

**Grupo 4 – Faculdade de Ciências   
Quizzes Tutor   
Software Architecture Document (SAD)**

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**Amarelo -remover Verde-Rever(o resto tb mas este com mais detalhe)As alineas tao todas cagadas mas depois isso ajustasse**

**\*Nota - No final do trabalho temos de por bem os indices e ter atenção no 1.5 porque tem mais alineas do que era suposto e ver se todos os indices tao ok \***

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| **BACKGROUND**  This template is based on the Software Engineering Institute’s “View and Beyond” method for documenting software architectures, as described in Clements, et al., [*Documenting Software Architecture: Views and Beyond*](http://www.sei.cmu.edu/architecture/books.html) (Addison Wesley, 2002). The current version is available for [free download](http://www.sei.cmu.edu/architecture/arch_doc.html) from the SEI’s architecture web site.  **TIPS FOR USING THIS TEMPLATE**  To create an instance of this document:   * Insert relevant information on cover sheet and in placeholders throughout. * Insert relevant information in page header: Move to a page of the body of the report, select *View > Header and Footer* from the main menu, and then replace relevant information in the header box at the top of the page.   To update the contents and page numbers in the Table of Contents, List of Figures, and List of Tables:   * Position the cursor anywhere in the table to be updated. * Click the *F9* function key. * Answer “Update entire table”.   To insert a figure or table caption:   * From the main menu, choose *Insert > Reference > Caption* and then either *Figure* or *Table* as needed. * Click the OK button. * Add a colon and a tab stop after the figure number in the caption itself. * The caption should use the *Caption* style. * Add a colon and a tab stop after the table/figure number in the caption itself.   **TIPS FOR MAKING YOUR DOCUMENT MORE READABLE**   * A gray box containing *CONTENTS OF THIS SECTION* is provided at the beginning of most sections and subsections. After determining what specific information will be included in your document, you can remove this gray box or leave it to serve as a quick-reference section overview for your readers. In the case that text has been provided in the template, inspect it for relevance and revised as necessary. * Consider hyperlinking key words used in the document with their entries in the [Glossary](#_2zbgiuw) or other location in which they are defined. Choose *Insert > Hyperlink*. * Don’t leave blank sections in the document. Mark them “To be determined” (ideally with a promise of a date or release number by which the information will be provided) or “Not applicable.” * Consider packaging your SAD as a multi-volume set of documentation. It is often helpful to break your documentation into more than one volume so that the document does not become unwieldy. There are many ways that this can be accomplished. The structuring of the document must support the needs of the intended audience and must be determined in the context of the project. Each document that you produce should include the date of issue and status; draft, baseline, version number, name of issuing organization; change history; and a summary. A few decomposition options are: * *A 2-Volume approach:* Separate the documentation into two volumes; one that contains the views of the software architecture and one that contains everything else. A common variant of this approach has one volume per view, and one volume for everything else. * *A 3-Volume approach:* Document organizational policies, procedures, and the directory in one volume, system specific overview material in a second, and view documentation in a third. * *A 4-Volume approach:* Create one volume for each viewtype [Clements 2002] (module, component-and-connector, allocation) that contains the documentation for the relevant [views](#1egqt2p). Include all of the other information in the fourth volume. * Software interfaces are often documented in a separate volume.   In *any* case, the information should be arranged so that readers begin with the volume containing the Documentation Roadmap (Section 1 in this template). |

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# Documentation Roadmap

The Documentation Roadmap should be the first place a new reader of the SAD begins. But for new and returning readers, it is intended to describe how the SAD is organized so that a reader with specific interests who does not wish to read the SAD cover-to-cover can find desired information quickly and directly.

Sub-sections of Section 1 include the following.

* **Section 1.1 (“Document Management and Configuration Control Information”)** explains revision history. This tells you if you’re looking at the correct version of the SAD.
* **Section 1.2 (“Purpose and Scope of the SAD”)** explains the purpose and scope of the SAD, and indicates what information is and is not included. This tells you if the information you’re seeking is likely to be in this document.
* **Section 1.3 (“How the SAD Is Organized”)** explains the information that is found in each section of the SAD. This tells you what section(s) in this SAD are most likely to contain the information you seek.
* **Section 1.4 (“Stakeholder Representation”)** explains the stakeholders for which the SAD has been particularly aimed. This tells you how you might use the SAD to do your job.
* **Section 1.5 (“Viewpoint Definitions”)** explains the *viewpoints* (as defined by IEEE Standard 1471-2000) used in this SAD. For each viewpoint defined in Section 1.5, there is a corresponding view defined in Section 3 (“Views”). This tells you how the architectural information has been partitioned, and what views are most likely to contain the information you seek.
* **Section 1.6 (“How a View is Documented”)** explains the standard organization used to document architectural views in this SAD. This tells you what section within a view you should read in order to find the information you seek
* **Section 1.7 ("Relationship to Other SADs")** notes whether this SAD is related to other architecture documents. If no related documents exist, it simply states "Not applicable," clarifying whether additional architecture documents should be consulted.
* **Section 1.8 (“Process for Updating this SAD”)** describes how to report issues or inaccuracies in the SAD, providing contact details and steps for handling feedback to maintain document accuracy.

## Document Management and Configuration Control Information

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| **CONTENTS OF THIS SECTION**: This section identifies the version, release date, and other relevant management and configuration control information associated with the current version of the document. Optional items for this section include: change history and an overview of significant changes from version to version. |

* Revision Number: 1.0
* Revision Release Date: 28/10/2024
* Purpose of Revision: Initial version created for the Software Architecture Design course project, to document the architecture of the Quizzes Tutor system. This document serves to fulfill course requirements and provide a reference for analyzing and documenting the system's architecture.
* Scope of Revision:This is the initial release of the Software Architecture Document (SAD) for the Quizzes Tutor system as part of an academic project. It covers the main architectural elements, including stakeholder definitions, quality requirements, and key architectural decisions. The document outlines the module, component-connector, and allocation views, detailing the interaction between the frontend in Vue.js, backend in Spring Boot, and data storage in PostgreSQL.

**Nota - Temos de ir alterando isto conforme vamos fazendo atualizações**

## Purpose and Scope of the SAD

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| **CONTENTS OF THIS SECTION**: This section explains the SAD’s overall purpose and scope, the criteria for deciding which design decisions are architectural (and therefore documented in the SAD), and which design decisions are non-architectural (and therefore documented elsewhere). |

This SAD specifies the software architecture for **<insert scope of SAD>.** All information regarding the software architecture may be found in this document, although much information is incorporated by reference to other documents.

**What is software architecture?** The software architecture for a system[[1]](#footnote-1) is the structure or structures of that system, which comprise software elements, the externally-visible properties of those elements, and the relationships among them [Bass 2003]. "Externally visible” properties refers to those assumptions other elements can make of an element, such as its provided services, performance characteristics, fault handling, shared resource usage, and so on. This definition provides the basic litmus test for what information is included in this SAD, and what information is relegated to downstream documentation.

**Elements and relationships**. The software architecture first and foremost embodies information about how the elements relate to each other. This means that architecture specifically omits certain information about elements that does not pertain to their interaction. Thus, a software architecture is an *abstraction* of a system that suppresses details of elements that do not affect how they use, are used by, relate to, or interact with other elements. Elements interact with each other by means of interfaces that partition details about an element into public and private parts. Software architecture is concerned with the public side of this division, and that will be documented in this SAD accordingly. On the other hand, private details of elements—details having to do solely with internal implementation—are not architectural and will not be documented in a SAD.

**Multiple structures.** The definition of software architecture makes it clear that systems can and do comprise more than one structure and that no one structure holds the irrefutable claim to being the architecture. The neurologist, the orthopedist, the hematologist, and the dermatologist all take a different perspective on the structure of a human body. Ophthalmologists, cardiologists, and podiatrists concentrate on subsystems. And the kinesiologist and psychiatrist are concerned with different aspects of the entire arrangement’s behavior. Although these perspectives are pictured differently and have very different properties, all are inherently related; together they describe the architecture of the human body. So it is with software. Modern systems are more than complex enough to make it difficult to grasp them all at once. Instead, we restrict our attention at any one moment to one (or a small number) of the software system’s structures. To communicate meaningfully about an architecture, we must make clear which structure or structures we are discussing at the moment—which *view* we are taking of the architecture. Thus, this SAD follows the principle that documenting a software architecture is a matter of documenting the relevant views and then documenting information that applies to more than one view.

For example, all non-trivial software systems are partitioned into implementation units; these units are given specific responsibilities, and are the basis of work assignments for programming teams. This kind of element will comprise programs and data that software in other implementation units can call or access, and programs and data that are private. In large projects, the elements will almost certainly be subdivided for assignment to sub-teams. This is one kind of structure often used to describe a system. It is a very static structure, in that it focuses on the way the system’s functionality is divided up and assigned to implementation teams.

Other structures are much more focused on the way the elements interact with each other at runtime to carry out the system’s function. Suppose the system is to be built as a set of parallel processes. The set of processes that will exist at runtime, the programs in the various implementation units described previously that are strung together sequentially to form each process, and the synchronization relations among the processes form another kind of structure often used to describe a system.

None of these structures alone is *the* architecture, although they all convey architectural information. The architecture consists of these structures as well as many others. This example shows that since architecture can comprise more than one kind of structure, there is more than one kind of element (e.g., implementation unit and processes), more than one kind of interaction among elements (e.g., subdivision and synchronization), and even more than one context (e.g., development time versus runtime). By intention, the definition does not specify what the architectural elements and relationships are. Is a software element an object? A process? A library? A database? A commercial product? It can be any of these things and more.

These structures will be represented in the views of the software architecture that are provided in Section 3.

**Behavior.** Although software architecture tends to focus on structural information, *behavior of each element is part of the software architecture* insofar as that behavior can be observed or discerned from the point of view of another element. This behavior is what allows elements to interact with each other, which is clearly part of the software architecture and will be documented in the SAD as such. Behavior is documented in the element catalog of each view.

### Purpose

The purpose of this Software Architecture Document (SAD) is to comprehensively document the architecture of Quizzes Tutor, an open-source platform for creating, managing, and evaluating educational quizzes. This SAD serves as a central reference for the system’s development, analysis, and maintenance, supporting effective stakeholder communication and ensuring a shared understanding of its design.

### Scope

This SAD outlines key architectural aspects of Quizzes Tutor, including:

**Stakeholders and Their Interests**: Identification of main stakeholders (teachers, students, development team, and system administrators), highlighting their specific needs and concerns to guide architectural decisions.

**Quality Requirements**: Definition of key quality attributes such as performance, security, scalability, and maintainability, supported by scenarios illustrating expected system behavior and performance benchmarks.

**Architectural Views**:

* + **Module View**: Describes the modular structure and main responsibilities of each module, including the Vue.js frontend, Spring Boot backend, and PostgreSQL database.
  + **Component-and-Connector View**: Visualizes interactions and data flows between components, detailing how modules cooperate to handle user requests.
  + **Allocation View**: Maps software components onto the physical and virtual infrastructure, detailing deployment and resource management strategies.

This document focuses on high-level architectural decisions and component interactions, leaving detailed technical specifications and implementation guidelines to supplementary documentation. This approach provides a top-down view, making the system’s architecture accessible without delving into low-level code details.

## How the SAD Is Organized

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| **CONTENTS OF THIS SECTION**: This section provides a narrative description of the major sections of the SAD and the overall contents of each. Readers seeking specific information can use this section to help them locate it more quickly. |

This SAD is organized into the following sections:

* **Section 1 (“Documentation Roadmap”) provides information about this document and its intended audience**. It provides the roadmap and document overview. Every reader who wishes to find information relevant to the software architecture described in this document should begin by reading Section 1, which describes how the document is organized, which stakeholder viewpoints are represented, how stakeholders are expected to use it, and where information may be found. Section 1 also provides information about the views that are used by this SAD to communicate the software architecture.
* **Section 2 (“Architecture Background”) explains why the architecture is what it is.** It provides a system overview, establishing the context and goals for the development. It describes the background and rationale for the software architecture. It explains the constraints and influences that led to the current architecture, and it describes the major architectural approaches that have been utilized in the architecture. It includes information about evaluation or validation performed on the architecture to provide assurance it meets its goals.
* **Section 3 (Views”) and Section 4 (“Relations Among Views”) specify the software architecture**. Views specify elements of software and the relationships between them. A view corresponds to a viewpoint (see Section 1.5), and is a representation of one or more structures present in the software (see Section 1.2).
* **Sections 5 (“Referenced Materials”) and 6 (“Directory”) provide reference information for the reader.** Section 5 provides look-up information for documents that are cited elsewhere in this SAD. Section 6 is a *directory*, which is an index of architectural elements and relations telling where each one is defined and used in this SAD. The section also includes a glossary and acronym list

This Software Architecture Document (SAD) is organized into several main sections to facilitate a comprehensive understanding of the architecture of the Quizzes Tutor system. Each section serves a distinct purpose, guiding readers through different aspects of the system’s design and architecture:

* **Section 1 - Documentation Roadmap**: This section introduces the document by outlining its purpose, scope, and structure. It provides details on document configuration and identifies the primary stakeholders and viewpoints, establishing the audience for whom the architecture is intended and the key perspectives it addresses.
* **Section 2 - Architecture Background**: This section provides context on the Quizzes Tutor system, describing the problem it aims to solve and the goals that guided its development. It includes an overview of the significant requirements and the architectural decisions that were made to meet those requirements, giving readers insight into the rationale behind the system's design.
* **Section 3 - Views**: This is the core section of the document, presenting multiple architectural views that illustrate different perspectives of the system's structure and behavior. The views included are:
  + **Module View**: Shows the system’s organization into modules, detailing the responsibilities and roles of the main modules, such as the Vue.js frontend, Spring Boot with Java backend, and PostgreSQL database.
  + **Component-and-Connector View**: Depicts the runtime interactions and data flow between the system's components, highlighting how these components communicate and share data to fulfill system functions.
  + **Allocation View**: Maps the software components to the physical and virtual infrastructure, describing how resources are allocated across servers and environments, which supports effective deployment and resource management.
* **Section 4 - Relations Among Views**: This section explains how the different architectural views relate to one another, demonstrating how they collectively represent the overall architecture. It clarifies dependencies and interactions across views, helping readers to understand the architecture as an integrated whole.
* **Section 5 - Referenced Materials**: Lists all sources, references, and supporting materials consulted to compile this SAD. This ensures traceability, allowing readers to verify the information and consult additional resources if needed.
* **Section 6 - Directory**: Contains a glossary of terms and a list of acronyms used throughout the document, providing definitions for technical terminology to aid readers' understanding.

## Stakeholder Representation

This section provides a list of the stakeholder roles considered in the development of the architecture described by this SAD. For each, the section lists the concerns that the stakeholder has that can be addressed by the information in this SAD.

Each stakeholder of a software system—customer, user, project manager, coder, analyst, tester, and so on—is concerned with different characteristics of the system that are affected by its software architecture. For example, the user is concerned that the system is reliable and available when needed; the customer is concerned that the architecture can be implemented on schedule and to budget; the manager is worried (in addition to cost and schedule) that the architecture will allow teams to work largely independently, interacting in disciplined and controlled ways. The developer is worried about strategies to achieve all of those goals. The security analyst is concerned that the system will meet its information assurance requirements, and the performance analyst is similarly concerned with it satisfying real-time deadlines.

This information is represented as a matrix, where the rows list stakeholder roles, the columns list concerns, and a cell in the matrix contains an indication of how serious the concern is to a stakeholder in that role. This information is used to motivate the choice of viewpoints chosen in Section 1.5.

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| **CONTENTS OF THIS SECTION**: The list of stakeholders will be unique for each organization that is developing a SAD. ANSI/IEEE 1471-2000 requires that at least the following stakeholders be considered:   * Users * Acquirers * Developers * Maintainers.   You may wish to consider the following additional stakeholders. | | |
| * Customer * Application software developers * Infrastructure software developers * End users * Application system engineers * Application hardware engineers | * Project manager * Communications engineers * Chief Engineer/Chief Scientist * Program management * System and software integration and test engineers * Safety engineers and certifiers | * External organizations * Operational system managers * Trainers * Maintainers * Auditors * Security engineers and   certifiers |

## 

This section provides an overview of the primary stakeholders involved in the development and use of the Quizzes Tutor system, along with their main concerns regarding the system’s architecture.

1. **Teachers**
   * **Role**: Creators and managers of quizzes.
   * **Main Concerns**:
     + Usability: An intuitive interface for creating and managing quizzes.
     + Reliability: System stability during usage to ensure smooth educational activities.
     + Performance Reporting: Access to reports tracking student progress and results.
2. **Students**
   * **Role**: End users who take quizzes.
   * **Main Concerns**:
     + Availability: Reliable access to the system at all times.
     + User Experience: A simple, user-friendly interface for completing quizzes.
     + Responsiveness: Fast response time, especially when submitting answers.
3. **Development Team**
   * **Role**: Engineers and developers responsible for system maintenance and expansion.
   * **Main Concerns**:
     + Modularity: An architecture that supports easy maintenance and future feature additions.
     + Scalability: The ability to handle an increase in users if necessary.
     + Documentation: Clear documentation to support ongoing development.
4. **System Administrators**
   * **Role**: Responsible for system deployment, stability, and monitoring.
   * **Main Concerns**:
     + Stability and Monitoring: Capability to monitor and resolve issues quickly.
     + Security: Protecting against unauthorized access and ensuring data integrity.
     + Resource Efficiency: Efficient management of server and storage resources.
5. **Project Manager**
   * **Role**: Supervisor ensuring project goals, timeline, and budget.
   * **Main Concerns**:
     + Schedule and Budget: Ensuring that the system is developed on time and within budget constraints.
     + Team Coordination: Facilitating collaboration among developers, designers, and stakeholders.
     + Architectural Flexibility: Ensuring that the architecture can adapt to changes or new requirements.

## 

## 1.5 Viewpoint Definitions

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| **CONTENTS OF THIS SECTION**: This section provides a short textual definition of a viewpoint and how the concept is used in this SAD. The section describes viewpoints that may be used in the SAD. The specific viewpoints will be tailored by the organization. |

The SAD employs a stakeholder-focused, multiple view approach to architecture documentation, as required by ANSI/IEEE 1471-2000, the recommended best practice for documenting the architecture of software-intensive systems [IEEE 1471].

As described in Section 1.2, a software architecture comprises more than one software structure, each of which provides an engineering handle on different system qualities. A *view* is the specification of one or more of these structures, and documenting a software architecture, then, is a matter of documenting the relevant views and then documenting information that applies to more than one view [Clements 2002].

ANSI/IEEE 1471-2000 provides guidance for choosing the best set of views to document, by bringing stakeholder interests to bear. It prescribes defining a set of viewpoints to satisfy the stakeholder community. A viewpoint identifies the set of concerns to be addressed, and identifies the modeling techniques, evaluation techniques, consistency checking techniques, etc., used by any conforming view. A view, then, is a viewpoint applied to a system. It is a representation of a set of software elements, their properties, and the relationships among them that conform to a defining viewpoint. Together, the chosen set of views show the entire architecture and all of its relevant properties. A SAD contains the viewpoints, relevant views, and information that applies to more than one view to give a holistic description of the system.

The remainder of Section 1.5 defines the viewpoints used in this SAD. The following table summarizes the stakeholders in this project and the viewpoints that have been included to address their concerns.

This section defines the viewpoints used in this Software Architecture Document (SAD) for the Quizzes Tutor system. In line with ANSI/IEEE 1471-2000 standards, this SAD adopts a stakeholder-focused, multiple-view approach, providing distinct perspectives to address specific concerns of different stakeholders—an approach recommended for documenting software-intensive systems.

As described in Section 1.2, the software architecture comprises multiple structures, each emphasizing different aspects of the system. A view specifies one or more of these structures, illustrating how elements relate within a given context. Documenting a system’s architecture involves creating multiple views, each tailored to the concerns of various stakeholders, while also including information that spans across views for a cohesive understanding.

According to ANSI/IEEE 1471-2000, viewpoints should be selected based on stakeholder interests and needs. Each viewpoint defines the concerns addressed, relevant modeling techniques, and key elements and relationships. A viewpoint acts as a framework for creating views, while a view is the specific representation of the system from that perspective. Together, the chosen viewpoints offer a comprehensive understanding of the architecture, ensuring stakeholders see how the system meets their requirements.

For the Quizzes Tutor system, we have identified three primary viewpoints to capture essential system qualities and address the specific needs of stakeholders:

* **Module Viewpoint**: Focuses on the static structure, dividing the system into modules.
* **Component-and-Connector Viewpoint**: Highlights runtime interactions, showing data flow and communication.
* **Allocation Viewpoint**: Maps software elements to their physical or virtual deployment infrastructure.

The following table summarizes the stakeholders in the Quizzes Tutor project and the viewpoints selected to address their specific concerns:

*Table 1: Stakeholders and Relevant Viewpoints*

| **Stakeholder** | **Viewpoint(s) that apply to that class of stakeholder’s concerns** |
| --- | --- |
| Teachers | Module Viewpoint |
| Students | Component-and-Connector Viewpoint |
| Development Team | Module Viewpoint, Component-and-Connector Viewpoint |
| System Administrators | Component-and-Connector Viewpoint, Allocation Viewpoint |
| Project Manager | Module Viewpoint |

### <Insert name of viewpoint> Viewpoint Definition

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| There will be one of these subsections for each viewpoint defined. The subsections are as follows:   * Abstract: A brief overview of the viewpoint * Stakeholders and their concerns addressed: This section describes the stakeholders and their concerns that this viewpoint is intended to address. Listed are questions that can be answered by consulting views that conform to this viewpoint. Optionally, the section includes significant questions that cannot be answered by consulting views conforming to this viewpoint. * Elements, relations, properties, and constraints: This section defines the types of elements, the relations among them, the significant properties they exhibit, and the constraints they obey for views conforming to this viewpoint. * Language(s) to model/represent conforming views: This section lists the language or languages that will be used to model or represent views conforming to this viewpoint, and cite a definition document for each. * Applicable evaluation/analysis techniques and consistency/completeness criteria: This section describes rules for consistency and completeness that apply to views in this viewpoint, as well as any analysis of evaluation techniques that apply to the view that can be used to predict qualities of the system whose architecture is being specified. * Viewpoint source: This section provides a citation for the source of this viewpoint definition, if any.   Following is an example of a viewpoint definition.  Vie1.5.1 **Module decomposition viewpoint definition**  1.5.1.1 Abstract. Views conforming to the module decomposition viewpoint partition the system into a unique non-overlapping set of hierarchically decomposable implementation units (*modules*).  1.5.1.2 Stakeholders and Their Concerns Addressed. Stakeholders and their concerns addressed by this viewpoint include   * project managers, who must define work assignments, form teams, and formulate project plans and budgets and schedules; * COTS specialists, who need to have software elements defined as units of functionality, so they can search the marketplace and perform trade studies to find suitable COTS candidates; * testers and integrators who use the modules as their unit of work; * configuration management specialists who are in charge of maintaining current and past versions of the elements; * system build engineers who use the elements to produce a running version of the system; * maintainers, who are tasked with modifying the software elements; * implementers, who are required to implement the elements; * software architects for those software elements sufficiently large or complex enough to warrant their own software architectures; * the customer, who is concerned that projected changes to the system over its lifetime can be made economically by confining the effects of each change to a small number of elements.   1.5.1.3 Elements, Relations, Properties, and Constraints. Elements of the module decomposition viewpoint are modules, which are units of implementation that provide defined functionality. Modules are hierarchically decomposable; hence, the relation is “is-part-of.” Properties of elements include their names, the functionality assigned to them (including a statement of the quality attributes associated with that functionality), and their software-to-software interfaces. The module properties may include requirements allocation, supporting requirements traceability.  1.5.1.4 Language(s) to Model/Represent Conforming Views. Views conforming to the module decomposition viewpoint may be represented by (a) plain text using indentation or outline form [Clements 2002]; (b) UML, using subsystems or classes to represent elements and “is part of” or nesting to represent the decomposition relation.  1.5.1.5 Applicable Evaluation/Analysis Techniques and Consistency/Completeness Criteria. Completeness/consistency criteria include (a) no element has more than one parent; (b) major functionality is provided for by exactly one element; (c) the union of all elements’ functionality covers the requirements for the system; (d) every piece of source code can be mapped to an element in the module decomposition view  (if not, the view is not complete); (e) the selection of module aligns with current and proposed procurement decisions. Additional consistency/completeness criteria apply to the specifications of the elements’ interfaces. Applicable evaluation/analysis techniques include (a) scenario-based evaluation techniques such as ATAM [Clements 2001] to assure that projected changes are supported economically by the decomposition; (b) disciplined and detailed mapping to requirements to assure coverage and non-overlapping functionality; (c) cost-based techniques that determine the number and composition of modules for efficient procurement.  1.5.1.6 Viewpoint Source. [Clements 2002, Section 2.1] describes the module decomposition style, which corresponds in large measure to this viewpoint. |

#### Abstract

#### Stakeholders and Their Concerns Addressed

#### Elements, Relations, Properties, and Constraints

#### Language(s) to Model/Represent Conforming Views

#### Applicable Evaluation/Analysis Techniques and Consistency/Completeness Criteria

#### Viewpoint Source

### 

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### 1.5.1 Module Viewpoint Definition

#### 1.5.1.1 Abstract

The Module Viewpoint organizes the Quizzes Tutor system into distinct modules, each representing a core function or service, such as user management, quiz handling, and data storage. This viewpoint provides stakeholders with a high-level view of the system’s structure and how responsibilities are distributed.

#### 1.5.1.2 Stakeholders and Their Concerns Addressed

* **Teachers**: Need a clear view of core functionalities for educational use.
* **Development Team**: Benefits from a modular structure for simplified implementation and maintenance.
* **Project Manager**: Uses the module structure to organize work and track progress.

#### 1.5.1.3 Elements, Relations, Properties, and Constraints

* **Elements**: Key modules include the frontend (Vue.js for UI), backend (Spring Boot in java), and database (PostgreSQL).
* **Relations**: Modules have “is-part-of” relationships in the system hierarchy, such as backend modules for quiz processing.
* **Properties and Constraints**: Each module should have distinct functions without overlap, to maintain independence and modularity.

#### 1.5.1.4 Language(s) to Model/Represent Conforming Views

* **Modeling Language**: Represented with UML class or package diagrams showing module hierarchy and dependencies.

#### 1.5.1.5 Applicable Evaluation/Analysis Techniques and Consistency/Completeness Criteria

* **Consistency**: Ensures that each functionality maps to a single module, avoiding redundancy.
* **Completeness**: Each module’s functionality covers its intended responsibilities, verified through requirements traceability.
* **Evaluation Techniques**: Scenario-based analysis (e.g., ATAM) to ensure that modules handle anticipated changes and growth.

#### 1.5.1.6 Viewpoint Source

* Based on [Clements 2002, Section 2.1] for module decomposition principles.

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### 1.5.2 Component-and-Connector Viewpoint Definition

#### 1.5.2.1 Abstract

The Component-and-Connector Viewpoint focuses on runtime interactions between components, such as data flow and communication protocols. This viewpoint is essential for understanding system behavior under various conditions and how components collaborate to deliver functionality.

#### 1.5.2.2 Stakeholders and Their Concerns Addressed

* **Students**: Concerned with system reliability and response during quizzes.
* **Development Team**: Needs to understand component interactions for debugging and optimization.
* **System Administrators**: Monitors component interactions to maintain performance and resolve issues.

#### 1.5.2.3 Elements, Relations, Properties, and Constraints

* **Elements**: Components include the frontend, backend APIs, and database connections.
* **Relations**: “Uses” and “connects-to” relations define interactions, e.g., frontend communicating with backend via RESTful APIs.
* **Properties and Constraints**: Each connection should ensure secure, high-availability communication.

#### 1.5.2.4 Language(s) to Model/Represent Conforming Views

* **Modeling Language**: Represented using sequence diagrams or component diagrams to illustrate interactions.

#### 1.5.2.5 Applicable Evaluation/Analysis Techniques and Consistency/Completeness Criteria

* **Consistency**: Ensures necessary connections exist without unnecessary duplication.
* **Completeness**: Each essential interaction for operations is mapped and validated.
* **Evaluation Techniques**: Load and performance testing to verify that components handle user demand effectively.

#### 1.5.2.6 Viewpoint Source

* Based on best practices in runtime interaction modeling.

### 1.5.3 Allocation Viewpoint Definition

#### 1.5.3.1 Abstract

The Allocation Viewpoint maps the Quizzes Tutor software components to physical or virtual infrastructure, detailing where each component operates. This viewpoint helps understand resource distribution and system scalability.

#### 1.5.3.2 Stakeholders and Their Concerns Addressed

* **System Administrators**: Concerned with resource allocation and system scalability.

#### 1.5.3.3 Elements, Relations, Properties, and Constraints

* **Elements**: Physical/virtual servers, cloud environments, and network connections.
* **Relations**: “Deployed-on” relationships showing where each software component is hosted.
* **Properties and Constraints**: Components should be distributed to optimize performance, with resources scaled to meet peak demand.

#### 1.5.3.4 Language(s) to Model/Represent Conforming Views

* **Modeling Language**: Deployment diagrams to visualize component allocation to infrastructure.

#### 1.5.3.5 Applicable Evaluation/Analysis Techniques and Consistency/Completeness Criteria

* **Consistency**: Ensures all components are deployed according to the architectural specifications.
* **Completeness**: Each software component is accounted for in the infrastructure map.
* **Evaluation Techniques**: Resource utilization analysis to optimize allocation and ensure scalability.

#### 1.5.3.6 Viewpoint Source

* Based on deployment and infrastructure management best practices.

## How a View is Documented

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| **CONTENTS OF THIS SECTION**: This section describes how the documentation for a view is structured and organized. If you change the *organization* of information in Section 3, then you should also change its description in here. Otherwise, this section is all boilerplate.  If you choose to document all information in a view in a single presentation, then you will not need view packets. In that case, the template is as follows:   * Section 3.i: Name of view * Section 3.i.1: View description * Section 3.i.2: Primary presentation. This section presents the elements and the relations among them that populate this view packet, using an appropriate language, languages, notation, or tool-based representation. * Section 3.i.3: Element catalog. Whereas the primary presentation shows the important elements and relations of the view packet, this section provides additional information needed to complete the architectural picture. It consists of subsections for (respectively) elements, relations, interfaces, behavior, and constraints. * Section 3.i.4: Context diagram. This section provides a context diagram showing the context of the part of the system represented by this view packet. It also designates the view packet’s scope with a distinguished symbol, and shows interactions with external entities in the vocabulary of the view. * Section 3.i.5: Variability mechanisms. This section describes any variabilities that are available in the portion of the system shown in the view packet, along with how and when those mechanisms may be exercised. * Section 3.i.6: Architecture background. This section provides rationale for any significant design decisions whose scope is limited to this view packet. |

Section 3 of this SAD contains one view for each viewpoint listed in Section 1.5. Each view is documented as a set of view packets. A view packet is the smallest bundle of architectural documentation that might be given to an individual stakeholder.

Each view is documented as follows, where the letter *i* stands for the number of the view: 1, 2, etc.:

* Section 3.i: Name of view.
* Section 3.i.1: View description. This section describes the purpose and contents of the view. It should refer to (and match) the viewpoint description in Section 1.5 to which this view conforms.
* Section 3.i.2: View packet overview. This section shows the set of view packets in this view, and provides rationale that explains why the chosen set is complete and non-duplicative. The set of view packets may be listed textually, or shown graphically in terms of how they partition the entire architecture being shown in the view.
* Section 3.i.3: Architecture background. Whereas the architecture background of Section 2 pertains to those constraints and decisions whose scope is the entire architecture, this section provides any architecture background (including significant driving requirements, design approaches, patterns, analysis results, and requirements coverage) that applies to this view.
* Section 3.i.4: Variability mechanisms. This section describes any architectural variability mechanisms (e.g., adaptation data, compile-time parameters, variable replication, and so forth) described by this view, including a description of how and when those mechanisms may be exercised and any constraints on their use.
* Section 3.i.5: View packets. This section presents all of the view packets given for this view. Each view packet is described using the following outline, where the letter *j* stands for the number of the view packet being described: 1, 2, etc.
* Section 3.i.5.j: View packet #j.
* Section 3.i.5.j.1: Primary presentation. This section presents the elements and the relations among them that populate this view packet, using an appropriate language, languages, notation, or tool-based representation.
* Section 3.i.5.j.2: Element catalog. Whereas the primary presentation shows the important elements and relations of the view packet, this section provides additional information needed to complete the architectural picture. It consists of the following subsections:
* Section 3.i.5.j.2.1: Elements.This section describes each element shown in the primary presentation, details its responsibilities of each element, and specifies values of the elements’ relevant *properties*, which are defined in the viewpoint to which this view conforms.
* Section 3.i.5.j.2.2: Relations.This section describes any additional relations among elements shown in the primary presentation, or specializations or restrictions on the relations shown in the primary presentation.
* Section 3.i.5.j.2.3: Interfaces.This section specifies the software interfaces to any elements shown in the primary presentation that must be visible to other elements.
* Section 3.i.5.j.2.4: Behavior. This section specifies any significant behavior of elements or groups of interacting elements shown in the primary presentation.
* Section 3.i.5.j.2.5: Constraints: This section lists any constraints on elements or relations not otherwise described.
* Section 3.i.5.j.3: Context diagram. This section provides a context diagram showing the context of the part of the system represented by this view packet. It also designates the view packet’s scope with a distinguished symbol, and shows interactions with external entities in the vocabulary of the view.
* Section 3.i.5.j.4: Variability mechanisms. This section describes any variabilities that are available in the portion of the system shown in the view packet, along with how and when those mechanisms may be exercised.
* Section 3.i.5.j.5: Architecture background. This section provides rationale for any significant design decisions whose scope is limited to this view packet.
* Section 3.i.5.j.6: Relation to other view packets. This section provides references for related view packets, including the parent, children, and siblings of this view packet. Related view packets may be in the same view or in different views.

## How a View is Documented

This section provides the structure and organization for documenting each view in Section 3 of the Software Architecture Document (SAD). If the format or layout in Section 3 is altered, it is essential to update this description accordingly to ensure consistency. This section acts as a standardized guide, which allows all views to follow a uniform documentation process, thus enhancing readability and comprehension across all stakeholder groups.

### Single-Presentation View Documentation

If a view’s documentation is presented in a single section without subdividing into view packets, the structure will be as follows:

* **Section 3.i: Name of view** – Specifies the view (e.g., *Module View*, *Component-and-Connector View*, etc.).
* **Section 3.i.1: View description** – Outlines the purpose and content of the view.
* **Section 3.i.2: Primary presentation** – Displays the main elements and their relationships using appropriate tools or notation.
* **Section 3.i.3: Element catalog** – Complements the primary presentation with further details on elements, relations, interfaces, behavior, and constraints.
* **Section 3.i.4: Context diagram** – Provides a diagram illustrating the context of the view within the system, marking its scope and interactions.
* **Section 3.i.5: Variability mechanisms** – Details any configuration or adaptation options within this view.
* **Section 3.i.6: Architecture background** – Explains rationale for major design decisions limited to this view.

### View Packet-Based Documentation

For views that require division into *view packets* to accommodate complexity, each view will be documented with the following structure:

* **Section 3.i: Name of view**
* **Section 3.i.1: View description** – Aligns with the viewpoint described in Section 1.5.
* **Section 3.i.2: View packet overview** – Lists all view packets within the view and explains why this set is comprehensive.
* **Section 3.i.3: Architecture background** – Describes relevant design decisions, requirements, and architectural choices specific to this view.
* **Section 3.i.4: Variability mechanisms** – Notes architectural mechanisms specific to this view, if applicable.
* **Section 3.i.5: View packets** – Each view packet follows the outline below:
  + **Section 3.i.5.j: View packet #j**
    - **Section 3.i.5.j.1: Primary presentation** – Depicts the core elements and their relationships.
    - **Section 3.i.5.j.2: Element catalog**:
      * **Elements** – Details the elements in the view packet.
      * **Relations** – Additional relations or constraints.
      * **Interfaces** – Visible software interfaces for each element.
      * **Behavior** – Any significant behavior of elements or interactions.
      * **Constraints** – Any specific constraints not covered earlier.
    - **Section 3.i.5.j.3: Context diagram** – Shows the scope and external interactions of this view packet.
    - **Section 3.i.5.j.4: Variability mechanisms** – Lists available configuration mechanisms.
    - **Section 3.i.5.j.5: Architecture background** – Rationale for design decisions specific to this packet.
    - **Section 3.i.5.j.6: Relation to other view packets** – References to related packets.

This organizational structure in Section 1.6 serves as a **template for Section 3**, ensuring consistency and clarity across all views in the SAD for the Quizzes Tutor project.

## Relationship to Other SADs

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| **CONTENTS OF THIS SECTION**: This section describes the relationship between this SAD and other architecture documents, both system and software. For example, a large project may choose to have one SAD that defines the system-of-systems architecture, and other SADs to define the architecture of systems or subsystems. An embedded system may well have a *system* architecture document, in which case this section would explain how the information in here traces to information there.  If none, say “Not applicable.” |

"Not applicable."

## Process for Updating this SAD

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| **CONTENTS OF THIS SECTION**: This section describes the process a reader should follow to report discrepancies, errors, inconsistencies, or omissions from this SAD. The section also includes necessary contact information for submitting the report. If a form is required, either a copy of the blank form that may be photocopied is included, or a reference to an online version is provided. This section also describes how error reports are handled, and how and when a submitter will be notified of the issue’s disposition. |

This section outlines the procedure for reporting any discrepancies, errors, inconsistencies, or omissions found in this Software Architecture Document (SAD). Stakeholders and users can follow the steps below to provide feedback or report issues:

**Report Submission:**All identified issues with this SAD should be documented and submitted through the designated contact channels. Reports can be directed to the system’s documentation administrator or the relevant project manager.

**Contact Information:**For reporting purposes, please use the following contact details:

* **Email:** [fc58168@alunos.fc.ul.pt](mailto:fc58168@alunos.fc.ul.pt) ; [fc58250@alunos.fc.ul.pt](mailto:fc58250@alunos.fc.ul.pt) ; [fc64361@alunos.fc.ul.pt](mailto:fc64361@alunos.fc.ul.pt)

**Report Format:**Reports should contain a clear description of the issue, including references to specific sections or subsections when applicable.

**Handling of Reports:**Upon submission, the documentation team will review each issue. Significant discrepancies or omissions will be evaluated and prioritized based on their impact on stakeholders and users of the SAD.

**Notification of Resolution:**The individual who submitted the report will be informed of the outcome once the issue has been reviewed. An update will be provided indicating whether the issue will be addressed in an upcoming revision or if immediate action is required.

# Architecture Background

## Problem Background

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| **CONTENTS OF THIS SECTION**: The sub-parts of Section 2.1 explain the constraints that provided the significant influence over the architecture. |

The Quizzes Tutor system was developed to address specific needs in the educational field, particularly in simplifying quiz creation and management. This demand emerged from a gap in traditional assessment methods, which can be time-consuming and difficult to tailor for each class and subject. Quizzes Tutor aims to fulfill these needs by providing a practical, accessible, and secure digital platform.

### System Overview

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| **CONTENTS OF THIS SECTION**: This section describes the general function and purpose for the system or subsystem whose architecture is described in this SAD. |

The Quizzes Tutor project considers the following key constraints and influences on its architecture:

* **Flexibility and Ease of Use:** The system must allow teachers to create quizzes with various question types (e.g., multiple-choice, true/false) and provide an intuitive interface for both teachers and students.
* **Data Security:** Protecting user data and quiz results is a primary concern. The architecture must support data encryption and user authentication.
* **Performance and Scalability:** Given the potential for multiple simultaneous accesses, particularly during peak assessment periods, the architecture must support horizontal scalability and high availability.
* **Chosen Technologies:** The use of Vue.js for the frontend, Spring Boot for the backend, and PostgreSQL for the database influences architectural decisions, as each of these tools provides specific capabilities in modularity, performance, and security.

These combined factors form the background for the architectural choices made for Quizzes Tutor, ensuring the system effectively meets pedagogical and technical requirements.

### Goals and Context

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| **CONTENTS OF THIS SECTION**: This section describes the goals and major contextual factors for the software architecture. The section includes a description of the role software architecture plays in the life cycle, the relationship to system engineering results and artifacts, and any other relevant factors. |

This section outlines the main goals and contextual factors shaping the architecture of Quizzes Tutor. The system’s primary goal is to facilitate teaching and learning through interactive quizzes, ensuring that teachers can easily create and manage quizzes, while students have a seamless experience accessing and completing them. In the educational context, the system needs to be robust, focusing on usability, scalability, and security. The architecture of Quizzes Tutor plays a central role in the software lifecycle, aligning with system engineering artifacts and meeting both pedagogical and technical needs.

### Significant Driving Requirements

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| **CONTENTS OF THIS SECTION**: This section describes behavioral and quality attribute requirements (original or derived) that shaped the software architecture. Included are any scenarios that express driving behavioral and quality attribute goals, such as those crafted during a Quality Attribute Workshop (QAW) [Barbacci 2003] or software architecture evaluation using the Architecture Tradeoff Analysis Method[[2]](#footnote-2)SM (ATAMSM) [Bass 2003]. |

This section highlights the behavioral and quality requirements that drive the architecture of Quizzes Tutor. Performance requirements include the ability to handle high volumes of simultaneous requests, particularly during peak testing periods. Security requirements ensure that only authorized users have access to sensitive information. Other quality attributes, such as availability and maintainability, were evaluated using methods like ATAM(Architecture Tradeoff Analysis Method,), ensuring the system can support future adaptations and enhancements without compromising data integrity or user experience.

## 2.2 Solution Background

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| **CONTENTS OF THIS SECTION**: The sub-parts of Section 2.2 provide a description of why the architecture is the way that it is, and a convincing argument that the architecture is the right one to satisfy the behavioral and quality attribute goals levied upon it. |

This section outlines the rationale behind the architecture chosen for Quizzes Tutor and explains how it meets the defined behavioral and quality objectives.

**Architecture Goal**: Designed to be a robust, scalable, and user-friendly platform for creating and managing educational quizzes, supporting both teachers and students. The system must be intuitive, reliable, and maintain consistent performance.

**Behavioral Goals**:

**User Experience**: The Vue.js frontend offers an interactive and responsive interface, crucial for a positive user experience in educational environments, where usability is key.

**Reliability**: Ensures consistent execution of core functionalities (e.g., quiz creation, submission, and grading), minimizing disruptions.

**Quality Attributes**:

**Performance**: The frontend-backend separation optimizes each component’s performance, keeping the interface responsive while the backend manages business logic and data processing efficiently.

**Scalability**: Using PostgreSQL and a modular implementation supports the system's growth for increasing users, while preserving integrity and performance.

**Maintainability**: The modular architecture facilitates feature additions and updates without impacting the entire application, enabling continuous improvement.

### Architectural Approaches

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| **CONTENTS OF THIS SECTION**: This section provides a rationale for the major design decisions embodied by the software architecture. It describes any design approaches applied to the software architecture, including the use of architectural styles or design patterns, when the scope of those approaches transcends any single architectural view. The section also provides a rationale for the selection of those approaches. It also describes any significant alternatives that were seriously considered and why they were ultimately rejected. The section describes any relevant COTS issues, including any associated trade studies. |

### Architectural Approaches

This section discusses the key design decisions underlying Quizzes Tutor’s architecture, including adopted architectural styles, patterns, and considered alternatives.

**Architectural Styles and Patterns**:

**Separate Frontend-Backend Architecture**: Vue.js is used for the frontend, separate from the Spring Boot (in java) backend, creating a responsive and scalable interface independent of business logic and data processing.

**Client-Server Model**: Sensitive operations and data are securely processed on the server (backend), while the client (frontend) offers an interactive user experience.

**Data Persistence with PostgreSQL**: Chosen for its reliability, scalability, and compatibility with complex transactions, PostgreSQL is ideal for managing quiz and assessment data.

**Design Rationale**:

**Vue.js for Frontend**: Chosen for its quick development cycle and easy learning curve, enabling the team to build an intuitive interface.

**Spring Boot for Backend**: Selected for robustness and modularity, managing business logic and integrating well with PostgreSQL.

**PostgreSQL as Database**: Ensures data integrity and consistency, essential for educational systems.

**Considered and Rejected Alternatives**:

**Frontend Frameworks**: React and Angular were considered, but Vue.js was chosen for simplicity and ease of integration.

**Databases**: MySQL and MongoDB were reviewed, but PostgreSQL was selected for handling complex transactions and ensuring data consistency.

**COTS Issues**:

**Use of Open-Source Solutions**: The architecture leverages open-source solutions, like PostgreSQL, to meet quality requirements without significant added cost.

**IST Authentication Integration**: Integrated with the Instituto Superior Técnico’s authentication system to ensure secure and straightforward access for users.

### Analysis Results

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| **CONTENTS OF THIS SECTION**: This section describes the results of any quantitative or qualitative analyses that have been performed that provide evidence that the software architecture is fit for purpose. If an Architecture Tradeoff Analysis Method evaluation has been performed, it is included in the analysis sections of its final report. This section refers to the results of any other relevant trade studies, quantitative modeling, or other analysis results. |

This section presents the results of the qualitative and quantitative analyses performed to validate that the Quizzes Tutor architecture meets the goals of performance, scalability, and security.

**Performance and Scalability Testing**: Load tests were conducted to evaluate the system's ability to handle a high number of simultaneous users, especially during peak times like assessments. The analysis demonstrated that the system can scale horizontally by adding backend server instances, maintaining acceptable response times thanks to the separation of responsibilities between frontend and backend and the use of PostgreSQL, which managed complex transaction loads effectively.

**Security Analysis**: The architecture was evaluated for resilience against unauthorized access attempts and data protection. The integration with Instituto Superior Técnico (IST)’s authentication system proved effective for access control, providing secure authentication. Additionally, data encryption and protection practices were implemented at the backend level, which prevented unauthorized access to sensitive information of students and teachers.

**Maintainability Analysis**: Based on metrics generated by SonarQube, areas of code requiring refactoring were identified to improve clarity and modularity. The modular architecture facilitated these improvements without impacting other parts of the system, confirming the choice of a modular design. (e o que vamos fazer asseguir)

**Conclusion**: The results of these analyses indicate that the architecture meets the defined goals for performance and security while allowing for interventions and updates without compromising the system’s continuous operation.

### Requirements Coverage

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| **CONTENTS OF THIS SECTION**: This section describes the requirements (original or derived) addressed by the software architecture, with a short statement about where in the architecture each requirement is addressed. |

### Requirements Coverage

This section summarizes how the Quizzes Tutor architecture meets both original and derived functional and quality requirements established for the project.

**Functional Requirements (Original)**:

**Quiz Creation and Management**: The modular architecture allows the backend to handle quiz creation and management independently, fulfilling the original requirement to support the educational process.

**User Interaction and Experience**: The Vue.js frontend ensures that the system is accessible and responsive, meeting the original requirement to provide an intuitive experience for students and teachers.

**Quality Requirements (Original and Derived)**:

**Security (Original)**: The architecture ensures data protection and controlled access through the integration of robust authentication mechanisms, meeting the original security requirement.

**Performance (Derived)**: The separation of frontend and backend, along with the choice of PostgreSQL, guarantees fast response times, addressing the derived requirement for performance even under heavy load.

**Scalability and Flexibility (Derived)**: The system’s modularity and the ability to add backend instances support user growth without significant reengineering, meeting the derived requirements for scalability and flexibility.

### Summary of Background Changes Reflected in Current Version

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| **CONTENTS OF THIS SECTION**: For versions of the SAD after the original release, this section summarizes the actions, decisions, decision drivers, analysis and trade study results that became decision drivers, requirements changes that became decision drivers, and how these decisions have caused the architecture to evolve or change. |

This section provides an overview of the architectural changes and their rationale since the initial release of the Software Architecture Document (SAD) for the Quizzes Tutor project. These changes have been influenced by ongoing analysis, requirement adjustments, and optimization opportunities identified through testing and stakeholder feedback.

**Improved Modularity**: Based on maintainability analysis with tools like SonarQube, certain parts of the code were refactored to improve modularity. This change enhances the ease of future updates and reduces interdependencies, allowing components to be updated independently.

**Enhanced Security Measures**: In response to stakeholder concerns and security assessments, the system now incorporates additional data protection measures, particularly in user authentication and data storage. This change was driven by the need to better protect sensitive information and align with updated security standards.

**Performance Optimization**: Performance testing revealed areas where system response times could be improved. As a result, database queries were optimized, and certain backend processes were restructured. These optimizations were necessary to ensure that the system can handle increased user load during peak times, enhancing scalability and user experience.

**Scalability Adjustments**: As part of the scalability strategy, the architecture has been updated to allow easier scaling by adding backend server instances as needed. This flexibility was essential to accommodate growing usage and was informed by load testing and anticipated growth.

These updates reflect a commitment to maintaining a robust and adaptive architecture that meets evolving project needs and aligns with quality standards in performance, security, and maintainability.

## Product Line Reuse Considerations

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| **CONTENTS OF THIS SECTION**: When a software product line is being developed, this section details how the software covered by this SAD is planned or expected to be reused in order to support the product line vision. In particular, this section includes a complete list of the variations that are planned to be produced and supported. "Variation" refers to a variant of the software produced through the use of pre-planned variation mechanisms made available in the software architecture. It may refer to a variant of one of the modules identified in this SAD, or a collection of modules, or the entire system or subsystem covered by this SAD. For each variation, the section identifies the increment(s) of the software build in which (a) the variation will be available; and (b) the variation will be used. Finally, this section describes any additional potential that exists to reuse one or more of the modules or their identified variations, even if this reuse is not currently planned for any increme |

# Not applicable. No current plans exist for developing product line variations based on the Quizzes Tutor system.

# Views

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| **CONTENTS OF THIS SECTION**: The sub-parts of Section 3 specify the views corresponding to the viewpoints listed in Section 1.5. |

This section contains the views of the software architecture. A view is a representation of a whole system from the perspective of a related set of concerns [IEEE 1471]. Concretely, a view shows a particular type of software architectural elements that occur in a system, their properties, and the relations among them. A view conforms to a defining viewpoint.

Architectural views can be divided into three groups, depending on the broad nature of the elements they show. These are:

* Module views. Here, the elements are modules, which are units of implementation. Modules represent a code-based way of considering the system. Modules are assigned areas of functional responsibility, and are assigned to teams for implementation. There is less emphasis on how the resulting software manifests itself at runtime. Module structures allow us to answer questions such as: What is the primary functional responsibility assigned to each module? What other software elements is a module allowed to use? What other software does it actually use? What modules are related to other modules by generalization or specialization (i.e., inheritance) relationships?
* Component-and-connector views. Here, the elements are runtime components (which are principal units of computation) and connectors (which are the communication vehicles among components). Component and connector structures help answer questions such as: What are the major executing components and how do they interact? What are the major shared data stores? Which parts of the system are replicated? How does data progress through the system? What parts of the system can run in parallel? How can the system’s structure change as it executes?
* Allocation views. These views show the relationship between the software elements and elements in one or more external environments in which the software is created and executed. Allocation structures answer questions such as: What processor does each software element execute on? In what files is each element stored during development, testing, and system building? What is the assignment of the software element to development teams?

These three kinds of structures correspond to the three broad kinds of decisions that architectural design involves:

* How is the system to be structured as a set of code units (modules)
* How is the system to be structured as a set of elements that have run-time behavior (components) and interactions (connectors) ?
* How is the system to relate to non-software structures in its environment (such as CPUs, file systems, networks, development teams, etc.)?

Often, a view shows information from more than one of these categories. However, unless chosen carefully, the information in such a hybrid view can be confusing and not well understood.

The views presented in this SAD are the following:

This section contains the software architecture views of the Quizzes Tutor system, with each view offering a representation of the system from the perspective of a specific set of stakeholder concerns, as described by [IEEE 1471]. Each view displays architectural elements, their properties, and the relationships between them according to a defined viewpoint.

Architectural views are divided into three main categories, based on the nature of the elements they represent:

**Module Views**: These focus on structuring the system as a set of modules or implementation units, each with a defined functional responsibility. Module views allow us to answer questions such as:

* + What is the primary functional responsibility assigned to each module?
  + What other software elements is a module allowed to use?
  + What modules are related to others by generalization or specialization relationships?

**Component-and-Connector Views**: These represent the runtime components and the connectors that facilitate communication between them. This view emphasizes the system’s behavior during execution, helping answer questions such as:

* + What are the major executing components, and how do they interact?
  + What shared data stores exist in the system?
  + Which parts of the system can run in parallel, and how does data progress through the system?

**Allocation Views**: These show how software elements relate to the physical or virtual infrastructure, including hardware and runtime environments. This view reveals how software is distributed across the infrastructure, addressing questions such as:

* + Where is each software element deployed in terms of physical or virtual infrastructure?
  + How are resources assigned to the system’s development teams?
  + What is the distribution of responsibilities for development, testing, and system building?

These three structures reflect the main types of architectural decisions:

The system's code structure (Module View),

The organization of runtime components and their interactions (Component-and-Connector View),

The allocation of software elements to physical or virtual infrastructure (Allocation View).

While some views may show information from more than one of these categories, this clear separation helps maintain focus and avoids confusion in presentation.

**The views presented in this document are as follows:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name of view** | **Viewtype that defines this view** | **Types of elements and relations shown** | **Is this a module view?** | **Is this a component-and-connector view?** | **Is this an allocation view?** |
| Module View | Modules (Frontend, Backend, Database) | Dependency, Ownership, Generalization | yes | no | no |
| Component-and-Connector View | Runtime Components (Frontend, APIs, Database connections) | Uses, Connects-to, Data Flow | no | yes | no |
| Allocation View | Physical/Virtual infrastructure (Servers, Cloud) |  | no | no | yes |

## <Insert view name> View

|  |
| --- |
| **CONTENTS OF THIS SECTION**: For each view documented in this SAD, the sub-parts of Section 3.1 specify it using the outline given in Section 1.6. This part of the template assumes you are using view packets to divide up a view into management chunks. If not, then see the note in Section 1.6 as to what outline to use for each view. |

### View Description

### View Packet Overview

This view has been divided into the following view packets for convenience of presentation:

<<list, table, or diagram>>

### Architecture Background

### Variability Mechanisms

### View Packets

|  |
| --- |
| **CONTENTS OF THIS SECTION**: For each view packet in the view, this section describes it using the outline given in Section 1.6. |

#### View packet # j

##### Primary Presentation

##### Element Catalog

###### Elements

###### Relations

###### Interfaces

###### Behavior

###### Constraints

##### Context Diagram

##### Variability Mechanisms

##### Architecture Background

##### Related View Packets

**3.1 Module View**

* **View Description**
* The Module View of Quizzes Tutor organizes the system into independent modules, highlighting main responsibilities and functionalities. Key modules include the frontend, backend, and database, each with a distinct role in supporting the overall system.
* **View Packet Overview**
* **Frontend Module**: Manages the user interface and quiz interactions.
* **Backend Module**: Handles business logic, such as quiz creation and evaluation.
* **Database Module**: Manages persistent data storage, including quizzes and student responses.
* **Architecture Background**
* The modular design allows for independent development, maintenance, and scaling, providing flexibility and robustness for future growth and enhancements.
* **Variability Mechanisms**
* Configuration and adaptation options include scaling for the backend module to accommodate higher loads, themes for the frontend, and replication options for the database.

#### **View Packets**

#### **Frontend Module (View Packet #1)**

* **Primary Presentation**: Diagram showing main frontend elements, e.g., QuizComponent, UserInterface.
* **Element Catalog**:
  + **Elements**: Main components managing user interactions.
  + **Relations**: Dependencies on backend APIs.
  + **Interfaces**: RESTful APIs for backend communication.
  + **Behavior**: Quick loading and responsiveness to user interactions.
  + **Constraints**: Browser compatibility and performance requirements.
* **Context Diagram**: Shows frontend interactions with users and backend.
* **Variability Mechanisms**: Options for themes and language settings.
* **Architecture Background**: Vue.js chosen for simplicity and responsiveness.
* **Related View Packets**: Backend, Database.

#### **Backend Module (View Packet #2)**

* **Primary Presentation**: Diagram of main backend components like QuizService, UserController.
* **Element Catalog**:
  + **Elements**: Handles business logic and user authentication.
  + **Relations**: API connections to frontend, CRUD to database.
  + **Interfaces**: Exposes RESTful APIs for frontend.
  + **Behavior**: Manages quiz submissions, authentication, and data processing.
  + **Constraints**: Security protocols and scalability.
* **Context Diagram**: Shows backend interactions with frontend and database.
* **Variability Mechanisms**: Scalable backend deployment.
* **Architecture Background**: Spring Boot for modularity and performance.
* **Related View Packets**: Frontend, Database.

#### **Database Module (View Packet #3)**

* **Primary Presentation**: Schema diagram showing main tables (Users, Quizzes, Results).
* **Element Catalog**:
  + **Elements**: Database tables for quizzes, users, results.
  + **Relations**: Foreign key relationships for data integrity.
  + **Interfaces**: SQL/ORM interfaces for backend data access.
  + **Behavior**: Concurrent data access and storage.
  + **Constraints**: Data integrity and backup schedules.
* **Context Diagram**: Shows database and backend interactions.
* **Variability Mechanisms**: Options for replication and clustering.
* **Architecture Background**: PostgreSQL for transactional integrity.
* **Related View Packets**: Backend.

### **3.2 Component-and-Connector View**

* **View Description**
* This view focuses on runtime interactions and data flow, describing how components communicate during operation.
* **View Packet Overview**
* **User Interaction Component (Frontend)**: Manages UI and data exchange with backend.
* **Backend Processing Component**: Handles core logic, data processing, and APIs.
* **Database Connection Component**: Ensures data persistence and integrity.
* **Architecture Background**
* RESTful APIs facilitate smooth communication, and load balancing ensures performance under high traffic.
* **Variability Mechanisms**
* Options include backend load balancing and frontend responsive design for various devices.

#### **View Packets**

#### **User Interaction Component (Frontend) (View Packet #1)**

* **Primary Presentation**: Diagram of frontend components like QuizComponent.
* **Element Catalog**:
  + **Elements**: User interface elements for interaction.
  + **Relations**: API connections to backend.
  + **Interfaces**: UI elements, RESTful APIs.
  + **Behavior**: Manages user actions like quiz submissions.
  + **Constraints**: Responsive design for multiple devices.
* **Context Diagram**: Shows frontend-user and backend interactions.
* **Variability Mechanisms**: Themes, languages, and responsive design.
* **Architecture Background**: Vue.js for interactive UI.
* **Related View Packets**: Backend Processing Component, Database Connection Component.

#### **Backend Processing Component (View Packet #2)**

* **Primary Presentation**: Diagram of backend services like AuthService, QuizService.
* **Element Catalog**:
  + **Elements**: Services for data validation and quiz processing.
  + **Relations**: API interactions with frontend and database.
  + **Interfaces**: RESTful endpoints.
  + **Behavior**: Manages requests, validates inputs, and processes data.
  + **Constraints**: Security and response time requirements.
* **Context Diagram**: Shows backend connections with frontend and database.
* **Variability Mechanisms**: Horizontal scaling for increased capacity.
* **Architecture Background**: Spring Boot for service modularity.
* **Related View Packets**: User Interaction Component, Database Connection Component.

#### **Database Connection Component (View Packet #3)**

* **Primary Presentation**: Diagram of backend-database interactions.
* **Element Catalog**:
  + **Elements**: Key tables and management tools.
  + **Relations**: Backend-database connections.
  + **Interfaces**: SQL or ORM interfaces for backend data access.
  + **Behavior**: Data persistence and concurrency handling.
  + **Constraints**: Query optimization and data protection.
* **Context Diagram**: Shows backend-database connections.
* **Variability Mechanisms**: Replication and clustering for high availability.
* **Architecture Background**: PostgreSQL chosen for robust data handling.
* **Related View Packets**: Backend Processing Component.

### **3.3 Allocation View**

* **View Description**

This view details how software components are mapped to physical or virtual infrastructure.

* **View Packet Overview**
* **Frontend Deployment**: Web server/CDN setup for frontend.
* **Backend Deployment**: Application server configuration for backend.
* **Database Deployment**: PostgreSQL database deployment.
* **Architecture Background**
* Cloud infrastructure provides scalability and reliability, while CDN optimizes frontend performance.
* **Variability Mechanisms**
* Load balancing and CDN options improve response time, while database replication ensures data availability.

#### **View Packets**

#### **Frontend Deployment (View Packet #1)**

* **Primary Presentation**: Diagram of frontend on web server with CDN.
* **Element Catalog**:
  + **Elements**: Frontend server instances, CDN.
  + **Relations**: Connections to load balancer.
  + **Interfaces**: HTTP/HTTPS for client-server communication.
  + **Behavior**: Manages requests, serves UI.
  + **Constraints**: Availability and loading time under high traffic.
* **Context Diagram**: Frontend connections to backend and user devices.
* **Variability Mechanisms**: CDN options for content delivery.
* **Architecture Background**: CDN for scalability and speed.
* **Related View Packets**: Backend Deployment, Database Deployment.

#### **Backend Deployment (View Packet #2)**

* **Primary Presentation**: Diagram of backend on app servers with load balancers.
* **Element Catalog**:
  + **Elements**: Backend servers, load balancer.
  + **Relations**: Connections to frontend and database.
  + **Interfaces**: HTTP/HTTPS for API communication.
  + **Behavior**: Distributes requests and manages sessions.
  + **Constraints**: Secure, high-availability setup.
* **Context Diagram**: Backend, frontend, and database interactions.
* **Variability Mechanisms**: Load balancing for scaling.
* **Architecture Background**: Cloud deployment for reliability.
* **Related View Packets**: Frontend Deployment, Database Deployment.

#### **Database Deployment (View Packet #3)**

* **Primary Presentation**: Diagram of PostgreSQL with replication.
* **Element Catalog**:
  + **Elements**: Primary and replica database instances.
  + **Relations**: Backend-database connections.
  + **Interfaces**: SQL interfaces for data handling.
  + **Behavior**: Ensures data persistence and integrity.
  + **Constraints**: Backup, data integrity, and access control.
* **Context Diagram**: Database and backend server connections.
* **Variability Mechanisms**: Replication and clustering for availability.
* **Architecture Background**: PostgreSQL for transactional support.
* **Related View Packets**: Backend Deployment.

# Relations Among Views

Each of the views specified in Section 3 provides a different perspective and design handle on a system, and each is valid and useful in its own right. Although the views give different system perspectives, they are not independent. Elements of one view will be related to elements of other views, and we need to reason about these relations. For example, a module in a decomposition view may be manifested as one, part of one, or several components in one of the component-and-connector views, reflecting its runtime alter-ego. In general, mappings between views are many to many. Section 4 describes the relations that exist among the views given in Section 3. As required by ANSI/IEEE 1471-2000, it also describes any known inconsistencies among the views.

## General Relations Among Views

|  |
| --- |
| **CONTENTS OF THIS SECTION**: This section describes the general relationship among the views chosen to represent the architecture. Also in this section, consistency among those views is discussed and any known inconsistencies are identified. |

In the "Quizzes Tutor" project, each view in Section 3 provides a distinct and essential perspective on the system architecture, interconnecting to form a complete understanding of the system. This section explains the relationships among these views and highlights their dependencies.

#### **General Relations Among Views**

The chosen views contribute to an integrated architecture:

* The **Module View** organizes the system into main components, like Frontend, Backend, and Database, highlighting their primary functions.
* The **Component-and-Connector View** illustrates runtime interactions, including data flows and API calls between components.
* The **Allocation View** maps these components onto physical infrastructure, ensuring performance and scalability.

These views align through mappings:

* Modules to runtime components that fulfill their designated functions.
* Components in the Component-and-Connector View to servers and network resources in the Allocation View, ensuring adequate infrastructure support.

## View-to-View Relations

* **Module and Component-and-Connector Views**: Each module, such as the Frontend or Backend, maps to runtime components. The Frontend includes user interface elements, while the Backend handles quiz logic and authentication, reflecting planned interactions.
* **Component-and-Connector and Allocation Views**: Components are deployed across physical infrastructure. For instance, the Backend operates on application servers, and the Database runs on PostgreSQL, ensuring integrity and scalability.
* **Module and Allocation Views**: Modules like the Backend and Database are mapped to appropriate servers, ensuring each has the necessary configuration to support load and security.

With this interconnected structure, the "Quizzes Tutor" system achieves a robust, scalable, and maintainable architecture that meets system requirements and accommodates future adaptations.

|  |
| --- |
| **CONTENTS OF THIS SECTION**: For each set of views related to each other, this section shows how the elements in one view are related to elements in another. |

# Referenced Materials

|  |
| --- |
| **CONTENTS OF THIS SECTION**: This section provides citations for each reference document. Provide enough information so that a reader of the SAD can be reasonably expected to locate the document. |

|  |  |
| --- | --- |
| Barbacci 2003 | Barbacci, M.; Ellison, R.; Lattanze, A.; Stafford, J.; Weinstock, C.; & Wood, W. *Quality Attribute Workshops (QAWs)*, Third Edition (CMU/SEI-2003-TR-016). Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University, 2003. <http://www.sei.cmu.edu/publications/documents/03.reports/03tr016.html>. |
| Bass 2003 | Bass, Clements, Kazman, *Software Architecture in Practice,* second edition, Addison Wesley Longman, 2003. |
| Clements 2001 | Clements, Kazman, Klein, *Evaluating Software Architectures: Methods and Case Studies,* Addison Wesley Longman, 2001. |
| Clements 2002 | Clements, Bachmann, Bass, Garlan, Ivers, Little, Nord, Stafford, *Documenting Software Architectures: Views and Beyond*, Addison Wesley Longman, 2002. |
| IEEE 1471 | ANSI/IEEE-1471-2000, *IEEE Recommended Practice for Architectural Description of Software-Intensive Systems*, 21 September 2000. |

# Directory

## Index

|  |
| --- |
| **CONTENTS OF THIS SECTION**: This section provides an index of all element names, relation names, and property names. For each entry, the following are identified:   * the location in the SAD where it was defined * each place it was used   Ideally, each entry will be a hyperlink so a reader can instantly navigate to the indicated location. |

## Glossary

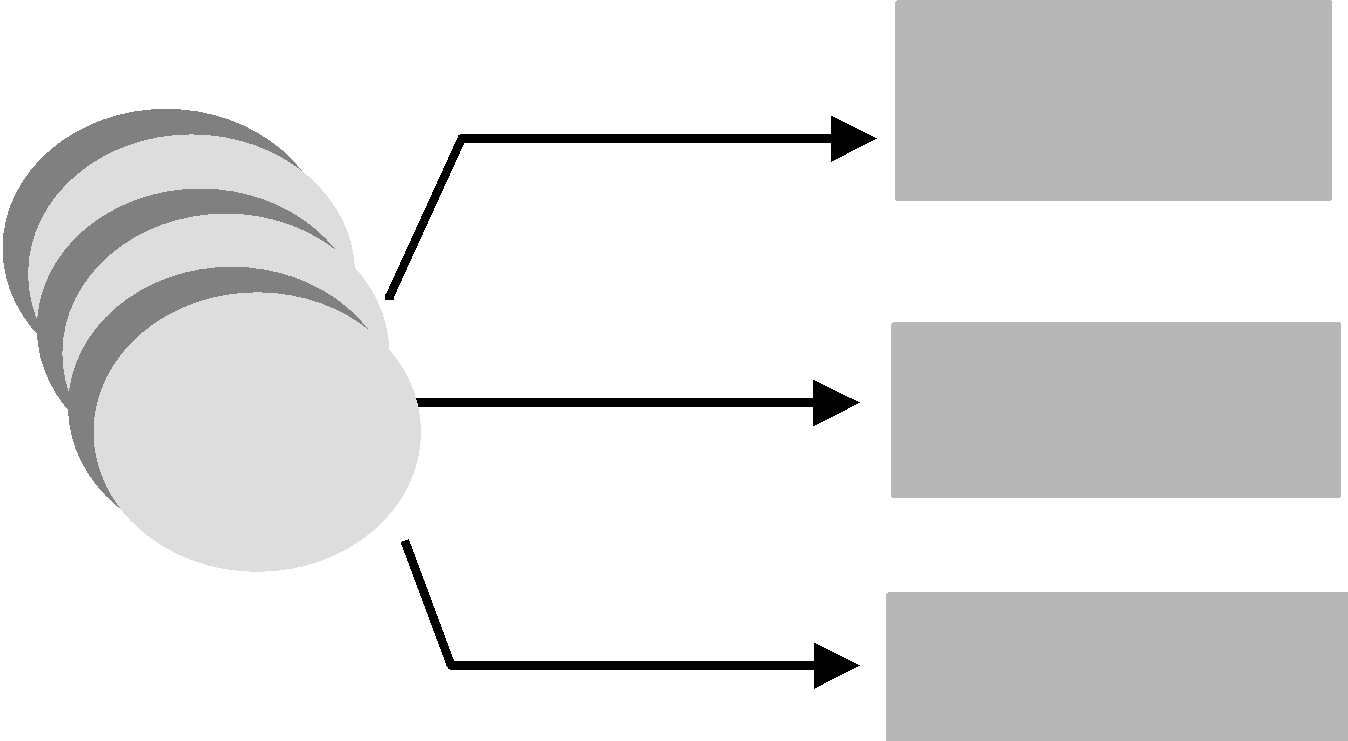
|  |
| --- |
| **CONTENTS OF THIS SECTION**: This section provides a list of definitions of special terms and acronyms used in the SAD. If terms are used in the SAD that are also used in a parent SAD and the definition is different, this section explains why. |

|  |  |
| --- | --- |
| Term | Definition |
| software architecture | The structure or structures of that system, which comprise software elements, the externally visible properties of those elements, and the relationships among them [Bass 2003]. "Externally visible” properties refer to those assumptions other elements can make of an element, such as its provided services, performance characteristics, fault handling, shared resource usage, and so on. |
| view | A representation of a whole system from the perspective of a related set of concerns [IEEE 1471]. A representation of a particular type of software architectural elements that occur in a system, their properties, and the relations among them. A view conforms to a defining viewpoint. |
| view packet | The smallest package of architectural documentation that could usefully be given to a stakeholder. The documentation of a view is composed of one or more view packets. |
| viewpoint | A specification of the conventions for constructing and using a view; a pattern or template from which to develop individual views by establishing the purposes and audience for a view, and the techniques for its creation and analysis [IEEE 1471]. Identifies the set of concerns to be addressed, and identifies the modeling techniques, evaluation techniques, consistency checking techniques, etc., used by any conforming view. |

## Acronym List

|  |  |
| --- | --- |
| API | Application Programming Interface; Application Program Interface; Application Programmer Interface |
| ATAM | Architecture Tradeoff Analysis Method |
| CMM | Capability Maturity Model |
| CMMI | Capability Maturity Model Integration |
| CORBA | Common object request broker architecture |
| COTS | Commercial-Off-The-Shelf |
| EPIC | Evolutionary Process for Integrating COTS-Based Systems |
| IEEE | Institute of Electrical and Electronics Engineers |
| KPA | Key Process Area |
| OO | Object Oriented |
| ORB | Object Request Broker |
| OS | Operating System |
| QAW | Quality Attribute Workshop |
| RUP | Rational Unified Process |
| SAD | Software Architecture Document |
| SDE | Software Development Environment |
| SEE | Software Engineering Environment |
| SEI | Software Engineering Institute  Systems Engineering & Integration  Software End Item |
| SEPG | Software Engineering Process Group |
| SLOC | Source Lines of Code |
| SW-CMM | Capability Maturity Model for Software |
| CMMI-SW | Capability Maturity Model Integrated - includes Software Engineering |
| UML | Unified Modeling Language |

# Sample Figures & Tables



*Figure 1: Sample Figure*

*Table 2: Sample Table*

| **Table Heading** | **Table Heading** | **Table Heading** | **Table Heading** |
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1. **Appendices**

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| **CONTENTS OF THIS SECTION**: Appendices may be used to provide information published separately for convenience in document maintenance (e.g., charts, classified data, API specification). As applicable, each appendix is referenced in the main body of the document where the data would normally have been provided. Appendices may be bound as separate documents for ease in handling. If your SAD has no appendices, delete this page. |

* 1. **Heading 2 - Appendix**
  2. **Heading 2 - Appendix**

1. Here, a system may refer to a system of systems. [↑](#footnote-ref-1)
2. SM Quality Attribute Workshop and QAW and Architecture Tradeoff Analysis Method and ATAM are service marks of Carnegie Mellon University. [↑](#footnote-ref-2)