



XAMEDIS

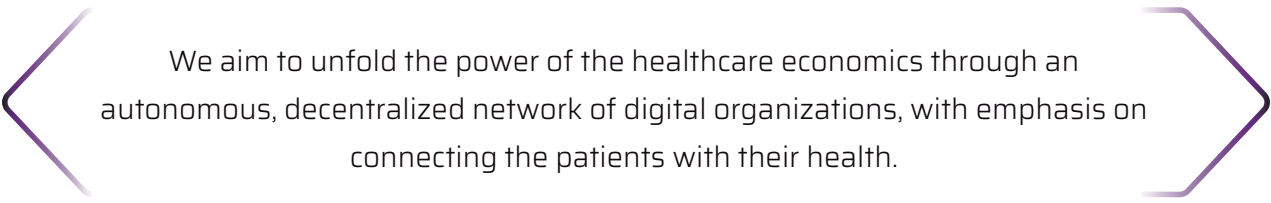
The logo features the word "XAMEDIS" in a purple, sans-serif, all-caps font. It is centered between two large, stylized purple brackets that point outwards. The entire logo is set against a background of three overlapping, rounded, arrow-shaped polygons pointing to the right, in shades of green.

THE XAMEDIS WHITE PAPER

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Co-founders of Xamedis

Version 0.1, first draft



We aim to unfold the power of the healthcare economics through an autonomous, decentralized network of digital organizations, with emphasis on connecting the patients with their health.

ABSTRACT

The Xamedis project is a solution for health insurances that wish to run decentralized, transparent and agile organizations. The avenue of the blockchain technology conceives unique tools and organizational schemes like the so-called decentralized autonomous organizations or DAOs[1]. The DAO model aims to empower organizations with transparency and decentralization of their governance structures, through liquid democracy[1] for instance. This project aims to solve some of the main Healthcare economy problems as the faulty financial management, the current obscure governance mechanism in a Health Insurance, and the adverse effects of medical data fragmentation.

Xamedis provides a complete set of functionalities powered by smart contracts with a web-based decentralized app and is built on top of the Aragon[3] platform. Xamedis will conduct the medical transactions and records while Aragon will empower transparency and efficient management of the HIs organizations. To this end, we introduce a novel mechanism for agile payment using a multi-peer to multi-peer (m2m) protocol for common healthcare transactions.

This paper describes the Xamedis solution to nowadays healthcare economy problems.

XAMEDIS ORGANIZATION

The World Health Organization has defined six building blocks of actions and priorities to face the worldwide healthcare challenges^[4]. They are:

- ◆ **Service delivery:** packages; delivery models; infrastructure; management; safety & quality; demand for care.
- ◆ **Health workforce:** national workforce policies and investment plans; advocacy; norms, standards and data.
- ◆ **Information:** facility and population based information & surveillance systems; global standards, tools.
- ◆ **Medical products, vaccines & technologies:** norms, standards, policies; reliable procurement; equitable access; quality.
- ◆ **Financing:** national health financing policies; tools and data on health expenditures; costing.
- ◆ **Governance:** health sector policies; harmonization and alignment; oversight and regulation.

Xamedis is a Decentralized Autonomous Organization (DAO) created to make some of these actions happen. Xamedis focuses along three axes of development:

1. Finance
2. Governance
3. Information

1. FINANCE

A Health insurance (HI) company has to guarantee high quality and accessible health programs for their customers, so a proper management of the HI finance is critical. In this scenario, the HI's shareholders (i.e. investors, payers, medical centers, doctors, patients, etc.) need to handle the costs, benefits and risks of a complex set of inter-dependent variables. To satisfy these requirements, the following features define the finance system of the HI:

- ◆ **Fluid cash:** A process to deliver the payments for each of the care providers (doctors, nurses, etc.) as the medical services are being delivered to the patient, and an easy way to collect premiums from subscribers.

- ◆ **Transparency:** A user friendly system that enables the shareholders and/or the public to survey the financial status of the HI.
- ◆ **Accountability:** A set of rules to distribute the responsibilities in the management of the financial procedures of the HI among all the stakeholders.

2. GOVERNANCE

The HI organization is conceived as a pool of stakeholders with different roles and responsibilities. It includes providers, investors, and beneficiaries of the healthcare. All them are owners of the HI. Then, the governance model needs to satisfy the following characteristics:

- ◆ **Quality:** An integrated system of feedbacks, incentives and reputation that permeates the interactions between subscribers and providers.
- ◆ **Consensus:** A system of voting to define the strategy and the changes of the organization, include/exclude services, define actions on the HI finances, etc.
- ◆ **Participation:** A definition of rules to guarantee the participation of the stakeholders in the life of the organization, together with a system of delegation of voting.

3. INFORMATION

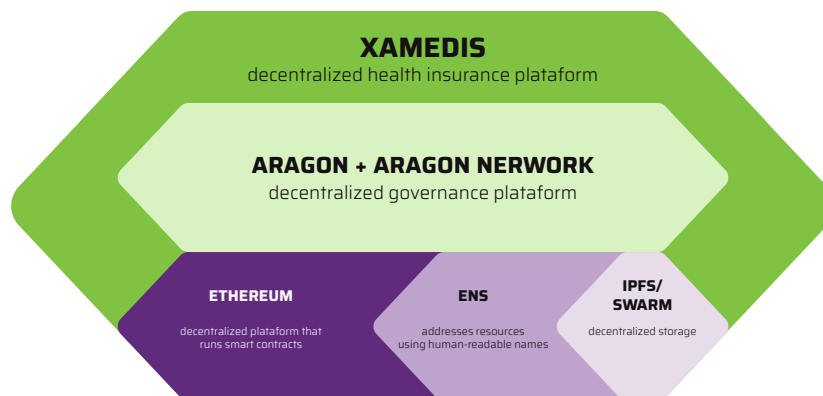
One of the most important needs of the healthcare ecosystem is the patient information. At any point in time, any participant of the HI should be able to provide his health data to the medical staff. This information should be complete, updated, easily retrievable albeit completely private. There are three features that are needed by the HI to satisfy these conditions:

- ◆ **Records:** These constitute a time ordered sequence of interactions between the patient and the healthcare system, with data about illnesses, diagnostic, treatment patterns, medicines, etc.
- ◆ **Privacy:** A protocol to guarantee that the ownership of the health info belongs to the beneficiaries, who decides when she locks/unlocks its content to be shared with the medical staff.
- ◆ **Inventory:** A set of trusted, possibly regional, repositories with standard information about medical procedures, pharmaceutical data, etc. Also, a provision of automatic methods that can be used to gather statistically significant information for the HI or the public.

XAMEDIS IMPLEMENTATION

Software Stack

Xamedis is a Dapp[5] that runs on top of Ethereum[6] and Aragon[7] as depicted below.



Software stack

Ethereum

Is a powerful shared global infrastructure based on blockchain technology[8] running unstoppable programmed applications called smart contract[9]. These features converges in a unique system: **1) unstoppable** (the whole system can't just be unplugged or can't halt its operations), **2) immutable** (the transactions, stored data and written programs are permanent) and **3) extremely secure** (it can't be altered or replicated). On the Ethereum blockchain, the user data remains private and apps are decentralized.

The Ethereum Name Service[10]

Is a distributed, open, and extensible naming system based on the Ethereum blockchain. This service was designed to resolve a wide variety of resources, initially assigning simple and human-readable names to the Ethereum addresses.

Swarm[11]

Is a distributed storage platform and content distribution service currently in active development and testing. The decentralized database service can be implemented using IPFS[12], Filecoin [13] or any other future variants.

The Aragon Platform[7]

Is a voting-driven platform that allows organizations to create transparent decentralized governance structures. Aragon is flexible enough to easily setup an HI and plug-in further modules that can extend HI's functionalities. AragonOS implements a UNIX-inspired permissioning system with a kernel and an access control list that safely controls entities[14] admittance to the resources. The platform can run a minimum functional organization (see [3]) with a set of AragonOS-compatible apps.

Model and Context

A decentralized health insurance organization (DHIO), provided by Xamedis, is a DAO has many capabilities that are shared with the more general ones. A well described set of the minimum characteristics and functionalities of a DAO can be found in the L. Cuende and J. Izquierdo's work [3]. According to the authors a voting driven DAO needs:

◆ An identity to establish who are the actors involved at any operation

This is common to all the DAO ecosystem, and can be defined using oraclized identity issuers, until fully decentralized identification is achieved (see, for example, some efforts in [15]). The services that the HI provides are not anonymous, because they require at least with the doctor-patient interaction. However, the services are private, in the sense that the rules that govern the interchange of care information between the patient and the doctor should be strictly enforced. At the DHIO level, the identity task required is the binding of a each participant with its own, private wallet and data.

◆ A permission system allowing individual or groups to perform certain actions or tasks

The people that integrates the DHIO are basically divided in two groups, beneficiaries or subscribers, (i.e. those seeking for a healthcare coverage), and providers, that includes all the participants that are involved in a health service operation. These actors will have different permissions and responsibilities in the DHIO. A key difference with present HI companies is that the beneficiaries are usually customers, i.e., they cannot vote on the evolution of the HI, nor cost, nor about the services the company provides. The DHIO is fully community driven.

◆ A reputation rate system that values the work of individuals or groups

It is customary in our social environment to transmit orally the feedback about a certain medical services, which includes doctors attention, treatment delays or costs, etc. However, in the DHIO, a set of reputation on the medical services will be set. Monetary incentives (both for beneficiaries and providers) can be tailored to this reputation scheme.

◆ A transparent and transferable ownership system

Since the DHIO is a community organization, ownership implies rights over voting and services provision. Transparency is guaranteed through public disclosure of DHIO finances. However, different mechanisms of transferring can be envisioned for owners, such as plans buying or delegation.

◆ An easy way to raise capital and manage the organization's funds

Once the DHIO is created, funds are obtained from subscribers periodically, and/or a per-service basis. Creation on the other hand, needs an initial capital to deploy contracts and starts operation (service contracts, medical equipment acquisition, facilities' adaptation, etc.). It is possible to include bylaws to guarantee that initial investors can retrieve their funds along time.

◆ A transparent payment system

The DHIO has to offer several Plans with health services, each one of them with clearly defined costs. The m2m protocol serves as a liquid money payment system.

Besides, there are some features that distinguish an DHIO from other DAOs:

A HEALTHCARE ADMINISTRATION SYSTEM

This is a management layer for designing insurance plans from individual services.

A FINANCE COSTS AND RISKS CENTER

This is a tool to follow the payments and costs of the healthcare provided to the participants. It should also have the ability to manage premium costs, leveraging risk.

A SET OF HEALTH SERVICES

Medical studies (X-rays, computerized tomography, blood tests, etc), medicines, outpatient care for diagnosis or treatment, etc.

A DATA UNIT:

A set of tools to deal with the medical data efficiently.

A RESEARCH UNIT

That organizes new services according to the advances of the medical science.

Some of these features are intertwined with each other, and some functionalities are already included within the set of core Aragon Apps. In the following sections we describe how these systems will be implemented.

Introducing MarketPlace

From the features described above there are two that distinguishes a DHIO from a common and market driven application [16][17]. First, we should note that the medical services provided to patients cannot be qualified as a peer-to-peer interchange, since usually involve many actors with different responsibilities and competencies. Second, health care cannot be viewed as a one time only anonymous transaction between patient and doctor: one is interested in securing health services for oneself along time, in any event, from a simple outpatient visit to a life-threatening emergency. Therefore, consumers will buy packages of services, bundled as Plans, and will distribute the cost of the healthcare along lifetime.

Xamedis DHIO introduces a new type of MarketPlace, where people subscribe to the organization's tailored healthcare Plans. These Plans can be organized and provided by different groups with different interests, from medical associations of specialists, to local communities, groups of investors, etc.

Evolution to a multi-peer to multi-peer model (m2m)

Most of the work done in blockchain/cryptocurrency was initially oriented to remove the centralized intermediation required to transfer value between two parties. This gave rise to the concept of peer to peer money^[18], which is deeply carved in the foundations of the virtual currencies framework. This is indeed the case for many blockchains, even the Ethereum network that Xamedis will make use of. The advantages of decentralized disintermediation are enormous to foster the access to money transfer to millions, without the need of banks or third parties.

However, there are certain cases where the transfer of money is more complex, for instance, when several sources pays to one. Multi-signature wallets address some of these cases, where different parties need to sign a transfer to another one.

M2M Concept

We introduce here the concept of **multi-peer to multi-peer (m2m)** transactions, which are required to implement a liquid cash solution in healthcare, or more generally, in any other trading exchange system with the similar characteristics. These m2m transactions have the following features:

- ◆ They consist of a bundle of several peer to peer transactions, that we call drops. They have multiple input sources, and multiple output sinks.
- ◆ The authorization of each drop is independent of each other, and does not correlate nor with the input payers neither with the output payees.
- ◆ The m2m transaction spans a non-trivial amount of time (that is, they cannot be considered simultaneous).
- ◆ m2m transactions are token agnostic.
- ◆ The m2m transaction has an expiration date.

< fluidCASH >

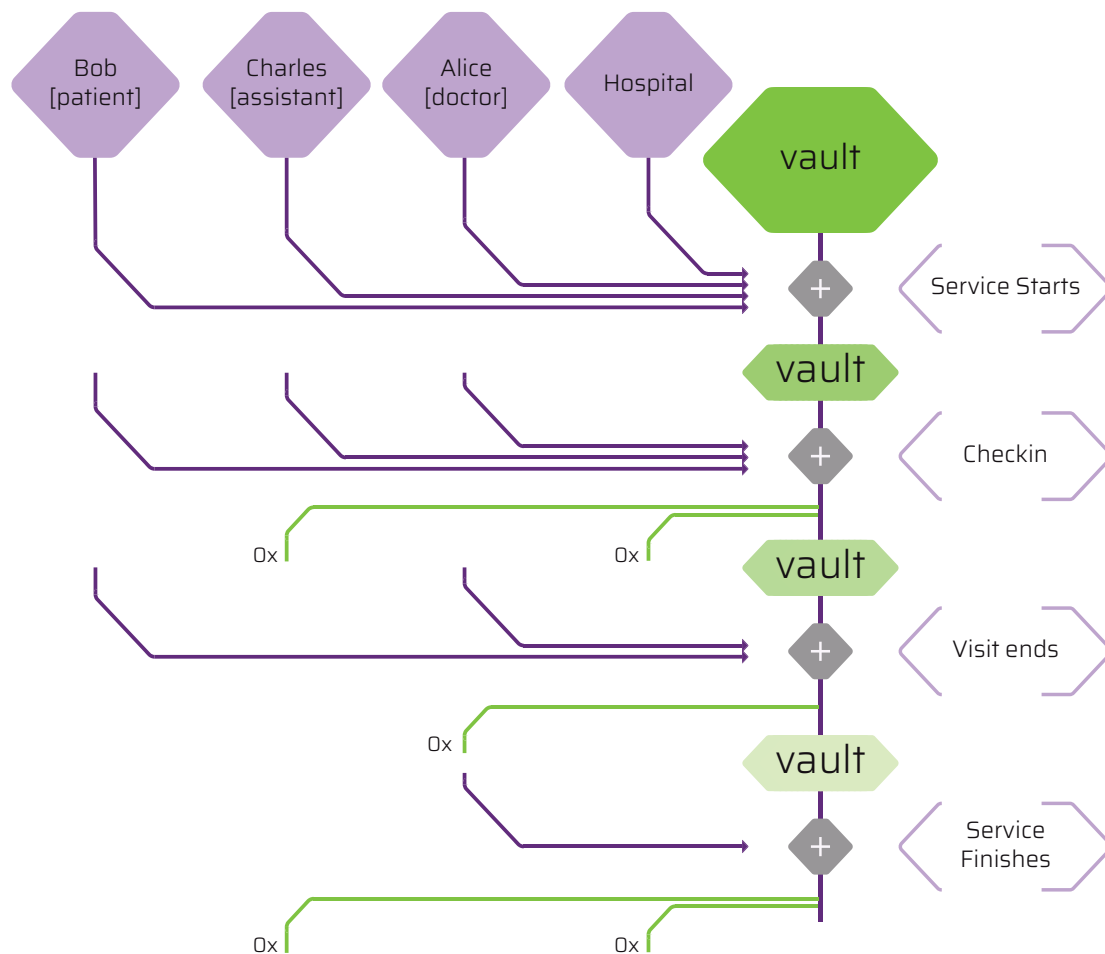
The application of an **m2m** transaction to a health insurance payment protocol is quite straightforward. HI collects each month the premium from their insured, that accumulate in the vault. Each medical service is payed partially by the HI, while the patient has to disburse a co-payment, if required. More over, for certain practices, a public contribution can also be accommodated by the m2m protocol. These constitutes the sources of the payment. The cost of each service in tokens is determined when Plans are created, and known prior to the

m2m transaction start time. When the medical service is required, the service cost is allocated according to the plan, with the contributions of all input sources. Each medical service also has its corresponding actors and the amount of tokens that should be distributed to each one, together with a set of authorizations for each payment. Therefore, as the service is being provided to the patient, each drop is cleared and payments are received by the providers just in time^[19].

The FLUIDCASH has the following features:

1. It has the total cost of the service assigned on the object, retrieved from the vault.
2. It includes all the actors involved in a service.
3. It contains all payment steps (p2p commands) involved for the successful completion of the service.
4. It includes a set of timeout to return back cash/tokens to the vault, if the service is only partially provided.
5. It contains a set of signatures or authorizations for each p2ppayment.
6. It is token agnostic.

Let us show the fluidCash in action with an example. Let us assume that Bob does not feel well, and decides to see his primary care doctor, Alice. He schedules an appointment with her. At that point, the medical services starts, and a fluidCash transaction is created. Bob, as a patient signs the start of the transaction, enabling the allocation of tokens for that medical service. Besides, all the payees addresses are included into the m2m transactions: doctor, office assistant, etc. (The number of payees will depend on the complexity of the medical service requested). If any of the payees addresses is not known at fluidCash creation time, it can be included at a later time with the proper authorizations. When Bob arrives to the doctor's office, he checks in with assistant Charles, and the first drop is executed, and payment to Charles is signed by Bob and received by him. When Bob's finishes his visit to doctor Alice, a second drop is executed, also signed by Bob, accepting that the medical service has been provided, and Alice gets her payment for that service.



fluidCash in action for a patient visit to a doctor. It intertwines **authorizations** by the Aragon framework and **payments** to each of the actors as the services are rendered.

The authorization scheme of each medical service is defined when bundled in a specific HI Plan, and can depend on the costs of the service, the proposed premiums, etc. The fluidCash scheme can accommodate any number of payees, with different authorizations for each drop. Moreover, m2m transactions can be chained if needed since they have their own address by themselves. This allows to build complex medical services as chains of m2m transactions. Finally, referrals can also be generated by the referring professional, simply creating a new m2mtransaction.

At an early stage, m2m transactions operate directly as Ethereum transactions, however, they can also be wired into state channels, in the event they are provided by the Aragon platform.

XAMEDIS CORE

Xamedis creates and governs DHIOs through ARAGONOS and ARAGON Network [7]. Therefore, it relies on Aragon core applications to perform general DAO tasks. For example, the governance mechanism is token driven and structured around the Voting app, that allows token holders to define which entities[14] can execute a particular set of actions (i.e. payments, proposals, etc.). Furthermore, certain actions can be customized to be executed after an approved vote decided by the token's holders (forwarder interface). The platform provides a Token Manager app that handle newly minted token and its vesting and can group entities according their function inside the organization. Likewise classical HI's, there is a vault (Vault app) that holds the assets of the organization and provides a way to execute and track its incomes/outcomes (Finance app).

The core of Xamedis relies on the interoperability of four apps: **the Service, the Plan, the MarketPlace**, and the **Record apps**. The specific details of each healthcare service are set in Service and must be validated by an oracle to comply with regulations by each local/regional jurisdiction. The DHIO's entities can define Plans (Plan app) by bundling a set of services thought for an specific type of customer. Plans can also be bundled together in more general ones. The MarketPlace is where service exchange happens, providers set a price for their service and beneficiaries can subscribe to a plan and keep track of available services. MarketPlace has the unique fluidCash payment interface that allows actors to get an instant reward (or drops) in tokens for each service provided.

The Plan app takes care of the definition of the amount of tokens that each actor of a services receives (in case of doctors, nurses, hospital facilities, equipment, etc.) and also defines the premiums payable by the beneficiary or the organization. Finally, the Record app will provide the logic to manage the privacy of medical records and will keep the links where medical data is stored through a proper interface with AragonOS.

The specs of the each Xamedis-Core apps are the following:

Service app:

- A. It can create a service identifying the actors in it, and their specific Role.
- B. It assigns the specific provider for each service Role.
- C. It stores and destroys services.
- D. It is able to automatically homologate a service by the local jurisdiction.

Plan app:

- A. It has the ability to create, store and destroy a bundle of services or other or set of Plans.
- B. It can assigning the costs payable by each party (subscriber, HI,etc.).
- C. It must define how many times each service can be used in a particular Plan.
- D. It can select Plans by total cost, provider, etc. according to specific Roles or search criteria.

MarketPlace app:

- A. It is able to define the payment/reward to the actors involved in a service, and the total service cost.
- B. It define the users that can access the service provision, previously defined.
- C. It stores provider's service/cost and subscriber's acquired Plans.
- D. It links the fluidCash object to the services when a subscriber buys or burns an acquired service..

Record app:

- A. It has the ability to create and store medical records off-chain, while saving a securely owned pointer to this data on-chain.
- B. It safely manages ownership of the record, defining only one owner for each patient record. Ownership can be forwarded to others in specific cases.
- C. It manages the permissions the owner can grant for viewing the data, with time locking functionality. Further versions will include trusted third parties access.
- D. It keeps the history of data viewing.
- E. It defines the cost in tokens the viewer has to pay to see the records.
- F. It has an AragonOS-compatible interface to secure private patient information.

ROAD MAP

Xamedis will roll out in a series of major releases, each one with one or more minor releases. This is possible due to the Aragon architecture design that enables logic and code upgradeability. We estimate that the development of Xamedis will take about two years.

IASO: the recuperation from illness release

This will be the first release, that will include the fluidCash payment system and the Service app. We will include services to mimic a variety of different complex healthcare procedures. The

release will focus on the smart contract interaction. All running on Ethereum Testnet. A simple web user interface to demo the DHIO will come out with this release.

HYGEIA: the cleanliness and sanitation release

Bundling services to Plans, through the Plan app, with a web interface.

ACESO: the healing process release

In this release, the MarketPlace is introduced, and the full interplay among three Xamedis core applications is developed.

AGLAEA: the glow of good health release

This release will be a first approach to face the medical record privacy problems. Xamedis will incorporate a aragonOS-compatible encrypted data store.

PANACEA: the universal remedy release

Full Xamedis network goes live into the MainNet.

Glossary

For all medical terms, we make use of the US HealthCare glossary[20]. Even though it is fully customized for US public, most of the terms are clearly explained and can be matched to your own country specific medical organizations. A thorough glossary was published by World Health Organization [21].\

References

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2. Liquid democracy, [Wikipedia](#).
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7. [Aragon project](#).
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9. [Smart contract definition](#).
10. [ENS project](#).
11. [Swarn project](#).
12. [IPFS project](#).

13. [Filecoin project](#).
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Thanks!