NGI ONTO CHAIN

Blockchain for the Next Generation Internet

ONTOCHAIN OPEN CALL 2

PROTOCOL SUITE AND SOFTWARE ECOSYSTEM FOUNDATIONS 2021-2022

Closing dates for proposals: 15th September 2021, 17:00 CEST

Grant Agreement n° 957338

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1 ONTOCHAIN SO FAR

1.1 OVERALL OBJECTIVE

Today, more than ever, our digital life is an extension of our physical world. Thanks to the Internet, it is now possible for citizens from all over the world to participate in the generation and use knowledge like never before. However, from the current Internet standpoint, the way knowledge is actually generated, curated, shared and stored raises critical concerns about security, privacy, fair and equal distribution of benefits, potential for abuse and adverse impact on individual rights. Citizens, everywhere, are at risk of being presented with partial or biased information reflecting the viewpoint of their provider.

From now on, it is time to handle our digital world with the same critical, moral and ethical thinking that we use in our physical one. The internet of the future should follow a human rights approach, be more resilient, trustworthy and sustainable. It is time to empower citizens by means for collective organisation as well as for contribution and use of knowledge thanks to smart solutions that support transparency, trust, plurality and democracy.

ONTOCHAIN - Trust traceable and transparent ontological knowledge on blockchain, is a European project funded by the European Commission under the European Union's Horizon 2020 Research and Innovation Programme, and part of the European Commission's Next Generation Internet (NGI) initiative.

ONTOCHAIN was launched in September 2020 to empower Internet innovators and end users to develop trustworthy blockchain-based knowledge management solutions that will be part of a novel software ecosystem, through 3 Open Calls and a budget to be distributed of 4,2M€. The concept underlying this ecosystem is a better share of knowledge and value on the internet and that for various domains such as health, economy, mobility, public services, energy and sustainability, news, media, entertainment, Industry 4.0, tourism.

The Figure 1 below shows an overview of the ONTOCHAIN ecosystem architecture.

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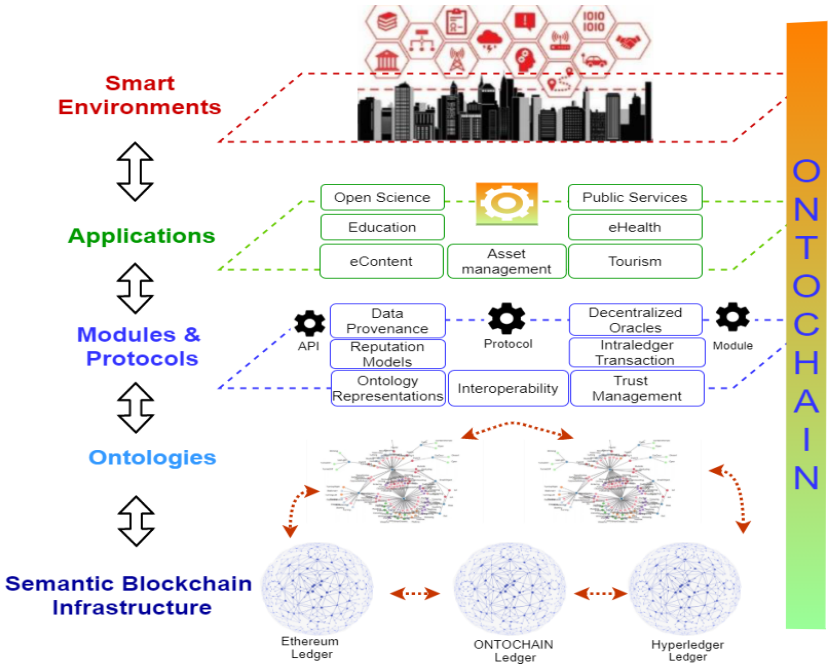

FIGURE 1: ONTOCHAIN ECOSYSTEM ARCHITECTURE

The merging of the semantic web, trust and blockchain constitutes its backbone. Building it with relevant actors such as internet technologists, researchers and innovators from both industrial and academic sectors is the catalyst for its achievement. In addition to Figure 1, Figure 2 below shows the mapping of the ONTOCHAIN technical topics on the architecture as well as existing and intended software development for each of the three open calls.

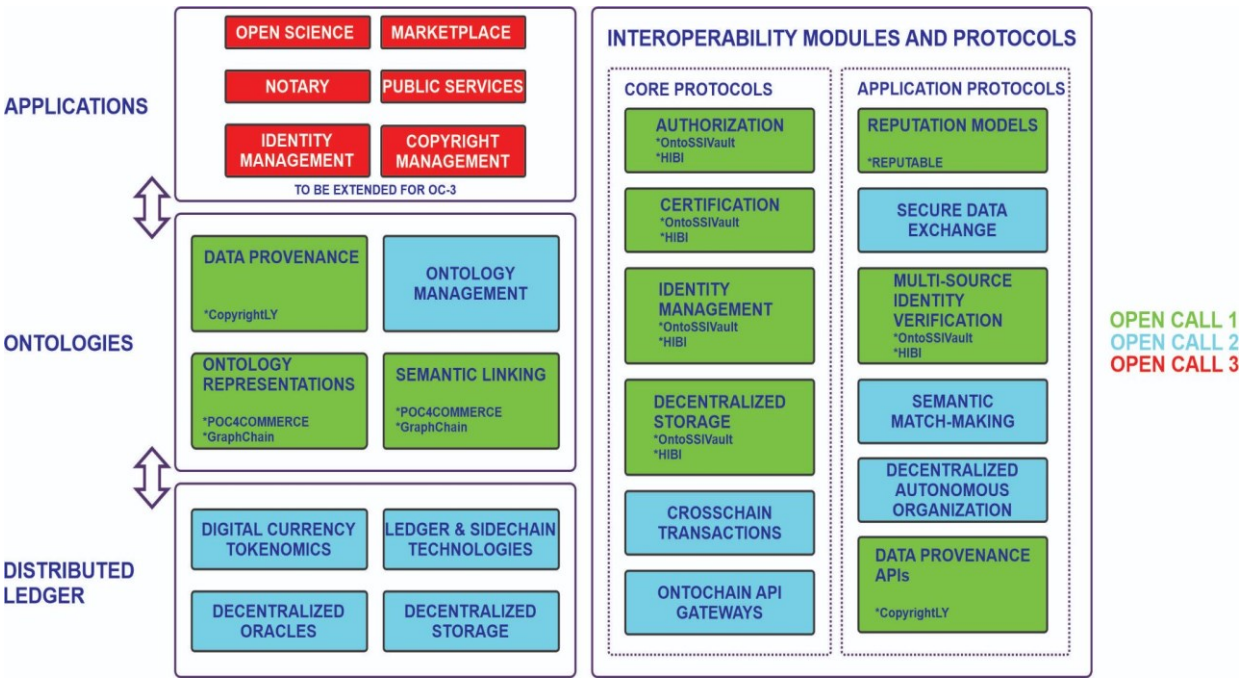

FIGURE 2: ONTOCHAIN VISION ARCHITECTURE FOR SOFTWARE DEVELOPMENT

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This document provide the technical details for the ONTOCHAIN Open call 2. It present first an overview of the ONTOCHAIN Open Call 1 outcomes that are available at the time of writing this document since they might be useful to understand the ONTOCHAIN vision and concept. Then a first use case that may serve as an umbrella use case for the project named "The Trustworthy Semantic Marketplace" is discussed as well as how the ONTOCHAIN Ecosystem could be used in real life. Finally, the Open Call 2 scope, topics and intended deliverables are detailed. As a reminder, the indicative timelines of this Open Call close the document.

1.2 ONTOCHAIN OPEN CALL 1 FIRST OUTCOMES

The Open Call 1 objective is to establish the ONTOCHAIN framework as a human-centric solution to achieve decentralisation & trustworthiness for various domains such as health, economy, mobility, public services, energy and sustainability, news, media, entertainment, Industry 4.0, tourism and so on.

It is breaking down into 3 phases:

- Phase 1 Research proposal,
- Phase 2 Research award,
- Phase 3 Challenges for conferences.

It was launched on the 16th of November 2020. 137 projects applied to contribute to the specification design of the ONTOCHAIN ecosystem. Selection and negotiations were successfully completed with 17 projects to proceed to Phase 1.

More specifically, the 17 third parties were enrolled to conceptualize along 2 phases, a research project for 1 of the 6 following topics:

- Applications,
- Semantic interoperability,
- On-chain data management,
- Off-chain knowledge management,
- Ecosystem economy,
- Ecosystem scalability & integration.

The concept they proposed are described hereafter per topics and third parties.

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TOPIC 1: APPLICATIONS

- CopyrightLY - It is a decentralised application that leverages blockchain and semantic web technologies to facilitate the copyright management for social media. It links social media content to on-chain authorship claims, in turn tied to creators' identities and content hashes. It is to state reuse conditions, allowing their negotiation and registering reuse agreements on-chain. Authorship claims are integrated with social media platforms through content hashes that creators add to media description. They are verified on-chain using oracles, which can also associate social media user profiles with on-chain identities.
- LCDP-ONT-APP - ONTOCHAIN Domain Builder is a model-driven approach that is centred on the research and development of a meta-language for application/components, ontologies to be used in domain-specific scenarios, and a low-code environment (IDE). Meta ontologies enable to model ONTOCHAIN applications components and formally define them. The IDE could be accessible in SaaS (via the AstraKode Blockchain platform).
- OntoSsiVault (Gimly ID) – It is a set of software applications (mobile and web) and libraries enabling self-sovereign identity and selective disclosure and verification of data for humans, organizations, machines, and objects. Gimly ID centers on the mobile application, which offers a password-less single-sign on experience and selective disclosure of data by leveraging decentralized identifiers (DIDs) and Verifiable Credentials (VCs) and a sovereign data vault. Gimly ID is built for interoperability, allowing a Gimly ID user to interact with other SSI conformant systems and solutions. The software developed can be consumed by other developers that will implement the SSO functionality and the issuance, management, and verification of identity and credentials into their applications and systems. The software can be used in open and closed ecosystems to manage and verify sovereign identities and data.

TOPIC 2: SEMANTIC INTEROPERABILITY

- ISLAND - Interlinked SemanticaLly-enriched BlockchAiN Data focuses on the generation of semantic data based on various sensors and Artificial Intelligence methods that can be aggregated and used as ONTOCHAIN metadata as well as for further operations of smart applications in various use cases (e.g. part tracking and similar). The ISLAND framework envisions a layer of intermediation between the exposed APIs from the participating smart-contract-users (southbound) and the data consumers (northbound). The framework is set to expose a unified abstraction model to any data consumer that aims to infer meaningful knowledge from smart contracts, while at the same time enabling the semantic interoperability of the data. The project solution framework lies also in indexing and querying capabilities to structure data from multiple blockchain networks, represented as RDF Graphs and annotated with rich metadata from ontologies, and ensure the data integrity of RDF data instances via blockchain solutions.
- OntoROPA - Ontology based ecosystem for trustworthy Records of Processing Activities (ROPAs) focuses on the validation and certification of the processes for data management, with particular focus on legal compliance (e.g. with data

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protection acts such as GDPR). Successful Semantic Web approaches such as Linked Data and OWL are combined with blockchain technologies for the aim of ensuring easy access, quality and trust of ROPAs.

- TENACIOUS - Trustworthy sEmaNtic Aware marketplaCe for Interoperable clOUd. This project focuses on building a trustable marketplace where semantically described Cloud Services can be researched, discovered, and composed, according to the specific requirements needed. This project also offers a storage of the composed solution in RDF format within the Blockchain, to ensure the compliance to a proposed contract.

TOPIC 3: ON-CHAIN DATA MANAGEMENT

- GraphChain – It is a framework for on-chain data management for ONTOCHAIN which implements decentralised On-chain graph management technologies, including the ability to perform usual graph operations. GraphChain proposes a radically different approach – instead of encapsulating the semantic data into Blockchain blocks, they propose to design and implement the Blockchain mechanisms on top of semantic data. The GraphChain solution provides different functionalities such as:
    - Hashing of subgraphs for the on-chain graph structures.
    - Procedural smart contracts with access to the on-chain semantic data.
    - Identification, authorization and data provenance for the on-chain data.
    - Sharding mechanisms and strategies.

  The whole idea of GraphChain is adding a new level of trust without sacrificing availability, query ability and performance of graph databases so the solution can be integrated in any software ecosystem that uses traditional LPG databases.
- SEIP - Service for Encrypted Information Provider focuses on delivering a framework to ensure granular data access control and confidentiality of data exchanged both On-chain, and Off-chain, in a decentralized and scalable fashion, by exploiting novel asymmetric, encryption mechanisms (Ciphertext-Policy Attribute-Based Encryption - CP-ABE) and credential-based approaches (W3C VCs). This project aims to reduce solution fragmentation that is critically impacting blockchain's large scale adoption and interoperability and also try to address current regulation constraints.
- UniProDaPI - Universal Proven Data & Process Interchange is a full-fledged platform for the exchange of verifiable and trustworthy data within industrial settings and sets up an interesting implementation scenario that can be used in industrial context. The solution addresses the key issues of Data and Identity Sovereignty and privacy, protection against CloudAct, GDPR or eIDAS compliance. It separates the probative and user metadata made public at sidechain level from the data itself, linked from the chain, made accessible only to authorized parties, and kept on producer's premises or securely accessed from distributed object storage. The proposed scheme allows for perfect file level auditability of the entire audit trail, from the blockchain to a (zipped) collection of all registry writes relative to some identifier, making it possible for lawyers to settle disputes. The unforgeable and

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easily verifiable registries of proofs of data, events and documents that produce the backbone of multi actor interaction is accessible through simple business APIs.

TOPIC 4: OFF-CHAIN KNOWLEDGE MANAGEMENT

- DART - A Distributed-OrAcles Framework for PRivacy-Preserving Data Traceability which provides methods to include Off-chain information with high probabilities of trustworthiness in the operation of services running on a semantic blockchain - ONTOCHAIN infrastructure. Their solution provides a scalable distributed oracles system, in which off-chain data to be stored in Ontoblocks pass through a consensus process autonomously handled by the involved oracles. A correlation model in order to enforce trust between oracles. They also can do a data traceability framework, in which content to be inserted in the ONTOCHAIN comes together with oracle measured contextual information.
- KnowledgeX - Trusted data-driven knowledge extraction focuses on establishing communities of data science professionals that can set up and perform various analyses on data (e.g. industrial data) in a trustworthy way globally. In its operation it makes use of secure processing enclaves and other means for the protection of the privacy of the data. KnowledgeX is applicable to any situation where knowledge for a specific problem is needed and data is valuable.
- REPUTABLE – It is a Provenance-aware Decentralized Reputation System for a cross-platform privacy-aware reputation system which leverages blockchain technology to achieve decentralised, verifiable calculation of reputation scores. It enables interaction with end users and systems through a secure, reputation analytics dashboard to facilitate user verification as seamless integration with other systems and services.

TOPIC 5: ECOSYSTEM ECONOMY

- DW-marking - Data Watermarking: The missing link to on-/off-chain implementation of distributed data marketplaces which provides methods to include watermarks in structured data sets. DW-marking can develop a new breed of digital watermarking techniques for protecting ownership, and establishing accountability, in the off-chain handling of datasets. Their solution provides three main functionalities such as:
    - Frequency Watermarking for datasets,
    - Recursive Watermarking as an off-chain provenance primitive,
    - Oracle for importing off-chain dataset transactions.

  Frequency Watermarking is planned to be implemented as a standalone primitive for off-chain handling of ownership issues in Data Marketplace (DM) and other distributed systems. Recursive Watermarking is planned to be implemented as an Oracle for allowing off-chain DMs to upload past transactions into a blockchain.
- POC4COMMERCE - Making ONTOCHAIN practical for eCommerce is fundamental. POC4COMMERCE focuses on the design of ontologies needed for eCommerce that

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can further be embedded and used by the services of the ONTOCHAIN software ecosystem in various use case scenarios related to trading of products (agricultural products in the current use case) including their traceability and the use of various token mechanisms. POC4COMMERCE contributes to a shift towards a novel micro-economic model where individuals and companies cooperate and coordinate, deciding the allocation and utilization of resources, without third-parties intermediaries. In practice, it aims to design an eCommerce search engine for offerings as a software agent on OC-Commerce and OC-Ethereum.

TOPIC 6: ECOSYSTEM SCALABILITY AND INTEGRATION

- HIBI - Human Identity Blockchain Initiative focuses on the ability of the users to establish their identities in a legal way and link them to blockchain network addresses, which unlocks immense possibilities to improve trustworthiness of the information stored and managed On-chain. To realise a blockchain transaction, it is required to perform authentication via an eIDAS compliant eID. The address is then tied directly to a trustworthy ID and can be represented in further interactions. HIBI will provide Decentralized Key Management infrastructure and contribute to a key management tool called Smart Distributed Key Recovery which enables the mapping of blockchain keys to eIDAS identities for the purpose of backup and recovery. The technology can be integrated by integrating an eID solution that leverages an official eID app like "AusweisApp2". This bridge will allow accessing the European eID servers to extract data from it and can be integrated into mobile- and desktop wallets. It will also be open-sourced.
- KUMO – It focuses on designing and developing a network crawler that can keep gathering information about the peers in the Eth2 network and their behaviour such as a sudden and sharp increase or decrease in the number of messages communicated. The information gathered by the network crawler can be general or specific. The crawler can gather information like: what is the latency and geographical distribution nodes in the network, version of node which client is using and how much data is it propagating to the network, in this way it can suspect bad actors and suggest different attacks that may occur.
- Solid Veriff - Verifiable Credentials and Solid is a project that focuses on the Solid framework with its W3C compliant storage solutions. It is a generic SDK design by which it is possible to achieve verifiable credentials. In this framework, actors can certify and verify the origin of data so that trust is increased and data can be reused with confidence.

All the aforementioned projects set up high standards and technologies for trustworthy content handling and information exchange, focusing on key aspects of the ONTOCHAIN architecture including identities, reputation (of identities, products and services), data protection (e.g. encrypting, governance, secure processing), On-chain metadata handling mechanisms that can be coupled with Off-chain data, the use of Smart Contracts, Decentralised Oracles, Verifiable Credentials and other existing mechanisms.

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Their contribution so far in ONTOCHAIN Open Call 1 led up to the definition of the necessary Blockchain infrastructure that could be used in order to support the operation of the ONTOCHAIN software ecosystem. They are leveraging of reliable, widely used and proven open-source technologies in order to further develop the software ecosystem with key necessary ingredients to unlock new applications that rely on processes for trustworthy metadata handling.

Actually, these 17 third parties have reached the end of Phase 1 and have been submitted to a high selective process where they have to highlight the reasons why their work is the best match to help establish the ONTOCHAIN framework as a human-centric, decentralised & trustworthy solution. From this contest, only 7 third parties could process. The context was both competitive and collaborative since building an ecosystem is all about co design, synergies and team work.

The teams granted for Phase 2 are: CopyrightLY, GraphChain, HIBI, KnowledgeX, OntoSsiVault (Gimly ID), POC4COMMERCE and REPUTABLE. Nonetheless, all projects that have collaborated so far were welcome to stay and collaborate with ONTOCHAIN around the development of the ecosystem.

For this phase 2, the selected teams elaborate on the concept proposed in Phase 1 and prepare design specifications to be implemented in this Open Call 2, dedicated to "Protocol Suite and Software Ecosystem Foundations".

The main intention to work with a comprehensive, smaller number of third parties is to be able to look into the details of those aspects that are deemed core to the establishment of the ONTOCHAIN ecosystem and in particular to the understanding of the possibility to integrate and provide an added value through collaboration in core design aspects.

1.3 AN UMBRELLA USE CASE FOR ONTOCHAIN: "THE TRUSTWORTHY SEMANTIC MARKETPLACE"

The first use case that may serve as an umbrella use case for the project has been named "The Trustworthy Semantic Marketplace".

Blockchains, being shared databases of cryptocurrency transactions, are all about trust, transparency and traceability when trading. Hence, it makes great deal of sense to think of using trustworthy metadata in the context of trading any kind of real or digital assets. In a way, the Trustworthy Marketplace is the ultimate place of testing the utility of ONTOCHAIN's infrastructure and software ecosystem.

Several existing OPEN Call 1 projects may rely on semantic descriptions and annotations of different entities, such as people (e.g. in the context of the KnowledgeX project), products (e.g. agricultural products of the case of the POC4COMMERCE project), data (e.g. the Copyrightly project) and internet services (e.g. in the context of the TENACIOUS project).

Trust, identities, verifiability of the provided information, and reputation matter a lot in the context of trading. When one goes to a marketplace, it is necessary to check out the Quality, which can be established by both on-chain and off-chain metadata

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management means and consensus mechanisms. In addition to this it may be necessary to verify and/or certify the properties of either the entities that participate in the trading system, or the processes that govern the trading of those items (e.g. real-world items or data) marketplace, including any contextual information such as geolocation, precise time, environmental conditions and similar.

Within blockchains and their consensus mechanisms, an ontology of a traded entity can easily be agreed and even recorded (or its hashtag) on a blockchain. Following this, various instance data can be included (off-chain or on-chain, encrypted or public, verifiable/non-verifiable, identity, digital signature) that relate to either the actual ownership, versioning, manipulation, trading, part-tracking and any other aspect of the traded entity. Semantic information can be gradually updated from by the various actors in the marketplace that can engage in different interactions. In addition to this, temporal and geospatial information could be included and can be always verified by using on-chain methods.

The other side of the market is that of its users, with the products and services they provide or consume. The users may all come with their public or private data, identities and verifiable credentials. They may be engaged in various interactions, such as storing their own data for their personal use, giving access to their data to external entities, providing Verifiable Credentials to other users, using sensor data and AI methods for further annotations of the traded entities and similar. Such data can be linked to time, geospatial, identity and versioning information whenever it is generated, and can further be used to establish trustworthiness and fine-grained choices in the trading process.

Each interaction of two users (such as a provider and a consumer) can be accompanied with various proofs of such interactions, such as proof of buying the apple for which the quality is being assessed on social media, or proof of being present in a room when something really interesting happened, proof of using an apartment for which the user can perform rating at the end of the rental period and similar.

Moreover, tokens are popular trading mechanisms that can be associated with different market concepts, and can be used in the trading system to achieve win-win situations among their users, and move assets from one blockchain to another, while relying on the semantics of such transactions. Mechanisms to achieve actual value sharing, be it information or actual real-world assets are currently embedded in various blockchains and should be possible to use along with semantic blockchain-based information.

1.4 HOW THE ONTOCHAIN ECOSYSTEM WOULD BE USED?

The idea behind the ONTOCHAIN Ecosystem is to focus on the needs of software companies that develop various smart applications and wish to include trusted knowledge management mechanisms in the operation of their applications. The main benefits of such smart application would be the added value of semantic blockchain metadata management mechanisms that can be used as essential trust-building measures.

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In the context of ONTOCHAIN Open Call 2, the consortium expects well-defined, open source software solutions that can be used within the ecosystem to establish both the necessary infrastructure, trading mechanisms and ability for exploitation by the use case proposers (Open Call 3).

Hence, it is expected that participants in the ONTOCHAIN Open Call 2 will develop interoperable and sustainable solutions and services that will be able to integrate within the rest of the ONTOCHAIN ecosystem and can be actively used by the use-case applications from Open Call 3.

2 ONTOCHAIN OPEN CALL 2

2.1 SCOPE

The overall goal of the ONTOCHAIN project is to generate an ecosystem of blockchain-based solutions, processes, and business models with strong market potential in the area of trusted blockchain-based data, metadata, ontology, knowledge and information management in order to achieve trustworthy content handling and information exchange as well as trustworthy service exchange in the Next Generation Internet/social networks and for vital sectors of the European economy.

The specific objective of the ONTOCHAIN Open Call 2 is to implement an infrastructure that will host ONTOCHAIN's trustworthy data, metadata and services, and specific software solutions that can be used widely, further extending the use cases and the architectural features planned by the end of the Open Call 1. To this end, again 6 paramount topics has been identified that should be addressed for the present call:

- Topic 1: Decentralized Oracles for ONTOCHAIN
- Topic 2: Market Mechanisms for ONTOCHAIN
- Topic 3: ONTOCHAIN Interoperability & API Gateways
- Topic 4: ONTOCHAIN Network Design and Scalability
- Topic 5: Semantic Based Marketplaces for ONTOCHAIN
- Topic 6: Data Provenance in ONTOCHAIN

They are further elaborated in the next section.

2.2 THE 6 TOPICS TO BE ADDRESSED IN OPEN CALL 2

Each table hereafter, elaborates on the challenge, the requirements, the use cases, the context, and the expected outcomes to be addressed in Open Call 2 as well as how it should work in practice.

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2.2.1 Topic 1 - Decentralised oracles for ONTOCHAIN

Title	Decentralised oracles for ONTOCHAIN
Definition	The essence of blockchain smart contracts is based on the execution of instructions in a decentralized architecture, in which the executing outputs are trusted and accepted by all including nodes in the network. However smart contracts run entirely isolated and cannot access data from the external world on their own. Oracles are software components which allow smart contracts to interact with off-chain (external) data sources: their primary job is to collect data and input to smart contracts. Because oracles bring arbitrary data to the blockchain they create a major vulnerability, and the trustworthiness of the imported data is extremely difficult to assess. The goal of this topic is to design, implement and showcase trustful and trustless oracle prototypes that are capable of interacting with the ONTOCHAIN infrastructure and providing necessary data for the operation of its applications.
Challenges	Activities may focus on designing and developing new decentralised oracle prototypes that rely on advanced technologies, including, but not limited to the areas of IoT, AI, social networking, mobile technologies in the generation of metadata that can be assessed from the viewpoint of trustworthiness and fed to the ONTOCHAIN's semantic blockchain infrastructure. Novel oracle frameworks for ONTOCHAIN, e.g. based on different topologies or incentive strategies are also in scope. Approaches should address the problems of detecting, preventing and mitigating sybil attacks (e.g., majority attack, mirroring, freeloading, data corruption) and collusion among oracles, estimating probabilities for trustworthiness, and particularly focus on practical design and implementation challenges which are in the context of the ONTOCHAIN services and applications. Additional focus is on the high Quality of Service and low operational costs of the oracles, while achieving the same or higher levels of trust. The designed oracles should be implementable within the time period of the project, and should be showcased within the initial applications (e.g. marketplace, part tracing, copyrights and similar).
Requirements	The prototype should address as much as possible the challenges mentioned above and in particular: o Definition of APIs for common (generic) use cases; o Integrate with at least Ethereum smart contracts and the EVM, although support for additional chains is encouraged; o Support for semantic data (e.g. properties such as a vehicle colour) and semantic queries (e.g. via SPARQL);

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	○ Rely on existing standards or propose new standards for data transmission and data definition, to ensure reliable communication between oracles and smart contracts; ○ Support a variety of data sources, data formats and off-chain storage mediums/services; ○ Integration of identity verification or decentralized identity management; ○ Demonstrate the approach with several templates and examples, to be released to the open source community; ○ Modularity of the approach so that the developed oracles are packaged and can be deployed and used seamlessly by different entities should be duly elaborated in the proposal.
Use cases	○ Feeding trustworthy information (geolocation, time location, IoT data, state, quality, size, price, reputation score, probability, etc.) to POC4COMMERCE about real-world items in supply chain use-cases (wheat, apple trade, car, apartment sharing, bio-food industry, etc); ○ Ingestion of verifiable documents (diplomas, licenses, etc.) for using as verifiable credentials in ONTOCHAIN projects (e.g. GIMLY ID, HIBI); ○ Social media oracles, e.g. for feeding a user's social media profile information to CopyrighLY; ○ Fact-checking in social media and data sharing platforms; ○ On-chain reputation and provenance, e.g. in the context of scientific research and COVID tracking; ○ IoT, sensor networks and crowd-sensing (e.g. for decentralized Insurance, traffic management); ○ Decentralized Finance, including collateralised lending and stablecoins; ○ Prediction market.
Context	Proposals should position the proposed solution on a landscape of existing services and platforms. Specific context for the action is provided by the following services, however, other contexts may apply: ○ *iExec:* a network of computers for running arbitrarily complex off-chain jobs with TEE and GPUs and pushing results directly in smart contracts, backed by reputation, decentralised consensus and economic incentives. ○ *ChainLink:* a trusted marketplace for oracles where clients and nodes are connected. ○ *Witnet:* a reputation-based decentralised oracle network in which correctness is defined by a consensus algorithm.

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	○ Provable blockchain: Leveraging all TEE environment providers to minimise vulnerability.
Expected outcomes	○ Downloadable open source software components that can be used to build systems of oracles, which will be used to feed truthful off-chain information to the ONTOCHAIN semantic blockchain infrastructure; ○ Semantic representation (e.g. in Linked Data format) of the involved data sources, data features/attributes, and trustworthiness score; ○ Smart contracts, on- and off-chain API for querying the trustworthiness of external data; ○ Software should be resilient to security and privacy threats (DDOS, Sybil attacks, reputation manipulation, identity theft, etc.); ○ New trust-building mechanisms to assure authentic and trustworthy data feed for smart contracts.
In practice	The downloadable open-source Oracle software components will be applied in the initial applications of the ONTOCHAIN ecosystem (resulting from the Calls 1, 2, and 3). They will be deployed for the purpose of demonstration and accessed through their APIs. Oracle clients will be smart contracts and Web 2 applications running on top of the ONTOCHAIN semantic blockchain infrastructure. Users will be able to examine the oracle (e.g. status, historical data) through a web interface.

2.2.2 Topic 2 - Market mechanisms for ONTOCHAIN

Title	Market mechanisms for ONTOCHAIN
Definition	Blockchain has the potential to mitigate uncertainty and enable "trustless trust" between buyers and sellers. Blockchain records all valid transactions among traders (B2C, B2B, C2C) on the platform. These transaction records are transparent to platform members, and are hard to be altered once recorded. Apart from this basic concept, to exploit the full potential of blockchain, several additional functionality has to be offered, e.g., service/product digitization, market service matching neutrality, decentralized auction mechanisms, automated inventory management, etc. Moreover, facilitating DeFi services on top of blockchain is a key functionality for unlocking the full business value of blockchain; however, nowadays, DeFi (on top of Ethereum) is suffering from high transaction fees. The goal of this topic is to design, implement and showcase prototype services in the scope of advanced decentralized market

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	and business-enabling mechanisms that offer win-win situations for all involved stakeholders, and are in line with the overall ONTOCHAIN objectives for trustworthy services/products exchange and trustworthy content handling.
Challenges	The challenge perceived is to build an unbiased service/product trading system on top of trustworthy information expressed in Semantic Web formats. This includes: o The ability to generate (mint) tokens of various types, i.e., Non-Fungible Tokens (NFTs), Fungible Tokens (FT), Semi-Interchangeable Tokens (SFT). o Support for building DeFi applications on top of the blockchain, i.e., token/stablecoin trading, interest on deposit accounts, token/stablecoin loans, crypto funds, etc. o The ability to facilitate the use of various types of tokens throughout the lifecycle of data and services. o The overall market mechanisms for tokenomics (e.g., token distribution strategies, token sharing for ecosystem sustainability, incentives for nodes etc.) o Enable stable transaction fees.
Requirements	The software prototype should address as much as possible the challenges mentioned above. In this context: o Support for token minting, distribution (for ecosystem economic sustainability) and exchange. o Support for developing unbiased trustworthy marketplaces of digitized (physical or virtual) assets. o Support for unbiased decentralized price determination mechanisms. o Support for service/product exchange. o Support for building efficient DeFi applications. o Design economic model prototype for all stakeholders (win-win situations, sustainability, incentives for the nodes and so on). o Support of necessary functionality for market enablement such as: eReceipts (attestations), inventory management, supply chain management, SLA compliance checking. The prototype should also focus on addressing one or more non-functional requirements, such as: o Reduce costs in primary transactions (frictionless trade); o Increase security and transparency of centralized markets (eliminate biases or market manipulation potential);

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	○ Improve transaction efficiency in networked businesses (and potentially integrate with existing business processes); ○ Monetize data in compliance with regulation (e.g., GDPR).
Use cases	Use cases include: ○ Provision of market mechanisms for at least 5 types of stakeholders (service providers, service users, regulators etc. based on the 1-st Open Call project results). ○ C2C, B2C, B2B commerce. ○ Efficient Decentralised Finance (Defi). ○ Data/service/product marketplace. ○ Business ecosystem enlargement.
Context	Proposals should position the proposed solution on a landscape of existing services and platforms. Specific context for the action is provided by the following services, however, other contexts may apply: ○ SAGA: a decentralized data marketplace, designed for users to monetize and acquire data in a trusted standardized and cost-effective way.
Expected outcomes	○ Provide API/SDK for token minting, distribution (for ecosystem economic sustainability) and exchange. ○ Provide API/SDK for developing unbiased trustworthy marketplaces of digitized (physical or virtual) assets. ○ Provide API/SDK for unbiased decentralized price determination mechanisms. ○ Provide support (involving smart contracts) for service/product exchange. ○ Provide API/SDK for building efficient DeFi applications. ○ Design economic model prototypes for all stakeholders (win-win situations, sustainability, incentives for the nodes and so on). ○ Provide SDK/APIs for necessary functionality for market enablement's design and implementation for market enablement, such as eReceipts (attestations), inventory management, supply chain managements, SLA compliance checking.
In practice	The software should be downloadable and have open-source software components and SDK that can be used to establish market/tokenomics mechanisms to be used by the various decentralized apps that will be built atop the ONTOCHAIN software ecosystem and infrastructure.

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2.2.3 Topic 3 - ONTOCHAIN interoperability & API Gateways

Title	ONTOCHAIN interoperability & API Gateways
Definition	This topic aims at developing the ONTOCHAIN cross-chain layer and Gateway APIs; this critical component must provide means for trusted bi-directional operations (e.g., transfer of information and assets) between the ONTOCHAIN network and a selection of the most widely used networks, as well as communications between different chains within the ONTOCHAIN network (e.g., Ethereum, CARDANO, COSMOS, KUSAMA, STELLAR, Hyperledger Fabric and Tezos). The ONTOCHAIN network itself will embrace several chains, with different protocols, to serve different applications and business cases. This topic must ensure that these networks integrate smoothly together and with the outside world.
Challenges	The challenge is to provide future-proof interoperability by developing a trustworthy, privacy-preserving, secure, transparent, democratic and traceable set of Blockchain APIs based on Semantic Web standards. The APIs must support the exchange of ontologies, of data and metadata, of knowledge and information from different blockchains towards ONTOCHAIN and vice versa. The proposed solutions must hide the heterogeneity of blockchain protocols which limit application development and can break important properties such as trust, consistency and security of data and services which are all paramount to mass adoption. Information and asset exchanges between chains with different protocols must ensure that semantic information, trust, identities and privacy are preserved while maintaining the highest possible level of security.
Requirements	The prototype should address as much as possible the challenges mentioned above, and in particular: o The topic is open to any existing blockchain solution but at least Ethereum, Tezos and Hyperledger Fabric must be supported. o Support for (at least) ERC-20, ERC-721, ERC-777 and ERC-1155. o Solutions must rely as much as possible on industry-wide standards and support existing chains with no modifications of their protocols, clients, virtual machines or programming framework. o The trust, validity and critical metadata attached to data/transactions must be preserved during a transfer within ONTOCHAIN and with external blockchains. o Provide efficient methods for reducing computational complexity and transaction sizes between ONTOCHAIN and other blockchain ecosystems.

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Use cases	○ Interledger communication. ○ Cross-chain oracles. ○ Legacy systems and Governance integration. ○ Cross blockchain token transfer. ○ Cross blockchain smart contract interaction.
Context	Proposals should position the proposed solution on a landscape of existing services and platforms. Specific context for the action is provided by the following services, however, other contexts may apply: ○ *Ark* uses SmartBridges architecture to address this challenge, and claims to provide universal interoperability, plus cross-blockchain communication and transfers. ○ *Cosmos* uses the Inter-blockchain Communication (IBC) protocol to enable blockchain economies to operate outside silos, and transfer files between each other.
Expected outcomes	○ Bridges (smart contracts and off-chain services) for transferring assets between smart contracts deployed to any combination of the above-mentioned chains. ○ Cross-platform SDK and APIs allowing two directional communication between ONTOCHAIN provided services and widely used networks. ○ Scalable API endpoint for connecting clients to ONTOCHAIN applications and services. The software must implement modern security protocols and standards and provide the highest level of security to the clients.
In practice	The software will be used by application developers that have deployed instances of their smart contracts to multiple chains within and outside ONTOCHAIN. For example, if a marketplace application is deployed on Ethereum Mainnet and on a L2 chain within ONTOCHAIN, the interoperability components must allow items for sale on any of the instances to be purchased through any of the other instances.

2.2.4 Topic 4 - ONTOCHAIN Network Design and Scalability

Title	ONTOCHAIN Network Design and Scalability
Definition	Blockchain offers a plethora of features, such as traceability, transparency, anonymity, democracy, automation, decentralization and security. Despite these promising features the technical

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	scalability of the network is still a key barrier which can put a strain on the adoption process, especially for real business environments. Throughput, storage, and networking are three aspects of scalability that should be considered to improve ONTOCHAIN network scalability. This topic aims to build an ONTOCHAIN client based on Ethereum that is a stable and well tested system for data transactions and has a cost-effective network for the operation of its applications.
Challenges	o Definition of stakeholders and their requirements. o Design of flexible services for the ONTOCHAIN ecosystem. o Deployment of the selected services and testing. o Optimization and Scalability of the network. o Operational costs of the network.
Requirements	The prototype should address as much as possible the above mentioned challenges and in particular: o Design suitable schemes to increase the throughput in order to sustain a huge volume of real world transactions for the ONTOCHAIN platform. o Solution can be focused on finding new approaches on how to store data effectively in the ONTOCHAIN platform with limited resources. o Design more efficient data transmission mechanisms for the ONTOCHAIN services and applications. o Design new prototypes on how different chains can be linked to each other on a hierarchical/scalable basis.
Use cases	o Faster and cheaper transaction o Real business environments o Scalability in adding new data linked to On-chain data. o Electricity energy resources
Context	Proposals should position the proposed solution on a landscape of existing services and platforms. Specific context for the action is provided by the following services, however, other contexts may apply: -*SegWit* can improve throughput and maintain good compatibility with the Bitcoin blockchain system, but the throughput improvement is limited. o Off-chain transaction (e.g., Lightning network, Duplex o Micropayment Channels) systems can reduce the number of transactions processed on the blockchain, but sacrifice transaction security and complicate the user experience.

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	○ Sharding(e.g., OmniLedger, Elastico) improves throughput and reduces the number of transactions processed by each node, but sacrifices global consensus ○ Decoupling management/control from execution supports QoS provisioning and improves decentralization, but increases the complexity of dynamic resource allocation and the decisions on which nodes should execute smart contracts. ○ Polygon: Framework for building and connecting multiple Ethereum-compatible blockchain networks. ○ Layer 2 solutions: Sidechains
Expected outcomes	○ Developing the use of Property Graphs (PGs)/ Labelled Property Graphs (LPGs) on blockchains as on-chain data. ○ A tight integration between on-chain data storage engine and blockchain code. ○ Reduction of the transaction size for increasing the number of transactions in ONTOCHAIN blocks. ○ Reduction of the number of transactions processed by ONTOCHAIN nodes to improve throughput. ○ Efficient approaches for ONTOCHAIN block generation. ○ Transmit the transaction information effectively and reduce the requirement for network bandwidth resources. ○ Compatible with Layer2 sidechain.
In practice	This open-source software result and documentation can be used to deploy and join new ONTOCHAIN nodes in the initial ONTOCHAIN infrastructure, or to build a new ONTOCHAIN infrastructure on its own.

2.2.5 Topic 5 - Semantic based marketplaces for ONTOCHAIN

Title	Semantic based marketplaces for ONTOCHAIN
Definition	This topic will develop a marketplace where ONTOCHAIN users can buy or sell any goods or services that can be described with an ontological representation. The resulting software will provide services for publishing ontology-based descriptions of goods and services, creating and publishing market orders, searching through the orders based and complex criteria and matching sell and buy orders. The marketplace can implement different market mechanisms, e.g. spot, limit orders and so on. Ontology matching is a solution to the semantic heterogeneity problem. Finding correlations between semantically related entities of ontologies can be used for different tasks such as ontology merging, query

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	answering, data translation, etc. In this topic, ontology matching is a requirement for finding compatible offer and demand (buy and sell orders) in semantic-based marketplaces. To guarantee the fairness of the transactions in the marketplace, the matching process should be fair to every party, e.g. preventing exclusion, censorship, price manipulation and fraud. The goal of this topic is to design and implement prototypes that will provide ontologies management and setup for decentralized semantic matching of demand and supply for different use case scenarios (e.g., apartments, land, cars, etc). The prototype should also make it possible to include oracles and reputation in its decision-making processes. It should operate on top of the ONTOCHAIN L2 sidechain.
Challenges	Developing a component that offers services similar to existing virtual marketplaces but for arbitrary goods/services, and ensuring the highest level of trust and fairness. The marketplace logic (including the propagation and the matching of market orders) must thus be as decentralized as possible, while offering high performance and low response time. The solution should leverage ONTOCHAIN services introduced in Open Call 1 for increasing trust between users (e.g., identity, reputation) and be open to all of the present and future ONTOCHAIN stakeholders. In addition to decentralization, particular care must be given to avoiding any censorship, market manipulation (e.g., by hiding, erasing or forging orders or ontological descriptions) and spam attacks. The semantic matching component must guarantee that every offer has been considered, that the returned service/good is always the most appropriate for the user, and that it satisfies every expressed requirement.
Requirements	The prototype should address as much as possible the aforementioned challenges and the following requirements: o Support different ambitious use-case scenarios (e.g., apartment rental, car sale, freelancing) based on metadata and semantic constraints (e.g., apartment size and location, etc.). o Rely on existing ONTOCHAIN components to provide new services like ontology description, evaluation, integration, etc. o Provide *fairness-first* solutions, i.e. a marketplace prototype that gives equal power to sellers, buyers and to the marketplace operator. o Find the best tradeoff for decentralized ontology matching for achieving higher throughput in large ontologies while maximizing trust and fairness. o Provide incorporation of Property Graphs (PGs)/ Labelled Property Graphs (LPGs) as an alternative data model for using semantics, this should include (but not limited to) the mechanism for encoding Ontologies using LPG data model,

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	mechanism for reference to OWL Ontologies and the mechanism for reasoning over LPGs.
Use cases	o Ontology engineering o Information integration o Linked data o Peer-to-peer information sharing o Web service composition o Autonomous communication systems o Navigation and query answering on the web
Context	Proposals should position the proposed solution on a landscape of existing services and platforms. Specific context for the action is provided by the following services, however, other contexts may apply: o Binance: is an online exchange platform where users can trade cryptocurrencies. The exchange also supports the users to earn interest or transact using cryptocurrencies. o Booking.com: connects millions of travellers with various services like a range of transport options and places to stay -from home to hotels and much more. It is the largest world's travel marketplace that enables properties all over the world to reach a global audience and grow their businesses. o OAEI: The main goal of OAEI is to support the comparison of the systems and algorithms on the same basis and to allow anyone to draw conclusions about the best matching strategies. o Open Knowledge Graph: a visual interface that dramatically increases the visibility of research findings for science and society alike. The goal is to offer a better way to explore and discover scientific knowledge.
Expected outcomes	The output of this task must be an API, a SDK and a GUI for interacting with the marketplace and implement the following functions: o Uploading ontological descriptions of goods and services; o Generating market buy and sell orders from an ontological description and specific qualitative and non-qualitative criterias; o Publishing and propagating orders; o Matching ontological market orders; o Sealing deals permanently in a smart contract on the underlying blockchain. o All the functions must be accessible to end users and applications through all three interfaces.
In practice	This open-source software outcome can be used mainly as a design of a potential front-end to the ONTOCHAIN infrastructure and

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	services. It can be used to showcase the potential of the new trustworthy knowledge management services provided by ONTOCHAIN.

2.2.6 Topic 6 - Data provenance in ONTOCHAIN

Title	Data provenance in ONTOCHAIN
Definition	Data Provenance or lineage is the technology field whose objective is to manage metadata associated with the history of data, from its inception to various stages of the data lifecycle. Thus, data provenance metadata helps to provide a detailed picture of how the data was created/collected, where it was stored and how it was used/modified/transformed. Data provenance metadata is also useful for auditing. For each data exchange and data handling a specific record of processing activity (ROPA) is recorded. ROPAs should be automatically checked against GDPR, so that the data processor (e.g., identifiable by means of DIDs) is authorized (e.g., by means of verifiable credentials) to apply the processing which is compatible with the GDPR; overall, this is termed to be trustworthy data handling. Data transformations, accesses and handling should be trustworthy and recorded, so that data provenance can be supported. Data provenance is particularly important for data lakes/aggregators (i.e., repositories of data belonging to multiple owners), data traders and business processes (especially supply chain management).
Challenges	In data lakes, creating a comprehensive immutable audit record of the data, which can be independently verified to ascertain the authenticity of the data is important. In the context of data trading, data owners can prove the legitimacy of owning data and trade it to others or control the number of legitimate copies of the data. Finally, in the context of business processes, associating a digital token to each high-value item in the supply chain, when the physical item changes hands in the real world, the corresponding digital token is re-assigned in the blockchain. This ensures that the blockchain tracks the journey of the high valued item in the real world. This allows the buyer on receipt of the item to backtrack and verify the chain back to the origin i.e. all the way to the manufacturer.
Requirements	The prototype should address as much as possible the above mentioned challenges and the following requirements: o Support automated checking of data-related transactions against GDPR. o Define/adopt ontology for ROPAs. o Store chains of ROPAs on data processing.

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	○ Record business processes, especially for supply chain management. ○ Automated verification of rule compliance in business processes. ○ Rely on existing ONTOCHAIN components for data semantics on business processes.
Use cases	The following use cases apply: ○ Data provenance in warehouses/lakes ○ Data Trading ○ Data Trustworthiness ○ Service/Product quality
Context	Proposals should position the proposed solution on a landscape of existing services and platforms. Specific context for the action is provided by the following services, however, other contexts may apply: ○ Example: Aravind Ramachandran and Murat Kantarcioglu. 2018. SmartProvenance: A Distributed, Blockchain Based DataProvenance System. In Proceedings of the Eighth ACM Conference on Data and Application Security and Privacy (CODASPY '18). ○ Another example is the system ProvChain A Blockchain-Based Data Provenance Architecture in Cloud Environment with Enhanced Privacy and Availability byXueping Liang and Alii 2017 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGRID)
Expected outcomes	○ Smart contracts for automated checking of data-related transactions against GDPR. ○ Define/adopt ontology for ROPAs. ○ Provide API/SDK for storing chains of ROPAs on data processing. ○ Provide API/SDK for recording business processes, especially for supply chain management. ○ Smart contracts for automated verification of rule compliance in business processes.
In practice	The open source software produced in this topic will enable data trustworthiness assessment, the creation of GDPR-compliant data marketplaces, and greater trustworthiness in service/product transactions.

The emergence and popularity of blockchain techniques will significantly change the way of digital and networking systems' operation and management. In the meantime, the application of blockchain will raise new requirements, more open issues and challenges.

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ONTOCHAIN seeks submissions of projects that invent novel technologies, provide new applications, supply advanced methodologies, propose promising software development directions and approaches for unsolved issues.

Note that ONTOCHAIN Open Call 2 includes the six topics aforementioned, but is not limited to them, A proposal under open topic will also be considered as long as it serves as a building block of the infrastructure and to the overall ONTOCHAIN vision and objectives (see Section 1), excluding ONTOCHAIN applications, to which the open call 3 will be specifically devoted.

2.2.7 Deliverables

Whatever the topic, the projects funded by the ONTOCHAIN consortium must deliver four deliverables during their participation process on the ONTOCHAIN foundation. In this context the deliverables that each project has to prepare are defined below:

- D1: Detailed technical specification of the solution and software implementation work plan
- D2: Software deployment and use case scenarios
- D3: Implementation, deployment, testing, demonstration and validation
- D4: Modularised software components ready for distribution

For more details regarding the delivery dates, see the ONTOCHAIN Open Call 2 Guide for Applicant.

2.3 SUPPORT SERVICES PROVIDED BY ONTOCHAIN TO THIRD PARTIES

All selected third parties will benefit of:

- Access to Infrastructure: All the teams selected will have access if willing and needing so, to the iExec blockchain platform, for their off-chain developments (see 8.1 for more details) and to the MyIntelliPatent web application, populated with updated blockchain applications, for patent analysis and monitoring (see 8.2 for more details).
  The use of the iExec platform and of the MyIntelliPatent web application are not mandatory. Applicants shall bear in mind that interoperability of the solutions build within the ONTOCHAIN project is a paramount requirement.
- Business support services: To support the teams to exploit their use cases and successfully reach the market, different trainings and sessions with mentors will be organised. Depending on the team profile, aspects such as Value Proposition, pitching or IPR (among others) will be explored.

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- **Communication support services:** Major visibility, promotion and networking opportunities are offered as part of the ONTOCHAIN project and the Next Generation Internet initiative. Selected teams will:
    - have access to communication tool kits and co-branding materials,
    - be showcased in the ONTOCHAIN project website,
    - be interviewed and promoted on relevant media channels
    - be invited to participate in top events
    - connect with a vibrant ecosystem of innovators, investors, industry players and public authorities.

Each third party selected will be assigned one or more mentors from the ONTOCHAIN consortium that will follow its updates on a weekly basis.

3 ANNOUNCEMENT

Submission to the ONTOCHAIN Open Call 2 will open on the 15th July 2021 at 12:00 PM CEST and close on the 15th September 2021 at 17:00 CEST. Dates for the different phases are outlined below but may be subject to change if any modifications in the project's schedule occur.

Call title:	ONTOCHAIN Open Call 2 - Protocol Suite & Software Ecosystem Foundations
Full name of the EU funded project:	Trusted, traceable and transparent ontological knowledge on blockchain
Project acronym:	ONTOCHAIN
Grant agreement number:	H2020–957338
Call publication date:	15th July 2021 at 12:00 PM CEST
Call deadline:	15th September 2021 at 17:00 CEST
Expected duration of participation:	5 (small projects) or 10 months programme (large projects)
Total EU funding available:	1 320 000 €

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Task description:	ONTOCHAIN will deliver a new software ecosystem for trusted, traceable and transparent ontological knowledge management. The specific objective of the ONTOCHAIN Open Call 2 is to implement an infrastructure that will host ONTOCHAIN's trustworthy data, metadata and services, and specific software solutions that can be used widely, further extending the use cases and the architectural features planned by the end of the Open Call 1.
Submission & evaluation process:	Proposals are submitted in a single stage and the evaluation process is composed of three phases as presented hereafter: o Phase 1: Admissibility & eligibility check o Phase 2: Proposals evaluation carried out by the ONTOCHAIN Consortium with the assistance of independent experts. o Phase 3: Online interviews (10 minutes pitching & 20 minutes of Q&As) and final selection carried out by the ONTOCHAIN Consortium and the ONTOCHAIN Advisory Board Members.
Further information:	Further details are available at: https://ontochain.ngi.eu/apply

4 SUPPORT TO APPLICANT

The ONTOCHAIN consortium will provide information to the applicants only via ontochain@ngi.eu. No binding information will be provided via any other means (e.g., telephone or other email).

- More info at: https://ontochain.ngi.eu/apply
- Apply via: https://www.f6s.com/ontochain-open-call-2/apply
- Support team: ontochain@ngi.eu
- Personal Data Protection Policy available at: https://ontochain.ngi.eu/Terms_of_Service_and_Privacy_Policy_v0.2

The ONTOCHAIN consortium will also organise webinars to connect with interested applicants. Stay update by following the ONTOCHAIN project on the following channels:

- Website
- Newsletter
- Twitter
- LinkedIn
- Facebook
- YouTube

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5 KIT FOR APPLICATION

The ONTOCHAIN Open Call 2 supported material is the following:

- The ONTOCHAIN Background

This document describes the ONTOCHAIN project context and the need for means for collective organisation as well as for contribution and use of knowledge thanks to smart solutions that support transparency, trust, plurality and democracy.

- The ONTOCHAIN Open Call 2 text

The present document.

- The ONTOCHAIN Guide for applicant

This document provide in details the information to help apply to the ONTOCHAIN Open Call 2 such as an abstract of the ONTOCHAIN action, a description of the ONTOCHAIN open call 2, the modalities for application, the eligibility criteria, the evaluation process, the scheme of the funding support, the IPR aspects related to ONTOCHAIN and how to prepare and submit a proposal.

- The ONTOCHAIN Application material
  - Administrative form preparation template, which presents the list of administrative information that you need to fill in directly in the F6S portal.
  - Proposal description template: a mandatory and editable document to describe your proposal.
  - ONTOCHAIN additional applicant's template: In case your proposal has more than 3 applicants participating as individuals (Natural persons) or/and more than 3 applicants participating as organisations (Legal entities), you will have to fill in this document and upload it in section 3 of the F6S form.

- The Indicative sub-grant agreement form

This document provide a template of the sub-grant agreement that only the selected applicants will be requested to sign. It is not necessary to send this document at the time of application.

All documents are available at: https://ontochain.ngi.eu/apply

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