MOBILITY SERVICES ENHANCED BY GALILEO & BLOCKCHAIN

D4.1 - MOLIERE Architecture & Components Description and Integration

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[1] PU = Public | CO = Confidential, only for members of the consortium (including the Commission) | CL = Classified, information as referred to in Commission Decision 2001/844/EC

Revision and history sheet

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1. Executive summary

This document complements and extends *D3.2 - System Design and Components Specification*, detailing MOLIERE's architecture and technical components, which are outlined in *D3.2*.

2. About Molière

Urban mobility is becoming an issue of great importance in today's society due to the increasing population movements towards big cities and the exponential growth of cities in developing countries. Today, urban mobility schemes are evolving faster than ever mainly due to social, economic and technological changes. The traditional choice between walking, taking public transport or buying a car is being extended with a wide range of new flexible mobility services, such as vehicle sharing and ride-hailing.

In this context, a new mobility paradigm is needed - from disconnected to complementing. Promoting more sustainable, affordable, equitable, and accessible mobility is crucial, where micromobility and shared mobility services increasingly complement public transport. The ultimate goal is to reduce dependence on single occupancy private vehicles.

MOLIERE aims to build the world's best open data commons for mobility services, the "Wikipedia of public transport and new mobility data", a Mobility Data Marketplace (MDM) underpinned by blockchain technology, raising the profile, visibility, availability, and utility of geo-location data from Galileo, and will test it to fuel and demonstrate a diverse set of concrete, highly relevant mobility scenarios and use cases where geo-location data is key, addressing the needs of cities, public transport authorities, mobility service providers, and end-users.

3. MOLIERE's components specification

The MOLIERE high-level technical architecture consists of several layers. Layers are interconnected by APIs meant to be utilized by one layer above (if any) or, in the case of the bottom two layers, directly by third parties that wish to interact with MOLIERE's MDM at an abstraction level of their choosing. These layers are, from top to bottom:

- **App**: an example Mobility-as-a-Service (MaaS) application based on the MOLIERE architecture.
- **Mobile SDKs**: a series of user interface components readily available to build a MaaS type application, or to integrate MOLIERE mobility services into an existing application.
- **Core services**: a set of decentralized services based on Blockchain technologies. Core functionalities are built within Blockchain nodes which are connected to one another conforming a peer-to-peer network.

  The nodes provide functionalities such as:

  - Storage and access to mobility service data for the purpose of discovery
  - Interconnectivity with journey planning engines
  - Abstraction of proprietary mobility service APIs to standardized modal APIs
  - Identity and document verification
  - Payment verification
  - Governance functionalities
  - Reputation system

The following figure shows an overview at high level of system architecture:

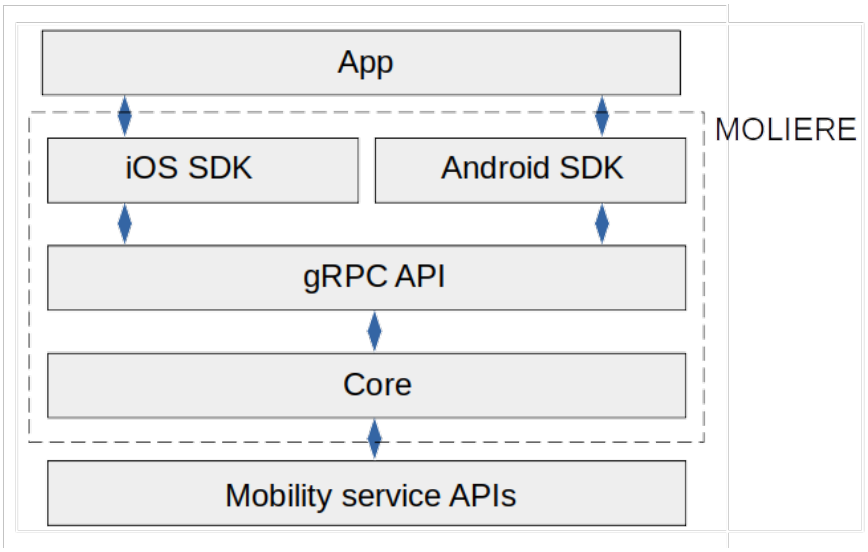

Figure 1 MOLIERE System Architecture overview

3.1. Application

- **Functional requirements**:
    - Creation of end users' mobility requests transactions
    - Membership registration, update, voting, funding
    - Proposals/referendums registration, update, voting, funding
    - Service reputation/feedback registration, update
- **Non-functional requirements**:
    - Appealing UX/UI

Apps may be developed by third companies or individuals (regardless, an example app implementation is to be provided within MOLIERE for demonstration purposes, hence why its functional and non-functional requirements are specified). Both apps and mobility providers require to be registered in the Blockchain to take part in the system. Every participant is registered in an identity registry module where all the required data is associated with an address.

Identity functionalities provide the possibility to create a portable, persistent, privacy-protecting, and personal identity where no one but oneself owns or controls its state.

Apps functionalities include mobility services requests, payments management to mobility providers and governance and membership functionalities for those joined by the user such as voting in proposals or participating in promotions to collect bounties.

All the decentralization-related features may be isolated in a separate user interface, especially considering that not all end-users may wish to engage in the governance of the platform.

3.2. Mobile SDKs

- **Functional requirements**:
    - Provide tools to implement standard use cases in a MaaS mobile application
- **Non-functional requirements**:
    - Appealing UX/UI
    - Provide components that easily integrable with others in the apps
    - Provide components that easily integrate with MOLIERE internal APIs
    - Support for both Android and iOS

Mobile SDKs offer certain components or building blocks, which include not only user interface elements but also calls to MOLIERE's internal API, which allow the implementation of certain standard use cases in a MaaS mobile application.

These components can be combined, and their output complemented with other MOLIERE processes or services accessed through API to construct a fully functional application, for both native IOS and Android.

Various specific use cases are covered by these components and partially configurable through different parameters. Usually, various transitions between screens and or dialog boxes are included in each of the components, who's flow cannot be changed.

Thus, the purpose of this SDK is to both facilitate the integration of the mobility services connected to MOLIERE (where their geo-location data will be provided by multi-constellation GNSS receivers with Galileo) in a new or existing app. However, it is not a fully functional mobility service app nor an abstraction layer on top of an API - it should be seen as an aid to build an app, in conjunction with the APIs provided by the core services.

3.3. Core services

- **Functional requirements**:

    - Identification of apps and mobility providers involved in the system
    - Acceptance of end users' mobility requests transactions
    - Acceptance of mobility providers availability transactions
    - Calculation of matching between mobility requests and providers availability
    - Membership registration, update, voting, funding
    - Proposals/referendums registration, update, voting, funding
    - Service reputation/feedback registration, update

- **Non-functional requirements**:

    - Decentralization
    - System's status storage
    - GDPR Compliance
    - High availability

As explained, the Mobile SDK and Core services are developed within MOLIERE. The Blockchain node code is to be released to those interested in becoming a node operator and hence need to deploy and maintain one (although in principle, they could develop an alternative implementation, which would be of course orders of magnitude more expensive). Those that contribute to the system by hosting a node are rewarded when a block of transactions is successfully mined by them.

The following figure shows the system architecture detailing the core:

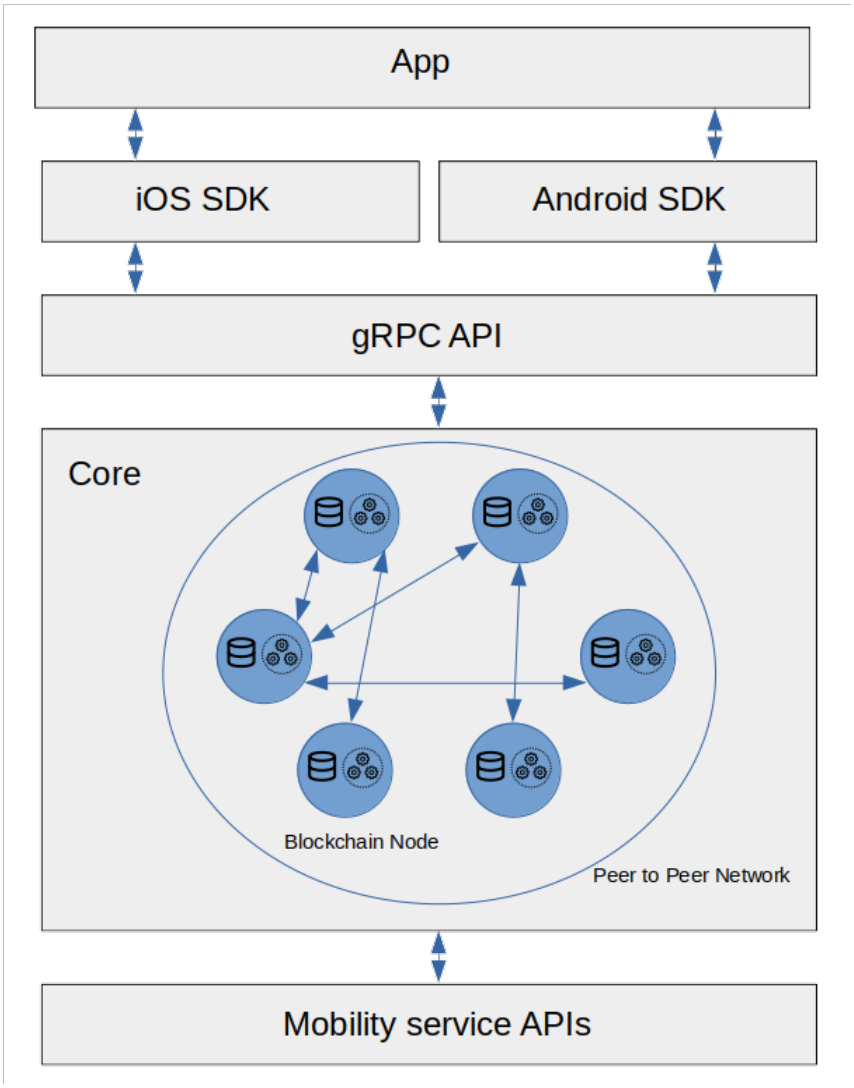

Figure 2 MOLIERE System Architecture (core)

After registration, mobility providers can send transactions to the Blockchain to state that they are available. Service information such as cost, or schedule may be provided at registration to the Blockchain and/or at this point depending on the nature of the service. End users send mobility request transactions to the Blockchain by means of one of the available apps.

The Blockchain node that receives the mobility request calculates the matching between mobility requests and available mobility services. The available matches are presented to the user who decides which one suits their needs best and accepts it through a blockchain transaction.

After service completion, the user may provide feedback regarding both mobility provider and app distributor. Since anyone may participate in the network as a mobility provider or as an app distributor, reputation is key for both parties to stay competent. End user misbehaviour may also be penalized in terms of reputation.

App distributors and mobility providers can create memberships to provide end users additional features to incentivize their participation in the system. Memberships may be related to using a certain group of mobility providers, a certain type of transportation, promote eco friendlier mobility, etc. while features offered might be community unlockable goals, challenges based on bounties, discounts for members etc.

Revenues are split among all actors involved, that is, app developer/distributor, blockchain node hosts and mobility providers.

4. Actors involved

The following figure summarizes the actors involved in the system and their interactions.

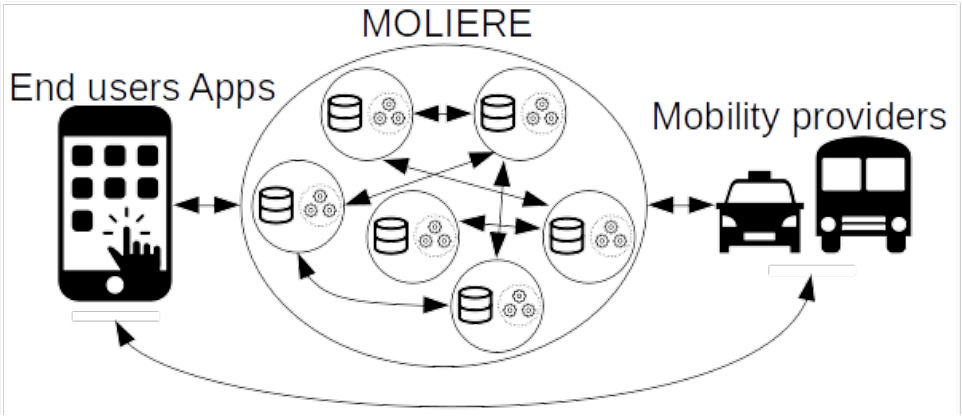

Figure 3 *Actors involved in the system*

- **End users**:
    - Request mobility services to MOLIERE
    - Perform payment to Mobility providers
    - Create memberships
    - Create proposals
    - Vote in proposals
    - Create challenges / bounties

- **MOLIERE** (SDKs + APIs + Blockchain nodes / network participants):
    - Calculates matches between mobility requests and mobility providers availability
    - Provides service information to End users
    - Mines transactions to update the status of the network

- **Mobility providers:**
    - State availability and service-related information to MOLIERE
    - Create memberships
    - Create proposals
    - Create challenges / bounties