Searchable multi-dimensional Data Lakes supporting Cognitive Film Production & Distribution for the Promotion of the EuropeaN Cultural HeritagE

Grant Agreement No 101095303

DELIVERABLE 2.6:

D2.6 – SCENE Reference Architecture.R1

Work Package: 2

LEAD BENEFICIARY:

CENTRE FOR RESEARCH & TECHNOLOGY HELLAS (CERTH)

Delivery Date: 31.01.2024

Document Sheet

Project acronym	**SCENE**
Project full title	Searchable multi-dimensional Data Lakes supporting Cognitive Film Production & Distribution for the Promotion of the EuropeaN Cultural HeritagE
Programme	Horizon Europe
Topic	HORIZON-CL2-2022-HERITAGE-01-06
Type of Action	HORIZON-Research and Innovation Actions
Grant Agreement	101095303
Start day	1 February 2023
Duration	36 months

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Document Information

Deliverable number	D2.6
Deliverable name	SCENE Reference Architecture.R1
Lead beneficiary	CERTH
WP	2
Related task(s)	T2.2
Type	PU - Public
Reviewers (Organisation)	Benjamin Molina (UPV), Helena Marti (EPICA)
Delivery date	31.01.2024
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Contributor(s)	LINKS, UPV, DTT, FOKUS, MOG, AUTH, ADDMA, GOF, HYPERTECH

Dissemination level

PU	Public	X
SEN	Sensitive, limited under the conditions of the Grant Agreement	
Classified R-UE/EU-R	EU RESTRICTED under the Commission Decision No2015/444	
Classified C-UE/EU-C	EU CONFIDENTIAL under the Commission Decision No2015/444	
Classified S-UE/EU-S	EU SECRET under the Commission Decision No2015/444	

Document history

Version	Date	Changes	Reviewer/Contributor
v0.1	02/10/2023	Initial table of contents	CERTH
v0.2	01/11/2023	Description of methodology	CERTH
v0.3	19/01/2024	Initial contribution with requested diagrams	LINKS, UPV, DTT, FOKUS, MOG, AUTH, ADDMA, GOF, HYPERTECH, CERTH
v0.4	29/01/2024	Description of components and diagrams	LINKS, UPV, DTT, FOKUS, MOG, AUTH, ADDMA, GOF, HYPERTECH, CERTH
v0.5	08/02/2024	Formatting and feedback	CERTH
v0.6	16/02/2024	Integration of updates	LINKS, UPV, DTT, FOKUS, MOG, AUTH, ADDMA, GOF, HYPERTECH, CERTH
v0.7	20/02/2024	First draft	CERTH
v0.8	23/02/2024	Internal reviewed version	UPV, EPICA, CERTH
v0.9	27/02/2024	Final version	CERTH

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Abbreviations

Abbreviations	Full name
3D	3 Dimensional
AAPS	AI-based Audience Preferences Scouting
AB	Audience Building
AI	Artificial Intelligence
API	Application Programming Interface
CRM	Customer Relationship Management
ERP	Enterprise Resource Planning
ETL	(Extract, Transform, Load)
GDPR	General Data Protection Regulation
GWs	Gateways
HTTPS	Hypertext Transfer Protocol Secure
IPR	Intellectual Property Rights
LLM	Large Language Model
MAM	Media Asset Manager
ML	Machine Learning
NeRF	Neural Radiance Fields
NFT	Non-Fungible Token
SCENE	Searchable multi-dimensional Data Lakes supporting Cognitive Film Production & Distribution for the Promotion of the EuropeaN Cultural HeritagE
SSL	Secure Sockets Layer
UC	Use Case
UI	User Interface
UWB	Ultra-Wide Band
WP	Work Package
YAML	Yet Another Markup Language

Publishable summary

This document describes the 1st release of the architecture report which aims to serve as both the foundational blueprint of the SCENE platform and a flexible guide for future enhancements. This deliverable D2.6 “SCENE Reference Architecture.R1” is part of the European SCENE project (Searchable multi-dimensional Data Lakes supporting Cognitive Film Production & Distribution for the Promotion of the EuropeaN Cultural HeritagE) under Grant Agreement No. 101095303. This document is the output of Work Package 2, specifically Task 2.5. The release of the SCENE reference architecture is considered as an important reference point – milestone in the project activities. It reports on the SCENE architecture definition as a result of the first year of the project and can be summarized from three different viewpoints, as described below.

Core Objectives and Methodology

At its heart, the deliverable outlines the purpose, scope, and methodology of the SCENE project, emphasizing a modular, scalable architecture that evolves alongside user requirements and technological advancements. Utilizing the 4+1 architectural viewpoints methodology [1], it offers a multi-faceted view of the system, encompassing Functional, Development, Information, and Deployment perspectives, augmented by real-world scenarios.

Architectural Insights and Practical Applications

The document provides an in-depth exploration of the SCENE platform's architecture, detailing the interactions between core components and their roles in the broader system. Key sections highlight the system's functionality, development organization, data management, and deployment strategies, presenting a clear roadmap for the platform's realization. Scenarios play a pivotal role, offering vivid narratives that demonstrate the platform's utility in addressing specific user needs and operational requirements. These scenarios validate the architectural design, ensuring it meets both functional and non-functional requirements.

Future Directions and Conclusion

Acknowledging the project's iterative nature, the document underscores the importance of flexibility in development and the potential for future architectural refinements. It recognizes the interdependencies within the platform, advocating for a strategic, prioritized approach to component implementation. The SCENE project's architectural deliverable establishes a solid foundation for innovation, embodying a user-centric, technologically resilient vision. It sets the stage for the project's development phases, driving towards the realization of a robust, adaptable platform that meets emerging needs and challenges.

1 Introduction

1.1 Purpose, Context and Scope of the document

The purpose of this deliverable is to document the architectural design of the SCENE project, based on the technologies brought to the project and the user needs. This deliverable focuses on the fundamental concepts and properties of the system following the 4+1 view model [1], acting as the blueprints of the system's implementation. Furthermore, it serves as a reference point for future iterations, facilitating seamless scalability and adaptability in response to evolving user needs and technological advancements [2].

This document is meticulously structured to provide a comprehensive understanding of the SCENE project's architectural framework. It begins by describing the methodology employed in designing the overarching system architecture. This methodology encompasses a detailed account [1] of the steps undertaken to conceptualize, design, and refine the system architecture, offering valuable insights into the evolution of the project from inception to its current stage. Following the methodology, the document delves into an in-depth exploration of architectural views. Each architectural view is described in detail, accompanied by comprehensive diagrams and figures that offer a visual depiction of the system's composition, functionality, deployment, and inter-component interactions. Subsequently, the document transitions into elucidating the various scenarios catered to by each system component. These scenarios offer a glimpse into real-world use cases, showcasing how each component seamlessly integrates into the broader system framework to fulfil specific user needs and operational requirements. In the final section, the hardware and software specifications of the individual components, as well as of the entire system are accumulated and listed.

1.2 Relationship with other deliverables

The present deliverable is based on Deliverable 2.2 [3], which is describing the goals, the requirements, and the functionality of the SCENE platform. In order to specify the architecture, the Consortium had to consolidate Deliverable 2.2 [3] and extensively discuss among all partners designing and creating tools for the platform. Based on the partner's input conceptual architecture was designed, which can be used on the subsequent stages for the implementation of the platform. Furthermore, special attention to the analysis of the functional and non-functional requirements during the definition of the use-cases, presented as sequence diagrams, for each tool. To ensure that all the functional requirements are met by SCENE architecture, Table 2 has been formed, mapping the functional requirements to the corresponding sequence diagrams, which are presented in section 4.

2 Architectural Design

This section presents the key concepts related to the methodology used to develop the architectural design of the software system in SCENE.

2.1 Methodology

Architectural design is a critical phase in software development, defining the high-level structure and behaviour of a system. The 4+1 architectural viewpoints methodology [1] is a widely adopted framework that facilitates a comprehensive understanding of a system from different perspectives. This methodology comprises four primary viewpoints (Functional, Development, Information and Deployment) along with a set of scenarios to provide a holistic view of the system's architecture.

In essence, this method breaks down the software design puzzle into four key perspectives:

1. **Functional viewpoint:** Provides insights into how various components of the system work together to achieve a desired functionality. This viewpoint delves into the intricacies of system behaviour, elucidating the dynamic interactions between components and their collective contribution to fulfilling user requirements. It identifies key system functions and their interactions, ensuring alignment with

user needs and organizational goals [4]. Additionally, the functional viewpoint illustrates the structural hierarchy of the system, highlighting entities, relationships, and their roles in the overall system architecture.

2. **Development viewpoint:** Explores the organizational dynamics of the software development process. It examines modularity, interdependencies, and deployment structures to facilitate efficient collaboration among development teams, ensuring seamless integration and deployment of software components [5]. Moreover, the development viewpoint identifies software modules, their dependencies, and interfaces.
3. **Information viewpoint:** Focuses on the detailed aspects of data within the system. This viewpoint explores the details of data management, encompassing data flow, storage mechanisms, and relationships within the system. It articulates data flow, tracing the journey of data from source to destination and highlighting critical transformations along the way. Moreover, the information viewpoint identifies data sources, transformations, and repositories, facilitating effective data management strategies and ensuring data integrity, security, and accessibility [6].
4. **Deployment viewpoint:** Focuses on the real-world operational environment of the software. This viewpoint provides a roadmap for deploying the software solution in production environments, detailing the hardware infrastructure and deployment configurations necessary for seamless operation. Additionally, the deployment viewpoint guides the deployment, installation, and maintenance of the software system, minimizing downtime and maximizing system availability. By aligning deployment strategies with organizational objectives, it enables stakeholders to realize the full potential of the software solution, driving business value and competitive advantage [7].

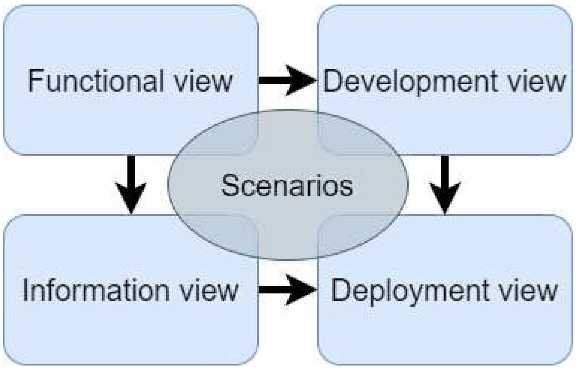

Figure 1: 4+1 architectural view model conceptual diagram

This multidimensional approach not only facilitates a holistic understanding of the system, but also fosters effective communication and collaboration among diverse stakeholders. Beyond the four core viewpoints, the inclusion of scenarios adds a practical dimension, providing tangible examples of system behaviour. The following sections of this document will delve deeper into each viewpoint, providing detailed descriptions and examples.

2.2 Implementation

The creation of this document shows a collaborative effort, where all partners of the SCENE project converged to synthesize individual components into a cohesive and functional system. Central to this endeavour was the collective description of specifications, scopes, and inter-connections, meticulously orchestrated to establish a robust architectural framework.

In the first phase, the high-level architecture was defined, which in turn helped the creation of the functional viewpoint of the architecture. Since the development and information viewpoints are both derived from the functional viewpoint, the second phase involves defining them for each individual component. Authors of each component contributed by providing the corresponding diagrams for the respective viewpoint, which present the way the component is structured, information flow dynamics between each sub-components and how it communicates with the rest of the components. Complementing these viewpoints were meticulously crafted scenarios, designed to illustrate real-world instances of the system's behaviour. These scenarios not only enhance understandability, but also imbue practicality into the architectural design, offering stakeholders tangible insights into the system's functionality and utility. In the final phase, the deployment plan of the system was defined, as it will be explained in more details in the corresponding section below. Since the project is in its early development iterations, the deployment viewpoint presents a preliminary vision of how each component will be deployed, subject to refinement accommodating future iterations and adaptations.

2.3 Technology Strategy and Vision

This paragraph aims to highlight the direction that will be followed in the development of Artificial Intelligence (AI) technologies within the scope of SCENE project. It is apparent that the last couple of years there is a major technological boom in the field of generative AI. The milestone in the era of generative AI started with the introduction of ChatGPT [8], a natural language processing AI model capable of understanding, reasoning, using resources and complete complex cognitive tasks. Concurrently, a novel generation of AI models, based on latent-diffusion [9], emerged. This technological advancement led to the development of models like DALL-E 3 [10] and stable-diffusion [11] capable of producing high-resolution images given a text description. Moreover, the introduction of Sora [12], a cutting-edge text-to-video generation model, marks a significant leap in media creation, offering superior quality video outputs compared to existing counterparts.

Given the recent and rapid technological advancements in the field of generative AI, a field strongly capable of influencing the processes of film-making, it is clear that SCENE shall embrace these trends to stay relevant. As the project progresses, it is essential for SCENE to integrate these innovative technologies into it’s workflows. Plans include developing chatbots for the location scouting and audience building tools, and implementing text-to-video generation models within the audience building framework. Furthermore, the project will explore the use of generative AI in lighting simulation and post-production effects, and assess additional applications such as AI assistants for scriptwriting, enhancing the project's scope and efficiency.

3 SCENE Architecture

In the following sections, the architectural viewpoints, described above, are explained in detail, accompanied by the related figures and diagrams.

3.1 High-level architecture

The high-level architectural viewpoint provides an overarching perspective on the entire system architecture, offering stakeholders a bird’s-eye view of the system’s structure and functionality. It serves as a strategic guide, outlining the system’s core components, their interactions and the overall design principles governing their integration. This view abstracts away from detailed implementation specifics, focusing instead on conceptual models and architectural patterns that underpin the system’s design.

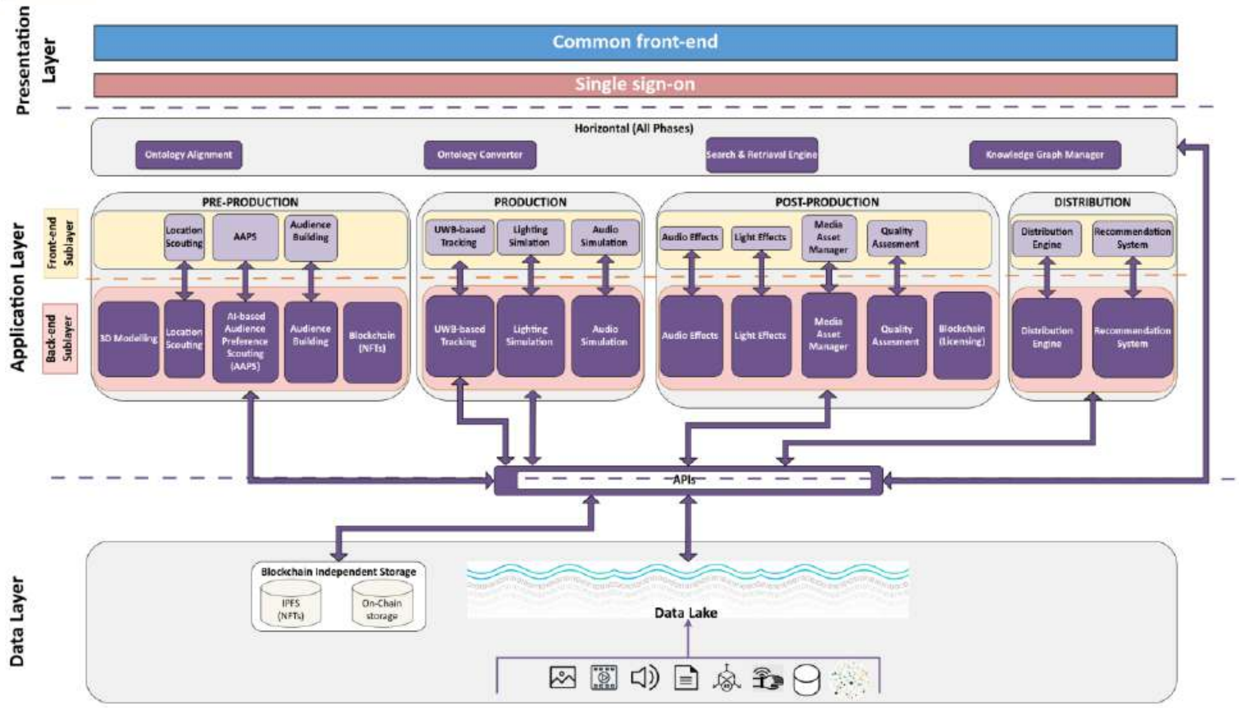

Figure 2: SCENE High-level architecture

Additionally, it lays the foundation for further elaboration and refinement of more detailed viewpoints, ensuring coherence and consistency across the entire architectural framework. The high-level architecture viewpoint of this project is presented in Figure 2.

Specifically, the high-level architecture of SCENE consists of three distinct layers:

- Presentation layer: It serves as the interface between the user and the system, focusing on the visual representation and interaction components. The user interfaces, graphical elements and user input/output processes of all the components belong in this layer.
- Application layer: It contains the core logic and functionality of the system, where the algorithmic components are implemented to perform specific tasks and operations. The application layers consist of two sublayers, the Backend and Frontend sublayer. The frontend and backend sublayers have been both included in the application layer to highlight the duality of functionality of each tool. The frontend sublayer showcases which tools will develop graphical user interfaces to allow the user to interact with the tool, whereas the backend sublayer contains the core logic for the tool's operation. The application layer in turn is composed by four filmmaking phases:
    1. The pre-production phase contains tools that involve with preliminary procedures of the filmmaking. Location-aware scouting, audience scouting and building and 3D reconstruction tools belong in this phase.
    2. The production phase has mainly to do with lighting and audio simulation tools that simplify content production and make it more sustainable.
    3. The post-production phase contains tools supporting audio and lighting effects, visual editing, quality evaluation and media classification and categorization.
    4. The distribution phase is responsible for the distribution and recommendation of the produced media to suitable audiences, enabling marketing and building audience engagement.
    5. Finally, the horizontal "phase" streamlines the filmmaking process, enhancing efficiency and collaboration across all stages of production. All the phases are connected, through the horizontal "phase", with a common ontology, including semantic annotation tools and converters, which align and integrate all existing ontologies into a holistic knowledge graph.

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- Data layer: It manages the storage and retrieval of information, through the Data Lakes, which is able to efficiently combine and store various types of media (images, videos, audio, metadata, etc.), ensuring data integrity, security and accessibility across the system. On top of that, the implementation of blockchain technologies enforce licensing agreements and content authentication, support tokenization of media and enhances the role of audience building.

3.2 Functional viewpoint

The Functional viewpoint is a crucial part of the 4+1 architectural approach, playing a key role in examining how the system works. It is derived by the first decomposition of the high-level architecture and all following viewpoints are partially based on it. Its main role is to present the functional and operational characteristics of each module, through an overview of the flow of actions. Its primary emphasis lies in the static structure of the system, implying a comprehensive understanding of how the components synergistically collaborate, to give rise to high-level functionalities. The system's functional viewpoint is presented in Figure 3.

The various tools and their respective components are present in the functional view. Each different coloured square in the figure corresponds to an individual task of the SCENE project. The arrows show the interactions and communications between the different tools, through which the multiple functionalities of the entire system come into play.

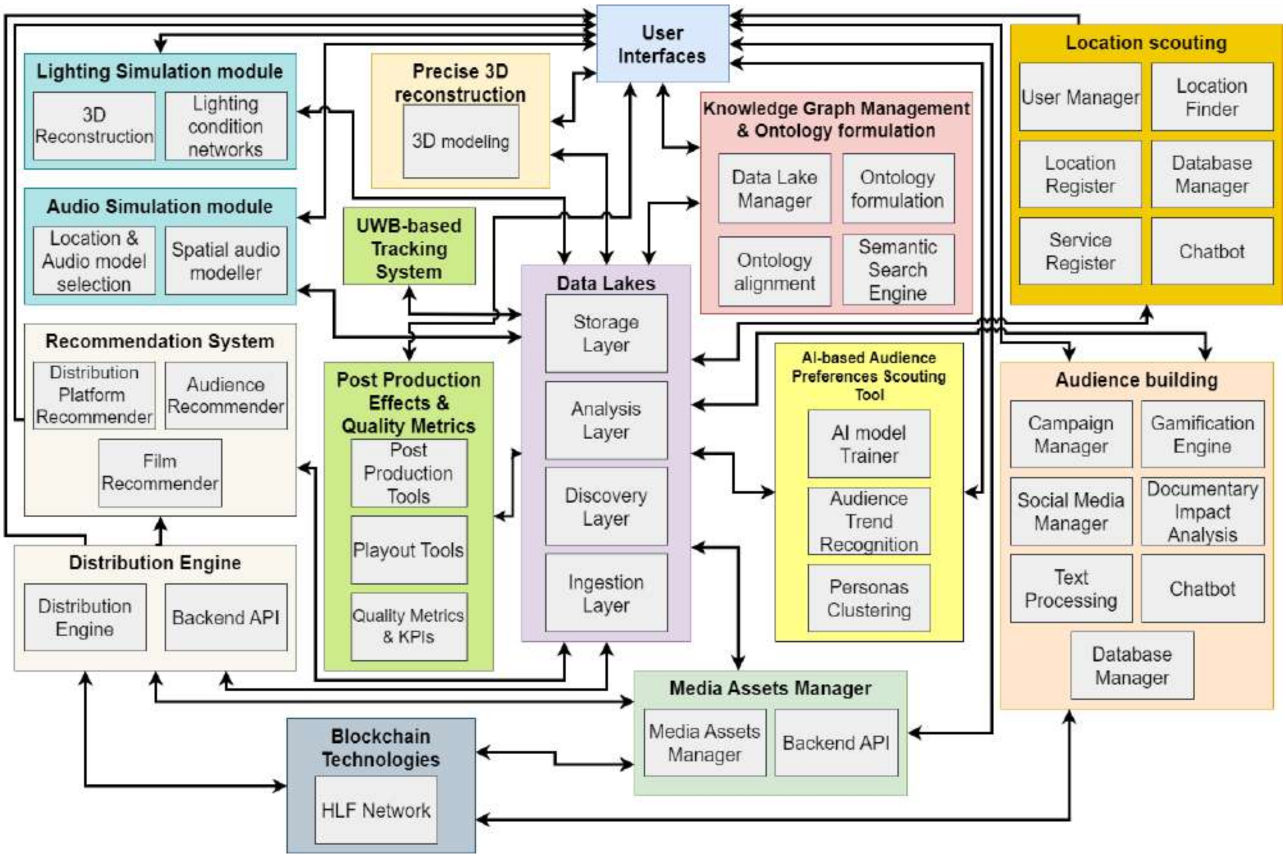

Figure 3: SCENE Functional viewpoint

In Table 1 below, a comprehensive list of all the existing tools, along with a brief description of them can be found. Links to their respective diagrams, showing their internal structure of components and the information flow between them is additionally provided.

Table 1: SCENE tools and components

Task	Tools	Description	Diagrams	Components
T3.1	Data Lakes	Represents the main data layer of the SCENE platform, by enabling the	Component: 3.3.1 Information: 3.4.1	Storage Layer Analysis Layer

		storing of files (video, audio, images, metadata, etc.), as well as databases.	Sequence:4.1	Discovery Layer Ingestion Layer
T3.2	Knowledge Graph Management & Ontology formulation	Provides a set of functionalities for handling and expanding the SCENE-O ontology. Promotes the openness and interoperability, by utilizing the ontology alignment tool that can accept arbitrary ontologies and automatically map them to the SCENE-O ontology.	Component: 3.3.2 Information: 3.4.2 Sequence: 4.2	Ontology alignment Ontology formulation Semantic search Data Lake Manager
T3.3	Media Assets Manager	Classifies and categorises the raw multimedia data through the knowledge base, rendering them easier to use during production and post-production phases. Provides a centralised repository that offers smooth collaboration and accessibility to various digital content, along with efficient management and monetization.	Component: 3.3.3 Information: 3.4.3 Sequence: 4.3	Media Assets Manager Backend API
T3.4	Precise 3D reconstruction	Generates precise and realistic 3D models of places/cultural sites. Contributes to the better understanding of the real environment and the prioritization of the technical setup.	Component: 3.3.4 Information: 3.4.4 Sequence: 4.4	3D Modeling
T3.5	Blockchain Technologies	Preserves the IPR and the legally binding licensing agreements between producers and consumers in Media Assets Manager. Exploits the construction and deployment of Non-Fungible Tokens, allowing the producer to issue tokens, related to the production, tradeable for production crowdfunding purposes.	Component: 3.3.5 Information: 3.4.5 Sequence: 4.5	HLF Network
T4.1	Location Scouting	Helps the best allocation of locations and services, by filmmakers in the movie-making process. Enables the search for desired locations that meet the filmmakers' needs, by providing images, tags or free text as a query. Supports the registration of locations and services by specialized providers or by searching for points of interests, through web crawling.	Component: 3.3.6 Information: 3.4.6 Sequence: 4.6	User Manager Location Register Service Register Location Finder Chatbot Database Manager Data Indexing
T4.2	AI-based Audience	Predicts trends, based on audience viewing behaviour and the	Component: 3.3.7 Information: 3.4.7	AI Model Trainer

	Preferences Scouting Tool	interaction with the presented content. Allows filmmakers and producers to test their ideas with the audience, to get insights about the preferences and engagement before the production.	Sequence: 4.7	Audience Trend Recognition Personas Clustering
T4.3	Audience Building	Hosts accounts for filmmakers, prospective audiences and funding agencies. Through the creation and sharing of campaigns and contests about the film on social media, enables the understanding of audience interests, attraction and engagement of viewers. Provides a brief overview, analytics and key points of interest to filmmakers, about the campaign and audience interactions, allowing them to manage and further promote their campaigns. Enables the participation of audiences during production, with a potential to receive rewards through contests. Grants access to funding agencies, offering public KPIs for documentaries and enabling the monitoring of current rankings for producers and documentaries.	Component: 3.3.8 Information: 3.4.8 Sequence: 4.8	Campaign Manager Gamification Engine Database Manager Social Media Manager Text Processing Chatbot Documentary Impact Analysis
T4.4	Lighting Simulation module	Provides a tool that enables filmmakers to dynamically experiment with different lighting conditions of a scene. The lighting at different phases of the day and under various artificial conditions can be simulated, in order to a-priori verify the fitness for filming of a certain location.	Component: 3.3.9 Information: 3.4.9 Sequence: 4.9	3D Reconstruction Lighting conditions networks
T4.4	Audio Simulation module	Helps filmmakers, producers and audio designers during the pre-production phase to check the on-site conditions and be prepared for the shooting. Allows testing the acoustics without the need of visiting the site beforehand.	Component: 3.3.10 Information: 3.4.10 Sequence: 4.10	Location & Audio model selection Spatial audio modeller
T4.5	Post Production Effects & Quality Metrics	Enhances the post-production phase of filmmaking process, by providing a set of tools for improving the aesthetic and artistic aspects of the content, along with evaluating the quality of the provided media.	Component: 3.3.11 Information: 3.4.11 Sequence: 4.11	Post Production Tools Playout Tools Quality Metrics & KPIs
T4.5	UWB-based Tracking System	Enables the tracking of the positions of actors during the production phase. Involves UWB-based wearable devices that communicate	Component: 3.3.12 Information: 3.4.12 Sequence: 4.12	UWB-based Tracking System

		wirelessly with a fixed UWB infrastructure.		
T4.6	Distribution Engine	Utilizes advanced clustering methods to target audiences for the distribution of films and programs.	Component: 3.3.13 Information: 3.4.13 Sequence: 4.13	Distribution Engine Backend API
T4.6	Recommendation System	Provides recommendations on the appropriate distribution platforms, ensuring optimal exposure of productions. Utilizes individual preferences of users and film metadata to suggest the most fit movie or clip, enhancing user engagement.	Component: 3.3.14 Information: 3.4.14 Sequence: 4.14	Audience Recommender Distribution Platform Recommender Film Recommender

3.3 Development viewpoint

The Development viewpoint assumes a central role in analysing how the software components get built. Within this perspective, the organization and structure of the software development process can be distinguished. By utilizing tools, like the component diagrams, a comprehensive understanding of how all the development pieces fit together is achieved. This viewpoint aids in navigating the complexities of the development process, ensuring an organised and modular approach.

The component diagrams for each of the system's individual components are presented in the following sections.

3.3.1 Data Lake

The Data Lake represents the main data layer of the SCENE platform and encompasses different sublayers, namely:

- The ingestion layer is able to retrieve all needed (input) data to the platform. As there might be heterogeneous sources, specific components (data agents) might be adapted to perform ETL (Extract, Transform, Load) operations. Input data might provide from various data sources (e.g. sensors, logs, etc.) as well as operational systems (CRMs, ERPs, Billing).
- The storage layer is divided into three areas as for Data Lakes, which represents the most flexible and modular approach to handle all the data.
- The analysis layer is able to perform (upon configuration) some filtering on the original data to assist in further ML analytics. External ML models (NOT part of the Data Lake) might typically get filtered data and generate productive data.
- The discovery layer integrates all related management of the data and how external users are able to request the data through an API. The SCENE ontology might also be integrated here to handle semantic metadata.
- A user interface is able to provide basic access for management and configuration purposes. As a data layer, users are mainly intended to be administrators or Data scientists to perform configuration tasks.

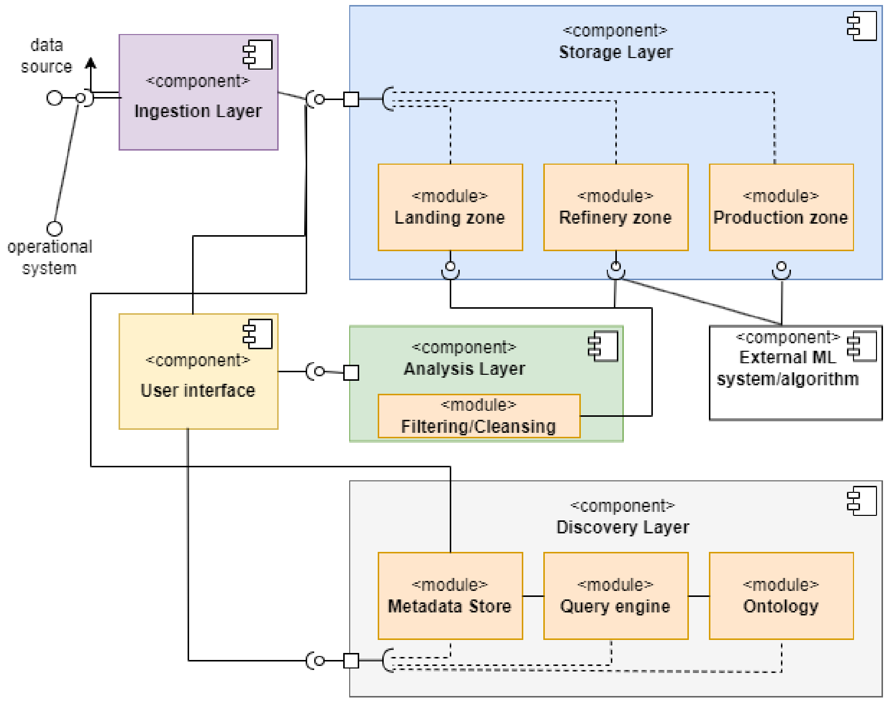

Figure 4: Data Lake component diagram

3.3.2 Knowledge Graph Management & Ontology Formulation

The ontology formulation and management tool will be developed under the task 3.2, to provide a set of functionalities for handling and expanding the SCENE-O ontology. Specifically, the Ontology formulation and management tool will include main components that will allow the expansion of the existing ontology. It will also promote the openness and interoperability by utilizing the ontology alignment tool that can accept arbitrary ontologies and automatically map them to the SCENE-O ontology. The main components of this tool are the following:

- Ontology alignment: The ontology alignment tool, as the name suggests, is responsible to accept arbitrary ontologies, either through the UI or the Data Lake, and map its entities to the SCENE-O ontology. This will allow for seamless integration with standard widely used ontologies with minimal user effort (when mapping cannot be resolved).
- Ontology formulation: The ontology formulation component will allow a user (related with filmmaking process) of the SCENE platform to expand the SCENE-O ontology by including new entities that will server her/his needs
- Semantic search: The semantic search component is one of the most crucial components that will be developed in this task. The component will utilize state-of-the-art graph neural networks alongside with large language models (LLMs) to allow for flexible search of media and information regarding a movie.
- Data Lake Manager: The Data Lake Manager will be a set of APIs responsible to store and retrieve information from the Data Lake.
- User Interface (UI): Finally, the user interface will be the medium that will allow an expert user of the platform to use the aforementioned functionalities of the tool.

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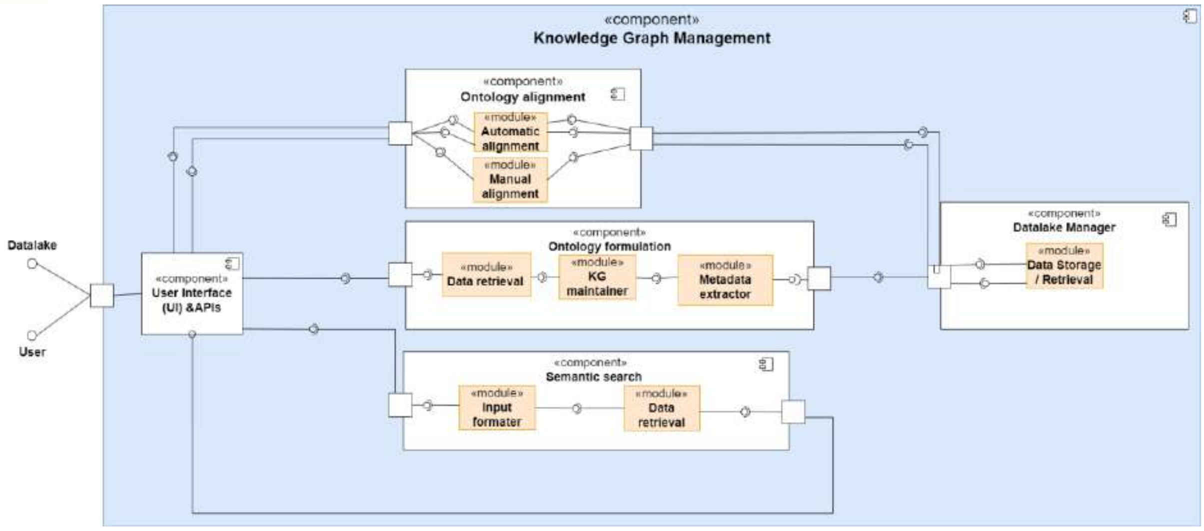

Figure 5: Knowledge Graph Management & Ontology formulation component diagram

3.3.3 Media Asset Manager

The Media Asset Manager shares a User Interface and API with the Distribution Engine from T4.6. From this API, the User service is used to manage user roles and permissions, while the product service is used to manage the film catalogues.

The Media Asset Manager Admin is responsible for managing the creation of new videos. It is supported by the Ingester, which is the component responsible for executing the media operations. The resulting videos should be stored in the Data Lake for later access.

There are two distinct databases, one for Users and another for the Media Asset Manager. These components are represented outside of their main components, since these should preferably be deployed in third-party database hosting services to ensure better availability and disaster recovery. However, if required, these components can be deployed alongside their main component.

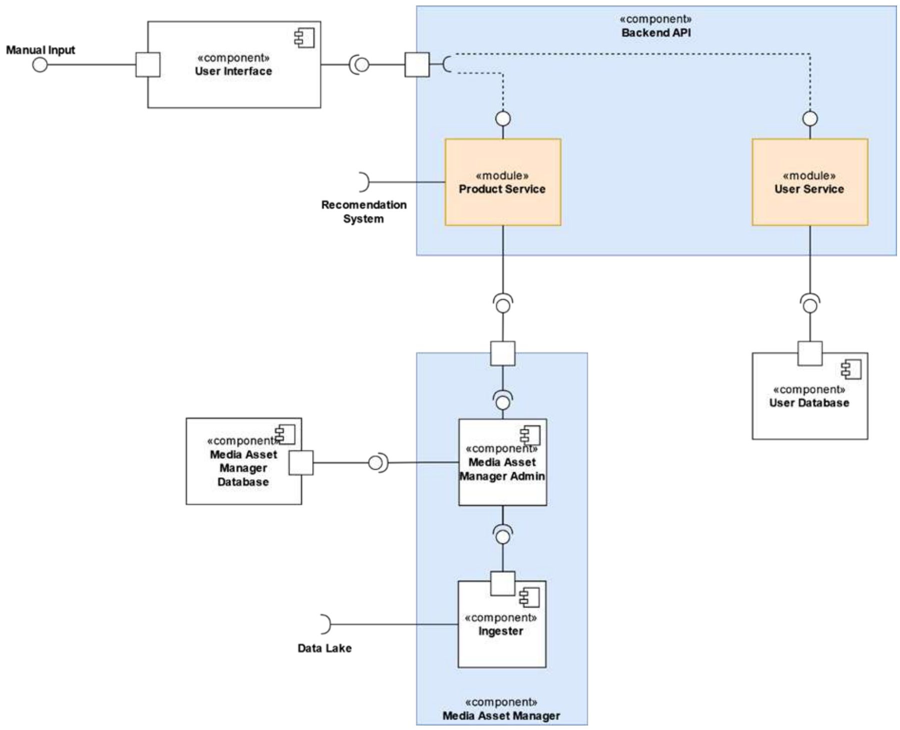

Figure 6: Media Asset Manager component diagram

3.3.4 3D Reconstruction

The diagram below depicts the relevant components of the 3D modelling module. Two main components are visible:

1) UI for 3D modelling,
2) Component 3D Reconstruction.

The UI component mainly takes input from data lake and manual input. Then the UI module communicates with 3D reconstruction component which is responsible for the reconstruction of a set of images to a 3D model. Finally, the interaction with the lightning simulation module is also depicted in this diagram.

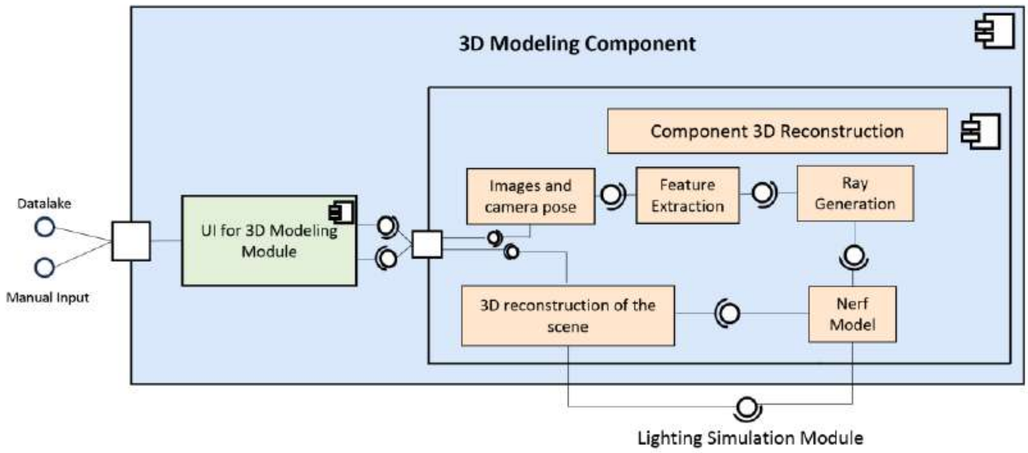

Figure 7: 3D Modelling component diagram

3.3.5 Blockchain Technologies

The scope of the Blockchain system splits in two major functionalities. The first regards the IPR preservation and the legally binding licensing agreements between producers and consumers in the Media Asset Manager. The second exploits the construction & deployment of Non-Fungible Tokens (NFTs) allowing the producer to issue tokens related to the production which will be trade-able for production crowdfunding purposes. The main components of the system, along with their role, are presented below:

- HLF ID Management API: This service simplifies X.509 public key certificate management for Hyperledger Fabric (HLF) networks by abstracting complexities and focusing on integration ease and security. It acts as an identity provider, generating and retrieving certificates during network initialization. It securely manages administrator credentials and allows registration and enrolment of digital identities for various roles, such as producers and consumers. The service separates registration and enrolment processes in HLF. It prevents duplicate certificate generation for registered entities.
- HLF Smart Contract API: The service provides APIs for interacting with smart contracts and managing credentials. It uses a YAML network connection profile to define the target blockchain network and a separate configuration file for HTTPS endpoints and smart contract details. It simplifies smart contract interaction with external systems while handling credential operations and network configurations.
- Metadata Storage: In the Blockchain system, IPFS is utilized as an external database to store Ricardian Contracts files and media files and metadata for NFT creation from the Audience Building Tool. Ricardian Contracts, which define the terms and conditions of smart contracts in a human-readable format, are stored off-chain. Each Ricardian Contract is uploaded to the IPFS network, and its unique IPFS hash is generated. Smart contracts reference these Ricardian Contracts using their corresponding IPFS hash. NFTs, representing unique digital assets, are associated with various types of files and metadata. The actual files (e.g., images, videos) associated with NFTs are uploaded to

IPFS, and their IPFS hashes are recorded on the blockchain. Metadata describing NFT attributes (e.g., title, description, creator information) is also stored on IPFS, with the metadata IPFS hash linked to the NFT token ID on the blockchain.

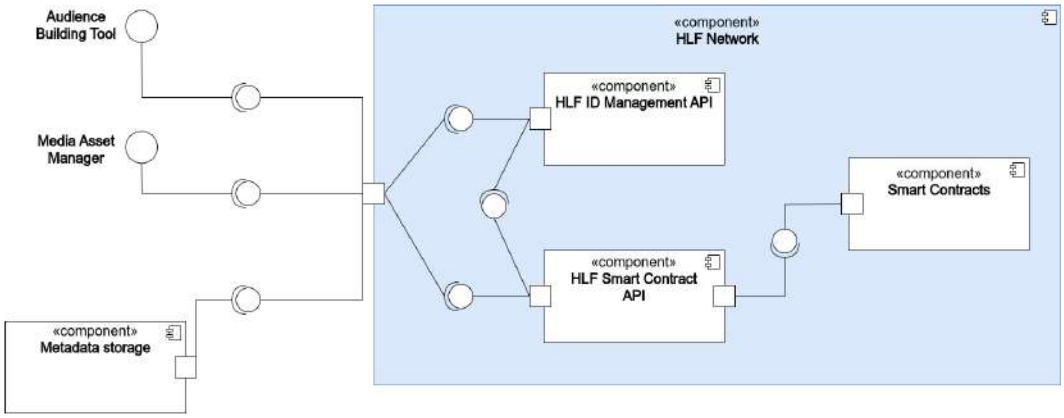

Figure 8: Blockchain component diagram

- Ricardian Contract Chaincode: This component represents a specialized type of smart contract deployed on a blockchain platform. It combines machine-readable code with human-readable contract terms, aligning with the principles of Ricardian contracts. This integration enables automated execution of contract terms by the blockchain while providing transparency and legal clarity for human participants. Ricardian contract chaincode enhances the technical functionality of smart contracts by ensuring they are both understandable and legally compliant, particularly valuable in complex transactions requiring precision and enforceability.
- NFT Chaincode: This component represents the business logic deployed on the blockchain system, designed to manage the creation, ownership, and transfer of non-fungible tokens (NFTs). This chaincode includes technical logic and rules that govern the unique properties of NFTs, such as their metadata, ownership records, and transferability. It ensures the accurate representation and enforcement of NFT ownership and attributes within the blockchain network, providing a secure and transparent framework for users to interact with and trade these digital assets.

3.3.6 Location Scouting

The location scouting tool, helps the filmmakers and location scouts to find the most suitable locations and services in the movie-making process. Specifically, it enables the search for desired locations that meet the filmmakers' needs, by providing images, tags or free text as a query. Supports the registration of locations and services by specialized providers or by searching for points of interests, through web crawling. Additionally, it is important to note generative AI technologies for natural language processing (NLP) will be utilized to implement a chatbot that will be capable to combine information from various sources and generate answers on questions that the user asks. Furthermore, the backend of the chatbot could be potentially used in other tasks like Audience Building Tool and the Recommendation System. Therefore, efforts on integrating generative AI technologies into various tools will be enhanced.

- User Manager (UM): This component handles the registration and login processes, offering different roles and functionalities for each type of user. The system enables the creation of user profiles with personal information and personal location collections, as well as the storage of information about users' past searches.
- Location Register (LR): The LR component allows users to input information and images about locations into the database. In addition to user descriptions, images are enriched with captions generated by the Image Captioning module, which utilizes a deep learning model. Furthermore, the Automatic Image Labelling module, employing deep learning techniques, annotates images to provide additional information through labels.

- Service Register (SR): The SR component allows service providers to inform locations about facilities such as museums, restaurants, and other services, along with corresponding images.
- Location Finder (LF): LF is a tool that enables users to search for points of interest using various query methods. Users can input an image and receive locations that are more similar to the provided image. Additionally, users can provide tags or free text as queries, and LF will respond with locations that match the tags or fit the user's description.
- Chatbot: With that component, users can ask questions and interact with the chatbot to obtain the desired information. The chatbot will be able to convert the free text query into embedded queries, which will later be used by the Data Indexing (DI) component to retrieve points of interest. The most relevant data retrieved by the DI component will be used for answer completion. The chatbot will use a large language model (LLM) to understand questions, interact with the users, and ultimately generate the desired answers based on the retrieved data. Open-source LLMs will be used and customized for the needs of the project.
- Data Indexing (DI): The DI component serves to index documents from the database, facilitating collaboration with the chatbot to execute queries and generate answers. Initially, unstructured text data from the database undergoes conversion into meaningful units, which are then vectorized and stored in a vector database for later use by the indexer. When the chatbot submits an embedding query to the DI, it performs a similarity search within the vector database and returns the top-K similar vectors. These vectors, representing document chunks, are then passed to the chatbot for answer generation.
- Data Manager (DM): The DM component is responsible for Database Interactions, storing and retrieving data about users, locations, services, points of interest, and additional metadata.
- Crawler: The Crawler module will perform additional searches on the existing points of interest, aiming to gather more information about locations and services, and to expand the database with new points of interest.
- User Interface (UI): The UI serves location providers, service providers, and filmmakers. Providers can submit images and information about locations and services, while filmmakers can access points of interest through specific queries or by interacting with the chatbot.

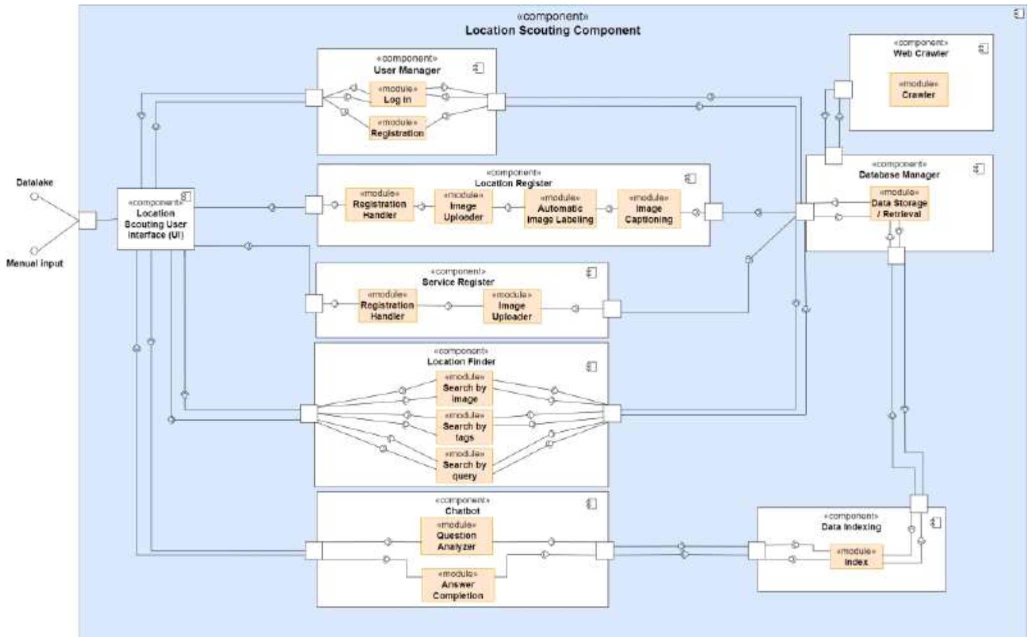

Figure 9: Location Scouting component diagram

3.3.7 AI-based Audience Preferences Scouting Tool

The AAPS tool might be simple in its form, but with a unique and important role in the SCENE platform. The objective of this tool is to predict trends based on audience viewing behaviour and the interaction with the presented content. AAPS, utilized in the pre-production phase will allow the filmmakers and producers to test their ideas with the audience to get insights about the preferences and engagement before the production. The components in which the AAPS can be decomposed alongside with their role is presented below:

- AI Model Trainer: The AI model trainer will be a component responsible to generate the trend prediction model by utilizing visual media presented to the viewer alongside with contextual data about the viewer (demographics, media usage patterns, group type etc.) and the interactions of the viewer with the media.
- Personas Clustering: The personas clustering component will be utilized to preserve the viewers' privacy. Specifically, leveraging clustering techniques the viewers will be associated with target group personas where each group will have distinct characteristics. The personas will be initially created from the information that has been collected from the user-base of the Audience Building Tool.
- Audience Trend Recognition: The current component will take into consideration the persona of the viewer, the interaction with the media and the media itself to predict the trends of this persona about the media. The insights that could be extracted about certain personas are engagement trends (e.g. watch times, likes, shares) and consumption trends (e.g. platform preferences (mobile, desktop), time of day, content length, etc.)
- User Interface: The user interface for the AAPS will target both the audience and the producers and filmmakers. The producers and filmmakers will be able to see the trend predictions for specific media while selected audience will be able to watch pre-release media so their reaction and interaction during watch time could be, voluntarily and with privacy-preserving manner, tracked.

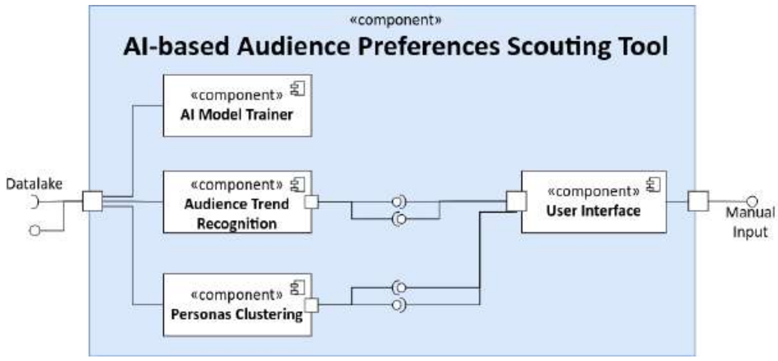

Figure 10: AI-based Audience Preferences Scouting Tool component diagram

3.3.8 Audience Building Tool

The AB will host accounts for filmmakers, prospective audiences, and funding agencies. With the AB tool, filmmakers can create and share campaigns and contests about the film on social media, enabling them to understand audience interests, attract, and engage viewers. The AB provides a brief overview, analytics, and key points of interest to filmmakers about the campaign and audience interactions, allowing them to manage and further promote their campaigns. Additionally, audiences can participate during production and potentially receive rewards through contests. Furthermore, the AB grants access to funding agencies, offering public KPIs for documentaries and enabling the monitoring of current rankings for producers and documentaries. Finally, we should make a special mention to the Gamification Engine and generative AI. Efforts will be put to utilize the chatbot that will be developed for location scouting and use it in conjunction with other generative AI models specified for image and video generation. The idea is that the campaign manager can request the creation of short promo videos or teasers tailored for specific target audience groups on demand.

- Campaign Manager (CM): The campaign manager is responsible for creating and managing campaigns, including their presence on social media, organizing competitions, and overseeing fundings. With the CM component, users can link campaigns to social media accounts and upload multimedia content to all associated accounts.
- Social Media Manager (SMM): The SMM component empowers producers to monitor campaign activity across multiple social media platforms. Additionally, this component enables the uploading of multimedia content and synchronizes social media interactions with the campaign.
- Documentary Impact Analysis (DIA): The DIA component will gather campaign analytics and social media activity to analyse and present them as Key Performance Indicators. It will track campaign and user account data, presenting the analytics through visualizations. Utilizing a tool that analyses and visualizes the campaign activity will assist producers in making better decisions.
- Gamification Engine: Through the Gamification Engine component, producers can create contests and encourage audience engagement. During the contest, users will be rewarded based on audience members' interactions and activity on the film's social media accounts. This allows filmmakers to track audience interactions with the campaign throughout the film's production process.
- Text Processing: The current component will process comments from social media, utilizing Language Models to generate summaries and perform sentiment analysis. This tool will provide a better understanding of audience interactions with the campaign, enhancing overall engagement strategies.
- Chatbot: This component allows producers to inquire about campaign analytics or engagement strategies. The chatbot, equipped with a Large Language Model, receives analytics and KPIs from the Documentary Impact Analysis component, as well as social media interactions and sentiment analysis from the Data Manager. The chatbot will generate the desired answer based on that data.

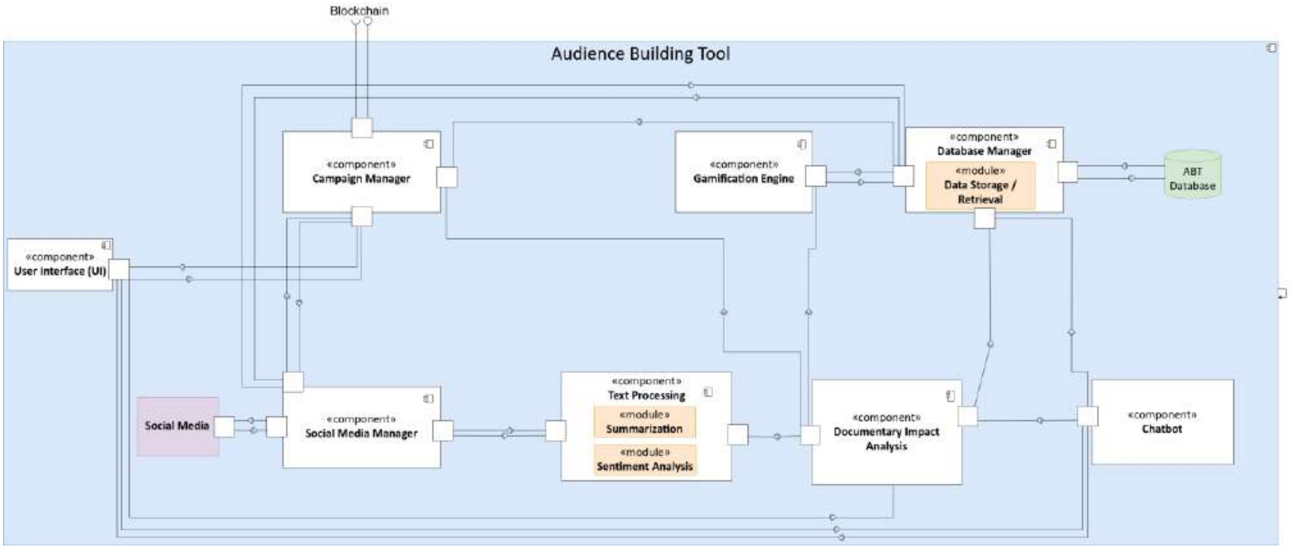

Figure 11: Audience Building Tool component diagram

3.3.9 Lighting Simulation Module

The Lighting Simulation module is mainly composed by a NeRF model, which is responsible for the accurate 3D reconstruction of the scene. The model is trained with a set of multi-view images of a location, which are selected and retrieved from the database by the user, through an interactive UI. Moreover, the module contains dedicated networks that are trained to control and reproduce the lighting and shadow conditions of the scene. The user can additionally use the interactive UI to produce novel views of the reconstructed scene, while simultaneously altering the lighting conditions of them.

The backbone NeRF model of the tool can be independently configured and trained by the user, until it meets the required output quality. However, the user can also utilize an existing pretrained model of an individual location and just experiment with the simulated lighting conditions. This way the user can skip the complex 3D reconstruction stage and directly focus on the re-lighting exploration.

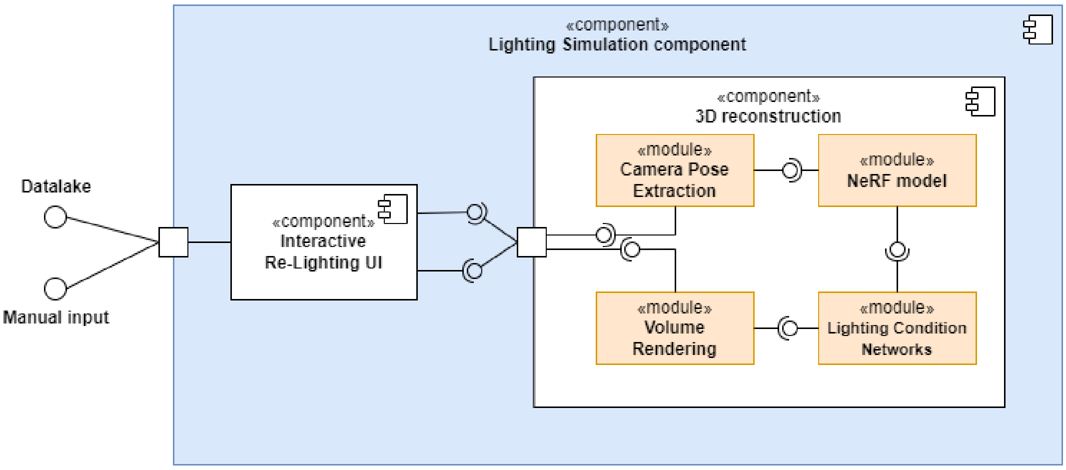

Figure 12: Lighting Simulation module component diagram

3.3.10 Audio Simulation Module

The Audio Simulation module is part of T4.4 (Lighting & Audio simulation modules). It is designed to help filmmakers, producers and audio designers during the preproduction phase to check the on-site conditions and be prepared for the shooting. The tool allows the users to make acoustics testing, without the need of visiting the site first, before the real installation in the field. The audio simulation module consists of the following main components:

- Location selection + Audio model selection: This component supports the Audio simulation UI and is the medium through which the user selects the location and audio model for which he/she wants to simulate the audio.
- Spatial audio modeller: The spatial audio modeller is the core component of the audio simulation module, since it is responsible for creating immersive sound environments that mimic real-life audio experiences.
- Audio simulation UI: The simulation UI will be the interface for the user to perform an audio simulation for a scene or a new position in a location, to reflect a change in the listener's perspective.
- Database: The database can be either a local one or accessed through the Data Lake. Both modes will be supported by the audio simulation module.

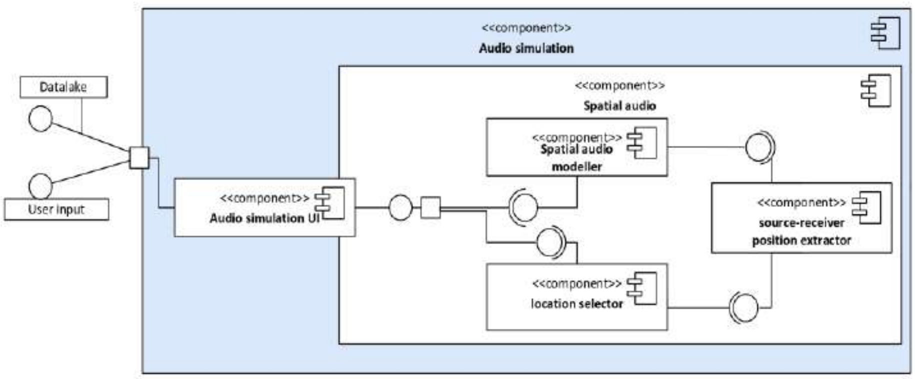

Figure 13: Audio Simulation module component diagram

3.3.11 Post-Production Effects & Quality Metrics

In the context of Task 4.5, a set of tools will be implemented to enhance the post-production phase of the filmmaking process. Concretely, the components that will be developed to serve a distinct and well-defined objective are the following:

- Post-Production Effects Information Library: This component will be an information library, classifying and categorizing available post-production effects over a wide range of vendors.
- Post-Production Tools: This component will contain a collection of post-production tools for video and audio effects and filter to improve the aesthetic & artistic aspects of the content. Generative AI techniques will be examined for generation of post-production effects based on the description, in natural language, provided by the user. Finally, generative AI could be utilized to refine the application of existing effects.
- Quality Metrics & KPIs: This component will be responsible to compute quality metrics & KPIs both for the audio and video media to quantify the quality level of each of the multimedia (3D model, audio, video, image) retrieved from the Data Lake. Furthermore, this tool will quantify the quality of the multimedia after applying post-production effects to ensure that the quality is retained after the post-processing.
- Playout Tools: The playout component is a crucial component since it is the mean that will enable interactive enrichment of newly producer and heritage digital visual media. This tool enables the users involved in this process (digital artists, filmmakers, media professionals) to see the effects of their modifications in real time, allowing for immediate feedback and iterative improvements.
- User Interface: The user interface will be the medium that will enable the users of this SCENE sub-system to interact with the back-end components and where the visualization of the content will take place.

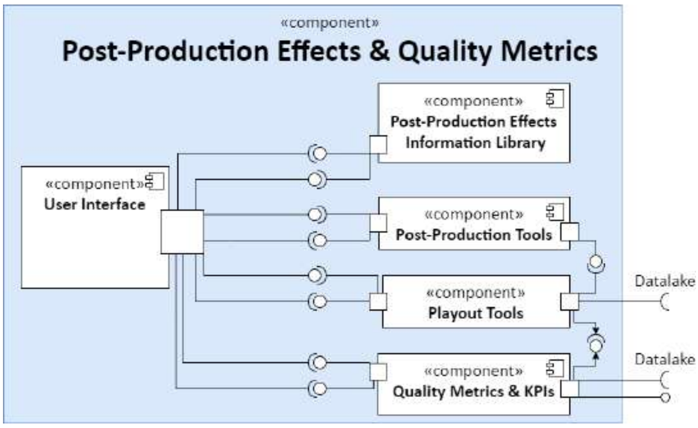

Figure 14: Post-Production Effects & Quality Metrics component diagram

3.3.12 UWB-based Tracking System

The UWB-based Tracking System will utilize UWB technology to monitor the position and movement of actors. The data generated by this tool can be leveraged across various stages, such as the post-production phase. Position tracking, for instance, can significantly enhance the filmmaking process by enabling the application of specific actions (like post-effects) contingent on the actor's location. Moreover, this becomes critically important for technologies employing generative AI, as it allows for the creation of visual effects or virtual "actors" to seamlessly substitute for real ones. The UWB-based tracking system is composed of two main components:

- UWB-based Devices: These could be of three types that are briefly presented as follows:
    - UWB Wearables used to localize the actors with a frequency up to 5 Hz (5 times per second per wearable).
    - UWB Anchors are deployed in the area of interest in fixed positions and have known coordinates. These devices interact with the wearables to perform ranging measurements (i.e. distances between wearables and anchors).
    - Gateways (GWs) are devices equipped with two interfaces: one based on the UWB radio, which is used to collect ranging measurements from anchors, while the other one is based

on either Wi-Fi or Ethernet, which is used to forward the measurements to the Tracking Manager component.

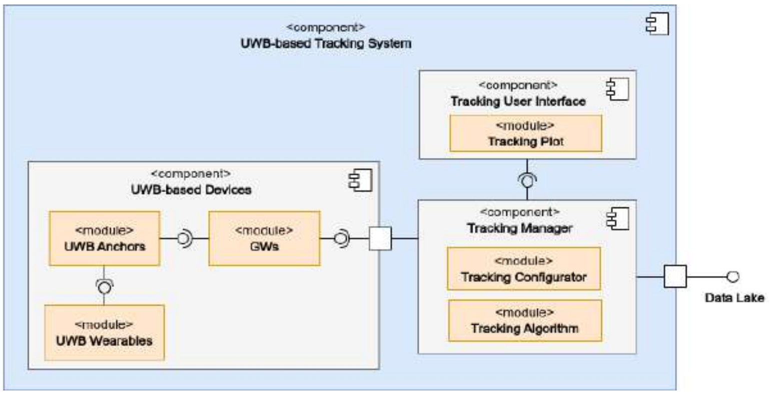

Figure 15: UWB-based Tracking System component diagram

- Tracking Manager: It allows the configuration of the parameters of the tracking algorithm and executes it to estimate the wearables' positions.

3.3.13 Distribution Engine

The Distribution Engine shares a User Interface and API with the Media Asset Manager from T3.3. From this API, the User Service is used to manage user roles and permissions, the License Service is used to manage film licenses and the Product Service is used to manage the user film catalogue. The Distribution Engine Reasoner accesses the Media Asset Manager Database to retrieve the assets associated with a particular user/audience. The User Database is used to access and store user information, while the Blockchain Network (IPR Module) is used by the User Service and License Service to store and access license information and respective permissions.

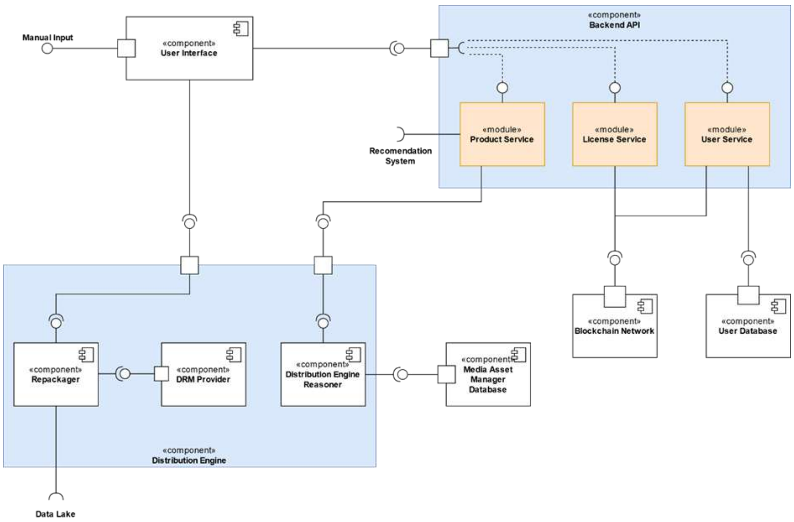

Figure 16: Distribution Engine component diagram

Both Database components are represented outside of their main components, since these should preferably be deployed in third-party database hosting services to ensure better availability and disaster recovery. However, if required, these components can be deployed alongside their main component. The User Interface also connects directly with the Repackager, which, together with the DRM Provider, serves the User Interface with encrypted video segments ready for playout.

3.3.14 Recommendation System

The recommendation system consists of six main components. Namely, the Backend APIs, Vector Generator, Audience Recommender, Distribution Platform Recommender, Multimedia Recommender, and the User Interface. The objective of each component can be summarized as follows:

- Backend-APIs: This component consists of a set of modules each of which is responsible for the communication with a specific tools within the SCENE architecture or external tools.
- Vector Generator: The vector generator component plays a central role in the recommendation system, since it is responsible to transform multimedia and audience metadata into embeddings. The embeddings merge the information of the raw data into vectors that serve as a mean for the recommendation algorithms to "understand" the concept for which the recommendation is requested.
- Audience Recommender: This audience recommender component is responsible for suggesting the filmmaker the target audience that a movie or documentary will interest more.
- Distribution Platform Recommender: The distribution platform recommender component generates recommendations to the filmmaker for which distribution platform the production shall be distributed to maximize the views and profit.
- Multimedia Recommender: The multimedia recommender will suggest movies and documentaries to the end-user (audience) taking into account the preferences and the content of similar movies. The information about the preferences of the audience will be provided by the Audience Building tool and the audience clustering module through the Data Lake.
- User Interface: The user interface will be the mean for the filmmaker and the end-user to request recommendations for one of the above-mentioned purposes.

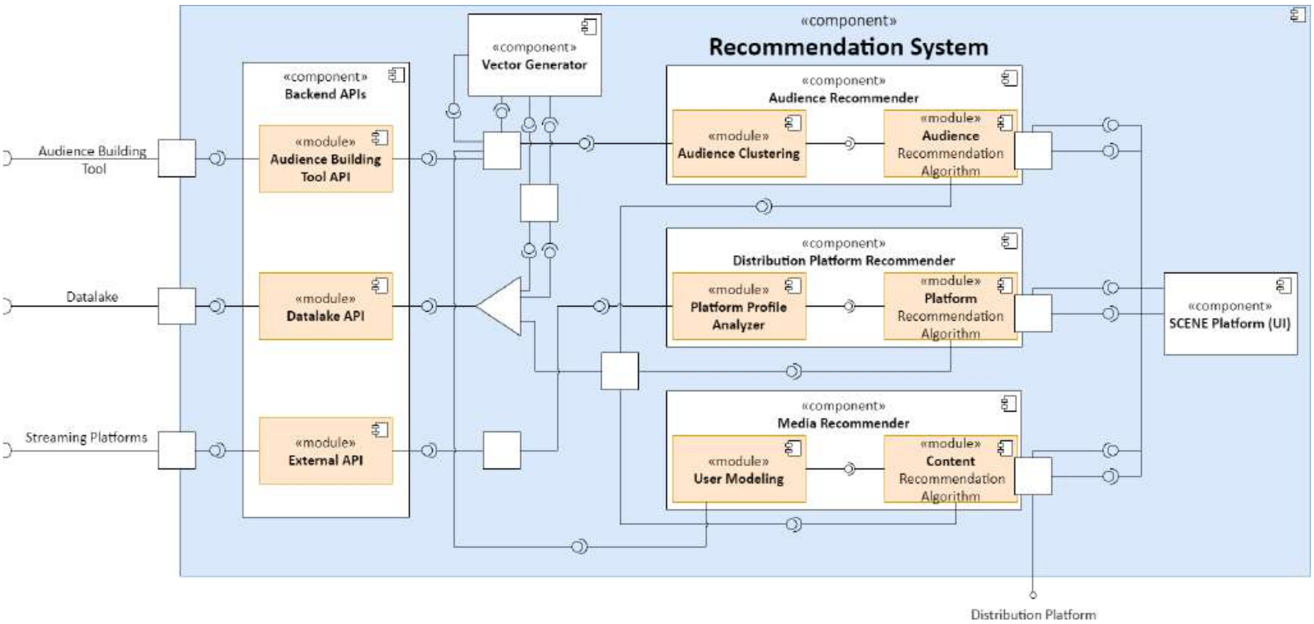

Figure 17: Recommendation System component diagram

3.4 Information viewpoint

The Information viewpoint offers a comprehensive perspective on how data is managed and processed, within a software system. This viewpoint aids the understanding of the organization, storage, retrieval and manipulation of information in the overall architecture. It is produced by combining information from the Functional and Development viewpoints.

Within the information viewpoint, information flow diagrams play a crucial role in visualizing the movement of data within the system and its individual components. These diagrams provide a graphical representation

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of how data is exchanged, transformed and processed between different components, subsystems and external interfaces. Information flow diagrams offer a clear and intuitive depiction of complex data flows, making it easier to grasp each component's data management architecture at a glance.

The information flow diagrams for each component, along with a brief description of it, are presented in the sub-sections below.

3.4.1 Data Lake

The diagram below showcases the interaction between the internal components of the tool and also the communication with external data sources.

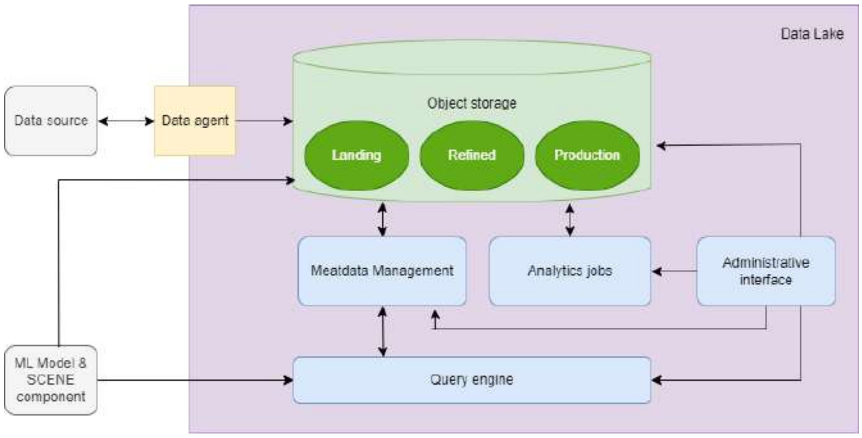

Figure 18: Data Lake information-flow diagram

3.4.2 Knowledge Graph Management & Ontology Formulation

The diagram below highlights the information flow in order to achieve the functionalities of the ontology formulation and management tool.

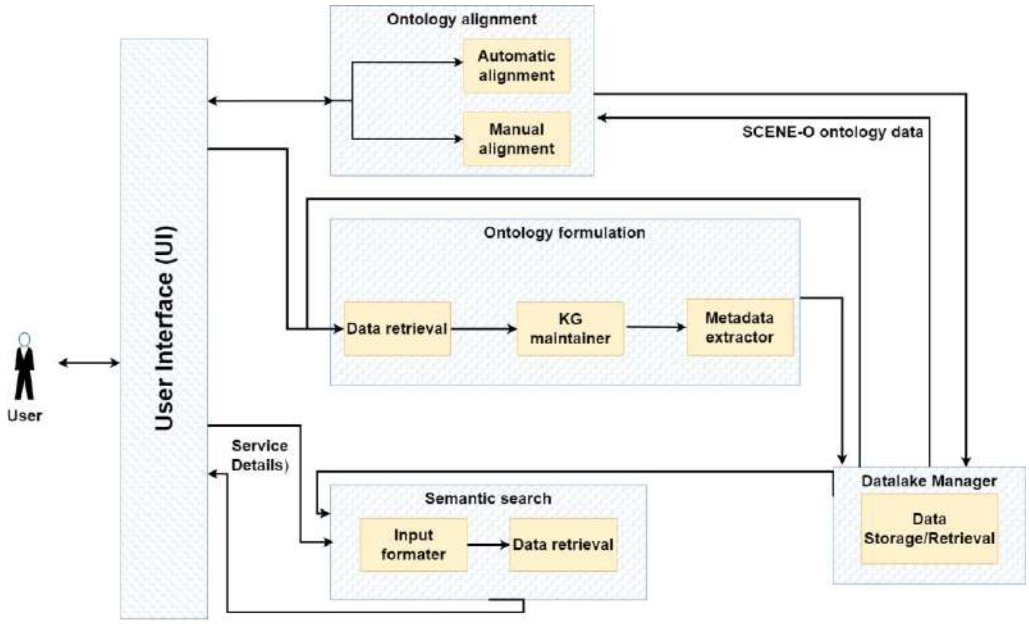

Figure 19: Knowledge Graph Management & Ontology formulation information-flow diagram

3.4.3 Media Asset Manager

The information-flow diagram of Media Asset Manager presents the way the user interacts with the tool, through the UI and how the two distinct databases are connected with the rest of the components.

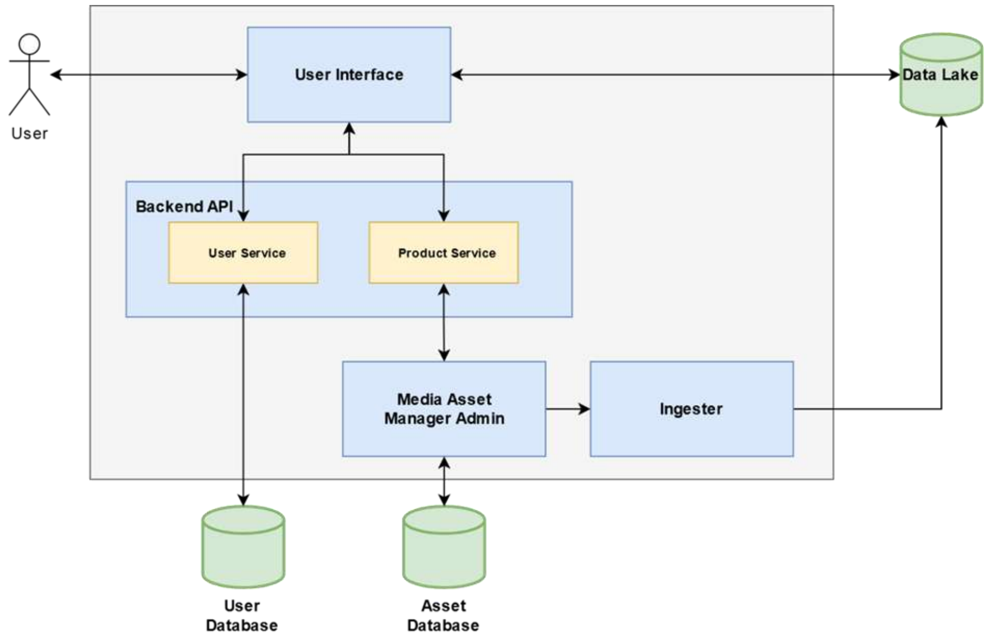

Figure 20: Media Asset Manager information-flow diagram

3.4.4 3D Reconstruction

The diagram below depicts the flow of information among different components/processes of the 3D Modeling module. When the user requests the interactive UI for 3D model, it acquires the set of images from different viewpoints along with camera poses. Then the NeRF model processes the input and generates camera rays using the camera calibration. The output of the NeRF model contains colour and density values, which can additionally pass through the lighting condition networks of the Lighting Simulation module to render the images.

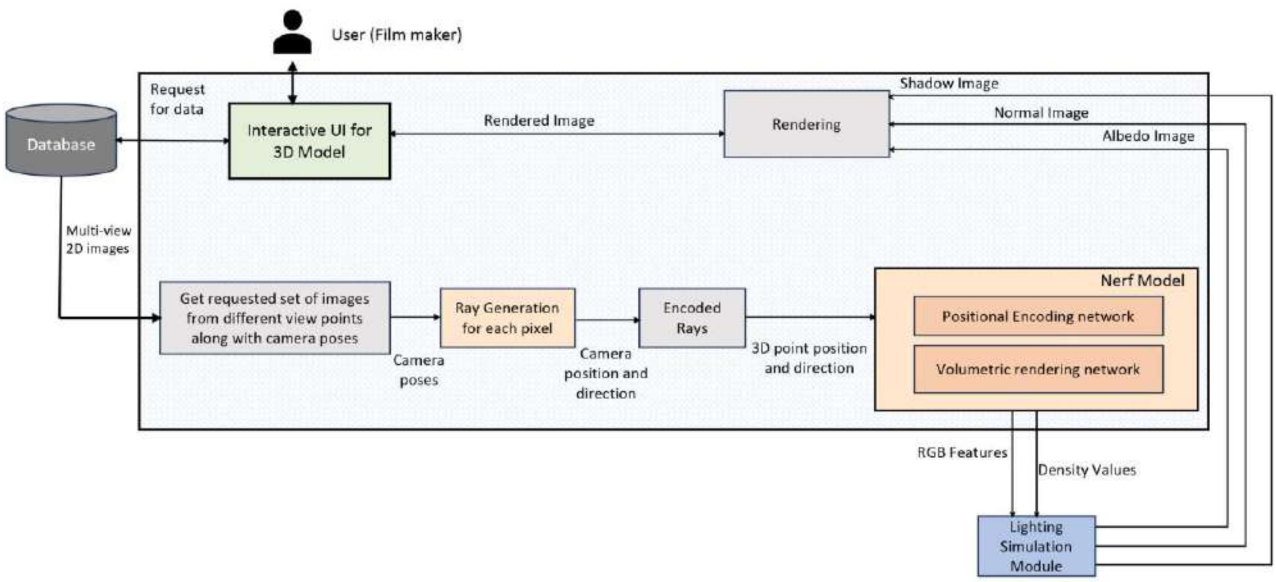

Figure 21: 3D Reconstruction component information-flow diagram

3.4.5 Blockchain Technologies

The distinct functionalities of the Blockchain Technologies tool are presented in the following information diagrams, to distinguish the use cases of Ricardian Contracts and NFTs respectively.

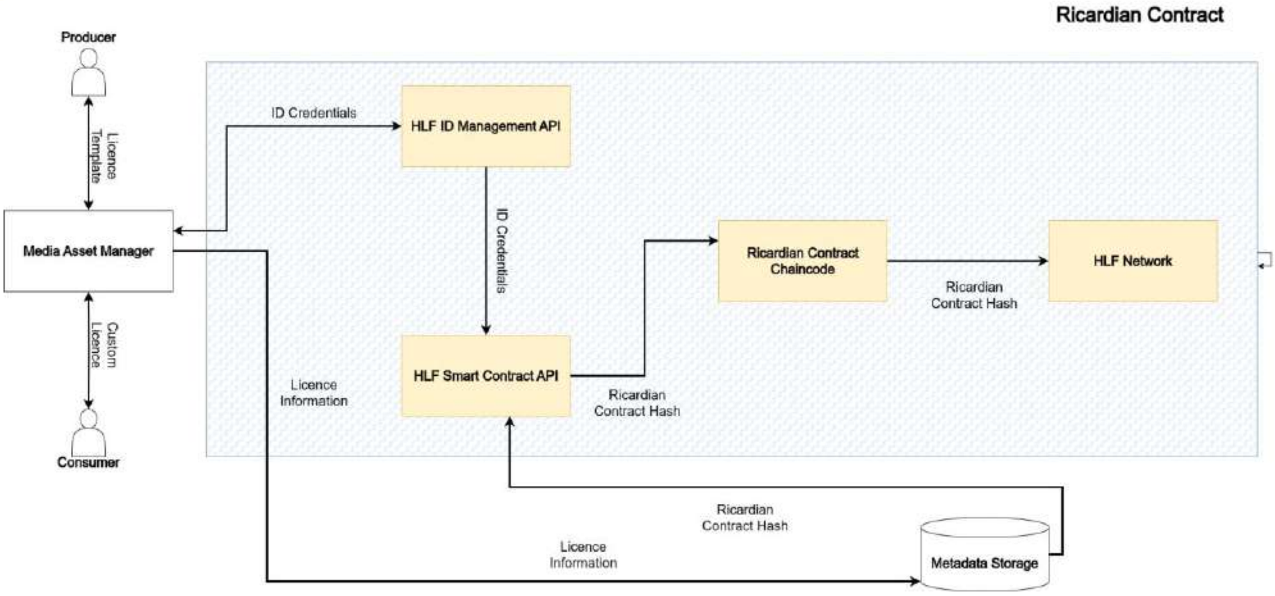

Figure 22: Ricardian Chaincode information-flow diagram

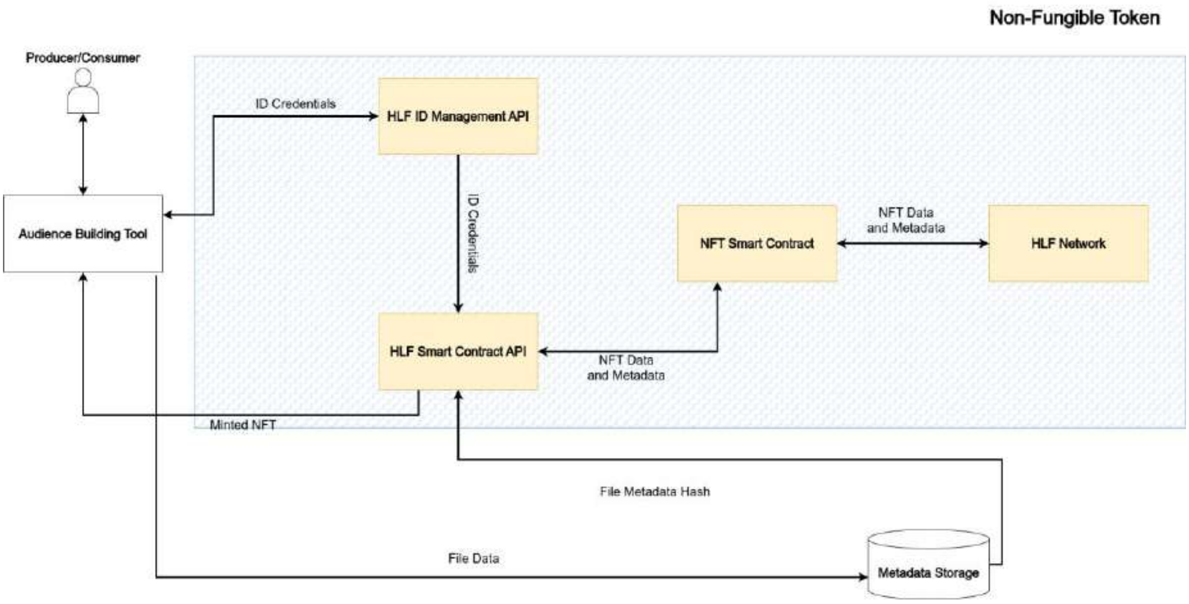

Figure 23: NFT Chaincode information-flow diagram

3.4.6 Location Scouting

The diagram below illustrates the information flow within the Location Scouting Tool. Location/service providers and filmmakers can interact with the interface and access LS components. Users initially interact with the User Manager component, which stores profile information and provides functionalities based on user type. The Data Manager, responsible for data storage, is connected to all components except the chatbot, which accesses data via a vector database built by the indexer. From the UI, users can search for locations using the Location Finder component or through the chatbot, depending on the user's query. Providers can easily register locations and services, along with additional image data, using the Location Register or Service Register components. The Web Crawler interacts solely with the Data Manager, where it reads existing documents in the database, searches based on this text, and updates or adds new points of interest.

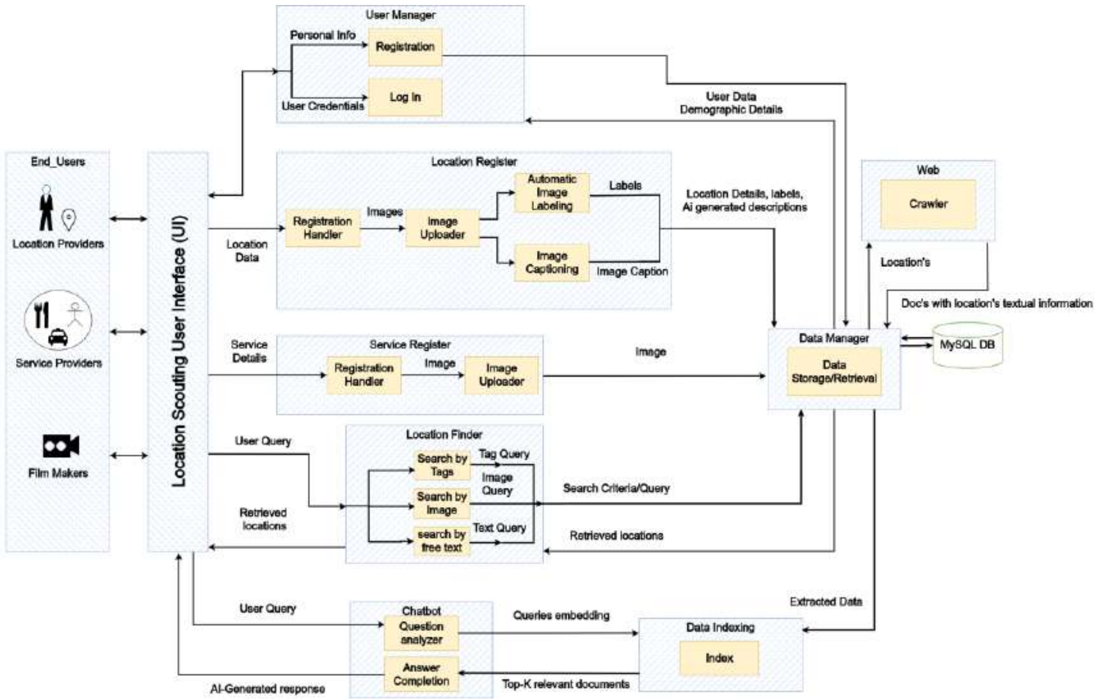

Figure 24: Location scouting information-flow diagram

3.4.7 AI-based Audience Preferences Scouting (AAPS) Tool

The figure below depicts the information diagram for the AAPS tool. The AI model Trainer can find all the required information through the Data Lake, which the Audience Building tool provides, which then consumes and produces as an output to the Data Lake the AI trend prediction model. The personas clustering component initially retrieves from the Data Lake the audience metadata that were produced from the Audience Building Tool to construct the target group personas that will be stored in the Data Lake. Subsequently, new viewers or audiences will be associated with target group personas. Finally, the audience trend recognition component makes use of the AI model, the persona, the media info and the interaction of the viewer with the media and predicts trends that are stored into the Data Lake.

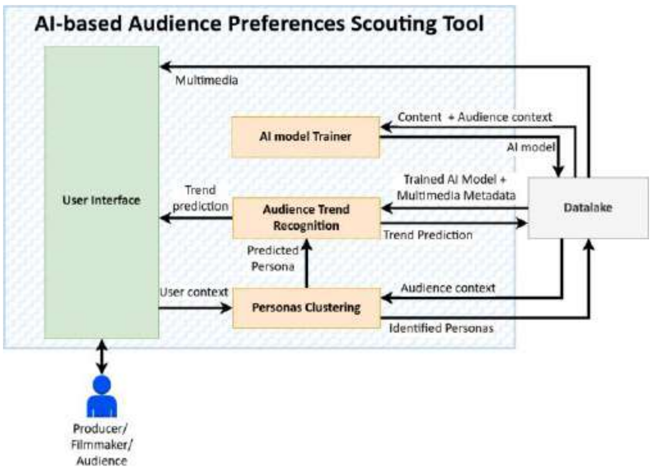

Figure 25: AI-based Audience Preferences Scouting Tool information-flow diagram

3.4.8 Audience Building (AB)

The diagram below illustrates the Audience Building information flow. Producers, investors, and audience members interact with the User Interface (UI) to access Audience Building Tool (ABT) components.

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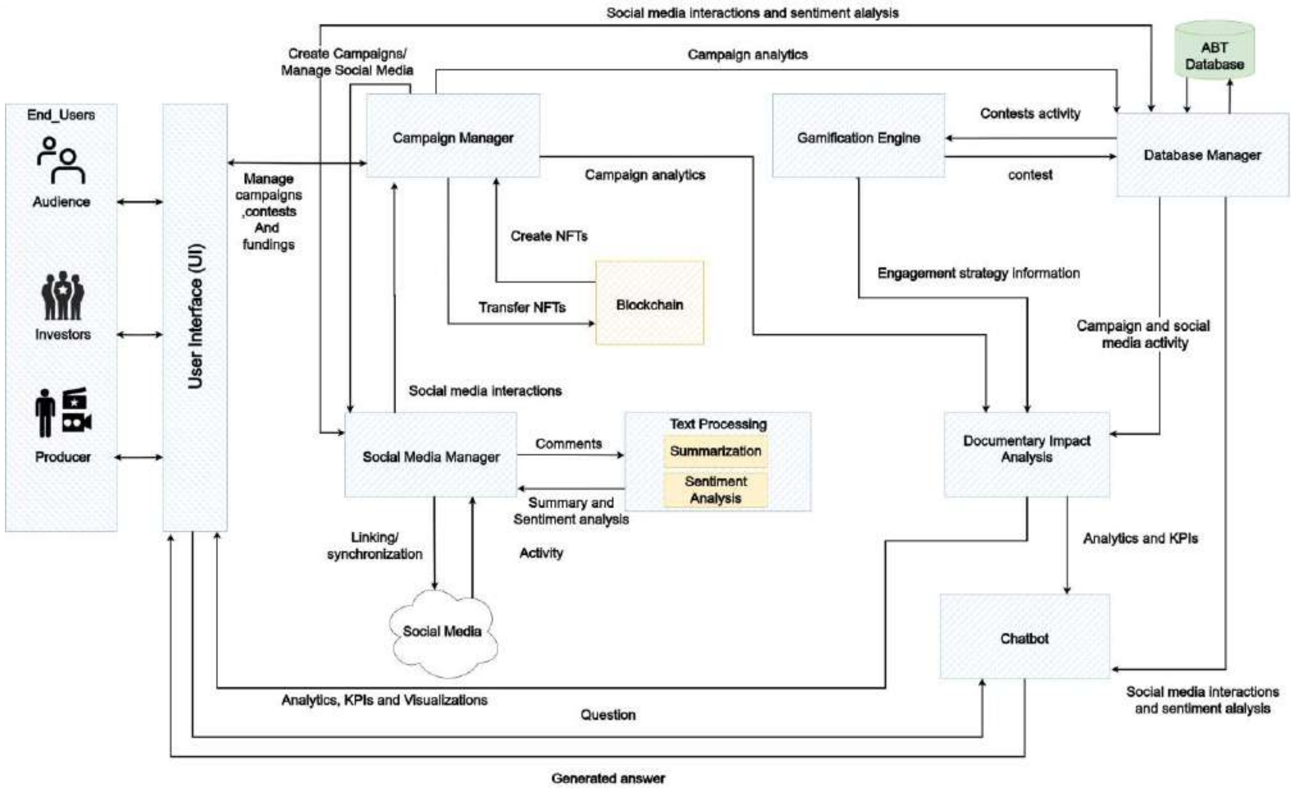

Figure 26: Audience Building Tool information-flow diagram

The UI allows producers to access the Campaign Manager (CM) component, enabling them to create and track campaigns across social media platforms via the Social Media Manager (SMM) component. SMM uploads campaign data, links various social media accounts to the campaign, and synchronizes audience interactions with the campaign. Additionally, SMM receives summaries and sentiment analyses from the Text Processing component, which analyzes social media comments.

This information, along with user interactions, is then passed to CM. CM is connected to the Documentary Impact Analysis component (DIA), which generates analytics and KPIs about the campaign. Users can access these analytics views via the UI. DIA also has access to the Gamification Engine and Database Manager (DM) to analyze contests and engagement strategies. Additionally, Users can utilize the Chatbot component via the UI to inquire about campaign analytics. The Chatbot receives information from DM and DIA to generate comprehensive reports. Furthermore, producers can create contests and foster audience engagement through the Gamification Engine component.

3.4.9 Lighting Simulation module

The Lighting Simulation module utilizes the interactive UI component to enable the communication of the user with the rest of the components. Through the UI, the user can retrieve the image set to be used for reconstruction, train a NeRF model and visualize the rendered output. After the camera pose extraction, the features produced by the NeRF model are forwarded through the lighting conditions networks and then the 3D rendered outputs the results with the simulated lighting. The user can additionally use the UI to change and experiment with multiple conditions at different viewpoints of the scene.

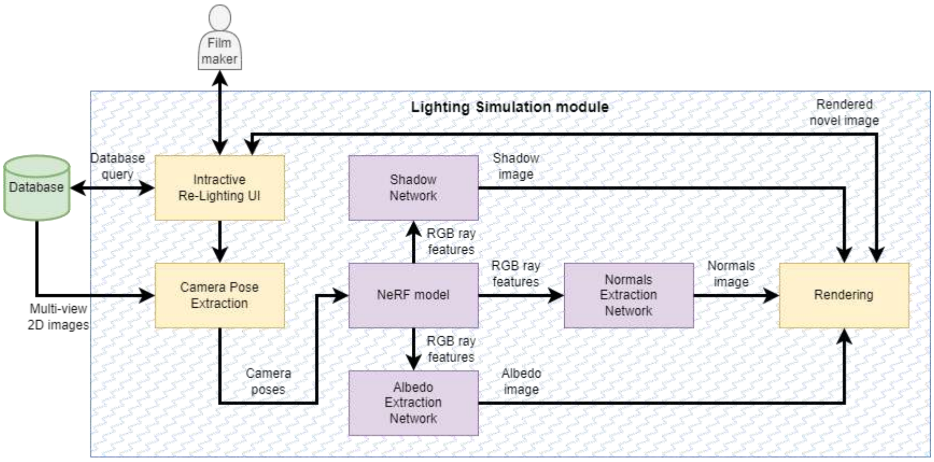

Figure 27: Lighting Simulation module information-flow diagram

3.4.10 Audio Simulation module

The information flow of the Audio Simulation module is displayed in the diagram below. Specifically, the information flow forms a closed loop incorporating the user through the UI, the simulation through the Spatial audio modeller and the data through the database.

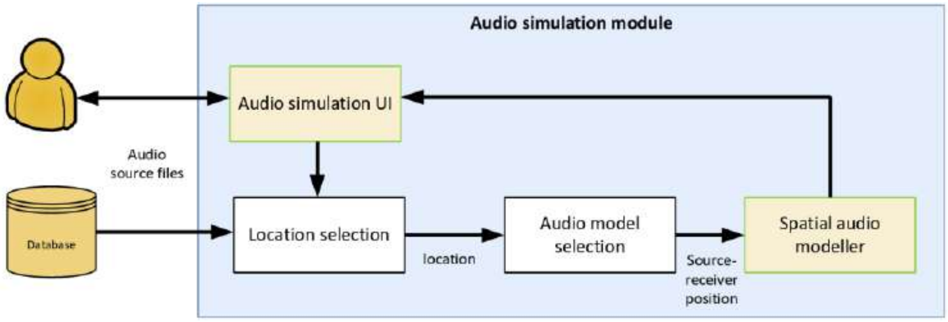

Figure 28: Audio Simulation module information-flow diagram

3.4.11 Post-Production Effects & Quality Metrics

The figure below is the information diagram for the Post-Production effects & Quality Metrics sub-system and depicts what information is exchanged between the involved components and the flow of the information. Specifically, the post-production effects information library sends the information about specific effects, which has been requested by the user, to the UI to be displayed. Furthermore, the user can request through the UI to load a specific media an apply certain effects. The playout tool retrieves the media from the Data Lake and applies the post-production effect selected and forwards the outcome to the UI to be displayed and stores the edited media back to the Data Lake as per user requests. Finally, the quality metrics & KPIs components computes various metrics & KPIs for the raw media itself or the post-processed one and sends the results to the UI to inform the user while it stores the result on the SCENE-O ontology after the post-processed media is stored to the Data Lake. The quantitative quality results will be stored to the SCENE-O ontology to allow experts in this phase or others to have easy access on this information.

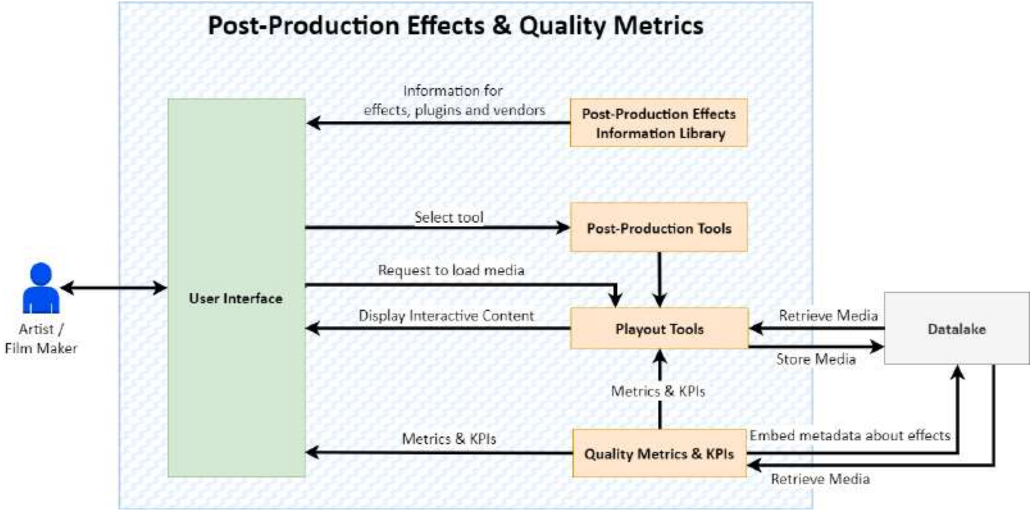

Figure 29: Post-production Effects & Quality Metrics information-flow diagram

3.4.12 UWB-based Tracking System

The diagram below shows the flow of data involving the UWB-based Tracking System. The UWB Wearables interact with the Anchors according to a specific procedure with the final goal to perform ranging measurements. After this procedure, the ranging measurements are available on the Anchors side. The Anchors send these measurements to the GWs, which then forward them to the Tracking Manager for estimating the actors' positions. The estimated positions along with identifiers and timestamp information are stored in a log file. These data will be stored in the Data Lake module to enable post-production use cases (UCs).

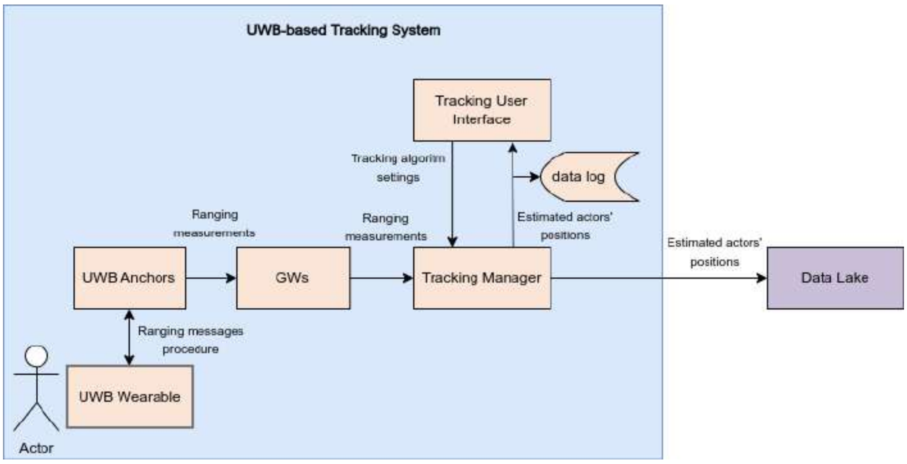

Figure 30: UWB-based Tracking System information-flow diagram

3.4.13 Distribution Engine

The Distribution Engine tool co-operates with the Media Asset Manager, by sharing a common user interface. The interaction of the user with the corresponding databases, through the backend API component can be seen in the information-flow diagram below.

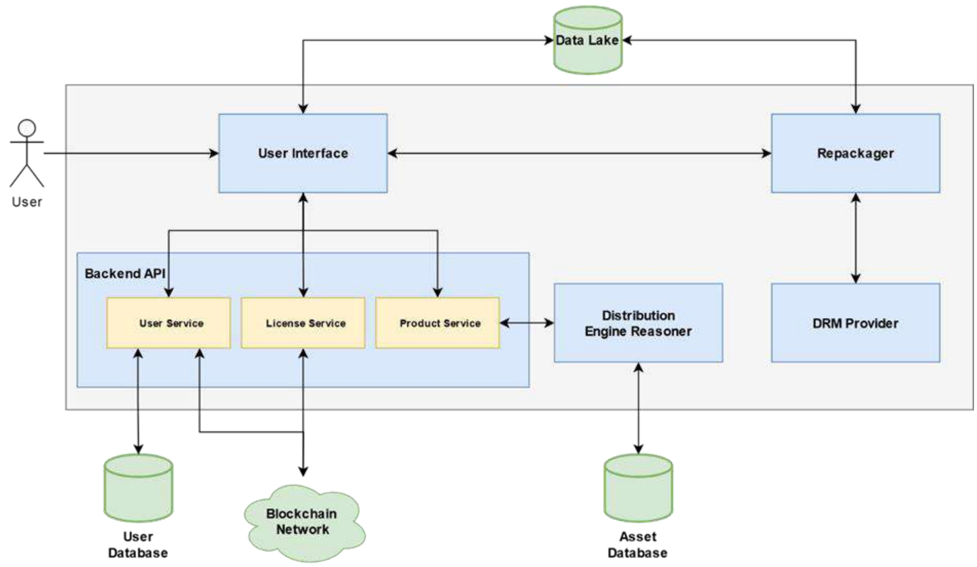

Figure 31: Distribution Engine information-flow diagram

3.4.14 Recommendation System

The figure below is the information diagram of the recommendation system. This diagram demonstrates what kind of information is exchanged between the various components and modules of the recommendation system itself and the external components as well. Specifically, the back-end APIs are responsible to communicate either with the Audience Building Tool, the Data Lake or a number of distribution platforms (Netflix, HBO etc.). The system considers information regarding the film (genre, cast etc.), information from the Audience Building tool (campaigns, past interest of audience for other films, demographics etc.) and viewing statistics from third party distribution platforms. This information will be then processed by the Vector Generator component, which will embed the information into vectors understandable from the recommendation algorithms. These vectors will be also stored in the Data Lake for future reference and to avoid unnecessary repeated computations. The raw information (before vector generation) will be passed to three modules, namely, Audience Clustering, Platform Profile Analyzer and User Modeling. This modules as the name suggest are responsible to identify cluster of audience with similar characteristics, trends and statistics for the distribution platforms and the profile of the user respectively. This information, alongside with the generated vectors will be fed into the recommendation algorithms respectively and the output will be forwarded to the UI to be visualized for the user. Finally, the user (filmmaker or audience) can provide feedback about the recommendation. The feedback will be then processed by the respective recommendation algorithm to improve and adapt accordingly.

Important note: The system will utilize information from the Location Scouting tool, such as information about historical monuments, about the aesthetics of the various Points of Interest present in the film, etc. Furthermore, it will consume information about the cast, the script and genre of the film. This information will be contained in the associated knowledge graph, constructed by the SCENE-O ontologies of the existing films, which will be retrieved from the Data Lake. Therefore, the direct connection with the location scouting tool has been omitted since the information will be retrieved through the Data Lake.

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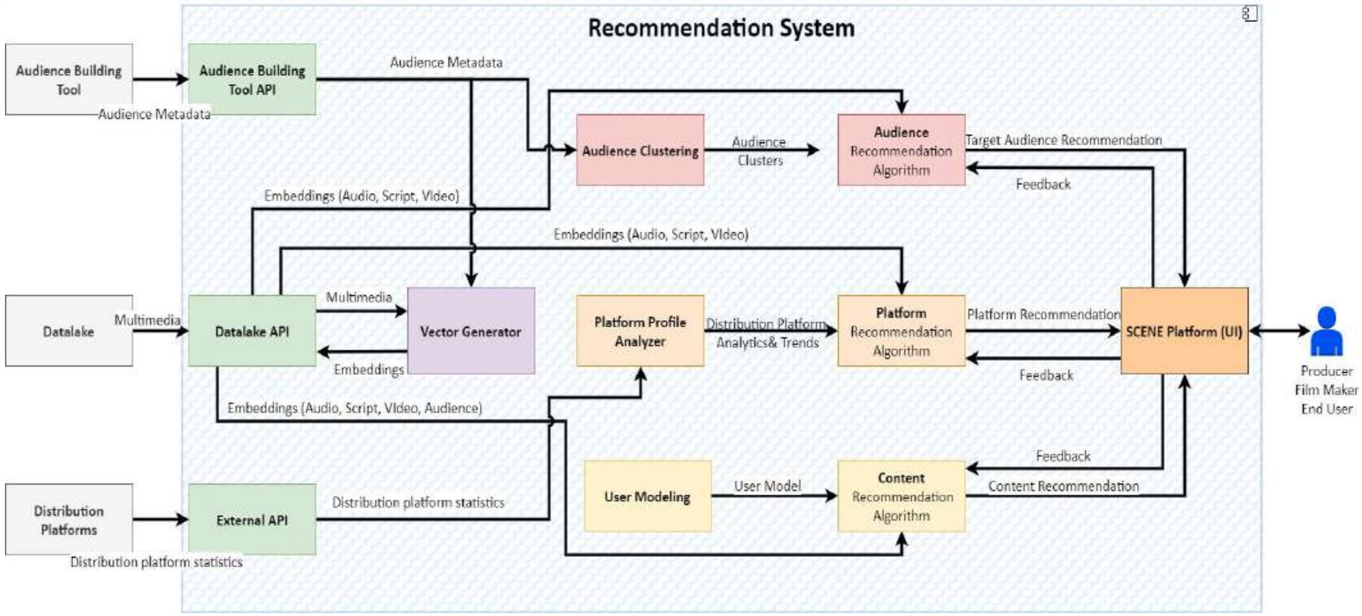

Figure 32: Recommendation system information-flow diagram

3.5 Deployment viewpoint

The deployment viewpoint is produced by the functional and development viewpoints. It depicts the setup of the system in a real-world functioning environment, grouping the components, based on their execution environment. It presents a comprehensive view of the way the entire system will function during production. The deployment viewpoint of the SCENE project is presented in Figure 33.

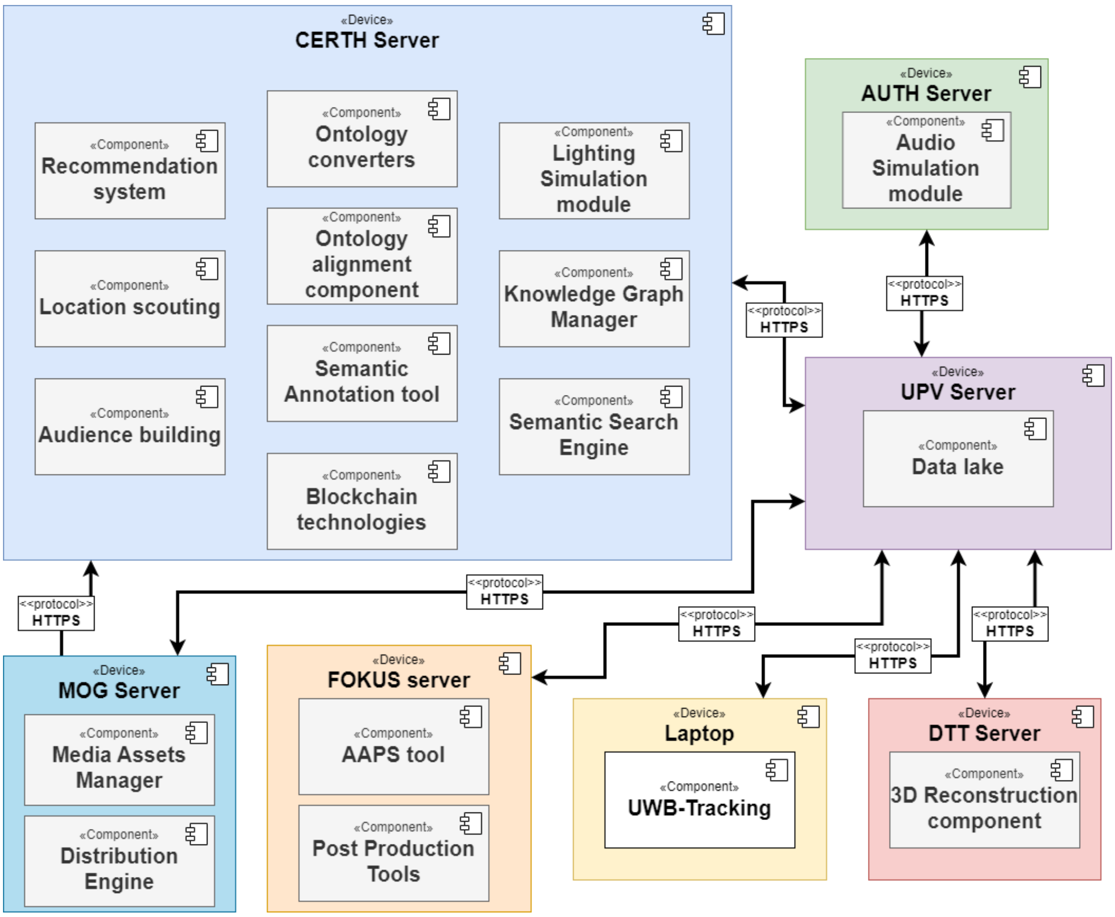

Figure 33: SCENE Deployment viewpoint

As it can be derived from the deployment diagram, the deployment of the SCENE system is envisioned to be done in a distributed way. This means that each partner will be responsible for the proper deployment and functionality of the corresponding component. The components are expected to be deployed as microservices, which ensures that they are all independently deployable and loosely coupled with each other. The microservices approach enables the delivery of complex systems, while also maintaining the reliability, scalability and sustainability of them.

4 Scenarios

Scenarios are detailed descriptions of specific interactions or sequences of events that demonstrate how users or external systems interact with the software system being designed. These scenarios are typically presented in a narrative format, describing the actions taken by users or external systems and the corresponding responses from the software system.

Each scenario typically includes:

1. Initiating Event: The trigger that initiates the scenario, such as a user action or an external event.
2. Actions: The sequence of actions taken by users or external systems.
3. System Response: The response of the software system to the actions taken, including any outputs, notifications, or changes in state.
4. Outcome: The result or outcome of the scenario, which may include successful completion, error conditions, or exceptional cases.

Scenarios may cover various aspects of system functionality, including user interactions, system integrations, error handling, performance, security, and scalability. The reasons that scenarios are included in the 4+1 architectural design pattern can be summarized as follows:

- **Enhanced Understanding**: Scenarios provide concrete examples that help stakeholders, including developers and users, better understand how the system will behave in different situations.
- **Validation**: Scenarios serve as a means of validating the architecture by demonstrating how it addresses specific user requirements and use cases. They help ensure that the architectural design meets the functional and non-functional requirements of the system.
- **Communication**: Scenarios facilitate communication among stakeholders by providing a common language for discussing system behaviour and requirements. They enable stakeholders to visualize and discuss system interactions in a tangible way.
- **Risk Mitigation**: Scenarios help identify potential risks and issues early in the design process by highlighting areas where the architecture may not adequately address user needs or system constraints.
- **Iterative Development**: Scenarios support an iterative development approach by providing feedback on the architecture at various stages of the development process. They enable architects and developers to refine and improve the architecture based on real-world use cases and user feedback.

Since the scenarios express the functionality of the system and the typical interactions of events in it, they are directly related with the functional requirements of the system. Each scenario of each tool corresponds to specific functional requirements, detailing how users interact with the system to accomplish tasks or achieve goals. The functional requirements have been described in detail in the deliverable D2.2 [3]. In the following table, the scenarios defined for each tool are mapped with their respective functional requirements.

Table 2: Mapping of scenarios to functional requirements

Tool	Scenarios	Requirements
Data Lake	Figure 34: Data Lakes main functionality sequence diagram	FR8, FR10, FR12, FR14, FR16, FR19, FR20
Knowledge Graph Management & Ontology Formulation	Figure 35: Semantic search sequence diagram	FR10, FR13, FR14, FR15, FR16, FR17, FR25, FR26, FR27, FR28, FR29, FR30, FR38
Media Asset Manager	Figure 36: Media Asset Manager video search sequence diagram	FR10, FR14, FR16, FR18, FR38
	Figure 37: Media Asset Manager upload video files sequence diagram	FR10, FR14, FR16, FR18, FR38
3D Reconstruction	Figure 38: 3D Reconstruction main functionality sequence diagram	FR1, FR2, FR3, FR4, FR10, FR14, FR38
Blockchain Technologies	Figure 39: Ricardian Contract sequence diagram	FR10, FR14, FR40, FR41, FR42, FR43
	Figure 40: NFT creation sequence diagram	FR10, FR14, FR44, FR45, FR46
Location Scouting	Figure 41: Location Scouting service manager sequence diagram	FR10, FR14, FR31, FR32, FR38
	Figure 42: Location Scouting location finder sequence diagram	FR10, FR5, FR14, FR38
	Figure 43: Location Scouting location register sequence diagram	FR6, FR7, FR10, FR14, FR26, FR33, FR38
	Figure 44: Location Scouting chatbot sequence diagram	FR10, FR14, FR38
AI-based Audience Preferences Scouting Tool	Figure 45: AAPS main functionality sequence diagram	FR10, FR14, FR36, FR38, FR54, FR60, FR61, FR62, FR63
Audience Building Tool	Figure 46: Account creation, campaign and synchronization of social media sequence diagram	FR10, FR14, FR34, FR35, FR38, FR39
	Figure 47: Analytics and KPIs Monitoring sequence diagram	FR10, FR14, FR35, FR36, FR37, FR38
Lighting Simulation module	Figure 48: Lighting Simulation module main functionality sequence diagram	FR1, FR2, FR3, FR4, FR10, FR14, FR38, RF47, FR48, FR49
Audio Simulation module	Figure 49: Audio Simulation module main functionality sequence diagram	FR10, FR14, FR38, FR56, FR57, FR58, FR59
Post Production Effects & Quality Metrics	Figure 50: Post Production Effects & Quality Metrics main functionality sequence diagram	FR10, FR14, FR38, FR64, FR65, FR66, FR67
UWB-based Tracking	Figure 51: UWB-based Tracking System main functionality sequence diagram	FR10, FR11, FR14
Distribution Engine	Figure 52: Distribution Engine play video sequence diagram	FR10, FR14, FR24, FR38
	Figure 53: Distribution Engine license creation sequence diagram	FR10, FR14, FR21, FR22, FR38
Recommendation System	Figure 54: Recommendation System main functionality sequence diagram	FR9, FR10, FR14, FR23, FR38, FR50, FR51, FR52, FR53, FR55

Overall, scenarios play a crucial role in the 4+1 architectural design pattern by providing concrete examples that validate the architecture, enhance understanding, facilitate communication, and support iterative

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development. They are an essential tool for ensuring that the architectural design effectively addresses user needs and system requirements.

The use-case scenarios for each component are presented in the following sections, utilizing sequence diagrams.

4.1 Data Lake

There are many different ways data can ingress and egress on/to the Data Lake. Below is one sequence diagram that tries to encompass most of the functionalities provided by the different layers of the Data Lake. The semantic management is still unclear but at least all data available in the storage layer of the Data Lake (landing area, refined area, production area) should be somehow mapped and linked with the SCENE ontology in order to allow a semantic discovery by means of specific vocabularies (metadata)

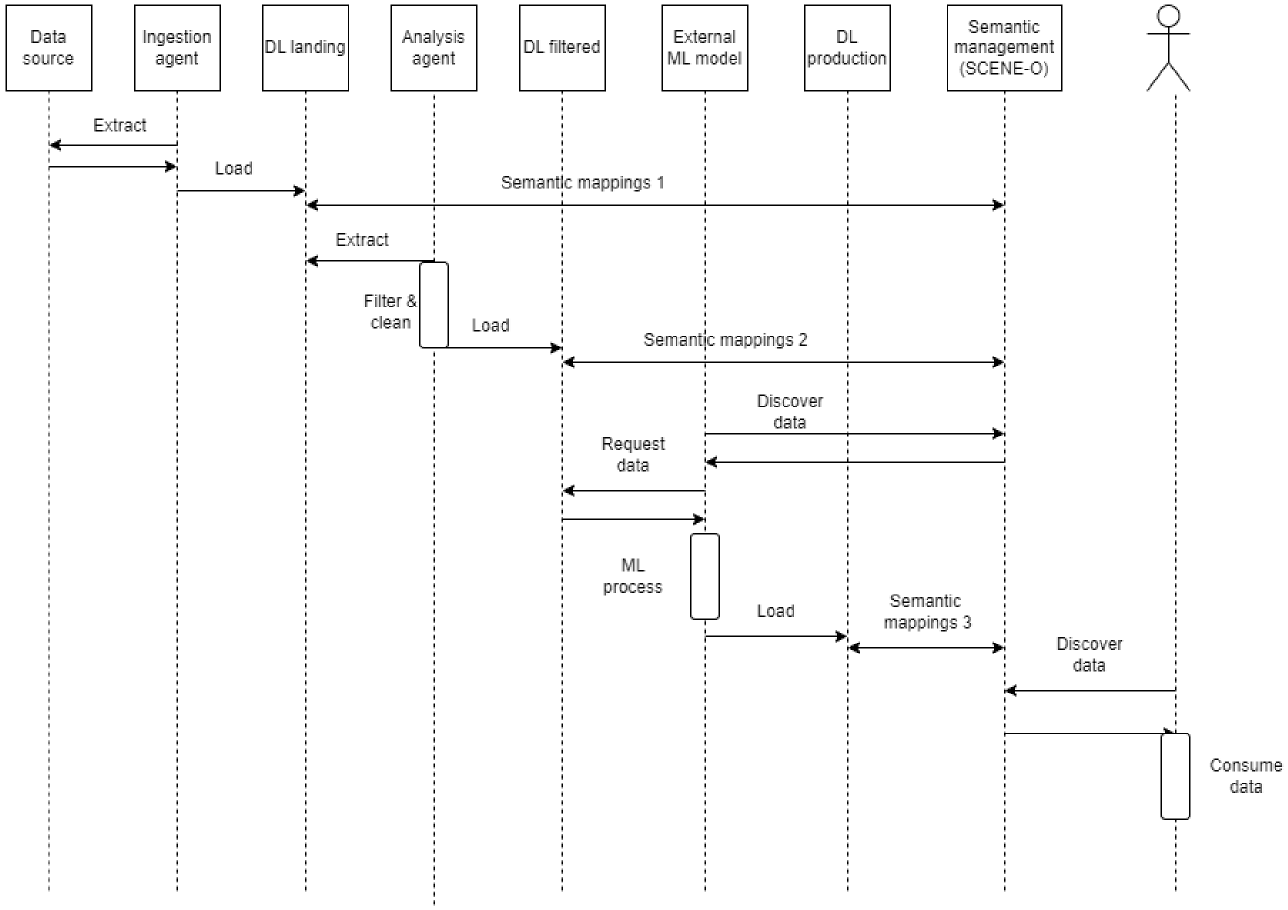

Figure 34: Data Lakes main functionality sequence diagram

4.2 Knowledge Graph Management & Ontology Formulation

The scenario depicted in the following sequence diagram, depicts the use of the tools implemented within T3.2. More specifically, the first tool concerns the use of the SCENE-O ontology for the information retrieval. According to the following scenario, the user will post a query in one of the SCENE project's tools, and with the use of the ontology, the relevant to this query information will be provided via the semantic search tool.

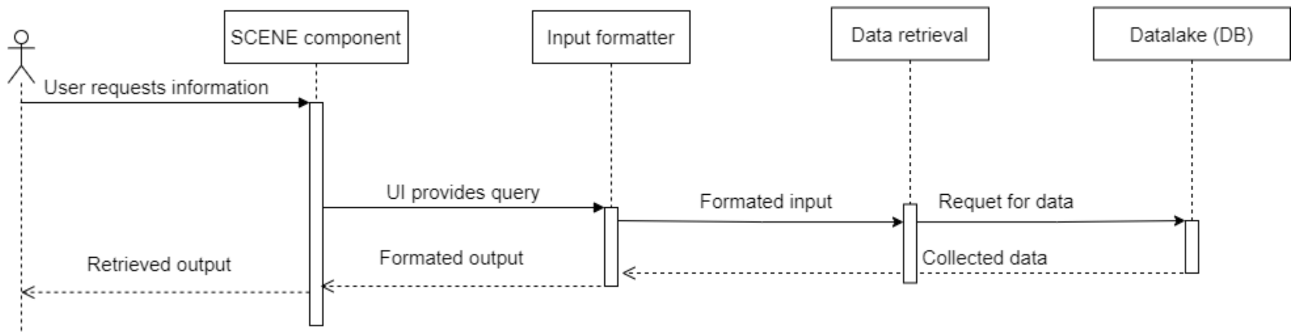

Figure 35: Semantic search sequence diagram

4.3 Media Asset Manager

The following diagrams describe two of the main usage scenarios of the Media Asset Manager. The first illustrates the process of searching for a given video in the SCENE repository and retrieving the most significant results. The second diagram represents the process of ingesting and registering finished video file in the Data Lake for later usage. It is important to note that the video is stored with the associated metadata that is described using the SCENE ontology and can be used for other scenarios such as video search or video recommendations.

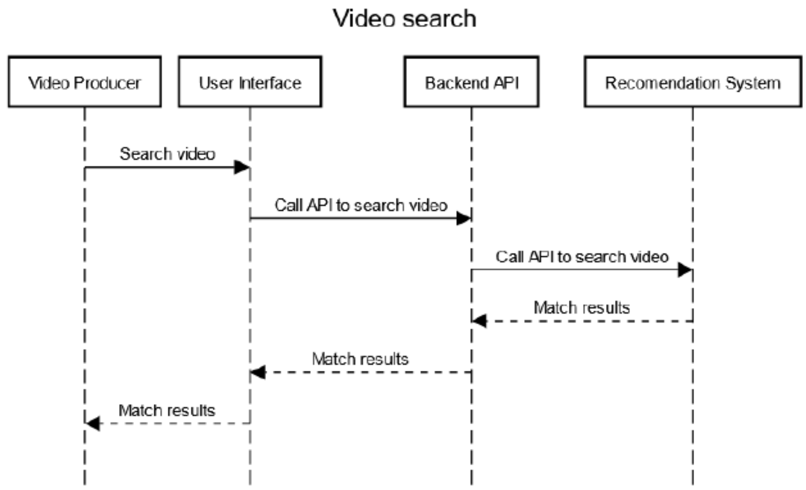

Figure 36: Media Asset Manager video search sequence diagram

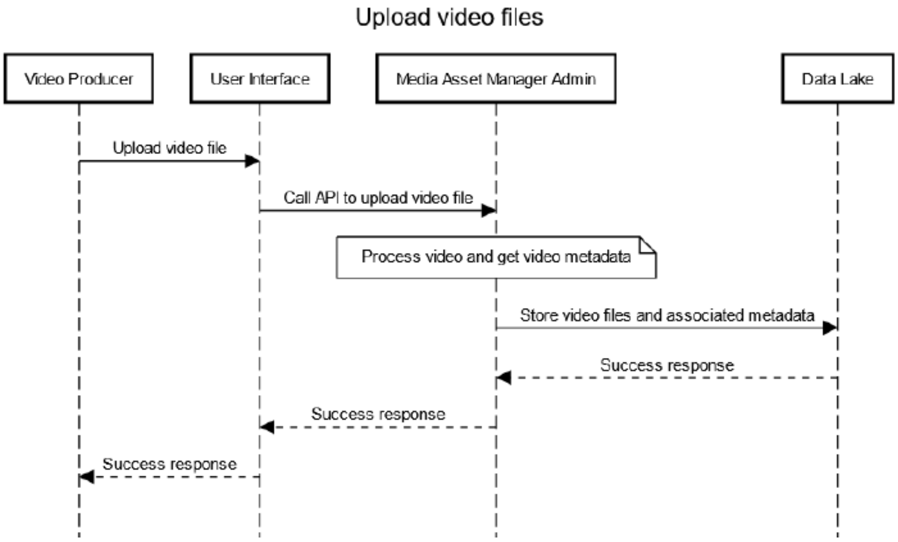

Figure 37: Media Asset Manager upload video files sequence diagram

4.4 3D Reconstruction

There below sequence diagram depicts the relevant components of the 3D Modeling module. The user requests 3D reconstruction using an interactive UI and then trains the NeRF model for a certain time after successful training the 3D model will be reconstructed. In the UI there are also other two options the user can request for the 3D model output: one is render view and another one is lightning simulation. The interaction with the lightning simulation module is also integrated in this diagram.

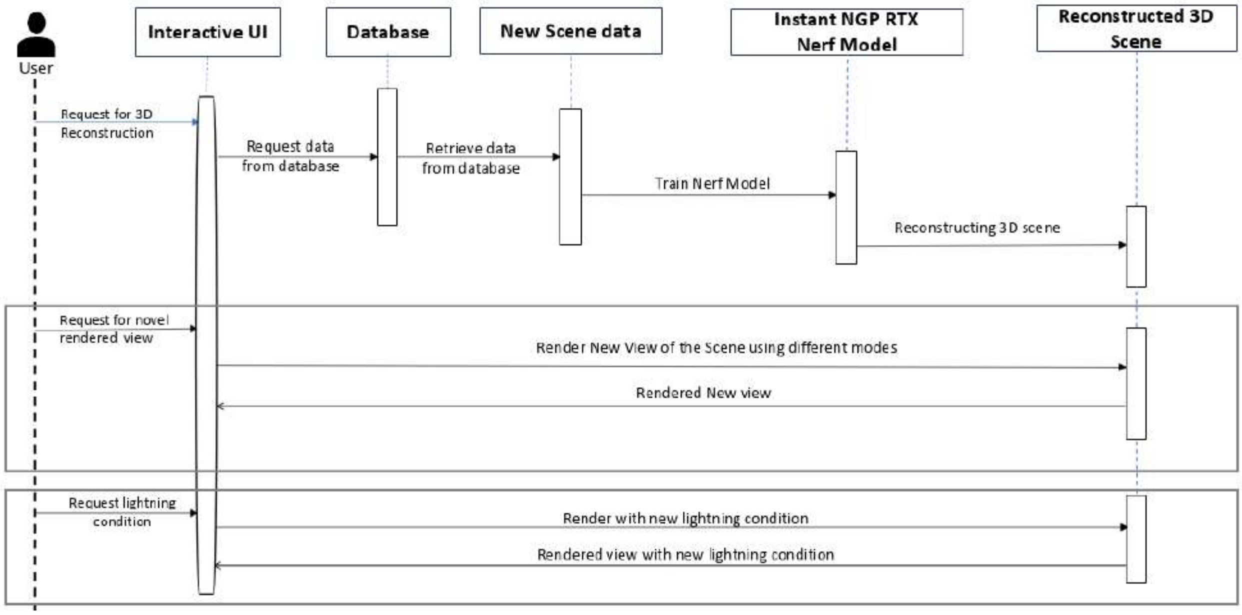

Figure 38: 3D Reconstruction main functionality sequence diagram

4.5 Blockchain Technologies

The presented sequence diagram illustrates the creation of a Ricardian Contract between the producer of a movie and the consumer through the Media Asset Manager. This contract represents a human-readable agreement that once agreed upon, get converted into a machine-readable contract signed by both parties and stored in the blockchain. The main purpose of Ricardian contracts is to define the contractual relationship between the parties and can be used outside a blockchain.

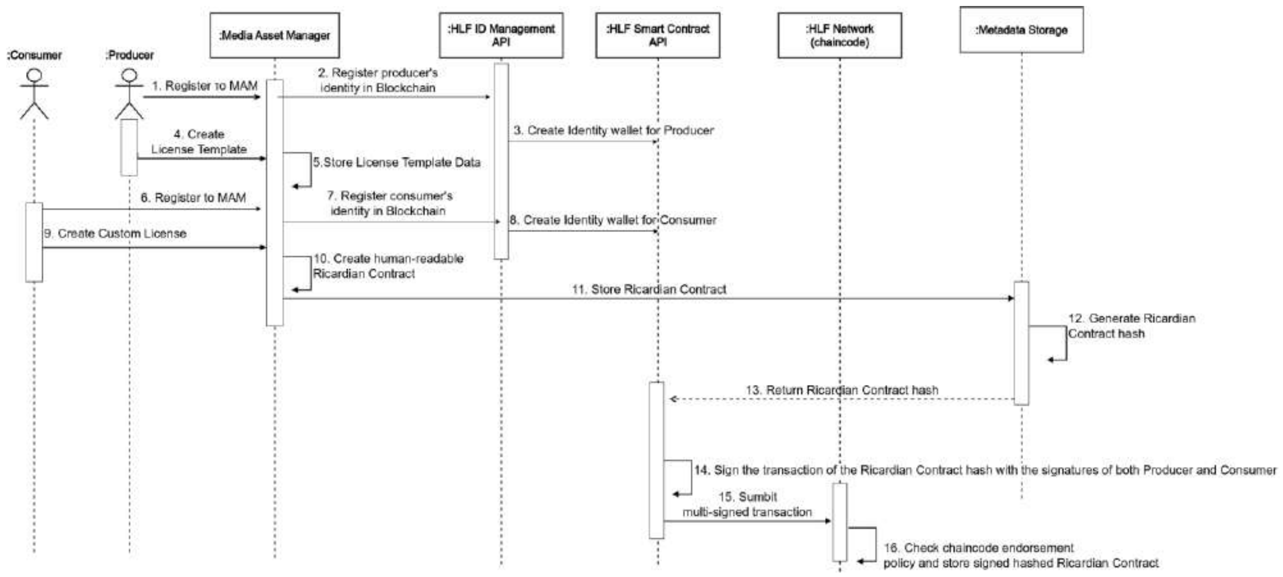

Figure 39: Ricardian Contract sequence diagram

The NFT sequence diagram demonstrates the pre-production process of generating NFTs for crowdfunding. The main parties of this service are the producer of a movie and the consumer interested in it. The producer creates an NFT (e.g. backstage photos or videos), through the Audience Building Tool. Any user interested in the movie can buy this NFT, using Blockchain coins (fungible tokens) to support its production. The main objective of this task is to raise the popularity of a movie enhanced by the widespread technology of the Blockchain.

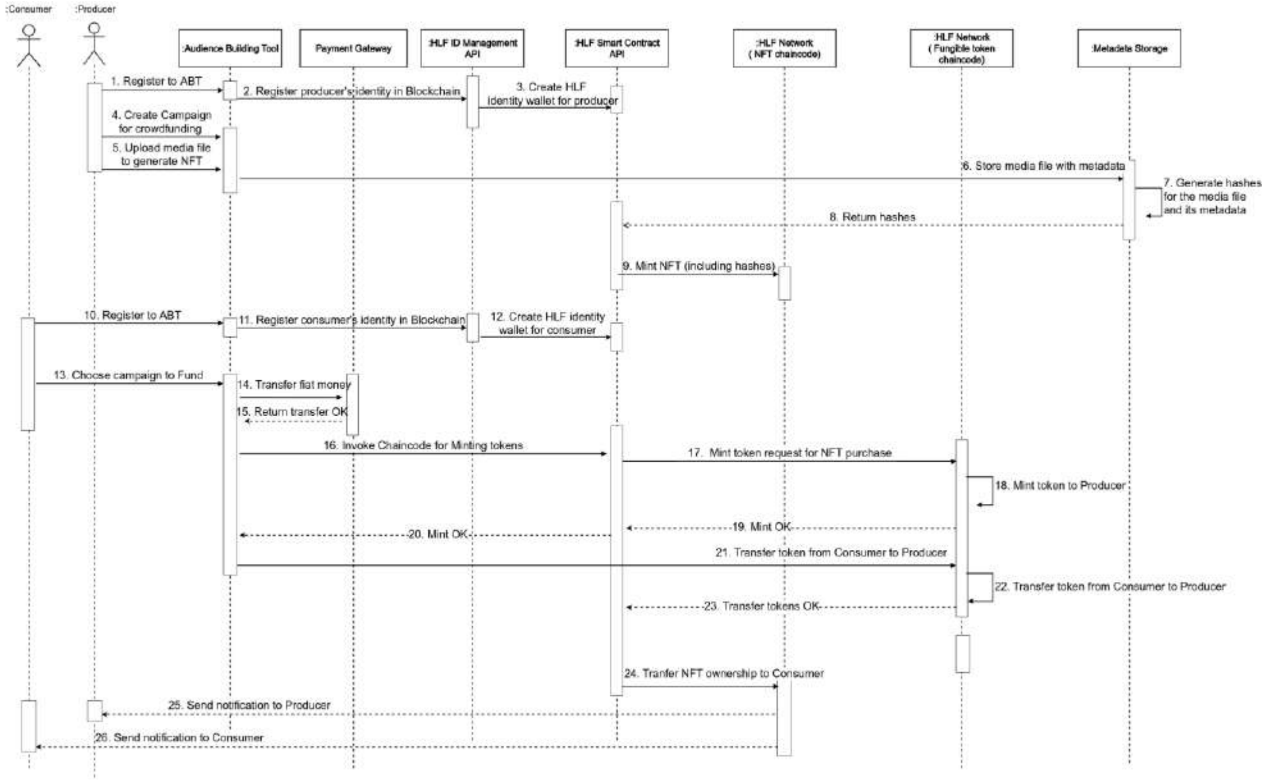

Figure 40: NFT creation sequence diagram

4.6 Location Scouting

The above diagram illustrates the user login to the Location Finder tool and the registration of services details to a location. Before the registration, the user must have service provider permissions to register services. Then the user provides images and details to the Service Register component, which is responsible for saving information and data about a location to the database.

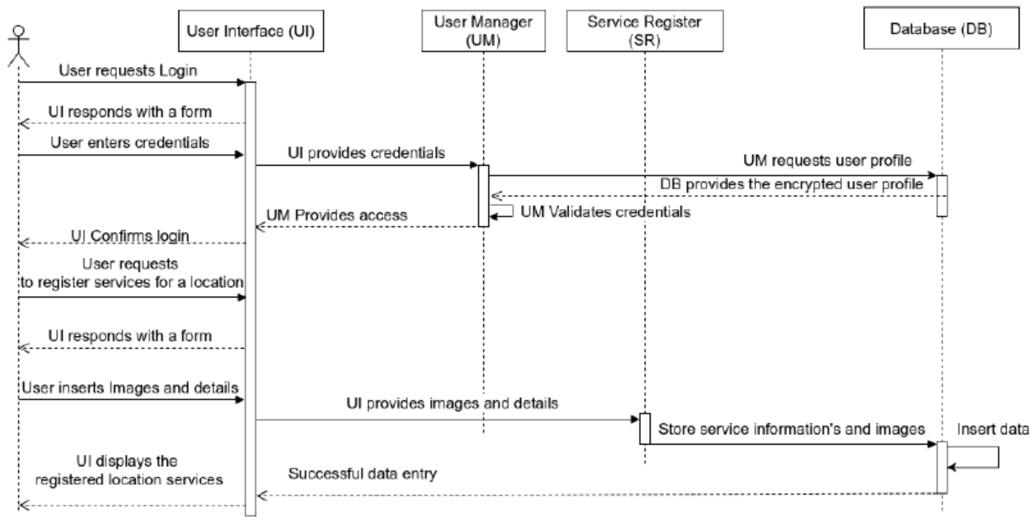

Figure 41: Location Scouting service manager sequence diagram

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The presented sequence diagram illustrates the process of a filmmaker retrieving desired locations using the Location Finder (LF) component. The LF component conducts searches in the database using tag, text, or image queries through different modules, enabling users to locate desired locations more efficiently.

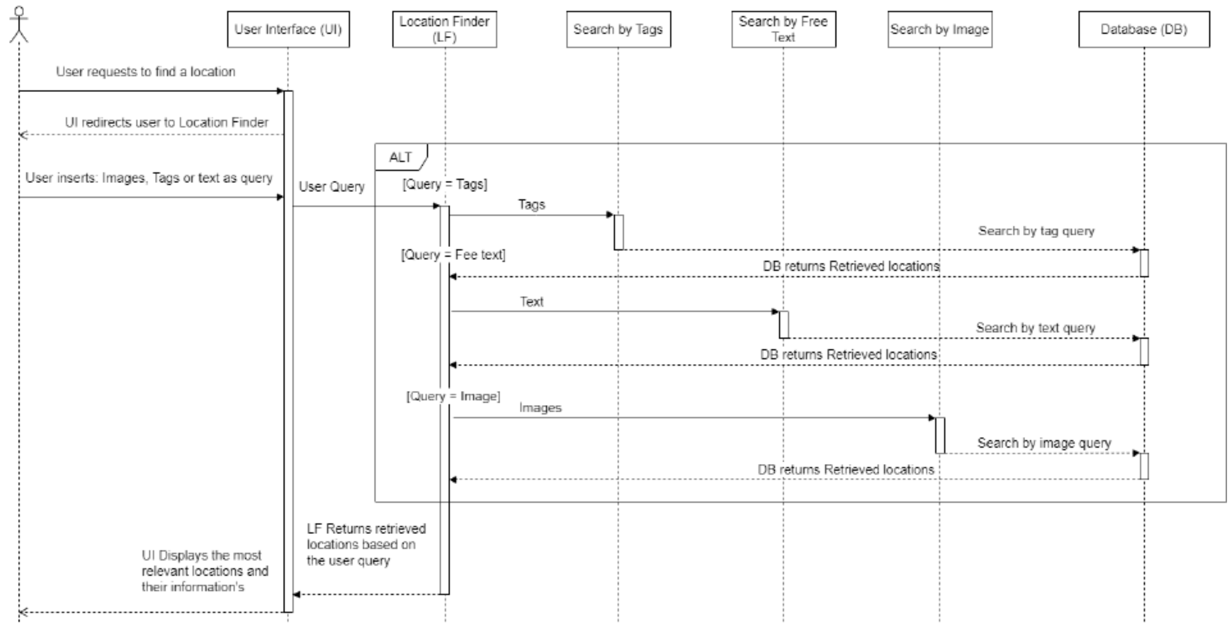

Figure 42: Location Scouting location finder sequence diagram

The presented sequence diagram illustrates the registration of locations along with images and information provided by location providers. The Location Register (LR) component uses Images Classification module to annotates user's images with labels. Subsequently, the images are passed to the Image Captioning module, which generates AI captions. Finally, all user input data, including images, details, and generated meta-data from the LR modules, are saved to the database.

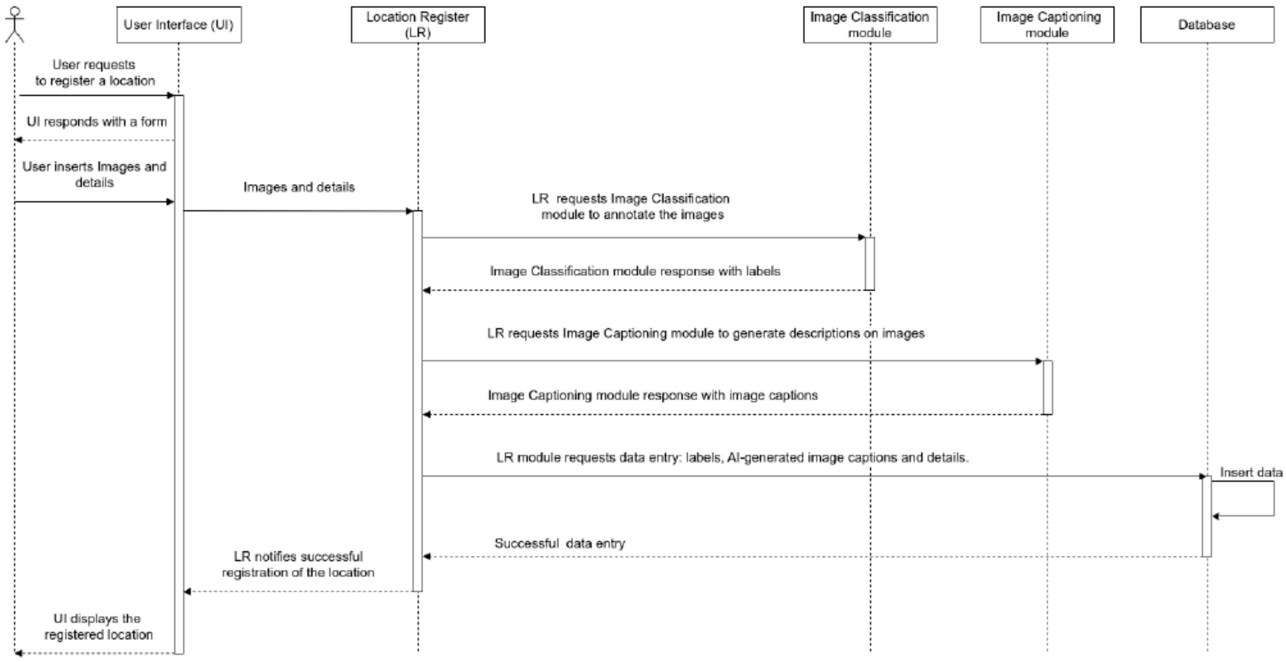

Figure 43: Location Scouting location register sequence diagram

The presented sequence diagram illustrates film makers interacting with the Chatbot component by asking questions and the process of answer generation. The Chatbot forwards the user question to the Question Analyzer module, which is responsible for converting the question into a useful embedding query for the Indexer module. The Indexer module executes the query in a vector database to search for the most similar documents from the database. Subsequently, the chatbot receives this information and proceeds to the Answer Completion module, which generates the answer.

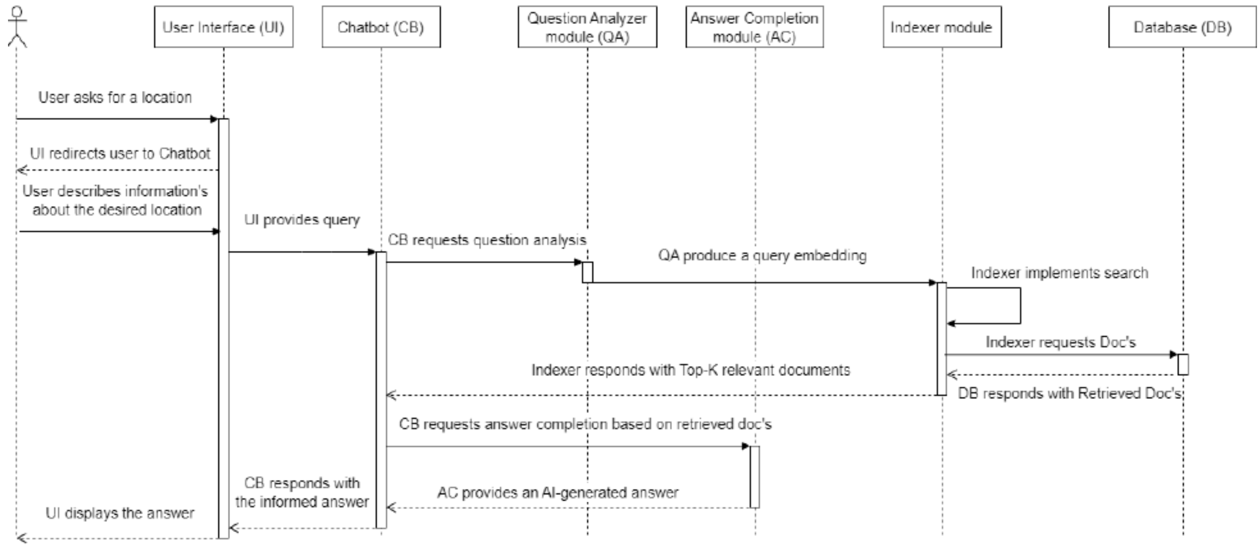

Figure 44: Location Scouting chatbot sequence diagram

4.7 AI-based Audience Preferences Scouting Tool

The figure below illustrates the internal steps required for the AI-based Audience Preferences Scouting tool in order to achieve the trend prediction of the audience about a film. This scenario concerns the end-user which has the role of the viewer. Initially, the viewer, will receive as set of instructions and the form stating the terms & conditions (what, how and why data and activities will be monitored). After the user has accepted the conditions then the back-end proceeds into an initialization face by loading the appropriate trend prediction models and assigning the viewer into a person based on his/her characteristics. Finally, the user begins the playback and the viewer's watching activity is monitored and used by the AI model to form predictions in specific interval and scenes of interest.

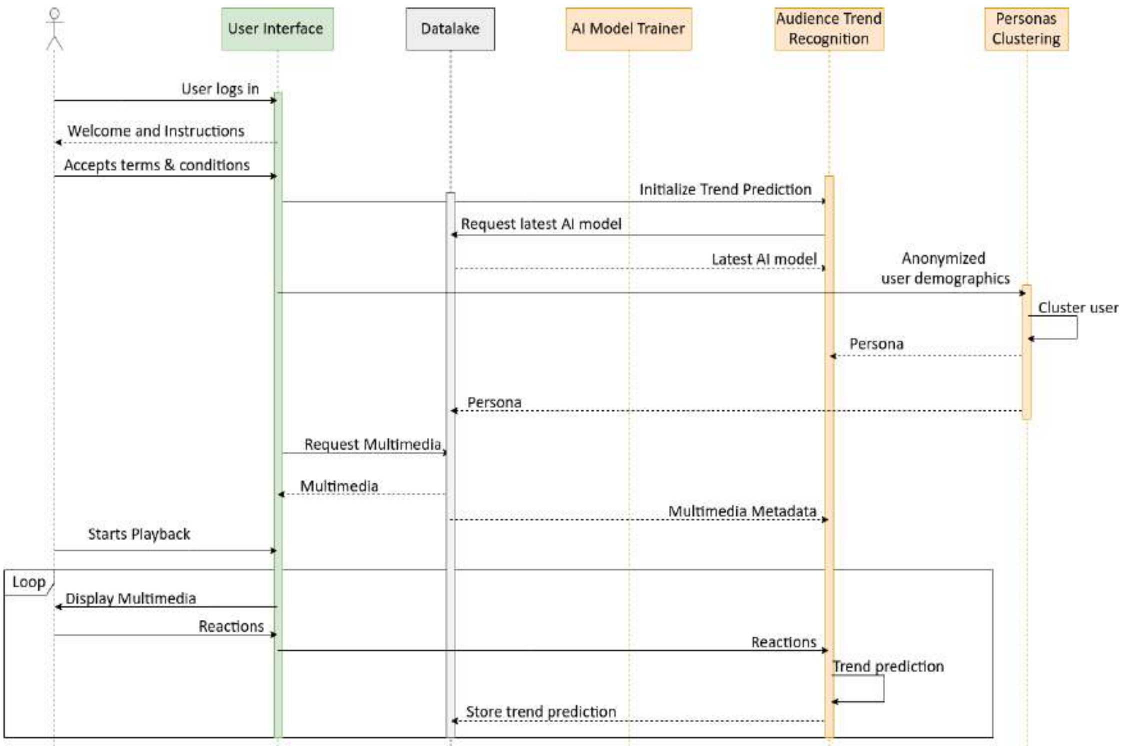

Figure 45: AAPS main functionality sequence diagram

4.8 Audience Building Tool

The diagram below illustrates the process of creating movie campaigns by a producer and their integration with social media. This involves the registration to the Audience Building Tool using the producer's social media account. Prior to campaign creation, the Social Media (SM) manager implements social media linking, and then the Campaign Manager creates the campaign. After the social media linking and campaign creation, multimedia content is uploaded by the SM manager and then social media activity is synchronized with the campaign.

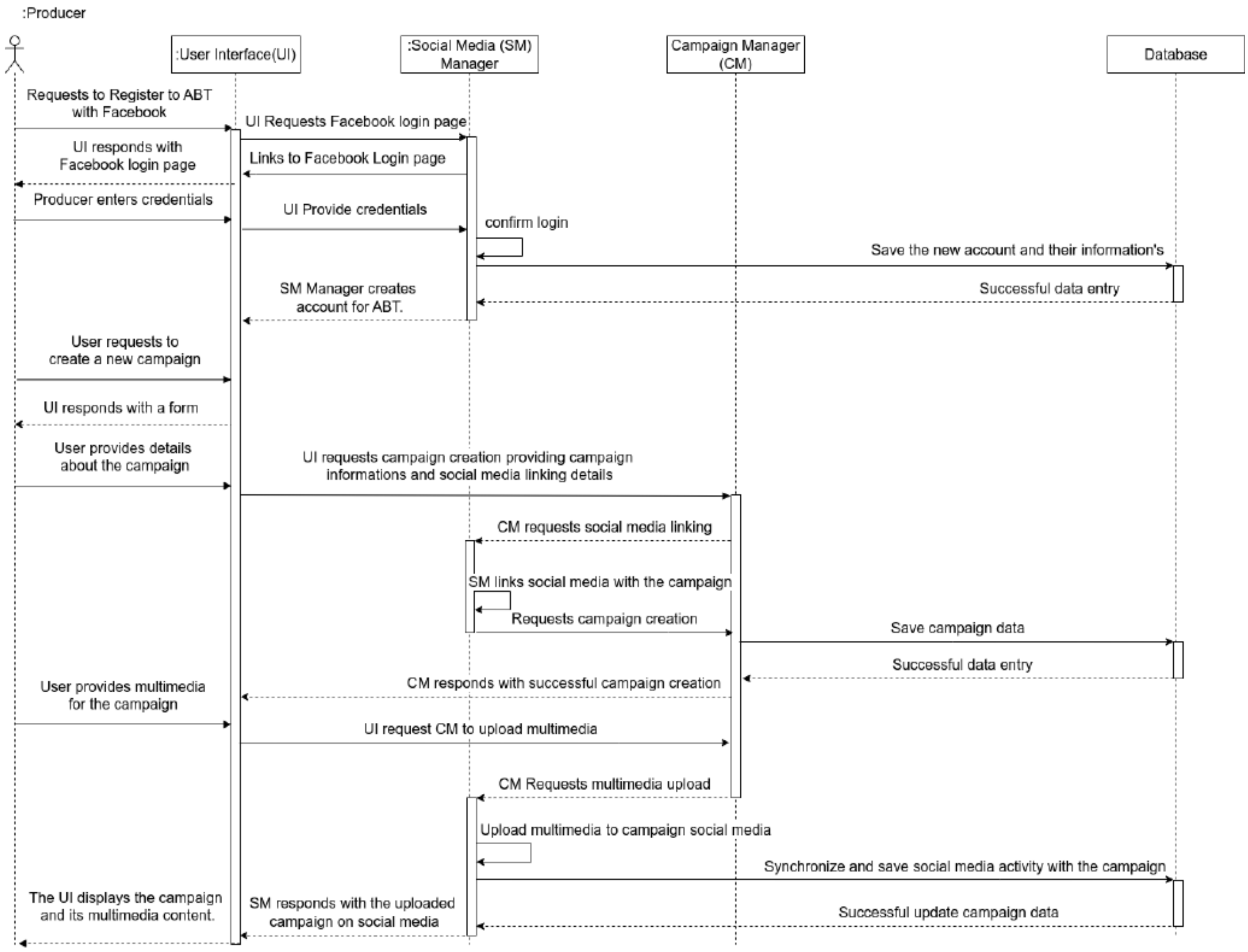

Figure 46: Account creation, campaign and synchronization of social media sequence diagram

The sequence diagram (See Fig 47) illustrates the process of providing useful analytics and Key Points of Interest (KPIs) for campaigns to film producers. Producers can request campaign analytics from the Documentary Impact Analysis (DIA) component, which retrieves campaign data and social media activity from the database and presents visual analytics and KPIs to the user. Moreover, producers can interact with a chatbot by asking free-text questions. The chatbot analyzes these questions and executes queries to both the database for campaign data retrieval and to the DIA for analytics and KPIs. Utilizing this data, the chatbot completes its response by generating a final report along with KPIs.

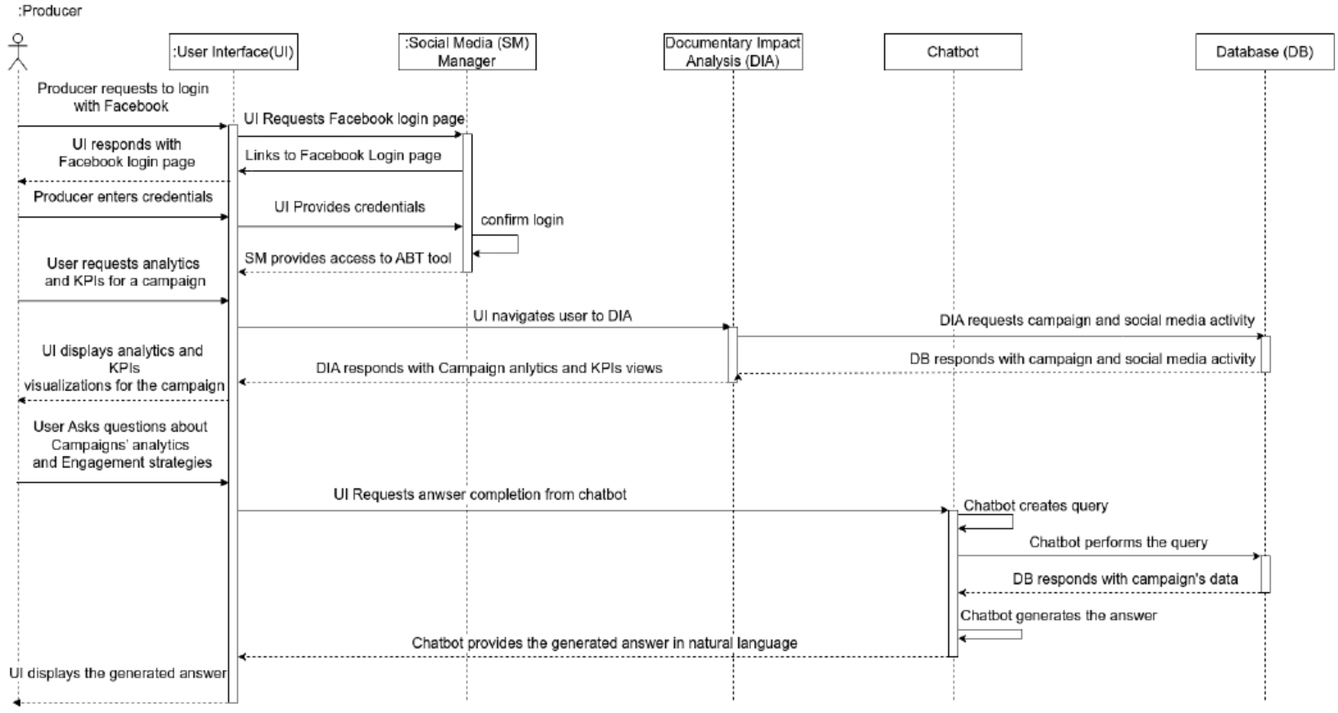

Figure 47: Analytics and KPIs Monitoring sequence diagram

4.9 Lighting simulation module

The presented sequence diagram illustrates film makers interacting with the Chatbot component by asking questions and the process of answer generation. The Chatbot forwards the user question to the Question Analyzer module, which is responsible for converting the question into a useful embedding query for the Indexer module. The Indexer module executes the query in a vector database to search for the most similar documents from the database. Subsequently, the chatbot receives this information and proceeds to the Answer Completion module, which generates the answer.

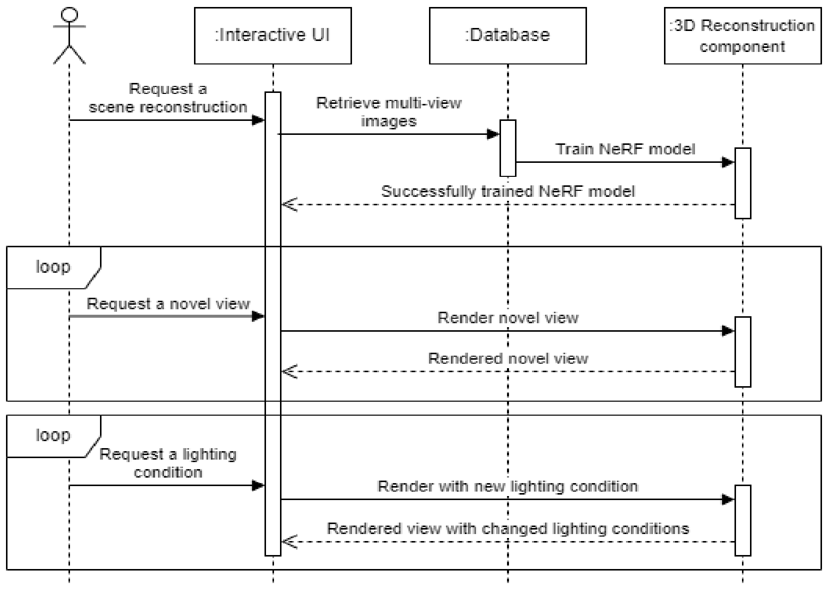

Figure 48: Lighting Simulation module main functionality sequence diagram

4.10 Audio simulation module

The presented sequence diagram illustrates film makers interacting with the Audio Simulation module. Through the UI, the film maker selects a location for which acoustic simulation is available, and, if there is more than one, the preferred simulation model. The UI communicates with the database and loads the required model. Within a loop, the user may request output for different positions of the sound source and the receiver, as well as different numbers and types of sound sources. The UI communicates with the database to load sample audio files upon request, and with the audio model to produce a new output according to the user input.

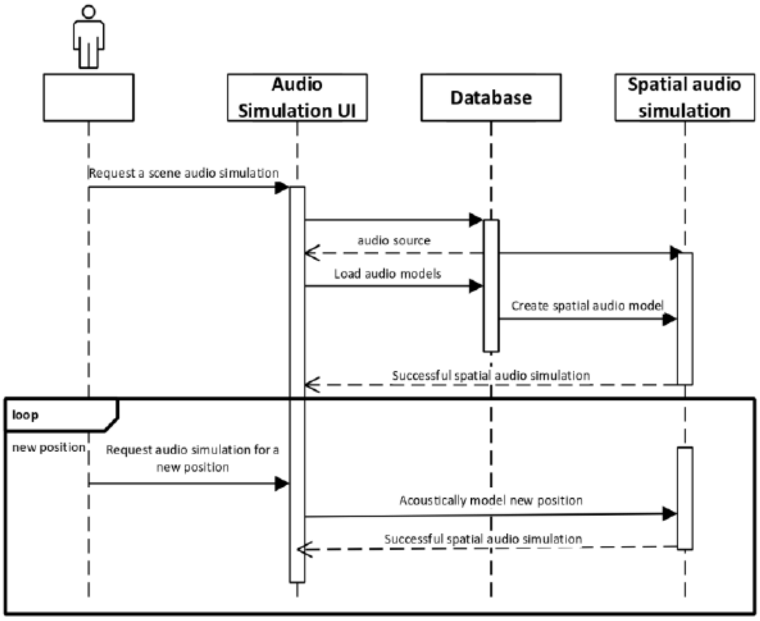

Figure 49: Audio Simulation module main functionality sequence diagram

4.11 Post-Production Effects & Quality Metrics

The sequence diagram below illustrates the supported functionalities of this tool. The specific scenario concerns the filmmaker and the expert artists and showcases how the internals of the tools collaborate to achieve the use-cases. Concretely, this use-case describes the interactive insertion of post-production effects and the quality assessment of the media and effects.

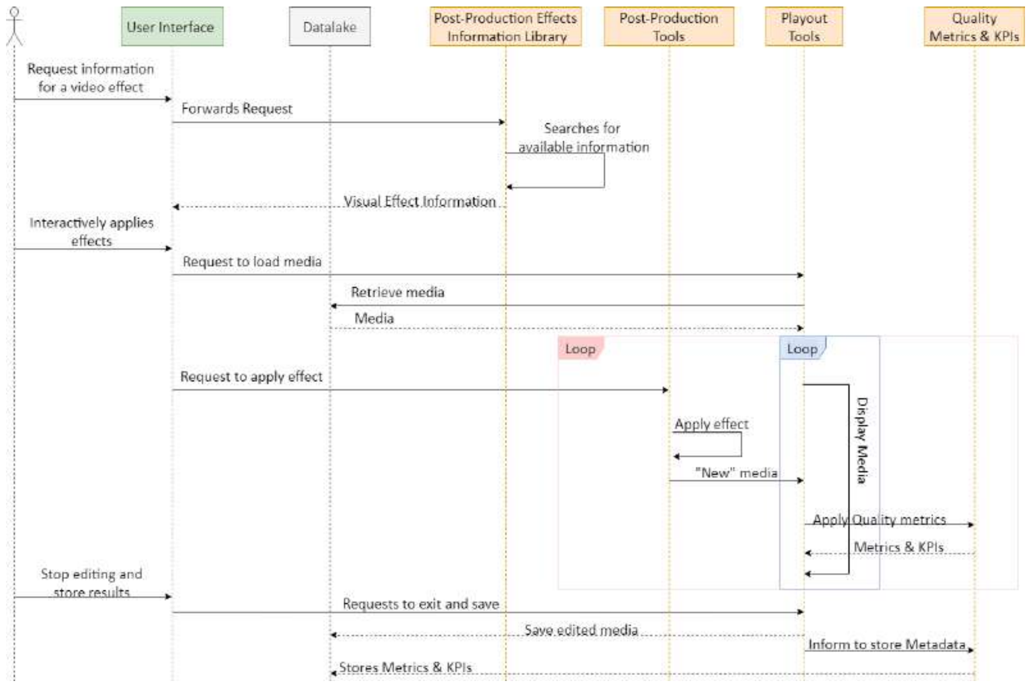

Figure 50: Post Production Effects & Quality Metrics main functionality sequence diagram

4.12 UWB-based Tracking

This sequence diagram presents a simple UC. During the production phase, the positions of actors will be tracked in real-time and relevant data, such as positions, wearable identifiers and time stamps, are saved into a log file. After the production phase, this log file will be stored into the Data Lake module where these data will be used during the post production phase according to the specific use cases.

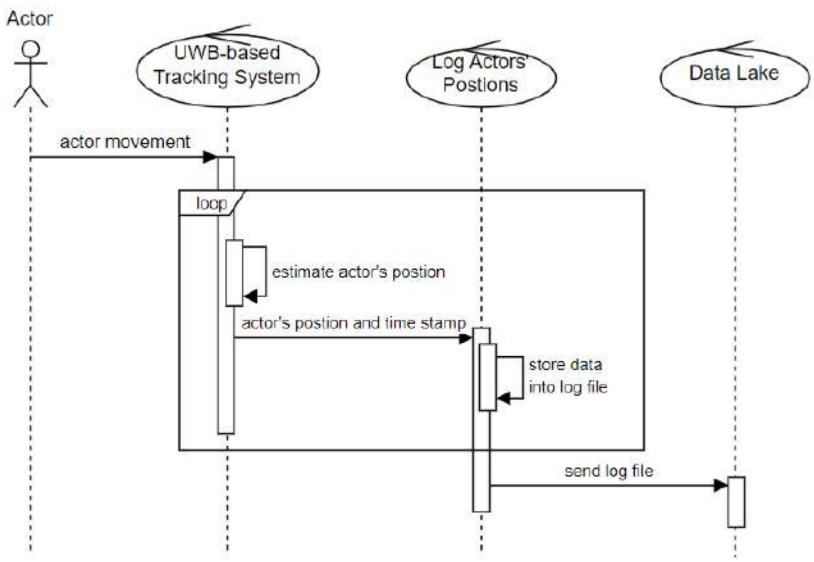

Figure 51: UWB-based Tracking System main functionality sequence diagram

4.13 Distribution Engine

The following diagrams describe two of the main usage scenarios of the Distribution Engine. The first scenario illustrates the process of playing a given video that is stored in the SCENE ecosystem. In it, it is possible to check the connections between the stored video and the one that is played in the end user devices, namely the Digital Rights Management validation and the repackaging of the video in different resolutions for adaptive bitrate scenarios. The second diagram the creation of licenses by the film producers in order to restrict the usage of the final videos. Therefore, in it we demonstrate the connections with the IPR module and how the video can be protected from unauthorized usage.

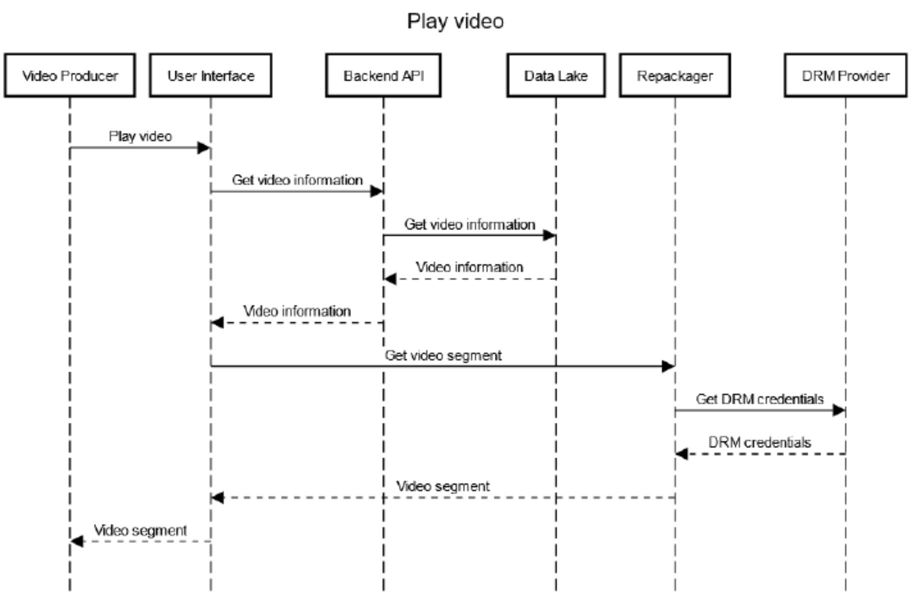

Figure 52: Distribution Engine play video sequence diagram

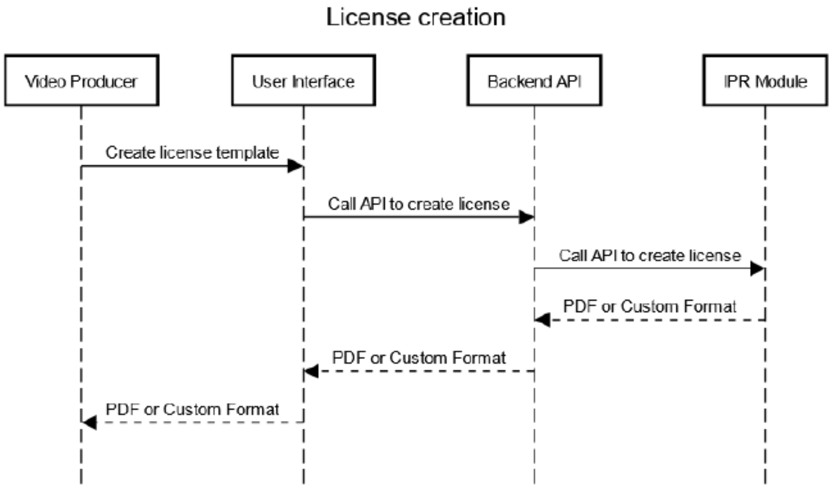

Figure 53: Distribution Engine license creation sequence diagram

4.14 Recommendation System

The sequence diagram below represents the main functionality of the recommendation system. Specifically, this use case depicts the order and the steps that are executed to perform a recommendation about the target audience that this film will be mostly suitable. The users of the specific use-case are either the filmmaker or the producer. The user selects a movie through the UI and asks from the recommendation system to recommend which target audience will be the most suitable for the target film. The actions are concentrated into two main sub sequences, the clustering of the audience and the vector generation. The recommendation system consists of 3 different recommendation systems, but the sequence diagrams are almost identical. Therefore, the sequence diagram for the most complex one is presented.

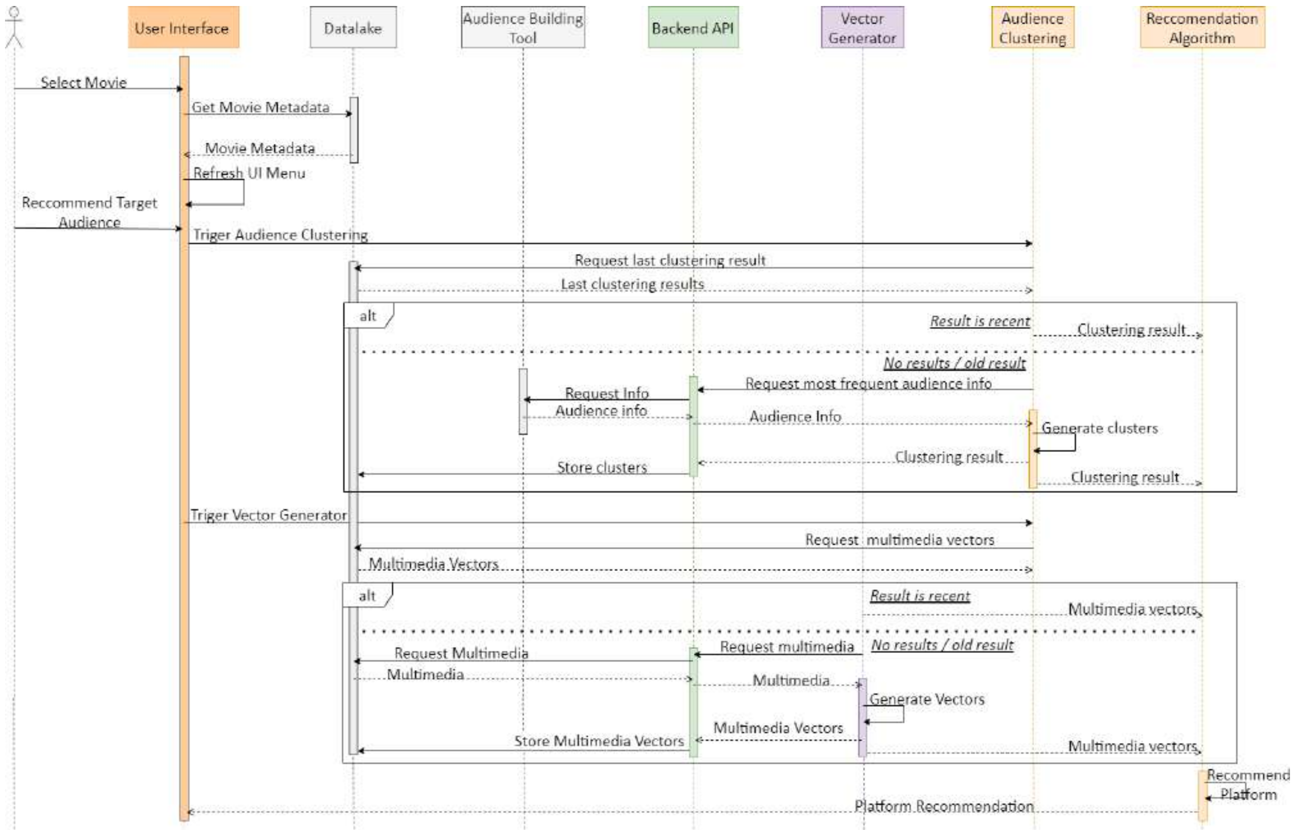

Figure 54: Recommendation System main functionality sequence diagram

5 System specification

The system presents a comprehensive architecture for an integrated and cognitive platform, capable of accommodating diverse application scenarios and addressing the evolving needs of stakeholders. It is designed to define specifications for individual components and the system as a whole entity, ensuring compatibility with existing and future requirements. By analysing user needs and scenarios from previous tasks, the system aims to deliver a solution that prioritizes interoperability, security, modularity, and adaptability.

5.1 Hardware requirements

As previously outlined in the deployment viewpoint, the SCENE project is set to utilize a distributed deployment model. This approach entails the deployment and execution of each system component within the premises of the respective collaborating partner. Consequently, meeting the hardware requirements is not anticipated to pose any significant risk. Additionally, the hardware requirements for the SCENE project as an entire system will be comprehensively detailed in Deliverable D2.5 of Task T2.4, scheduled for Month 18. Furthermore, the hardware specifications for each individual component are meticulously outlined in the technical requirements section of Deliverable D2.2.

5.2 Software requirements

Continuing on the distributed deployment plan, employing a microservices architecture ensure that the system is composed of independently deployable modules, enhancing flexibility and facilitating updates. Cross-platform compatibility is imperative to ensure that the system can operate seamlessly across various operating systems and environments, maximizing accessibility and user reach. Interoperability standards will be adhered, allowing the system to easily integrate with external applications and services, fostering data exchange and collaboration. The dedicated APIs of each component enable the interoperability between components. Furthermore, modularity is a cornerstone of the software design, facilitating future changes, updates and expansions, while maintaining system integrity and coherence.

5.3 Security and Privacy

Security and privacy are crucial considerations within the system, with strict adherence to regulations such as the General Data Protection Regulation (GDPR) to safeguard user data and privacy rights. All communication channels within the system will utilize HTTPS and SSL protocols to ensure end-to-end encryption and mitigate the risk of data interception or tampering. Additionally, sensitive data will undergo anonymization processes to protect user identities and maintain confidentiality. Robust access controls and encryption mechanisms will be implemented to restrict unauthorized access to sensitive information, thus bolstering data security. Regular security audits and vulnerability assessments will be conducted to identify and address potential risks proactively. Furthermore, user consent mechanisms will be integrated to ensure compliance with privacy regulations, empowering users to control their data and privacy preferences effectively. By prioritizing security and privacy measures at every level, the system aims to instil trust and confidence among users while upholding regulatory compliance standards.

6 Conclusion & Future work

This deliverable has effectively presented all the aspects of the architecture of SCENE. The definition of the architecture is based on the 4+1 architecture design, incorporating four architectural viewpoints (functional, development, information and deployment) along with the components' scenarios. The viewpoints are used to describe the system from the point of different stakeholders, such as end-users, developers, system engineers and project managers. Additionally, the scenarios are used to illustrate the way each component is supposed to function in real-world use cases. The related diagrams for every software component are presented in each corresponding viewpoint, decomposing the internal structure of the component and showcasing the information flow within it.

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All technical work to be done on the project will be based on the outcomes of this document. In terms of development, the implementation team needs to pay special attention in how the information will be stored in the Data Lake and how specific metadata will be embedded to the ontology. The reason about this is that the Data Lake and SCENE-O ontology will (in most cases) replace the need for direct communication between components and the format and standardization of the data both in Data Lake and SCENE-O ontology will have high impact both in the efforts for during integration and efficiency of ingestion and retrieval of the data. There are many interdependencies between the modules that are hindered from the presence and unique role of the Data Lake, a fact that imposes special care for the design of the Data Lake. Finally, special effort will be given to include state-of-the-art AI technologies, like generative AI for natural language generation and video generation, to ensure that SCENE remains relevant to the recent trends in film industry.

On the second deliverable of this task (D2.7 – which comes as a second version of the current deliverable) some details of the architecture may be changed; specifically, some parts of the architecture may need to be redesigned due to unforeseen constrains or requirements. Moreover, there may be some technical specifications, which need to be altered in order to meet some new needs.

The figure below presents the expected timeline for the rest of Task 2.5 (M19-M24).

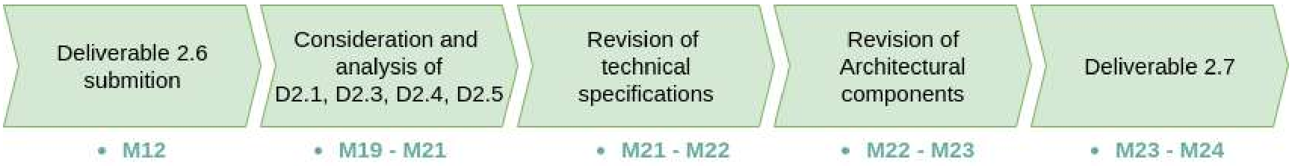

Figure 55: Timeline for T2.5

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