

A Blockchain infrastructure for public interest applications:
RBB - the Brazil Blockchain Network

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Disclaimer: *The published statements are of my sole and exclusive initiative and do not necessarily represent the opinions, the strategy and the positioning of BNDES – the Brazilian development bank - on the subject.*

Executive Summary

This thesis presents RBB – the Brazil Blockchain Network, a project developed by BNDES – the Brazilian Development Bank, along with other partner institutions, including governmental and multilateral agencies and the academia. The purpose of RBB is to provide a digital infrastructure to foster innovation in the use of blockchain and DLT for applications of public interest, with a special emphasis on enabling the necessary trust to implement anti-fraud and pro-transparency measures.

After going through a serious crisis of confidence, the BNDES identified that blockchain technology could be a powerful tool to improve transparency, combat fraud and corruption in the public sector, regain the trust of society, and help to answer the following question: what can be done so that, even if citizens do not trust an institution, they can trust information related to their activities? In the BNDES case, this translates to the tracking of public budget invested in development projects.

While developing proofs of concepts and pilot projects such as TruBudget (a logbook approach using private blockchain) and BNDESToken (a hyper transparent digital asset transfer approach using the Ethereum public network), BNDES endeavored a deep understanding of the blockchain ecosystem in Brazil, and more specifically on the public sector. BNDES identified that other governmental agencies also had their own needs and expectations in the use of blockchain technology. Nevertheless, they would also have some similar requirements of the BNDESToken, such as identification requirements, or notarization requirements, which suggested that parts of the BNDESToken could be reused by other applications. These organizations also stated that blockchain technology exploration would be accelerated if they had lower costs to onboard, develop and test their solutions. The understanding that there was a need for greater coordination and governance was increasingly reinforced. That meant that it was necessary to provoke the development of a blockchain ecosystem for Gov DApps involving other actors.

So, the BNDESToken development was pivoted and the original application concept was split into four different interdependent services, in different layers of architecture. This

vision would later be enhanced and inspired by the architecture of networks like EBSI (European Blockchain Services Infrastructure), Alastria and LACChain, which led to the inauguration of what nowadays is called the RBB - Rede Blockchain Brasil (Brazil Blockchain Network) project, a public permissioned blockchain network using the Ethereum client Hyperledger Besu. Just like a highway and associated services constitute a physical infrastructure that enables different modalities of transportation, such as private and collective people mobility and cargo transportation, run by a diversity of vehicles, the RBB is intended to be a digital infrastructure that supports blockchain based applications for public interest.

Currently, the first phase of RBB, known as the RBB Laboratory has eight nodes from four different institutions already connected, in an architecture inspired by LACChain, the Inter-American Development Bank blockchain initiative. Four other institutions are expected to connect their nodes in the first semester of 2021. RBB Laboratory has also deployed monitoring tools and three applications in the core service layer, that manage generic functionalities that can be bound and reused by other smart contracts in the business applications layer: blockchain identification service for legal entities, document notarization service and token service, which manages issuance, transfers and burn of tokens under rules that guarantee the transparency of the token flow.

For the future, RBB is envisioned as a network of networks, agnostic and interoperable, digitally integrating several networks running blockchain applications for public interest developed in various configurations of platforms and software.

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Chapter I - Introduction

The Final Master Thesis of this Global Master's in Blockchain Technologies Program describes RBB – the Brazil Blockchain Network, a project that is actually underway at the company I work for, BNDES - the Brazilian development bank, in partnership with other federal and state governmental agencies, R&D institutions and multilateral agencies. The RBB is the most recent result of many steps and milestones already developed within the scope of the blockchain initiative at the BNDES, since the end of 2017. Revisiting this history and reflecting on what steps have already been taken, which others deserve to be refined or resumed and, more importantly, what tools can be used in the next steps from the knowledge acquired in this program will add much value to the progress of the RBB project. So, this Thesis constitutes a piece of documentation of activities carried out, decisions made, and planning possibilities for future stages.

Due to the inherent characteristics of the blockchain technology, it has the potential to provide developing and underdeveloped countries with possibilities to achieve a leap frog in many financial and government services. And being a 100% state-owned company, and also being a bank, the BNDES might find in blockchain a very powerful tool to leverage its mission to foster Brazilian development.

These are the main motivations for blockchain to be a very significant initiative of the Digital Innovation team at the BNDES, which develops projects to explore the possibilities in applying blockchain technology to the businesses. As the major financing agent for development in Brazil since its foundation, in 1952, the BNDES has played a fundamental role in stimulating the expansion of industry and infrastructure in Brazil, and its operations have evolved in accordance with the Brazilian socio-economic challenges. Nowadays, this includes support for technological innovation, sustainable socio-environmental development and the modernization of public administration.

In the search for a solution to a pain related to the crisis of confidence that it had been suffering as an institution, the BNDES identified that other government agencies were also dealing with similar or related issues, and realized that blockchain could be a strong ally to effectively combat fraud throughout governments. Moreover, as an institution that

has in its historical mission the support and promotion of Brazilian infrastructure in the physical world, the BNDES noted that, also in the digital world, there is a need to create an infrastructure to foster the development of IT applications for the provision of efficient and effective services to citizens. And this is especially true with regard to blockchain technology, which presents challenging governance aspects, so that the decentralized nature of its network architecture can be put into production and be widely adopted. That is the role RBB comes to fulfill.

Therefore, in Chapter II this thesis will discuss blockchain implications for governments and public interest, focusing on the BNDES initiatives to foster innovation and build up confidence and pro-transparency measures in the public sector. Also, it will detail how the RBB was designed as a blockchain solution that will address this major challenge. Chapter III will discuss technical aspects, describing the use of the blockchain technology in RBB and details of the technical setup. Finally, Chapter IV will present the learning journey in this Master's Program.

Chapter II - Blockchain Implications for governments and public interest

Blockchain is a technology that promises to revolutionize the public sector, making it more democratic and secure, more efficient, more transparent and less corrupt. Traditional governmental services such as land and vehicle registry, citizenship, identity and passports, notarizations, public procurement, voting and public record keeping such as health and educational data management are natural use cases for the blockchain technology that are being tested around the world.

The Estonian e-Residency team is working with private companies to provide universal authentication services, the most significant of which is the application of blockchain technology to authenticate identity and identity documents. (Sullivan & Burger, 2017). The Emirates Blockchain Strategy 2021 (UAE, 2021) aims to capitalize on the blockchain technology to transform 50 per cent of government transactions into the blockchain platform by 2021. The Dubai Blockchain Strategy will help Dubai to be the first city fully powered by Blockchain. In Brazil, the Federal University of Paraíba issued the first digital

diplomas in a pioneering way, as it promotes the use of blockchain technologies, digital certification and digital preservation (Gov.br, 2019).

According to the World Economic Forum (2020), blockchain is a technology to address corruption because the use of cryptography and distributed consensus mechanisms, provides the unique combination of permanent and tamper-evident record-keeping, transaction transparency and auditability, automated functions with “smart contracts”, and the reduction of centralized authority and information ownership within processes.

Schmidt and Sandner (2017) discuss blockchain powered budget tracking applications to fight corruption, improve governance and serve as an information system, and assess the solution as having high potential impact, medium implementation feasibility and low likelihood of adoption, because there are barriers such as the willingness of the governments to accept a solution for their countries and their conflicts of interests.

Although this is certainly a wicked problem, this is exactly the challenge that the BNDES set out to solve with the projects of its Blockchain Initiative.

The original problem - from transparency to confidence

From 2015, the BNDES began to suffer with a serious process of mistrust of the population in relation to the services it provides to society. The BNDES was dubbed "the black box", and accused of committing several frauds involving financial support to infrastructure projects. Thus, for at least the next four years, the Bank underwent a traumatic process of extensive investigations by control bodies, the Federal Police, the Public Ministry, Justice and Congress, without any employee being convicted of any crime related to its activities in the Bank to date. Many, including renowned lawyers, the Public Defender's Office and the Brazilian Bar Association, understand that there were injustices and arbitrariness in the investigation phase (Defensoria Pública do Rio De Janeiro, 2017).

This is a pain that many BNDES employees experienced to a greater or lesser extent, and which caused major mobilizations: many events such as meetings, assemblies, protests,

TV and newspapers debates, with internal and external participants, were carried out to discuss these events and its impacts on the institutional and personal reputations.

However, it was not only the BNDES that suffered from these accusations. Other public companies such as Petrobras (oil company), Caixa (public bank), Correios (mail company), as well as dozens of politicians and public officials have also undergone investigations, that in some cases turned into accusations and also into convictions.

So, similar mobilizations happened not only at BNDES, but at other public agencies. The imminence of the stoppage of public services due to insecurity in public decision-making by public agents had become such a serious issue that it has given rise to the approval of Law nº 13.655 of April 25, 2018. This law aimed to speed up the administration, eliminating obstacles to the action of the public manager, clearly specifying responsibilities and imposing rules even to prevent abuses by the control bodies (Brasil, 2018).

One might think that it is an essentially Brazilian problem, but it is not the case. Trust is in crisis in several parts of the world, and not only in relation to governments (Edelman, 2018). While the Internet and social networks promote widespread dissemination and democratization of information, expanding the reach of personal opinions, institutions and media deal with the population's discredit. Still, among institutions, governments are the ones with the lowest confidence levels in Brazil. And, as a result of mistrust, fake news and facilities provided by technology, it became clear that society is demanding an increasingly agile and transparent government.

When the BNDES launched ideiaLab, an innovation contest for the Bank employees, the group that later started the BNDES Blockchain Lab took the opportunity to propose a solution to deal with this painful issue. Thus, based on all these events, discussions and a lot of research, the problem posed was basically: what can be done so that, even if citizens do not trust an institution, they can trust information related to their activities – in the BNDES case, the tracking of public resources invested in projects - without depending on eventually excessive and expensive inspections or investigations by other authorities?

In a few brainstorming processes, it became clear to the team that blockchain technology, especially the arrangement of a public network like Ethereum, running smart contracts, could be the key to solve this pain from BNDES. For the advent of the contest, the team competed preparing folders and participated in a fair to explain and disseminate the idea to employees. With that, it reached the finalist phase in the popular vote, and prepared a planning proposal and a pitch for presentation to the Management Committee formed by the Bank's Superintendents. And winning the contest opened the opportunity to execute the proposed planning, which essentially consisted of deepening the study of blockchain technology and developing a proof of concept to test the solution.

Among several candidate use cases, at the end two of them were chosen, because they would allow to develop proofs of concept without having to face discussions about banking secrecy, as they are projects that demand full transparency by nature: tracking the application of funds donated to projects, and tracking the application of funds invested in public administration projects.

And these use cases would be tested in two different traceability approaches (Braden, 2019, p.67-69): i) a logbook approach, that records the steps of a workflow to manage the application of donated funds in a permissioned blockchain (Multichain), using TruBudget, an open source tool developed by the German development bank KfW; and ii) the BNDESToken approach, which involves the tokenization of the Brazilian fiduciary money in a limited ecosystem, where all transactions are processed by the Ethereum blockchain, from the BNDES disbursement, through clients' payments to providers of goods and services, which in turn are allowed to redeem the tokens, exchanging them again for fiduciary money. In this way, it is possible to identify agents and track digital asset flow, increasing the level of confidence about how the money is spent on the chain.

In relation to TruBudget (BNDES, 2021a), the BNDES used it to record the disbursement of funds from the Amazon Fund¹ to its clients, such as NGOs, federal and state government agencies and universities. On the other hand, customers registered the receipt

¹ The Amazon Fund is a REDD+ mechanism managed by the BNDES, created to raise donations for non-reimbursable investments in efforts to prevent, monitor and combat deforestation, as well as to promote the preservation and sustainable use in the Brazilian Amazon. (www.amazonfund.gov.br)

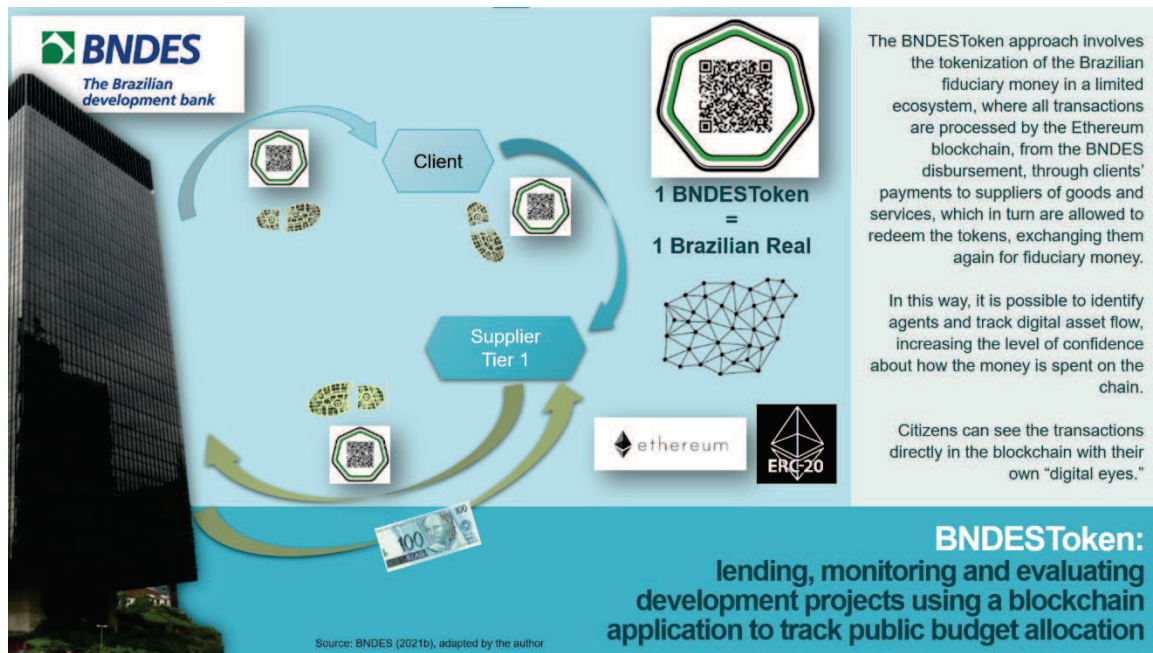
of these resources in TruBudget. The effect is similar to the circularization technique performed by the auditing companies, when they send a letter requesting information directly to third parties, who are sources of information external to the audited entity, to confirm the occurrence of accounting facts on their respective recorded balances. In doing so, the project aimed to improve the guarantee that the funds are being invested properly through the direct and reliable sharing of critical information between the different institutions involved.

After a successful proof of concept, in which KfW, as a donor of resources for the Amazon Fund, demonstrated having perceived value in the proposal, the project entered a pilot phase with limited scope, focusing on the disbursement process. In this phase, an integration was developed between TruBudget and SAP, the ERP used by the BNDES, in addition to several improvements in TruBudget based on suggestions from the proof of concept. In the end, although TruBudget was seen as a provider of value to donors and an easy and fluid experience for customers, it was put on hold due to scaling up challenges of technical and process nature.

Regarding the BNDESToken, Arantes et al. (2018) describe in details the original proposal of a tokenization approach for tracking public budget allocation. BNDES issues and backs an ERC-20 stablecoin running on Ethereum, that represents 1 Brazilian Real and has a hyper transparent flow visible on the public blockchain. Unlike regular cryptocurrencies, the main challenge here is to guarantee an identification process that unequivocally associates a blockchain address to a legal entity through its e-CNPJ², guaranteeing non-repudiation under the Law, and to the token flows associated to these accounts.

² Cadastro Nacional de Pessoas Jurídicas Eletrônico - Brazilian digital certificate of a legal entity, issued under the trust protocol enabled by the Brazilian Public Key Infrastructure - ICP-Brasil

Figure 1 – Representation of the tracking process of the BNDESToken



In the current process, the BNDES makes disbursements in Brazilian Reais, which are deposited in a checking account and are managed by the clients to pay suppliers of goods and services, accordingly to the progress of the approved and contracted projects. Subsequently, the client is responsible for submitting a strict and costly accountability process. In the BNDESToken approach, the client receives BNDESTokens instead in its blockchain address, and use these tokens to pay for goods and services, transferring the tokens to suppliers that are also registered in this ecosystem. Once in possession of BNDESTokens, suppliers can then request the BNDES to redeem these tokens, exchanging them for fiduciary money. Therefore, all financial transactions are processed by the BNDESToken smart contract on Ethereum, being totally accessible to the citizens and linked to the legal entities involved in an irrefutable way. Also, as it involves transactions with a programmable asset, the process can include proactive checking and controlling of the business rules, with the added benefit of compliance by design.

BNDESToken's proof of concept was based in a use case involving an infrastructure project undertaken by a client of the public administration, which also had a great interest in the hyper transparency benefit. After that, other use cases explored involved the Amazon Fund and the financial support to audiovisual productions with tax incentives.

But in this journey of development of the BNDESToken, BNDES realized that the application approach by itself might not be sufficient or efficient. Increasing number of iterations, the involvement of new actors, and maturation of the idea suggested a different perspective: the infrastructure approach.

From the BNDESToken to the RBB – Brazil Blockchain Network: the infrastructure perspective

Other governmental agencies that were getting involved in the project, while playing a fundamental role in the development of the BNDESToken project, also had their own needs and expectations in the use of blockchain technology. Nevertheless, they would also have some similar requirements of the BNDESToken, such as identification requirements, or notarization requirements, which suggested that parts of the BNDESToken could be reused by other applications. These organizations also stated that blockchain technology exploration would be accelerated if they had lower costs to onboard, develop and test their solutions. The understanding that there was a need for greater coordination and governance was increasingly reinforced. That meant that it was necessary to provoke the development of a blockchain ecosystem for Gov DApps involving other actors.

During the development of the BNDESToken solution, several hypotheses that defined the choices and decisions in the project were tested, collecting data, information and useful lessons for the project.

First, on September 2018, the BNDES launched the Public Consultation “Blockchain Solutions for BNDESToken” (BNDES, 2018a), with the aim of obtaining information and demonstrating solutions for (i) account management; (ii) transaction tracking; and (iii) account association with CNPJs³ and/or CPFs⁴, which are compatible with a Blockchain that uses smart contracts incorporated into BNDESToken. The public consultation received formal expressions of interest from 22 applicants, of which 19 were qualified to demonstrate their solutions to BNDES by meeting all or part of the

³ Cadastro Nacional de Pessoas Jurídicas - Brazilian registry of legal entities

⁴ Cadastro de Pessoas Físicas - Brazilian registry of natural persons

requirements. The solutions presented were created using 10 different platforms (Ethereum, Hyperledger Fabric, Corda, NEM, NEO, Stellar, EOS, Waves, Bizanc.io and Interchains) from developers of three different countries (Brazil, United States and Russia). The findings led BNDES to focus on the Ethereum platform and later define the architecture that would be used by the BNDESToken, being possible to choose among the public option, the fully permissioned option or some hybrid option, in which a permissioned network sends periodic information to the public network.

Also, it was important to assess whether government organizations were interested in blockchain technology. To test this hypothesis, in 2018 the BNDES promoted the BlockchainGov Forum (BNDES, 2018b), an open event in partnership with ITS Rio, an NGO that studies the relationship between technology and society. The Forum discussed the contributions of blockchain technology to the digital transformation of governments, identifying proofs of concept and pilot projects in the Brazilian scenario, and also debating blockchain regulation. The success of the first edition, which brought together 260 people, in addition to 70 online, proved the interest of public managers, participants from GovTechs, blockchain developers and IT companies. It also led to the well-succeeded second edition of the Forum the following year (BNDES, 2019).

To evaluate if government organizations were already investing in blockchain technology, also in 2018 the BNDES promoted a mapping of the blockchain ecosystem in Brazil, which aimed to provide an overview of ongoing initiatives and discuss how to stimulate the Brazilian blockchain ecosystem. Maranhão (2018) showed that, of 350 mapped initiatives, only 8% were related to the Public Interest. And in this category, the most explored themes were: Transparency in public spending, Data sharing, Digital identity, Notary systems, Certifications, Civic innovation and voting, and Transportation.

In 2019, along with the second edition of the BlockchainGov Forum, a closed side event was held: the face-to-face BlockchainGov Workshop, facilitated by the ITS Rio, that brought together those responsible for the most relevant governmental projects identified in the blockchain ecosystem. At this time, it was important to understand if government agencies understood the benefits and potential advantages of blockchain technology, as

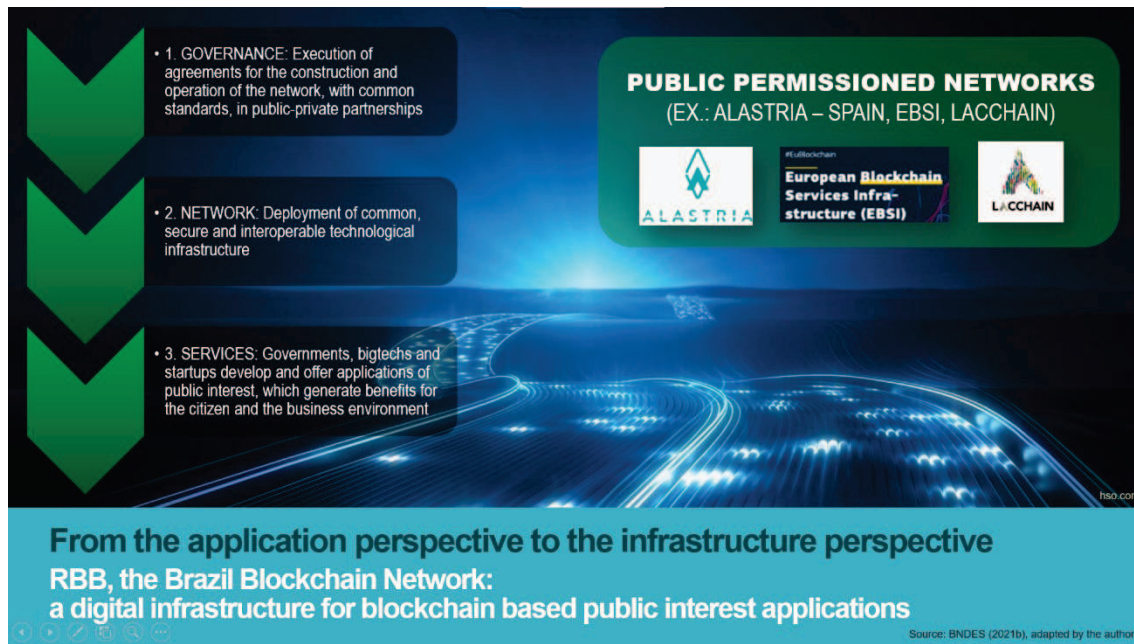
well as the implementation challenges, and if they were willing to establish partnerships to implement common projects.

This event was very important, as it revealed the need for a change in the development strategy of BNDESToken. The Workshop conclusions (ITS Rio, 2021) suggested that, for national solutions in blockchain to converge, the ecosystem needed to articulate better and agree on a governance model that would give sustainability to a national network. And that the network should guarantee the interoperability of solutions, the security of transactions and the evolution of the infrastructure. Therefore, it suggested two main guidelines: i) the creation of a hybrid network - validated by permissioned nodes, but allowing open consultations with other nodes -, based on existing models, such as the Alastria, LACChain, and EU Blockchain Infrastructure networks; and ii) the creation of a governance model with mutual support between the public, private, third sector and academic sectors. Also, the workshop showed that, although trust was a common problem, and also solution, to all agencies, there were other relevant problems to be attacked, such as:

- Database integration: need for instant data sharing between different databases of institutions, with the digitalization of formal processes, reducing bureaucracy and speeding up the process of formal interinstitutional communication.
- Data security: the need to ensure data integrity and authenticity in the exchange of information, reducing the possibility of fraud and the number of failures, in addition to mitigating improper access to available information.

So, the BNDESToken development was in a certain way pivoted. The original application concept was split into four different interdependent services, in different layers of architecture, as described in more detail in Chapter III. This vision would later be enhanced and inspired by the architecture of networks like EBSI (European Blockchain Services Infrastructure), Alastria and LACChain, which led to the inauguration of what nowadays is called the RBB - Rede Blockchain Brasil (Brazil Blockchain Network) project.

Figure 2 – Representation of the infrastructure perspective: RBB – the Brazil Blockchain Network features



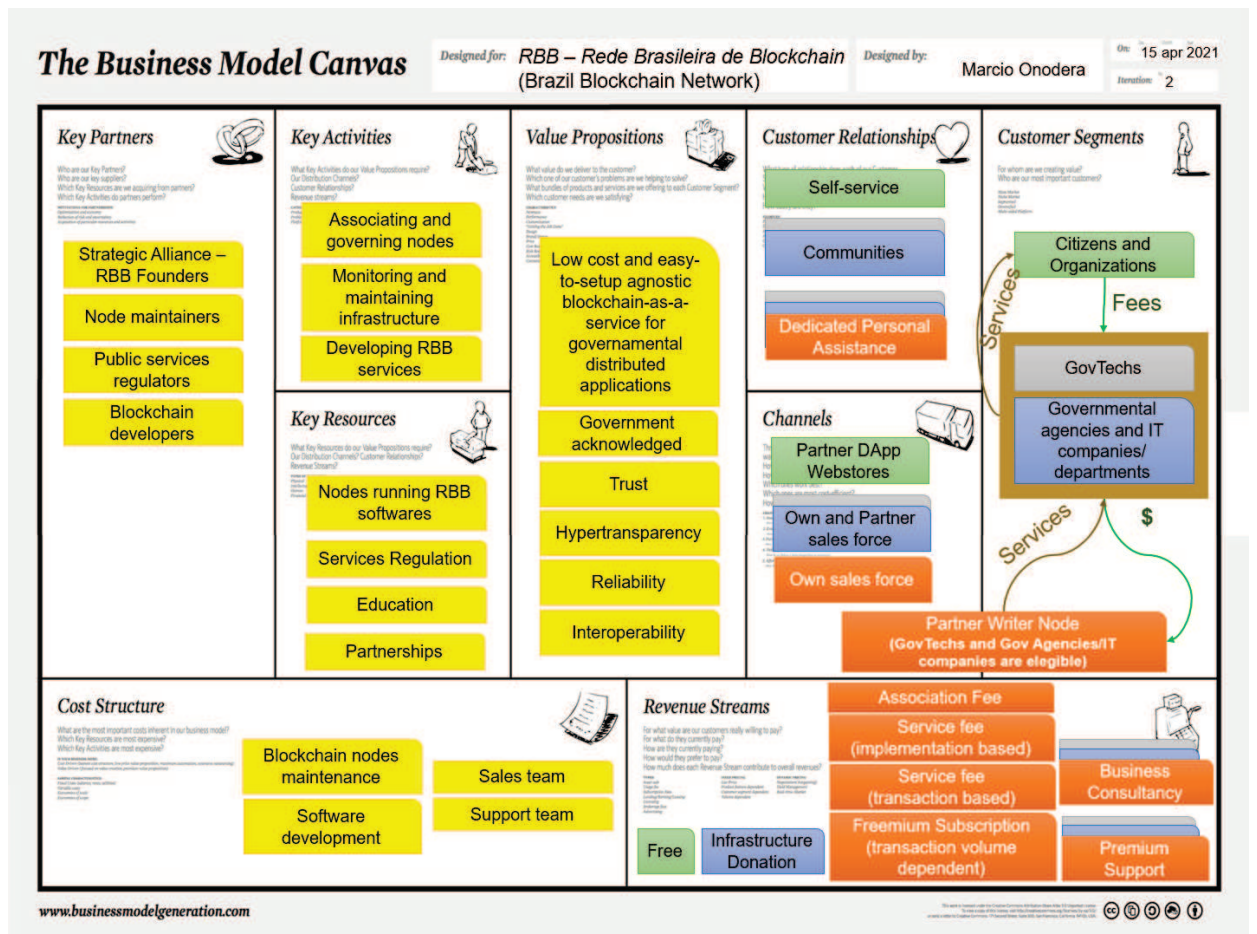
With the difficulties arising from the expansion of the governance challenge of involving and coordinating different institutions for the implementation of the RBB, the BNDES obtained support from the State Modernization Secretariat of the Presidency of the Republic. There was the expectation that formal political and institutional support could leverage a cooperation agenda between different government agencies, to implement RBB as blockchain infrastructure for GovDApps. This led to the creation of the Blockchain Working Group, linked to the CCGD - Federal Government's Central Data Governance Committee, in May 2020. For about 7 months, this Group managed to move forward with important alignments, but unfortunately the work of the group was halted at the end of 2020, impacted by the change of the Minister responsible for this agenda. It is still unknown if the Blockchain Working Group will persist.

Meanwhile, technical development is ongoing in parallel. To do and learn fast, the key is to be pragmatic in building prototypes, reducing the complexities and submitting them to the partners to collect feedback. The group agreed that a good MVP could be to enable a blockchain network with partners who run boot, writer and validating nodes in a test environment, which should bring together the main attributes: be functional, reliable, usable, offer the necessary support to enable simple final applications to run and demonstrate its value. This is the current strategy of the project, implementing its first phase, called the RBB Laboratory Network, structured in a technical cooperation

agreement with LACChain, a project of the Inter-American Development Bank with a similar proposal in many aspects. RBB Laboratory is designed as a public permissioned blockchain network using the Ethereum client Hyperledger Besu.

The Business Model Canvas for the RBB

Figure 3 – The Business Model Canvas for RBB



Source: prepared by the author, based on the Business Model Canvas

This chapter discuss how the Business Model Canvas was used to help design the solution, by describing each one of the nine Building Blocks of the canvas.

Customer Segments

RBB will reach and serve four interdependent segments of customers, in a multi-sided approach.

The first segment, represented in green, is composed by the Brazilian Citizens and Organizations, who will consume digital public services through blockchain-based applications that will run on RBB. The segment is very important to provide network effects, as they are also the final customers.

The other three segments are exclusively B2B, basically formed by GovTechs, Governmental Agencies and IT companies. These customers will be segmented in two categories, based on different interests:

- a) Providers of Blockchain-based Application Services: GovTechs (represented in grey), Governmental Agencies and IT companies (represented in blue) can be developers and providers of public interest services to final customers, B2B or B2C.
- b) Providers of Access to the RBB infrastructure as Writer Nodes: GovTechs, Governmental Agencies and IT companies may candidate to run RBB writer nodes, so they are able to offer the right to access and submit transactions to RBB. Solution developers and providers may also prefer to run their own writer nodes in RBB.

Value Proposition

For Citizens and Organizations in general, RBB value proposition is more linked to the offering of low-cost government acknowledged digital services. Government should make its services more accessible, efficient and effective, and one way to do this is by making a transition for e-gov services. Citizens will benefit from blockchain characteristics as reliability, trust and hyper transparency, but these attributes are more transparent to them, and in general, they don't need to be aware of what specific

technologies are behind the public services they consume. Nevertheless, some organizations, as corporate consumers, may be more aware of trust and hyper transparency proposals that are offered by the blockchain technology. This adds a lot more value to the basic government acknowledged low-cost public services, as they are more demanding consumers and may have a deeper understanding of the blockchain technological attributes.

Providers of Blockchain-based Application Services and Providers of Access to the Blockchain infrastructure as Writer Nodes are not only interested on the value RBB delivers to final customers, but they are also very interested in more technical attributes such as reliability, easiness to set up the blockchain, and interoperability that facilitates the development of solutions in different platforms; and, not to forget, the low-cost and government acknowledged proposal is also critical.

Channels

The main interfaces with RBB customers will be:

- Own sales force: responsible for raising awareness on RBB value proposition, contracting and post-purchase support to the corporate customers. Although this force might approach corporate final consumers and Providers and developers of Blockchain-based application services, it will focus its efforts on the Providers of Access to the Blockchain Infrastructure as Writer Nodes. That is because these writer nodes will actually become very important Partners of the RBB, to the extent of becoming a distribution channel themselves.
- Partner Sales Force: it is expected that Partner Writer Nodes will develop their own sales force teams, joining the RBB sales force efforts to deliver RBB value propositions to the blockchain developers and providers of the applications that will run in RBB. Partner Sales Force will also be the main interface with corporate final consumers of RBB solutions.
- Partner DApp stores: Awareness, access, purchase and post-purchase support to the citizens and organizations as final customers of the RBB based solutions will be delivered through online DApp stores managed by the Partners and the Providers of blockchain based solutions.

Customer Relationships

RBB will establish different customer relationships types according to each Customer Segment.

- **Self-service:** this will be the main kind of relationship between RBB and Citizens and Organizations as final customers. This means that RBB and Partners will provide all the necessary means for final customers to help themselves, from acquisition of services to tech support. Although RBB is not intended to have direct relationship with the final customers, Partners and Service Providers may want to sophisticate their approach at their own interest, with automated services or even personal assistance.
- **Communities:** due to the very steep learning curve and the wealth of results that the exchange of knowledge and experiences among participants in this ecosystem can bring, RBB will establish and foster a community relationship among all its corporate clients through a digital platform.
- **Dedicated Personal Assistance:** this will be the most important approach to B2B clients, that need to be assisted in a customized manner, not only for customer acquisition, but also for customer retention. RBB own sales force will be more dedicated to maintain personal relationships with Providers of Access to the RBB as Writer Nodes, and Providers of Blockchain-based Application Services. Partner Sales Force will reach both Providers of Blockchain-based Application Services, and eventually Organizations as corporate final consumers.

Revenue Streams

The development phase of RBB is being financed through a collective of corporate projects, from each initial partner. There is no direct financial contribution, but each initial partner is committed to investing IT and human resources to carry out activities related to the implementation of the RBB Laboratory.

Most of the time, and it is what happens in the case of the BNDES, the RBB is seen as an innovation project of the governmental organization. As a typical investment in innovation, it is accepted that it involves risk, uncertainty and an indefinite time

perspective, because in the early stages of innovation there is great difficulty in understanding how the resulting benefits will be appropriated. Still, it is common for organizations to set aside some volume of their own resources to finance this type of activity.

Another way to justify investment in RBB development phase, which makes sense especially because the entities involved in this stage are governmental agencies, is to understand this network as an infrastructure. Digital infrastructure, to provide blockchain-as-a-service for decentralized government applications. Although it is difficult to understand how the benefits of an infrastructure like this will be appropriated, there is no doubt that the project will generate positive externalities, providing a series of indirect gains and producing beneficial results for third parties.

However, thinking about the project sustainability, it is worth noting that at this moment, there are still many doubts and controversies among the project initial partners in defining the business's revenue streams. Many understand that, in order to safeguard the network neutrality as much as possible, the writer nodes should not compete with each other, and should function as a pool, being considered a cost to be subsidized. For this reason, many believe that there are fundamental arguments for a relevant part or even all of the costs related to RBB to be covered by the public budget.

On the other hand, considering the typical budgetary constraints caused by the fiscal crisis that has hit the Brazil since 2016, and which have been greatly aggravated by the impact of the Covid-19 pandemic on the economy and the government's budget, this is a remote possibility. And betting on that vision alone can be deadly for the project.

Therefore, in the context of development of this business model, an exercise is carried out on the possibilities of revenue streams that aim at the financial sustainability of this infrastructure, seeking a considerable degree of independence from the public budget. Although it does not aim to generate financial profit, RBB should pay for its maintenance, research, development and expansion costs. Therefore, most of the revenue streams are based on the provision of services for accessing and sending transactions to the network. In this model, Writer Nodes are the main generators of direct revenue streams, offering

their services to government agencies, government IT companies and GovTechs. So, the main revenue streams are described as follows:

- RBB does not intend to remunerate itself directly from citizens and organizations that are final consumers, so for them RBB services are free and there is no corresponding revenue stream for this consumer segment. However, it is possible that, in order to access some services, even public ones, it is necessary to pay a fee to the service provider.
- Infrastructure Donation is expected from Governmental Agencies and Governmental IT companies, especially the ones who intend to compose the pool of initial Partners while the project shifts from development to production.
- The Partner Writer Nodes are responsible for the central revenue streams in this model:
 - Association Fee: in order to participate as a writer node on the RBB, the Partner will pay an annual association fee.
 - Service Fee: when deploying a blockchain application in the network, the writer node will pay a service fee. There are two options regarding the Service Fee:
 - Implementation based: the writer node pays for the deployment of an application in RBB, contracting network processing capacity in advance based on the estimated demands of the application over a period of time.
 - Transaction based: the writer node pays for the processing of each transaction related to their applications.
 - Freemium subscription: the writer node contracts a freemium subscription plan, based on the blockchain's transaction processing capacity. This gives free access to a certain number of transactions processed by the network and, only when this processing capacity is exceeded, the customer starts to pay for the service. It is a way to democratize access to the network. The subscription plan will also offer decreasing prices as a greater amount of transaction processing capacity is contracted.
 - Business and Tech Consultancy: RBB services will include consultancy to Providers of Blockchain-based Application Services and Providers of

Access to the Blockchain infrastructure as Writer Nodes. RBB may support the study and development of use cases for public services.

- Premium Support: RBB can also offer premium support services for usage-intensive customers, such as the Providers of Blockchain-based Application Services and Providers of Access to the Blockchain infrastructure as Writer Nodes.

Key Resources

Key resources to make the business model work include:

- Nodes running RBB software: physical network of servers distributed in different partner organizations are responsible to run and deploy different layers of software, from infrastructure to services and applications.
- Services Regulation: it is the RBB role to articulate with governmental agencies to regulate the digital services to be provided by RBB. For instance, if a use case for blockchain-based Digital Diplomas issuance is identified as an opportunity, demand or public policy, the service will only be made possible when the Ministry of Education publishes the norms that will regulate the conditions and procedures for the provision of this official government acknowledged service.
- Education: blockchain technology is relatively new and knowledge-intensive. RBB needs to foster and partner to accelerate the learning curve on technological and business aspects related to the application of this technology. For RBB success, it is essential to create enough critical mass to leverage and scale the adoption of this technology, especially in the public sector.
- Partnerships: partnerships, both with private and public organizations, must be structured to accelerate the maturation of the blockchain ecosystem and strengthen fields that are needed to scale RBB, acquiring assets and resources such as R&D and standardization. It is also fundamental to exchange knowledge, practical experiences and lessons learned.

Key Activities

Key activities needed to operate RBB include:

- Associating and governing nodes: RBB is a network running different types of nodes (see Chapter III). For the network to scale, it is important to foster and

maintain new clients, developing an increasing number of use cases for public interest and establishing contracts to new Writer Nodes Partners.

- Monitoring and maintaining infrastructure: although it is decentralized, it is necessary to keep the nodes running, so nodes must be monitored to guarantee service availability at the necessary quality and trust levels.
- Developing RBB services: an increasing number of generic open source applications of the core services layer - such as notarization and identification, that can be reused by other applications in the business layer, must be developed to aggregate value to RBB services.

Key Partnerships

- Strategic Alliance: RBB Founders: the initial Partners of RBB Laboratory are crucial to deliver the MVP strategy and to prove the RBB concept. Also, they are strong candidates to be the responsible for the validator nodes of the network, which will be responsible to participate in the consensus protocol and validate the transactions submitted to the network.
- Node maintainers: as components of a decentralized network of different types of nodes, with different functions, the node maintainers must establish strategic partnership relationships, even among potentially competing nodes, as it is the case of the writer nodes.
- Public services regulators: these agencies are essential to deliver one of the critical value propositions, which is governmental acknowledgment.
- Blockchain developers: these are very important partners to develop new products and services to be provided to the final customers.

Cost Structure

The most relevant costs to operate RBB include:

- Blockchain nodes maintenance: costs related to keep the nodes running, including servers, software, monitoring, cybersecurity and other resources.
- Software development: salaries and other costs related to employees dedicated to developing and testing software to meet requirements and launch new services to the network.

- Sales team: salaries, commissions and other costs related to employees dedicated to associate new partners, develop use cases to prospect new clients, and support the network governance.
- Support team: salaries and other costs related to employees dedicated to technically support the network and also support service to clients and partners.

Outlook and Roadmap

Currently, RBB Laboratory Network is running eight nodes of four different institutions. Other three institutions are in the phase of setting up their nodes to join the network, while other two are negotiating their participation. The choice of the initial partners for this strategic alliance considers not only the availability of infrastructure resources and technical support to implement the nodes of the Laboratory Network, but also, and mainly, the desired institutional profiles to safeguard the network neutrality as much as possible. More information on RBB's technical development is discussed in Chapter III.

Concerning the RBB next steps, the initial partners must address:

- Knowledge sharing and support between partners for installing nodes: for the project to proceed quickly, and for learning to be fast, it is necessary that partners have the availability of human resources to exchange experiences with each other in the installation of nodes. Therefore, the group needs to invest in adequate documentation of the processes defined, to create usage guides and tutorials and accelerate the learning of future partners in an efficient way, share experiences, templates and lessons learned. Improving the BNDES blockchain project's Github environment (<https://github.com/bndes/>), where all open source codes are available, is an important action in this matter.
- Demonstration effect: build mock-up of structural applications and enabling services such as RBB - Identification, RBB - Notarization and RBB Token. Also, it is important to choose and build a mock-up of a finalistic business application for demonstration.
- Establish formal cooperation agreements with partner entities to enable the RBB Laboratory network to evolve into production.
- Define on-chain and off-chain governance: decisions about the consensus protocol, whether there will be a utility token, the number of boot nodes and validator nodes,

for example, might be made with a relatively limited amount of information. It is also worth mentioning that the rules of on-chain governance and the DApp or smart contract designed to implement it must be aligned and maintain harmony with the decisions and rules established by the off-chain governance of partnerships in defining the role of each actor involved. One other important decision is whether to have a more robust off-chain governance from the beginning, or a more flexible and learn by doing approach on governance, which may be critical in DLT technology implementations.

- Requirements and strategy to scale from the RBB Laboratory network to the production network: the initial partners must define technical and governance requirements to go into production, and if production network will consist of the promotion of the current Laboratory network, with late creation of a new test network, or invest efforts to create a production network from scratch, in parallel to the current Laboratory.
- Being a public permissioned network, all entities are required to be identified. Also, person and legal entities will be end users of the applications running on RBB. So, a key issue is the need to define the identification protocols for the RBB.
- Interoperability implementation: the network proposes to be a public permissioned blockchain network, agnostic in relation to the blockchain platforms used. Partners need to maintain discussions about the next platforms to be explored in RBB, and how to advance in interoperability protocols.

Regarding a broader perspective on the blockchain for trust and transparency on public administration, it would be important to register that the BNDESToken initiative has already inspired the Municipality of Rio de Janeiro to join forces with Investtools, a startup of the private sector which had participated on the 2018 Public Consultation, to develop GOV Token, a blockchain application very similar to BNDESToken, to track the use of Rio's public budget. The project, part of the InovaÇÃO Rio program, was accelerated by the innovation support public agencies Finep, Faperj and AgeRio, receiving about USD 300k to develop the solution (CNN Brasil, 2021). This is a very gratifying unfolding of BNDESToken and shows the potential impact that this idea can have on policies to combat fraud and corruption in the Brazilian public administration.

And, in the blockchain ecosystem perspective, it is urgent that a minimum level of regulation on blockchain is developed. If, on the one hand, it is important to maintain an environment that does not stifle innovation, on the other hand the signaling of regulatory and legislative bodies is essential to guide and provide the minimum level of security necessary for investments in this technology to scale. Brazil faces the challenge to unlock the enormous potential that digital assets have to develop new markets, but it is necessary to provide legal security to the ecosystem.

Although in Brazil there are already several pilot and production projects using blockchain, both in the private sector and in the public sector, the national strategy for implementing the technology is very timid, consisting in two initiatives of the Digital Governance Strategy, instituted by Decree nº 10.332 (Brasil, 2020a) within Objective 8 - Public services of the future and emerging technologies. Therefore, it is more than necessary that the federal government articulates itself to launch a National Blockchain Plan, detailing guidelines, and specific objectives and actions, for both public and private sectors, and defining an advisory body or Steering Committee, such as the one launched for Internet of Things, for example (Brasil, 2019).

Otherwise, not only crypto assets, but also the use of blockchain technology in use cases that have nothing to do with them or even with the financial system are undermined. And in this sense, even projects regarding legal validity of information or notary documents implemented in blockchain, or exchange of interinstitutional data that have a high demand for security, efficiency and transparency, have their development delayed. They can, for example, leave Brazil on the margins of productive chains that begin to implement blockchain use in productive integration processes.

Also, the discussion about taxonomy need to be urgently overcome in law, with debate and approval of bill PL 2060/2019 (Câmara dos Deputados, 2019), so that regulatory bodies can develop clear guidelines for the market, and focus their specific efforts on critical issues involving blockchain technology, such as the trend of technology development for privacy, prevention of money laundering and combat to terrorist financing, blockchain based digital assets as securities, Central Bank Digital Currencies, DeFi, among others. And, above all, to make it clear the types of applications that can

follow their development without further monitoring by regulatory bodies, as long as they comply to guidelines. Because there is no doubt that innovations will continue to appear in this ecosystem, in Brazil and in the world, it is not an option to be left out of this process.

Chapter III - Blockchain Technology

Using blockchain technologies

This initiative started from the idea of developing an application that allows any citizen to trust the information related to the BNDES' financial operations, even if they did not trust the BNDES as an institution. For this, blockchain proved to be the ideal solution: a source of complete and transparent information, guaranteed by a consensus generated by a computational algorithm that runs on a decentralized network of computers around the world: the machine of trust. Thus, the BNDES, a state bank that finances the development of Brazil, would no longer be called a “black box”, a nickname that referred to its supposed lack of transparency towards society. This application, initially called BNDESToken, had proofs of concept running on Ethereum's Rinkeby - TestNet, and a controlled pilot project running on Ethereum's MainNet.

As the idea matured, it was identified the need to create an infrastructure network for a variety of government applications based on blockchain, for the improvement of public services, which was called RBB - the Brazil Blockchain Network. In the future, RBB is envisioned as a network of networks, which is agnostic and interoperable in terms of platforms. And, as the first network to be built in an MVP RBB Laboratory with other partner institutions, the chosen objective was to implement a network to foster innovation in the use of blockchain / DLT technology for applications of public interest, with special emphasis on enabling the necessary confidence for pro-transparency and anti-fraud measures. It is important to note that this objective is in line with the conclusions and recommendations issued by the TCU - Brazilian Federal Court of Accounts, the Brazilian Congress control body, in a judgment that approved the study on the use of Blockchain technology in Public Administration and the respective guidelines for public managers (Brasil, 2020b)

Thus, RBB intends to be implemented as a public permissioned blockchain network, agnostic in relation to the blockchain platforms used. This is a model that has been chosen by reference experiences: Alastria already runs Hyperledger Besu, Quorum and is committed to making Hyperledger Fabric available; EBSI runs Hyperledger Besu as a client for Ethereum Enterprise, and Hyperledger Fabric. And LACChain runs Hyperledger Besu, and is also developing an EOS network.

For RBB, Hyperledger Besu was the platform chosen to develop the MVP RBB Laboratory, due to the degree of adoption and maturity already achieved by these reference networks, and also due to the partnership signed with LACChain through the Memorandum of Understanding between BNDES and the Inter-American Development Bank.

In addition, Besu has been implementing EEA - Enterprise Ethereum Alliance specifications, including addressing data privacy issues. Thus, it is possible to use an Ethereum network client and create private groups where it is possible to define specific criteria for reading or writing access to data on the blockchain, which is a recurring concern of developers and adopters of blockchain technology, in the light of regulations such as the LGPD - the Brazilian General Data Protection Law, which was created based on the European GDPR.

Technical Setup

About the consensus protocol

The IBFT 2.0 method, a consensus protocol of the Proof of Authority type, will be used, which is appropriate when the network participants know each other and there is a level of trust between them, as is the case with government agencies. This allows the network to have faster block generation times and a much higher transaction rate, without the transaction costs incurred in the Ethereum MainNet Proof of Work.

Another interesting feature of this type of consensus is that there is an immediate finality, since all valid blocks are included in the main chain and there are no forks, which brings robustness to the network and seems quite adequate from the legal point of view for a

network with the purpose of the RBB. Thus, after validation, all transactions become permanent, immutable and guaranteed forever.

With IBFT 2.0, there is the figure of the validator nodes, responsible for validating the transactions and the blocks. For the network to be Byzantine fault tolerant, that is, to be able to function correctly even if a node fails, at least four validator nodes are required. And, for a new block to be processed and added, at least $2/3$ of the validator nodes must sign the block.

In relation to governance, to add or remove a validator node, it is necessary that the validator nodes vote and the election result has more than 50% of the votes.

The issue of the number of validator nodes is fundamental and permanent, as the time to add new blocks increases as the number of validators increases, and it is the main factor affecting scalability. Currently, tests carried out by LACCChain indicate a processing rate ranging from 300 to 400 transactions per second.

In the concrete case, validator nodes must be chosen in a way that it is impossible to any participant to dominate the network, and this analysis must take into consideration not only each participant institution individually, but also aspects of their governance, as in the case where two or more of them are, at the end, subject to the same authority, for instance, the President of the Republic, chief of the Federal Executive Branch.

In addition to the validator nodes, which participate in the consensus protocol and validate the transactions submitted to the network, there are other types of nodes, and RBB is configured to use the network architecture proposed by LACChain as a reference (Figure 4):

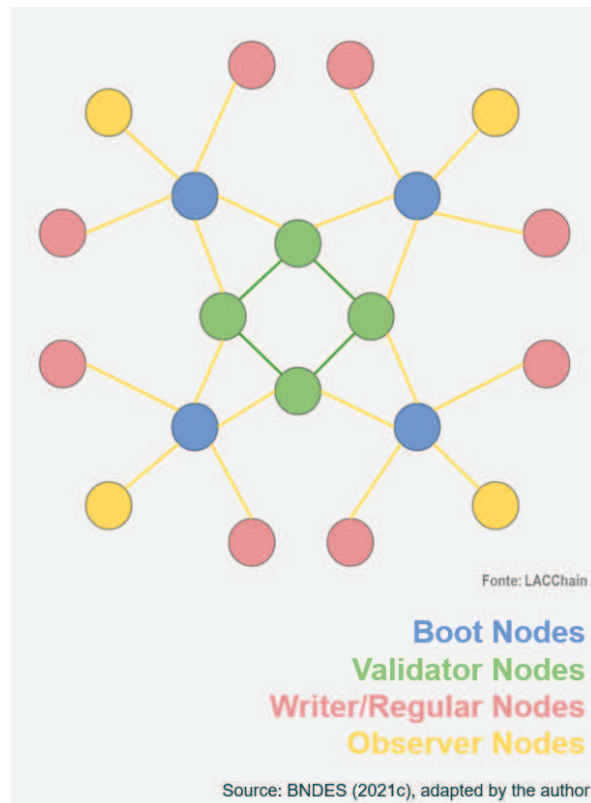
- **Boot Nodes:** responsible for connecting new nodes. The entity responsible for the node must electronically sign the terms of use for the network.
- **Writer Nodes:** can submit transactions to the network. These nodes can also create private channels with each other.
- **Observer Nodes:** can only read information registered on the network.

Simply put, the communication between the nodes and the processing of transactions should take place as follows in the RBB:

1. Authorized blockchain account address sends a signed transaction to a writer node.
2. Writer node verifies that the transaction is signed by an authorized account address.
3. Writer node signs and sends transaction to the boot nodes.
4. Boot nodes pass on transactions to validator nodes.
5. Validator nodes agree with the generation of new blocks between themselves, and transmit the new generated blocks to the boot nodes.
6. Boot nodes update the validator and observer nodes on the new blocks generated by the validator nodes.

In RBB concrete case, it is important how nodes architecture impact publicity, which is a key feature of RBB. This means that, although RBB is a permissioned network, all transactions must be public and citizens must be able to see them with their own “digital

Figure 4 – RBB Architecture for node categories



eyes”. Therefore, network participants also must be public and identified, and in particular, the validator nodes. Also, deploy observer nodes in a way that observation can be executed independently of other nodes is very important, and the citizens should be able to observe the network without the need to identify themselves.

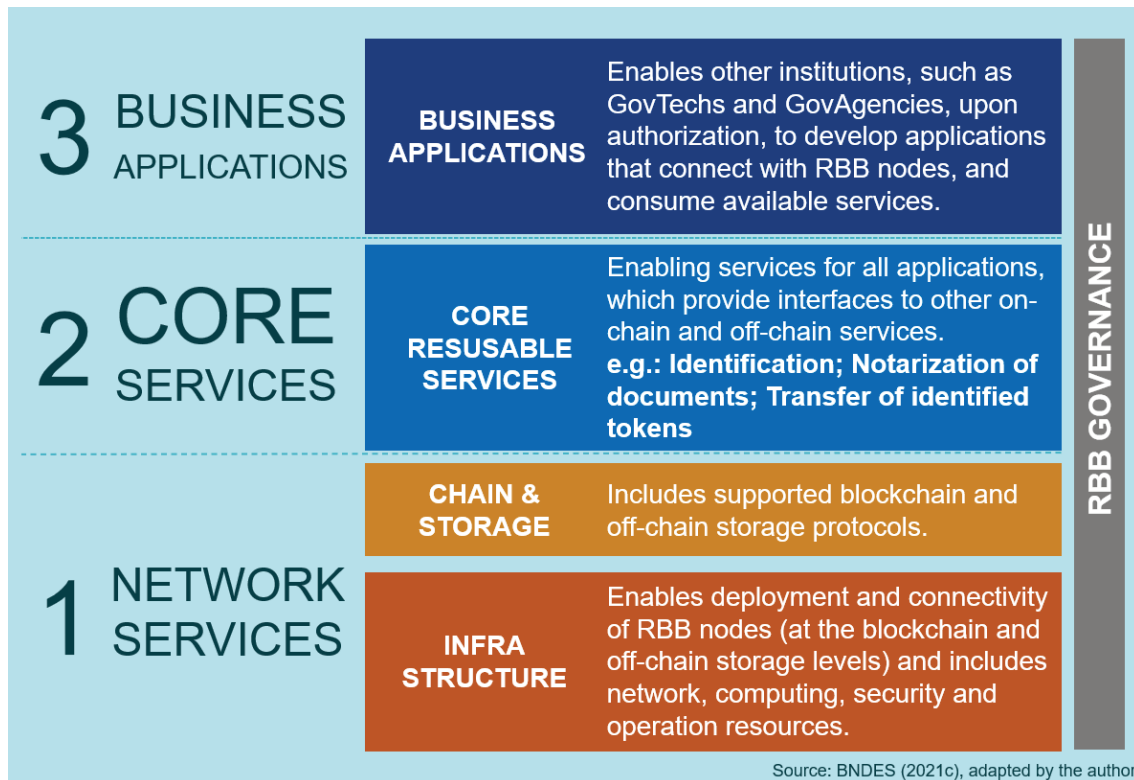
As Proof of Authority is used at RBB, there is no mining process, so transactions costs no longer depend on gas prices subject to supply and demand of processing capacity and the price of the Ether, as it occurs on the public network Ethereum. However, there is a discussion on how to cover maintenance costs. As seen in the discussion of revenue streams on the Business Model Canvas in Chapter II, possibilities range for total cost subsidy by the public budget, until a model that, although not aimed at generating financial profit, seeks independence from the public budget to support maintenance costs, research, development and expansion.

Strategies to enable the network to function and avoid DoS are not yet defined, but the creation of the algorithm to control the use of the network may involve the configuration of a native utility token for the network to regulate the use of services, including or not the use of a faucet.

About architecture layers, services and smart contracts

RBB is based in smart contracts, and is also intended to provide computation services, so third parties smart contracts can be deployed and executed in the blockchain. Figure 5 presents the RBB architecture in layers of services and applications.

Figure 5 – RBB Architecture layers



The inspiration for this architecture is the fact that many of the functionalities of the original BNDESToken were also requirements for blockchain projects of other governmental agencies. So, the original smart contract for the BNDESToken was split and re-written in function-specific smart contracts with generic business rules, that can be bound to other smart contracts responsible for specific business rules. Therefore, the new BNDESToken smart contract is now a set of customized business rules that belongs to the Business Applications layer. The once embedded Identification and Notarization functions were segregated in separate applications of the Core Services layer as RBB-Identification and RBB-Notarization, and can be reused by other applications. Also in the Core Applications layer, the basic functions of the original BNDESToken smart contract, such as management of issuance, transfers and burn of tokens, and rules that guarantee the transparency in the token flow were consolidated in what is now called the RBBToken application, that can be customized by combination and reuse with specific business rules determined by other smart contracts at the business application layer.

At this point, it is important to make some comments on identification. Being a public permissioned network, all legal entities responsible for boot, validator and writer nodes

are required to be identified. For this purpose, RBB-Identification can be used because it was developed to identify legal entities in RBB, by binding them to their e-CNPJ, digital certificates for virtual identification of legal entities under the trust protocol enabled by the Brazilian Public Key Infrastructure - ICP-Brasil. Once the e-CNPJ is bound to a blockchain address, access to RBB can be managed using Metamask.

As RBB intends to offer computing services to execute smart contracts and process transactions from third parties, this raises questions of legality and, more specifically, of liability. There was a need for clear attribution of liability in cases of illegal transactions or contracts, and RBB defined that the responsibility will fall on the writer nodes. As they will be jointly and severally responsible for the transactions and contracts, it will be crucial for the writing nodes to define identification protocols for the RBB. Also, besides legal entities, natural persons may be end users of the applications running on RBB, and to the moment there is not a decentralized application to directly identify natural persons in RBB. At the moment, there are two relevant discussions in this issue. Conceptually, the initial partners show great interest to study and develop decentralized, self-sovereign identities. Also, identification could be one of the gateways for interoperability between RBB Laboratory running Hyperledger Besu and other networks to compose the “network of networks” vision. Finally, there is the need to seek compatibility with the Brazilian Federal Government's Single Login Project, developed for authentication of natural and legal persons to access many applications of the official Digital Government initiatives, mainly centralized. Therefore, the group must articulate with the Secretary of Digital Government of the Ministry of Economy, to converge an integrated outlook and roadmap in the middle term for blockchain identification. This also must be aligned to the Brazilian LGPD.

There are other important discussions on liability that must be addressed by RBB, such as how to deal with vulnerabilities that can cause frauds and losses, hackers who can exploit flaws in smart contract codes, a court order to halt or modify a smart contract. Therefore, good practices, use of standard tools and libraries in the development of smart contracts, testing, code audits, development of governance for change management and even a governance to block, interrupt or modify smart contracts are essential actions to

and mitigate security and legal issues at the business applications and core services smart contracts layer.

Finally, on the basis of this architecture there is the Network Services layer. This comprises Infrastructure, which enables deployment and connectivity of RBB nodes, including network, computing, security and operation resources. Also, this layer deals with the supported blockchain protocols and off-chain storage protocols. As the RBB is not intended to be a repository of raw data, only hashes and some metadata should be stored by RBB. Raw data and large amounts of information will be stored off-chain, keeping the blockchain small in size to scale. Possible solutions are distributed databases, or, in the future, distributed filesystems.

Chapter IV - The Learning Journey

In this Master's Program, I went through a learning journey that I may never have experienced before. It was a rich and dynamic learning experience. And it was even unexpected in some aspects, as it also involved the impacts of the Covid-19 pandemic.

There were contributions from several sources, like being in a new environment, different from everyday life; the content presented in a structured way and adaptable to the student's profile; the people I met on the program, including classmates, professors, tutors and school staff.

Regarding the course modality, it was my first experience in a long-term course entirely online and in a foreign language. It was very interesting to know and use the tools made available via Canvas, with well-produced and high-quality content, and to maintain a good level of communication with the class and professors through the Zoom meetings and forums. But, above all, it was an exercise in discipline to keep up with the studies, tasks and projects throughout the course. Also, it is a course that was already very well structured to face the challenges imposed by the unexpected Covid-19 pandemic, so that, from the perspective of management and the tools provided by the course, there was a quick adaptation and a very satisfactory result. I learned a lot, I was happy with the result and I would not hesitate to take new courses with this infrastructure.

Regarding the proposal and the content of the course, despite already working with blockchain, the course gave me the opportunity to deepen my knowledge about the technology and its applications in an unprecedented way. I was provoked to know and understand the subjects that were not the priority in the development of my work, but that contributed a lot to reduce the information asymmetry before my colleagues and to give more speed and fluidity in the decision making about the ongoing blockchain projects. That's because I'm a Public Administrator, coming from the business area, interacting full time with a team of IT analysts and architects. That was the case, especially, of modules 2 (Cryptography & Security), 3 (Basics of Blockchain Technology & Architecture) and 6 (Advanced Blockchain Technology & Architecture). These are contents with the right level of depth for people who, like me, are not technicians in the IT field and have chosen the Business Path in this Master's Program.

This does not mean that the other modules did not bring relevant contributions, quite the contrary. First, confirming and reinforcing the knowledge foundations I already had was essential in module 1 (Blockchain and the Economy of Trust and Transparency). Module 4 (Cryptocurrencies, Token Economy & ICOs / STOs) was very important to present an overview of the segment in which blockchain may have had the greatest impact on our society so far. Module 7 (Business Applications & Use Cases) was incredible, allowing us to navigate through a diversity of industries, showing what types of blockchain applications are already being developed and envisioned, through a multisectoral and practical perspective and bringing us many provocations and ideas. Likewise, the questions, doubts and challenges discussed on in module 9 (Challenges, Scalability and the Future of Blockchain) were very provocative and leave us with a reflection on our responsibility to understand and make blockchain technology a tool to obtain the maximum positive impact for the whole society.

In terms of bottlenecks and challenges, in my experience it was module 5 (Legal and Regulatory) that touched on the most relevant issues. After taking us on a wonderful journey through the history of innovation and situating blockchain in that dynamics, the program brought references on Legal, Governance and Regulation aspects around the world and provided deep reflections on the issues that, in general, constitute the biggest gaps found during the development of the projects. And, even though in the experiences,

proofs of concept and even pilot projects these issues are resolved to some degree - and ideally in an organized way with the creation of sandboxes -, the truth is that the more we go deeper in the development and explore the technology, we realize that its potential for social, economic and even cultural transformation makes it clear that knowledge, maturity, critical mass and many discussions and definitions are still lacking, in order to create a more stable and secure environment that allows blockchain technology to establish itself and be widely adopted.

And finally, as the concepts and tools for entrepreneurship and business modeling were provided in module 8 (Lean Business Modeling for Blockchain), it was possible to associate them with the steps and milestones already developed within the scope of the project developed in my work at the BNDES. This has already added value to planning and, mainly, to the execution of our project. But without a doubt, the most interesting thing is also to know that these tools and methods can be applied to the future endeavors of life.

In short, participation in this Master's Program has brought me profound results: new and feasible ideas for projects under development in my work; a broader view of the blockchain ecosystem, on a global scale, of applications, ongoing changes, synergies and opportunities; a renewed energy to go deeper into the theme, connected to an awareness of the wealth of contributions that we can give to the world with this technology; and a more accurate perception of my potential as an innovative and entrepreneurial leader at work, even within an already well-structured and mature environment, such as we find at the BNDES.

Conclusion

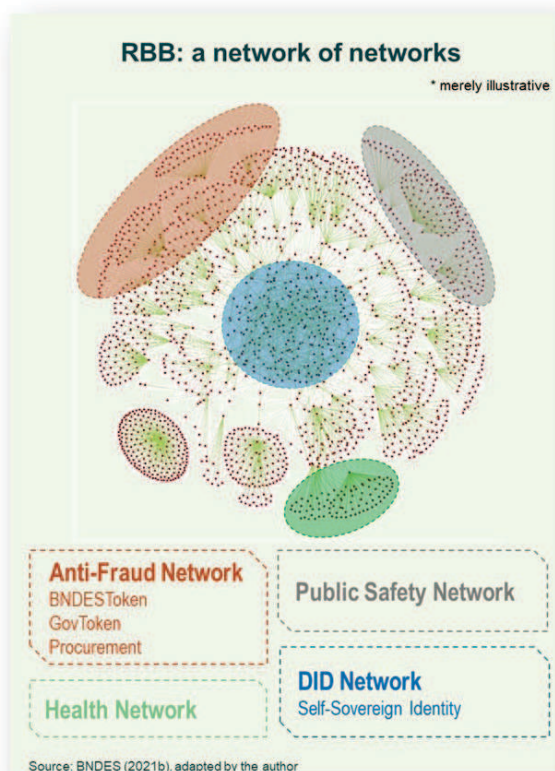
Projects from the BNDES blockchain initiative, such as TruBudget, BNDESToken and RBB, are in line with Schmidt and Sandner's (2017) view that an important impact of budget tracking mechanisms is increasing the difficulty of corruption in governments. They are also probably correct in believing that uncertainty about governments and their conflicts of interest represents the main barrier, as it discourages companies from building a solution.

But the BNDES is committed to articulating itself with the right partners, both in the public and private sectors and in the academic environment, to overcome these barriers and prove that, in Brazil, it is possible and viable to combat fraud and corruption through disruptive technologies like blockchain, to implement pro-transparency measures with an unprecedented level of trust for society. Seeing a project like the GOV Token, derived directly from BNDESToken, is very motivating, as it shows that startups in the private sector, the prefecture of the second largest Brazilian city and public agencies that promote innovation are able to articulate themselves to endeavor a project of this nature. And that this venture has the potential to multiply the impact of the vision that BNDESToken brought to the budget of a single public bank for the entire budget of the public administration of the Executive Branch.

In addition, it is important to highlight how changing the perspective of developing a decentralized budget tracking application, such as BNDESToken, to the RBB perspective, which is a blockchain infrastructure network, puts the challenge in another dimension. In this first stage of the RBB Laboratory, in which the focus is to provide an infrastructure that supports blockchain applications from public and private agents that rely on trust and transparency to combat fraud and corruption, the challenges of coordination and governance are already enormous. But the network of institutions committed to the cause also grows and the potential for a positive impact on results is multiplied.

And, finally, it is worth remembering that, if the fight against fraud and corruption is the focus of the first stage of implementing the RBB, the vision of the future contemplates what can be called an interoperable “network of networks”, in which several initiatives that use blockchain technology for the public interest can digitally articulate and integrate themselves, regardless of the platform or software used. Therefore, trust, transparency, database integration, data security, data integrity and authenticity, reduction of friction and bureaucracy, can be real characteristics of a new public sector, engaged in providing all kinds of public services to citizens and the society with transparency, efficiency and effectiveness.

Figure 6 –Network of networks: a possible future for RBB



Annex A – A brief overview of the blockchain ecosystem in Brazil

Brazil can be considered a breeding ground for blockchain development for startups. Research conducted in 2020 by the Distrito platform (Distrito, 2020) identified 181 startups dedicated to solutions and services involving cryptocurrencies and blockchain, distributed in the following business areas:

- Financial Services (49.7%), with solutions such as payments, transfers, foreign exchange, trading of digital assets and credit offers;
- Blockchain-as-a-service (23.2%), which offers the creation of platforms for third parties as a product;
- Digital Security (12.7%), with resources to improve regulatory processes and the viability and security of contracts and other digital documents;
- Asset Management and Tracking (9.9%), with technology applied to locate physical assets, fleets, production chains and inventory;
- Marketing and Digital Media (4.4%), with solutions in the provision of services in marketing and retail, focusing on the user experience.

Regarding corporations, in Brazil companies from different sectors have increased interest in understanding and studying the potential impacts of blockchain technology on their businesses, with the hiring of professionals and execution of proofs of concept and pilot projects. However, there is a concentration in two areas: financial services and supply chain traceability. And, in relation to projects in production, the emphasis is on the supply chain, mainly food security, provenance and origin.

For example, in food safety, the animal protein producer BRF develops a project in which some products can be tracked using a QR code on the packaging. Thus, the consumer checks the factory of origin of that product, date of production, packaging and transport, in addition to its validity. Any irregularity in manufacturing or distribution can be detected by the customer. In addition, there is an improvement in the compliance and quality of the process because, coupled with technologies such as sensing by IoT devices, the blockchain prevents managers from ignoring problems in the chain.

Another company that has used blockchain in a similar way in Brazil is Carrefour, which involved more than 40 suppliers that produce more than 150 products sold under the Carrefour brand in the “Guarantee of Origin” program, including for example milk, meat, fruits and vegetables. In the same way, the end consumer is able to follow the entire route, from the farm to the supermarket shelf, with guarantee and integrity of the information received.

Another initiative in the food industry, but with a focus on provenance, is that of the animal protein company JBS. The so-called Green Platform JBS is an initiative that registers and cross-checks the information of the company's suppliers with the animal traffic data. Due to the great demand of society in Brazil and in the world in relation to deforestation and climate change, it soon became apparent that blockchain allows the application of socio-environmental monitoring policies to various indirect links of the JBS production network that were only carried out with direct suppliers. Thus, the main benefits of Blockchain perceived so far are related to the automation of processes between partners in the production chains, with fast, secure and reliable sharing of incorrupt data.

However, there are still countless other applications, opportunities and benefits of blockchain technology to be better understood, tested and explored in production, including other industries, and not only by large companies, but also by other institutions, such smaller companies, universities and the government. These scenarios were explored back in December of 2018 by the BNDES, when it carried out a mapping of the blockchain ecosystem in Brazil, which aimed to draw an overview of ongoing initiatives and to discuss how to stimulate the Brazilian blockchain ecosystem. The results were presented at the BlockchainGov Forum, an event promoted by the BNDES, dedicated to discussing blockchain's contributions to the digital transformation of governments. When presenting the results, Maranhão (2018) showed that more than 350 initiatives were identified, and three main categories stood out in number of initiatives: Finance (33%), Consulting and technology (26%), and Education, hub and media (25%). Other relevant categories were Industry (8%) and Public Interest (8%). In terms of maturity, meaning the phase of development of the initiatives, the survey showed that the sector with the most initiatives in production was Consulting and technology, followed by Finance, Education, hub and media, Public Interest and Industry.

Further analysis about the context of Public Interest - the focus of the work developed by the BNDES -, showed that the most relevant themes explored were: Transparency in public spending, Data sharing, Digital identity, Notary systems, Certifications, Civic innovation and voting, and Transportation.

When asked about the three main opportunities for DLT and blockchain in the Brazilian context, the respondents pointed out the topics Transparency and control of public expenses (81%), Notary systems (72%), Access to the financial system (52%), Supply chain (41%) and Medical Data Records (36%). Energy and Insurance were also mentioned themes.

When answering about which are considered the three main challenges for the blockchain ecosystem, the respondents pointed out: Legal and regulatory difficulties (80%), Lack of labor force (74%), Difficulty in accessing markets (47%) and Lack of capital (32%). Culture and Strength of the traditional financial system were also mentioned.

Finally, when asked about the three best actions that the government could take to help the development of the Brazilian ecosystem, the respondents pointed out: Favor the regulatory environment (79%), Promote incubators and accelerators (60%), Grant tax incentives (60%), Promote training (43%), Define a national digital identity standard (37%), Implement a national permissioned network (30%) and Provide access to markets (29%).

This mapping, along with two editions of the BlockchainGov Forum promoted by the BNDES in 2018 (BNDES, 2018) and 2019 (BNDES, 2019), constituted a very important instrument for the BNDES to articulate with other government agencies, civil society organizations and the private sector to promote and establish joint initiatives such as events and workshops, partnerships, public consultations, and official governmental guidelines to foster the blockchain ecosystem in Brazil.

Annex B - The legal and regulatory frameworks in Brazil

Regarding to the blockchain legal and regulatory frameworks in Brazil, the most robust legal initiatives began to emerge in 2015. Bill PL 2303/2015 (Câmara dos Deputados, 2015), authored by federal deputy Aureo Ribeiro, proposed to include digital assets and airline mileage programs in the definition of “payment arrangements” under the supervision of BCB – Central Bank of Brazil.

Afterwards, bill PL 2060/2019 (Câmara dos Deputados, 2019) was proposed by the same deputy Aureo, already with a text that reflects an increase in maturity on the understanding of the blockchain technology, proposing to classify digital assets as a value reserve, means of payment and digital commodity. Also, it brings a taxonomy for digital assets, dividing them into units of value, units representing goods and virtual tokens for access, or utilities. In addition, it also proposes punishments for crimes that use cryptocurrencies to form financial pyramids and fraudulent schemes, with penalties ranging from a fine to 5 years of imprisonment for the perpetrators of these crimes. In April 2021, this bill was appended to PL 2303/2015 and both are still being discussed in Congress.

In Senate, there are currently two bills being discussed. Bill PL 3825/2019 (Senado Federal, 2019) was presented by Senator Flavio Arns, specifically to regulate the activity of exchanges. It foresees that the BCB standardize, authorize and supervise the activity of exchanges, and defines that crypto assets should not be submitted to the supervision of the CVM - Securities and Exchange Commission of Brazil, except when they have a security profile. Bill PL 4207/2020 (Senado Federal, 2020) was presented by Senator Soraya Thronicke, and intends to regulate virtual assets and legal entities that perform the activities of intermediation, custody, distribution, settlement, transaction, issuance or management of these virtual assets, as well as defining crimes related to the fraudulent use of virtual assets.

Although there's a lot of discussion, it is not possible to say that the subject is well regulated in Brazil. Nowadays, for example, blockchain technology is included in two initiatives of the Digital Governance Strategy, instituted by Decree nº 10.332 (Brasil,

2020a) within Objective 8 - Public services of the future and emerging technologies. One of the initiatives has the goal of making at least nine datasets available through blockchain solutions in the federal public administration, by 2022. And the other seeks to create an interoperable blockchain network, using reliable identification and secure algorithms. These objectives suggest two initial approaches to the implementation of blockchain in the Brazilian government: i) search for advantages in cost, time and complexity savings in the exchange of intergovernmental and public-private information; and ii) implementation of a blockchain-based digital infrastructure that serves a variety of decentralized applications developed by public agencies in providing services to citizens. This work takes place under the coordination of the CCGD - Central Data Governance Committee, in the General Secretary of the Presidency of the Republic.

However, Brazil does not yet have a National Blockchain Plan, detailing guidelines, and specific objectives and actions, or defining an advisory body or Steering Committee, such as the one launched for Internet of Things, for example (Brasil, 2019).

On the other hand, the TCU - Federal Court of Accounts, the control body of the Legislative Branch, carried out a research to identify experiences and areas of application for DLT technology in the public sector, assessing the main risks, success criteria and challenges for control. In this study (Brasil, 2020b), TCU identified high potential for generating value in use cases in which there is the occurrence or a need for: i) Shared repositories; ii) Multiple participants with writing rights; iii) Low confidence or conflict of interest; iv) Unnecessary intermediaries; v) Dependence on transactions; vi) Traceability and provenance of information; and vii) Agreement between participants on data and transactions. Also, the study highlighted that the decentralizing aspect and the automation of trust provided by blockchain solutions, which allows the consultation and carrying out of authenticated transactions without the need for a central authority, facilitates the implementation of digital public services guided by the perspective of the citizen. On the other hand, it concluded that there is still a lack of regulatory maturity in Brazil to take advantage of the full potential to increase productivity and boost the economy. As a result, it determined that several public administration bodies carry out feasibility studies to verify challenges, risks and opportunities provided by DLT technologies in their respective areas of activity.

Still within the scope of the federal government, the position of RFB - the Federal Revenue Service, is that virtual currencies, although not considered as currency according to the regulatory framework, are considered, for reporting purposes, as financial assets and, therefore, subject to the declaration of assets based on the acquisition value and payment of capital gain taxes in case of sale at a profit. Subsequently, RFB published Normative Instruction 1888/2019 (RFB, 2019), which requires individual and corporate investors and cryptocurrency exchanges to report monthly transactions carried out with crypto, involving any type of cryptocurrency transfer whose monthly value exceeds 30.000 Brazilian Reais (approximately USD 6.000).

Regarding the financial control bodies, the outstanding actions are those of BCB - Central Bank of Brazil, along with the CVM - Securities and Exchange Commission of Brazil and the SUSEP - Superintendence of Private Insurance.

BCB classifies Bitcoin and other crypto assets as "non-financial assets produced" and mining activity as "production process". In addition, following guidance from the International Monetary Fund, it considers the purchase and sale of crypto assets in the country's trade balance. In 2019, the BCB also opened public consultations for the implementation of the Open Financial System (Open Banking) and the Controlled Test Environment for Financial and Payment Innovations (Regulatory Sandbox).

It is interesting to note that the Regulatory Sandbox is a joint strategy of BCB with the SUSEP and also the CVM for the Brazilian financial, insurance and capital markets. The objective is to allow the necessary flexibility to adapt its regulations to technological changes and innovations, encouraging the emergence of new business models, and the offering of products and services of higher quality with the use of innovative technologies, such as DLT, blockchain, robot advisors and artificial intelligence.

"I have studied and devoted myself intensely to designing what the financial system of the future will be like. I have participated in studies on blockchain and digital assets. One of the contributions I hope to bring to the Central Bank is to prepare the institution for the future market, in

which technologies advance exponentially, generating more accelerated transformations".

Roberto Campos Neto, in his Letter to the Senate to evaluate the nomination for Governor of the Central Bank of Brazil, in February 2019

This statement by Campos Neto, current Governor of the BCB, is very adherent to his previous professional experience, at Santander Bank, in which he became involved in the global project on technological innovation, in the group responsible for the digital bank (Ayres, 2019). At the same time, it is also aligned with a path that the BCB has taken since the previous administration, which gave great incentives to the development of fintechs, with regulation of new activities and the creation of LIFT - Laboratory of Technological Financial Innovations - that promotes prototypes of financial and technological innovation in partnership with fintechs, academia and major players in the financial and technology market.

Campos Neto believes that the future of the Brazilian financial system will be very different from what it is today, and will be much more technological and digital. He also believes that there must be a modernization of financial intermediation, with more efficiency, competition and the development of new business and financial services models.

In fact, Brazil has made great strides towards innovation, with the entry into production in November 2020 of PIX, a new system of instant digital payments, and also with the Brazilian Open Banking roadmap.

In this sense, there is also an expectation that, in addition to these innovations, Campos Neto could proceed with the creation of a CBDC for Brazil, with a digital version of the Brazilian Real to be used mainly in foreign exchange and tourism operations, possibly using blockchain technology – although the PIX program, after testing blockchain, decided not to use it at all.

It is also worth mentioning that OAB, the Brazilian Bar Association, advocates soft regulation for the sector, or self-regulation of the market.

Appendix - List of Abbreviations

B2B	Business-to-business
B2C	Business-to-consumer
BCB	Banco Central do Brasil - Central Bank of Brazil
BNDES	Banco Nacional de Desenvolvimento Econômico e Social – the Brazilian development bank
CBDC	Central Bank Digital Currency
CCGD	Comitê Central de Governança de Dados - Central Data Governance Committee, General Secretary of the Presidency of the Republic
CVM	Comissão de Valores Mobiliários - Securities and Exchange Commission of Brazil
DeFi	Decentralized Finance
DLT	Distributed Ledger Technology
ERP	Enterprise Resource Planning
GDPR	European General Data Protection Regulation
Gov DApp	Governmental Decentralized Application
GovTech	Government technology driven business
IBFT	Istanbul Byzantine Fault Tolerance
IoT	Internet of Things
IT	Information Technology
LGPD	Lei Geral de Proteção de Dados Pessoais - Brazilian General Data Protection Law
LIFT	Laboratório de Inovações Financeiras e Tecnológicas - Laboratory of Technological Financial Innovations
MVP	Minimum Viable Product
NGO	Non-governmental organization
OAB	Ordem dos Advogados do Brasil - the Brazilian Bar Association
PIX	Brazilian Service for Instant Payment System
PL	Projeto de Lei – Bill
R&D	Research and Development
RBB	Rede Blockchain Brasil - the Brazil Blockchain Network
RFB	Receita Federal do Brasil –Federal Revenue Service
SUSEP	Superintendência de Seguros Privados - Superintendence of Private Insurance
TCU	Tribunal de Contas da União - Federal Court of Accounts

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