SUPER EDGE

Edge Computing Token(ECT)

Whitepaper

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WHITEPAPER HISTORY

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1. BLUEPRINT FOR DECENTRALIZED CLOUD COMPUTING

Edge Cloud computing, larger, faster and stronger, can be deployed to the cloud,Everyone is a node network. The edge computing has the following characteristics: distributed and low delay computing edge computing focused real-time and short period data analysis, which can better support the real-time intelligent processing and execution of local business, which is more efficient because of the edge computing distance to the user, and the filtering and analysis of data at the edge node.

ECT leverages a set of research technologies that have been developed at the INRIA and CNRS research institutes in the field of **Desktop Grid** computing.The idea of Desktop Grid (aka. **Volunteer Computing**) is to collect the computer resources that are underutilized on the Internet to execute
very large parallel applications at the fraction of the cost of a traditional supercomputer.

We support equality for all, and everyone can become one of our node networks. Some nodes turn to a cluster. Full nodes run on cloud servers. Each cluster separate calculate to achieve the most efficient.

ECT is developing a new **Proof-of-Contribution (PoCo) protocol**, that will allow off-chain consensus. Thanks to the Proof-of-Contribution, external resource providers will have the usage of their resources certified directly in the blockchain.

SuperEdge allows open versions of such services to be created on its **public chain**, and then incorporated by private networks in the form of building blocks. Token holders ensure governance and allow developers to customize it to meet their own needs.

2. BACKGROUND

The concept of ECT first appeared at the end of 2017. Our current lifestyle (clothes, food, housing, etc.) has been grasped by major companies using big data calculations. ECT is doing the same thing as them, but we hope that everyone can manage their own information data and not be taken over by others.

We will adopt a node election method to create a huge ECT community. Everyone can control the node and upload the data in the node to other companies' databases. However, it is anonymous and will not reveal our privacy, but it can provide More convenient service for our lives.

Maybe you don't believe in decentralization. We will have a more convenient, more transparent, yet more able to protect our privacy in the future. Our lifestyle will undergo tremendous changes. This is also the direction we are working hard for!

3. CURRENT LIMITATIONS

3.1. Blockchain Computing Challenges

Blockchains like Ethereum offer a new approach to run decentralized applications (also referred to as DApps). Ethereum allows programmers to write smart contracts - code which is executed on the blockchain virtual machine. This represents a potential revolution in designing and executing ser- vices such as investment, finance, crowdfunding, internet of things, insurance, prediction markets, gambling, distributed data processing, and many more - in essence, disrupting a wide swath of cen- tralized incumbents.

Despite their unique promise, blockchains offer very limited computing capacities to run decen- tralized applications: few kilobytes of storage, very inefficient virtual machine and very high la- tency protocol. Eventually, blockchain technology will evolve to overcome some of these issues, but there will be an ever growing need to provide additional capacities to all but the simplest applications.

3.2. Traditional Computing Infrastructure Challenges

The existing clouds cannot fulfill the requirements of DApps that need fully decentralized infrastruc- tures for their execution. Meanwhile, there is a **growing demand for computing power from indus- tries and scientific communities to run large applications and process huge volumes of data.**

The computing power to run big data applications is most often provided by cloud and High Perfor- mance Computing (HPC) infrastructures. However, **cloud and HPC infrastructures are complex and expensive.** That means that innovative small businesses often don’t have the means and the exper- tise to acquire and operate HPC platforms, while traditional cloud infrastructure vendors like Amazon AWS are still very expensive for demanding applications (e.g. GPU rendering).

Furthermore, **data centers consume massive amounts of energy for running servers and the coo- ling systems. This is not only costly but can have a huge negative impact on the environment.** We need a new form of decentralized cloud that can enable blockchain computing and lower the cost of infrastructure usage.

4. THE ECT SOLUTION

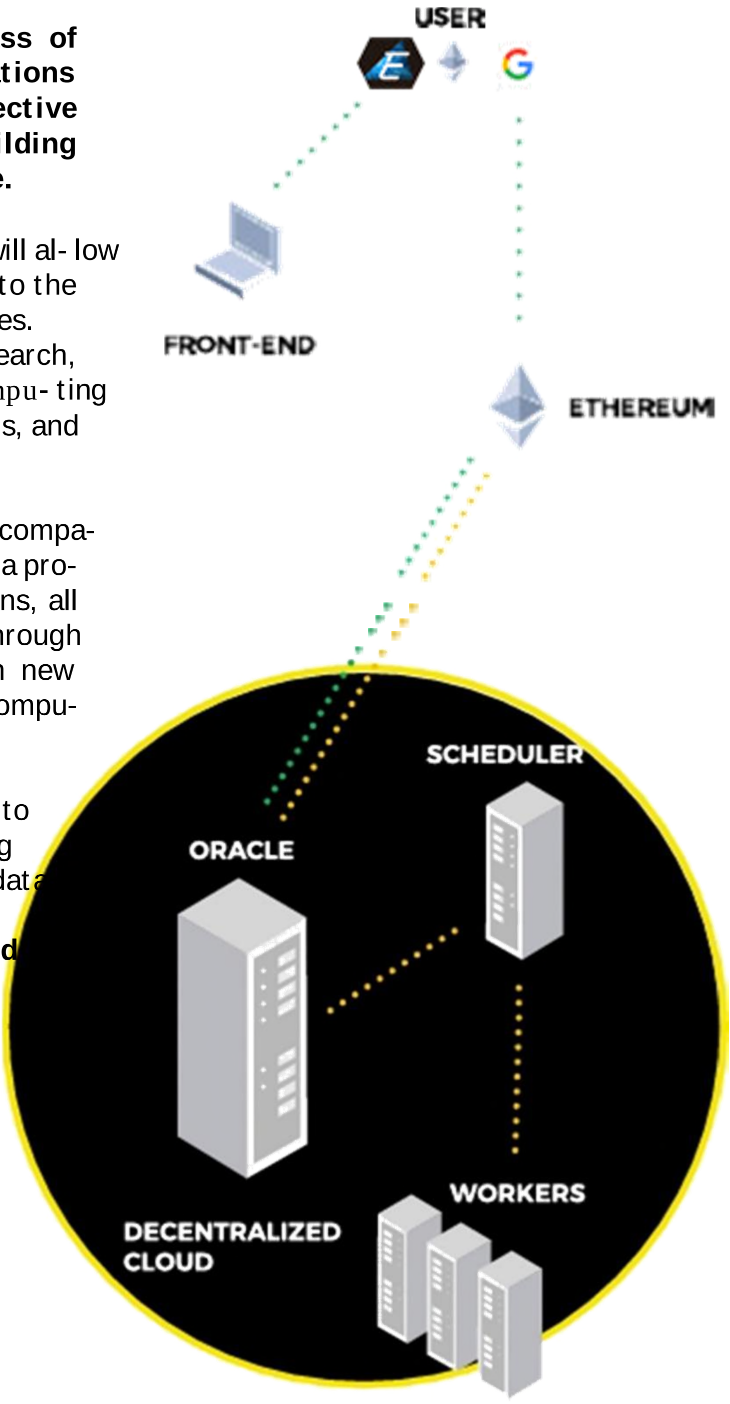
4.1. Technical Overview

ECT will support the emerging class of blockchain-based distributed applications and enable cost effective high-performance com- puting by building a decentralized cloud in- frastructure.

A blockchain-based decentralized cloud will al- low on-demand, secure and low-cost access to the most competitive computing infrastructures. DApps will rely on ECT to automatically search, find, provision, use, and release all the compu- ting resources they need: applications, datasets, and servers.

ECT envisions a new ecosystem of compa- nies offering storage, computer farms, data pro- viders, web hosting, and SaaS applications, all conducting business with each other through ECT. The decentralized cloud will open new markets for aggressive usage of existing compu- ting infrastructures.

To lower the amount of energy required to run the servers and the air conditioning systems, servers can be pushed out of data centers. **By easing the access to such machines, a distributed cloud would allow to drastically decrease the environmental footprint of data centers, while bringing the data closer to their producers and consumers.**



4.2. Core Value Proposition

ECT addresses the needs of all the decentralized businesses:

- DApp providers can perform off-chain computations on demand.
- Application providers can radically lower the computing costs of their decentralized applica-
tions by using a safe, robust and reliable infrastructure.
- Data providers can expand their potential market size by integrating their services with the
ECT marketplace.
- Server providers can monetize underused computing resources and increase the return on investment on their existing infrastructure, by seeking higher profits in providing their servers
in the ECT marketplace.

Existing infrastructure providers

ECT allows the rapid monetisation of existing computing resources for home users or additional monetisation for existing infrastructure providers like miners. **Functionalities like sharing spare cy-
cles, using servers in a compensatory approach and usage of resources from different providers without the hassle of resource management allows new use cases** and simple additional moneti- sation.

Decentralized applications or cloud infrastructure users

ECT will provide computing resources to decentralized applications at a much lower cost than tra- ditional blockchain computing resources, helping them drive more value for their customers. **Trans-
parent reputation of resource providers will reward reliable providers, with integrated Qua-
lity-of-Service controls** providing the required level of computing resources. Support for different resource providers and full visibility into partial contributions from each provider will also contribute to transparency.、

4.3. Key Technological Advancements

Developing a robust decentralized computing market network requires several technical break- throughs:

- Development of a Proof-of-Contribution protocol to offer provable consensus, traceability and
trust,
- Development of smart contracts to enable the acquisition and provisioning of computing re-
sources and automatic post-execution payments,
- Development of a technology that allows DApps to access off-chain computing resources on
demand,
- Development of a technology to advertise and utilize computing resources on the market network,
- Support for Service Level Agreements in resource utilisation by tracing resource usage and
providing verification of SLA fulfillment to both customers and providers.

The upcoming solutions proposed by ECT will position it as the world's premier

decentralized computing market.

5. MARKET OPPORTUNITY

5.1. The Perfect Timing for Go-to-Market

The convergence of several trends has created the optimal business environment for a decentralized cloud infrastructure.

1. The emergence of blockchain Proof-of-Work tokens has resulted in vast pools of computing resources that are optimised to seek the highest return on investment, providing ample resources on the supply side.
2. Smart contracts have reached the point where they can include all the complexity of a market network for decentralized computing resources, therefore vastly simplifying the infrastructure.
3. In addition to traditional cloud computing users, a new breed of distributed applications is coming into prominence, disrupting the incumbents and showing potential great promise for the future.

The sum of these trends justifies an imminent go-to market, in order to take the lead in cloud computing for dapps and be ready to scale with the increasing demand for cloud resources in the years to come.

5.2. The Blockchain Market

An ICO is an alternative means of financing a company. In this new operational model, the market approach of blockchain startups focuses on the circular economy and the needs of a well-defined ecosystem. Thanks to these cryptocurrency fundraisers, startups can raise millions in just a few days or even minutes. **In 2017, more than $4 billion was raised through ICOs around the world.** As of the time of writing, the total market capitalization of cryptocurrencies is over **$400 billion**. The demand for distributed ledger technology, reduced total cost of ownership, rising cryptocurrencies market cap and initial coin offerings, increasing demand for simplified business processes, trans- parency and immutability, faster transactions, and Blockchain-as-a-Service are all said to fuel the growth of this market.

In a report published on January 3, 2018, Royal Bank of Canada (RBC)' capital markets' analyst, Mitch Steves, confidently stated that the **cryptocurrencies and blockchain technology applications market could increase thirteenfold in 15 years, reaching $10 trillion.**

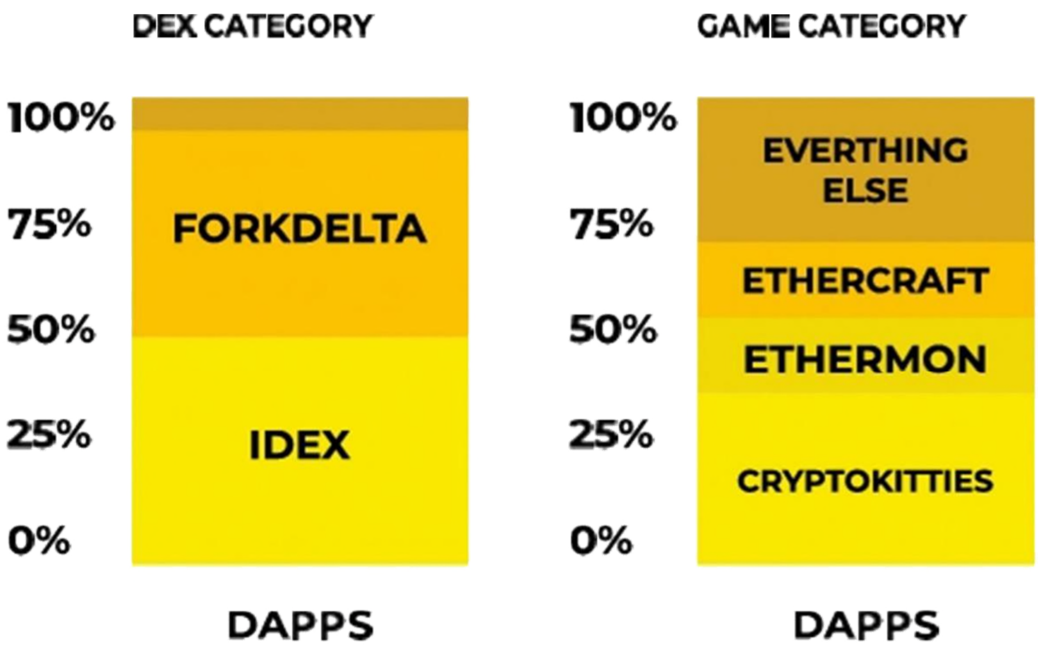
Blockchain-based cryptocurrencies will permit creating decentralized versions of value storage services like Dropbox or iCloud. The $10 trillion figure represents one third of the current size of the market for value storage.

At the same time, Steves warns that **cloud service providers are likely to be the most impacted from blockchain technology, with negative results if they don't manage to adapt.**

5.3. The DApps Market

In April 2018, Chris Mccann, from State of the DApps, has analyzed the top decentralized applications (dapps) built on top of Ethereum, the largest decentralized application platform.

The 312 dapps currently deployed can be clustered into 4 main broad categories: decentralized exchanges, games, casino applications and pyramid schemes.



One key takeaway from his research is that **the top dapps in each category are all still very small relative to traditional consumer web and mobile applications.** «We are orders of magnitudes away from consumer adoption of dapps, as no killer app (outside of tokens and trading) have been created yet. Any seemingly large dapp (e.g. IDEX, CryptoKitties) has low usage overall», observes Mccann.

	Transactions (over the last 7 days)	Estimated Daily Active Users (DAU)
Etheroll	18,322	53
IDEX	73,487	1,921
CryptoKitties	41,673	907

McCann concludes that "**we as an ecosystem need to build better tools and infrastructure for more widespread adoption of dapps.**" ECT envisions itself as one of these tools, by allowing decen- tralized applications to have a simple, secure and scalable access to powerful off-chain computing resources.

These resources will enable computational support for a wide plethora of CPU or GPU-intensive dapps, in the fields of artificial intelligence, cryptography, 3D rendering or scientific computing.

ECT has chosen to focus on dapps as a first step of its adoption strategy, and envisions a crypto sphere of more valuable and diversified applications that make use of the unique properties of blockchain, and grow throughout their journeys to compete with traditional consumer web ap- plications.

5.4. The Traditional Cloud Market

The cloud delivery and consumption model has revolutionized the entire IT industry over the past decade, as evidenced by the dramatic rise of public cloud services. In its first forecast of the «whole cloud» opportunity, International Data Corporation (IDC) estimates that worldwide **whole cloud**

revenues will reach $554 billion in 2021, which represents more than double those of 2016. The past few years have produced a steady stream of innovative new services introduced by the major public cloud service providers, including blockchain services, IoT back-end data services, encryption services, serverless computing services, and even new computing hardware services.

ECT will identify the areas where its decentralized cloud market network can best compete with existing cloud infrastructure providers, and focus its efforts on these potential competitive advantages. **The team's speed-to-market due to a comprehensive existing technological foundation will grant ECT first mover advantage, positioning ECT as the go-to computing provider for the decentralized applications of the future.**

ECT will allow traditional cloud services to be run in a new fashion within its decentralized network, enhanced by the Ethereum blockchain and the ECT sidechain. **This unique infrastructure will give birth to the first global market for computing resources, in which these resources are provided by a mix of private data centers and public workers.**

5.5. The Edge and Fog Computing Market

The Internet of Things is rapidly expanding its potential to transform everyday life with smart homes, cities, farms and manufacturing facilities. **There are huge growth prospects for the market**, with Gartner forecasting that 20.4 billion connected things will be in use worldwide by 2020.

Developing solutions for the Internet of Things requires unprecedented collaboration, coordination, and connectivity for each piece in the system, and throughout the system as a whole. All devices must work together and be integrated with all the other devices, and all devices must communicate and interact seamlessly and securely with connected systems and infrastructures. It is possible to achieve, but it can be expensive, time-consuming, and difficult, unless new lines of thinking and new approaches to IoT security emerge away from the current centralized model.

Fog computing is a horizontal, system-level architecture that distributes computing, storage, control and networking functions closer to the users along a cloud-to-thing continuum. The global fog computing market has the potential to reach more than $18 billion worldwide by 2022, according to a recent study from the 451Research OpenFog Project.

451 Research anticipates that adoption of the Fog-as-a-Service model will initially trail product-oriented approaches among early adopters, but that FaaS will grow to represent more than one-third of all deployments by 2022, as the outcome-based lease model grows in familiarity and popularity. **The cloud segment will grow from a 16.4% segment share in 2018 to a 35% segment share in 2022, to reach $6,3 billion in 2022.**

Growth of Fog as a Service

Research OpenFog project analysis

Vertical Market	2018	2019	2020	2021	2022	18-22 CAGR
Product	$862	$2.933	$6.012	$8.819	$11.810	92%
Y/Y Growth	-	240.1%	105.0%	46.7%	33.9%	
Segment Share	83.6%	79.1%	74.0%	69.5%	65.0%	
Cloud	$170	$773	$2.116	$3.875	$6.365	147%
Y/YGrowth	-	355.7%	173.6%	83.1%	64.2%	
Segment Share	16.4%	20.9%	26.0%	30.5%	35%	
Total	**$1.032**	**$3.706**	**$8.128**	**$12.694**	**$18.175**	**105%**
Y/YGrowth	0.0%	259.1%	119.3%	56.2%	43.2%	

ECT addresses both the edge and fog computing markets, since our open infrastructure can also work with a private pool of workers. Fog and cloud complement each other to form a service conti- nuum between the cloud and things, by providing mutually beneficial and interdependent services.

ECT actively participates in the elaboration of standards and contribute to building a frame of reference in the fields of fog and edge computing. To do so, ECT has joined the OpenFog Consor- tium, a thriving ecosystem of organizations who share a collective vision that fog computing is a key enabler to IoT and other advanced concepts in the digital world.

OpenFog includes ARM, Cisco, Dell, Intel, Microsoft, and Princeton University, and has since grown into a robust organization with nearly 50 members from across the globe. **ECT's goal and role within this consortium is to accelerate the deployment of fog computing technologies, with a focus on developing blockchain-based open architectures that will support intelligence at the edge of IoT.**

5.6. Competitive Landscape

We restrict our review of the competitive landscape to blockchain related activities, in particular to projects offering: off-chain computations, data hosting, and computing resources.

Several projects allow computing on untrusted resources, like **Enigma or Truebit.** While these projects are interesting from a research point of view, they often rely on solutions that severely limit their applicability, e.g. Multi-Party Computation for Enigma. In contrast, Proof-of-Contribution al- lows ECT to integrate any legacy applications or libraries.

ECT doesn't compete with blockchain-based online storage solution such as **Storj, Filecoin or Sia.** Instead, ECT allows the monetization of data sets usage, i.e. data access for a particular applica- tion execution. Oraclize acts as an intermediary between the smart contract and the source of data providing the guarantee that no-one else can push wrong data within the smart contract. These are complementary technologies, with which synergies can be found.

There exists few projects that offer computing resources through the blockchain. Gridcoin creates a cryptocurrency based on the computations provided to Boinc-based volunteer projects, thus it is mainly limited to altruistic contributions for scientific projects.

Golem, SONM and ECT share the same vision of a new Internet infrastructure enabled by the blockchain. However, their respective go-to-market strategies differ. Golem aims at first assembling a network to attract regular 3D rendering users to their platform, SONM is approaching the fog and edge computing from the beginning, while ECT first focuses on supporting dapps to build a decen- tralized cloud that eventually will be competitive enough to attract cloud and HPC users.

Besides, ECT has the following advantages compared with existing and future challengers:

- ECT leverages decades of research by its founding members in the field of Desktop Grid com- puting
- The ECT team was instrumental in establishing the European Desktop Grid Infrastructure, and has therefore strong ties with key industrial companies like Total, IBM, Airbus, Orange, IFP Energy, as well as innovative startups
- Reduced time-to-market because ECT is backed by mature technologies, such as the XtremWeb-HEP middleware
- Enterprise-oriented features
- Proof-of-Contribution (PoCo) is a unique and advanced algorithm that incentives network growth and optimal usage of the platform
- Revenue model at each version of the development roadmap

6. BUSINESS USE CASE: EFAST

Based on the typical distributed application requirements, we have prepared a business use case for a service that improves financial trading based on sophisticated computational methods that require HPC for their execution: eFast.

An important feature of ECT is the interconnection between applications, services, data and computing resources. In this use case, eFast is using data and computing resource providers avai- lable via blockchain technologies.

Application providers

eFast is an application created with the goal of helping small investors improve their trading deci- sions via different services such as clusterization of stocks based on sophisticated computational methods. The computational complexity requires high performance computing (HPC) for the execu- tion that is until now, available only to large financial institutions. By using the ECT distributed cloud as a virtual supercomputer, eFast will be able to offer its clients a budget-friendly and secure service to improve their investment decisions.

Each new service developed in eFast will be sold directly on the blockchain, similarly to the Software-as-a-Service approach from traditional cloud. eFast customers will use dedicated smart contracts, which define the eFast functionalities and usage rights within ECT.

Data providers

Data is an important source of business, technical and scientific innovation. This has driven the emer- gence of a blockchain-based data marketplaces with companies like Ledgys and Kaiko.com, an archive of cryptocurrency stock exchange data. ECT will enable eFast, the application provider, to connect to the data provider Kaiko.com, enabling eFast to run based on a specific user-defined portfolio.

Computing resource providers

AWS or Microsoft Azure, decentralized cloud service providers like Qarnot Computing or Stimergy, or blockchain mining companies like Genesis Mining which are always looking to optimize their resource profitability for example, by running HPC computations in conjunction with mining Ethereum blocks. A user can select eFast as the application to be used, Kaiko as the data provider and Stimergy as the resource provider. Application, data, and resource are afterwards represented as smart contracts deployed on the blockchain, embedding their terms of use.

7. TECHNOLOGY OVERVIEW

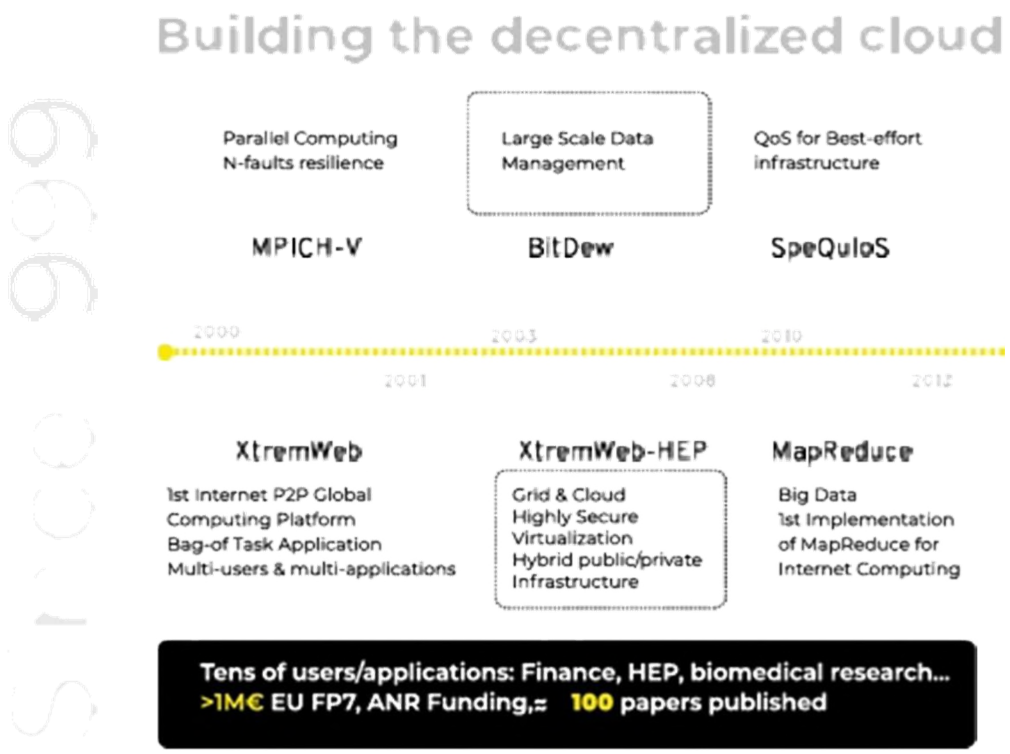
7.1. Background: Desktop Grid Computing

Desktop Grid (i.e. Volunteer Computing) uses underutilized computing resources to execute very large parallel applications at the fraction of the cost of a traditional supercomputer. Some examples include well-known applications like SETI@Home, Folding@home, and distributed.net.

Desktop Grid Computing includes several features that make it a good platform for a fully-decentralized cloud:

- **Resilience:** if a node fails, computing continues on the other working nodes.
- **Efficiency:** applications get excellent performances even if computing nodes are highly heterogeneous.
- **Ease of deployment:** allows to use any nodes without specific configuration, even those located on the edge of the Internet.

This makes Desktop Grid the perfect solution for assembling hybrid infrastructures, whose computing resources can range from classical high performance computing clusters, cloud infrastructure providers and home personal computers.



ECT relies on Desktop Grid open-source software that we have developed at the CNRS and INRIA research institutes to assemble loosely distributed computing resources for HPC and Big Data.

XtremWeb-HEP is a mature, solid, and open-source Desktop Grid software that allows to use any kind of computing resources for executing compute-intensive or data-intensive applications.
During the last decade, we have also developed a large portfolio of technologies for distributed computing: MPICH-V for parallel computing, BitDew for large scale data management, SpeQuloS for providing quality of service to application execution, the first implementation of MapReduce for Internet computing, and more. Many of our research results have been published in top scientific conferences and journals (over 80 papers published) and we successfully raised more than €1,000,000 of public funding including several EU research grants.
We have obtained a unique expertise in making the Desktop Grid technology running and available to

various scientific communities as well as startups and innovative industries.

- From 2007 to 2012, with several European partners, we established the European Desktop Grid Infrastructure (EDGI). This considerable effort was supported by the European Union, which funded 4 FP7 projects (EDGeS, EDGI, DEGISCO, IDGF). The goal was to provide researchers and academics with additional computing power coming from Desktop Grid infrastructures. EDGI has been a huge success. We connected a dozen of sites (Hungary, France, UK, Spain and The Netherlands) to the main European e-infrastructures, such as the one supporting the Large Hadron Collider in Switzerland. We gained a considerable experience in connecting clouds and HPC systems to Desktop Grids as we succeeded in transparently executing millions of jobs on more than 200,000 nodes.
- The ECT team showed the applicability of the technology in many fields of science: high energy physics, biomedical research, mathematics, financial algorithms, material research, 3D rendering, and more.
- We collaborated with the key industry players such as Total, Airbus, or IFP. More recently, we received funding from the French National Research Industry in order to provide innovative SMEs access to low-cost, on-demand and secure HPC services. We conducted many interviews with SMEs from the biomedical and e-health sector to understand their needs and requirements and designed MVPs and PoCs. The emergence of blockchain was the key enabler that triggered our motivation that eventually led to the ECT project.
- The knowledge and experience gained by exploring, inventing and establishing Internet-wide distributed computing infrastructures is a crucial part in creating a distributed cloud for blockchain-based distributed applications, while the foundation of already developed techno- logy guarantees a fast time to market and timely project completion.

7.2. The iExec Sidechain Infrastructure

ECT relies on the blockchain to coordinate the access of computing resources to distributed applications. This approach led to several innovations with respect to classical blockchain technologies - in particular, the Proof-of-Contribution consensus protocol and a domain-specific sidechain.

7.3. Proof-of-Contribution

7.3.1. Consensus Protocols

Traditional blockchains such as Bitcoin or Ethereum rely on the Proof-of-Work protocol, which ensures that token transactions that happen on the blockchain between participants are validated by a large number of nodes using cryptographic challenges. With ECT, a contribution, i.e. some actions that happen out of the blockchain (like providing a data set, transferring a file, performing a computation, giving a human expertise) will lead to token transactions between participants.

This means that a new protocol is needed to prove the fact that contribution actually happened correctly and that the corresponding token transactions can take place in the blockchain. We call this kind of consensus protocol Proof-of-Contribution.

There are several similar protocols [Filecoin, Gridcoin, Fatcom], which allow the building of a consensus between the blockchain and off-chain resources. For example, Gridcoin proposed the Proof-of-Research protocol to reward volunteers who donated part of their computer time to a great scientific computation [BOINC] such as biomedical research (Folding@Home). Proof-of-Contribution is designed to be a more universal framework, allowing to validate a greater number of actions.

7.3.2. The Need for PoCo

ECT is building a decentralized cloud platform where application providers, dataset owners, owner of computing resources (workers) and users can value their assets using the RLC token.
While the platform can be compared to existing ones, the fully decentralized nature of ECT implies that no single agent needs to be trusted and that those agents require incentives to contribute correctly. In this context, PoCo (for Proof-of-Contribution) is a protocol developed by ECT, which des-

cribes the interactions between the different agents and leverage features such as staking to build the required incentives.

7.3.3. The Role of PoCo within the iExec Platform

The ECT platform requires two entities in order to work:

- A marketplace where agents propose their resources and where deals are made using the RLC token.
- A distributed computing infrastructure based on the middleware XtremWeb-HEP.

PoCo acts as a link between those two entities. When a deal is sealed, PoCo initiates a consensus which will validate the different contributions made by workers in the middleware. When consensus on the result of the computation is reached, PoCo triggers the relevant transaction which takes place in the marketplace.

As stated previously, different agents have different roles and different incentives. Before describing the protocol itself lets first list those agents:

- **Workers:** They are individuals or companies who own computing resources and are willing to make them available for the computation of tasks against payments in RLC. Similarly to blockchain miners, they want a simple solution that will make their computer part of a large infrastructure that will take care of the details for them.
- **Worker pools:** Worker pools organize workers contributions. They are led by a scheduler, who organises the work distribution. They can either be public and federate resources from anyone or private and try to optimise the management of specific hardware. While not doing the actual computation, they receive a fee for the management of the infrastructure. They compete to attract workers, which they do by achieving an efficient management which guarantees the income of workers.
- **App providers:** They deploy applications on the ECT platform. Those applications can be Dapps using the full potential of blockchain-based decentralized Cloud or legacy applications which could benefit from the ECT decentralized Cloud. They can make their applications avai- lable for free or ask for a fixed fee for each use of their application.
- **Dataset providers:** They own valuable datasets and are willing to make them available, in a secure paradigm that protects their ownership, against payments in RLC.
- **Users:** They are individuals or smart contracts paying for the execution of tasks, with or without specific datasets, using the computing resources of workers. They want to make sure that the results they receive are correct.
- **The ECT Hub & Marketplace:** This is a smart contract, deployed by ECT, and without privileged access. It acts as an escrow for the different agents' stake and ensures the security and transparency of all transaction in the ECT ecosystem.

The ECT Hub &Marketplace decentralization, security and confidence are ensured by the blockchain technology. All others agents are considered as potentially malicious. The design of PoCo's oversight of all transactions between the agents is done in such a way that it creates strong economic incentives to behave correctly. This makes ECT much more than other conventional cloud providers by giving it the capability of organising a trusted computing platform on top of an infrastructure of untrusted agents. Not only is this trust building process an interesting feature to have, it is essential to providing any result to blockchain users and smart contracts.

7.4. Domain Specific Sidechain

Ethereum allows code to be executed on the blockchain using smart contracts - a great advance for blockchain technology. However, the DAO attack [HackDistrib] has shown that dealing with smart contracts is a complex issue, especially when everyone is allowed to deploy them. To prevent potential security issues, ECT will follow a more restrictive approach: a Domain Specific Sidechain.

Domain Specific Sidechain also means that we will adapt the blockchain to meet the requirement of distributed infrastructure management. There might be the case where transactions would arrive "en masse" (i.e. tasks submissions) or case where low latency (communication/acknowledgement) is re- quired. In this case, relying on a sidechain with specific capabilities can allow to process these events.

For Josh Stark, co-founder at L4, the projects working to build the Ethereum infrastructure and expand its capabilities are commonly referred to as scaling solutions. These take many different forms, and are often compatible or complimentary with each other.

"Cryptoeconomic consensus gives us a core hard kernel of certainty—unless something extreme like a 51% attack happens, we know that on-chain operations—like payments, or smart-contracts—will execute as written. The insight behind layer 2 solutions is that we can use this core kernel of certainty as an anchor—a fixed point to which we attach additional economic mechanisms. This second layer of economic mechanisms can extend the utility of public blockchains outwards, letting us have interactions off of the blockchain that can still reliably refer back to that core kernel if necessary", explains Josh Stark.

Many layer 2 scaling solutions are currently being developed, each offering a specific tradeoff between speed, finality, and overhead. Among these, we can cite state channels, 0x, Plasma, Raiden, PoA and Parity Bridge, Cosmos, etc.

ECT will leverage a Domain Specific Sidechain to lower the costs of gas on Ethereum, while choosing a solution differentiating itself by its applicability to other main chains.

7.5. iExec Smart Contracts: Matchmaking

A Matchmaking algorithm [Matchmaking] is used in distributed systems to pair a resource request with a resource offer according to their description. When designing a distributed Cloud, the Matchmaking algorithm is an essential building block in resource provisioning. It basically answers the question: can I run this task on this machine? We envision the ECT blockchain to store smart contracts describing the computing resources characteristics, such as for example amount of RAM, CPU type, disk space. That means that some contracts will describe the requirements for running a task or deploying a VM instance (minimum amount of disk space, RAM, GPU runtime requirement, expected hypervisor etc.). A Matchmaking contract will do the pairing, possibly implementing different kind of policies.

Several Matchmaking description languages have been described in scientific articles and implemented in software. ECT team plans to design and adapt a simplified version of the well-known and tested ClassAd [ClassAds] that powers the CondorHTC distributed system, developed at the University of Wisconsin.

7.6. iExec Smart Contracts: Multi-Criteria Scheduling

In distributed systems, a scheduling algorithm distributes a set of tasks to execute on a set of computing resources. The scheduler is a key component of any distributed computing systems, as the performance of the application execution mainly depends of its effectiveness. In particular, a challenge is to design multi-criteria scheduler, i.e. an algorithm that has several strategies to select the computing resources and schedule the tasks. For instance, one customer may want to minimize the price even if the computation takes a longer time, while another customer may want the best performances even at a higher cost.

The ECT team has developed an advanced multi-criteria scheduler [MulticritSched], which allows customers to define their own preferences based on criteria such cost, performance, trust, reliability, and energy efficiency. ECT will adopt a simplified version of this scheduler.

7.7. iExec Smart Contracts: A Market Management Framework

There is still no Ethereum framework to manage a market, allowing the users to put offers and demands to be stored and updated dynamically. ECT will develop a simple API to register bids and a set of template contracts to easily deploy customized markets. ECT will also provide web user interface and the JavaScript code that allows interacting with the contracts and easily placing orders.

7.8. iExec Smart Contracts: Result-Checking on the Blockchain

Result checking is a process that verifies that a result has been correctly computed by an untrusted node [Sarmenta], and there exist several approaches to implementing it. However, existing methods (replication and voting, spot checking, reputation etc.) have been designed with the assumption that the computation were done for free (ignoring the economic perspective). ECT will develop a new result checking algorithm that leverages the blockchain and the smart contract features. By this approach, users will be able to choose business partners from the market based on their provable reputation and on the established budget.

This will enable for example escrow type mechanisms, where payments for the execution will be deferred until the result has been certified. This mechanism can also be coupled with a reputation system that is stored on the blockchain and enables the platform to only run redundant computations for the less trusted nodes, greatly reducing the required resources and price of computing.

7.9. Verified File Transfers

It is likely that commercial content distribution will be one of the biggest functions of distributed applications using the ECT blockchain. This would for example mean customers paying for high value datasets (like genetic or financial data) using smart contracts that would give them access to data.

ECT will guarantee that a content provider was actually able to provide the file, and confirm that the file has actually been downloaded before processing the payment, therefore protecting the data recipient. ECT also protects data providers against malicious downloaders, who could pretend that the file transfer didn't succeed in order to reclaim the payment.

7.10. Governance

Because ECT will only authorize signed smart contracts to be deployed on the blockchain, a form of governance is necessary to consider, such as peer reviews, and sometimes revoking smart contracts. A smart contract should include:

- A proposition describing the contract, written similarly to RFC standards,
- The code of the smart contract associated with the description.

Eventually, a distributed standardization body will collaboratively evaluate and elaborate the smart contract propositions.

7.11. Proof-of-Concepts

To demonstrate the potential of the platform and to show its technical feasibility, we have prepared several Proof-of-Concepts, based on our already developed technology.

There are many commercial and research distributed applications well-suited for running on the ECT platform. This not only provides lower costs but also highly scalable performance. Here are just a few examples that have been integrated in the PoC platform and that can immediately be used:

- **Video transcoding:** Ffmpeg, a complete, cross-platform solution to record, convert and stream audio and video.
- **Physics simulation:** Guineapigpp, simulation of beam-beam interactions in high energy e+e-colliders.
- **Digital signal processing (DSP):** University of Westminster.
- **Physics Computation (ISDEP):** Fusion, solving the dynamics of fusion plasma.

- **Audio Analysis:** Dart, a framework for Distributed Audio Analysis and Music Information Retrieval.
- **Optimization Algorithms:** BNBSS, different type of deterministic and heuristic optimization algorithms for solving global optimization problems.

Blockchain-based cloud computing

Announced at Devcon2, ECT, INRIA and the Stimergy startup in France have collaborated on the provisioning of a distributed data-center through a smart contract deployed on the Ethereum blockchain.

Off-chain computations

In November 2016, within the Supercomputing Conference (Salt Lake City), we have demoed how off-chain computations can easily be made thanks to ECT. It only takes minutes to insert an application in the ECT application repository. Then end-users can interact with their applications using the Metamask front-end - like executing the application, by sending a transaction to its corresponding smart contract. After the execution of the application, the result is available directly on the blockchain.

High scalability

In order to evaluate the scalability of the solution, we have conducted preliminary performance evaluation using the Grid5000 research infrastructure in France. Our results are very encouraging, as ECT shows excellent performances for a single worker pool that contains up to 3,000 nodes and using the DSP applications. Of course, being a distributed Cloud, anyone will be able to deploy its own ECT pool.

8. THE MARKETPLACE FOR CLOUD RESOURCES

8.1. The Cloud Computing Marketplace

8.1.1. Cloud Computing as a Commodity

ECT introduces a new paradigm in cloud computing: it will allow the trading of computing resources as commodities; in the same way we may observe with resources such as oil, gold or rice.

To understand the benefit of a global market for computing power, let us draw comparisons with the oil market. When you are stopped at a gas station, filling your car with oil, you have little to no idea where that oil comes from or how it arrived at that gas pump. There is an entire industry behind the scenes, that has standardized the whole process from petroleum extraction, to processing, to transport and delivery, and eventual utility being consumed by vehicles.

Now take the example of an application developer. A developer needs resources too, in the form of computing power from cloud vendors to 'fuel' his applications. However, in contrast, they do not have the luxury of benefiting from an organized and global market with abundant choice of vendors and competitive prices.

Let's imagine you are a driver in the same situation, with no choice but to fuel a car in the same way developers fuel their apps. Being a driver in this case, you would have to call a specific Iranian or Venezuelan extractor to organize oil transported directly to your car. What's worse is that, because each oil company produces its specific oil without standardization, the driver would probably have to process or 'transform' the oil so that it is compatible with his car. Today, this is the situation developers find themselves in, in the current age of cloud computing.

Therefore, the entire infrastructure must be changed. **Our vision with ECT is to create the first global market for computing resources.**

8.1.2. Workers Pools

Computing resources will have the possibility to be integrated into the ECT network, making it the first decentralized cloud that is able to execute any type of applications using (almost) any type of resource. Any machine will be able to become a "worker", i.e. getting paid in RLC for executing appli- cation tasks.

Workers will be organized in **worker pools.** Each worker pool is managed by a **scheduler**, whose responsibility is to distribute tasks to workers. Thus, a worker pool is somewhat similar to what we know as 'mining' pools. An individual miner often joins a mining pool to maximize their chances of getting reward computations. Similarly, as a worker, you would join a public worker pool that will make sure that it has sufficient workload to distribute.

An interesting feature is that several **public worker pools** will compete, therefore allowing for the best possible quality of service. As a worker, if you switch to a different worker pool, you will still be able maintain your reputation, bringing it 'with you' to the new pool, as this is all recorded on the blockchain.

In the marketplace, you will also find what we call **"private" workers pools**, where all machines are provided by a single cloud provider running his own scheduler. We already have sealed agreement deals with several cloud companies in the area of 'Green IT' that offer more sustainable approaches to data centers.

What does it change for developers? A piece of 'work' is now defined as triplet: an application, a dataset, and a worker pool. It means that **every dapp can now have access to unlimited off-chain computing resources** just by specifying this triplet. Developers simply have to deploy their legacy applications (as Docker containers) and datasets, and to connect to an existing worker pool.

8.1.3. The ECT Marketplace

Thanks to the ECT Marketplace, users will be able to view all the different worker pools, the available resources, the prices for using them, and so on.

Based on these different offers, users and developers will select the corresponding pool to execute their task. **The marketplace is implemented as a smart contract and is already part of our 'PoCo' protocol. The marketplace provides an easy-to-use interface so that users and developers can see how the market and ecosystem is dynamically evolving.**

8.1.4. Pay-per-Task (PPT)

To make this market possible, we have to change the way pricing is done in traditional cloud computing. With AWS for instance, you use a particular instance, which have known characteristics for some time. Hence, the common way of pricing the usage is the renting of an instance per hour, depending on the zone. Such method cannot be used to build a global marketplace, because the resources will come from many providers (including Internet users) and thus will be very heterogeneous.

To address this issue we are **introducing a new method for pricing that we call Pay-per-Task**, and we have defined several task categories that describe the execution boundaries. We'll start with a very simple definition for task categories, namely wall clock time on a reference machine and amount of data transferred. We'll setup a test infrastructure so that application developers can evaluate the category of their submissions. Conversely, **worker pools will be able to benchmark their infrastructures against the reference machine.** Later, we'll refine the categories, and provide more advanced tools for helping developers to maximize the usage of the infrastructure.

8.2. The DApp Store

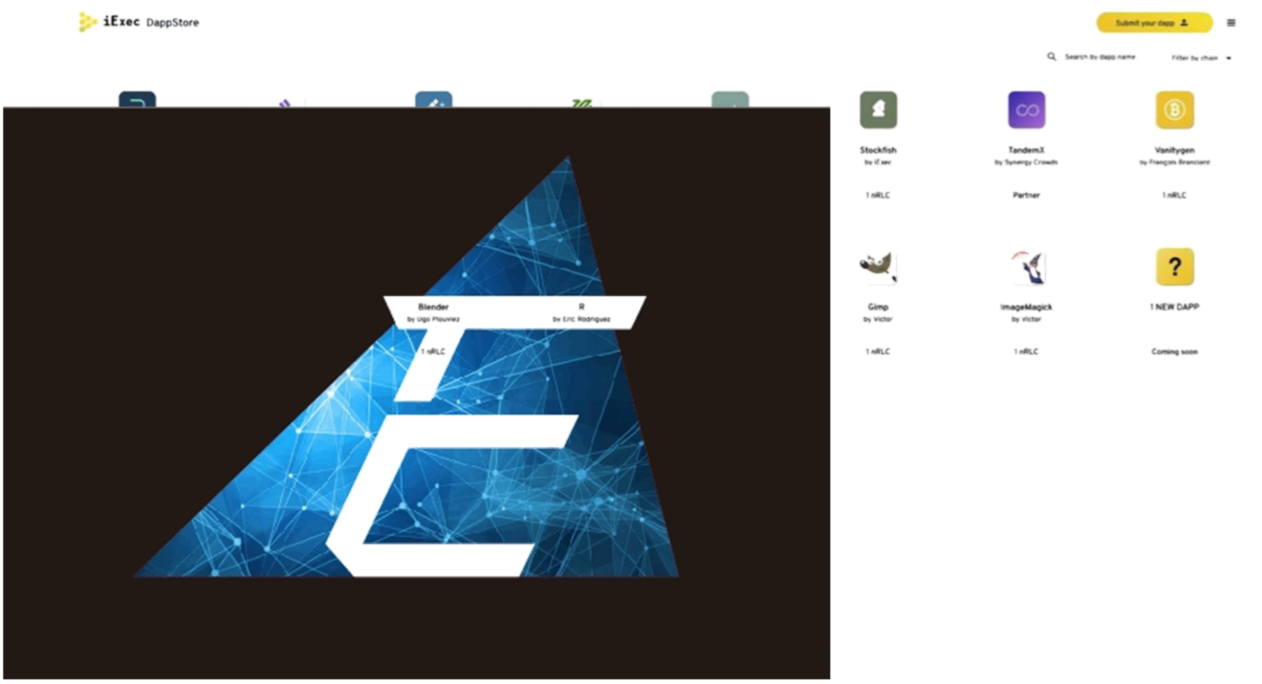
The decentralized cloud opens the way to a whole new generation of applications based on the Ethereum blockchain. These decentralized applications are referred to as 'dapps'. By design, the capacity of the Ethereum blockchain is limited to applications with very low computation requirements; ECT increases the computing capacity for all these new decentralized applications.

On the journey of becoming a cutting-edge cloud network, **ECT has launched the first-ever DApp Store** for decentralized applications in mid-December 2017. Targeted sectors will be artificial intelligence, big data, IoT and fintech-based applications that require intensive computing power.

All the applications built on top of ECT will be listed on the DApp Store. **Users will be able to browse through the existing dapps and use their favorites, while developers can submit their own dapps and earn money if they wish to monetize them.**

The DApp Store can be seen as a collection of applications spanning all use cases. These apps are curated and classified into multiple categories. Applications are ranked following their reputation, and users can discuss and leave comments on each dapp page.

This Dapp Store is connected to the Cloud Computing Marketplace, as well as to the Data Marketplace, realizing the triptych that will power a new generation of powerful dapps. Providing a platform



for dapps with an open marketplace model is an important step towards a decentralized economy. We are proud to be a strong actor being able to deliver products to feed this trend.

In order to boost the development of applications on the blockchain, ECT will organize regular challenges aimed at funding the most innovative and impactful applications relying on the ECT cloud resources. The first edition of the DApp Challenge has reserved a prize pool of $150,000 to support the most promising proposals received.

8.3. The Data Marketplace

Today in the world of Big Data, massive datasets are waiting to be turned into value. Facebook and Google do it well, but we at ECT believe this can be done by anyone, which is why we will build a marketplace to connect those that have data to those that don't have it, but would like to leverage it. Applications running on ECT will be able to make use of an ocean of data at their disposal.

The Data Marketplace allows anyone to sell data, whether it is an application that accumulates data, big corporations or individuals. Data can span from a wide variety of fields such as financial data from stock markets, user behavior data from an e-commerce website, or anonymized medical data from a hospital. Applications can then buy and run algorithms on this new tap of data, by relying on the decentralized computing resources provided on the Cloud Marketplace.

Together, the ECT Cloud Marketplace, DApp Store, and Data Marketplace represent the three bricks of the triptych that will power blockchain-based decentralized applications and beyond.

9. ROADMAP

To achieve our goals, we developed the following implementation roadmap according to several funding levels.

With the minimum funding (2,000 BTC), ECT will deliver an initial market network that allows to monetize applications and servers. With a maximum funding (10,000 BTC), ECT will gradually develop the market network including data providers and HPC applications, then establish recurrent sources of revenue to ECT.

9.1. Go-To-Market Strategy

We will develop 5 versions of the product (V1 to V5) that correspond to 3 steps in terms of go-to-market strategy.

- **Community Edition (V1)**
  Features to create an open-source software that allows to build the decentralized cloud.
- **Enterprise Edition (V2, V3, V4)**
  Features to establish a full market network profitable for a wide range of businesses.
- **Research Edition (V5)**
  Features to make serious advances that can address wider topics than cloud computing (IoT, Fog/ Edge computing).

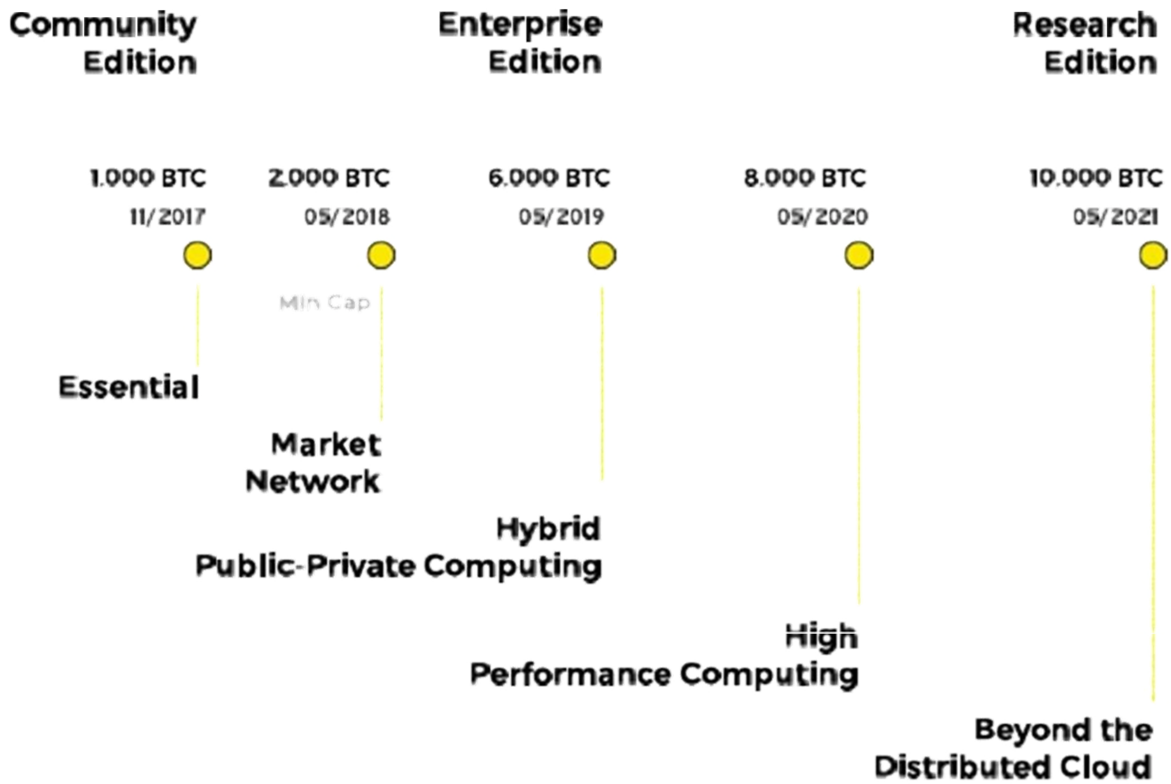
With the minimum funding **(2,000 BTC)**, ECT will deliver an initial market network that allows to monetize applications and servers. With a maximum funding **(10,000 BTC)**, ECT will gradually de- velop the market network including data providers and HPC applications, then establish recurrent sources of revenue to ECT.

9.2. V1: Essential (Community Edition)

The Essential version aims to provide DApps running on the Ethereum blockchain an access to off-chain computing resources. This is an essential step in blockchain computing as it allows a broader range of applications to run on the blockchain.

At the moment, the gas mechanism provided by the Ethereum blockchain makes the execution of algorithms with computation and/or memory requirements rapidly costly and performance prohibitive. Thanks to the Essential version of ECT, DApps will have a simple, secure, and prac- tical way to reach off-chain computing resources to execute their applications.

To this end, the Essential version will provide a smart contract API for task execution. In our proof-of-concept, we have already bridged Ethereum with the XtremWeb-HEP Desktop Grid middleware. The bridge monitors the Task smart contract, and when a transaction is detected, it triggers the computation on off-chain computing resources. When the computation is over, the result is sent back to the smart contract. To avoid a part of the security risks, the infrastructure will only include trusted computing resources. Also, in this version, no resource payment scheme will be considered yet.The Essential version will target an initial number of dapps, whom we consider our future early adopters. ECT will provide a set of in-house applications, and will provide support for early adopters that want to deploy their applications on ECT.



9.3. V2: Market Network (Enterprise Edition)

In this version we build the Market Network, firstly addressing the Application providers and Server providers. We introduce a Pay-per-Task scheme that allows the payment from the Task smart contract to the Application and the Server providers. ECT users can access the Market Network to launch compute intensive applications in different ways, e.g. an API, a GUI or a CLI. Application providers can decide on a payment scheme through a smart contract API.

This version will target the classic compute intensive open-source applications with a very large user base - particularly 3D rendering (like Blender, Luxrender), biomedical research (like Blast, Autodock), mathematics (R) and finance for which we already have significant experience. With respect to Server providers, the focus will be on establishing partnerships with infrastructure providers, such as smaller Cloud providers, individuals and miners interested in renting their server farms, mining rigs or home servers.

Through its Pay-per-Task scheme, this version opens the first revenue stream through agreements with the approved resource providers. This is the very beginning of doing business between providers by monetizing their resources. The usage of the ECT computing service will expand, making the business within the Network Market to grow.

9.4. V3: Hybrid Public-Private Infrastructure (Enterprise Edition)

This version includes key features for the enterprises to widely adopt the ECT market network by providing them with full control over the private/ public employment of their resources.

To be well grounded in the needs of industry, in 2014 we designed an MVP (Minimum Viable Product), interviewing 20 startup companies from the Lyon Biopole healthcare innovation competitiveness cluster to understand how they would interact with a distributed Cloud. Thanks to this study we identified three mandatory requirements:

- **Data must be treated with at least the same importance as computations,**
- A **clear distinction between public/ private access** of resources. For example, a private resource can only be accessed by the proprietary company or by a restricted set of trusted partners. Conversely, a public resource can be handled by any hosts.
- Have a clear **vision of cost vs. performance** when provisioning computing resources.
- At a first glance, designing a system which provides these three features is challenging on fully decentralized infrastructures. Fortunately, we already have strong research results and practical experience in each of these three areas.

This version will target Data providers, allowing them to join the Market Network. Moreover, a broader range of enterprises will be able to start shipping their applications and DApps through ECT. With this version, the market network will allow several direct connections between different resource providers.
This version strengthens the revenue stream of ECT by allowing new revenue models conceived for DApps requiring a higher level of trust and quality-of-service. These applications will benefit from dedicated environments using selected resource providers, as well as specific QoS features through a performant SLA.

9.5. V4: High Performance Computing (Enterprise Edition)

This version allows miners to join the ECT market network as Server providers, and provide their customers with true supercomputing capabilities.

At the moment, the mining farms monetize their GPU resources by computing blockchain consensus. Through ECT, these providers will gain access to a new market of blockchain-based HPC applica- tions. By this, the providers will be offered the opportunity to better exploit their vast amount of computing power and extend their businesses.

For instance, Genesis Mining operates the largest Ethereum mining farms, which are composed of tens of thousands GPU cards, all together representing a considerable computing power (>15 PetaFlops). For the first time at the Supercomputing Conference (SC16), along with key actors of the domain (JenHsun Huang, CEO of nVIDIA and Marco Streng, CEO of Genesis Mining), we initiated clear synergies between HPC and blockchain computing. This ECT version will provide all the technology building blocks to make this happen.

In addition to miners, the ECT HPC version will extend the Application providers pool to GPU-based applications. These applications address deep learning, 3D rendering, computational fluid dynamics, molecular dynamics, finance, and many more. We'll put a focus on Deep Learning applications be- cause of its incredible fast growing usage, and because actors are already keen on using GPU Cloud computing for that.

This version aims to extend the previously existing revenue models based on the integration of advanced enterprise features that bring higher value to providers.

9.6. V5: Beyond the Distributed Cloud (Research Edition)

The goal of this edition is to allow new usage of ECT beyond the Distributed Cloud. This will be a clear step further in Blockchain computing, as DApps will be fully autonomous applications, able to provision resources, data, and applications directly from the blockchain in a fully decentralized way.

To this end, it's necessary to integrate several software and protocols that are emerging now, or that may be developed during the course of the project, like devp2p, swarm, uport etc. Combined with a full development of the Proof-of-Contribution, this will open new areas in the field of serverless services, directly hosted on the blockchain. It will also be necessary to design new consensus protocols able to handle the ECT workload. We plan to lead those researches in partnership with recognised research labs in Europe and in China.

This will open the Market Network to new applications specifically deployed on ECT to take advantage of the distributed Cloud: IoT, Fog/ Edge computing, Smart City. For instance, a recent study shows that telecom companies (AT&T, Verizon, Huawei, Orange ...) can halve their infrastructure costs by distributing small data-centers along their network point-of-presence. ECT will be the building block for such approaches.

As the platform increases in complexity, ECT will provide advanced method for deploying ECT ready DApps, making it the "Heroku/ Docker for blockchain computing". Thus, new revenue stream will be gained by offering a hassle free deployment and development platform on top of the Market Network.

10. FINANCIALS

10.1. Revenues

ECT will generate revenues from different sources:

- Partnerships with resource providers (V2) and application providers (V4)
- Providing a private mode for applications/ data/ servers (V3)
- Providing advanced services for DApps (V5)
- Monetization possibilities from the ECT DApp Store
- Advanced financial services on cloud resources

10.2. Costs

The funding is planned to cover development and operational costs for four years. There will be three main sections of operation:

- Development and maintenance of the ECT platform,
- Marketing and expansion of the ECT market network,
- Academic collaboration to support the most advanced research programs in this area.

The main cost categories are the following:

Office and indirect costs include costs of offices in both France and Hong Kong, as well as other in- direct, employment-related costs.

Marketing and communication activities are mainly focused on building a network of application providers, data providers and key computing infrastructure providers (clouds and miners). This in- cludes two people that will work dedicated with sales and marketing efforts, one towards the tradi- tional industry and one towards blockchain-based companies.

Research programs will be conducted in collaboration with the most recognized research institutes and universities in Europe (INRIA, CNRS, ENS-Lyon, UPMC, University Paris XI) and China (University of Tsinghua, Chinese Academy of Sciences). Complementary funding will be obtained through natio- nal (ANR, NSFC) and European (H2020) research agencies.

Contractors security audits will be commissioned to independent subcontractors: Qirinus for plat- form security and S3 Lab for incentives design.

10.3. Air Drop

ETCtokens will be used to access the resources provided by the market network. It will be the unique way of payment for application providers, server providers and data providers.