Next Generation

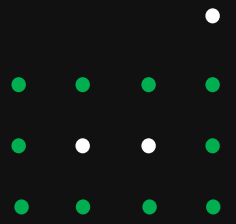# Trust for IoT

LoRaTRUST
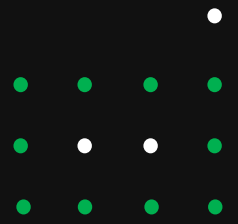
2023

Table of **Contents**

Introduction

Background

LoRaTRUST is an innovative and comprehensive application that has been specifically designed to process environmental IoT data with unmatched accuracy and reliability. It enhances **trust** in measured **IoT data** and encourages external participation in IoT monitoring applications. The project introduces a new concept that attributes value to both IoT data and devices, such as **sensor nodes** and **gateways**, and leverages distributed ledger technology to enable a data trust system.

LoRaTRUST's technologies will enable novel open and public IoT infrastructures that incentivize participation and produce valuable data for a diverse range of stakeholders. By enhancing trust and encouraging participation, LoRaTRUST aims to revolutionize the IoT monitoring landscape.

Vision – Mission - Approach

Our vision is to promote trust and accountability to IoT data, delivering a key framework for environmental monitoring applications. Our approach involves the accounting of data and device contributions, incentivizing participants and leading to sustainable IoT networks.

We want to support sensing networks adding value to data and promote the global share of data as commons on the web.

| Collect Data | Audit Data | Report & Broadcast | Online Status |

Fig.1: LoRaTRUST process IoT data and makes trust verification available to third party

Introduction

Problems and Challenges

Lack of trust standards and tools to verify the reliability of IoT datasets.

No accountability for the organizations and individuals generating IoT data.

No recognition and incentives for the data contributors collecting IoT data in the network.

Low sustainability and high maintenance costs of IoT networks and tools.

Current environmental monitoring solutions fail to incentivize users who contribute IoT data and measurement tools, and they do not guarantee the trustworthiness of the data. LoRaTRUST addresses these issues and enables novel open and public IoT infrastructures sustained by participation incentives, resulting in valuable data for diverse stakeholders.

LoRaTRUST proposes a new concept for IoT environmental monitoring that uses blockchain-based distributed ledgers to register and account for the contribution of IoT devices and their data. By attributing value to both the measured IoT data and the devices themselves, LoRaTRUST enables the development of a data trust system that enhances the trustworthiness of the data.

The Idea Behind

Data quality and Trust for IoT
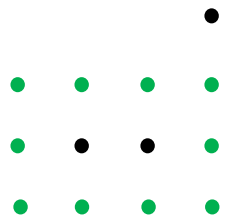
LoRaTRUST leverages the power of blockchain technology to provide a robust and secure platform for data verification and quality control. The decentralized ledger technology allows for immutable datasets, ensuring that data cannot be tampered with or altered in any way.

With our smart contract-enabled system, we automate the audit process and ensure that data is accurate and reliable.

The platform ensures that data is generated responsibly and that the network is maintained with the highest standards of quality and reliability. It can support incentivized network by recognizing and rewarding contributions made by data producers. A distributed network offers real-time data access, ensuring that data is readily available and up-to-date.

We understand that data quality is essential for a wide range of applications, from scientific research to financial services. With LoRaTRUST, we aim to revolutionize the way that data is managed and ensure that data is always accurate, trustworthy, and secure. We believe that blockchain technology can play a pivotal role in achieving this vision, and we are committed to delivering innovative solutions that enable a more decentralized and secure future.

The Consortium

LoRaTRUST was established in 2022 through a partnership between the Polytechnic University of Catalonia and Hacking Ecology, with support from the European fund NGI TruBlo (grant agreement No. 957228). The UPC is a public institution dedicated to higher education and research, specializing in architecture, engineering, and technology. The university's Distributed Systems Research Group (DSG) https://dsg.ac.upc.edu/ is involved in the LoRaTRUST project and has developed the LoRaCoin[1] concept for a blockchain-managed IoT infrastructure.

Hacking Ecology is an SME that develops open-source technologies for citizen science, ecological research, and environmental monitoring. The Hacking Ecology team has developed the Nayad Modular[2], an Open Science Datalogger, which is the first hardware integration for the LoRaTRUST MVP.

1. E. Cruz Harillo and F. Freitag. LoRaCoin: Towards a blockchain-based platform for managing LoRa devices. IEEE Infocom 2022).
2. Partner Hacking Ecology Nayad project repository https://gitlab.com/hacking-ecology/nayad-modular
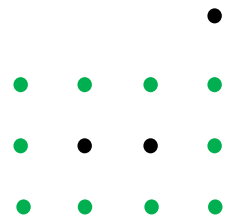
The Idea Behind

Open Source

Open source technologies have the potential to enhance software development by promoting innovation, access, and collaboration. The use of licences encourages community building and knowledge sharing, can lead to cost savings for organizations, and provide flexibility in terms of customization and tailoring to specific needs. By using open source licences, developers can build upon existing code, share their work with others, and create new solutions that benefit everyone. The benefits of open source licences extend beyond software development and have implications for industries and communities as a whole.

LoRaTRUST uses Affero GNU Public License (AGPL), ensuring that any derivative will use the same license with benefits shared with the whole community.

Data Ownership

Data ownership refers to the legal right of individuals or organizations to control and manage the use of data they create or collect. It is a critical concept in today's digital age, with profound implications for privacy, security, and innovation. By owning their data, individuals and organizations can safeguard privacy, prevent misuse, and foster innovation by developing new products and services. Data ownership also promotes ethical and responsible data use, building a more secure, equitable, and innovative data ecosystem.

In LoRaTRUST we provide a customizable framework in which data providers have control over their data and set the best policies to manage their data.

LoRaTRUST Platform

Overview

The use of blockchain technology in the LoRaTRUST system ensures that the stored data is authentic, tamper-proof, and reliable, making it a game-changer in the field of environmental IoT data processing. The system provides trust and transparency for the IoT data, which is crucial for informed decision-making.

The system's blockchain smart contract is a key feature that ensures the trustworthiness of the IoT data. It contains proofs for the stored IoT data in the persistent data service. These proofs are hashed documents with location information that guarantee that the stored IoT data is not manipulated.
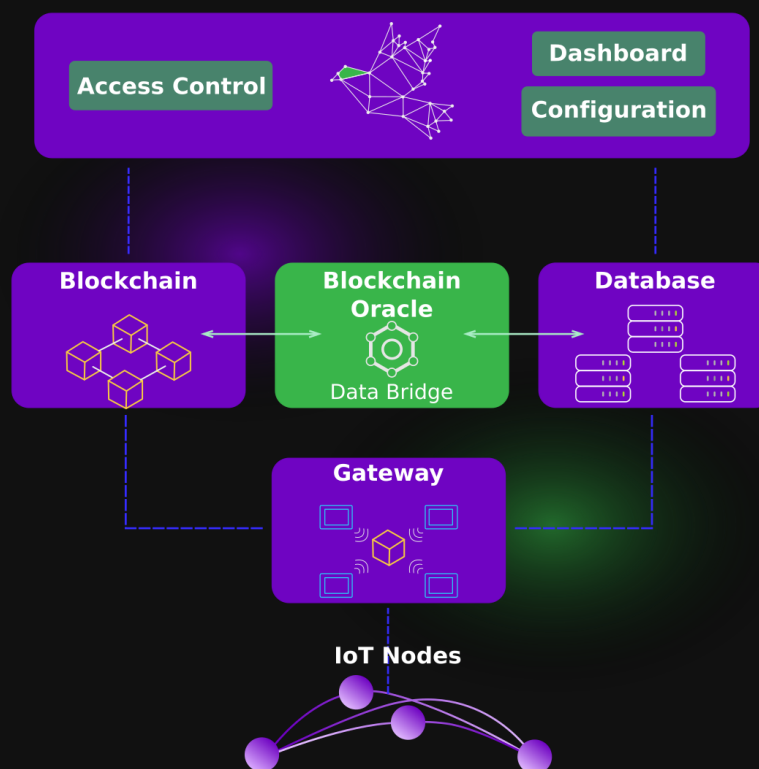

Fig.2: LoRaTRUST Overview

LoRaTRUST Platform

Smart Contract

A Smart Contract is a computer code that **automatically executes** prespecified functions when a specific condition or conditions occur, without a third party involved between participants. It can define strict rules and consequences, just like a traditional contract, but it can also take input information, process it through the contract's rules, and take any necessary actions as a result.

Providing Trust With Smart Contract

LoRaTRUST uses **Smart Contract** to define rules and methods for validating and processing interactions between **IoT devices** and the network. This provides an interface to access information and enhances traceability, accountability and data trust in a Blockchain IoT architecture. The **Trust System** includes the **Data Quality Dimensions**, which improve verification tests. LoRaTRUST is also designed to combine with a lightweight IoT data trust process.

IoT Device
Unverified Data

Smart Contract
Verifies Data

IoT
Verified Data

Fig.3: IoT Data Trust

Verifiable IoT Data is translated as a set of information necessary to identify the source, the **integrity** and the **quality** of data coming from an IoT device. In LoRaTRUST, Smart Contract verifies:

- Device Signature
- GPS Location
- Owner Address
- Device Address
- Data Quality Dimensions: completeness, currentness and confidentiality

LoRaTRUST Platform

Efficiency for Data Storage

LoRaTRUST is a system that enhances the efficiency of a Blockchain IoT by minimizing Blockchain storage. This is done by storing only IoT metadata transactions in the Blockchain through the LoRaTRUST Smart Contract. All IoT data is stored Off-chain to handle non-transactional data that is too large to be efficiently stored in the Blockchain. The system connects both IoT data and their respective metadata through the LoRaTRUST Oracle.

LoRaTRUST Oracle

Blockchain **Oracles** are software solutions that provide a secure middleware to facilitate communication between a smart contract and the outside world. LoRaTRUST uses an Oracle to enable **connection** link between **on-chain** and **off-chain** counterparts.

The LoRaTRUST Oracle handles the data exchange in and out, serving as a solution for **providing trust** to off-chain data, based on the transactions processed by the Smart Contract and recorded on the Blockchain.
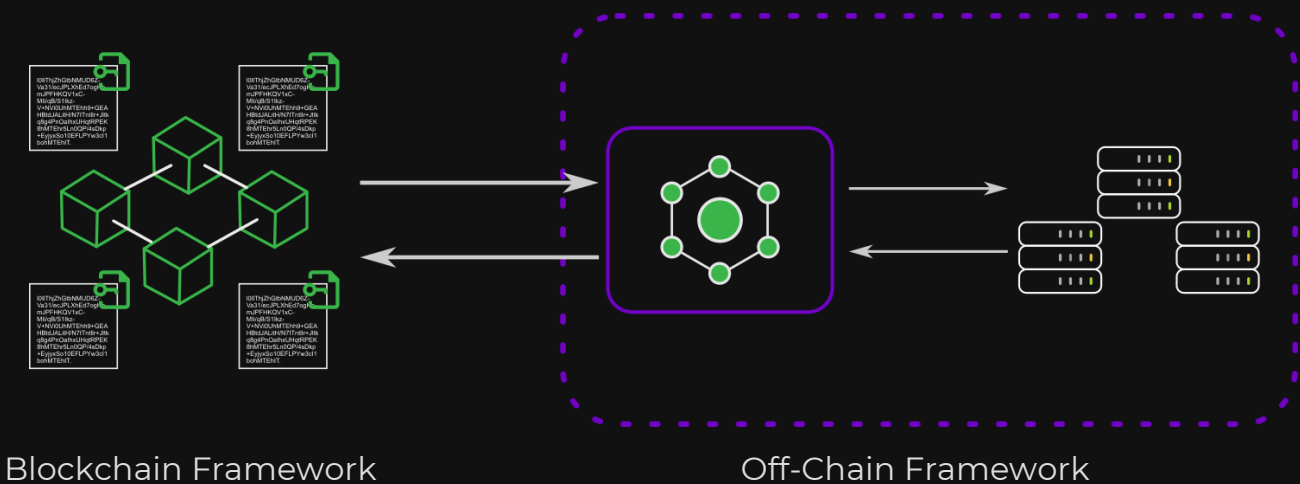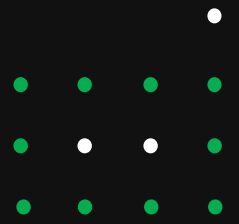

Blockchain Framework   Off-Chain Framework

Fig.4: Blockchain Oracle

LoRaTRUST Platform

IoT Data Trust
Proof of Veracity

Through the trust system for IoT data, LoRaTRUST provide the technological foundation to verify IoT data integrity and veracity, that will support decision-making for emergency plans, public policies, and environmental assessments. It automates the verification of IoT devices and ensures auditable and traceable data, increasing its value and recognition of data contribution.
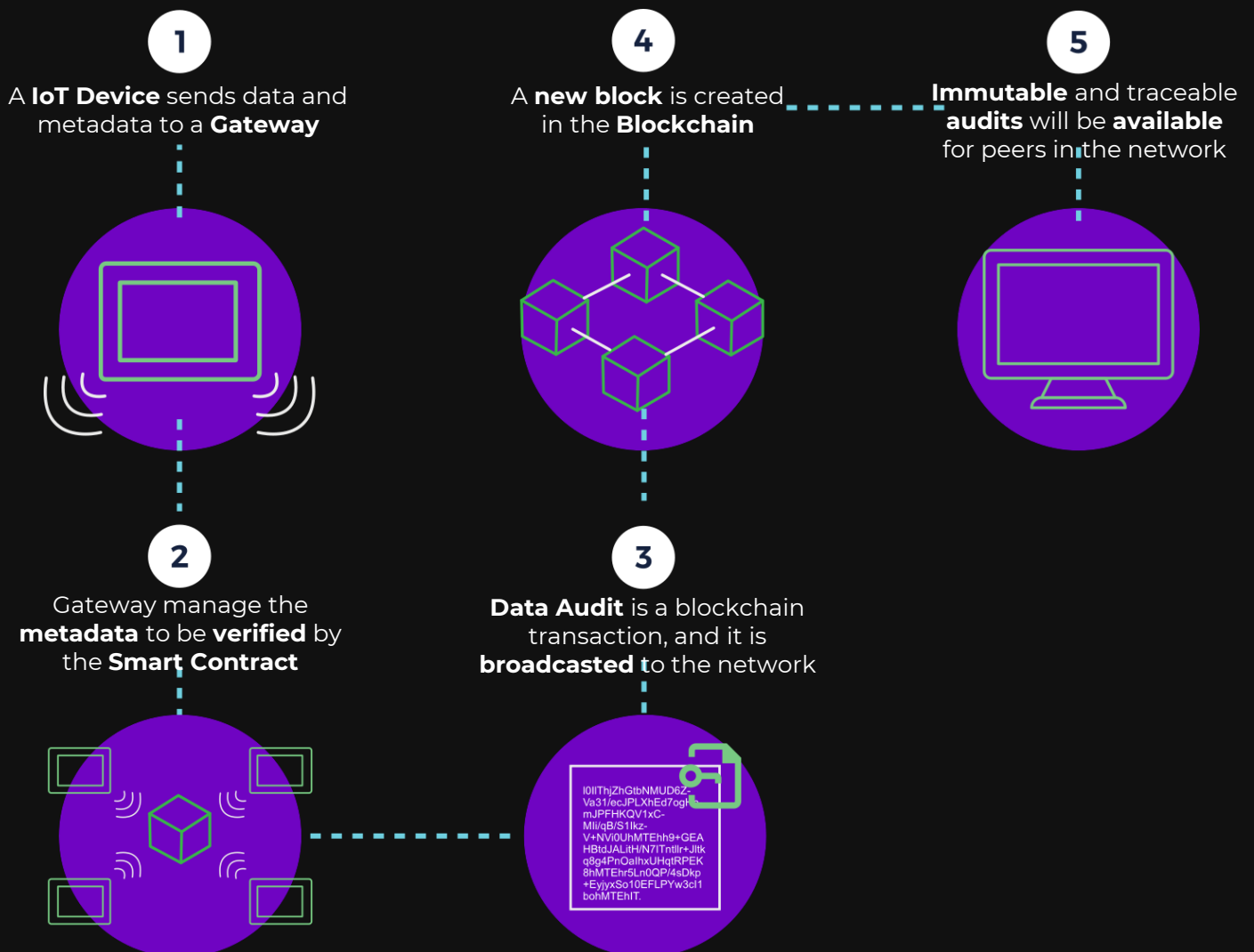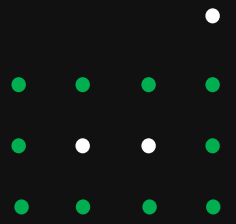
1

A **IoT Device** sends data and metadata to a **Gateway**

4

A **new block** is created in the **Blockchain**

5

Immutable and traceable **audits** will be **available** for peers in the network

2

Gateway manage the **metadata** to be **verified** by the **Smart Contract**

3

Data Audit is a blockchain transaction, and it is **broadcasted t**o the network

I0IIThjZhGtbNMUD6Z-
Va31/ecJPLXhEd7ogH
mJPFHKQV1xC-
MIi/qB/S1Ikz-
V+NVi0UhMTEhh9+GEA
HBtdJALitH/N7ITntIlr+Jltk
q8g4PnOaIhxUHqtRPEK
8hMTEhr5Ln0QP/4sDkp
+EyjyxSo10EFLPYw3cl1
bohMTEhIT.

Fig.5: Verification of IoT device metadata

LoRaTRUST Platform
User Interface

The LoRaTRUST **user interface** provides an overview of open data collected from LoRaTRUST projects, with reliable data distinguished from unverified data. Users can manage their devices, access reports on data contribution, errors, and alerts, to improve data quality and efficiency. The user interface also offers tools to **claim a device** and perform an **audit** on IoT devices and generated data.

The platform is complementary to IoT dashboard, providing tools for data contribution visualization, data auditing, and creating incentivized IoT networks.

In the **statistics** tab, users can see data contribution and impact in absolute and percentage numbers, including the size of a specific deployment, data availability, and the amount of verified data, which will be linked to compensation for the user.

Alerts related to the dataset are also available and divided into **Warnings** and **Errors**. Warnings, related to Calibration, Battery, Connectivity, Standard Deviation, Variance, do not invalidate the data and can be revised by the user.

Errors are related to outdated calibration, missing values and out-of-range data. They result in invalidate the data verification by LoRaTRUST smart contract, and the data will not be tagged as verified dataset.
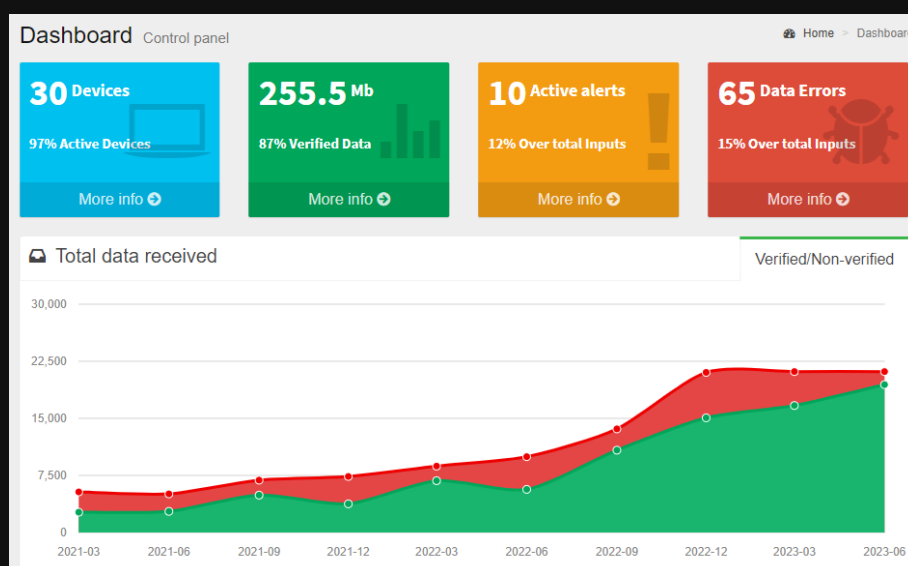

Fig.6: Report of IoT data contribution

LoRaTRUST Platform
Main Features

1

Audit IoT Data

To audit data, users will the devices and the date ranges they want to verify. By running a new audit, users will send a request to the LoRaTRUST Smart Contract that will process a transaction. The audit can also be automated according to user's configuration.

LoRaTRUST Platform

Main Features

2

Improve IoT Data

Users contributing with data can check all the warnings and errors associated with their sensors. The alerts are central for the better management of the network health in terms of data quality.

Sensors Data

TYPE	LAST VALUE	DATE (LAST AVAILABL...	STATUS
battery_level	20%	12/3/2023, 17:26:47	WARNING
temperature	14	12/3/2023, 17:23:54	OK
gps	41.42466213915947 2.077...	12/3/2023, 17:01:42	OK
Ph	8	12/3/2023, 12:45:00	ERROR

(!) **Calibration Error**

Your device has not been calibrated correctly. Consult our documents and FAQS for a correct calibration or find help in our costumer service.

(!) Calibration Error

See Error Details →

(!) Calibration Error

See Error Details →

Your last calibation date registered was 06/10/2022 and it is expired. Please recalibrate this sensor and validate.

VALIDATE

TYPE	DEVICE ADRESS	TRUSTED PROVIDER	STATUS	PROVIDER NAME
IoT Device	0x2554d735047cA32B10C...	0xC24A1968bB52Ea90C4...	OK	Hacking Ecology
Gateway	0x1f937923EAB8C37A265...	0xC24A1968bB52Ea90C4...	ERROR (!)	Hacking Ecology

LoRaTRUST Platform
Main Features

3

Download Certified IoT Data

Data contributors can also access and download the audit resolution as a proof of validity of your datasets.

LoRaTRUST Platform

Main Features

(4) Configure the Alert System

The LoRaTRUST platform offers advanced customization options for Warnings and Errors associated with each variable measured in a specific project. This feature allows project owners to select specific alerts relevant to their unique use cases, ensuring that the data collected is of the highest quality possible. By tailoring the warnings and errors to the specific needs of the project, LoRaTRUST helps to maximize the efficiency and accuracy of the data collection process.

As of the current development stage, the following variables have been identified for each category:

Low Connectivity

Calibration Expiring Soon

Missing Values

Critical Battery Level

Outdated calibration

High Data Variance

Values outside the sensor's range
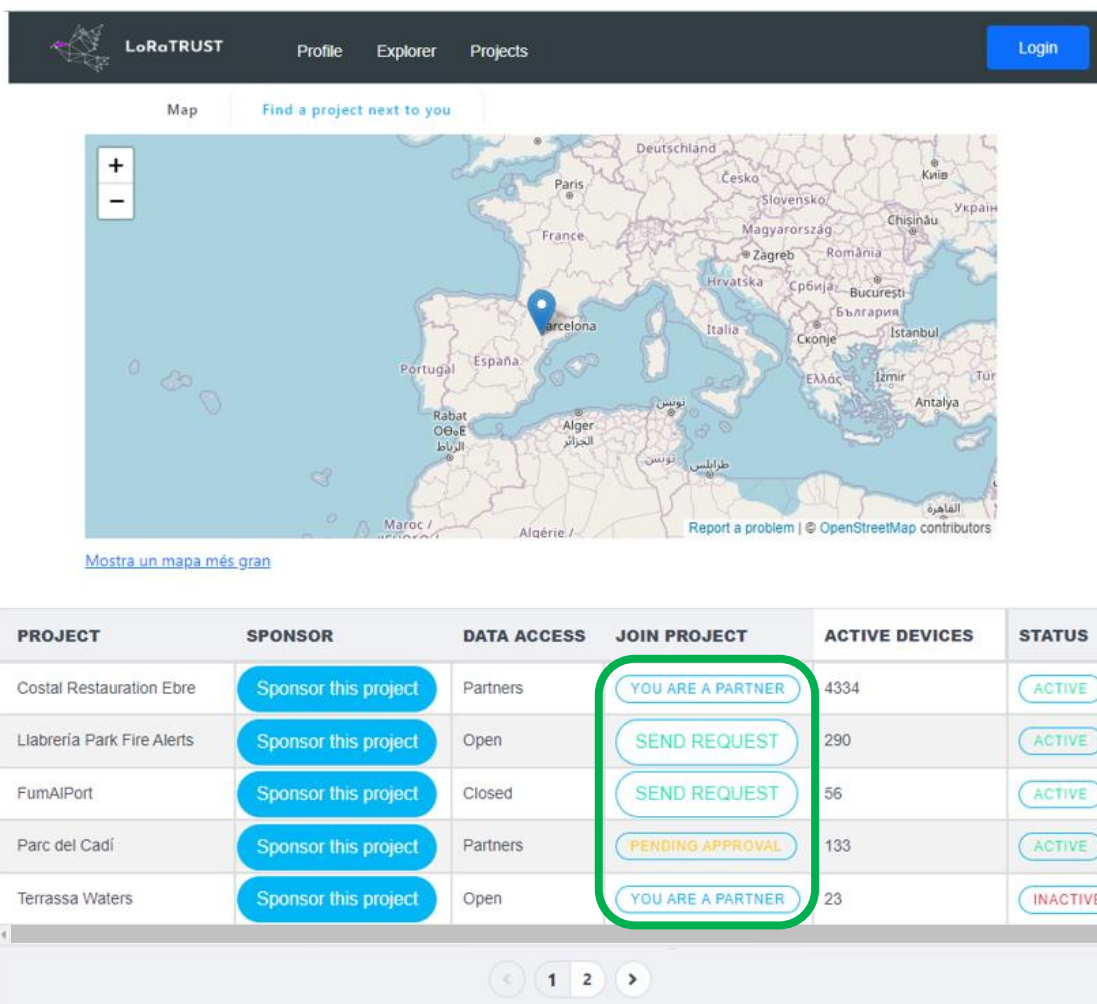
High Standard Deviation

LoRaTRUST Platform
Main Features

5

Build a community of partners

Once data contributors open a project, they can invite different partners such as citizens, businesses, local entities and associations to contribute to the project. Every partner can use sensors to contribute to the project and be rewarded, according to their contribution. It is also possible to data contributor to join an existent project and start collaborating.

LoRaTRUST Platform

Main Features

6

Customize the Reward Systems

The data contribution accountability system enables an incentivized network for data contributors, that could be adapted for multiple use cases.

The incentive solutions will range from tokens, reputation system, public incentives through discounts and taxes subsidizes, private sector initiatives providing discounts to costumers among others.

COLLECT DATA → IMPROVE DATA QUALITY → GET 1 LORACOIN FOR EVERY DATASET OF AUDITED DATA → GET A COMPENSATION FOR YOUR CONTRIBUTION

Fig.7: LoRaTRUST process IoT data delivering feedback on data quality, and compensating the user according to the amunt of quality data collected.

Some examples of personalized compensation:

DISCOUNT ON PUBLIC TRANSPORT

**TAX REDUCTION FOR
LOW ENVIRONMENTAL IMPACT**

REPUTATION SCORE

DISCOUNT ON A BRAND OR SHOP

FREE THEATRE TICKETS

LoRaTRUST Platform

Unique Advantages

TRUST AND ACCOUNTABILITY

Network contribution is recognized and data producer responsible for the data they generate.

A NETWORK OF PARTNERS

Decentralized Ledger Technology enables immutable dataset. Efficiency and resilience in a distributed network ready for real-time database.

CERTIFY DATA QUALITY

Smart Contract enables automated audit verifying data trust but also identifying lack of data quality.
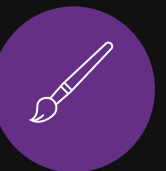
CUSTOMIZED PROJECT

LoRaTRUST is based on Projects. Data contributor can join a project or start a new one, according to their needs

LoRaTRUST Platform

Try the DEMO

LoRaTRUST Platform

Onboarding Process

The LoRaTRUST system is currently operational and fully integrated with ESP32-based hardware models using LoRa technology. It is possible to adapt different models, with small changes in the library, to be used in LoRaTRUST, providing trust verification staring at the IoT node level.
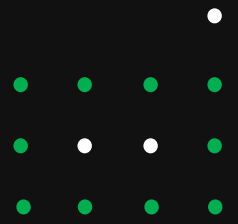
1 **ACCESS LoRaTRUST PLATFORM**

Use the Metamask wallet integrated to your browser

2 **CREATE OR JOIN A PROJECT**

Find a project in your region or with shared objectives to join. You can also create a new one.

3 **CLAIM YOUR DEVICES**

If you already have a device, you can associate its address to your personal address.

4 **PERSONALIZE ALERTS AND ERRORS**

Each project and user might need different alerts and errors according to the type of data they are working.

5 **START COLLECTING DATA, AUDITING AND BUILDING YOUR PARTNERS NETWORK**

Once the setup is finished, the data contributor is able to send and verify data in the network.

LoRaTRUST Platform

Levels of Integration

The LoRaTRUST system is currently operational and fully integrated with ESP32-based hardware models using LoRa technology. It is possible to adapt different models with minor changes to the library for use in LoRaTRUST, providing trust verification at the IoT node level.

To integrate proprietary devices, LoRaTRUST has been developed with different levels of integration. In the case of proprietary nodes, they can be connected to an open hardware gateway required for verification in the LoRaTRUST platform.

1	**FULL INTEGRATION** Open Source IoT Devices

- **Node Verification**
- **Gateway Verification**
- **Node Signature**
- **Gateway Signature**

2	**PARTIAL INTEGRATION** Proprietary IoT Devices

- Node Verification
- **Gateway Verification**
- Node Signature
- **Gateway Signature**

3	**PARTIAL INTEGRATION** IoT Cloud Service

- **API integration**

At the platform level, LoRaTRUST provides an API that enables IoT Cloud services to easily improve trust in the service. However, this integration requires improvements in scalability tests that will be developed during Stage 2.

Scalability
Readiness Levels - Stage 1
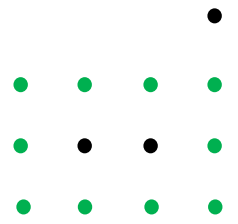
During Stage 1, we developed a proof-of-concept implementation and a prototype of LoRaTRUST, covering different dimensions such as scientific, technological, and business. We measured the improvements using the KTH Readiness Level. The **Technical Readiness Level** (TRL) started at TRL1 and ended at **TRL5** when the LoRaTRUST platform was deployed and evaluated in a testbed environment consisting of open-source hardware nodes and gateways, as well as blockchain nodes connected to the Ethereum testnet.

July 2022   April 2023
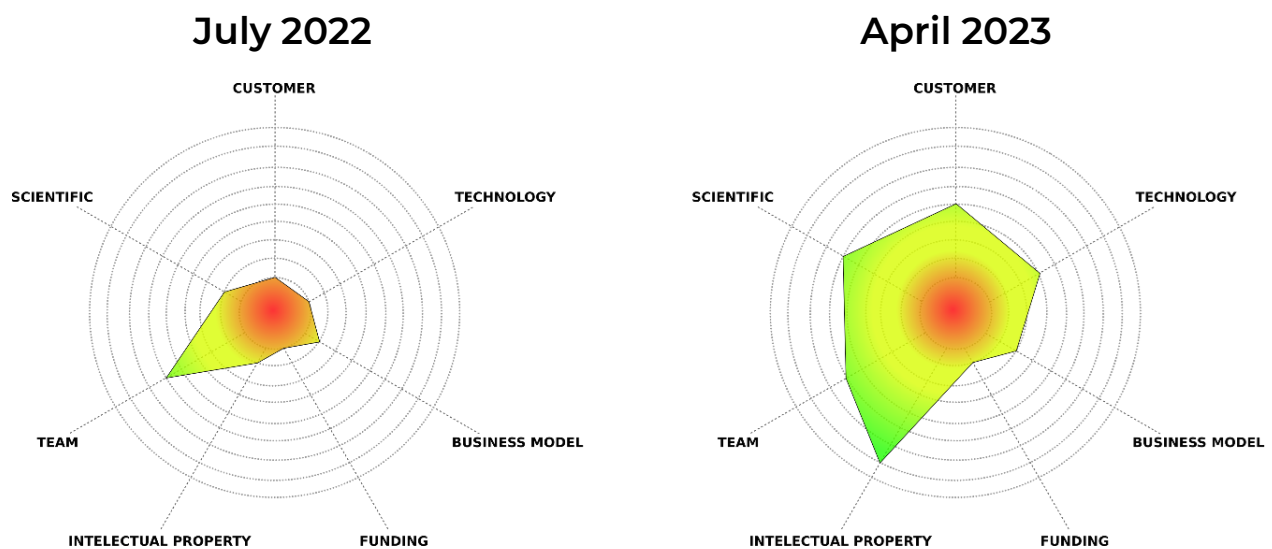
Fig.8: LoRaTRUST KTH Readiness Level from TruBlo Month 1 to TruBlo Month 9.

The **Scientific Readiness Level** (SRL) was improved from SRL2 to **SRL6** through research based on previous works within the team. We internally revised a paper and have already submitted it to an open-access journal.

LoRaTRUST started at **Business Readiness Level 1** (BRL1) and reached **BRL3** during Stage 1, with the draft for its business model and an overview of the market potential and competitors. We started with the **Customer Readiness Level** (CRL) at CRL1 and reached **CRL5** through partnerships with our first clients in Conservation, Food Chain, and Pollution Control.

Regarding intellectual property, LoRaTRUST is at **Intellectual Property Readiness Level** 8 (**IPRL8**). Our project is an open-source technology with a business model built on top of it. LoRaTRUST license is focused on community benefits and has a commercial version for companies that want to integrate it into proprietary solutions.

We kept the **Team Readiness Level** (TMRL) at **TMRL6** during Stage 1.

Scalability
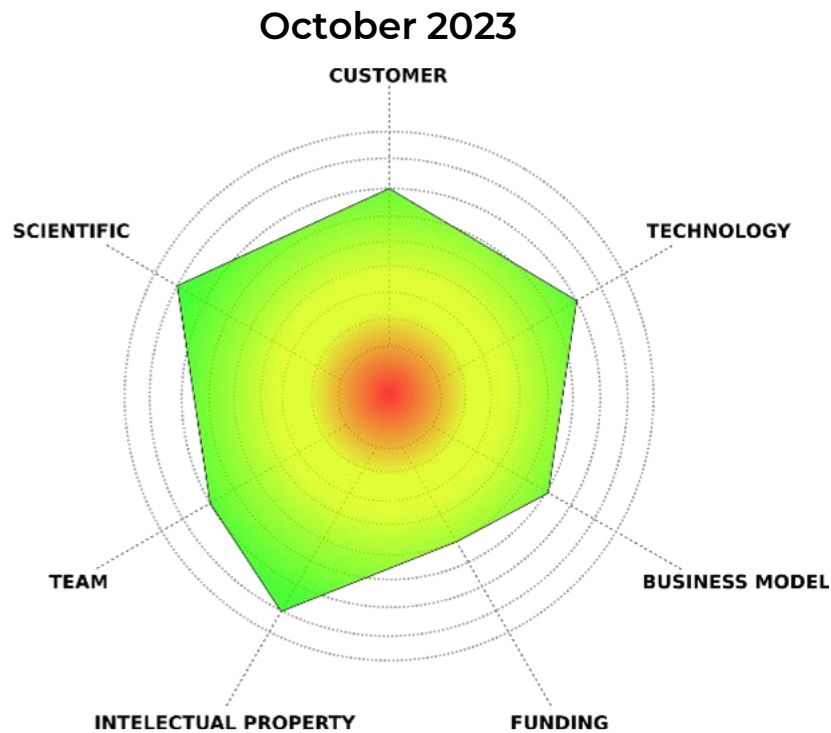## Readiness Levels - Stage 2

October 2023

Fig.9: LoRaTRUST KTH Readiness Level projected to the end of stage 2 (Month 15).

During **Stage 2**, our main objective is to consolidate the LoRaTRUST prototype into a Minimum Viable Product (**MVP**) and conduct pilots in actual environments to reach **TRL7**. We will focus on integrating the LoRaTRUST prototype into open hardware models and IoT services, which will be deployed in partnership with the REST-COAST project (see page 34) and extended to other partners (see page 38). During the pilots, we will advance the development and test of LoRaTRUST in a realistic and operational environment. Additionally, we aim to reach **SRL8** by publishing the currently submitted scientific paper, as well as another one in preparation that covers laboratory tests and validation results.

At the end of Stage 2, we aim to reach **BRL6** by making our first test sales and establishing an initial price for LoRaTRUST services. Our goal for Customer Readiness Level (CRL) is to consolidate interest in the product and extend our reach to more testers and testing sales, ultimately reaching **CRL7**.

To ensure long-term sustainability, the LoRaTRUST team is actively seeking funding and complementary opportunities to NG TruBlo. We anticipate receiving more funds to support LoRaTRUST's initial development stage, which will help us reach Funding Readiness Level 5 (**FRL5**). Our ultimate objective is to apply an updated plan for building the necessary team for the longer term, with a goal of achieving **TMRL8** by the end of Stage 2.

Sustainability

Business Potential

Global Environmental Monitoring market* and related software are forecasted to growth at CARG 4.82% by 2029

12.1 billion €
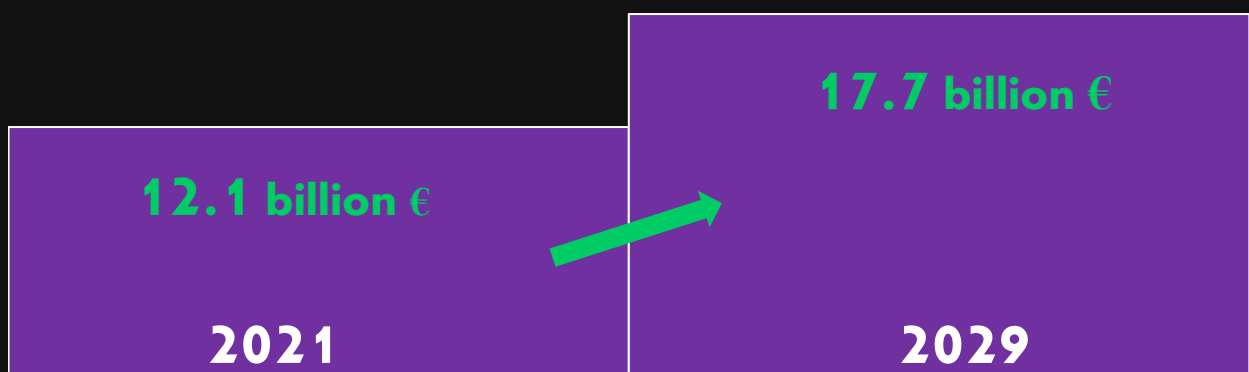
2021

17.7 billion €

2029

Fig.10: Global Environmental Monitoring market forecasted growth by 2029

The environmental monitoring market includes software, hardware, and services for pollution monitoring. Monitoring systems analyze air, water, and soil samples to monitor the quality of the environment.

These systems are used to monitor the environmental state during and after industrial operations, check the health status of cities or natural environments, identify sources of pollutants, monitor climate change effects, and verify vehicle and factory contamination.

Market growth is mainly driven by companies reorganizing operations after the COVID-19 impact, increasing public awareness of the health implications of environmental pollution, and rising levels of PM2.5 in the air. Additionally, governments' focus on pollution monitoring standards is expected to provide growth opportunities for environmental monitoring market players.

Most nations' economies depend on natural resources, including fossil fuels, metals, non-metallic minerals, biomass, water, and land. Sustainable use of natural resources to enhance productivity and reduce depletion rates would benefit the environment and promote economic growth. Lowering material inputs reduces waste and emissions, minimizes health and well-being risk factors, and cuts production and consumption costs in the short-term, as well as societal costs in the long-term. Sustainable resource management in agriculture, forestry, fishing, mining, and quarrying can limit the environmental impacts of these industries and help mitigate climate change and biodiversity loss.

* Source: Global Environmental Monitoring Market by researchandmarkets.com
Environmental Monitoring Technology Market: Industry Analysis (maximizemarketresearch.com)

Sustainability

Business Potential
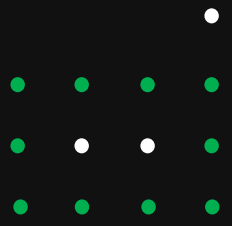
LoRaTRUST has enormous potential for application in all areas that rely on environmental sensors for measuring and verifying pollution control, and the data audit offered by LoRaTRUST can be instrumental in achieving this objective.

Specifically, we have identified the European software and Services Environmental monitoring market as our first target market. According to recent market studies, this market segment is expected to grow at a rate of 4.82% (CARG), and its size is estimated to reach €3 billion by 2029. By capturing just 0.5% of this market segment, we can generate an annual turnover of €6.934.796.

European Software and Services Environmental Monitoring market, 2029

Hardware 55%

Services 15%

Software 30%

Europe 17,4%

3 billion €

- North America
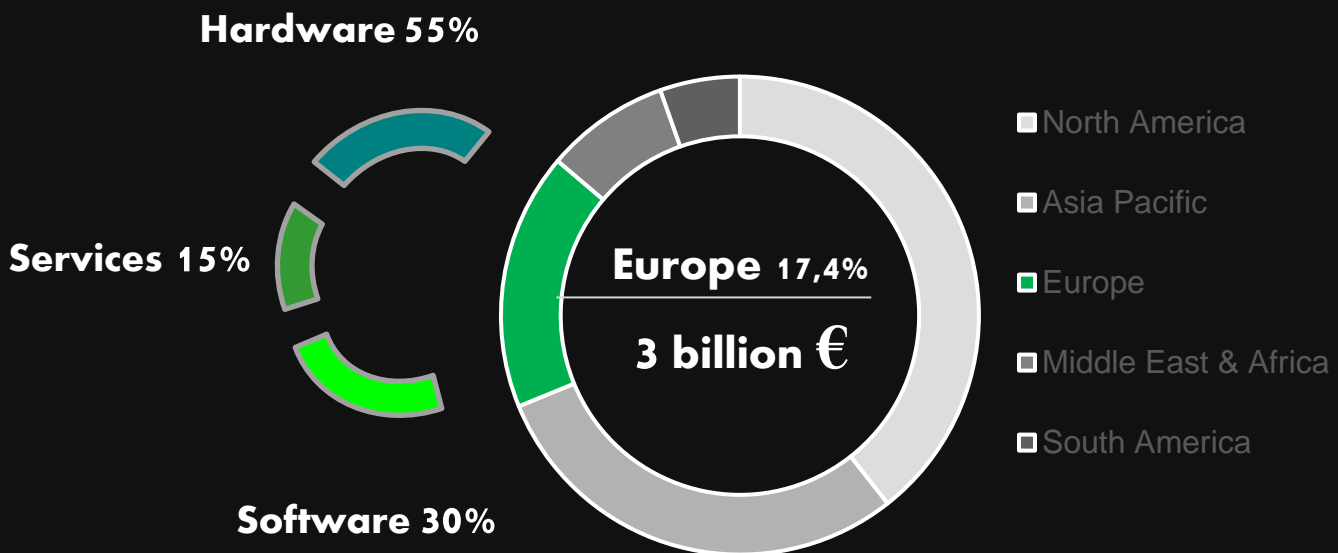- Asia Pacific
- Europe
- Middle East & Africa
- South America

Fig.11: European Environmental Monitoring market split by Hardware, Services and Software

European Software and Services Market make up 45% of the total European environmental monitoring market
whose projected value to 2029 is 1.38 billion €

0,5% MARKET SHARE = 6.934.796 €

Sustainability
## Implementation Possibilities

Environmental data quality, studies and conservation

LoRaTRUST is particularly suited for environmental monitoring, conservation of natural ecosystems, and restoration efforts. The platform was developed as a collaboration between the Polytechnic University of Catalonia's decentralized systems department and Hacking Ecology, a startup that creates open-source tools for environmental monitoring. Our team has first-hand experience with the challenge of unreliable environmental data and how improving data collection quality and efficiency can enhance studies and decision-making. We are proud to partner with the Center for Climate Resilience and the EURECAT office on the REST-COAST project, with plans to implement LoRaTRUST for coastal restoration starting in May 2023.

Fire Risk Control in large natural areas

Spain has been one of the European Union countries most impacted by forest fires, and this problem is likely to intensify due to the effects of climate change. In fact, 2022 has been the worst year in the last decade for forest fires in Spain.
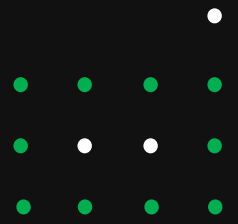

Hectares burned

309.000

30.318

29.870,75

| Last 10 years average | 2021 | 2022 |
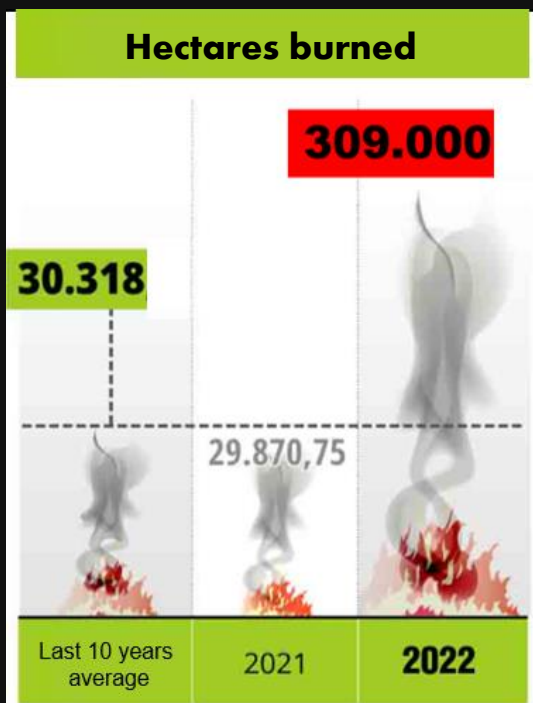
Certain sensors, such as those measuring temperature, humidity, and CO_2 levels, can be used to detect a high risk of fire or a fire in its early stages. LoRaTRUST has the potential to be a valuable tool in this context, as it can provide continuous monitoring of large, remote natural areas using radio connections and real-time alert systems.

The goal of LoRaTRUST in this context is to control environmental risks in protected and high-risk natural areas by providing connectivity for sensors deployed in these areas through LoRaTRUST's IoT layer.

Source: https://www.miteco.gob.es/es/biodiversidad/temas/incendios-forestales/estadisticas-avances.aspx

Sustainability

Implementation Possibilities

Pollution Levels, Environmental Impact Proof and Production Chain quality standards

As previously mentioned, various industries will be required to comply with pollution monitoring standards and demonstrate their environmental impact. Currently, environmental monitoring sensors are the primary tools used to gather data on environmental impact, and LoRaTRUST has the potential to be implemented for verifying pollution levels.

In addition to monitoring pollution levels, LoRaTRUST can also be used as a tool to determine the positive or negative environmental impact of a company or a specific action on the environment. By monitoring aspects of the production chain in industries that are monitored through sensors, LoRaTRUST can verify compliance with environmental regulations and ensure sustainable practices. As such, LoRaTRUST has the potential to not only improve environmental monitoring, but also facilitate sustainable development in various industries.

Smart cities

A smart city is a municipality that leverages information and communication technologies (ICT) to enhance operational efficiency, share information with the public, and improve the quality of government services and citizen welfare. The backbone of a Smart City's infrastructure is its network of Smart Sensors, which are deployed across the city and provide real-time information to public administrators and citizens via Wi-Fi. Smart Sensors commonly used in Smart Cities measure a range of variables such as humidity, light, traffic, parking, weather, air and water quality, water and electricity consumption, noise, and concentration of particles in the atmosphere. Many of these sensors have the goal of detecting and reducing levels of pollution in the city.

The role of LoRaTRUST in this context is two-fold:

- Firstly, municipalities will soon be required to account for their pollution levels and measure improvements in key performance indicators resulting from their policies. The integration of LoRaTRUST provides irrefutable evidence of the information reported in environmental impact reports.
- Secondly, there is a significant opportunity to involve organizations and citizens in data collection through their own sensors that can be integrated into their homes, means of transportation, or worn as wearable technology. LoRaTRUST allows for the verification of the reliability of the data shared by contributors and provides incentives for those who contribute such valuable information.

Sustainability
Implementation Possibilities
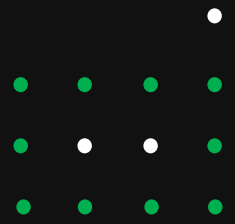
Maritime Industry

Maritime traffic is a significant contributor to global carbon emissions, responsible for 3% of the world's total carbon output. In addition to carbon dioxide, ships also emit other pollutants, including black carbon (BC), nitrogen oxides (NOx), and nitrous oxide (N_2O), all of which contribute to global climate change. Without action, the growing shipping sector's environmental impact could double in the coming decades.

To address this issue, the International Maritime Organization (IMO) has set clear targets for reducing the sector's carbon emissions. By 2030, the sector must reduce its carbon emissions by 40%, and by 2050, greenhouse gases from ships must be reduced to represent only 30% of the total, thereby decreasing the environmental impact by 70%. The IMO has also implemented an economic charge system that levies fees on polluting fuels to offset emissions.

However, the accurate measurement of pollutants from each vessel remains a significant challenge. To address this, a range of innovative techniques, including drones, satellites, and coastal sensors, are currently used to measure pollution from ships. Static sensors placed along coasts and bridges can monitor maritime traffic and identify various types of pollutants emitted by ships. These sensors can also be used by ships as monitoring systems.

To ensure the accuracy and reliability of pollution data from sensors, LoRaTRUST can play a critical role in validating contaminant data and serving as uncompromising proof of the veracity of this important information. As such, new technologies like LoRaTRUST are essential for quantifying and reducing the environmental impact of the shipping sector.

Sustainability
Implementation Possibilities
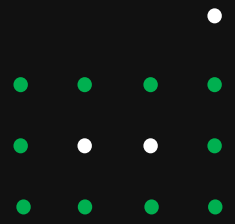
Coastal Conservation

LoRaTRUST is particularly suited for environmental monitoring, conservation of natural ecosystems, and restoration efforts. The platform was developed as a collaboration between the Polytechnic University of Catalonia's decentralized systems department and Hacking Ecology, a startup that creates open-source tools for environmental monitoring. Our team has first-hand experience with the challenge of unreliable environmental data and how improving data collection quality and efficiency can enhance studies and decision-making. We are proud to partner with the Center for Climate Resilience and the EURECAT office on the REST-COAST project, with plans to implement LoRaTRUST for coastal restoration starting in May 2023.

Food Chain Production *&* Ecosystem Services

The food industry has changed, embracing new standards that align with environmental, social, and governance initiatives, as the public invests more in sustainability. Farms, factories, and restaurants are integrating new technologies to make food systems more sustainable and streamline processes.

The focus on food product origin and the environmental impacts of production practices is increasing, and it has become necessary to trace shipped assets throughout the supply chain. The food services industry is now using technology to reduce environmental impact and gather asset data in real time. This data not only helps ensure environmental and social commitments are met, but also allows companies to accurately track assets throughout the supply chain.

The application of IoT sensors to the food industry has many benefits, including logistics tracking and monitoring environmental conditions to ensure food is properly preserved and safe to eat. IoT-enabled sensors and GPS allow food companies to track assets from the time they leave a farm or warehouse to their location on a store shelf.

In this area, the integration with LoRaTRUST can play an important role in monitoring or certifying the sustainability and environmental impact of all food production chains, particularly those linked to the exploitation of populations or territories and with little transparency due to a lack of legislation or controls. An example is the cocoa production chain in Latin America, which is one of the pilots planned in the LoRaTRUST roadmap.

Sustainability

Business Model

1 **SOFTWARE AS A SERVICE**
Monthly / Year subscription fee according to data points, dashboards, devices, data storage, assets, groups, feeds, white labelling

2 **TECHNICAL SUPPORT**
LoRaTRUST initial and ongoing integration, Setup fee + Technical support over time

3 **COMMERCIAL LICENSE**
For all organizations non-compatible with AGPLv3

4 **PRIVATE DECENTRALIZED IoT SERVICE**
Powered by LoRaTRUST Blockchain with Advanced Cryptographic Features

Sustainability
Business Model

5

MICROPAYMENTS
Sponsor a Project

The "SPONSOR THE PROJECT" link is crucial for ensuring the sustainability of each existing project within LoRaTRUST. Environmental monitoring projects can be initiated not only by companies but also by citizen associations, NGOs, or research institutions. The data generated from these projects can be made available to all citizens and useful for environmental studies and governments. Thus, it is reasonable for these beneficiaries to consider sponsoring some of the active projects to ensure their continuity and recognize the production of high-quality data as a reward.

Roadmap
LoRaTRUST
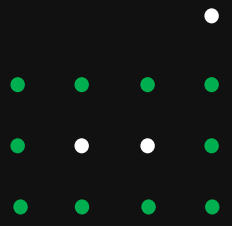
TRUBLO PROOF OF CONCEPT AND MVP

Development of the core architectural components

JULY 2022

LoRaTRUST Components, Design and technological solutions.

LoRaTRUST Prototype and validation. Online Demo Release

Scientific Paper, White paper

APRIL 2023

FIRST PILOT

Full Business Plan

Integrating LoRaTRUST into IoT Service: Pilot MVP

Pilot Deployment: Relevant Environment Test (REST-COAST)

Scale up pilot test on relevant environment

LoRaTRUST Beta Version

OCTOBER 2023

First paying client

PILOTS EXPANSIONS AND MARKET LAUNCH

Build the Commercial Team

Integration of LoRaTRUST into the 8 REST-COAST Pilots

New Pilots
Smart Cities
Maritime Pollution
Food Chain Production

Product/Services/Price Redefinition
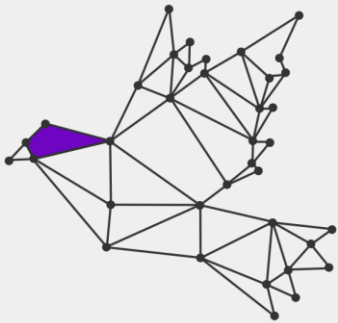
Next Steps

During the first stage of development, which was funded by the TruBlo grant, the LoRaTRUST team focused on developing an IoT data trust system that took into account end users and various use cases. We received feedback from different projects during this stage, and some of these projects expressed interest in testing LoRaTRUST by integrating it into their existing projects.

Our first official pilot partner is the Center of Climatic Resilience of Amposta (Eurecat), which is a member of the REST-COAST project. They reached out to us during the EcologyHUB acceleration program, and we agreed to co-finance a pilot between REST-COAST and LoRaTRUST. This pilot will help us develop the first marketable version of LoRaTRUST, which will be expanded to the other 8 pilots planned in REST-COAST after the first 6 months of testing.

In January, we also started conversations with Fum Al Port, which is the main project of The Things Network Mallorca. They are interested in verifying air pollution caused by ships and the maritime industry. We are also in talks with the Open Food Chain team about a pilot related to cacao production called Open Cacao Chain. The focus of this pilot is to add the ecosystem service dimension to the production chain to trace the positive environmental impact of sustainable agriculture.

Beyond TRUBLO, our objective for LoRaTRUST is to extend its implementation to various use cases and create success stories in key markets to prepare for commercial expansion. We offer partnerships in co-financed pilots to integrate our IoT data trust service and incentivized contribution.

THE FUTURE AHEAD

Next Pilots

LoRaTRUST for:

Costal Restoration:

The reliability of environmental data should be verified and connected to an alert and error system. This will improve data quality, network efficiency, and ensure well-informed decision-making.

Fire Risk Control

To provide early fire risk alerts in protected, extended, and high-risk natural areas, LoRaTRUST's IoT layer will be used to deliver real-time information from a sensor network with high reliability.

Maritime Industry Pollution

LoRaTRUST can enhance the trustworthiness of the sensors used to monitor the impact of ship activities on air quality.

Food Chain Production

To quantify and prove the environmental impact of the food production chain, GPS tracking and environmental data collected through sensors can be used to verify the geolocation and measure the positive effects of sustainable production practices on the environment.

Smart Cities

To improve the quality and efficiency of IoT data networks in cities, it is crucial to establish trust in the data provided by these networks. This can be achieved by implementing LoRaTRUST for reliable data collection, and fostering collaboration among stakeholders.

THE FUTURE AHEAD

A call for a Pilot

LoRaTRUST IN YOUR BUSINESS

At LoRaTRUST, we are actively seeking new opportunities for implementing and conducting pilots. If you have read our White Paper and are interested in collaborating, please do not hesitate to contact us.

We would be happy to explore the possibility of collaborating with you.

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DE CATALUNYA
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NGI TRUBLO

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ECOLOGY