Architectural Evaluation Of Health Information System by Architecture Tradeoff Analysis Method(ATAM):

Participants in ATAM:

1. Evaluation Team
   (Team Leader, Evaluation Leader, Scenario & processing scribe, Timekeeper,
   Process observer)
2. Project Decision Maker
3. Architecture stakeholders
   (Builders of the system, Testers, Developers (Frontend and backend developer),

Users, system users:(Patients, Hospitals Staff, Clinical Researchers, Health Professionals, Administration, and Public Health Officials.)

Method Step#01:

ATAM (Architecture Tradeoff Analysis Method) is an evaluation process that assesses software architectures, identifying risks, tradeoffs, and potential issues to make informed decisions. It involves presenting the architecture, analyzing approaches against quality attributes, and providing recommendations for improvement.

A health information system is a comprehensive framework that involves the collection, storage, management, and exchange of health-related data and information. In implementing ATAM on a Health Information System (HIS), the evaluation team consisting of architects, developers, and stakeholders will analyze the HIS architecture, assess tradeoffs, and identify risks associated with design decisions, ensuring the system meets the desired quality attributes and aligns with healthcare requirements. The findings will be used to refine the architecture, propose mitigation strategies, and make informed decisions for improving the HIS's performance, security, usability, and other critical aspects.

Method Step#02:

The aim of a Health Information System (HIS) is to improve the accessibility, quality, and efficiency of healthcare by effectively managing and exchanging health-related data and information. The desired attributes of a Health Information System (HIS) include accuracy, accessibility, security, interoperability, scalability, and usability. The constraints of a Health Information System (HIS) may include budget limitations, regulatory compliance requirements, technological infrastructure constraints, interoperability with existing systems, and data privacy and security regulations. A health information system is an all-encompassing structure that encompasses the gathering, retention, administration, and sharing of data and information pertaining to health, including but not limited to medical records, facilitating seamless healthcare processes. It encompasses the use of technology, processes, and policies to facilitate the acquisition, storage, retrieval, and utilization of health data for various purposes, such as patient care, research, public health monitoring, and administrative functions. Health information systems can include electronic health records (EHRs), health information exchanges (HIEs), clinical decision support systems, and other components that support the effective management and sharing of health information.

Method Step#03:

The 4+1 architecture for a Health Information System includes:

Logical Viewpoint:	Development Viewpoint:
• Identify major components of the HIS, such as EHRs, clinical decision support systems, and user interfaces. • Create class diagrams to represent relationships between classes/entities in the HIS and use case diagrams to illustrate system functionality.	• create module/package diagrams to showcase the modular structure and interactions of HIS components during the development process. • Discuss development tools, technologies, and methodologies utilized in building the HIS.
Process Viewpoint:	**Physical Viewpoint**
• Use sequence diagrams to showcase interactions and message exchanges between components during specific scenarios, such as patient registration or medical record retrieval. • Utilize activity diagrams to depict the flow of activities and processes within the HIS, highlighting steps involved in healthcare processes.	• Develop deployment diagrams to illustrate the physical distribution and connectivity of HIS components across servers, hardware devices, and networks. • Address scalability and performance considerations, including hardware resources, load balancing mechanisms, and optimization strategies. • Deployment on servers, such as cloud and dedicated servers.

The 4+1 architecture provides an additional use case viewpoint that gives view of functionality, development, runtime behavior, deployment, and user interactions.

Method STEP#04: (Identify Architectural Approaches**)**

Client-server architecture is well-suited for a Hospital Information System, offering scalability, modularity, security, centralized data management, and concurrent access support. It allows for system growth, easy maintenance, and secure data protection. The architecture ensures consistent record management and enables multiple users to work simultaneously. It provides a reliable foundation for an efficient Hospital Information system.

Method STEP#05: (Quality attribute utility tree.**)**

1. Performance - Responsiveness - Throughput	**2. Security** - Authentication - Authorization - Data Privacy	**3. Usability** - Intuitive User Interface - User-Friendly Navigation - Error Handling and Feedback
4. Reliability - Availability - Fault Tolerance - Data Integrity	**5. Scalability** - Handling Increased User Load - Accommodating Growing Data	**6. Maintainability** - Modularity - Extensibility - Testability

7. Efficiency
- Optimal Resource Utilization
- Minimized Processing Time

8. Compatibility
- Cross-Platform Support
- Integration with External Systems

9. Accessibility
- Compliance with accessibility Standards
- Support for Assistive Technologies

Method STEP#06: (Analyze the architectural approaches.)

The client-server architectural approach in a Health Information System (HIS) allows for scalability, centralized data management, and simplified maintenance. However, it introduces dependencies on network performance and potential bottlenecks. Considerations include data security, network reliability, and user interface design. The client-server architectural approach introduces dependencies on network performance because the clients rely on network communication to interact with the server. The speed and reliability of the network connection can impact the overall system performance and user experience. Additionally, potential network bottlenecks or connectivity issues can affect the availability and responsiveness of the HIS. Therefore, the system's functionality is dependent on the quality and stability of the network infrastructure.

Method STEP#07: (Brainstorm and prioritize scenario)

The scenarios for the Health Information system have been prioritized based on their impact on the quality attribute utility tree. The prioritized scenarios are as follows:

S.No.	Priority	Impact on Quality Attribute
1.	High	**Log in to the system:** Security (Authentication, Authorization)
2.	High	**Display User information:** Usability (User-Friendly Navigation and Interface)
3.	Medium	**Insert new User record:** Attribute: Reliability (Data Integrity)
4.	Medium	**Update User information:** Maintainability (Modularity, Extensibility)
5.	Medium	**Delete User record:** Reliability (Data Integrity)
6.	High	**Signup as a new user(patient):** Security (Data Privacy)
7.	High	**Reset password:** Usability (Error Handling and Feedback)

Here Users are: Patients, Hospital Staff including Health Professionals, Administration, and Public Health Officials.

Method STEP#08(Re-analyze the architectural approach):

The team re-evaluated the client-server architecture for the Hospital Information System (HIS) and determined that it remains the optimal approach. The architecture provides modularity, scalability, and efficient data management capabilities. It aligns with the system's requirements, supports secure access controls, and ensures optimized performance. After exploring alternatives, the team has confirmed the stability and suitability of the client-server architecture for the HIS project.

Method STEP#09:

In this phase, the outcomes of the ATAM evaluation are documented, the finalized architecture is recorded, quality attribute scenarios are identified, and risks and non-risks associated with the Health Information system are documented.

Phases of ATAM:

Phase 0:

Activity: Preparation.
Participants: Evaluation
Team, Leadership & Key Project Decision maker.

#Phase 1:

Activity: Evaluation steps (1-6)
Participants: Evaluation team & project decision maker.

#Phase 2:

Activity: Evaluation steps (7-9)
Participants: Evaluation team, Project Decision maker & stake-holders.

#Phase 3:

Activity: Follow up.
Participants: Evaluation team & evaluation client

Outputs:

• The implementation of the client-server architecture in the Health Information System (HIS) is deemed optimal, providing modularity, scalability, efficient data management, and secure access controls.

• The critical quality attributes for the success of the HIS are usability, performance, security, and maintainability. These require an intuitive and user-friendly system interface, efficient handling of healthcare operations, robust security measures to protect patient data, and a modular and extensible architecture to facilitate system maintenance and updates.

• Scenario 1: "A substantial number of patient records need to be simultaneously inserted into the system."

• Scenario 2: "Multiple healthcare providers are concurrently updating patient records."

• Scenario 3: "Administrators need to efficiently delete patient records from the system."

In the context of a Health Information System (HIS), the client-server architecture proves to be an ideal choice, providing key benefits such as modularity, scalability, efficient data management, and robust access controls. Considering the critical quality attributes of usability, performance, security, and maintainability, the HIS requires an intuitive and user-friendly interface to ensure ease of use, efficient handling of healthcare operations for improved performance, robust security measures to safeguard patient data, and modular and extensible architecture for easier system maintenance and updates.

Several scenarios further illustrate the system's functionality within the HIS context. In Scenario 1, the system must efficiently handle the simultaneous insertion of a significant number of patient records. Scenario 2 highlights the capability of multiple healthcare providers to concurrently update patient records, ensuring smooth collaboration and data integrity. Additionally, in Scenario 3, administrators should be able to efficiently delete patient records when necessary, streamlining data management processes within the system.

By considering these outputs and addressing the identified scenarios, the HIS can be designed and implemented to meet the specific needs of the healthcare environment, supporting improved patient care, data management, and system performance.

Quality Requirement	**Architectural Decision**
Usability	Design a user-friendly interface with clear labels and logical organization of information for login, sign up, record display, and data manipulation.
Performance	Optimize database queries and implement caching mechanisms to improve response times and reduce database load.
Security	Employ secure authentication mechanisms, authorization controls, and protection against common vulnerabilities like SQL injection.
Reliability	Implement transaction management, backups, and error handling to ensure data integrity and minimize the risk of data loss.
Scalability	Design a scalable and distributed architecture with load balancing and horizontal scaling capabilities.
Compatibility	Develop the system using web standards, responsive design, and ensure compatibility with different browsers and devices.
Data Privacy	Implement encryption for sensitive data, access controls, and compliance with privacy regulations.
Maintainability	Use a modular and well-documented architecture with code reusability, version control, and development workflow.
Accessibility	Adhere to accessibility standards, provide alternative text, support keyboard navigation, and assistive technology compatibility
Compliance	Implement features to comply with health regulations, accreditation, capture audit logs, and maintain data integrity.

• It identifies a set of risks and non-risks. Health Information Systems (HIS) face data security risks, technical issues, user errors, and system performance challenges that can significantly impact data integrity, user experience, and system reliability.

• To mitigate risks in a Health Information System, it is crucial to implement robust access controls, encryption mechanisms, regular backups, comprehensive testing procedures, continuous system monitoring, timely software updates, validation processes, effective error handling mechanisms, and comprehensive user training programs. These measures ensure data protection, system stability, and accurate data management within the HIS.

During the review, ATAM explicitly facilitates the convergence of the following three groups:

1. The Review Team
2. The Project Team
3. Representatives of System's stake Holders.

Two Validation Sessions:

The Health Information System (HIS) underwent both Initial and Final ATAM sessions to validate its architecture. These sessions involved the identification of critical quality attributes, assessment of risks and tradeoffs, validation of risk mitigation strategies, and consideration of architecture changes. The purpose was to ensure improved system performance, alignment with desired quality attributes, and the identification of any new security risks specific to batch processing.

Initial Session:

During the Initial ATAM session, a small group of technically oriented stakeholders, including the Architecture Evaluation Team, System Owners, Software Architects, Project Managers, Development Team Members, and Domain Experts (if technically oriented), participated. Key critical quality attributes such as usability, performance, security, and maintainability were identified. Risks associated with performance were evaluated, and tradeoffs involving security were carefully assessed.

Final Session:

The Final ATAM session involved a larger group of stakeholders, including non-technical stakeholders. This group comprised the Architecture Evaluation Team, System Owners, Software Architects, Project Managers, Development Team Members, End Users (non-technical stakeholders such as administrators, healthcare providers, and patients), Domain Experts (non-technical stakeholders providing domain-specific insights), Business Stakeholders (representing business interests and objectives), and Regulatory and Compliance Representatives (ensuring adherence to relevant regulations and standards). The Final ATAM session encompassed a review of architecture changes, validation of risk mitigation strategies, and the identification of a new security risk associated with the batch processing mechanism. These sessions ensured that the HIS architecture adequately addressed risks, improved performance, and effectively fulfilled the desired quality attributes.

These validation sessions played a crucial role in refining the HIS architecture, mitigating risks, and ensuring the system's overall effectiveness and compliance with requirements.

Highest Level:

At the highest level, the Health Information System (HIS) strives to achieve desired attributes encompassing efficiency, reliability, scalability, maintainability, compatibility, data privacy, and accessibility. However, constraints such as technical compatibility, project timelines, budgetary limitations, and resource availability need to be considered and addressed during the development and implementation process of the HIS.

Next level:

In a Health Information system, the quality attributes can be refined as follows:

Compatibility	Ensure the system works across different browsers, operating systems, and devices
Data Privacy	Implement security measures, encryption, and comply with data protection regulations
Accessibility	Adhere to accessibility standards, provide alternative text, and support keyboard navigation
Compliance	Meet legal, regulatory, and institutional requirements
Maintainability	Write clean, modular code, document the system, and follow software engineering best practices.
Scalability	Design the system to handle growing numbers of patients , health professionals and optimize performance

Usability	Enhance ease of signup/login, interface clarity, intuitive data entry, search, and navigation.
Security	Implement secure authentication, protect against common threats, and conduct audits
Reliability	Ensure high availability, implement backups, and monitor system performance.
Performance	Optimize database queries, caching, and code to improve overall system performance.

Lower Level:

The Health Information System (HIS) encompasses several scenarios, as outlined in step 7. However, in the lower level of the utility tree, the stimuli, responses, and measurements for specific scenarios are detailed as follows:

Scenario #01: "A large number of patients need to be registered into the system simultaneously."

Stimuli: A substantial influx of patient registration requests occurs concurrently.

- The system experiences a high volume of data insertion requests within a short time frame.

Response:

- The system should handle the data insertion requests efficiently and effectively.

- It should maintain acceptable performance levels and ensure data integrity and consistency throughout the registration process.

- **Response Time**: The time taken by the system to process and complete each data insertion request is measured.

- **Scalability**: The system's ability to scale horizontally or vertically to accommodate the increased load during simultaneous data insertion is evaluated.

Scenario #02: "Multiple healthcare providers are concurrently updating patient records."

Stimuli:

- Multiple healthcare providers simultaneously add, modify, or delete information in patient records.

- Concurrent update requests from multiple users occur within the system.

Response:

- The system manages concurrent updates by promptly acknowledging requests, handling conflicts, and ensuring data consistency.

Measurement:

- Response Time: The duration between a user submitting an update request and the system acknowledging it, indicating the system's responsiveness to concurrent updates.

- **Scalability:** The system's capability to handle an increasing number of concurrent users and updates while maintaining optimal performance. This involves optimizing infrastructure, configuration, and resource allocation to accommodate growing workloads.

Scenario #03: "Administrators need to delete patient records efficiently."

Stimuli:

- Administrators initiate delete requests for patient records within the system.

System Response:

- The system handles delete requests from administrators efficiently and accurately.

- Data integrity and consistency are maintained throughout the deletion process.

Measurement:

1. Deletion Time: The duration taken by the system to process each delete request is measured.

2. Throughput: The rate at which the system can process and delete patient records is measured within a given time frame.

3. Data Integrity: The system's data integrity and consistency are verified after the deletion process.

4. Error Handling: The system's ability to effectively handle errors or exceptions encountered during the deletion process is ensured.