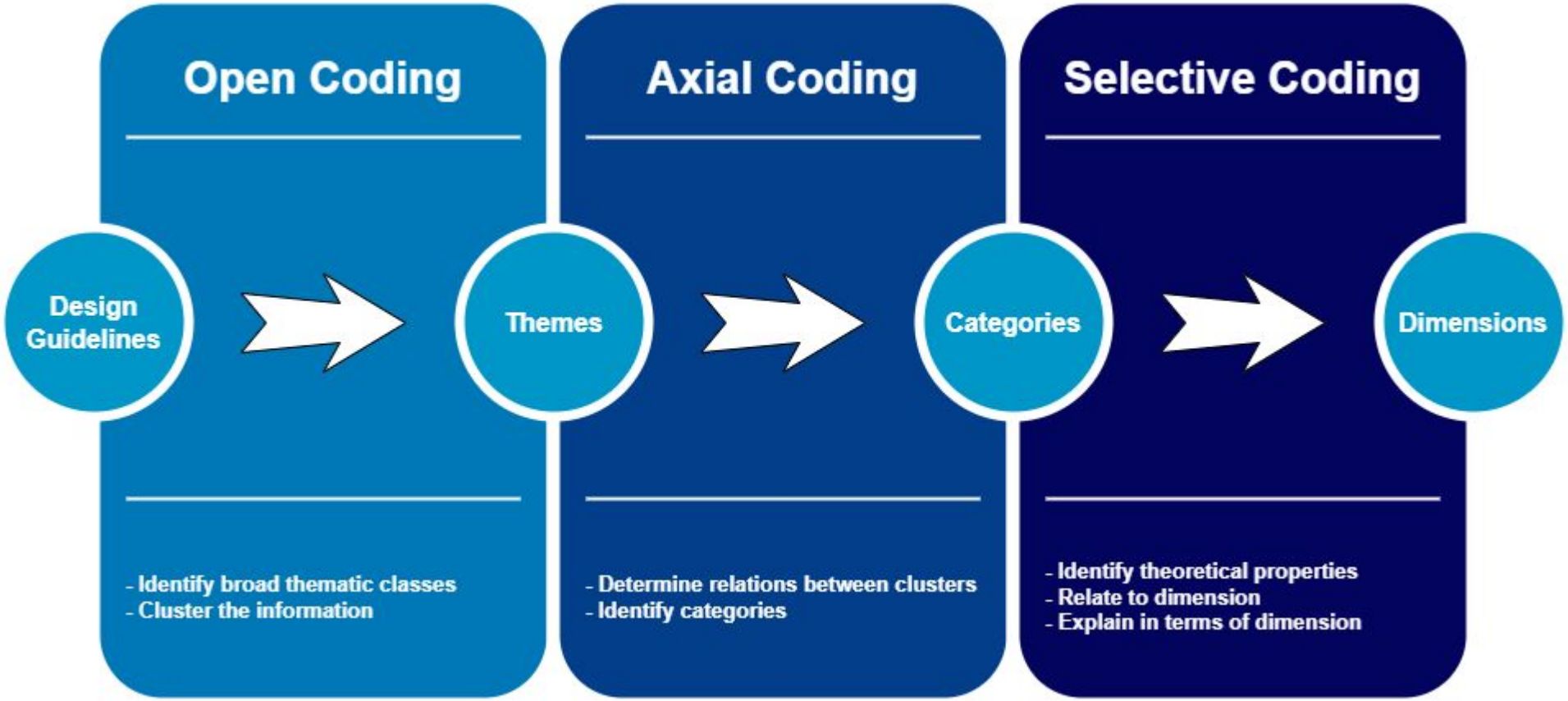


Research Approach: RQ1 - GTM

- **Complex** nature of our collection of MSA design guidelines
- Needed a **fitting** method to derive **categories** for the collected information
- GTM aims to add **structure**, in stages, to unstructured data
- GTM identified key **themes** and concepts across the catalogue
- Performed **three** sequential steps: *open coding*, *axial coding*, and *selective coding*

Research Approach: RQ1 - GTM

GTM Steps



Research Approach: RQ2

- **RQ2*:*** Which **quality characteristics** adequately describe the quality of MSA and how can they be meaningfully represented in the form of a **Quality Model**?

- **Approach:**
  - **Extracted** and **described** *quality characteristics* relevant to MSA from academic literature
  - **Extended** the *ISO/IEC 25010 Quality Model* using the *Concept Discovery* method
  - **Evaluated** the resulting *preliminary* Quality Model via semi-structured **interviews**
  - **Integrated** the evaluation **feedback** to obtain the *revised* Quality Model

Research Approach: RQ2 - Extending ISO/IEC 25010 Quality Model

- The **ISO/IEC 25010** Product Quality Model determines which **quality** characteristics will be considered when evaluating the properties of a software product

Research Approach: RQ2 - Evaluation of Preliminary Quality Model

- **Question*:*** To what extent does the *preliminary* Quality Model, including all its **elements**, adequately describe the quality of MSA? 

- **Approach:** 
  - **Developed** an interview protocol
  - **Interviewed** 13 seasoned microservices professionals (7 practitioners and 6 researchers)
  - **Reviewed** different segments of the *preliminary* Quality Model (structure + descriptions)
  - **Noted** the answers and comments into a **feedback** document

Research Approach: RQ3

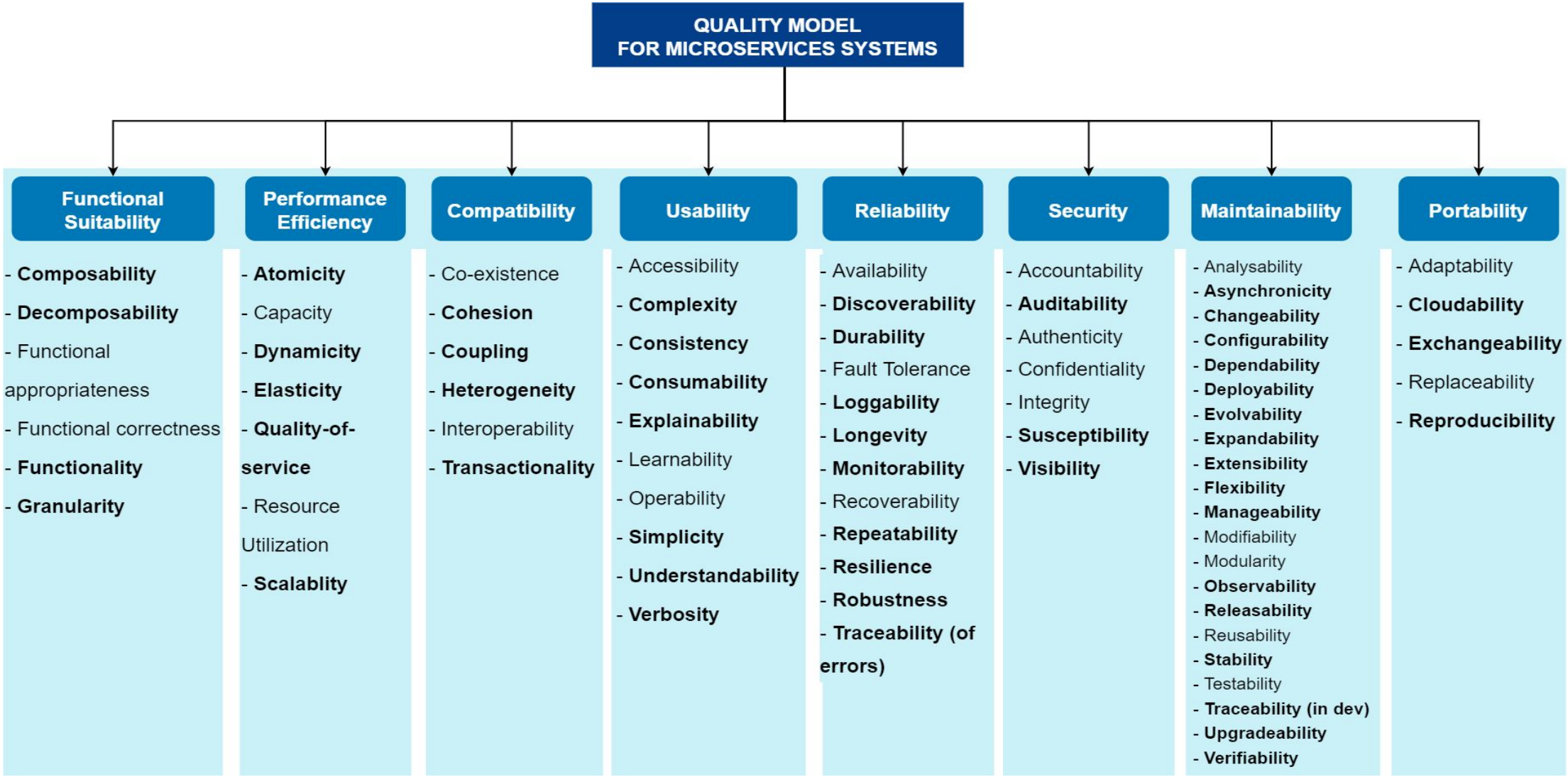
- **RQ3*:*** Which quality characteristics are **affected** by the existing design guidelines of MSA?

- **Approach:**
  - **Mapped** each of the **discovered** design guidelines to their **affecting** quality characteristics using academic literature

Results: (Preliminary) Quality Model for MSA

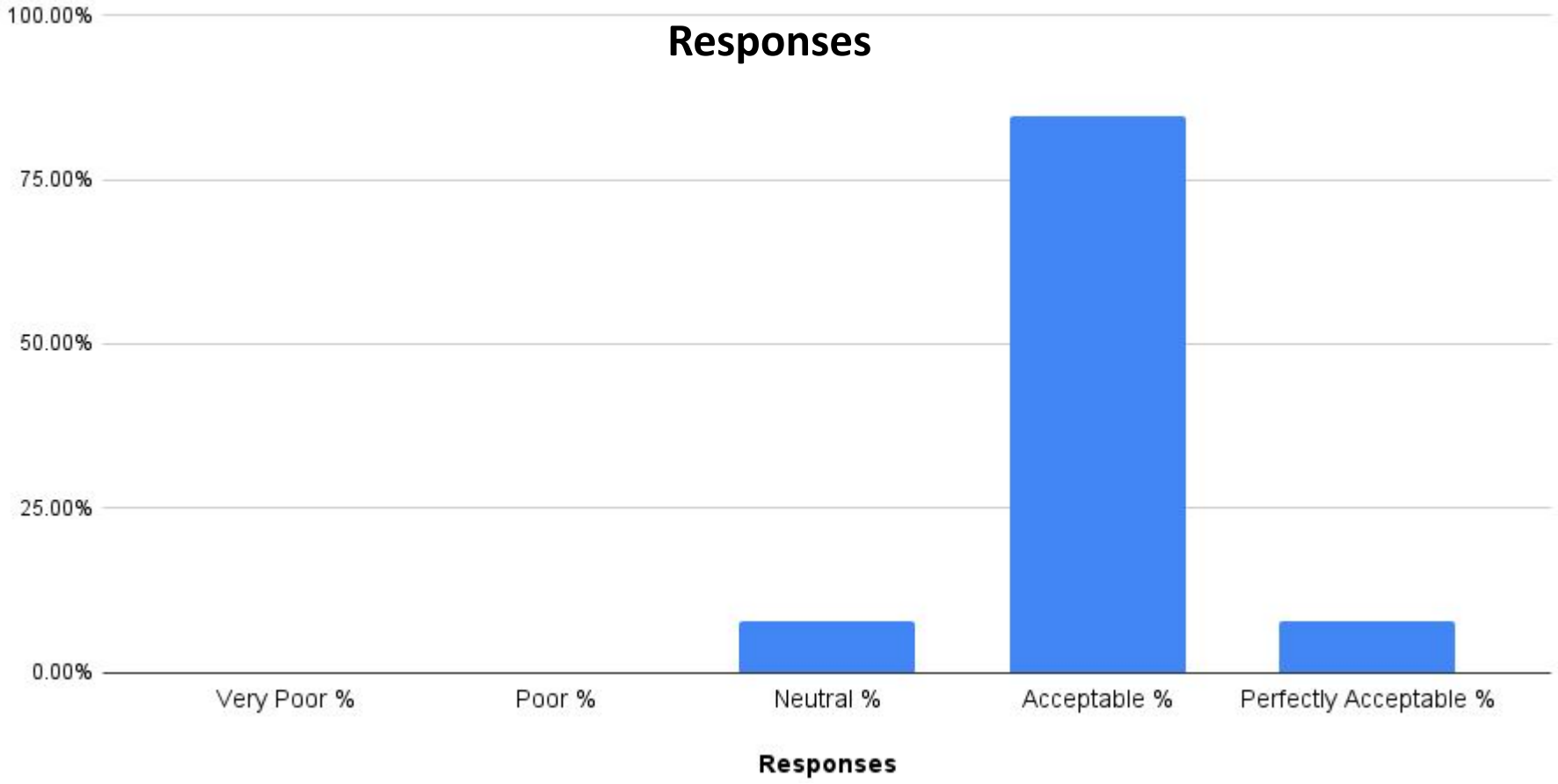
- 82 **quality** characteristics relevant to MSA, including 51 **novel** Quality Factors + 23 **ISO** Quality Factors
- A **Quality Model** which meaningfully **describes** and **structures** the quality characteristics

Results: Preliminary Quality Model



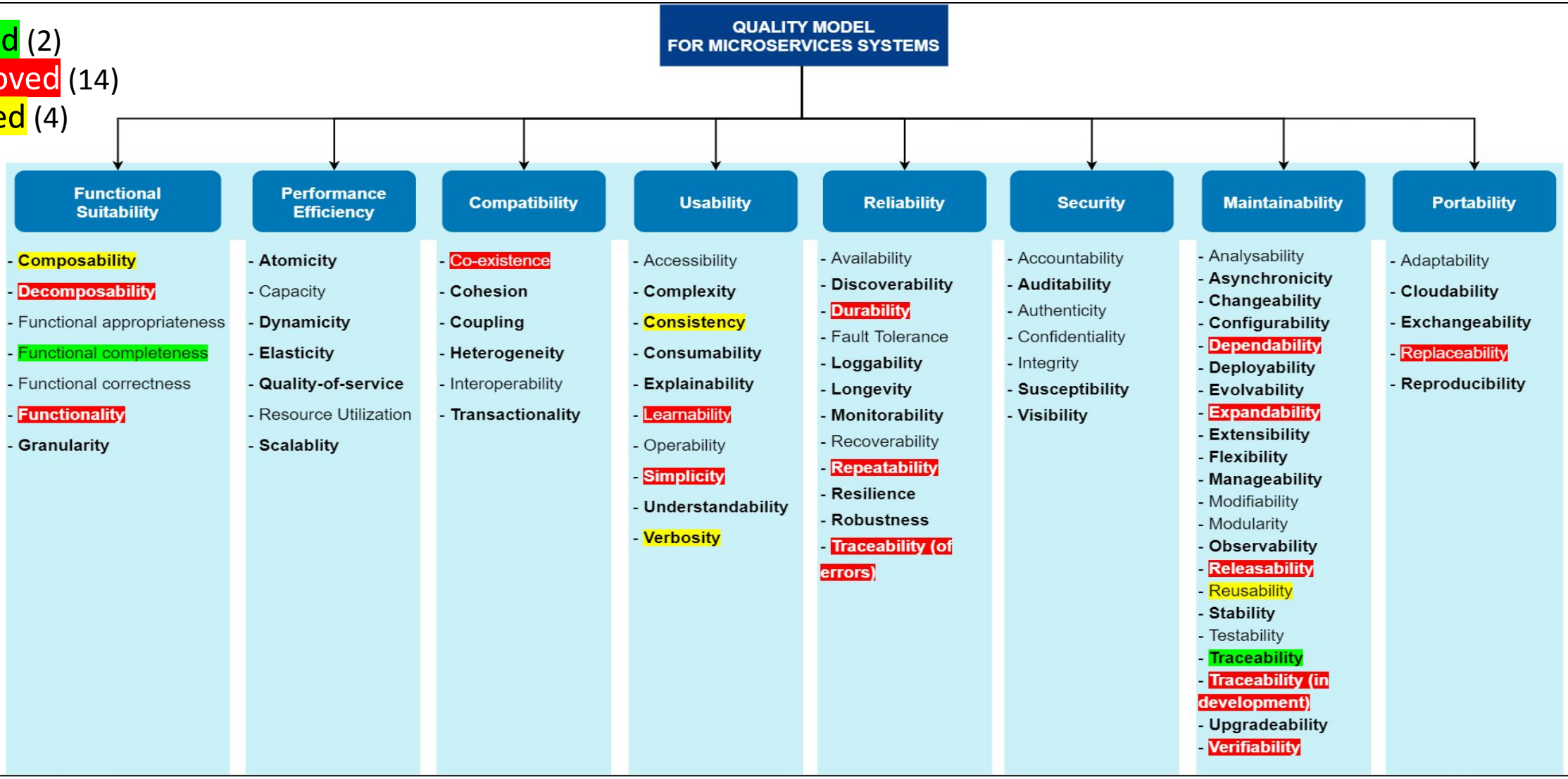
Results: Evaluation of Preliminary Quality Model

Question: On a scale from 1 (Poor) to 5 (Perfectly Acceptable), how would you assess the overall appropriateness of the proposed Quality Model for MSA?



Results: Revision of Preliminary Quality Model

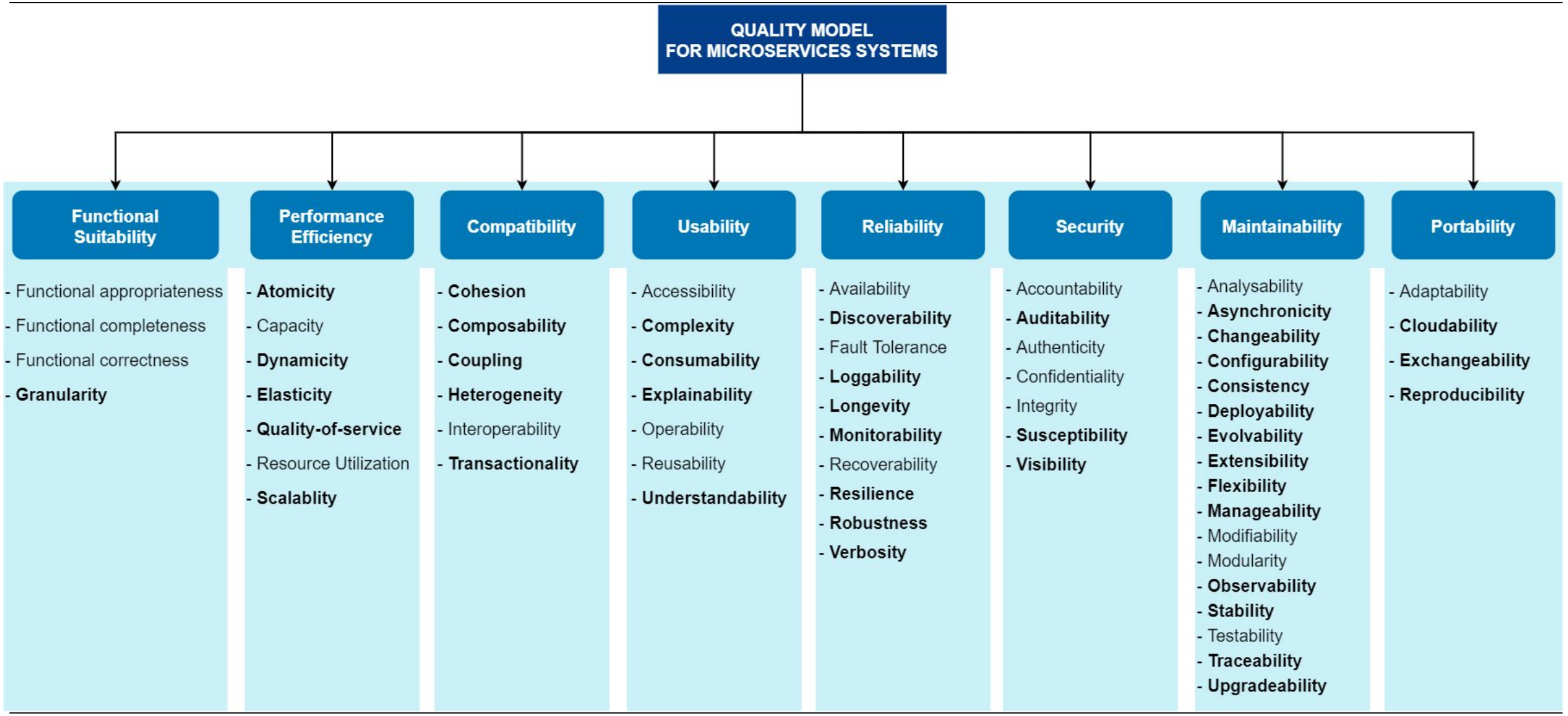
Added (2)
Removed (14)
Moved (4)



Results: (Revised) Quality Model for MSA

- 70 **quality** characteristics relevant to MSA, including 41 **novel** Quality Factors + 21 **ISO** Quality Factors
- A **Quality Model** which meaningfully **describes** and **structures** the quality characteristics

Results: Revised Quality Model



Results: Descriptions of Quality Characteristics

Descriptions of Quality Attributes in Revised Quality Model

Quality Attribute	Description	Literature Source(s)
Maintainability	Degree of effectiveness and efficiency with which a microservices system can be modified according to changes in its environment and requirements.	[25],[26],[28],[32],[33],[34],[35],[42],[43],[45],[49],[50],[51],[58],[60],[63],[5],[6],[9],[12],[16],[21],[22],[46],[52]
Reliability	Degree to which a microservice operates independently for a specified period of time, regardless of whether other microservices in the system crash, or are attacked or destroyed.	[17],[26],[27],[28],[30],[32],[33],[35],[37],[38],[41],[42],[43],[49],[51],[54],[58],[59],[62],[1],[2],[5],[9],[14],[20],[29],[44],[53]

Descriptions of Quality Factors in Revised Quality Model

Quality Attribute	Quality Factor	Description of Quality Factor	Literature Source(s)
Maintainability	Deployability	Degree to which microservices can be deployed independently without downtime, and without restarting the entire microservices system.	[10],[15],[26],[27],[28],[30],[33],[57],[60],[7],[11],[12],[46]
Reliability	Availability	Degree to which a microservices system is operational and usable when accessed by an authorized entity.	[10],[15],[17],[23],[25],[26],[27],[28],[31],[32],[34],[35],[38],[40],[41],[43],[47],[51],[54],[58],[59],[60],[62],[1],[5],[13],[20],[29],[44],[61]

Results: Guidelines Catalogue

- A structured **catalogue** of 239 design guidelines, including *best practices*, *design principles*, and *design patterns* that are employed for constructing MSA

- A clear and sound three-dimensional **categorisation scheme** for the catalogue

Results: Catalogue Categorisation Scheme

Three-Dimensional Categorisation Scheme

Type	Scope	Design
Design Pattern	Architecture	Migration
Design Principle	Code Management	Universal
Best Practice	Communication	
Context-sensitive Best Practice	Data Consistency	
	Data Management	
	Data Persistence	
	Decomposition	
	Deployment	
	Development	
	Distribution	
	Entry Point	
	Fault Tolerance	
	Infrastructure	
	Monitoring	
	Security	
	Supplementals	
	Testing	

Results: Catalogue Categorisation Scheme - Dimensions

- **Dimensions**:
  - *Type* represents the **semantic** group of the design guideline
  - *Scope* describes the **area** which the design guideline is responsible for
  - *Design* reports the type of **activity** that the design guideline undertakes with respect to **designing** the system architecture

Results: Catalogue Categorisation Scheme - *Type* categories

- A *Design Pattern* explains the **solution** to a well-defined **problem**, in such a way that we are able to use the solution repeatedly
  - Naming schema: Nouns (e.g. *API Gateway*)

- A *Design Principle* constitutes a set of **prescribed** considerations that support **consistency** in design decisions
  - Naming schema: Nouns and verbs (e.g. *Statelessness, Vertical Layering*)

Results: Catalogue Categorisation Scheme - *Type* categories

- A *Best Practice* serves as a means for appropriate **adherence** to established rules, along with detecting **deviations** from their adherence
  - Naming schema: Imperatives (e.g. *Encrypt sensitive data*)

- A *Context-sensitive Best Practice* is a best practice that **only** proves to be optimal in **certain** practical contexts or complex situations
  - Naming schema: Imperatives (e.g. *Limit language diversity*)

Results: Catalogue Categorisation Scheme - *Scope* categories

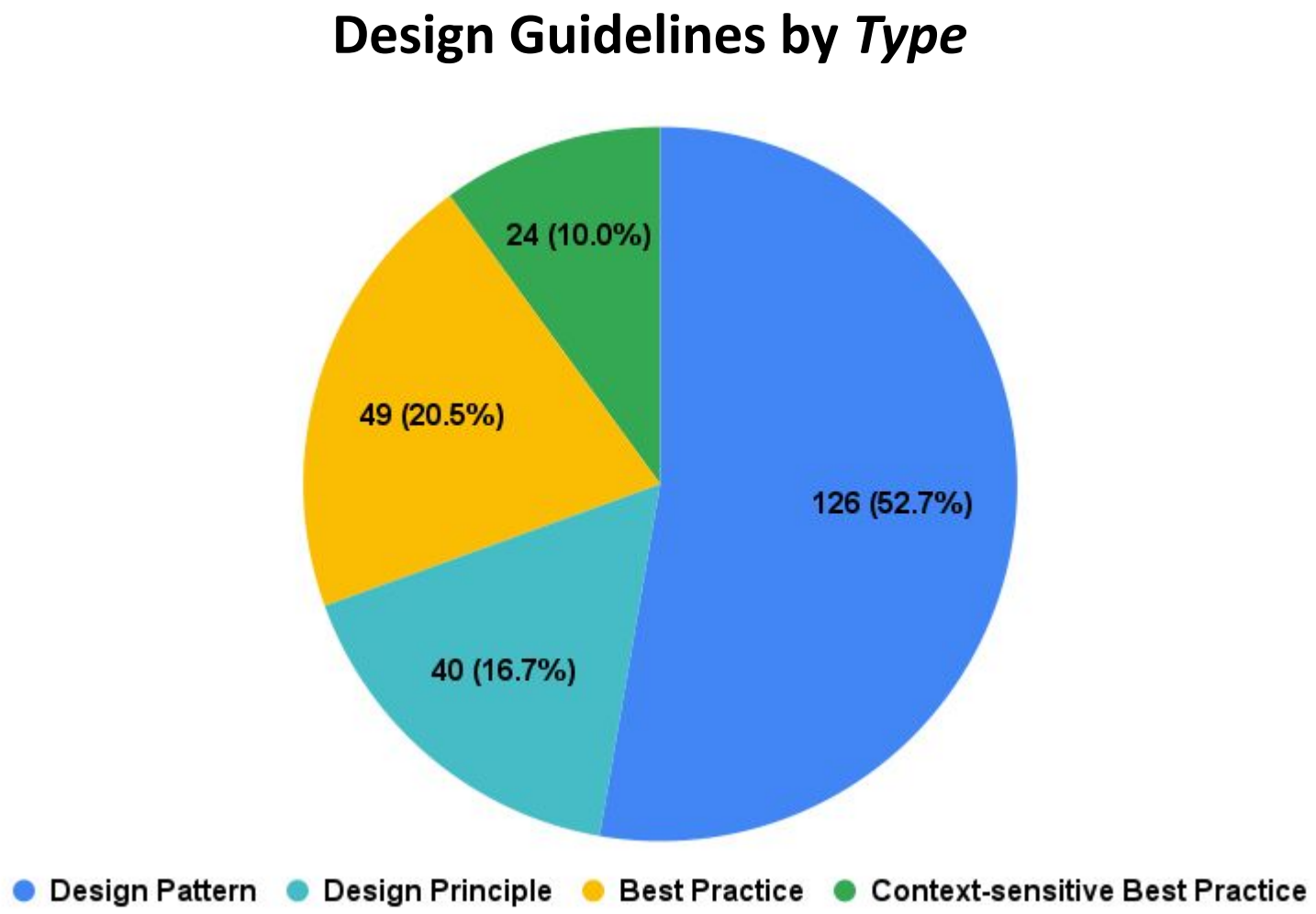
- *Architecture*
- *Code Management*
- *Communication*
- *Data Consistency*
- *Data Management*
- *Data Persistence*
- *Decomposition*
- *Deployment*
- *Development*
- *Distribution*
- *Entry Point*
- *Fault Tolerance*
- *Infrastructure*
- *Monitoring*
- *Security*
- *Supplementals*
- *Testing*

Results: Catalogue Categorisation Scheme - *Design* categories

- A *Migration* guideline is **exclusively** meant to be used for the migration from monolithic architectures to MSA

- A *Universal* guideline is generally applicable and **always** holds in microservices design and development

Results: Categorisation of the Guidelines Catalogue



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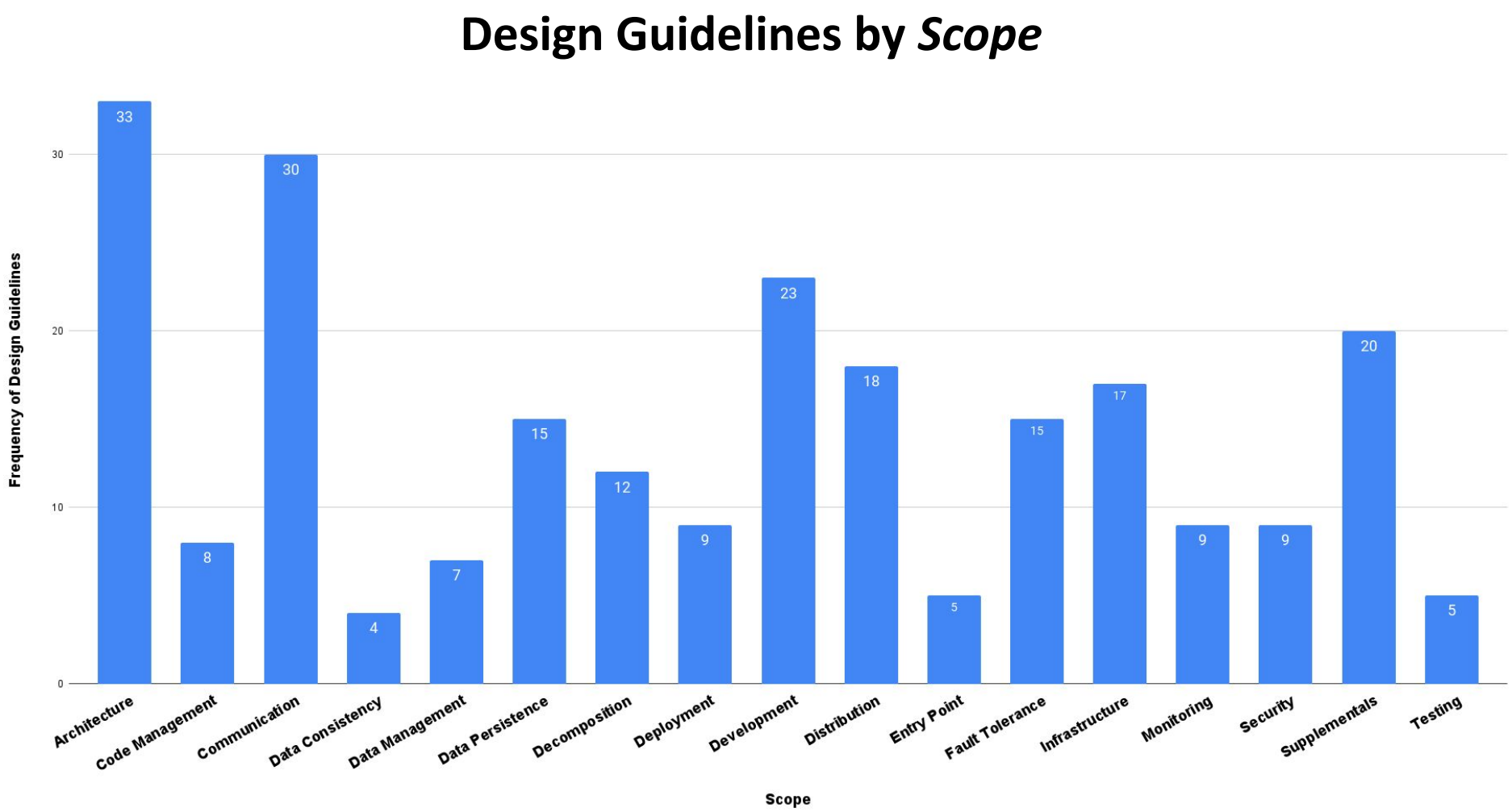

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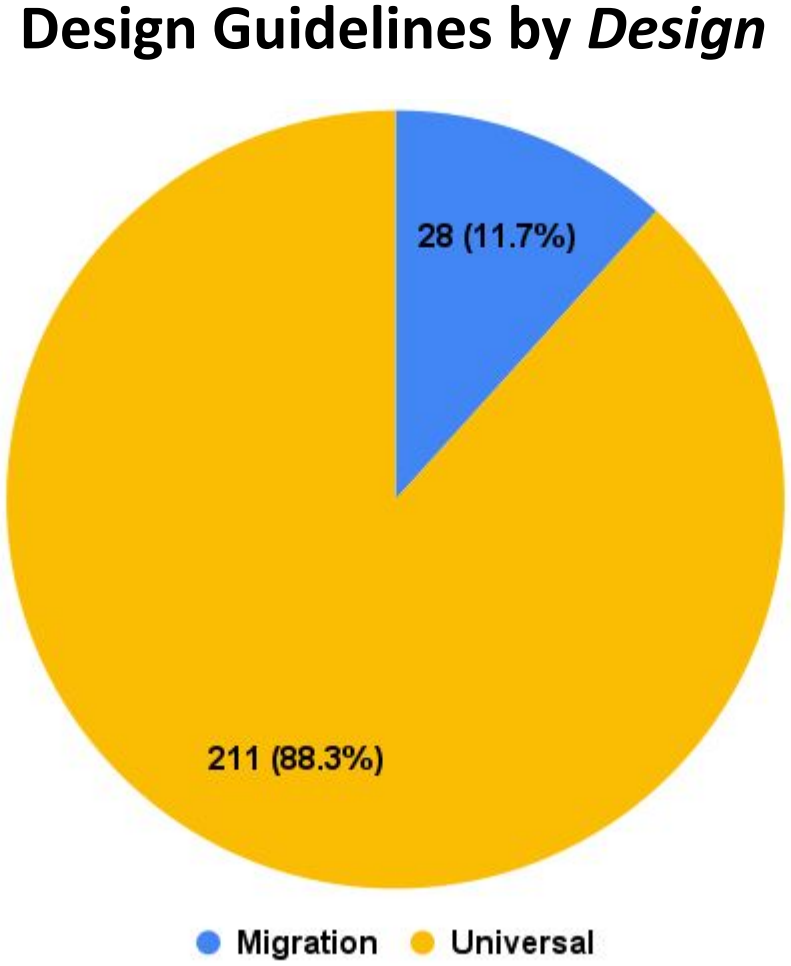

Results: Guidelines Catalogue

Guideline (G#)	Type	Scope	Design	Name	Description	Affecting Quality Characteristic(s)	Literature Source(s)
G1	Best Practice	Architecture	Migration	Administer rehosting	Move a legacy system from one platform to a more modern alternative, with minimal changes.	Accessibility, Scalability	[58]
G2	Design Pattern	Communication	Universal	Publish-subscribe	Offers message exchange using broadcast communication where microservices can subscribe to a channel to which other microservices can publish.	Coupling, Asynchronicity, Reliability, Availability, Complexity, Performance Efficiency, Quality-of-service	[5],[7],[10],[18],[22],[27],[28],[32],[37],[36],[38],[47],[50],[54]
G3	Design Principle	Architecture	Universal	Single Responsibility Principle (SRP)	A microservice should address a single part of the functionality and should have responsibility to address it completely.	Elasticity, Resilience, Functional completeness, Longevity, Maintainability, Reusability, Granularity	[2],[6],[8],[15],[19],[21],[22],[27],[28],[30],[42],[43],[45],[48],[54]

Results: Key Findings

- **Most** frequent *Type* of design guidelines: *Design Patterns*
- **Least** frequent *Type* of design guidelines: *Context-sensitive Best Practices*
- **Most** frequently reported design guidelines:
  - *Independent and automated deployment (including independent development)*
  - *Isolation of failures*
  - *Lightweight containerization*
- **Most** frequently mapped quality characteristics:
  - *Complexity*, *Coupling*, *Scalability*, *Evolvability*, *Resource Utilization*, *Availability*

Conclusion

- Investigated **MSA** from the architectural **design** and system **quality** perspectives
- Collected and categorised 239 MSA design guidelines into a **Guidelines Catalogue**
- Extracted, structured and described 70 quality characteristics into a **Quality Model**
- Performed **evaluation** to validate and improve the developed Quality Model
- Determined a set of quality characteristics **affecting** each of the design guidelines

Future Work

- **Adjustment** of the SLR method to enhance the catalogue
- **Grey Literature Review** to determine particularly industry-driven MSA design guidelines
- Performing **evaluation** of the Guidelines Catalogue
- Determining the **applicability** of the proposed Quality Model in particular **use cases**
- Formulating a Quality Model around **process-oriented** quality characteristics

Summary

Research Questions

- **RQ1**: Which **design guidelines** exist for **constructing** meaningful MSA?
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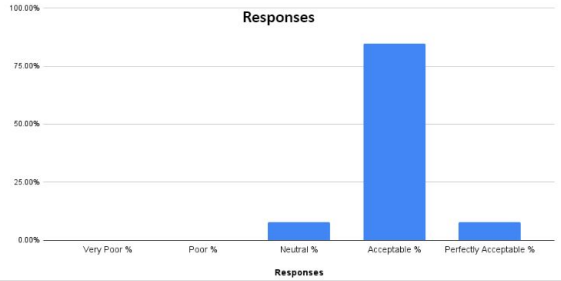

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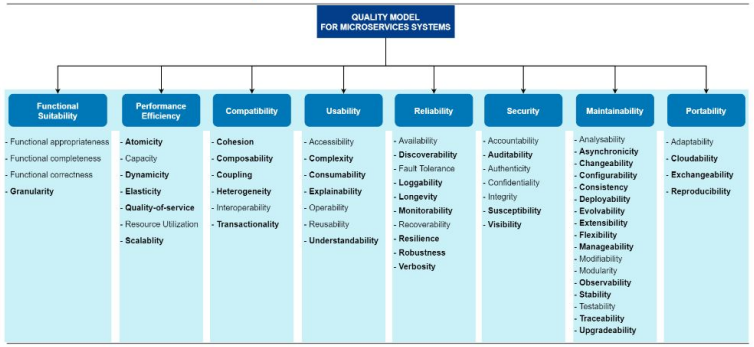

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